Middle St. Croix Watershed Management Organization 2010 Water Monitoring Report

Prepared For:

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Washington Conservation District

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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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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

CAMP	Citizen-Assisted Lake Monitoring Program
cf	cubic feet
cfs	cubic feet per second
Chl-*a*	Chlorophyll-*a*
COD	Total Chemical Oxygen Demand
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
MPN	most probable number
MSCWMO	Middle Saint Croix Watershed Management Organization
NTU	nephelometric turbidity units
OHW	Ordinary High Water level
Ortho-P	Ortho-phosphate
TBOD	Total Biochemical Oxygen Demand
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
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 2010 and previous years. In 2010 the Middle St. Croix Watershed Management Organization (MSCWMO) monitored water quality and elevation on McKusick Lake and Lily Lake, water quality on Brick Pond, and elevation on Perro Pond. Discharge and water quality were monitored on Perro Creek, along with water quality being monitored at Meadowlark Drive and Myrtle Street. (Figure 1). Information from the Brown's Creek Diversion Drainage 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 the current water quality conditions of the lakes and streams and to continue a long-term monitoring program that will enable the MSCWMO to identify trends associated with the land use changes in their watershed.

In 2010 Brick Pond, Lily Lake and McKusick Lake had average water quality. All three lakes were classified as mesotrophic (Table 2). The overall 2010 lake grades for MSCWMO lakes were: Brick Pond – B-, the same as in 2009, McKusick Lake – B+, up from a B last year, and Lily Lake – C+, down from a B+ last year (Table 3). When comparing the 2010 with the 2009 monitoring season, McKusick Lake showed a slight improvement in water quality, Brick Pond had the same water quality grade, and Lily Lake showed a slight decrease in water quality. Lily Lake was within the ecoregion range for total phosphorus and Secchi disk transparency, with one water quality sample exceeding the Minnesota Pollution Control Agency (MPCA) threshold for Secchi disk transparency impairment. Lily Lake was worse than the ecoregion range for chlorophyll-*a* with three water quality samples exceeding the MPCA threshold. This number was most likely skewed due to a missing chlorophyll-*a* value for the August 5, 2010 water quality sample collected. The Metropolitan Council Environmental Services (MCES) Lab was unable to analyze the sample due to missing information from the time of collection. McKusick Lake was within the ecoregion range for total phosphorus, chlorophyll-*a*, and Secchi disk transparency, with only one water quality sample exceeding the MPCA shallow lake threshold for Secchi disk transparency impairment. Brick Pond was poorer than the ecoregion range for total phosphorus and for Secchi disk transparency, but was within the ecoregion range for

chlorophyll-*a*. Several samples exceeded the shallow lake impairment threshold for phosphorus and all samples exceeded the impairment threshold for Secchi disk transparency (Table 1).

Both Perro Creek and the Brown's Creek Diversion Structure Drainage sites showed a general increase in discharge from 2009 to 2010 (discharge was not estimated at the Myrtle Street and Meadowlark Drive sites). In 2010, Perro Creek discharged a total load of 179 lbs. of phosphorus (a decrease of 63 lbs. from 2009) and 191,200 lbs. of suspended solids (up from 51,874 lbs in 2009 and 29,343 lbs. in 2008) to the St. Croix River. The significant increase in suspended solids loading observed in 2010 could have resulted from two possible causes. The first could be attributed to the overall greater amount of flow that occurred in 2010 (38,802,342 cf) when compared to 2009 (16,272,950 cf). There was roughly double the amount of water flowing though the site in 2010, which likely translated into an increased observed load. Another possible cause of the load increase could be the further degradation of the stream channel. At the location of the monitoring station, the banks have steadily degraded over the past three monitoring seasons, with large sections of bank sloughing into the channel. It is likely that this degradation is occurring along the entirety of the channel, and would certainly contribute to the increases in solids loading that have been observed.

While total discharge for the year was not measured at the Myrtle Street and Meadowlark Drive sites, samples were taken after storm events at these sites, and TP and TSS loads are known. When comparing the Myrtle Street and Meadowlark Drive sites for TP and TSS in lbs/day, it can be seen that all values for the Myrtle site are greater than those at the Meadowlark site. Comparison of 2010 TP and TSS loads with 2009 loads was difficult, as the Myrtle Street and Meadowlark Drive sites were sampled twice as many times in 2010. Values from 2009, however, showed the same trend that is seen now, where the majority of samples taken at the Myrtle Street site were greater than the samples collected from Meadowlark Drive.

For the Brown's Creek Diversion Structure Drainage site, TP increased by 64 lbs. in 2010 to 608 lbs. of phosphorus exported, up from 544 lbs. in 2009. TSS also showed an increase in amount of pounds exported to 353,007 in 2010, up from 227, 372 lbs, an increase of 125,635 lbs. This equates to an increase in TP and TSS loadings that are entering McKusick Lake.

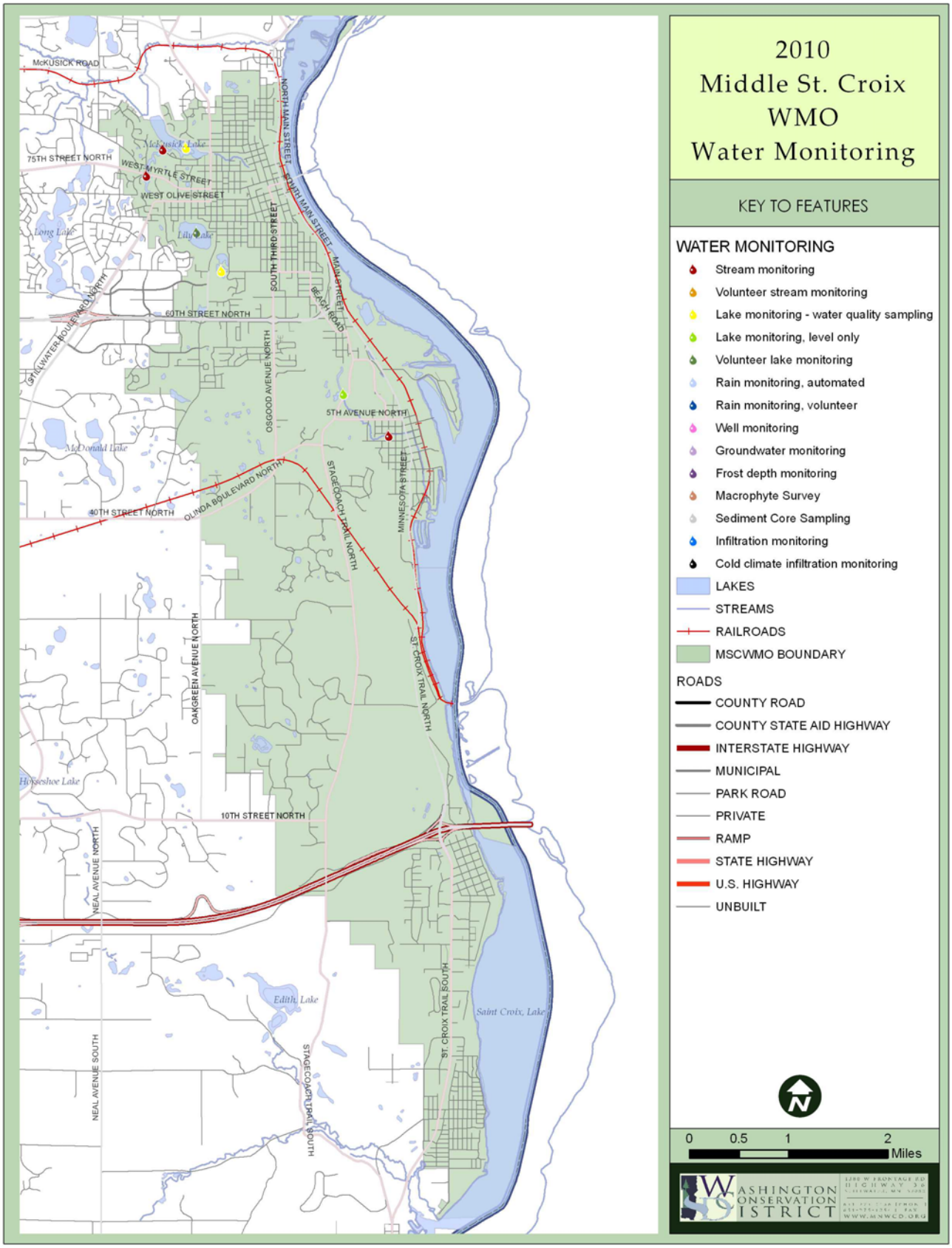


Figure 1. MSCWMO 2010 Water Monitoring Locations

LAKES

A. METHODS, RESULTS AND DISCUSSION

In 2010, water quality data was collected monthly (Brick Pond) or biweekly (Lily Lake and McKusick Lake) over seven consecutive months (April–October) by the WCD and a volunteer that helped collect samples on Lily Lake. Two meter (6.56 feet) integrated surface water samples were collected with a column sampler. Metropolitan Council Environmental Services Lab analyzed surface samples for total phosphorus, chlorophyll-*a*, and total Kjeldahl nitrogen. Field measurements of Secchi disk transparency, dissolved oxygen and temperature profiles, and lake level were also recorded, as well as a user perception ranking (physical and recreational suitability) of the lake. A full description of the WCD Standard Operating Procedures is available on the Washington Conservation District website at http://www.mnwcd.org/water_monitoring_standards.php.

Measurements obtained over the summer sampling season (June 1-September 30) are averaged for a comparison of individual lake dynamics from year to year, for comparisons between lakes within the watershed, and for a comparison with the average North Central Hardwood Forest Ecoregion values. Average values for all parameters, as well as the typical ranges for lakes in this ecoregion are presented in Table 1. Figure 2 through Figure 4 show the current and historic annual averages for each parameter at each site.

Table 1: Ecoregion Values and Average 2010 Parameters

2010 MSCWMO Lakes Summer Averages (June-September)			
Lake/Units	**Total Phosphorus (mg/L)**	**Chlorophyll-a (ug/L)**	**Secchi Disk (meters)**
Eco-Region Value	*0.023-0.050*	*5.00-22.00*	*1.5-3.2*
Lily	0.027	26.5	1.90
McKusick	0.03	5.4	2.32
Brick Pond	0.061	8.4	0.5

1. LAKE WATER QUALITY RESULTS

TRANSPARENCY (SECCHI DISK)

The measurement of depth of light penetration using a Secchi disk gives a simple measure of water transparency, or clarity. It is also a possible indication of turbidity in the water and an indication of the trophic state of the lake. A reduction in water transparency is usually the result of turbidity composed of suspended sediments, organic matter and/or phytoplankton (algae). The summer average (June-September) water transparency in MSCWMO lakes, as measured by Secchi disk during the 2010 study period, was 1.8 meters in Lily Lake, 2.3 meters in McKusick Lake, and 0.5 meters in Brick Pond (Table 1). Typical ranges for this ecoregion are 1.5 – 3.2 meters. Lily Lake and McKusick Lake had Secchi disk readings within the ecoregion range. No significant trend in Secchi transparency was seen for Lily Lake. McKusick Lake, on the other hand, has seen statistically significant improvements in Secchi transparency from 1994 through the present. Brick Pond exceeded (was poorer than) the ecoregion value in 2010. It should be noted, however, that it is difficult for transparency results to fall within the ecoregion range due to the shallowness of Brick Pond (the maximum depth of the pond is about 1.52 meters, just over the minimum ecoregion value). Historical Secchi disk summer average values for all three lakes can be found in Figure 2.

CHLOROPHYLL-*a*

Chlorophyll-*a* is a photosynthetic component found in algae and aquatic plants. It is also an indication of algal productivity. The 2010 summer average chlorophyll-*a* concentrations of MSCWMO lakes can be seen in Table 1. The ecoregion value range for chlorophyll-*a* is 5-22 μg/L. McKusick Lake (5.4 μg/L) and Brick Pond (8.4 μg/L) were within the ecoregion range for chlorophyll-*a* while Lily Lake (26.5 μg/L) exceeded the ecoregion range. It should be noted that there was one chlorophyll-*a* value missing from Lily Lake, from the August 5, 2010 sample collected. The MCES lab was unable to analyze the sample due to incomplete information recorded during sampling. This missing value may have skewed the average number. Historical summer average chlorophyll-*a* values can be found in Figure 3.

PHOSPHORUS

Phosphorus is a major nutrient involved in eutrophication of lakes and is generally associated with the growth of aquatic plants and algal blooms. Common sources of phosphorus include runoff from agricultural fields, livestock areas, urban areas, lakeshore lawns, and improperly operating septic systems. In most lakes in this region, phosphorous is the least available nutrient; therefore, its abundance or scarcity controls the extent of algal growth. Algal growth, in turn, affects the clarity of the water and light penetration. Total phosphorous (TP) summer average concentrations in MSCWMO lakes for 2010 were 0.027 mg/L in Lily Lake, 0.030 mg/L in McKusick Lake and 0.061 mg/L in Brick Pond (Table 1). The typical range of the ecoregion for total phosphorous is 0.023 – 0.050 mg/L. Lily and McKusick Lakes were within the normal range of ecoregion values. While Lily Lake showed improvement over 2009 TP values, there was no significant trend. McKusick Lake did not exceed the shallow lake water quality standard for TP in 2010, which is an improvement over 2009, when TP exceeded this range. McKusick Lake has also seen significant improvements in TP from 1994 to the present. Brick Pond exceeded (was poorer than) the ecoregion value in 2010, but did slightly improve over last year. Historical summer average TP values can be found in Figure 4.

NITROGEN

Several forms of nitrogen are responsible for health problems and can also increase the rate of lake eutrophication. Total Kjeldahl nitrogen (TKN) is one of these forms, and was measured during the 2010 monitoring season. Average TKN concentrations in 2010 were 0.88 mg/L in Lily Lake, 0.9 mg/l in McKusick Lake and 0.79 mg/L in Brick Pond. The ecoregion range for total Kjeldahl nitrogen is 0.60-1.20 mg/L. All lakes were within the ecoregion range for total Kjeldahl nitrogen in 2010.

TEMPERATURE AND DISSOLVED OXYGEN

Temperature and dissolved oxygen readings were taken during each sampling event (with the exception of Lily Lake, where dissolved oxygen was not measured during 2010). In addition to

surface water measurements, a temperature and dissolved oxygen profile was taken at each lake during each sampling event (with the exception of Lily Lake, where only surface water temperature was measured). These profiles were recorded at meter increments from the surface to the lake bottom. Data collected from these profiles are contained in a database at the WCD. 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, bottom nutrients become available and can result in increased algal production. McKusick Lake exhibited thermal stratification during the summer months (with a thermocline varying between 2-3 meters), and was therefore less likely to completely mix. Conversely, Brick pond is a shallow, non-stratifying lake that may mix throughout the summer, allowing for internal loading.

TROPHIC STATE AND LAKE GRADES

Many water quality scientists classify lakes according to their trophic state. Average summer values of total phosphorus, chlorophyll-*a*, and transparency (measured with the Secchi disk) are most often used to determine a lake's trophic state. The Carlson Trophic State Index is used to quantify the relationship between trophic status and water quality data. Oligotrophic lakes, such as lakes common in the northeast part of Minnesota, have low biological activity as a result of low phosphorus concentrations, low chlorophyll-*a* concentrations, and high Secchi disk transparencies. A good local example of an oligotrophic lake is Square Lake, located in Section 23 of May Township. Mesotrophic lakes have slightly more biological production, and are characteristic of lakes found in the north central forest regions of Minnesota. On the other end of the spectrum, lakes with high biological productivity, characterized by high phosphorus concentrations, high chlorophyll-*a* concentrations, and low Secchi disk transparencies, are eutrophic or even hypereutrophic (Table 2).

Based upon the 2010 data and utilizing the Carlson's Trophic State Index (Table 2), Brick Pond, McKusick Lake, and Lily Lake are all classified as mesotrophic. Lakes within the eutrophic or hypereutrophic range typically receive excess nutrient loading from sources within their

watersheds. Some percentage of these nutrients, however, can also be attributed to internal loading within the lake, which is typical of shallow, sediment-rich lakes or lakes that receive large amounts of runoff from the surrounding drainage area.

Table 2: Trophic State Index and Ranges

	Trophic State Index	TP (ug/L)	CLA (ug/L)	Secchi (m)
Oligotrophic	<40	<10	<4	>4.8
Mesotrophic	40-50	10-30	4-10	4.8-1.8
Eutrophic	50-70	30-60	10-30	1.8-0.8
Hypereutrophic	>70	>60	>30	<0.8

To allow for a better understanding of lake water quality data and to aid in the comparison of lakes, a Lake Grading System is also used in this report (Table 3). 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 curve represents percentile ranges for three water quality indicators: the June through September average values for total phosphorous, chlorophyll-*a* and Secchi disk transparency. These percentiles use ranked data from 119 lakes sampled from 1980-1988 and are shown in Table 3.

