Middle St. Croix Watershed Management Organization 2009 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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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 2009 and previous years. In 2009 the Middle St. Croix Water 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 and Myrtle St. (Figure 1). 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 which will enable the MSCWMO to identify trends associated with the land use changes in their watershed.

In 2009 Brick Pond, Lily Lake and McKusick Lake had average water quality. Brick Pond was classified as eutrophic, and both Lily Lake and McKusick Lake were classified as mesotrophic (Table 2). The overall 2009 lake grades for MSCWMO lakes were: Brick Pond – B, up from a C+ last year, McKusick Lake – B, up from a C+ last year, and Lily Lake – B+, up from a C last year (Table 3). When comparing the 2009 with the 2008 monitoring season, all three lakes showed a slight improvement in water quality. Lily Lake was within the ecoregion range for total phosphorus, chlorophyll-*a*, and Secchi disk transparency, with only two water quality samples exceeding the Minnesota Pollution Control Agency (MPCA) threshold for phosphorus impairment. McKusick Lake was considered worse than the ecoregion range for total phosphorus, but within the ecoregion range for chlorophyll-*a* and Secchi disk transparency. Three water quality samples from McKusick Lake exceeded the MPCA phosphorus impairment threshold for shallow lakes. Brick Pond was considered worse than the ecoregion range for total phosphorus and for Secchi disk transparency, but was considered slightly better than the ecoregion range for chlorophyll-*a*. Several samples exceeded the shallow lake impairment threshold for phosphorus (Table 1).

Using 2009 data total phosphorus and total suspended solid loads were calculated for Perro Creek to determine the total load sent to the St. Croix River and to determine load per hectare (1 hectare ~2.471 acres) per year. In 2009 Perro Creek discharged a total load of 242 lbs. of phosphorus and 51,847 lbs. of suspended solids to the St. Croix River (Table 4), more than twice

the 2008 amount. When comparing the load per hectare per year to literature estimates of land use type, Perro Creek's phosphorus load of 0.26 kg/ha/yr (0.08 lb/ac/yr) falls within the range of export found present in precipitation and the pastureland use category (Figure 11). It can be observed from the 2009 loading data that there was a significant increase in total phosphorus (TP) loading and a total suspended solids (TSS) loading value of more than double from the previous year (Table 4). This could be attributed to the creek being dry for the majority of the season due to the abnormally dry summer we had and the Perro Pond dam being closed until the first part of July. Once it did rain or the dam was opened there were large flushes of water, which would send all of the debris and dead plant material that had been collecting in the dry creek bed down the stream. This may have been one reason for the high numbers that were reported in 2009.

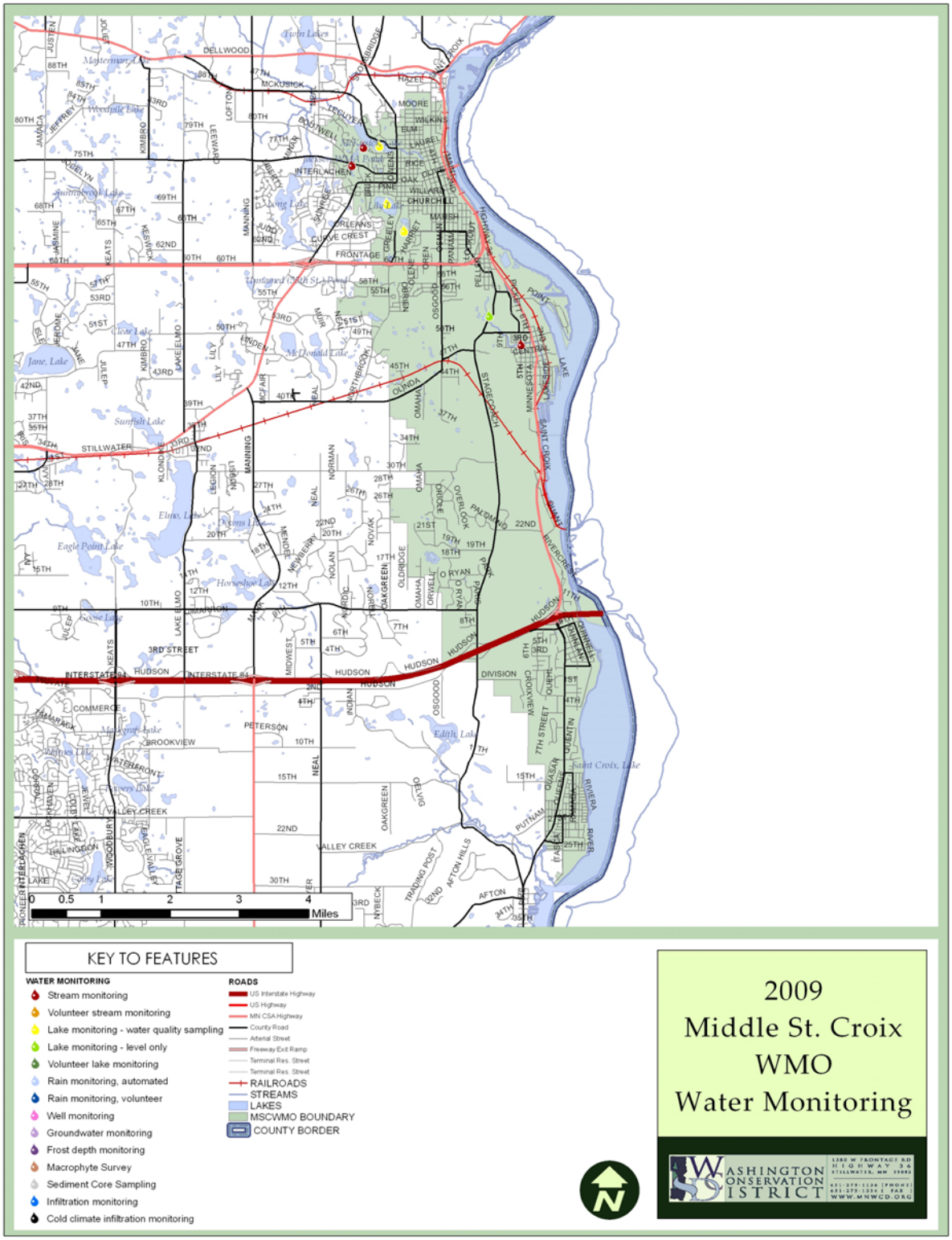


Figure 1. MSCWMO Water Monitoring Locations

LAKES

A. METHODS, RESULTS AND DISCUSSION

In 2009 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. Additionally, hypolimnion samples were collected at Lily Lake with a Van Dorn sampler. These samples were collected approximately 1 meter (3.28 feet) from the lake bottom. Metropolitan Council Environmental Services Lab analyzed surface samples for total phosphorus, chlorophyll-*a*, and total Kjeldahl nitrogen. Hypolimnion samples were analyzed for total phosphorus, total Kjeldahl nitrogen, ortho phosphates and total iron. 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 2009 Parameters

2009 MSCWMO Lakes Summer Averages (June-September)			
Lake/Units	**Total Phosphorus (mg/L)**	**Chlorophyll-a (ug/L)**	**Secchi (meters)**
Eco-Region Value	*0.023-0.050*	*5.00-22.00*	*1.5-3.2*
Lily	0.027	8	2.77
McKusick	0.059	8.3	2.70
Brick Pond	0.0678	4.9	0.82296

1. 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 2009 study period, was 2.77 meters in Lily Lake, 2.70 meters in McKusick Lake, and 0.82 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. Brick Pond exceeded (was poorer than) the ecoregion value in 2009. However, it should be noted 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 can be found in Figure 2.

2. CHLOROPHYLL-*a*

Chlorophyll-*a* is a photosynthetic component found in algae and aquatic plants. It is also an indication of algal productivity. The 2009 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. Lily Lake (8 μg/L), McKusick Lake (8.3 μg/L) and Brick Pond (4.9 μg/L) were all within the ecoregion range values for chlorophyll-*a* and at lower concentrations than the previous year. Historical summer average chlorophyll-*a* values can be found in Figure 3.

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 2009 were 0.027 mg/L in Lily Lake, 0.059 mg/L in McKusick Lake and 0.067 mg/L in Brick Pond (Table 1). The typical range of the ecoregion for total phosphorous is 0.023 – 0.050 mg/L. Lily Lake was within the normal range of ecoregion values. McKusick Lake and Brick Pond exceeded (were poorer than) the ecoregion value in 2009, but did improve over last year. Historical summer average TP values can be found in Figure 4.

4. NITROGEN

Several forms of nitrogen are responsible for health problems and can increase the rate of lake eutrophication. 2009 average total Kjeldahl nitrogen (TKN) concentrations were 0.9 mg/L in Lily Lake, 1.2 mg/l in McKusick Lake and 0.79 mg/L in Brick Pond, all improving over the 2008 values. 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 2009.

5. TEMPERATURE AND DISSOLVED OXYGEN

Temperature and dissolved oxygen readings were taken during each sampling event. In addition to surface water measurements, a temperature and dissolved oxygen profile was taken at each lake during each sampling event. These profiles were recorded at one-meter increments from the surface, down 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. Lily Lake and McKusick Lake both exhibited thermal stratification during the summer months. This shows that these lakes are less likely to completely mix during the summer months. Conversely, Brick pond is a shallow, non-stratifying lake that may mix throughout the summer, allowing for internal loading.

6. 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. Lakes with low biological productivity or oligotrophic lakes, like lakes common in the northeast part of Minnesota, have 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 2009 data and utilizing the Carlson's Trophic State Index (Table 2), Brick Pond is classified as eutrophic. McKusick Lake and Lily Lake are classified as mesotrophic, as compared to being classified as eutrophic in 2008. Lakes within the eutrophic or hypereutrophic range typically receive excess nutrient loading from sources within their watersheds. However, some percentage of these nutrients can also be attributed to internal loading within the lake, which is usually 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. 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 2009 with results presented in Appendix A. Comparing the Lake Trophic Status and the Lake Grading System shows a fair to good correlation between the two systems.