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

The variables used in the grading system strongly relate to open-water nuisance aspects of a lake (i.e. algal blooms), which can indicate accelerated aging (cultural eutrophication). The Lake Grading System was used for lakes sampled in 2010. Lily Lake received a grade of C+. The overall water quality of McKusick Lake improved when compared to the previous three years—from a C+ in 2007 and 2008, to a B in 2009, and now to a B+ in 2010. When compared to last year, Brick Pond data showed that overall water quality improved slightly, going from a grade of

a C+ in 2008 to B- in 2009, to a grade of B- in 2010. Summaries of all lake results are presented in Appendix A. Comparing the Lake Trophic Status and the Lake Grading System shows a fair to good correlation between the two systems.

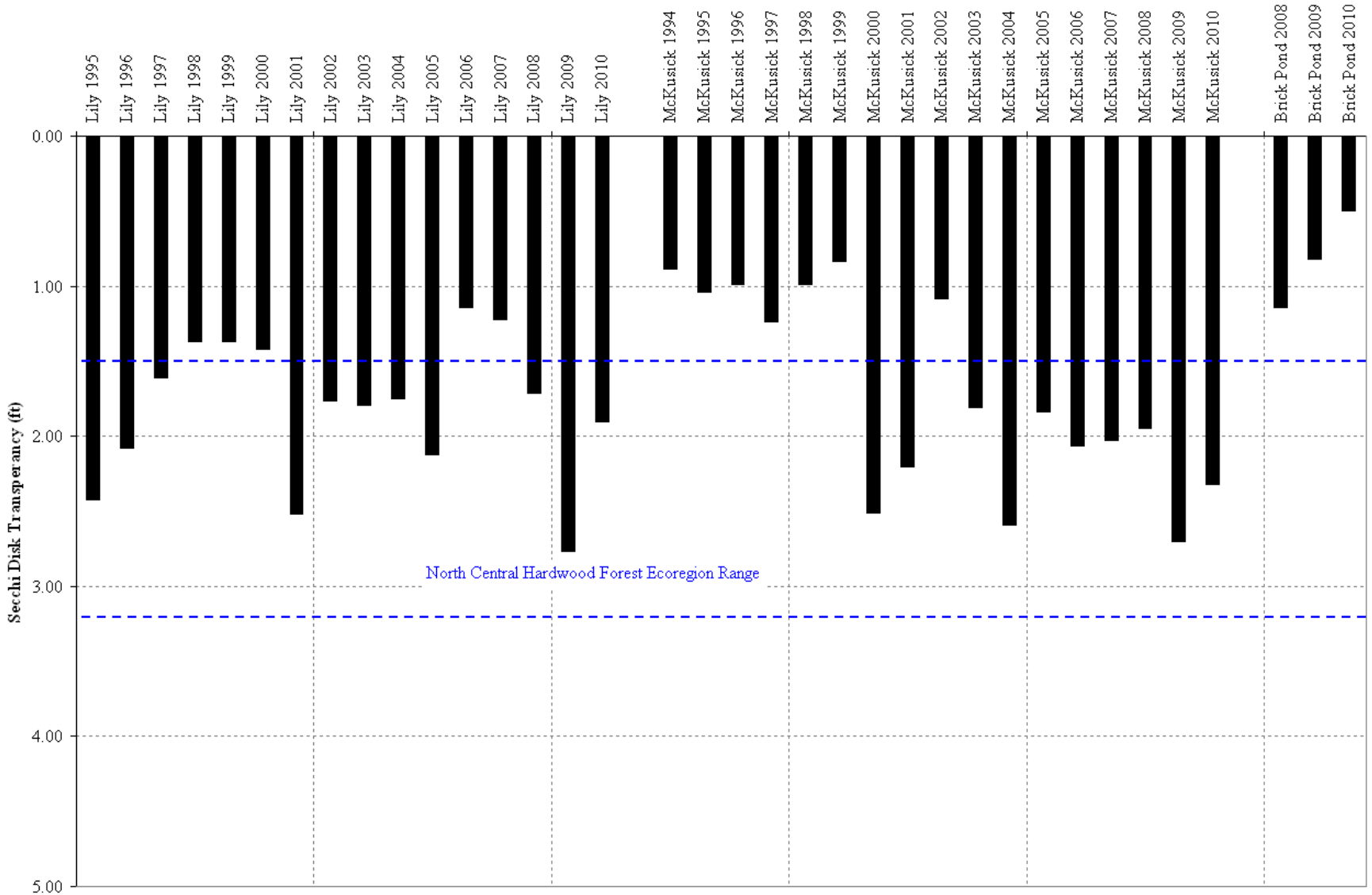


Figure 2. MSCWMO Historic Secchi Records

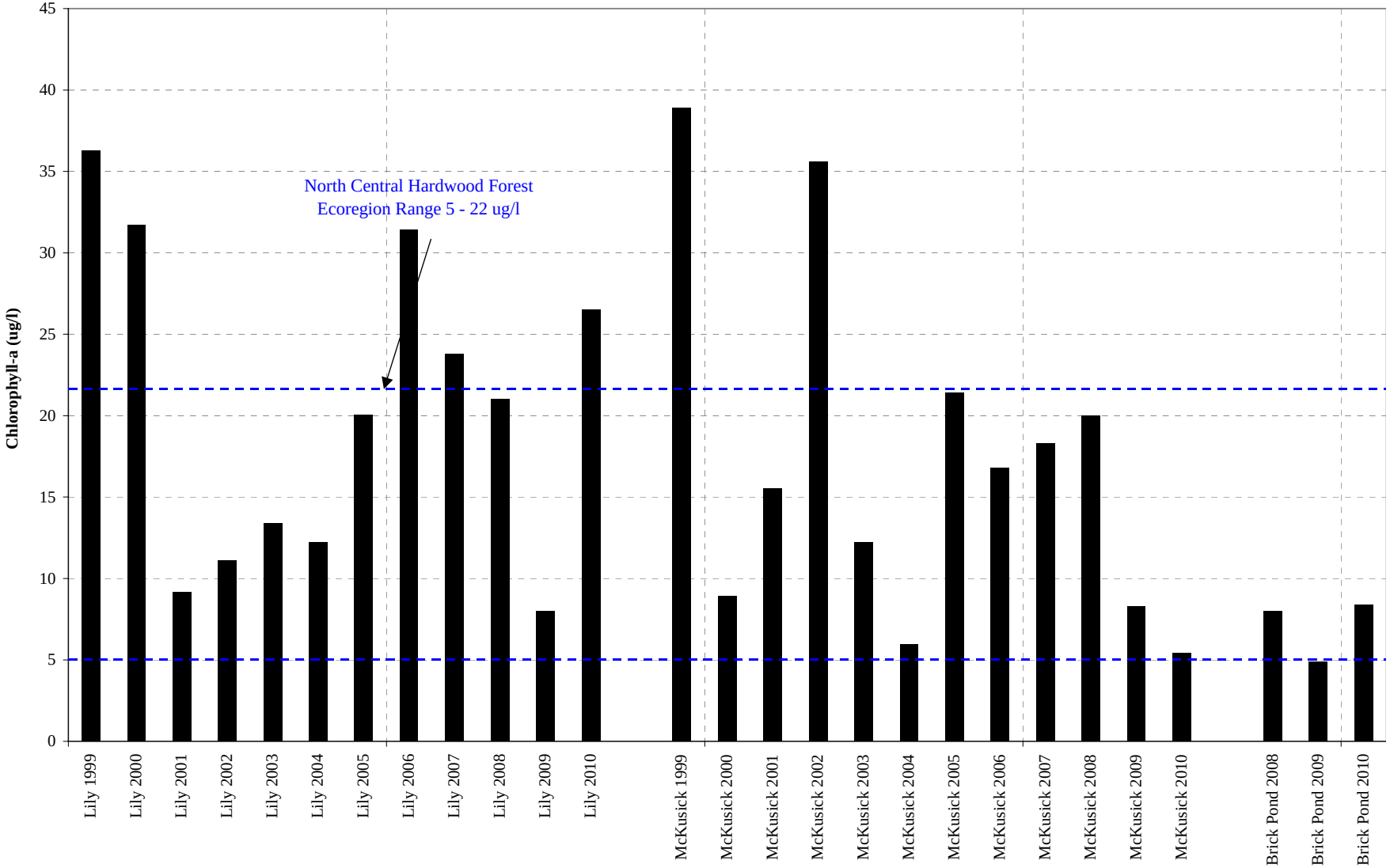


Figure 3. MSCWMO Historic Chlorophyll-*a* Data

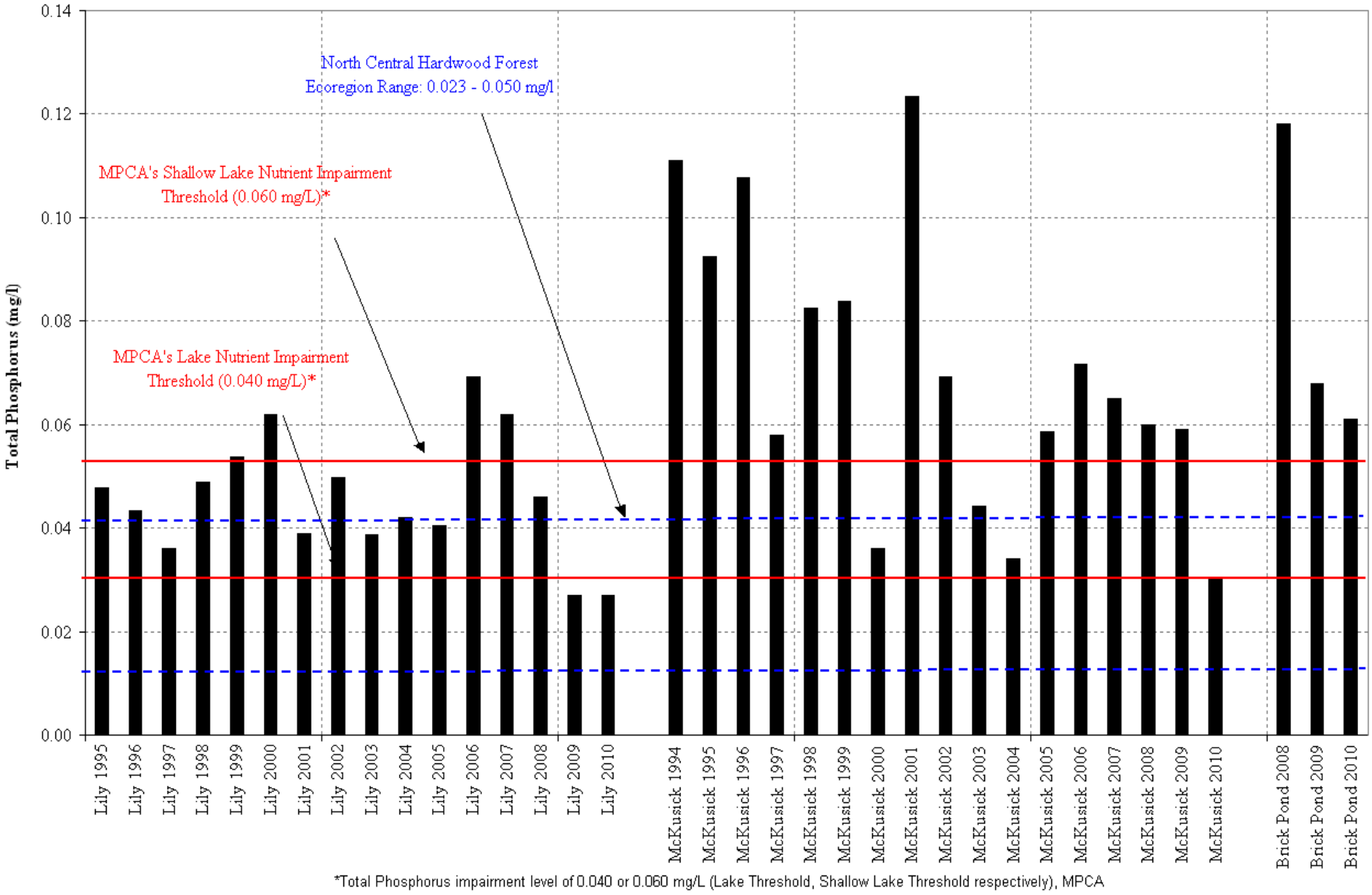


Figure 4. MSCWMO Historic Total Phosphorus Data

2. LAKE ELEVATIONS

Lake elevation gages are located on two lakes (Lily and McKusick Lakes) and one wetland (Perro Pond) throughout the MSCWMO and are monitored by WCD staff. Complete lake elevation data for 2010 can be found in Figure 5 through Figure 7. Lily Lake fell below the Ordinary High Water level (OHW)[1] during a short period of time (from mid-July to the beginning of August) reaching its lowest recorded elevation on July 30th at 844.62 ft (Figure 5). Lily Lake elevations then rebounded after an early August storm, dropped somewhat during the early part of September, and then rose to its highest elevation (845.14 ft) on October 28, 2010. Despite the dry summer of 2010 (Figure 8), the elevation of McKusick Lake was above the OHW for the entire monitoring season. McKusick Lake's elevation was at its lowest recorded level on April 13th, at the beginning of the monitoring season, and rose steadily due to large amounts of rainfall in June to its highest recorded level on June 27th. From here, it declined until a large rain event in early August, declined again until a large rain event in late September, and then ended at an elevation that was close to the average elevation for the entire monitoring season (Figure 6).

Perro Pond does not have an established OHW for comparison purposes (Figure 7). A small dam holds back Perro Pond, which was not open during the month of April, keeping the water elevations higher. On April 29th, the dam was opened letting water discharge into Perro Creek. Perro Pond's large elevation increase at the end of July could be attributed to a closure of the outlet structure, however no records of when this occurs are currently being kept. All three resources reflect significant decreases in elevation during the summer of 2010 when precipitation was below normal. For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

[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.

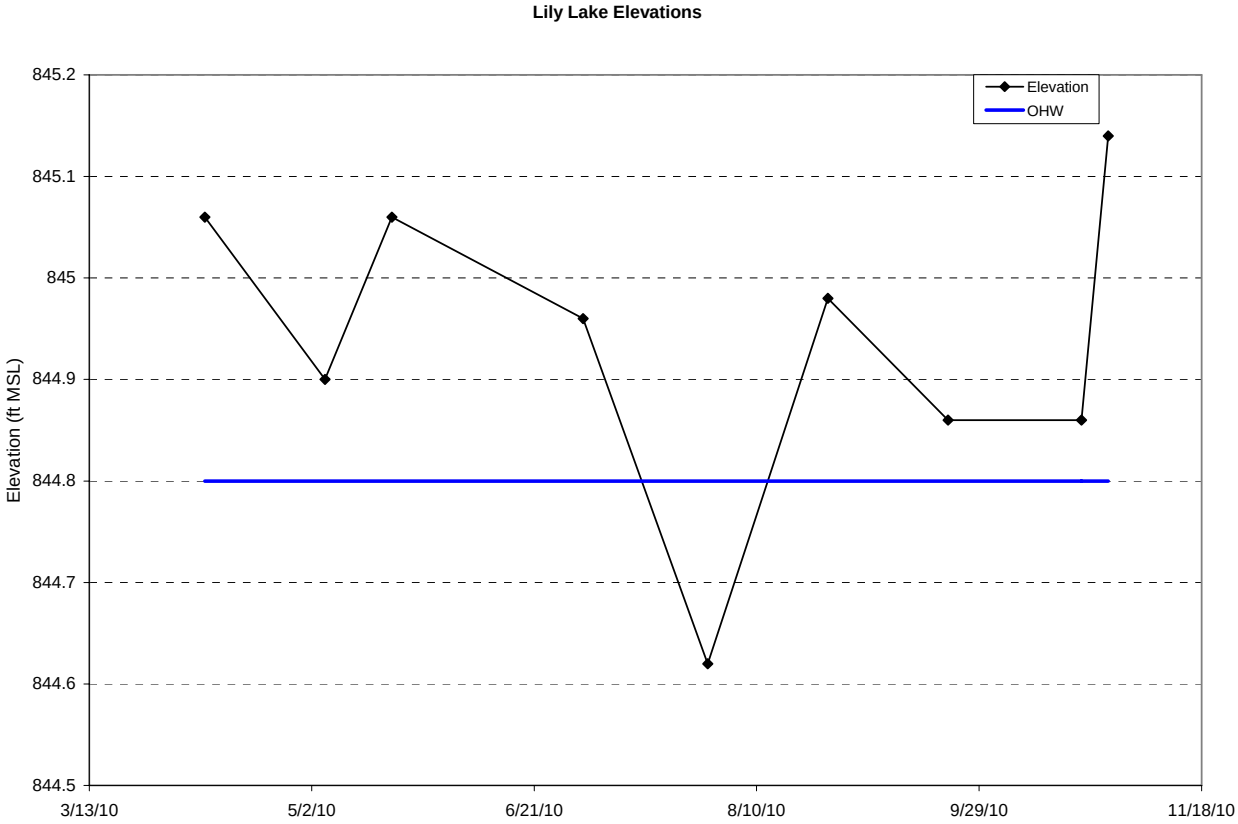


Figure 5. Lily Lake 2010 Elevations

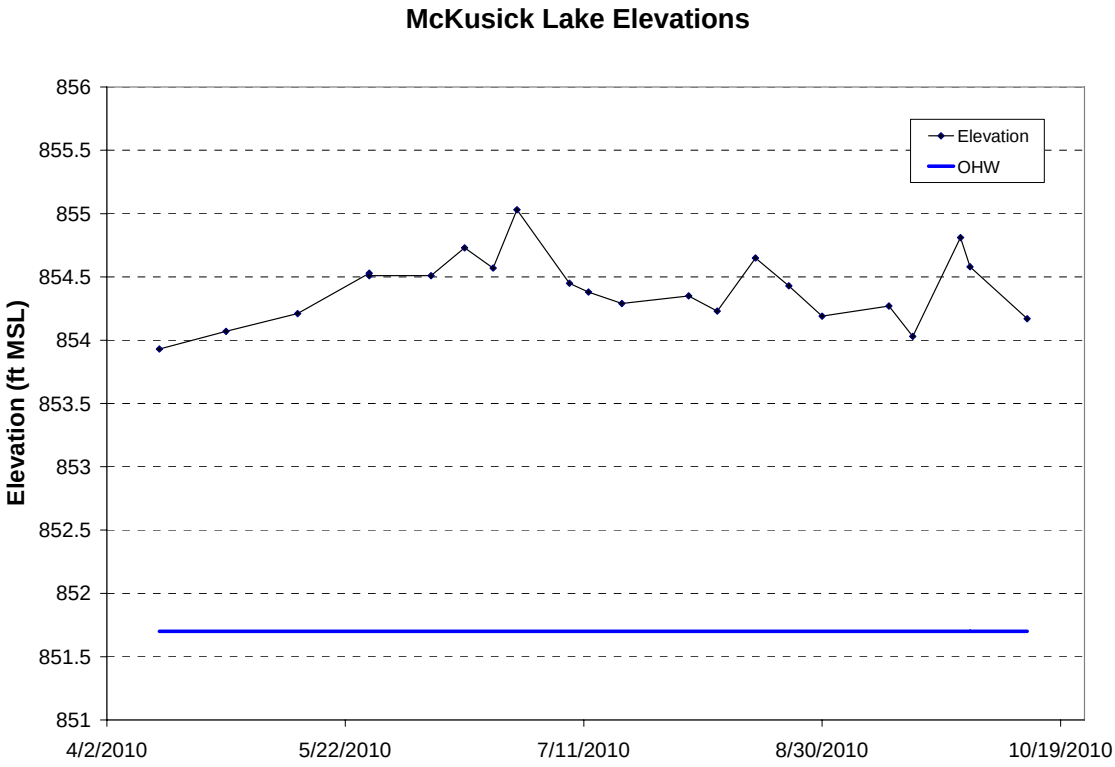


Figure 6. McKusick Lake 2010 Elevations

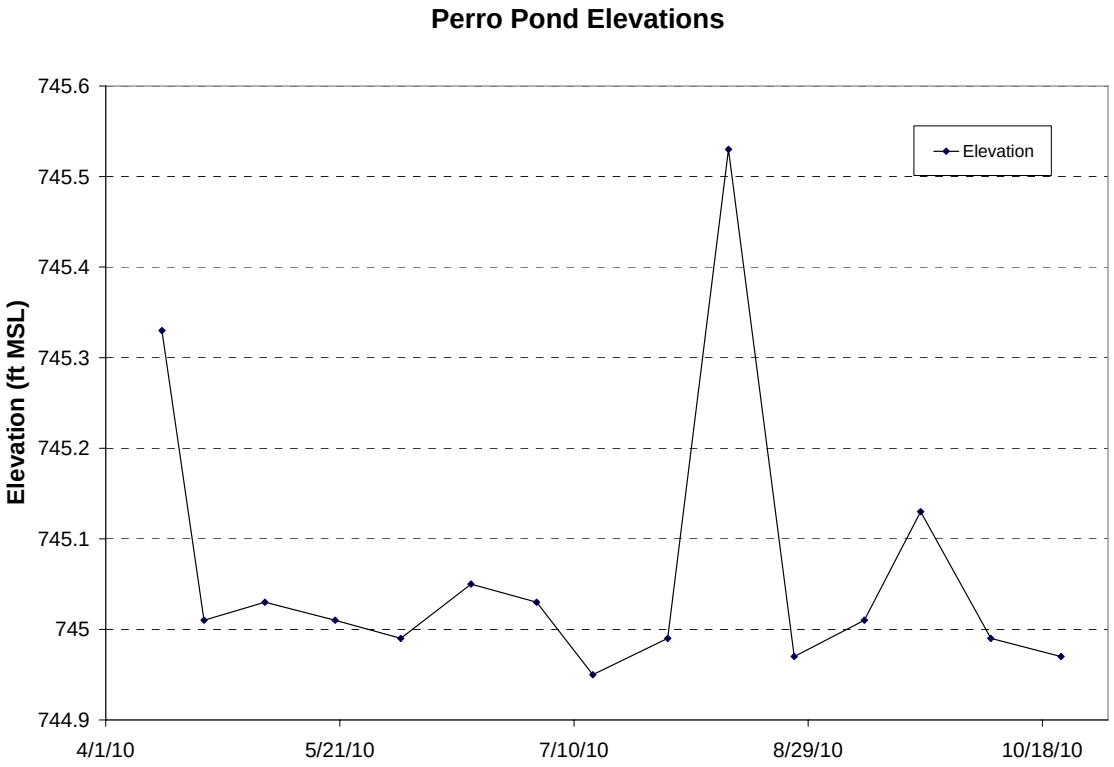


Figure 7. Perro Pond 2010 Elevations

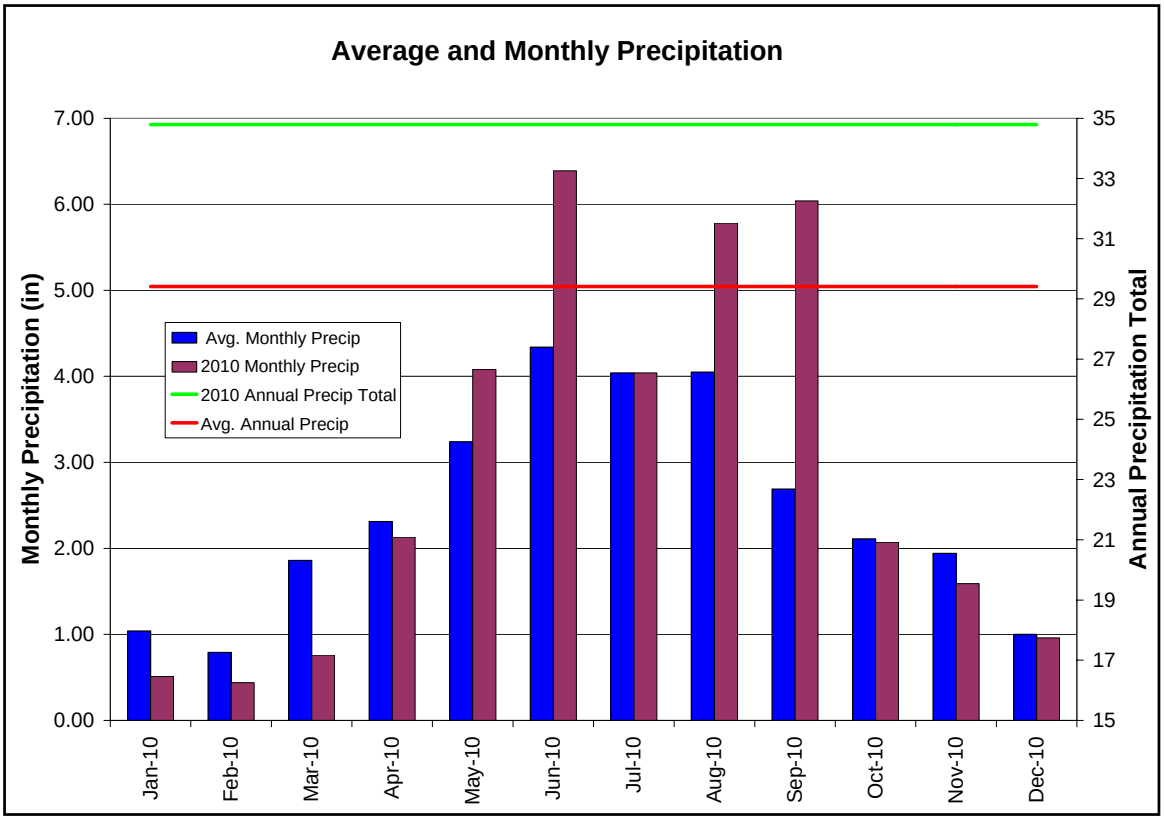


Figure 8: 2010 Annual Precipitation, Historical 30-Year Average Monthly Precipitation and 2010 Monthly Precipitation

2010 Data from WCD Precipitation Gage T 30N R 20W Sec 32

*Average monthly precipitation totals derived from historical 30-year (1971-2000) average for this region

B. MSCWMO LAKES: CONCLUSIONS AND RECOMMENDATIONS

Lake monitoring in MSCWMO will continue 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 with other lakes in the region.

In 2010 Brick Pond, Lily Lake and McKusick Lake had average water quality ratings with all three lakes classified as mesotrophic. The overall 2010 lake grades for MSCWMO lakes were: Brick Pond: B-, Lily Lake: C+, and McKusick Lake: B+. When compared with data after 2006, McKusick Lake and Lily Lake have shown improvement in water quality every year. McKusick was no exception for the 2010 monitoring season, however Lily Lake did show a slight decrease in water quality. It should be noted that no statistically significant trend can be determined about the water quality at this time, whether it is improving or declining as a whole.

Lily Lake was within the ecoregion range for total phosphorus and Secchi disk transparency and only one water quality sample exceeded the MPCA lake threshold for Secchi disk transparency impairment. Lily Lake exceeded the ecoregion range for chlorophyll-*a* with three water quality samples exceeding the MPCA lake threshold for chlorophyll-a impairment. Summertime (June-September) Secchi disk transparency, total phosphorus (TP), and chlorophyll-*a* (CLA) averages have remained relatively consistent over the last ten years in Lily Lake (D+ to C+) with the exception of 2001 and 2009 (B and B+ lake grades) where overall water quality dramatically improved for one year each time (Figure 2, Figure 3, Figure 4). In 2001 CLA levels and the lake grade improved significantly, and may indicate when copper sulfate treatment began in Lily Lake. In 2006 and 2007, summer average TP, CLA, and Secchi disk transparency all deteriorated when compared to averages seen in 2001 to 2005. TP and Secchi disk transparency again improved from the previous year. In 2010 the level of the water fluctuated over the course of the summer. In 2009 Lily Lake improved over all previously recorded years and received a B+ lake grade. In 2010 sample results returned back to the long term average, and a lake grade of C+ was given. The cause of these one-year increases (2009, 2001 and 1995) in water quality is presently unknown, and should be investigated further in the future. The summer average grade for CLA should be interpreted with caution, as one of the sample values

was undeterminable due to a recording error. Lake water quality management measures known to WCD staff were copper sulfate treatment and the completion of a native buffer planting at the public access. The starting date of the copper treatment is unknown, the buffer was completed mid 2010.

McKusick Lake was within the ecoregion range for total phosphorus, chlorophyll-*a*, and Secchi disk transparency. In 2010, no water quality samples from McKusick Lake exceeded the MPCA phosphorus impairment threshold for shallow lakes, which is a large improvement over last year, which had three exceeded values. The City of Stillwater completed the Trout Stream Mitigation Project in June 2003 and has been functioning to divert stormwater from the 1800-acre Annexation Area away from Brown's Creek, through McKusick Lake 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 residences' concerns about the amount of water and nutrients entering McKusick Lake are being investigated by the 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 Table 11, Table 12, and Table 13.

2010 marked the third year that Brick Pond was monitored. Total phosphorus showed a very slight improvement in 2010 from 2009, just slightly worse than the ecoregion range and above the MPCA's Shallow Lake Nutrient Impairment Threshold. Chlorophyll-*a* was within the ecoregion range for 2010, an increase from 2009. Secchi transparency decreased and went from being in the ecoregion range in 2008, to being worse than the ecoregion range in 2009 and 2010 (Figure 2, Figure 3 and Figure 4). Several samples exceeded the shallow lake impairment threshold for phosphorus and all samples exceeded the standard for Secchi disk transparency impairment. (Figure 2, Figure 3 and Figure 4). It should be noted, however, that it is difficult for transparency results to fall within the ecoregion range due to the shallowness of Brick Pond (the maximum depth of the pond is about 1.52 meters, just over the minimum ecoregion value).

Water quality in a lake depends on a number of different variables such as: size of the contributing watershed, depth of the lake, and current amount of nutrients available to be periodically released from the lake bottom, as well as external nutrient sources. Low water quality ratings of MSCWMO lakes are most likely due to the shallowness of the lake (McKusick Lake and Brick Pond) or from long-term periods of urban runoff (Lily Lake). Shallow lakes typically will exist in a low algal production, clear-water state or a high-algal production, turbid water state, but not in between the two states. Shallow lakes may not completely stratify in the summer (Brick Pond); therefore, they have the capability to continually mix. Mixing causes phosphorus to be distributed throughout the water column, causing more frequent and heavy algal blooms. This is unlike deeper, stratified lakes where the phosphorus below the thermocline is not available for primary production.

The MPCA has listed both Lily and McKusick Lake on the 303d Impaired water's list for nutrient/eutrophication impairment, with a target completion year for both of 2012. If a water body is listed, it indicates that it is not currently meeting water quality criteria. In order to meet criteria, a total maximum daily load (TMDL) must be implemented. A TMDL will outline what pollutants are degrading water quality and what will need to be done in order to meet current water quality standards. The MPCA has tentatively scheduled a three lake TMDL for Long Lake, Lily Lake and McKusick Lake in 2010. As indicated previously, it is the WCD's recommendation to utilize the city's exiting Lake Management Plan as a template for a TMDL study and Implementation plan for the most expeditious route to water quality improvement project funding and eventual de-listing.

There were two lakes and one wetland monitored for water elevation from April to October 2010 (Figure 5 to Figure 7). The highest recorded elevations in 2010 occurred at different times for each water body: late-October for Lily Lake, late-June for McKusick Lake, and mid-August for Perro Pond. Changes in lake/wetland elevation can be attributed to changes in monthly precipitation. As noted in Figure 8, precipitation was below normal from January through April, above normal from May to June, average for the month of July, above normal for August and September, and below normal for October and November, and right at the average monthly precipitation level for December. The total precipitation amount for 2010, however, was 5.38

inches above the historical annual average (34.79 total inches in 2010 compared to 29.41 inches for the historical annual average). It is recommended that water level monitoring continue in the MSCWMO lakes and wetland.

STREAM MONITORING

A. METHODS, RESULTS, AND DISCUSSION

Perro Creek is a tributary of the St. Croix River. It is 1.8 miles long, flowing from its source, Perro Pond, through an urban landscape until it reaches the St. Croix River. In the upper reach, much of the creek flows through residential backyards. The lower reach of the creek has been substantially channelized, even through the use of concrete. The lower reach also flows through a more urban, industrial environment where it is prone to more runoff from the surrounding area.

The Myrtle Street site is located on Myrtle Street between Bayberry Avenue and Deer Path on the south side of the road. It receives water from the urban area and wetland on the south side of Myrtle Street, and ultimately from Lily Lake. This site is monitored to see if any additional loading to McKusick Lake is coming from this area to the south.

The Meadowlark Drive site is located downstream of the Myrtle Street site, where the tributary crosses the waking path that extends from Meadowlark Drive. It receives water from the Myrtle Street site and the wetland located between the two sites. This site is monitored to see if any additional loading is coming into McKusick Lake from the wetland between the Myrtle Street site and the Meadowlark site.

Data from the Brown's Creek Diversion Structure Drainage was also included in this report for 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, Meadowlark St., and Myrtle St. are the only stream monitoring sites referenced as being within the MSCWMO.

A list of the WCD standard operating procedures can be found at http://www.mnwcd.org/water_monitoring_standards.php .

1. PERRO CREEK

In 2010, the WCD took grab samples and automated flow-weighted composite samples during base flow and storm event conditions at the Perro Creek site. An automated sampler located about 1 mile upstream of the St. Croix River (Figure 1), continuously monitored stream flow and collected storm flow composite samples from April through November. Base grab samples were also collected over the course of the monitoring season. Data collected at this site by the WCD included total discharge, precipitation, and water quality analysis. All stream flow and chemistry data from 2010 can be found in Figure 9, Table 5, Table 6, Table 7 and Table 8. Total flow during the 2010 monitoring season for Perro Creek was 63,096,920 cf, and total precipitation was 26.36 in. Peak discharge for this site was 63.976 cfs, which occurred on August 13th. The highest values for TP, TSS, VSS and TKN were all from a storm composite sample occurring after a large storm event on April 7th, with values of 2.08 mg/L, 7230 mg/L, 500 mg/L, and 11 mg/L, respectively. Of the ten storm samples collected, TSS exceeded the water quality standard for turbidity for six of these samples.