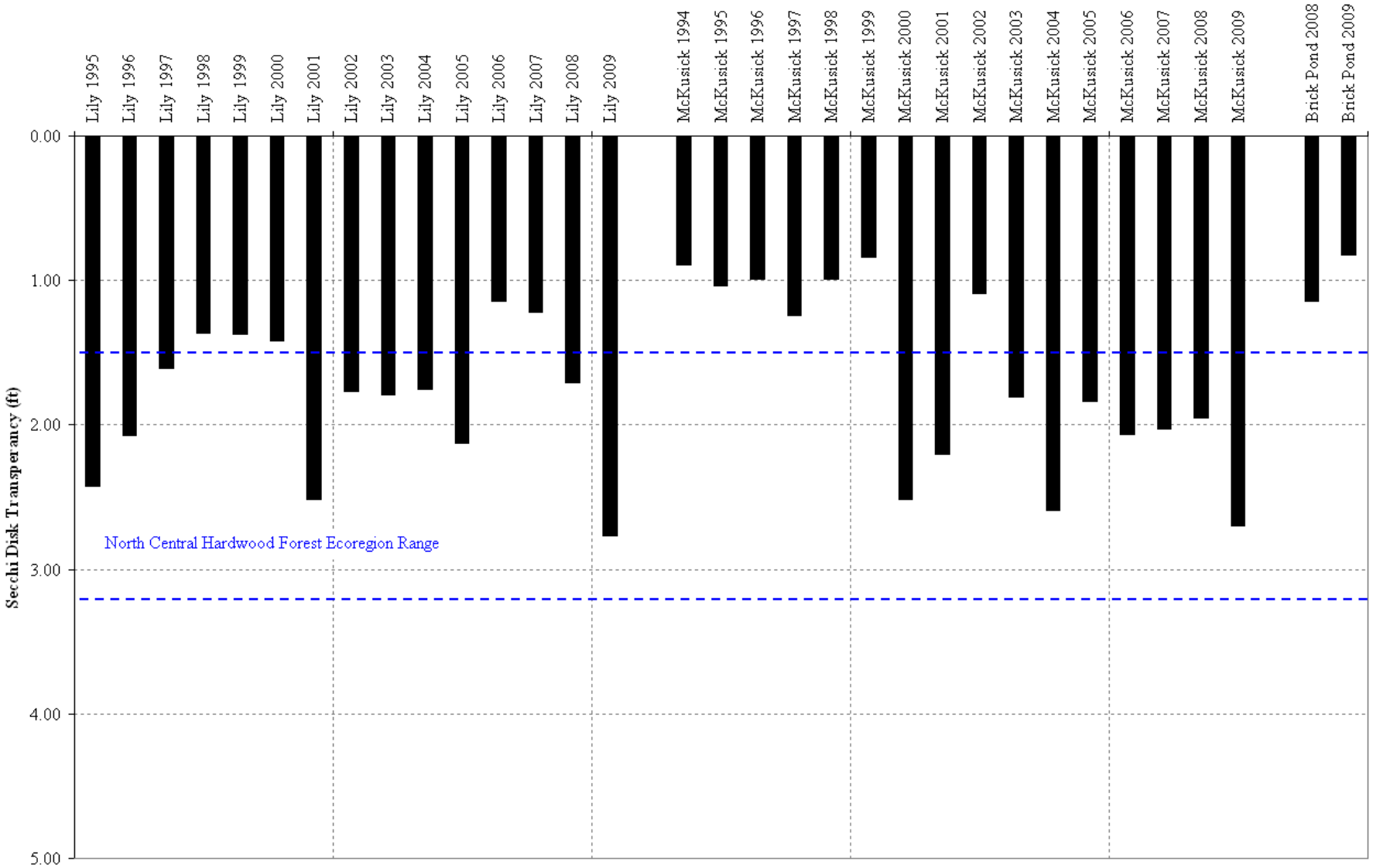


Figure 2. MSCWMO Historic Secchi Records

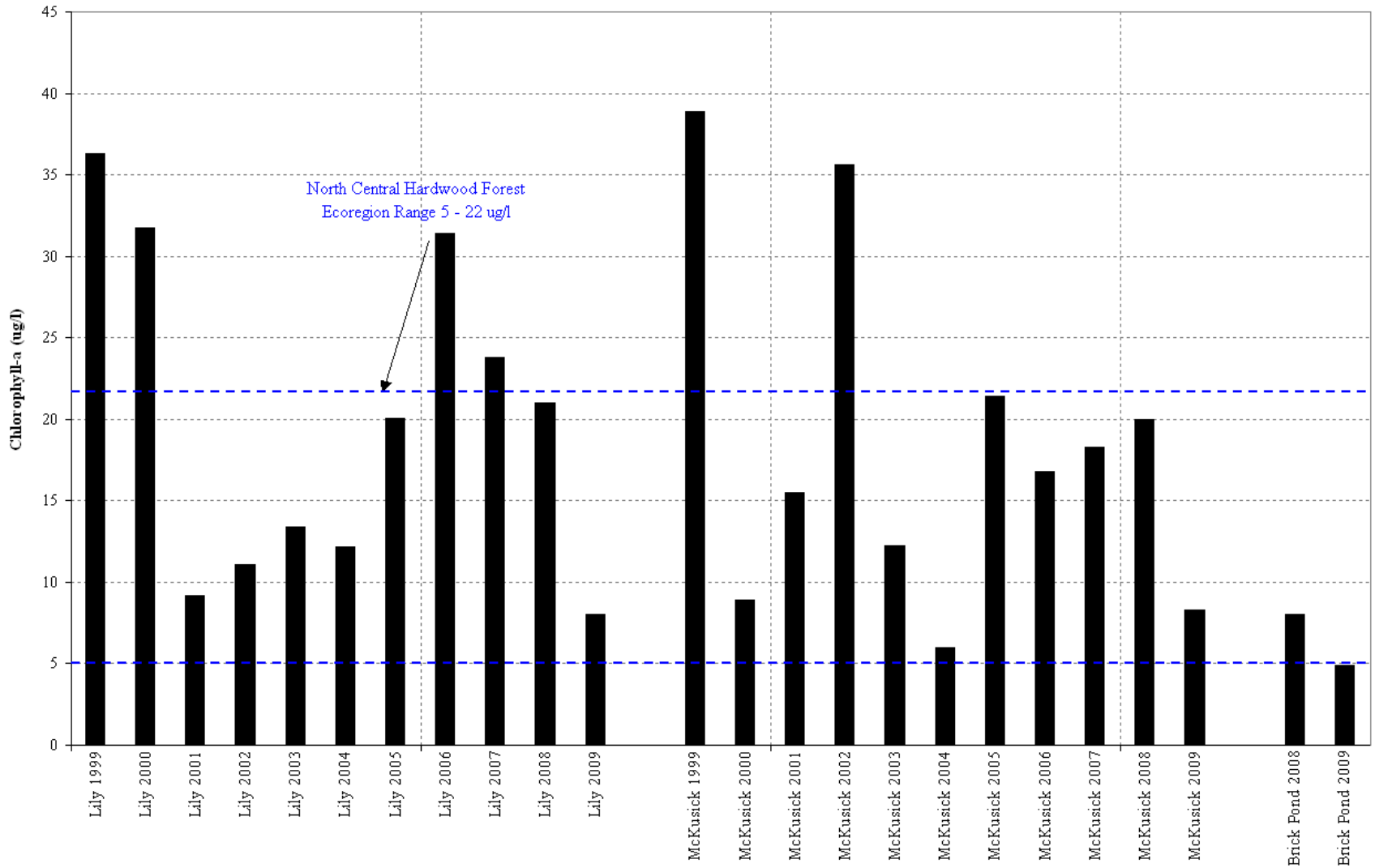


Figure 3. MSCWMO Historic Chlorophyll-*a* Data

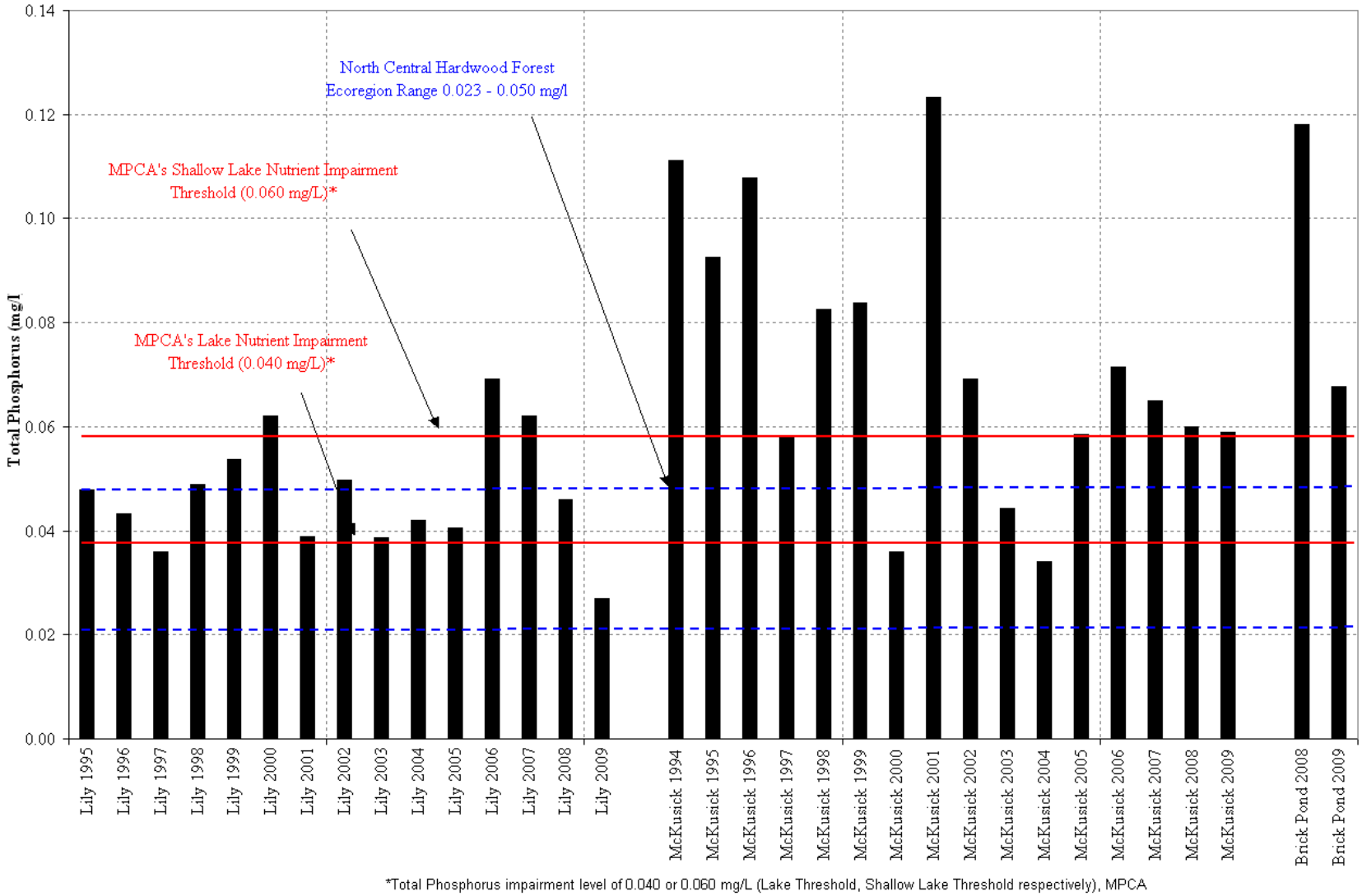


Figure 4. MSCWMO Historic Total Phosphorus Data

7. LAKE ELEVATIONS

Lake elevation gages are located on two lakes and one wetland throughout the MSCWMO and are monitored by WCD staff. Complete lake elevation data for 2009 can be found in Figure 5 through Figure 7. Despite the dry summer of 2009 (Figure 8), the elevation of McKusick Lake was above the Ordinary High Water level (OHW) for the entire monitoring season. Lily Lake did fall below the OHW for a few months (from the end of May to the beginning of August) and Perro Pond does not have an established OHW for comparison purposes. All three resources reflect significant decreases in elevation during the summer of 2009 when precipitation was below normal. Lily Lake and McKusick Lake elevations dropped from the spring into mid-summer, but later rebounded in August when storm events occurred (Figure 5, Figure 6). Perro Pond's large elevation change during the summer could be attributed to the smaller watershed drainage area compared to both McKusick Lake and Lily Lake. A small dam holds back Perro Pond, which was not open for the first part of the summer, keeping the water elevations higher. In the first part of July the dam was opened letting water discharge into Perro Creek and dropping the elevation of Perro Pond for the rest of the monitoring season (Figure 7). For historical lake elevations, visit the MN DNR Lake Finder webpage at http://www.dnr.state.mn.us/lakefind/index.html.