Using 2010 data, total phosphorus and total suspended solid loads were calculated for Perro Creek in order to determine total discharge to the St. Croix River and to determine load per hectare (1 hectare ~2.471 acres) per year. In 2010, Perro Creek discharged a total load of 179 lbs. of phosphorus (a decrease of 63 lbs from the 2009 load) and 191,200 lbs. of suspended solids (up from 51,874 lbs. in 2009 and 29,343 lbs. in 2008) to the St. Croix River (Table 14).

Escherichia coli (E. Coli) is a bacterium 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].

Perro Creek exceeds this standard for the months of June, July and August, where the geometric mean of the five samples taken in this month exceed the value of 126 #/100 mL (Table 4). Continued monitoring of *E. Coli* at this site will continue to help in determining if exceedance during the summer months is occurring.

Table 4. Perro Creek *E. coli* Monthly Geometric Mean

Site	May	June	July	August	September	October
Perro Creek Monthly Geometric Mean	Insufficient Data	192.40	224.65	656.48	Insufficient Data	Insufficient Data
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		
7/29/2009 9:30			261			
8/27/2009 10:25				1120		
9/30/2009 8:50					163	
5/25/2010 9:00	99					
6/24/2010 9:15		225				
7/28/2010 11:25			93			
8/26/2010 9:49				111		
9/30/2010 9:51					95	
	Exceeds geometric mean of 126 #/100mL from not less than 5 samples in a calendar month					
	10% of samples taken in the last 10 years exceed 1260 #/100mL					

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

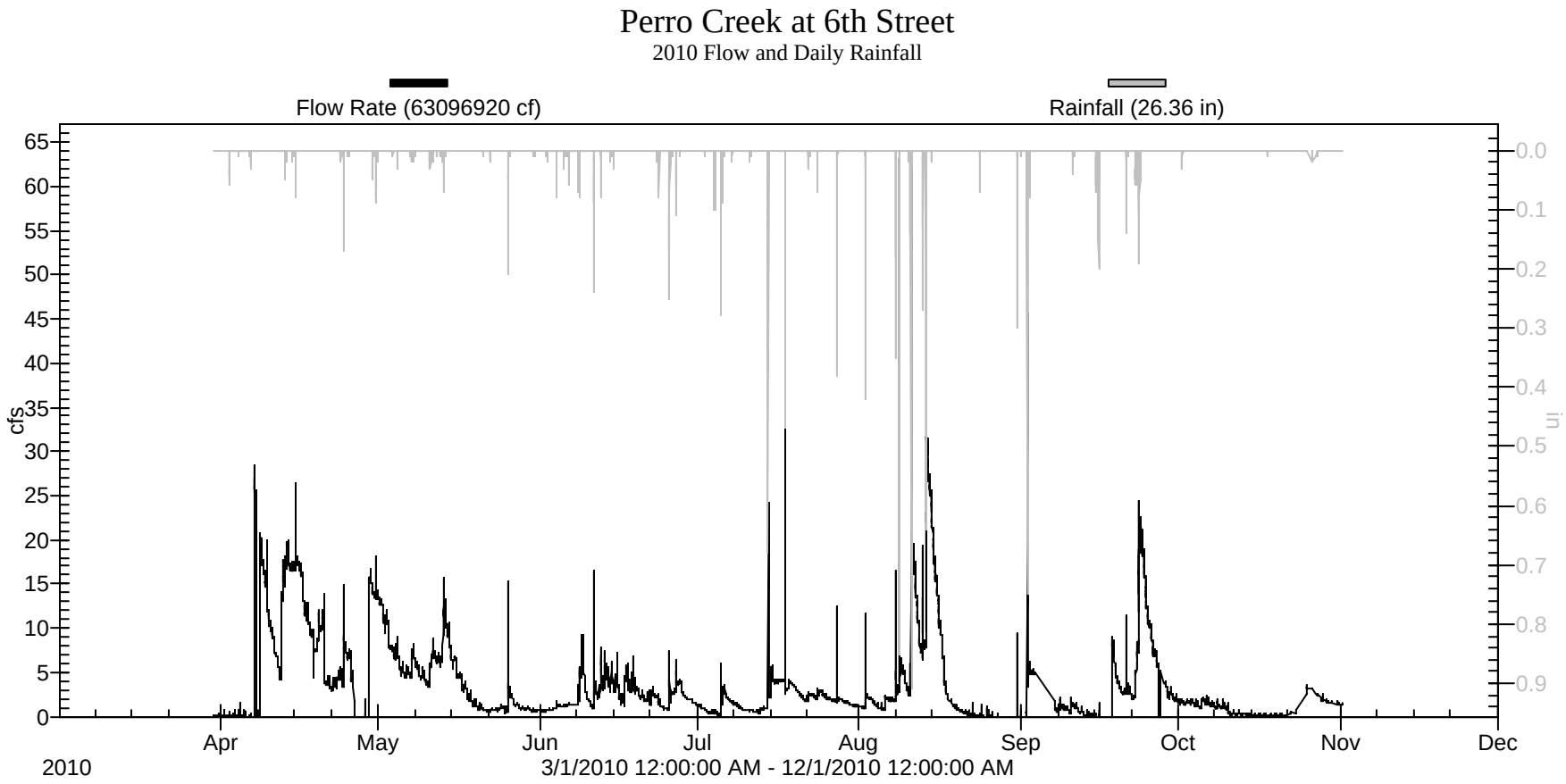


Figure 9. Perro Creek 2010 Discharge and Daily Rainfall

Table 5. Perro Creek 2010 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)
*No Flow**			*0*	*0.000*	*1/1/2010 0:00*	*3/30/2010 9:15*	*0*	*0.00*	*0*	*0.00*
Base			*3*	*0.041*	*3/30/2010 9:15*	*4/7/2010 11:15*	*196,650*	*4.51*	*37*	*0.50*
Storm Composite	4/7/10 11:33	4/7/10 13:08	7230	2.080	4/7/2010 11:15	4/8/2010 13:30	196,159	4.50	88,535	25.47
Storm Grab	4/7/10 13:50	4/7/10 13:50	571	0.157	4/8/2010 13:30	4/8/2010 18:45	111,969	2.57	3,991	1.10
Base			*3*	*0.041*	*4/8/2010 18:45*	*4/12/2010 15:30*	*1,933,342*	*44.38*	*362*	*4.95*
Storm			*345*	*0.234*	*4/12/2010 15:30*	*4/13/2010 18:15*	*1,573,934*	*36.13*	*33,898*	*22.99*
Base			*3*	*0.041*	*4/13/2010 18:15*	*4/15/2010 2:30*	*688,354*	*15.80*	*129*	*1.76*
Storm			*345*	*0.234*	*4/15/2010 2:30*	*4/15/2010 11:00*	*193,273*	*4.44*	*4,163*	*2.82*
Base			*3*	*0.041*	*4/15/2010 11:00*	*4/24/2010 8:15*	*3,139,475*	*72.07*	*588*	*8.04*
Storm			*345*	*0.234*	*4/24/2010 8:15*	*4/24/2010 16:00*	*116,993*	*2.69*	*2,520*	*1.71*
Base			*3*	*0.041*	*4/24/2010 16:00*	*4/29/2010 9:45*	*555,404*	*12.75*	*104*	*1.42*
Storm (dam open)			*345*	*0.234*	*4/29/2010 9:45*	*4/29/2010 14:15*	*98,432*	*2.26*	*2,120*	*1.44*
Base			*3*	*0.041*	*4/29/2010 14:15*	*4/30/2010 16:45*	*547,461*	*12.57*	*103*	*1.40*
Storm			*345*	*0.234*	*4/30/2010 16:45*	*4/30/2010 18:00*	*28,512*	*0.65*	*614*	*0.42*
Base			*3*	*0.041*	*4/30/2010 18:00*	*5/7/2010 9:30*	*2,432,994*	*55.85*	*456*	*6.23*
Storm			*345*	*0.234*	*5/7/2010 9:30*	*5/7/2010 21:00*	*159,999*	*3.67*	*3,446*	*2.34*
Base			*3*	*0.041*	*5/7/2010 21:00*	*5/10/2010 18:30*	*882,677*	*20.26*	*165*	*2.26*
Storm			*345*	*0.234*	*5/10/2010 18:30*	*5/11/2010 19:30*	*375,608*	*8.62*	*8,089*	*5.49*
Base			*3*	*0.041*	*5/11/2010 19:30*	*5/13/2010 1:30*	*463,532*	*10.64*	*87*	*1.19*
Storm			*345*	*0.234*	*5/13/2010 1:30*	*5/13/2010 21:00*	*347,345*	*7.97*	*7,481*	*5.07*
Base Grab	5/24/10 12:46	5/24/10 12:46	7	0.038	5/13/2010 21:00	5/25/2010 20:45	2,582,287	59.28	1,128	6.13
Storm			*345*	*0.234*	*5/25/2010 20:45*	*5/26/2010 2:45*	*65,169*	*1.50*	*1,404*	*0.95*
Base			*3*	*0.041*	*5/26/2010 2:45*	*6/4/2010 3:15*	*950,126*	*21.81*	*178*	*2.43*
Storm			*345*	*0.234*	*6/4/2010 3:15*	*6/4/2010 16:00*	*72,113*	*1.66*	*1,553*	*1.05*
Base			*3*	*0.041*	*6/4/2010 16:00*	*6/5/2010 13:30*	*115,410*	*2.65*	*22*	*0.30*
Storm			*345*	*0.234*	*6/5/2010 13:30*	*6/5/2010 21:00*	*46,830*	*1.08*	*1,009*	*0.68*
Base			*3*	*0.041*	*6/5/2010 21:00*	*6/8/2010 5:45*	*368,659*	*8.46*	*69*	*0.94*
Storm Composite	6/8/10 21:02	6/9/10 4:14	26	0.060	6/8/2010 5:45	6/9/2010 5:45	308,271	7.08	500	1.15
Base			*3*	*0.041*	*6/9/2010 5:45*	*6/11/2010 6:15*	*401,481*	*9.22*	*75*	*1.03*
Storm			*345*	*0.234*	*6/11/2010 6:15*	*6/11/2010 14:30*	*74,854*	*1.72*	*1,612*	*1.09*
Base			*3*	*0.041*	*6/11/2010 14:30*	*6/12/2010 12:00*	*177,449*	*4.07*	*33*	*0.45*
Storm			*345*	*0.234*	*6/12/2010 12:00*	*6/12/2010 16:00*	*46,729*	*1.07*	*1,006*	*0.68*
Base			*3*	*0.041*	*6/12/2010 16:00*	*6/25/2010 18:30*	*2,614,555*	*60.02*	*490*	*6.69*
Storm			*345*	*0.234*	*6/25/2010 18:30*	*6/26/2010 0:30*	*57,757*	*1.33*	*1,244*	*0.84*
Base			*3*	*0.041*	*6/26/2010 0:30*	*6/26/2010 21:45*	*214,121*	*4.92*	*40*	*0.55*
Storm			*345*	*0.234*	*6/26/2010 21:45*	*6/27/2010 4:45*	*86,418*	*1.98*	*1,861*	*1.26*
Base			*3*	*0.041*	*6/27/2010 4:45*	*7/5/2010 15:15*	*1,063,100*	*24.41*	*199*	*2.72*
Storm Composite	7/5/10 16:02	7/6/10 9:27	47	0.101	7/5/2010 15:15	7/6/2010 9:30	180,893	4.15	531	1.14
Base			*3*	*0.041*	*7/6/2010 9:30*	*7/14/2010 14:30*	*794,558*	*18.24*	*149*	*2.03*
Storm			*345*	*0.234*	*7/14/2010 14:30*	*7/14/2010 20:30*	*63,052*	*1.45*	*1,358*	*0.92*
Base			*3*	*0.041*	*7/14/2010 20:30*	*7/17/2010 20:45*	*1,035,512*	*23.77*	*194*	*2.65*
Storm Composite	7/17/10 21:23	7/17/10 21:43	1040	0.522	7/17/2010 20:45	7/18/2010 0:45	68,044	1.56	4,418	2.22
Base Grab	7/20/10 16:11	7/20/10 16:11	3	0.035	7/18/2010 0:45	7/27/2010 20:30	1,867,404	42.87	350	4.08
Storm			*345*	*0.234*	*7/27/2010 20:30*	*7/28/2010 3:30*	*45,435*	*1.04*	*979*	*0.66*
Base			*3*	*0.041*	*7/28/2010 3:30*	*8/2/2010 2:45*	*523,157*	*12.01*	*98*	*1.34*
Storm			*345*	*0.234*	*8/2/2010 2:45*	*8/2/2010 11:30*	*51,007*	*1.17*	*1,099*	*0.75*
Base			*3*	*0.041*	*8/2/2010 11:30*	*8/8/2010 1:30*	*619,926*	*14.23*	*116*	*1.59*
Storm			*345*	*0.234*	*8/8/2010 1:30*	*8/8/2010 6:30*	*43,706*	*1.00*	*941*	*0.64*
Base			*3*	*0.041*	*8/8/2010 6:30*	*8/8/2010 19:00*	*94,134*	*2.16*	*18*	*0.24*
Storm Composite	8/8/10 19:34	8/9/10 0:15	313	0.211	8/8/2010 19:00	8/9/2010 0:15	74,180	1.70	1,449	0.98
Base			*3*	*0.041*	*8/9/2010 0:15*	*8/10/2010 20:45*	*396,862*	*9.11*	*74*	*1.02*
Storm Composite	8/10/10 22:54	8/11/10 1:32	419	0.389	8/10/2010 20:45	8/11/2010 4:00	129,086	2.96	3,376	3.13
Base			*3*	*0.041*	*8/11/2010 4:00*	*8/13/2010 3:45*	*697,782*	*16.02*	*131*	*1.79*
Storm			*345*	*0.234*	*8/13/2010 3:45*	*8/13/2010 9:00*	*68,858*	*1.58*	*1,483*	*1.01*
Base			*3*	*0.041*	*8/13/2010 9:00*	*8/13/2010 16:30*	*93,185*	*2.14*	*17*	*0.24*
Storm Composite	8/13/10 16:42	8/14/10 14:56	42	0.125	8/13/2010 16:30	8/14/2010 15:00	574,484	13.19	1,506	4.48
Base Grab	8/23/10 15:03	8/23/10 15:03	2	0.077	8/14/2010 15:00	8/31/2010 4:00	1,436,175	32.97	179	6.90
Storm			*345*	*0.234*	*8/31/2010 4:00*	*8/31/2010 10:00*	*5,038*	*0.12*	*109*	*0.07*
Base			*3*	*0.041*	*8/31/2010 10:00*	*9/2/2010 3:00*	*4,020*	*0.09*	*1*	*0.01*
Storm Composite	9/2/10 3:46	9/2/10 4:30	303	0.479	9/2/2010 3:00	9/2/2010 7:00	47,227	1.08	893	1.41
Base			*3*	*0.041*	*9/2/2010 7:00*	*9/15/2010 19:30*	*573,140*	*13.16*	*107*	*1.47*
Storm			*345*	*0.234*	*9/15/2010 19:30*	*9/16/2010 0:00*	*2,293*	*0.05*	*49*	*0.03*
No Flow			*3*	*0.041*	*9/16/2010 0:00*	*9/18/2010 10:30*	*0*	*0.00*	*0*	*0.00*
Storm			*345*	*0.234*	*9/18/2010 10:30*	*9/18/2010 14:30*	*41,364*	*0.95*	*891*	*0.60*
Base			*3*	*0.041*	*9/18/2010 14:30*	*9/22/2010 21:00*	*645,127*	*14.81*	*121*	*1.65*
Storm Composite	9/23/10 1:23	9/24/10 17:25	16	0.063	9/22/2010 21:00	9/24/2010 17:30	721,671	16.57	721	2.84
Base Grab	10/5/10 11:42	10/5/10 11:42	1	0.014	9/24/2010 17:30	11/1/2010 14:15	2,661,439	61.10	166	2.33
*Base**			*3*	*0.041*	*11/1/2010 14:15*	*12/1/2010 0:00*	*1,956,141*	*44.91*	*366*	*5.01*
*No Flow**					*12/1/2010 0:00*	*1/1/2011 0:00*	*0*	*0.00*	*0*	*0.00*
Storm Average			345	0.234						
Base Average			3	0.041						
All Average			716	0.311						
Total							**38,802,342**	**891**	**191,200**	**179**
Perro Creek Major Subwatershed Total Acres							1,063			
Total TP/TSS (lb/ac/yr)									179.95	0.17
Total TP/TSS (kg/ha/yr)									201.69	0.19

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

*Interval volumes from 1/1/10 to 3/30/10 and 11/1/10 to 12/1/11 were estimated based upon baseflow conditions.

Table 6. Perro Creek 2010 Water Quality Chemistry Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	E. Coli (mpn/ 100 mL)	Nitrite N (mg/L)	Nitrate N (mg/L)	Ammonia Nitrogen (mg/L)
Base Grab	5/24/2010 12:46	5/24/2010 12:46	7	4	0.42	~0.038	~0.015		<0.03	0.14	~0.04
Base Grab	7/20/2010 16:11	7/20/2010 16:11	3	~2	0.36	~0.035	~0.016		<0.03	0.09	<0.02
Base Grab	8/23/2010 15:03	8/23/2010 15:03	~2	~1	0.57	0.077	0.057		<0.03	0.12	<0.02
Base Grab	10/5/2010 11:42	10/5/2010 11:42	~1	~1	0.21	~0.014	<0.01		<0.03	0.24	<0.02
Storm Composite	4/7/2010 11:33	4/7/2010 13:08	7230	500	11	2.08	0.079		<0.03	0.36	0.06
Storm Grab	4/7/2010 13:50	4/7/2010 13:50	571	56	1	0.157	~0.017		<0.03	0.19	0.08
Storm Composite	6/8/2010 21:02	6/9/2010 4:14	26	8	1	0.060	~0.021		<0.03	0.06	~0.02
Storm Composite	7/5/2010 16:02	7/6/2010 9:27	47	13	0.75	0.101	~0.021		<0.03	0.14	~0.06
Storm Composite	7/17/2010 21:23	7/17/2010 21:43	1040	118	2.8	0.522	0.108		<0.03	0.32	0.08
Storm Composite	8/8/2010 19:34	8/9/2010 12:15	313	33	1.3	0.211	0.054		<0.03	0.35	~0.05
Storm Composite	8/10/2010 22:54	8/11/2010 1:32	419	52	1.4	0.389	0.066		<0.03	0.18	<0.02
Storm Composite	8/13/2010 16:42	8/14/2010 14:56	42	10	0.66	0.125	0.062		0.04	0.15	~0.05
Storm Composite	9/2/2010 3:46	9/2/2010 4:30	303	40	1.5	0.479	0.115		<0.03	0.37	<0.02
Storm Composite	9/23/2010 1:23	9/24/2010 17:25	16	5	1.2	0.063	~0.021		<0.03	0.19	~0.03
E. Coli Grab	5/25/2010 9:00	5/25/2010 9:00						99			
E. Coli Grab	6/24/2010 9:15	6/24/2010 9:15						225			
E. Coli Grab	7/28/2010 11:25	7/28/2010 11:25						93			
E. Coli Grab	8/26/2010 9:49	8/26/2010 9:49						111			
E. Coli Grab	9/30/2010 9:51	9/30/2010 9:51						95			

Water Quality Standard Exceedance

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

Table 7. Perro Creek 2010 Sample Metal Chemistry Results

Sample Type	Start Date	End Date	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Hardness (mg/L_CaCO3)
Base Grab	5/24/2010 12:46	5/24/2010 12:46	0.0007	0.0016	0.0004	0.007	<0.0005	<0.005	192
Base Grab	7/20/2010 16:11	7/20/2010 16:11	0.0005	0.0017	0.0002	<0.005	<0.0005	<0.005	152
Base Grab	8/23/2010 15:03	8/23/2010 15:03	0.0005	0.002	<0.0001	<0.005	<0.0005	<0.005	214
Base Grab	10/5/2010 11:42	10/5/2010 11:42	<0.010	<0.020	<0.003	<0.020	<0.001	<0.010	210
Storm Composite	4/7/2010 11:33	4/7/2010 13:08	0.0459	0.0213	0.11	0.278	<0.0005	0.0339	216
Storm Grab	4/7/2010 13:50	4/7/2010 13:50	0.0039	0.0029	0.0056	0.013	<0.0005	<0.005	236
Storm Composite	6/8/2010 21:02	6/9/2010 4:14	0.0022	0.0017	0.0013	0.005	<0.0005	<0.005	160
Storm Composite	7/5/2010 16:02	7/6/2010 9:27	0.0028	0.0019	0.0026	0.007	<0.0005	<0.005	132
Storm Composite	8/8/2010 19:34	8/9/2010 12:15	0.0077	0.0054	0.0138	0.0299	<0.0005	<0.005	116
Storm Composite	8/10/2010 22:54	8/11/2010 1:32	0.0088	0.0046	0.0181	0.0314	<0.0005	0.0055	44
Storm Composite	8/13/2010 16:42	8/14/2010 14:56	0.0023	0.0018	0.0029	0.006	<0.0005	<0.005	96
Storm Composite	9/2/2010 3:46	9/2/2010 4:30	0.0077	0.0037	0.0136	0.0256	<0.0005	0.0053	54
Storm Composite	9/23/2010 1:23	9/24/2010 17:25	<0.010	<0.020	<0.003	<0.020	<0.001	<0.010	82

No Exceedance Determinable

Exceeds Chronic Standard

Exceeds Max Standard

Exceeds Final Acute Standard

Table 8. Perro Creek 2010 Field Measurement Results

Date	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
4/7/2010 13:50		11	9.75		
5/24/2010 12:46	>100	26.5	6.89	398	8.4
7/20/2010 16:11	>120	25.2	7.93	324	7.5
8/23/2010 15:03	>120	27.2	8.66	395	8.3
8/26/2010 9:49	>100	20.4	8.65		8.15
10/5/2010 11:42	>120	12.5	10.69	416	8

Water Quality Standard Exceedance

2. MYRTLE STREET AND MEADOWLARK DRIVE

To identify other possible sources of loading into McKusick Lake, the WCD monitored the tributary on the south end of the lake at Meadowlark Drive and at Myrtle Street through grab samples collected during or directly following storm events. Results from this monitoring can be found in Table 9. This tributary drains the area south of McKusick Lake including the outlet of Lily Lake, some wetlands, and a residential area. Table 10 shows the difference in results at the Meadowlark Drive site (downstream location) compared to those collected at the Myrtle Street site (upstream location), in order to determine what parameters are increasing or decreasing as a result of runoff into this tributary between these sites. All TSS and VSS samples showed a decrease from the Myrtle to the Meadowlark site, while flow increased between these locations for seven out of the nine times that samples were taken. TKN showed a decrease for seven out of the nine samples. TP is reduced for all samples when compared to 2009.

When comparing the Myrtle Street and Meadowlark Drive sites for TP and TSS in lbs/day, it can be seen that all values for the Myrtle site are greater than those at the Meadowlark site. In other words, the concentrations are decreasing as the water moves downstream. Comparison of 2010 TP and TSS loads was difficult, as the Myrtle Street and Meadowlark Drive sites were sampled twice as many times in 2010. Values from 2009, however, showed the same trend that is seen now, where the majority of samples taken at the Myrtle Street site were greater than the samples collected from the Meadowlark Drive site.

Table 9: Myrtle Street and Meadowlark Drive 2010 Sample Chemistry Results

Site	Date	Sample Type	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Flow (cfs)	TP lb/day*	TSS lb/day*
Myrtle St.	3/12/10 12:00	Snowmelt Grab	13	6	1.9	0.21	0.4915	**0.56**	**34.47**
Myrtle St.	5/11/10 13:50	Storm Grab	19	~5	0.96	0.186	0.2425	**0.24**	**24.85**
Myrtle St.	5/26/10 10:12	Storm Grab	16	~8	0.9	0.249	0.2242	**0.30**	**19.35**
Myrtle St.	6/11/10 9:52	Storm Grab	7	3	0.75	0.084	3.33	**1.51**	**125.74**
Myrtle St.	8/2/10 10:46	Storm Grab	~5	~6	1.2	0.166	0.107	**0.10**	**2.89**
Myrtle St.	8/11/10 10:32	Storm Grab	7	~4	0.71	0.081	1.631	**0.71**	**61.59**
Myrtle St.	9/2/10 8:56	Storm Grab	5	~3	0.77	0.136	0.4528	**0.33**	**12.21**
Myrtle St.	9/16/10 8:32	Storm Grab	8	5	0.8	0.116	0.241	**0.15**	**10.40**
Myrtle St.	9/23/10 14:07	Storm Grab	17	3	0.78	0.169	1.8885	**1.72**	**173.18**
Meadowlark Dr.	3/12/10 11:55	Snowmelt Grab	4	3	2.3	0.163	0.166	**0.15**	**3.58**
Meadowlark Dr.	5/11/10 13:30	Storm Grab	~1	~1	0.58	~0.039	0.2815	**0.06**	**1.52**
Meadowlark Dr.	5/26/10 9:55	Storm Grab	3	~2	0.67	0.06	0.608	**0.20**	**9.84**
Meadowlark Dr.	6/11/10 9:33	Storm Grab	3	~2	1.3	~0.049	1.638	**0.43**	**26.51**
Meadowlark Dr.	8/2/10 10:56	Storm Grab	~4	~4	0.66	0.053	0.184875	**0.05**	**3.99**
Meadowlark Dr.	8/11/10 10:19	Storm Grab	~5	~4	0.58	0.061	1.73825	**0.57**	**46.88**
Meadowlark Dr.	9/2/10 8:51	Storm Grab	~2	<1	0.52	~0.022	0.99205	**0.12**	**10.70**
Meadowlark Dr.	9/16/10 8:20	Storm Grab	~1	~1	0.43	<0.010	0.31625	**0.01**	**1.71**
Meadowlark Dr.	9/23/10 13:50	Storm Grab	~2	~1	0.42	<0.010	2.266	**0.06**	**24.45**

* Loadings are based on instantaneous flow measurement and values should be used with caution

Table 10: Myrtle Street and Meadowlark Drive 2010 Sample Comparison

Site	Date	Sample Type	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Flow (cfs)	TP lb/day	TSS lb/day
Meadowlark Dr.	March 12, 2010	Snowmelt Grab	(9)	(3)	0.40	(0.047)	(0.32550)	**(0.41)**	**(30.89)**
Meadowlark Dr.	May 11, 2010	Storm Grab	(18)	(4)	(0.38)	(0.147)	0.03900	**(0.18)**	**(23.34)**
Meadowlark Dr.	May 26, 2010	Storm Grab	(13)	(6)	(0.23)	(0.189)	0.38380	**(0.10)**	**(9.51)**
Meadowlark Dr.	June 11, 2010	Storm Grab	(4)	(1)	0.55	(0.035)	(1.69200)	**(1.08)**	**(99.23)**
Meadowlark Dr.	August 2, 2010	Storm Grab	(1)	(2)	(0.54)	(0.113)	0.07788	**(0.04)**	**1.10**
Meadowlark Dr.	August 11, 2010	Storm Grab	(2)	0	(0.13)	(0.020)	0.10725	**(0.14)**	**(14.70)**
Meadowlark Dr.	September 2, 2010	Storm Grab	(3)	(3)	(0.25)	(0.114)	0.53925	**(0.21)**	**(1.51)**
Meadowlark Dr.	September 16, 2010	Storm Grab	(7)	(4)	(0.37)	(0.111)	0.07525	**(0.14)**	**(8.69)**
Meadowlark Dr.	September 23, 2010	Storm Grab	(15)	(2)	(0.36)	(0.164)	0.37750	**(1.66)**	**(148.73)**

* Loadings are based on instantaneous flow measurement and values should be used with caution
(Values in parentheses equate to a decrease in concentration from Myrtle to Meadowlark)
Values in red equate to an increase in amount from Myrtle to Meadowlark

3. 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 2010. The City of Stillwater constructed the Diversion Structure in June of 2003, as part of the completion of the Trout Stream Mitigation Project. It has been functioning to divert water from the 1800-acre Annexation Area away from Brown's Creek, through McKusick Lake, to the St. Croix River. While this diversion structure will keep the warmer urban stormwater from the southern tributary of the creek out of the temperature and nutrient sensitive Brown's Creek Ravine, it will mean that this water will be entering McKusick Lake, and could therefore affect 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 2010 can be found in Table 11, Table 12, and Table 13. Water quality results showed a majority of storm samples exceeding the standard for TSS (ten out of fifteen), as well as water quality standard exceedances in four out of the five *E. Coli* samples.

Using a combination of composite and grab samples, total phosphorus (TP) and total suspended solid (TSS) loads were calculated at the Brown's Creek Diversion Structure Drainage. TP increased by 64 lbs in 2010 to 608 lbs of phosphorus exported, up from 544 lbs in 2009. TSS also showed an increase in amount of pounds exported to 353,007 in 2010, up from 227, 372 lbs in 2009, an increase of 125,635 lbs. This equates to an increase in TP and TSS loadings that are entering McKusick Lake.

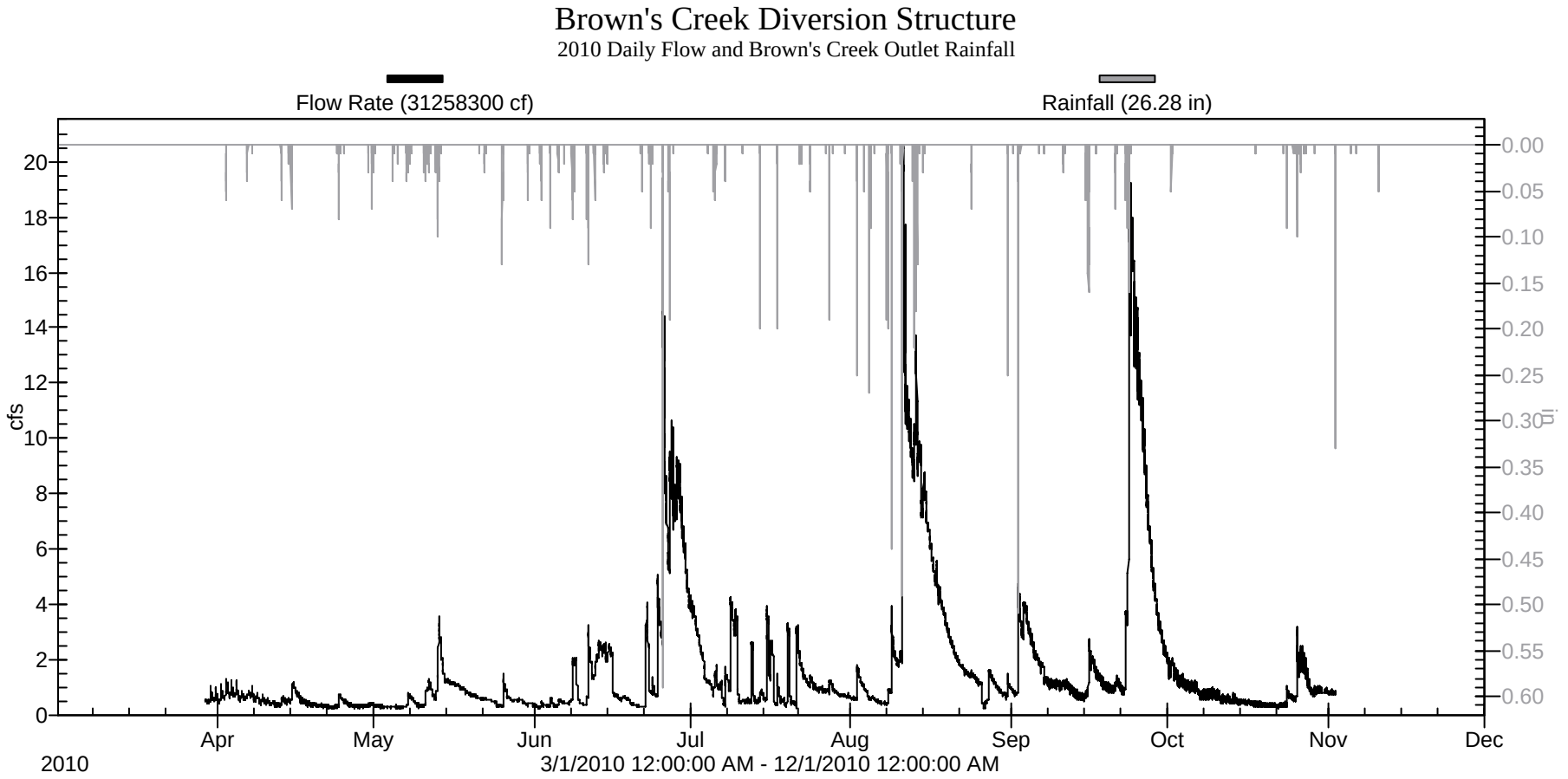


Figure 10. Brown's Creek Diversion Structure Drainage 2010 Flow and Browns Creek Outlet Rainfall