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.

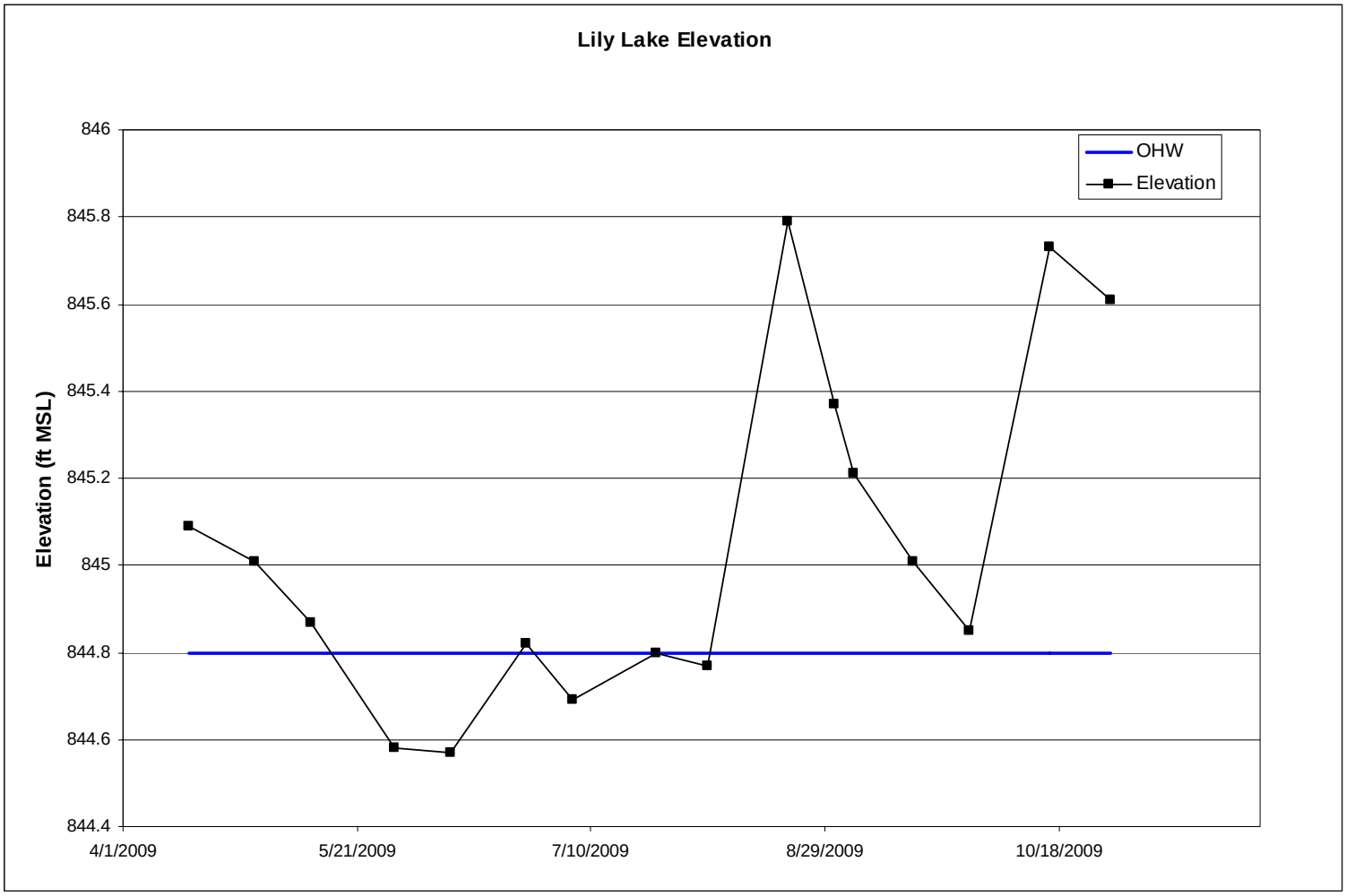


Figure 5. Lily Lake 2009 Elevations

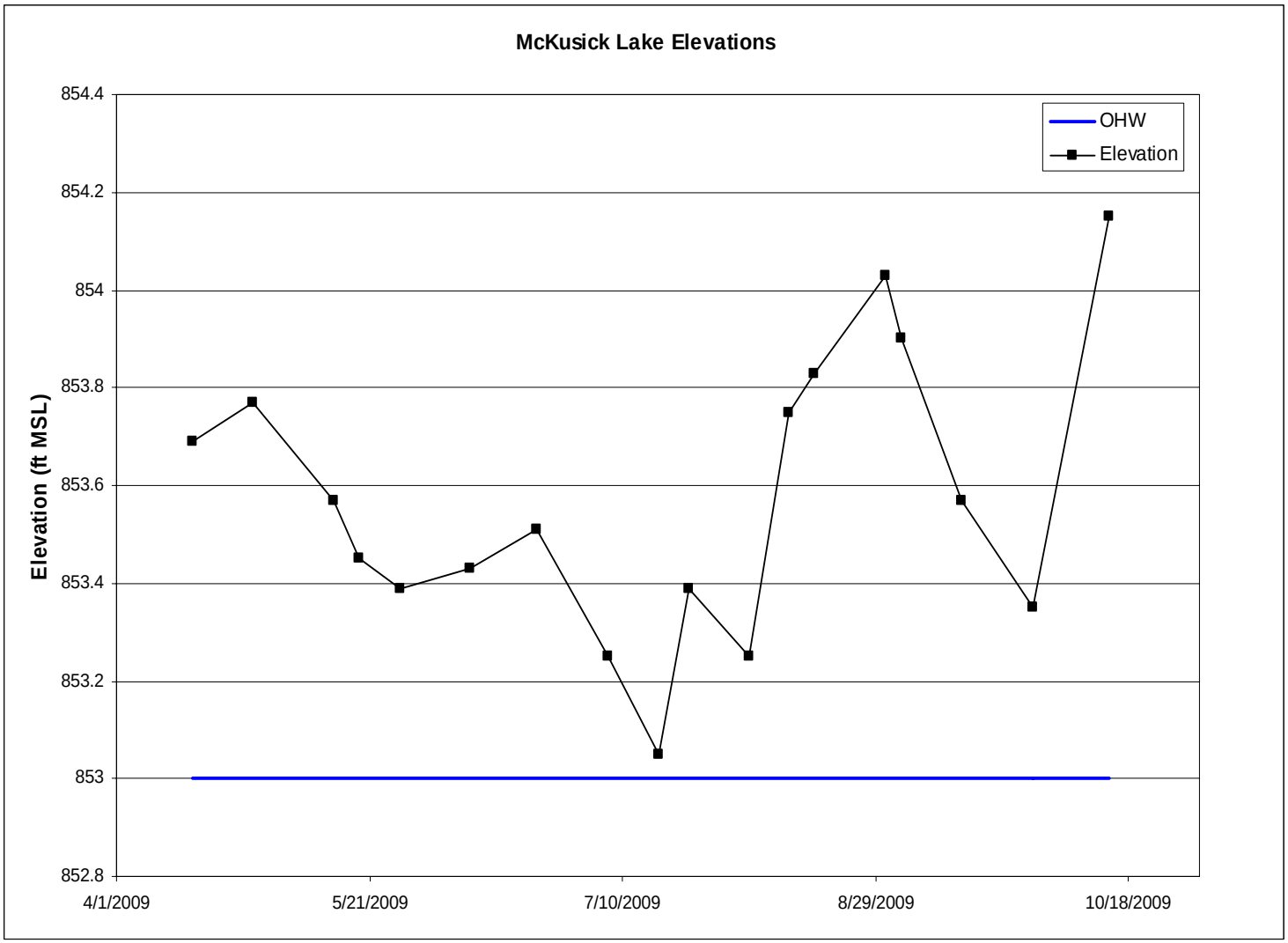


Figure 6. McKusick Lake 2009 Elevations

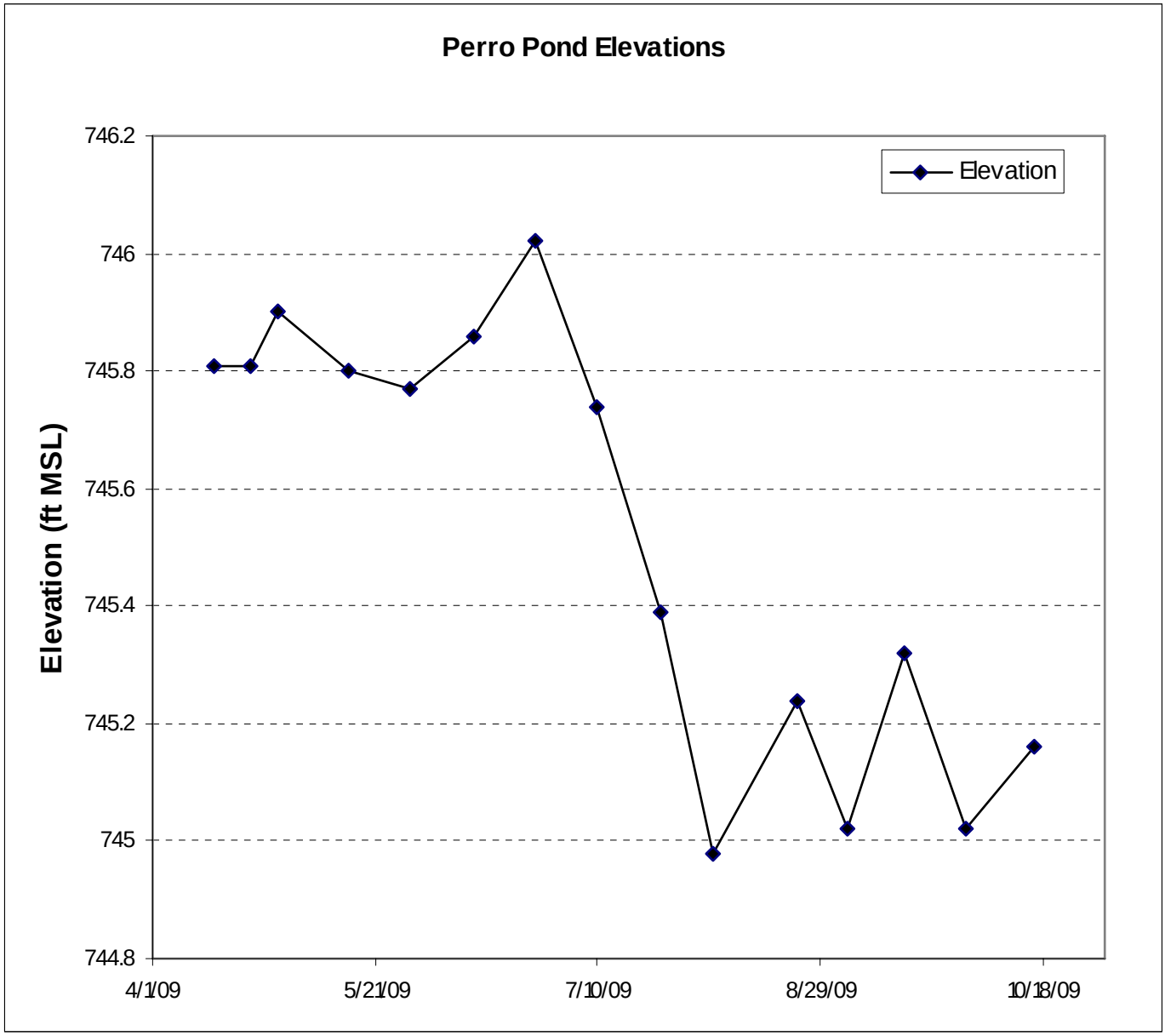


Figure 7. Perro Pond 2009 Elevations

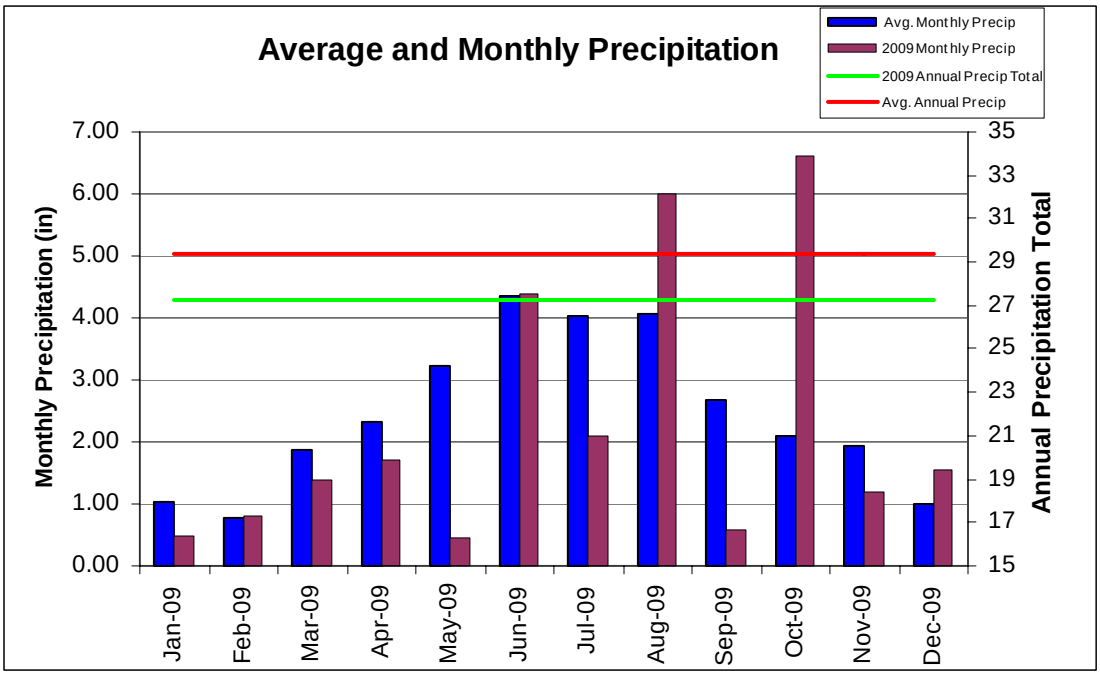


Figure 8: **2009 Annual Precipitation, Historical 30-Year Average Monthly Precipitation and 2009 Monthly Precipitation**

2009 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

Lily Lake

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 (B lake grade) where overall water quality dramatically improved for one year (Figure 2, Figure 3, Figure 4). In 2009 Lily Lake improved over all previously recorded years and received a B+ lake grade. The only lake water quality management measure known to WCD staff was copper sulfate treatment. The starting date of this treatment is unknown. In 2001 CLA levels and the lake grade improved significantly, and may indicate when treatment began in Lily Lake. In 2006 and 2007, summer average TP, CLA, and Secchi transparency all deteriorated when compared to averages seen in 2001 to 2005. But the water quality has improved every year since 2006 with the averages since 2007 being more in line with averages seen in 2001 to 2005. Using historical data, a kendall-tau statistical test was used to determine if there was a statistically significant trend in water quality. According to the results of those water quality tests, there is no significant trend in Secchi transparency or total

phosphorus. CLA average concentrations, TP and Secchi transparency again improved from the previous year. 2009 has provided the best water quality seen in Lily Lake since monitoring has started, with summer average CLA and TP concentrations at the lowest recorded level and summer average Secchi transparency at the deepest recorded level. This may be attributed to the abnormally dry summer and the lack of runoff going into Lily Lake. In 2009 the level of the water fluctuated over the course of the summer. The highest recorded elevation was on August 21, 2009 due to a two-inch precipitation event in mid-August. Lake elevations then dropped and rebounded with another high reading on October 16, 2009 due to the precipitation events in early October. Lake elevations did fall below the OHW from about mid-May to mid-August (Figure 5). Lily Lake is listed on the Minnesota Pollution Control Agency's (MPCA) 303d Impaired Waters List for excess nutrients. The MPCA tentatively planned to start a Total Maximum Daily Load (TMDL) study in 2010 to determine how to reduce the amount of nutrients introduced into the lake in order to meet water quality criteria, but work is being done to expedite the process of a TMDL to meet the established water quality standard. It is also recommended to utilize the city's Lake Management Plan, and with some modifications, turn the plan into a TMDL study and implementation plan. With a completed TMDL and implementation plan, the opportunity exists for more available funding for water quality improvement projects to meet the water quality standards.

McKusick Lake

The overall water quality of McKusick Lake improved when compared to the two previous years—from a C+ to a B. Reflecting back on McKusick Lake's data from 1994 to present, the lake has seen statistically significant improvements in both total phosphorus and Secchi transparency. In 2009 McKusick Lake was within the ecoregion ranges for Secchi disk transparency and chlorophyll-*a* but exceeded the range for total phosphorus (Figure 2, Figure 3, Figure 4). This is not surprising considering the dynamics of water quality possible in a shallow lake. McKusick Lake did exceed the shallow lake water quality standard in 2009, which indicates the TP levels are likely above normal compared to what would be considered normal for an unaltered, natural lake in this ecoregion. McKusick Lake's elevation declined for the first half of the summer due to rainfall accumulations that were below average for those months reaching its lowest recorded level on July 17, 2009 (Figure 6). With the rainfall in August,

McKusick Lake rose in elevation, fell again in September, but rose to its highest recorded level of the monitoring season on October 14, 2009. The basin remained above the ordinary high water mark for the entire monitoring season.

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 storm water 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 monitoring stream flow 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 8, Table 9, and Table 10. McKusick Lake is on the Minnesota Pollution Control Agency's (MPCA) 303d Impaired Waters List because it does not meet water quality criteria due to excess nutrients. The MPCA had tentatively planned to start a Total Maximum Daily Load (TMDL) study on this lake in 2008 to determine how to reduce the amount of nutrients introduced into the lake in order to meet water quality criteria, but work is being done to expedite the process of a TMDL to meet the established water quality standard. The best recommendation to the city would be to develop and initiate a TMDL study and implementation plan using the city's existing Lake Management Plan as a template. This would allow the city to position itself ideally for available water quality improvement project funding as soon as possible.

Brick Pond

2009 marked the second year that Brick Pond was monitored. 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. Total phosphorus improved in 2009, just slightly worse than the ecoregion range and above the MPCA's Shallow Lake Nutrient Impairment Threshold. Chlorophyll-*a* also improved over the previous year and even became slightly better than the ecoregion range. Secchi transparency decreased and went from being in the ecoregion range in 2008, to being worse than the ecoregion average in 2009 (Figure 2, Figure 3, Figure 4).

B. 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 2009 Brick Pond, Lily Lake and McKusick Lake had average water quality ratings with Brick Pond classified as eutrophic, and both Lily Lake and McKusick Lake classified as mesotrophic. The overall 2009 lake grades for MSCWMO lakes were: Brick Pond – B-, Lily Lake – B+ and McKusick Lake – B. When compared with data after 2006, McKusick Lake and Lily Lake have shown improvement in water quality every year, including the 2009 monitoring season. Lily Lake was within the ecoregion range for total phosphorus, chlorophyll-*a*, and Secchi disk transparency, and only two water quality samples exceeded the MPCA lake threshold for phosphorus impairment. McKusick Lake was considered worse than the ecoregion range for total phosphorus, but within the ecoregion range for chlorophyll-*a* and Secchi disk transparency. Three water quality samples from McKusick Lake exceeded the MPCA phosphorus impairment threshold for shallow lakes. Brick Pond was within the ecoregion range for chlorophyll-*a*, but was considered worse than the ecoregion range for Secchi disk transparency and total phosphorus. Several samples exceeded the shallow lake impairment threshold for phosphorus and one for chlorophyll-*a* (Figure 2, Figure 3, Figure 4).

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. 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 2009 (Figure 5, Figure 6, Figure 7). The highest recorded elevations in 2009 happened mid to late August, after the storms that caused precipitation to be above normal for that month. One can see how precipitation was below normal throughout the beginning of the year, and August, October, and December was above normal for the second half of the year (Figure 8). The total precipitation amount for the year was more than 6.5 inches less than 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 is very channelized, even by use of concrete in order to channelize the creek in areas. 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 stream grab site is located on Myrtle Street between Bayberry Avenue and Deer Path on the south side of the road. It is upstream of the Meadowlark site and receives its water from the urban area on the south side of the road, the wetland that is south 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 stream grab site is located on the southwest side of the path on Meadowlark Drive and is a tributary to McKusick Lake. It is downstream of the Myrtle Street site on McKusick Lakes' south end. 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.