Table 11. Brown's Creek Diversion Structure Drainage 2010 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 TP (lb)**	**Interval TSS (lb)**
*Base***			*7*	*0.072*	*1/1/2010 0:00*	*3/11/2010 7:00*	*2,334,852*	*53.63*	*10.49*	*1,020*
Snowmelt Grab**	3/11/2010 8:29	3/11/2010 8:29	29	0.219	3/11/2010 7:00	3/11/2010 18:00	63,360	*1.46*	*0.87*	*115*
*Base***			*7*	*0.072*	*3/11/2010 18:00*	*3/12/2010 7:00*	*35,100*	*0.81*	*0.16*	*15*
Snowmelt Grab**	3/12/2010 11:40	3/12/2010 11:40	58	0.387	3/12/2010 7:00	3/12/2010 18:00	63,360	1.46	1.53	229
*Base***			*7*	*0.072*	*3/12/2010 18:00*	*3/29/2010 14:15*	*1,091,475*	*25.07*	*4.91*	*477*
Base			*7*	*0.072*	*3/29/2010 14:15*	*4/15/2010 3:15*	*869,266*	*19.97*	*3.91*	*380*
Storm			*929*	*1.310*	*4/15/2010 3:15*	*4/15/2010 19:15*	*58,807*	*1.35*	*4.81*	*3,410*
Base			*7*	*0.072*	*4/15/2010 19:15*	*4/24/2010 8:15*	*300,580*	*6.90*	*1.35*	*131*
Storm			*929*	*1.310*	*4/24/2010 8:15*	*4/24/2010 16:15*	*17,655*	*0.41*	*1.44*	*1,024*
Base Grab	4/29/2010 11:27	4/29/2010 11:27	3	0.050	4/24/2010 16:15	5/7/2010 11:15	360,911	8.29	1.13	68
Storm			*929*	*1.310*	*5/7/2010 11:15*	*5/8/2010 8:15*	*47,874*	*1.10*	*3.92*	*2,776*
Base			*7*	*0.072*	*5/8/2010 8:15*	*5/11/2010 0:15*	*90,113*	*2.07*	*0.41*	*39*
Storm Composite	5/11/2010 1:55	5/13/2010 7:42	39	0.152	5/11/2010 0:15	5/13/2010 8:15	174,240	4.00	1.65	424
Storm			*929*	*1.310*	*5/13/2010 8:15*	*5/13/2010 21:15*	*119,738*	*2.75*	*9.79*	*6,944*
Base			*7*	*0.072*	*5/13/2010 21:15*	*5/20/2010 21:15*	*643,887*	*14.79*	*2.89*	*281*
Base Grab	5/24/2010 11:24	5/24/2010 11:24	14	0.109	5/20/2010 21:15	5/25/2010 21:15	210,470	4.83	1.43	184
Storm Grab	5/26/2010 7:48	5/26/2010 7:48	40	0.178	5/25/2010 21:15	5/26/2010 8:15	43,988	1.01	0.49	110
Base			*7*	*0.072*	*5/26/2010 8:15*	*6/4/2010 3:15*	*328,899*	*7.55*	*1.48*	*144*
Storm			*929*	*1.310*	*6/4/2010 3:15*	*6/4/2010 7:15*	*7,216*	*0.17*	*0.59*	*418*
Base			*7*	*0.072*	*6/4/2010 7:15*	*6/8/2010 6:15*	*140,709*	*3.23*	*0.63*	*61*
Storm Composite	6/8/2010 13:05	6/9/2010 1:54	660	0.504	6/8/2010 6:15	6/9/2010 2:15	119,000	2.73	3.74	4,903
Base			*7*	*0.072*	*6/9/2010 2:15*	*6/11/2010 4:15*	*92,580*	*2.13*	*0.42*	*40*
Storm Composite	6/11/2010 8:35	6/11/2010 22:39	1800	0.860	6/11/2010 4:15	6/11/2010 23:15	140,909	3.24	7.56	15,834
Base			*7*	*0.072*	*6/11/2010 23:15*	*6/22/2010 13:15*	*1,015,489*	*23.32*	*4.56*	*444*
Storm Composite***	6/22/2010 14:25	6/22/2010 21:33	7660	4.280	6/22/2010 13:15	6/22/2010 22:15	107,118	2.46	*28.62*	*51,222*
Base			*7*	*0.072*	*6/22/2010 22:15*	*6/24/2010 16:15*	*150,461*	*3.46*	*0.68*	*66*
Storm Composite	6/24/2010 17:11	6/25/2010 7:15	2100	1.860	6/24/2010 16:15	6/25/2010 7:15	211,957	4.87	24.61	27,786
Base			*7*	*0.072*	*6/25/2010 7:15*	*6/25/2010 18:15*	*111,986*	*2.57*	*0.50*	*49*
Storm Composite	6/25/2010 19:35	6/26/2010 9:19	2600	4.020	6/25/2010 18:15	6/26/2010 10:15	633,651	*14.55*	*159.02*	*102,847*
Base			*7*	*0.072*	*6/26/2010 10:15*	*7/17/2010 18:15*	*5,103,553*	*117.22*	*22.94*	*2,230*
Storm			*929*	*1.310*	*7/17/2010 18:15*	*7/18/2010 1:15*	*20,043*	*0.46*	*1.64*	*1,162*
Base Grab	7/21/2010 8:08	7/21/2010 8:08	4	0.080	7/18/2010 1:15	8/2/2010 5:15	1,315,439	30.21	6.57	328
Storm Grab	8/2/2010 8:40	8/2/2010 8:40	29	0.139	8/2/2010 5:15	8/2/2010 9:15	21,578	*0.50*	*0.19*	*39*
Base			*7*	*0.072*	*8/2/2010 9:15*	*8/8/2010 18:15*	*392,773*	*9.02*	*1.77*	*172*
Storm Composite	8/8/2010 20:15	8/8/2010 20:50	929	1.280	8/8/2010 18:15	8/8/2010 23:15	49,287	1.13	3.94	2,858
Base			*7*	*0.072*	*8/8/2010 23:15*	*8/10/2010 22:15*	*355,626*	*8.17*	*1.60*	*155*
Storm Composite	8/10/2010 23:20	8/11/2010 12:36	768	1.300	8/10/2010 22:15	8/11/2010 13:15	788,854	*18.12*	*64.02*	*37,820*
Base Grab	8/23/2010 14:20	8/23/2010 14:20	6	0.063	8/11/2010 13:15	8/24/2010 13:15	5,904,441	*135.62*	*23.22*	*2,212*
Base			*7*	*0.072*	*8/24/2010 13:15*	*8/31/2010 4:15*	*554,392*	*12.73*	*2.49*	*242*
Storm			*929*	*1.310*	*8/31/2010 4:15*	*8/31/2010 7:15*	*13,814*	*0.32*	*1.13*	*801*
Base			*7*	*0.072*	*8/31/2010 7:15*	*9/2/2010 3:15*	*140,821*	*3.23*	*0.63*	*62*
Storm Composite	9/2/2010 4:03	9/3/2010 7:11	218	1.330	9/2/2010 3:15	9/3/2010 7:15	349,799	8.03	29.04	4,760
Base			*7*	*0.072*	*9/3/2010 7:15*	*9/15/2010 19:15*	*1,607,768*	*36.93*	*7.23*	*703*
Storm			*929*	*1.310*	*9/15/2010 19:15*	*9/16/2010 2:15*	*58,813*	*1.35*	*4.81*	*3,411*
Base Grab	9/16/2010 8:42	9/16/2010 8:42	11	0.083	9/16/2010 2:15	9/22/2010 21:15	732,043	16.81	3.79	503
Storm Composite	9/23/2010 0:24	9/23/2010 9:33	365	0.592	9/22/2010 21:15	9/23/2010 10:15	137,245	3.15	5.07	3,127
Storm Composite	9/23/2010 10:52	9/24/2010 11:18	714	1.090	9/23/2010 10:15	9/24/2010 12:15	1,442,772	33.14	98.17	64,308
Base			*7*	*0.072*	*9/24/2010 12:15*	*10/5/2010 12:15*	*4,596,382*	*105.57*	*20.66*	*2,009*
Base Grab	10/6/2010 9:13	10/6/2010 9:13	2	0.045	10/5/2010 12:15	10/7/2010 12:15	155,800	3.58	0.44	19
Base			*7*	*0.072*	*10/7/2010 12:15*	*10/25/2010 22:15*	*802,160*	*18.42*	*3.61*	*351*
Storm			*929*	*1.310*	*10/25/2010 22:15*	*10/26/2010 4:15*	*43,676*	*1.00*	*3.57*	*2,533*
Base			*7*	*0.072*	*10/26/2010 4:15*	*11/2/2010 14:00*	*674,002*	*15.48*	*3.03*	*295*
*Base***			*7*	*0.072*	*11/2/2010 14:00*	*11/20/2010 14:00*	*1,275,264*	*29.29*	*5.73*	*557*
*Base***			*7*	*0.072*	*11/20/2010 14:00*	*1/1/2011 0:00*	*2,075,472*	*47.67*	*9.33*	*907*
Storm Average			929	1.310						
Base Average			7	0.072						
All Average			498	0.941						
Total							**38,197,468**	**877**	**608**	**353,007**
Brown's Creek Major Subwatershed Total Acres							3,837			
Total TP/TSS(lb/ac/yr)									0.16	92.00
Total TP/TSS (kg/ha/yr)									0.18	103.12

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

**Interval volumes from 1/1/10 to 3/29/10 and 11/2/10 to 1/1/11 were estimated using recorded base flow

*** TSS Value ommited from average storm event

Table 12: Brown's Creek Diversion Structure Drainage 2010 Primary Water Quality Results

Sample Type	Start	End	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Dissolved P (mg/L)	E Coli (mpn/100 mL)	COD (mg/L)
Snowmelt Grab	3/11/2010 8:29	3/11/2010 8:29	29	10	0.92	0.219	0.116		
Snowmelt Grab	3/12/2010 11:40	3/12/2010 11:40	58			0.387			
Base Grab	4/29/2010 11:27	4/29/2010 11:27	3	~1	0.32	0.05	~0.033		
Base Grab	5/24/2010 11:24	5/24/2010 11:24	14	7	0.84	0.109	0.053		
Base Grab	7/21/2010 8:08	7/21/2010 8:08	4	~2	0.54	0.08	~0.048		
Base Grab	8/23/2010 14:20	8/23/2010 14:20	6	3	0.68	0.063	0.051		
Base Grab	9/16/2010 8:42	9/16/2010 8:42	11			0.083			
Base Grab	10/6/2010 9:13	10/6/2010 9:13	~2	~1	0.51	~0.045	~0.029		
Storm Composite	5/11/2010 1:55	5/13/2010 7:42	39	17	1	0.152	~0.037		33
Storm Grab	5/26/2010 7:48	5/26/2010 7:48	40			0.178			
Storm Composite	6/8/2010 13:05	6/9/2010 1:54	660	340	4.3	0.554	~0.033		
Storm Grab	6/11/2010 11:09	6/11/2010 11:09	126			0.404			
Storm Composite	6/11/2010 8:35	6/11/2010 22:39	1800	840	9.4	0.86	0.061		
Storm Composite	6/22/2010 14:25	6/22/2010 21:33	7660	3190	45	4.280	~0.049		
Storm Composite	6/24/2010 17:11	6/25/2010 7:15	2100	960	18	1.86	0.06		
Storm Composite	6/25/2010 19:35	6/26/2010 9:19	2600	680	17	4.02	0.106		
Storm Grab	8/2/2010 8:40	8/2/2010 8:40	24			0.149			
Storm Grab	8/2/2010 8:40	8/2/2010 8:40	29	~14	0.95	0.139	~0.039		30
Storm Composite	8/8/2010 20:15	8/8/2010 20:50			9	1.280	0.057		
Storm Composite	8/10/2010 23:20	8/11/2010 12:36	768	228	6.7	1.3	0.109		290
Storm Composite	9/2/2010 4:03	9/3/2010 7:11	218	71	7.60	1.330	0.058		
Storm Grab	9/2/2010 9:10	9/2/2010 9:10	84			~0.341			
Storm Composite	9/23/2010 0:24	9/23/2010 9:33	365	137	3.5	0.592	0.064		
Storm Composite	9/23/2010 10:52	9/24/2010 11:18	714	206	0.94	1.09	0.091		
E. Coli Grab	5/25/2010 8:05	5/25/2010 8:05						214	
E. Coli Grab	6/24/2010 9:25	6/24/2010 9:25						248	
E. Coli Grab	7/28/2010 11:55	7/28/2010 11:55						166	
E. Coli Grab	8/26/2010 9:17	8/26/2010 9:17						308	
E. Coli Grab	9/30/2010 8:07	9/30/2010 8:07						54	

Exceeds Water Quality Standard

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

Table 13: Brown's Creek Diversion Structure Drainage 2010 Secondary Water Quality Results

Sample Type	Start Date	End Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Nitrite (mg/L)	Nitrate mg/L)	Ammonia Nitrogen (mg/L)	Hardness (mg/L _CaCO3)
Snowmelt Grab	3/11/2010 8:29	3/11/2010 8:29	0.0022	0.0025	0.0007	0.006	<0.0005	<0.005	42	<0.03	0.94	0.07	128
Snowmelt Grab	3/12/2010 11:40	3/12/2010 11:40											
Base Grab	4/29/2010 11:27	4/29/2010 11:27	0.0006	0.0032	<0.0001	0.0062	<0.0005	<0.005	41	<0.03	0.81	<0.02	232
Base Grab	5/24/2010 11:24	5/24/2010 11:24	0.0012	0.0016	0.0003	<0.005	<0.0005	<0.005	61	<0.03	0.41	0.06	116
Base Grab	7/21/2010 8:08	7/21/2010 8:08	0.0008	0.0016	0.0001	<0.005	<0.0005	<0.005	67	<0.03	0.49	~0.04	140
Base Grab	8/23/2010 14:20	8/23/2010 14:20	0.0012	0.0011	0.0002	<0.005	<0.0005	<0.005	83	<0.03	0.11	~0.02	56
Base Grab	9/16/2010 8:42	9/16/2010 8:42											
Base Grab	10/6/2010 9:13	10/6/2010 9:13	<0.010	<0.020	<0.003	<0.020	<0.001	<0.010	63	<0.03	0.25	~0.04	92
Storm Composite	5/11/2010 1:55	5/13/2010 7:42	0.0021	0.0032	0.0007	0.0202	<0.0005	<0.005	38	<0.03	0.35	<0.02	170
Storm Grab	5/26/2010 7:48	5/26/2010 7:48											
Storm Composite	6/8/2010 13:05	6/9/2010 1:54	0.0081	0.0092	0.0047	0.0309	<0.0005	0.0052	47	<0.03	0.19	~0.02	132
Storm Grab	6/11/2010 11:09	6/11/2010 11:09											
Storm Composite	6/11/2010 8:35	6/11/2010 22:39	0.0113	0.0156	0.0092	0.0563	<0.0005	0.0079	31	<0.03	0.16	~0.02	130
Storm Composite	6/22/2010 14:25	6/22/2010 21:33	0.0627	0.0903	0.0428	0.303	0.0014	0.0539	70	<0.03	0.08	<0.02	92
Storm Composite	6/24/2010 17:11	6/25/2010 7:15	0.018	0.0216	0.0145	0.0826	<0.0005	0.0163	66	<0.03	0.11	0.07	88
Storm Composite	6/25/2010 19:35	6/26/2010 9:19	0.0244	0.0264	0.032	0.102	<0.0005	0.0293	26	<0.03	0.16	0.13	82
Storm Grab	8/2/2010 8:40	8/2/2010 8:40											
Storm Grab	8/2/2010 8:40	8/2/2010 8:40	0.0014	0.0018	0.0005	<0.005	<0.0005	<0.005	64	<0.03	0.13	~0.04	20
Storm Composite	8/8/2010 20:15	8/8/2010 20:50							34	<0.03	0.56	<0.02	92
Storm Composite	8/10/2010 23:20	8/11/2010 12:36	0.0124	0.0135	0.0136	0.0549	<0.0005	0.0144	24	<0.03	0.41	~0.06	63
Storm Composite	9/2/2010 4:03	9/3/2010 7:11	0.0144	0.0166	0.01310	0.0583	<0.0005	0.0137	46	<0.03	0.22	<0.02	92
Storm Grab	9/2/2010 9:10	9/2/2010 9:10											
Storm Composite	9/23/2010 0:24	9/23/2010 9:33	<0.010	<0.020	0.004	0.022	<0.001	<0.010	47	<0.03	0.33	<0.02	130
Storm Composite	9/23/2010 10:52	9/24/2010 11:18	<0.010	<0.020	0.008	0.033	<0.001	<0.010	35	<0.03	0.4	<0.02	208
E. Coli Grab	5/25/2010 8:05	5/25/2010 8:05											
E. Coli Grab	6/24/2010 9:25	6/24/2010 9:25											
E. Coli Grab	7/28/2010 11:55	7/28/2010 11:55											
E. Coli Grab	8/26/2010 9:17	8/26/2010 9:17											
E. Coli Grab	9/30/2010 8:07	9/30/2010 8:07											

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

B. MSCWMO STREAMS: CONCLUSIONS AND RECOMMENDATIONS

While Perro Creek saw an increase in discharge and total pounds of TSS exported in 2010 as compared to 2009, it saw a decrease in total pounds of phosphorus exported. It can be observed from the historical loading data that there is no increasing or decreasing trend in TP, whereas TSS has been steadily increasing since 2007, after a big drop from 2006. Monitoring of Perro Creek started at the end of the monitoring season in 2005 and did not have enough data to calculate loading values for that year.