1. FLOW AND WATER QUALITY

In 2009 the WCD took grab samples and flow-weighted 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 base and storm flow composite samples from April through November. Data collected at this site by the WCD included total discharge, precipitation, and water quality analysis. A list of the WCD standard operating procedures can be found at http://www.mnwcd.org/water_monitoring_standards.php . All stream flow and chemistry data from 2009 can be found in Figure 9, Table 4, Table 5 and Table 6. Using a combination of composite and grab samples, total phosphorus and total suspended solid loads were calculated at Perro Creek. The results were compared to a chart of export coefficients in a variety of land use scenarios and show that Perro Creek was better than the regional averages for total phosphorus based on its land use type (Figure 11).

As additional data provided to the MSCWMO, the WCD took grab samples and flow-weighted samples during both base flow and storm event conditions at the Brown's Creek Diversion Structure for BCWD in 2009. For those not familiar with the Diversion Structure, the City of Stillwater completed the Trout Stream Mitigation Project in June 2003 and 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. This diversion structure will keep the warmer urban stormwater from the southern tributary out of the temperature and nutrient sensitive Brown's Creek Ravine. Data collected at this site by the WCD includes total discharge and water quality sample analysis. All stream flow and chemistry data from 2009 can be found in Table 8, Table 9, and Table 10. Using a combination of composite and grab samples, total phosphorus and total suspended solid loads were calculated at the Brown's Creek Diversion Structure Drainage. The results were compared to a chart of export coefficients in a variety of land use scenarios and show the Brown's Creek Diversion Structure Drainage was below regional averages for total phosphorus based on its land use type (Figure 11).

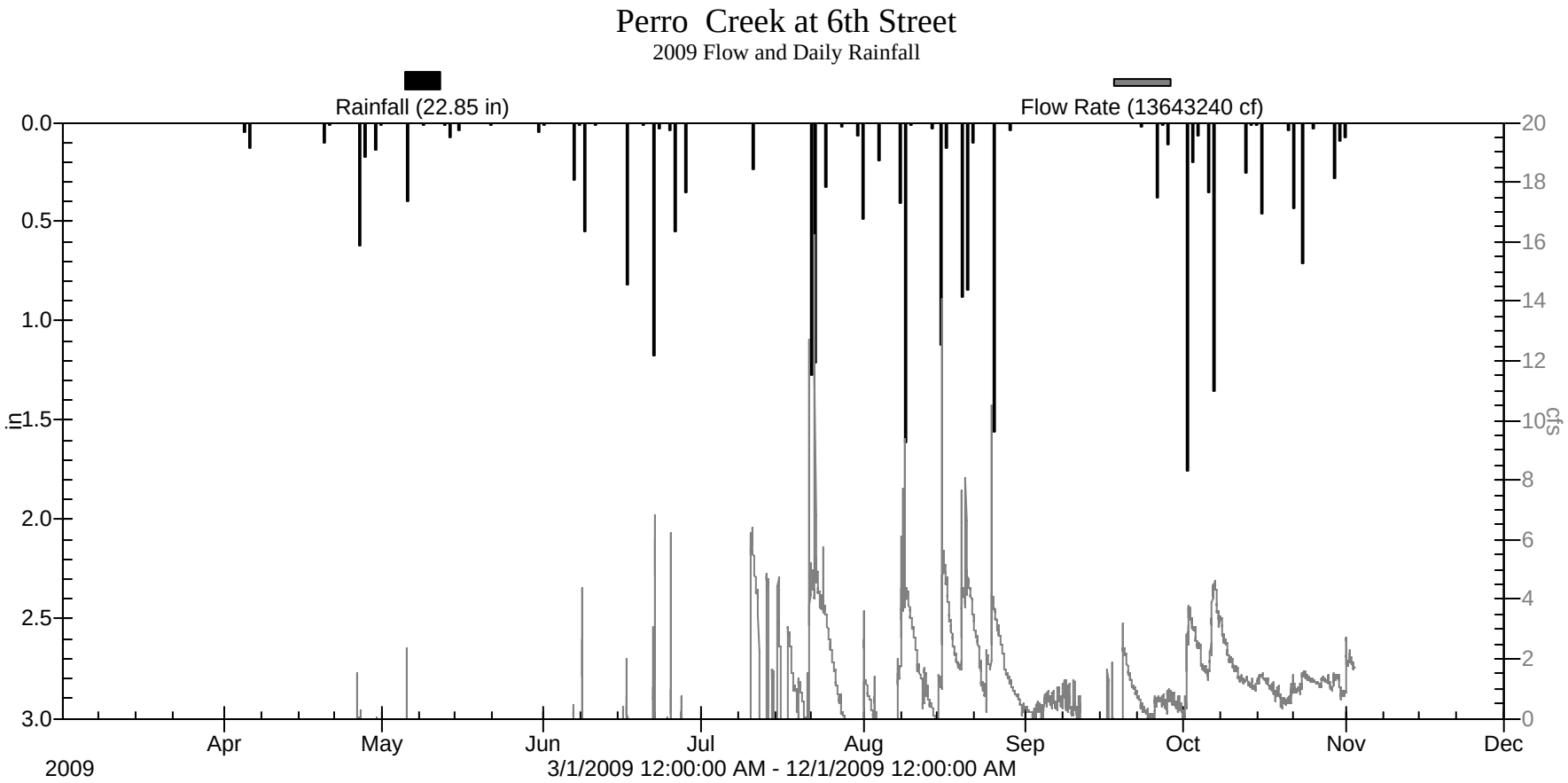


Figure 9. Perro Creek 2009 Discharge and Daily Rainfall

Table 4. Perro Creek 2009 Total Suspended Solids (TSS) and 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	1/1/2009 0:00	4/3/2009 15:30	0	0.00	0	0.00
Intermitent flow			*115*	*0.284*	*4/3/2009 15:30*	*6/21/2009 17:30*	*36,249*	*0.83*	*260*	*0.64*
Storm Composite	6/21/09 22:33	6/21/09 22:54	105	0.326	*6/21/2009 17:30*	6/22/2009 1:30	32,224	0.74	211	0.66
No Flow			0	0.000	*6/22/2009 1:30*	6/25/2009 0:30	0	0.00	0	0.00
Storm			*200*	*0.284*	*6/25/2009 0:30*	*6/25/2009 8:30*	*12,821*	*0.29*	*160*	*0.23*
No Flow			0	0.000	6/25/2009 8:30	6/27/2009 2:30	0	0.00	0	0.00
Storm			*200*	*0.284*	*6/27/2009 2:30*	*6/27/2009 9:30*	*2,591*	*0.06*	*32*	*0.05*
No Flow			0	0.000	6/27/2009 9:30	7/10/2009 10:30	0	0.00	0	0.00
Base Composite	7/10/09 11:29	7/11/09 21:00	26	0.096	7/10/2009 10:30	7/11/2009 23:30	651,231	14.95	1,057	3.90
No Flow			0	0.000	7/11/2009 23:30	7/13/2009 9:30	0	0.00	0	0.00
Base			*8*	*0.206*	*7/13/2009 9:30*	*7/13/2009 21:30*	*177,331*	*4.07*	*89*	*2.28*
No Flow			0	0.000	7/13/2009 21:30	7/14/2009 9:30	0	0.00	0	0.00
Base			*8*	*0.206*	*7/14/2009 9:30*	*7/14/2009 21:30*	*59,967*	*1.38*	*30*	*0.77*
No Flow			0	0.000	7/14/2009 21:30	7/15/2009 15:30	0	0.00	0	0.00
Base Grab	7/16/09 14:45	7/16/09 14:45	3	0.051	7/15/2009 15:30	7/16/2009 13:30	134,901	3.10	25	0.43
No Flow			0	0.000	7/16/2009 13:30	7/17/2009 11:30	0	0.00	0	0.00
Base			*8*	*0.206*	*7/17/2009 11:30*	*7/20/2009 21:30*	*336,667*	*7.73*	*168*	*4.33*
No Flow			0	0.000	7/20/2009 21:30	7/21/2009 7:30	0	0.00	0	0.00
Storm			*200*	*0.284*	*7/21/2009 7:30*	*7/22/2009 0:30*	*172,417*	*3.96*	*2,153*	*3.06*
Base			*8*	*0.206*	*7/22/2009 0:30*	*7/22/2009 17:30*	*282,014*	*6.47*	*141*	*3.63*
Storm			*200*	*0.284*	*7/22/2009 17:30*	*7/23/2009 23:30*	*495,820*	*11.38*	*6,190*	*8.79*
Base			*8*	*0.206*	*7/23/2009 23:30*	*7/24/2009 8:30*	*119,782*	*2.75*	*60*	*1.54*
Storm			*200*	*0.284*	*7/24/2009 8:30*	*7/24/2009 10:30*	*31,300*	*0.72*	*391*	*0.55*
Base			*8*	*0.206*	*7/24/2009 10:30*	*7/28/2009 16:30*	*573,117*	*13.16*	*286*	*7.37*
No Flow			0	0.000	7/28/2009 16:30	7/31/2009 22:30	0	0.00	0	0.00
Storm			*200*	*0.284*	*7/31/2009 22:30*	*8/1/2009 8:30*	*39,053*	*0.90*	*488*	*0.69*
Base			*8*	*0.206*	*8/1/2009 8:30*	*8/3/2009 0:30*	*84,596*	*1.94*	*42*	*1.09*
Storm			*200*	*0.284*	*8/3/2009 0:30*	*8/3/2009 11:30*	*9,001*	*0.21*	*112*	*0.16*
Base			*8*	*0.206*	*8/3/2009 11:30*	*8/4/2009 10:30*	*463*	*0.01*	*0*	*0.01*
No Flow			0	0.000	8/4/2009 10:30	8/7/2009 9:30	0	0.00	0	0.00
Storm Composite	8/8/09 10:35	8/8/09 10:35	*200*	0.356	8/7/2009 9:30	8/9/2009 12:30	605,376	13.90	*7,558*	13.45
Base			*8*	*0.206*	*8/9/2009 12:30*	*8/14/2009 17:30*	*713,765*	*16.39*	*356*	*9.18*
No Flow			0	0.000	8/14/2009 17:30	8/15/2009 8:30	0	0.00	0	0.00
Storm Composite	8/15/09 23:10	8/15/09 23:24	415	0.640	8/15/2009 8:30	8/16/2009 21:30	463,781	10.65	12,015	18.53
Base			*8*	*0.206*	*8/16/2009 21:30*	*8/19/2009 12:30*	*588,279*	*13.51*	*294*	*7.57*
Storm			*200*	*0.284*	*8/19/2009 12:30*	*8/19/2009 19:30*	*87,533*	*2.01*	*1,093*	*1.55*
Base			*8*	*0.206*	*8/19/2009 19:30*	*8/20/2009 11:30*	*234,123*	*5.37*	*117*	*3.01*
Storm			*200*	*0.284*	*8/20/2009 11:30*	*8/20/2009 21:30*	*167,471*	*3.84*	*2,091*	*2.97*
Base			*8*	*0.206*	*8/20/2009 21:30*	*8/25/2009 5:30*	*905,590*	*20.79*	*452*	*11.65*
Storm Composite	8/25/09 6:20	8/25/09 6:34	384	0.230	8/25/2009 5:30	8/25/2009 12:30	104,372	2.40	2,502	1.50
Base Grab	9/8/09 11:41	9/8/09 11:41	1	0.470	8/25/2009 12:30	9/11/2009 10:30	1,354,461	31.09	85	39.74
No Flow			0	0.000	9/11/2009 10:30	9/19/2009 10:30	0	0.00	0	0.00
Base			*8*	*0.206*	*9/19/2009 10:30*	*9/25/2009 8:30*	*430,193*	*9.88*	*215*	*5.53*
Storm			*200*	*0.284*	*9/25/2009 8:30*	*9/26/2009 6:30*	*41,825*	*0.96*	*522*	*0.74*
Base			*8*	*0.206*	*9/26/2009 6:30*	*9/27/2009 20:30*	*77,954*	*1.79*	*39*	*1.00*
Storm			*200*	*0.284*	*9/27/2009 20:30*	*9/28/2009 5:30*	*25,430*	*0.58*	*317*	*0.45*
Base Grab	9/28/09 15:02	9/28/09 15:02	2	0.046	9/28/2009 5:30	10/1/2009 8:30	126,524	2.90	16	0.36
Storm Composite	10/1/09 16:41	10/3/09 20:29	52	0.087	10/1/2009 8:30	10/3/2009 20:30	571,348	13.12	1,855	3.10
Base			*8*	*0.206*	*10/3/2009 20:30*	*10/5/2009 18:30*	*305,000*	*7.00*	*152*	*3.92*
Storm Composite	10/6/09 8:54	10/8/09 4:09	45	0.104	10/5/2009 18:30	10/8/2009 4:30	705,714	16.20	1,982	4.58
Base			*8*	*0.206*	*10/8/2009 4:30*	*10/14/2009 22:30*	*969,461*	*22.26*	*484*	*12.47*
Storm			*200*	*0.284*	*10/14/2009 22:30*	*10/16/2009 4:30*	*147,435*	*3.38*	*1,841*	*2.61*
Base			*8*	*0.206*	*10/16/2009 4:30*	*10/21/2009 12:30*	*408,155*	*9.37*	*204*	*5.25*
Storm			*200*	*0.284*	*10/21/2009 12:30*	*10/22/2009 2:30*	*47,712*	*1.10*	*596*	*0.85*
Base			*8*	*0.206*	*10/22/2009 2:30*	*10/23/2009 8:30*	*103,782*	*2.38*	*52*	*1.33*
Storm			*200*	*0.284*	*10/23/2009 8:30*	*10/24/2009 3:30*	*90,716*	*2.08*	*1,133*	*1.61*
Base			*8*	*0.206*	*10/24/2009 3:30*	*10/29/2009 11:30*	*571,124*	*13.11*	*285*	*7.34*
Storm			*200*	*0.284*	*10/29/2009 11:30*	*10/30/2009 18:30*	*153,078*	*3.51*	*1,911*	*2.71*
Base			*8*	*0.206*	*10/30/2009 18:30*	*10/31/2009 21:30*	*84,696*	*1.94*	*42*	*1.09*
Storm			*200*	*0.284*	*10/31/2009 21:30*	*11/1/2009 0:30*	*25,235*	*0.58*	*315*	*0.45*
*Base**			*8*	*0.206*	*11/1/2009 0:30*	*12/1/2009 0:00*	*2,911,274*	*66.83*	*1,454*	*37.44*
No Flow*			0	0.000	12/1/2009 0:00	1/1/2010 0:00	0	0.00	0	0.00
Storm Average			200	0.284						
Base Average			8	0.206						
All Average			115	0.241						
Total							**16,272,950**	**374**	**51,874**	**242**
Perro Creek Major Subwatershed Total Acres							1,063			
Total TP/TSS (lb/ac/yr)									48.82	0.23
Total TP/TSS (kg/ha/yr)									54.72	0.26
Italics indicate estimated concentrations based on average base and storm flow concentrations										
*Interval volumes from11/2/09 to 12/1/09 were estimated based upon baseflow conditions.										