Table 14: Perro Creek Historical TP and TSS Loads

	2010	2009	2008	2007	2006
Perro Creek					
Discharge (cf)	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
Total pounds of Phosphorus exported	179	242	87	212	241
TP (lb/ac/yr)	0.17	0.23	0.08	0.20	0.23
Total pounds of TSS exported	191,200	51,874	29,343	13,023	162,938
TSS (lb/ac/yr)	179.95	48.82	27.62	12.26	153.35

Changes in discharge in Perro Creek are related to precipitation (Figure 9), but are also related to anthropogenic sources. There is a small dam that holds back Perro Pond and releases water into Perro Creek. This dam was not opened until April 29, 2010 and Perro Creek did not flow continuously until that dam was opened. In previous years WCD staff has observed artificial blockages in the channel and dumping of yard waste into the creek. The changes in discharge caused by artificial means (such as channel blocking) can and has caused deterioration in stream bank stability and has created difficulty in monitoring. Additional waste dumped into the stream causes larger loads observed in the stream, and more nutrients and waste products discharged to the St. Croix River.

When examining TP and TSS in lbs/day for the Myrtle Street and Meadowlark Drive sites, the majority of samples showed a decrease between these two sites in amount for loading, with only one sample for TSS showing an increase. The Meadowlark Drive site (located downstream of Myrtle Street) is monitored to see if any additional loading is entering the tributary from the wetland between Myrtle Street and Meadowlark Drive. It can be seen from the results, however, that this wetland could actually be acting as a sink for nutrients rather than a source, since only

one sample for TSS showed an increase. All other TP and TSS values showed a decrease in values between these sites, which could be a result of particulates settling out in the wetland area. Few conclusions, however, can be made from these results at the present time, as future years of monitoring should provide a better insight to the system and the effect this tributary could be having on McKusick Lake water quality.

The Brown's Creek Diversion Structure Drainage data is extremely valuable for determining current and future impacts to McKusick Lake. The large load observed coming from this site is likely one of the major impacts on the water quality of the lake. 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 which types of best management practices 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. Accurately monitored loading data will continue to provide evidence of reductions in total phosphorus load to McKusick Lake from water quality improvement projects.

The following are WCD recommendations to the MSCWMO:

- Continue to monitor Perro Creek for any potential water quality trends and water quality standard exceedances.
- Work with Perro Creek's neighboring landowners to improve stewardship along the creek to prevent future channel blockage and excess waste dumping.
- 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.
- Initiate the TMDL process for Lily and McKusick Lakes.
- Continue monitoring Myrtle Street and Meadowlark Drive drainages to McKusick Lake to identify other possible sources of loading into McKusick Lake.

- Allow for flexibility in lake and stream monitoring, so monitoring protocols can be adjusted from year to year.

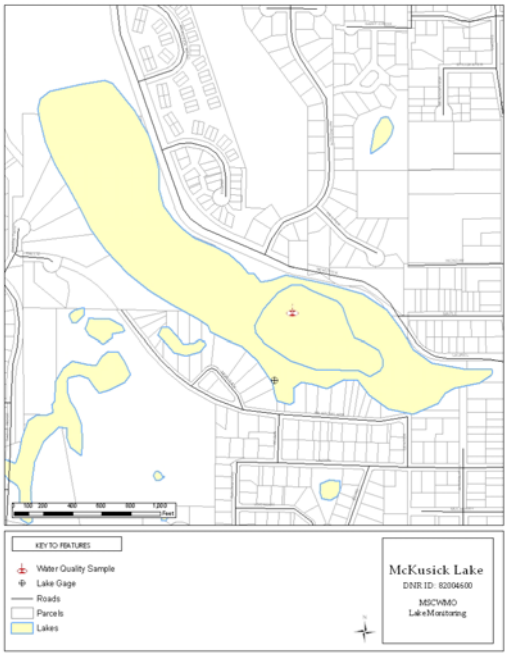
Appendix A

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

McKusick Lake

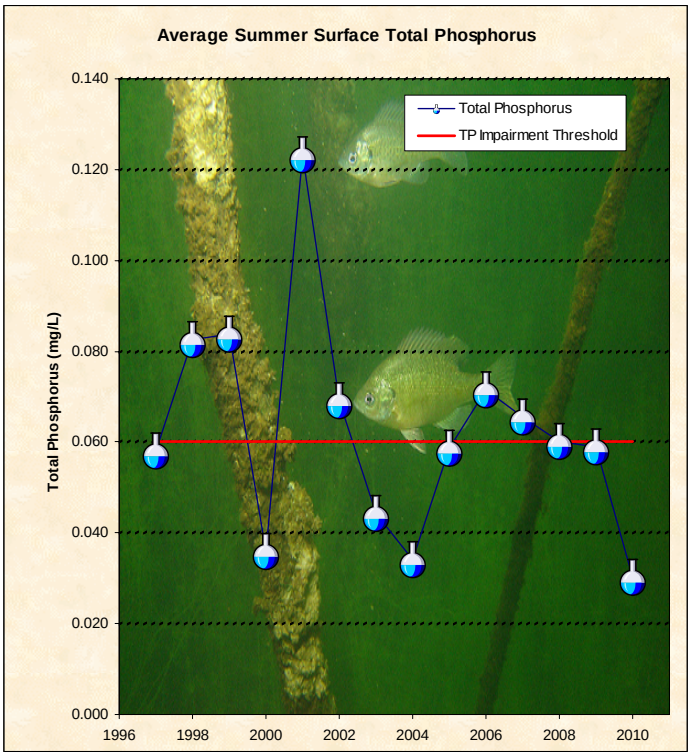
2010 Lake Grade: B+

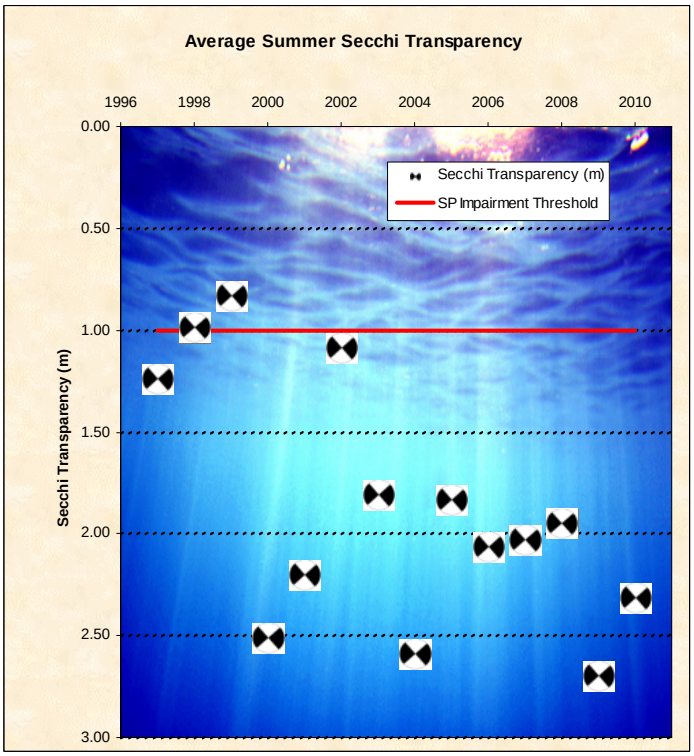
- DNR ID #: 820020
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth (2010): 16 ft
- Ordinary High Water Mark: 853 ft
- 100%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- McKusick Lake was considered mesotrophic in 2010, based on the Carlson Trophic State Index.
- There is a statistically significant **improving trend** for average Secchi transparency and a statistically significant **improving trend** for average total phosphorus.
- The major land use is urban/residential.
- The lake did stratify in 2010 with the thermocline varying between 2 to 6 meters.
- McKusick Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





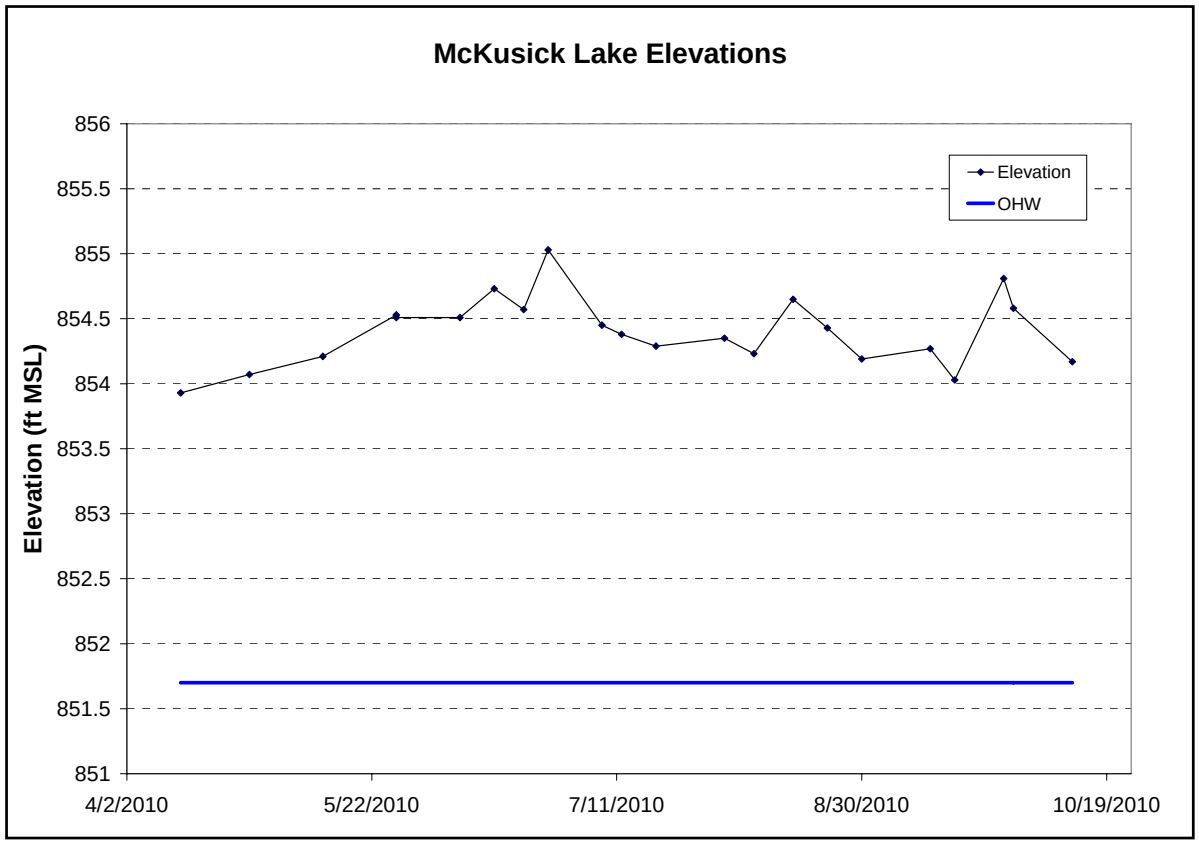
Date	Total Phosphorus (mg/l)	Chlorophyll-*a* (ug/l)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/l)	Surface Temperature Levels (Celsius)
4/13/2010	0.033	7.2	0.61	2.6	11.99	14.0
4/27/2010	0.031	4.2	0.72	2.7	9.57	16.9
5/12/2010	0.027	4.9	0.5	3.5	10.45	11.7
5/27/2010	0.034	4.1	0.64	3.2	8.64	21.7
6/9/2010	0.026	3.9	0.71	2.1	5.73	20.6
6/22/2010	0.026	4.9	0.69	3.0	11.16	24.8
7/8/2010	0.026	5.6	0.5	2.3	9.11	26.2
7/19/2010	0.033	5.8	0.86	2.1	7.12	26.5
8/2/2010	0.03	6.1	1.1	2.3	8.86	28.1
8/16/2010	0.022	6.7	0.95	2.0	6.44	23.9
8/30/2010	0.024	2.9	0.92	2.6	10.19	26.9
9/13/2010	0.032	6.5	0.94	1.5	9.89	19.6
9/28/2010	0.048	7.7	1.7	2.0	9.78	15.4
10/12/2010	0.044	7	1	0.9	12.31	17.9
2010 Average	0.031	6	0.8	2.4	9.37	21.0
2010 Summer Average	0.030	5.4	0.9	2.3	8.69	23.37

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
2010 Elevation (ft)	855.03	6/27/2010	853.93	4/13/2010	854.41

*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) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."



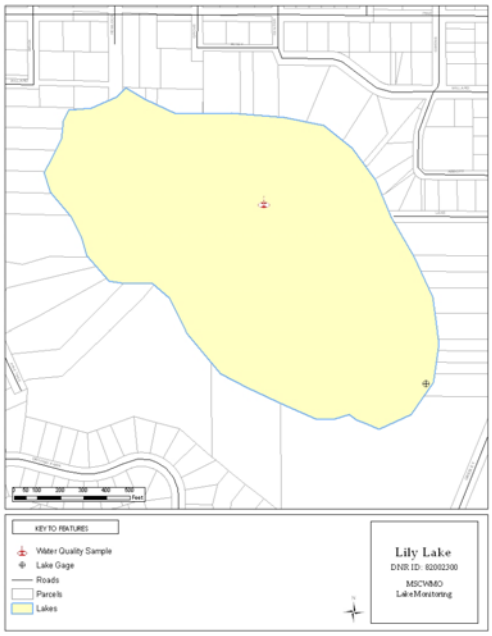
Lake Water Quality Summary

	Trophic Status	Summertime Lake Grades									
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
Total Phosphorus (mg/l)	Mesotrophic	B	C	C	C	D	C	C	C	C	C
Chlorophyll-*a* (ug/l)	Mesotrophic	A	A	B	B	B	B	A	B	C	B
Secchi depth (ft)	Mesotrophic	B	B	C	C	C	C	B	C	D	B
Overall	Mesotrophic	B+	B	C+	C+	C	C+	B	C+	C+	B-

Lily Lake

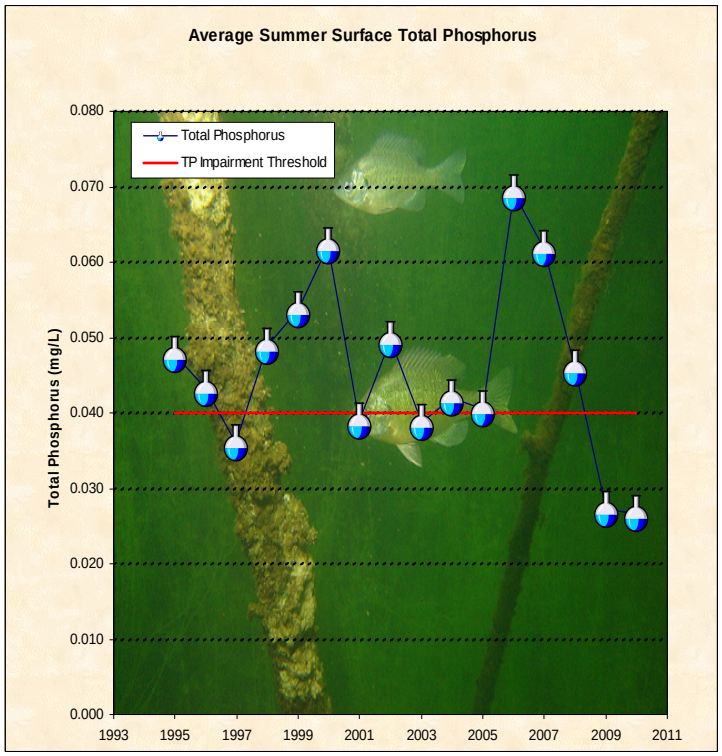
2010 Lake Grade: C+

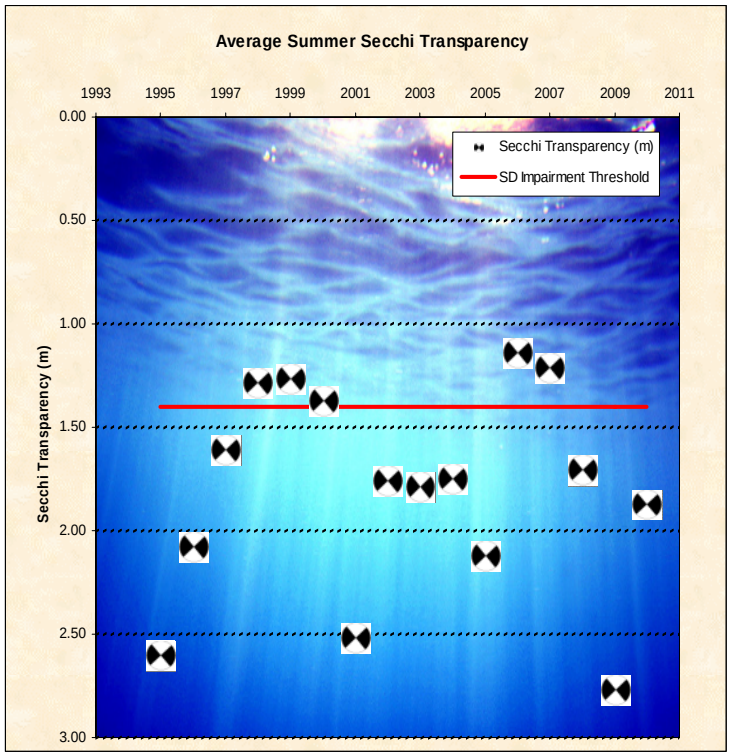
- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth: 51 ft
- Ordinary High Water Mark: 844.8 ft
- 55%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.
- Public access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