Table 5. Perro Creek 2009 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)
Snowmelt Grab	2/10/2009 9:55	2/10/2009 9:55	9	5	5.6	0.8	0.721		0.05	0.74	1.21
Storm Composite	6/21/2009 22:33	6/21/2009 22:54	105	23	1.5	0.326					
Base Composite	7/10/2009 11:29	7/11/2009 21:00	26	9	0.56	0.096	~0.039		<0.03	<0.05	0.07
Base Grab	7/16/2009 14:45	7/16/2009 14:45	3	~1	0.4	0.051	0.055		<0.03	0.06	<0.02
E. Coli Grab	7/29/2009 9:30	7/29/2009 9:30						261			
Storm Composite	8/8/2009 10:35	8/8/2009 10:35			3	0.356	<0.010		0.1	0.33	0.38
Storm Composite	8/15/2009 23:10	8/15/2009 23:24	415	84	2.8	0.64	0.104		<0.03	0.48	
Storm Composite	8/25/2009 6:20	8/25/2009 6:34	384	76	1.5	0.23	0.062		<0.03	0.26	~0.06
E. Coli Grab	8/27/2009 10:25	8/27/2009 10:25						1120			
Base Grab	9/8/2009 11:41	9/8/2009 11:41	~1	<1	0.24	0.47	0.489		<0.03	<0.05	<0.02
Base Grab	9/28/2009 15:02	9/28/2009 15:02	~2	~1	1.9	~0.046	~0.038		<0.03	0.5	<0.02
E. Coli Grab	9/30/2009 8:50	9/30/2009 8:50						163			
Storm Composite	10/1/2009 16:41	10/3/2009 20:29	52	11	0.31	0.087	~0.049		<0.03	0.2	~0.04
Storm Composite	10/6/2009 8:54	10/8/2009 4:09	45	9	0.41	0.104	0.072		<0.03	0.23	0.06

Water Quality Standard Exceedance

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

Table 6. Perro Creek 2009 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
Snowmelt Grab	2/10/2009 9:55	2/10/2009 9:55	0.0085	0.0017	0.0015	0.0238	<0.0005	<0.005	72
Storm Composite	6/21/2009 22:33	6/21/2009 22:54	0.0079	0.0034	0.0098	0.0317	<0.0005	<0.005	
Base Composite	7/10/2009 11:29	7/11/2009 21:00	0.0023	0.0018	0.0017	0.0106	<0.0005	<0.005	184
Base Grab	7/16/2009 14:45	7/16/2009 14:45	0.0008	0.0011	0.0003	<0.005	<0.0005	<0.005	194
E. Coli Grab	7/29/2009 9:30	7/29/2009 9:30							
Storm Composite	8/8/2009 10:35	8/8/2009 10:35							
Storm Composite	8/15/2009 23:10	8/15/2009 23:24	0.0158	0.0066	0.0242	0.0593	<0.0005	0.0087	48
Storm Composite	8/25/2009 6:20	8/25/2009 6:34	0.0005	0.0011	0.0002	0.0069	<0.0005	<0.005	78
E. Coli Grab	8/27/2009 10:25	8/27/2009 10:25							
Base Grab	9/8/2009 11:41	9/8/2009 11:41	<0.0005	0.0014	<0.0001	<0.005	<0.0005	<0.005	190
Base Grab	9/28/2009 15:02	9/28/2009 15:02	0.0061	0.002	0.0002	0.011	<0.0005	<0.005	220
E. Coli Grab	9/30/2009 8:50	9/30/2009 8:50							
Storm Composite	10/1/2009 16:41	10/3/2009 20:29	0.0025	0.0021	0.0034	0.0099	<0.0005	<0.005	154
Storm Composite	10/6/2009 8:54	10/8/2009 4:09	0.0025	0.0019	0.0032	0.0111	<0.0005	<0.005	68

No Exceedance Determinable

Exceeds Chronic Standard

Exceeds Max Standard

Exceeds Final Acute Standard

Table 7. Perro Creek 2009 Field Measurement Results

Date	Transparency (cm)	Water Temperature (C)	Dissolved Oxygen (mg/L)	Conductivity (umhos/cm)	pH
7/13/2009 13:31	>100	22.5	7.13	360	
7/16/2009 14:45	>100	22.1	4.77	386	8.5
7/24/2009 15:20	>100	22.8	7.78	290	8.0
8/11/2009 8:58	>100	23.6	7.40	302	8.4
8/17/2009 12:46	>100	23.3	7.45	285	8.2
8/26/2009 14:56	>100	22.2	7.70	285	8.0
8/27/2009 10:22	>120	21.2	7.83	296	8.3
9/8/2009 11:40	>100	20.8	10.25	384	8.7
9/28/2009 15:02	>100	15.0	10.20	518	8.3
10/8/2009 8:43	>100	10.0	10.60	297	8.1
	Water Quality Standard Exceedance				

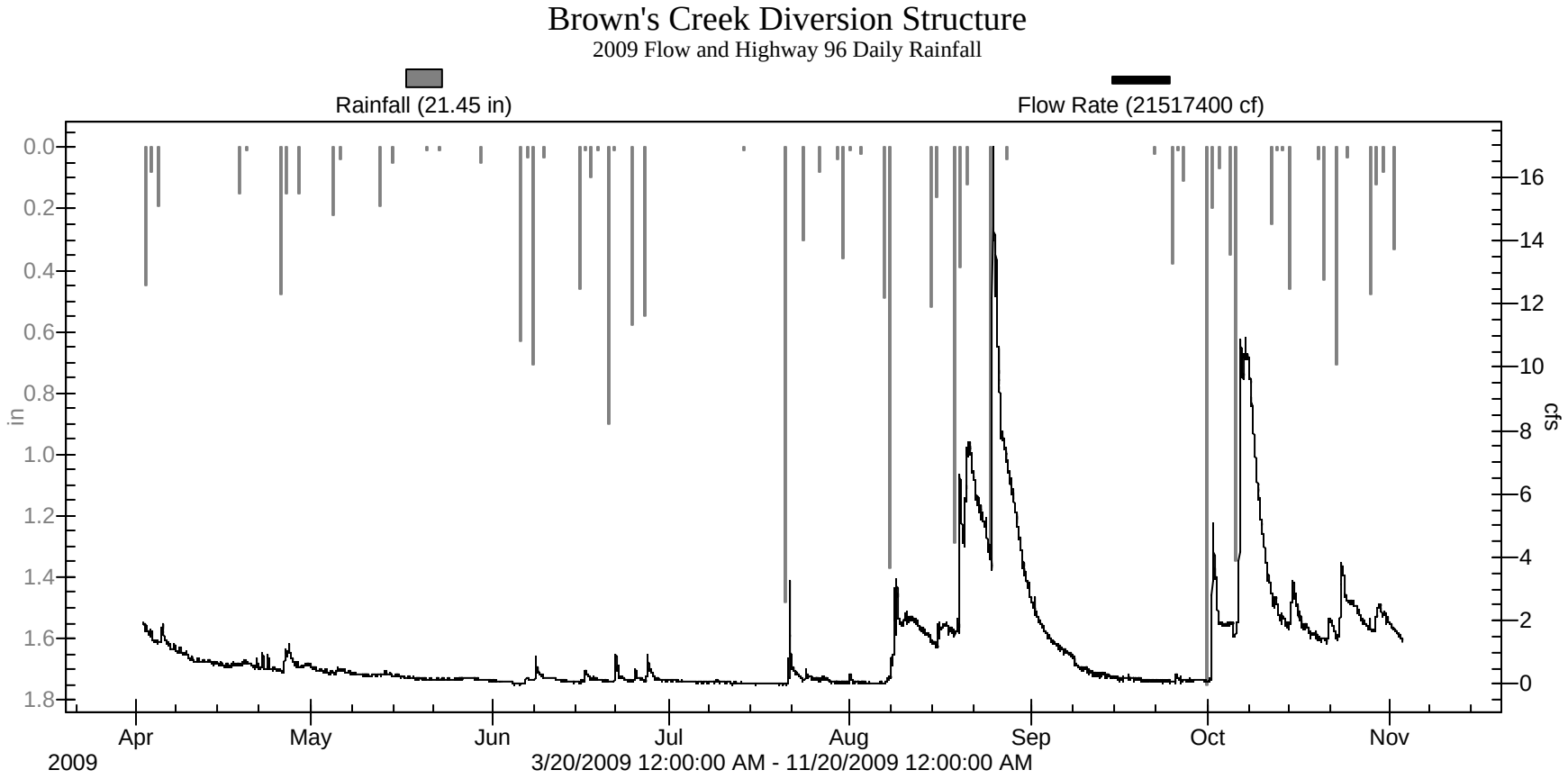


Figure 10. Brown's Creek Diversion Structure Drainage 2009 Flow and Browns Creek at Highway 96 Daily Rainfall

Table 8. Brown's Creek Diversion Structure Drainage 2009 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***			*11*	*0.126*	*1/1/2009 0:00*	*3/17/2009 5:00*	*2,534,220*	*58.21*	*19.93*	*1,740*
Snowmelt Grab**	3/17/09 10:40	3/17/09 10:40	52	0.317	3/17/2009 5:00	3/19/2009 5:00	276,480	*6.35*	*5.47*	*897*
*Base***			*11*	*0.126*	*3/19/2009 5:00*	*3/24/2009 5:00*	*548,640*	*12.60*	*4.32*	*377*
Storm Grab**	3/24/09 9:03	3/24/09 9:03	44	0.145	*3/24/2009 5:00*	3/26/2009 5:00	276,480	*6.35*	*2.50*	*759*
*Base***			*11*	*0.126*	*3/26/2009 5:00*	*4/2/2009 12:15*	*801,234*	*18.40*	*6.30*	*550*
Base			*11*	*0.126*	*4/2/2009 12:15*	4/3/2009 13:15	155,363	3.57	1.22	107
Storm			*435*	*0.754*	*4/3/2009 13:15*	*4/4/2009 0:15*	*63,063*	*1.45*	*2.97*	*1,712*
Base			*11*	*0.126*	*4/4/2009 0:15*	4/5/2009 10:15	163,922	3.77	1.29	113
Storm			*435*	*0.754*	*4/5/2009 10:15*	*4/6/2009 3:15*	*96,747*	*2.22*	*4.55*	*2,627*
Base			*11*	*0.126*	*4/6/2009 3:15*	*4/26/2009 10:15*	*1,255,536*	*28.84*	*9.88*	*862*
Storm			*435*	*0.754*	*4/26/2009 10:15*	*4/28/2009 1:15*	*128,376*	*2.95*	*6.04*	*3,486*
Base Grab	5/18/09 13:30	5/18/09 13:30	3	0.071	4/28/2009 1:15	5/21/2009 1:15	691,789	15.89	3.07	130
Base Grab	6/4/09 13:00	6/4/09 13:00	8	0.131	5/21/2009 1:15	6/6/2009 10:15	172,006	3.95	1.41	86
Storm			*435*	*0.754*	*6/6/2009 10:15*	*6/7/2009 0:15*	*6,744*	*0.15*	*0.32*	*183*
Base			*11*	*0.126*	*6/7/2009 0:15*	*6/8/2009 5:15*	*14,592*	*0.34*	*0.11*	*10*
Storm			*435*	*0.754*	*6/8/2009 5:15*	*6/8/2009 23:15*	*32,362*	*0.74*	*1.52*	*879*
Base			*11*	*0.126*	*6/8/2009 23:15*	*6/16/2009 16:15*	*90,737*	*2.08*	*0.71*	*62*
Storm			*435*	*0.754*	*6/16/2009 16:15*	*6/17/2009 8:15*	*17,610*	*0.40*	*0.83*	*478*
Base			*11*	*0.126*	*6/17/2009 8:15*	6/21/2009 17:15	49,285	1.13	0.39	34
Storm Grab	6/22/09 8:50	6/22/09 8:50	36	0.188	6/21/2009 17:15	6/22/2009 17:15	32,411	0.74	0.38	73
Base			*11*	*0.126*	*6/22/2009 17:15*	*6/27/2009 3:15*	*64,266*	*1.48*	*0.51*	*44*
Storm			*435*	*0.754*	*6/27/2009 3:15*	*6/28/2009 11:15*	*52,446*	*1.20*	*2.47*	*1,424*
Base Grab	7/13/09 9:12	7/13/09 9:12	33	0.184	6/28/2009 11:15	7/21/2009 7:15	124,641	2.86	1.43	257
Storm Composite	7/21/09 9:44	7/21/09 21:10	416	0.936	7/21/2009 7:15	7/21/2009 23:15	51,988	1.19	3.04	1,350
Base Grab	7/27/09 8:41	7/27/09 8:41	13	0.148	7/21/2009 23:15	7/31/2009 22:15	151,933	3.49	1.40	123
Base Grab	8/5/09 15:24	8/5/09 15:24	18	0.177	7/31/2009 22:15	8/7/2009 10:15	29,452	0.68	0.33	33
Storm Composite	8/8/09 11:06	8/10/09 13:44	448	0.693	8/7/2009 10:15	8/10/2009 15:15	444,783	10.22	19.24	12,439
Base			*11*	*0.126*	*8/10/2009 15:15*	*8/19/2009 11:15*	*1,320,725*	*30.34*	*10.39*	*907*
Storm Composite	8/19/09 15:23	8/20/09 20:17	1090	1.910	8/19/2009 11:15	8/20/2009 22:15	639,608	*14.69*	*76.26*	*43,522*
Base			*11*	*0.126*	*8/20/2009 22:15*	*8/25/2009 5:15*	*2,114,050*	*48.56*	*16.63*	*1,452*
Storm Composite	8/25/09 6:34	8/25/09 9:34	1130	1.830	8/25/2009 5:15	8/26/2009 6:15	1,148,531	*26.38*	*131.21*	*81,019*
Base			*11*	*0.126*	*8/26/2009 6:15*	*9/5/2009 6:15*	*3,435,438*	*78.91*	*27.02*	*2,359*
Base Grab	9/8/09 10:17	9/8/09 10:17	5	0.078	9/5/2009 6:15	9/15/2009 6:15	504,339	*11.58*	*2.46*	*157*
Base Grab	9/18/09 8:15	9/18/09 8:15	2	0.118	9/15/2009 6:15	9/25/2009 12:15	123,956	*2.85*	*0.91*	*15*
Storm			*435*	*0.754*	*9/25/2009 12:15*	*9/25/2009 21:15*	*6,899*	*0.16*	*0.32*	*187*
Base Grab	9/28/09 14:25	9/28/09 14:25	4	0.099	9/25/2009 21:15	10/1/2009 16:15	61,111	*1.40*	*0.38*	*15*
Storm Composite	10/1/09 17:47	10/5/09 7:40	630	0.909	10/1/2009 16:15	10/2/2009 3:15	141,884	*3.26*	*8.05*	*5,580*
Storm Grab	10/2/09 9:49	10/2/09 9:49	30	0.205	10/2/2009 3:15	10/2/2009 17:15	160,910	*3.70*	*2.06*	*301*
Base			*11*	*0.126*	*10/2/2009 17:15*	*10/6/2009 10:15*	*619,012*	*14.22*	*4.87*	*425*
Storm Composite	10/6/09 9:41	10/7/09 14:46	524	0.606	10/6/2009 10:15	10/7/2009 9:15	802,051	*18.42*	*30.34*	*26,236*
Storm Grab	10/7/09 9:45	10/7/09 9:45	2	0.113	10/7/2009 9:15	10/8/2009 18:15	1,161,273	*26.67*	*8.19*	*145*
Base			*11*	*0.126*	*10/8/2009 18:15*	*10/15/2009 0:15*	*1,991,966*	*45.75*	*15.67*	*1,368*
Storm			*435*	*0.754*	*10/15/2009 0:15*	*10/16/2009 7:15*	*300,486*	*6.90*	*14.14*	*8,160*
Base			*11*	*0.126*	*10/16/2009 7:15*	*10/21/2009 11:15*	*750,056*	*17.23*	*5.90*	*515*
Storm			*435*	*0.754*	*10/21/2009 11:15*	*10/22/2009 10:15*	*158,552*	*3.64*	*7.46*	*4,306*
Base			*11*	*0.126*	*10/22/2009 10:15*	*10/23/2009 10:15*	*139,103*	*3.20*	*1.09*	*96*
Storm			*435*	*0.754*	*10/23/2009 10:15*	*10/24/2009 14:15*	*305,944*	*7.03*	*14.40*	*8,308*
Base			*11*	*0.126*	*10/24/2009 14:15*	*10/29/2009 11:15*	*919,982*	*21.13*	*7.24*	*632*
Storm			*435*	*0.754*	*10/29/2009 11:15*	*10/30/2009 18:15*	*252,648*	*5.80*	*11.89*	*6,861*
Base			*11*	*0.126*	*10/30/2009 18:15*	*11/3/2009 9:15*	*568,825*	*13.07*	*4.47*	*391*
*Base***			*11*	*0.126*	*11/3/2009 9:15*	*12/2/2009 0:00*	*3,708,450*	*85.18*	*29.17*	*2,547*
*Base***			*11*	*0.126*	*12/2/2009 0:00*	*1/1/2010 0:00*	*1,503,360*	*34.53*	*11.82*	*1,032*
Storm Average			435	0.754						
Base Average			11	0.126						
All Average			236	0.466						
Total							**31,166,264**	**716**	**544**	**227,372**
Brown's Creek Major Subwatershed Total Acres							3,837			
Total TP/TSS(lb/ac/yr)									0.14	59.26
Total TP/TSS (kg/ha/yr)									0.16	66.42