Summary Points

- Lily Lake was considered mesotrophic in 2010, based on the Carlson Trophic State Index.
- At this time no statistically significant trend can be determined for water quality.
- The major land use is urban/residential.
- The lake stratified in 2009 with the thermocline varying between 6 to 7 meters, but this is unknown for 2010, as only surface temperature was measured.
- 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 Dissolved Oxygen Levels (mg/l)	Surface Temperature Levels (Celsius)
4/18/2010	0.024	2.6	0.59	2.5	N/A	16.2
5/9/2010	0.024	2	0.57	2.8	N/A	15.8
5/18/2010	0.029	1.4	0.63	3.4	N/A	20.9
6/6/2010	0.017	4.8	0.35	3.6	N/A	22.4
7/14/2010	0.029	15	1.00	2.0	N/A	27.6
8/5/2010	0.026		0.81	1.4	N/A	35.4
8/27/2010	0.035	68	1.30	0.5	N/A	24.0
9/22/2010	0.030	18	0.92	1.7	N/A	18.3
10/18/2010	0.020	6.6	0.63	3.4	N/A	14.1
2010 Average	0.026	14.8	0.76	2.37	N/A	21.6
2010 Summer Average	0.027	26.5	0.88	1.84	N/A	25.5

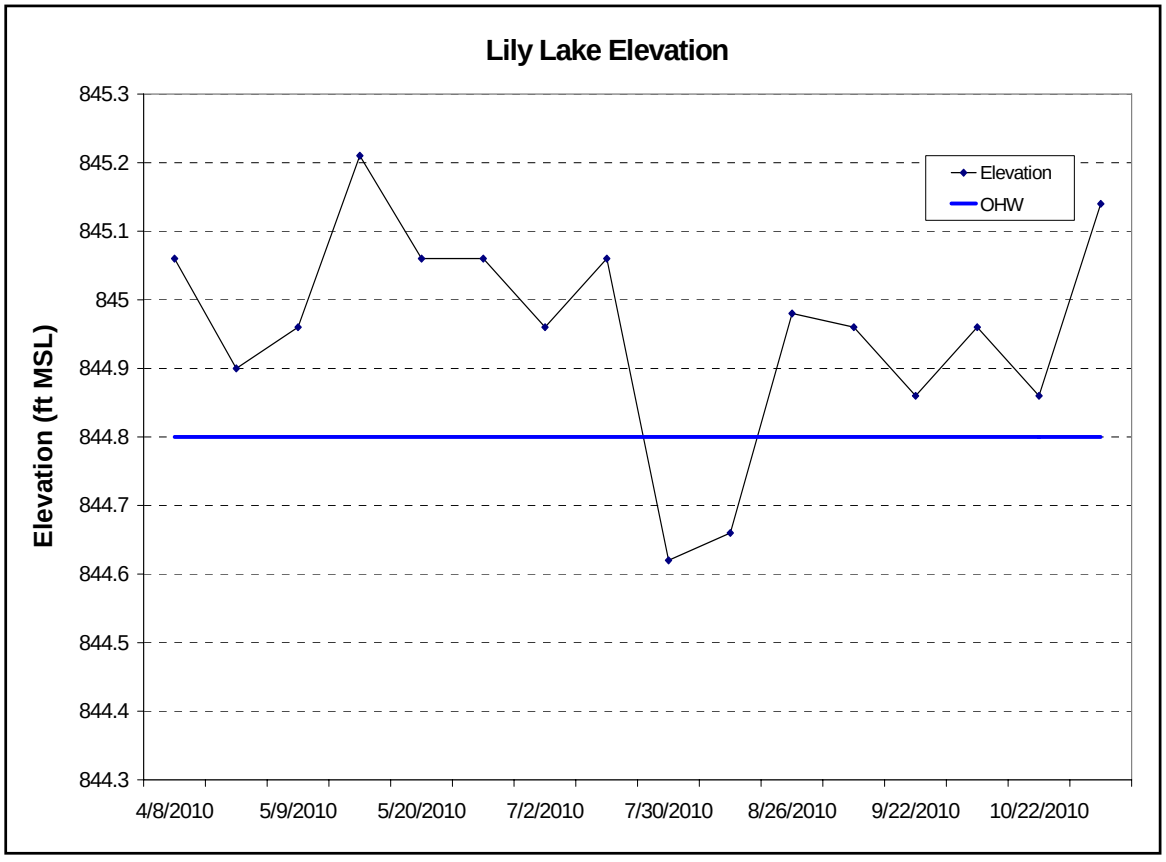
Water quality thresholds are 0.04 mg/L TP, 14 µg/L CL-a, 1.4 m Secchi depth*

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

Missing value from lab

	High	High Date	Low	Low Date	Average
2010 Elevation (ft)	845.21	5/18/2010	844.62	7/30/2010	844.96

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) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

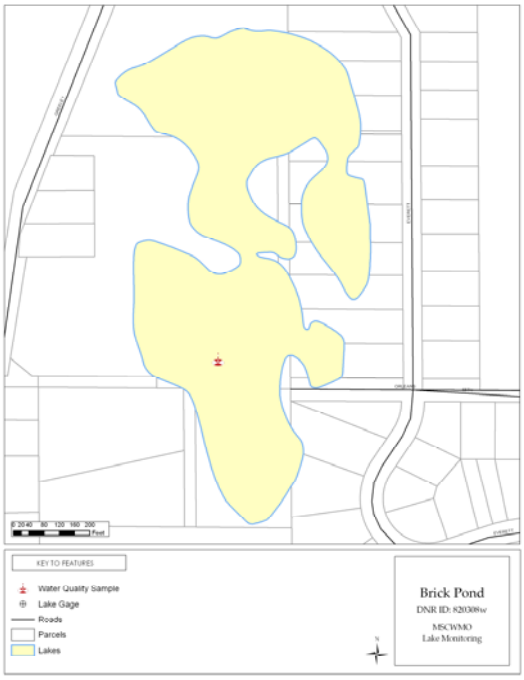


Lake Water Quality Summary	Trophic Status	Summertime Lake Grades									
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
Total Phosphorus (mg/l)	Mesotrophic	B	B	C	C	D	C	C	C	C	C
Chlorophyll-*a* (ug/l)	Eutrophic	C	A	C	C	C	B	B	B	B	A
Secchi depth (ft)	Mesotrophic	C	B	C	C	D	C	C	C	C	B
Overall	Mesotrophic	C+	B+	C	C	D+	C+	C+	C+	C+	B

Brick Pond

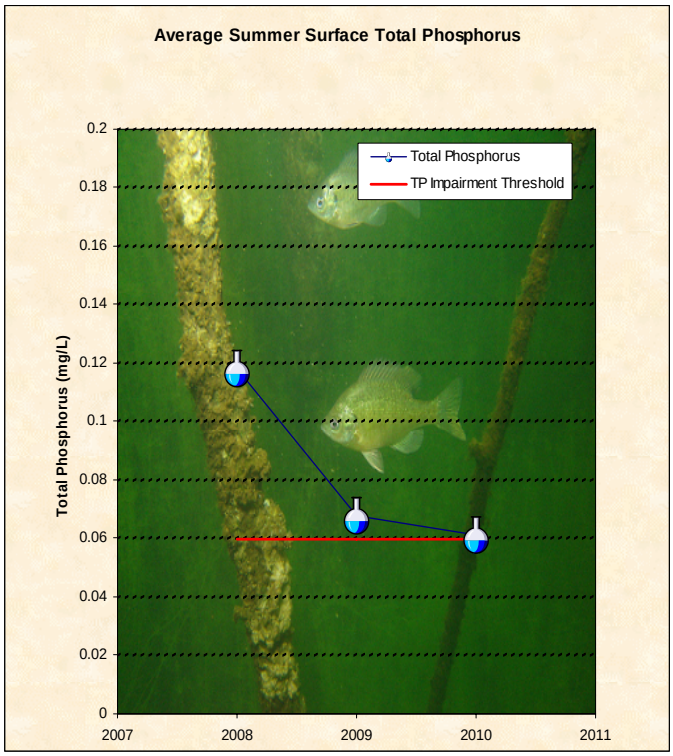
2010 Lake Grade: B-

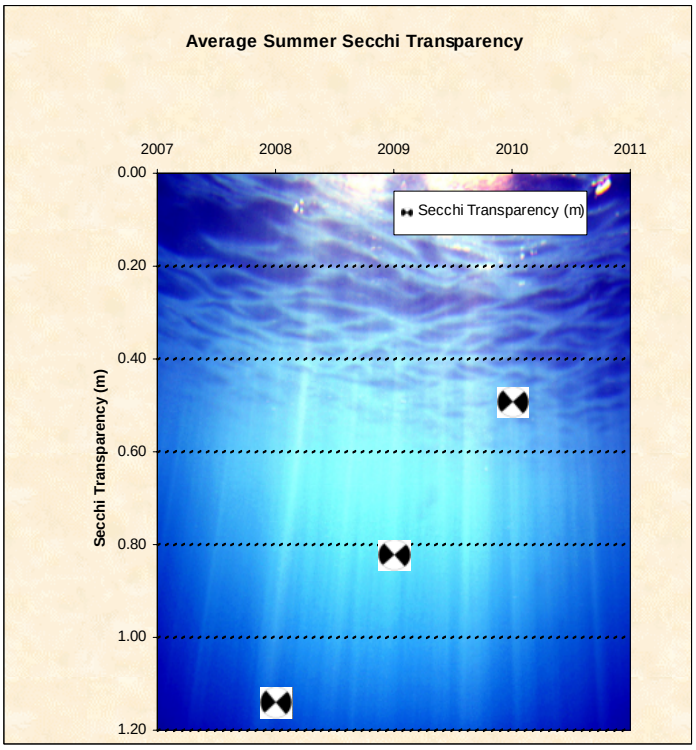
- DNR ID #: 820308
- Municipality: City of Stillwater
- Location: NW ¼ Section 33, T30N-R20W
- Lake Size: 12 Acres
- Maximum Depth (2010): 2 ft
- Ordinary High Water Mark: N/A
- 100%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Brick Pond was considered mesotrophic in 2010, based on the Carlson Trophic State Index.
- At this time there are not enough years of data to determine a statistically significant overall water quality trend.
- The major land use is urban/residential.
- The pond did not stratify in 2010.





Date	Total Phosphorus (mg/L)	Chlorophyll-a (ug/L)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/L)	Surface Temperature Levels (Celsius)
5/3/2010	0.047	4	0.6	0.46	3.42	15.1
5/19/2010	0.07	2.7	0.58	0.91	11.24	19.3
6/28/2010	0.091	15	0.63	0.61	9.26	23.5
7/27/2010	0.065	3.9	0.95	0.46	13.74	30.0
8/24/2010	0.053	8.6	1	0.46	10.82	25.6
9/20/2010	0.036	6	0.58	0.46	14.78	15.4
10/22/2010	0.065	3	0.62	0.30	14.29	7.0
2010 Average	0.061	6.2	0.71	0.52	11.08	19.41
2010 Summer Average	0.061	8.4	0.79	0.50	12.15	23.63

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
2010 Elevation (ft)	N/A	N/A	N/A	N/A	N/A

*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) of paired TP, chlorophyll-a, and Secchi disk data and provide a basis for evaluating their interrelationships and hence the trophic status of the lake."

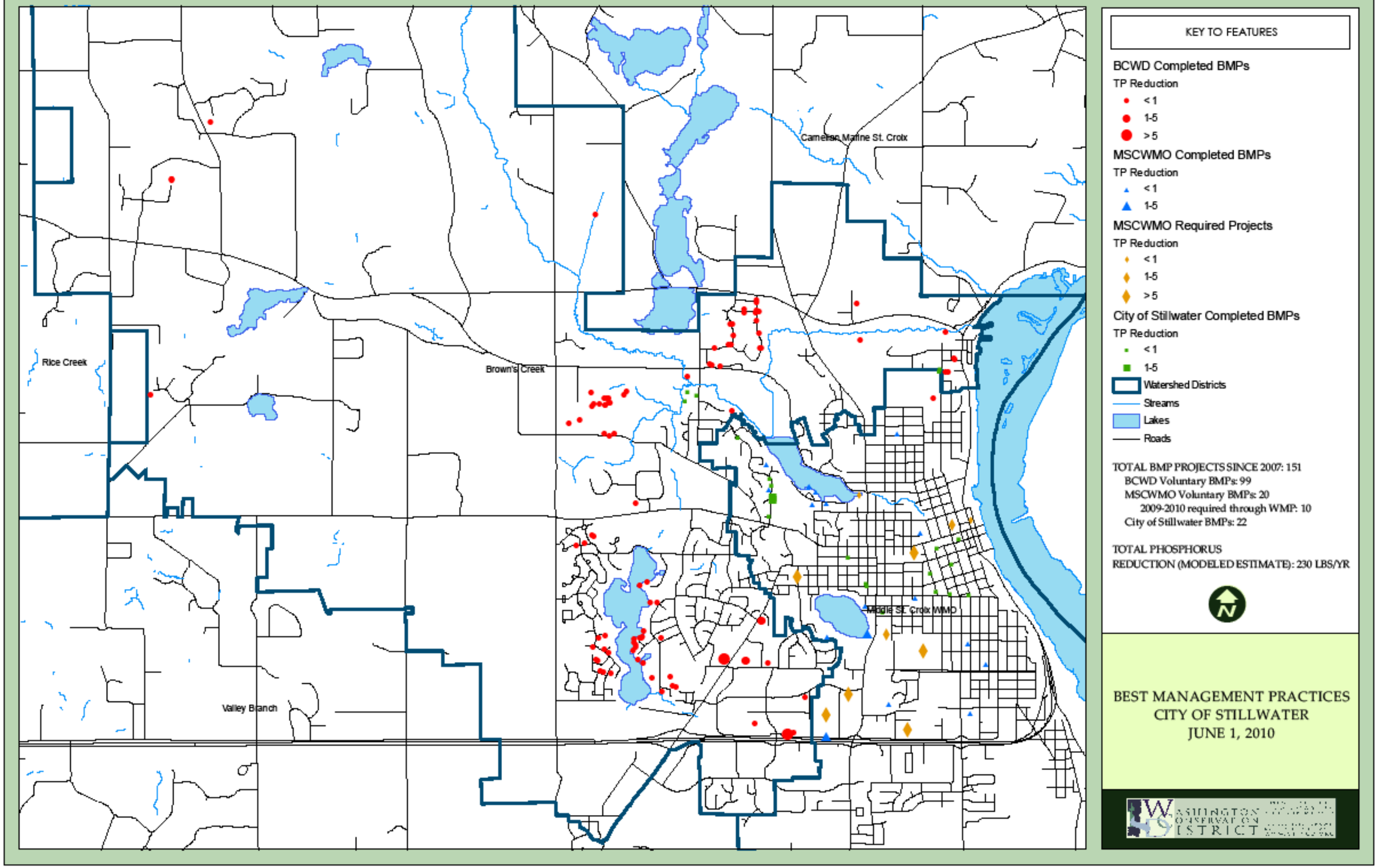
Lake Water Quality Summary

	Trophic Status	Summertime Lake Grades									
	2010	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
Total Phosphorus (mg/l)	Eutrophic	C*	C	D	NA	NA	NA	NA	NA	NA	NA
Chlorophyll-*a* (ug/l)	Mesotrophic	A	A	A	NA	NA	NA	NA	NA	NA	NA
Secchi depth (ft)	Mesotrophic	C*	C	C	NA	NA	NA	NA	NA	NA	NA
Overall	Mesotrophic	B-	B-	C+	NA	NA	NA	NA	NA	NA	NA

*Adjusted for shallow lake

Appendix B

City Of Stillwater BMP Map


Rice Creek
Brown's Creek
Cameron Marine St. Croix
Middle St. Croix WMD
Valley Branch
KEY TO FEATURES
BCWD Completed BMPs
TP Reduction
< 1
1-5
> 5
MSCWMO Completed BMPs
TP Reduction
< 1
1-5
MSCWMO Required Projects
TP Reduction
< 1
1-5
> 5
City of Stillwater Completed BMPs
TP Reduction
< 1
1-5
Watershed Districts
Streams
Lakes
Roads
TOTAL BMP PROJECTS SINCE 2007: 151
BCWD Voluntary BMPs: 99
MSCWMO Voluntary BMPs: 20
2009-2010 required through WMP: 10
City of Stillwater BMPs: 22
TOTAL PHOSPHORUS
REDUCTION (MODELED ESTIMATE): 230 LBS/YR
BEST MANAGEMENT PRACTICES
CITY OF STILLWATER
JUNE 1, 2010