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

**Interval volumes from 1/1/09 to 4/2/09 and 11/3/09 to 1/1/10 were estimated using recorded base flow

Table 9: Brown's Creek Diversion Structure Drainage 2009 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/100mL)	COD (mg/L)	CBOD (mg/L)	TBOD (mg/L)	Turbidity
Snowmelt Grab	3/17/2009 10:30	3/17/2009 10:30	53	18	3.00	0.371	0.108		67	5.2	7.5	26
Snowmelt Grab	3/17/2009 10:40	3/17/2009 10:40	52			0.317						
Storm Grab	3/24/2009 9:03	3/24/2009 9:03	44	17	0.97	0.145	0.056					
Base Grab	5/18/2009 13:30	5/18/2009 13:30	3	~2	0.37	0.071	~0.011					
E. Coli Grab	5/28/2009 9:51	5/28/2009 9:51						23				
Base Grab	6/4/2009 13:00	6/4/2009 13:00	8			0.131						
Storm Grab	6/22/2009 8:50	6/22/2009 8:50	36			0.188						
E. Coli Grab	6/30/2009 8:50	6/30/2009 8:50						180				
Base Grab	7/13/2009 9:12	7/13/2009 9:12	33	14	0.91	0.184	0.078					
Storm Composite	7/21/2009 9:44	7/21/2009 21:10	416	148	5.9	0.936	0.077					
Base Grab	7/27/2009 8:41	7/27/2009 8:41	13			0.148						
E. Coli Grab	7/29/2009 10:00	7/29/2009 10:00						1046				
Base Grab	8/5/2009 15:24	8/5/2009 15:24	18	7	0.6	0.177	0.07					
Storm Composite	8/8/2009 11:06	8/10/2009 13:44	448	212	7.30	0.693	0.069					
Storm Grab	8/20/2009 8:44	8/20/2009 8:44	25			0.148						
Storm Composite	8/19/2009 15:23	8/20/2009 20:17	1090	350	11	1.91	0.073					
Storm Composite	8/25/2009 6:34	8/25/2009 9:34	1130	~280	6.5	1.83	0.087					
E. Coli Grab	8/27/2009 9:15	8/27/2009 9:15						74				
Base Grab	9/8/2009 10:17	9/8/2009 10:17	5	~2	1.2	0.078	~0.049					
Base Grab	9/18/2009 8:15	9/18/2009 8:15	<2			0.118						
Base Grab	9/28/2009 14:25	9/28/2009 14:25	4	~2	0.2	0.099	0.069					
E. Coli Grab	9/30/2009 9:47	9/30/2009 9:47						1046				
Storm Grab	10/2/2009 9:49	10/2/2009 9:49	30			0.205						
Storm Composite	10/1/2009 17:47	10/5/2009 7:40	630	288	8.2	0.909	~0.035					
Storm Composite	10/6/2009 9:41	10/7/2009 14:46	524	146	1.7	0.606	0.082					
Storm Grab	10/7/2009 9:45	10/7/2009 9:45	<2			0.113						

Exceeds Water Quality Standard

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

Table 10: Brown's Creek Diversion Structure Drainage 2009 Secondary Water Quality Results

Sample Type	Start Date	Start Time	Copper (mg/L)	Nickel (mg/L)	Lead (mg/L)	Zinc (mg/L)	Cadmium (mg/L)	Chromium (mg/L)	Chloride (mg/L)	Hardness (mg/L)	Nitrite (mg/L)	Nitrate mg/L)	Ammonia Nitrogen (mg/L)
Snowmelt Grab	3/17/2009 10:30	3/17/2009 10:30	0.0177	0.0029	0.0012	0.008	<0.0005	<0.005	71	62	<0.03	0.21	0.35
Snowmelt Grab	3/17/2009 10:40	3/17/2009 10:40											
Storm Grab	3/24/2009 9:03	3/24/2009 9:03	0.0021	0.002	0.0008	0.0063	<0.0005	<0.006	65	88	<0.03	0.18	0.08
Base Grab	5/18/2009 13:30	5/18/2009 13:30	0.0007	0.0022	<0.0001	<0.005	<0.0005	<0.005	40	218	<0.03	0.59	<0.02
E. Coli Grab	5/28/2009 9:51	5/28/2009 9:51											
Base Grab	6/4/2009 13:00	6/4/2009 13:00											
Storm Grab	6/22/2009 8:50	6/22/2009 8:50											
E. Coli Grab	6/30/2009 8:50	6/30/2009 8:50											
Base Grab	7/13/2009 9:12	7/13/2009 9:12	0.0014	0.0029	0.0009	0.0085	<0.0005	<0.005	41	244	<0.03	1.2	0.09
Storm Composite	7/21/2009 9:44	7/21/2009 21:10	0.0095	0.009	0.0065	0.0291	<0.0005	0.0099	27	130	<0.03	0.61	~0.05
Base Grab	7/27/2009 8:41	7/27/2009 8:41											
E. Coli Grab	7/29/2009 10:00	7/29/2009 10:00											
Base Grab	8/5/2009 15:24	8/5/2009 15:24	0.0011	0.0024	0.0005	<0.005	<0.0005	<0.005	44		<0.03	1.28	0.07
Storm Composite	8/8/2009 11:06	8/10/2009 13:44	0.0101	0.0092	0.0052	0.0314	<0.0005	0.0069	75	112	0.03	0.17	0.16
Storm Grab	8/20/2009 8:44	8/20/2009 8:44											
Storm Composite	8/19/2009 15:23	8/20/2009 20:17	0.0195	0.0198	0.021	0.0848	<0.0005	<0.005	74	88	<0.03	0.05	~0.05
Storm Composite	8/25/2009 6:34	8/25/2009 9:34	0.012	0.0139	0.015	0.044	<0.0005	0.0153	56	80	<0.03	<0.05	~0.04
E. Coli Grab	8/27/2009 9:15	8/27/2009 9:15											
Base Grab	9/8/2009 10:17	9/8/2009 10:17	0.0015	0.0012	0.0001	<0.005	<0.0005	<0.005	97	86	<0.03	0.21	~0.04
Base Grab	9/18/2009 8:15	9/18/2009 8:15											
Base Grab	9/28/2009 14:25	9/28/2009 14:25	0.0007	0.0023	0.0001	<0.005	<0.0005	<0.005	38	240	<0.03	0.95	~0.05
E. Coli Grab	9/30/2009 9:47	9/30/2009 9:47											
Storm Grab	10/2/2009 9:49	10/2/2009 9:49											
Storm Composite	10/1/2009 17:47	10/5/2009 7:40	0.0102	0.0111	0.0078	0.0368	<0.0005	0.0127	67	106	<0.03	0.23	0.09
Storm Composite	10/6/2009 9:41	10/7/2009 14:46	0.0077	0.0077	0.0074	0.0283	<0.0005	0.0078	65	136	<0.03	0.19	~0.02
Storm Grab	10/7/2009 9:45	10/7/2009 9:45											

No Exceedance Determinable

Exceeds Chronic Standard

Exceeds Max Standard

Exceeds Final Acute Standard

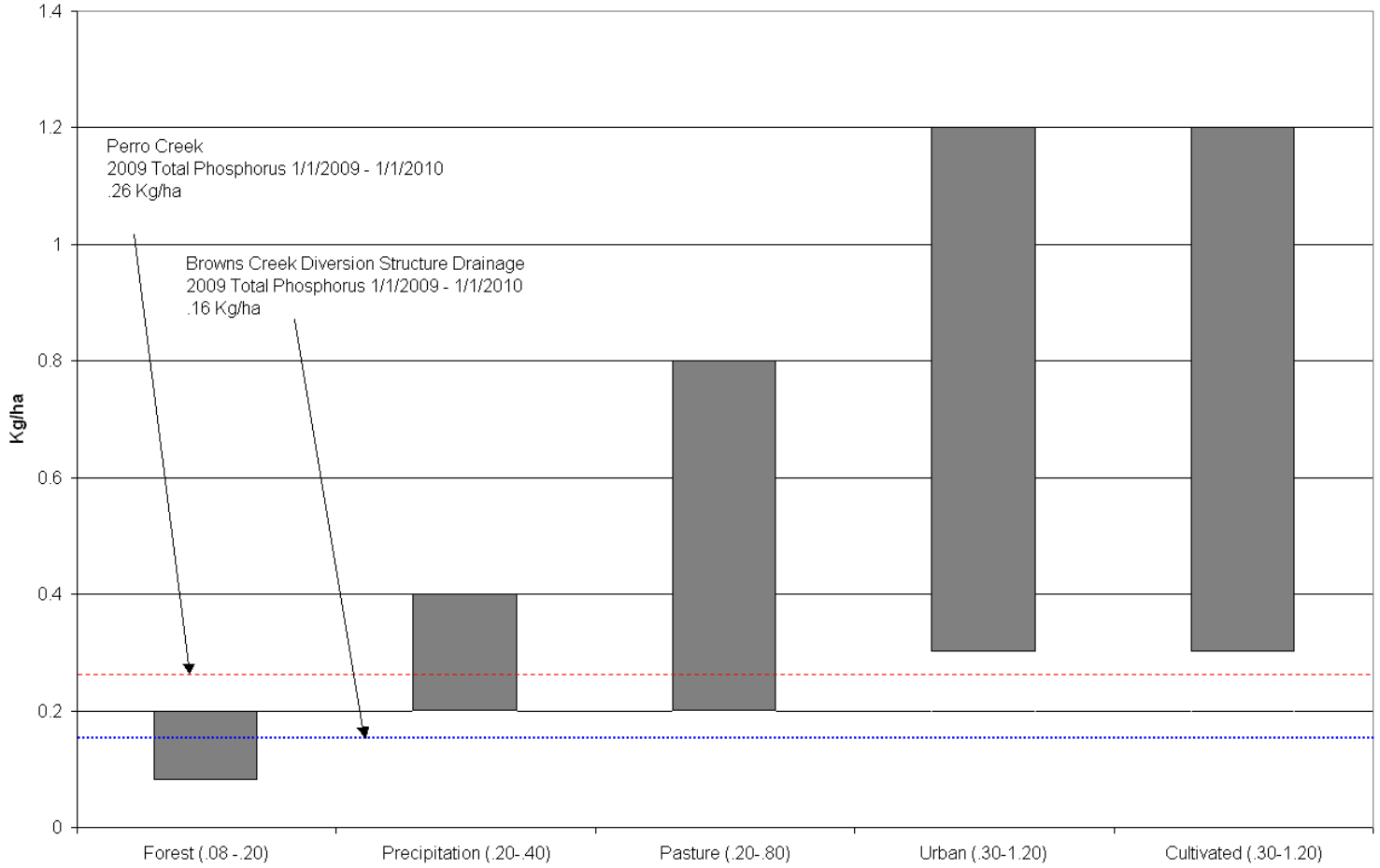


Figure 11: Total Phosphorus Export Coefficients: Perro Creek and Estimated Range by Land Use (literature estimates)

B. CONCLUSIONS AND RECOMMENDATIONS

Using 2009 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 2009 Perro Creek discharged a total load of 242 lbs. of phosphorus, up from 87 lbs. in 2008, and 51,874 lbs. of suspended solids, up from 29,343 lbs. in 2008, to the St. Croix River. When comparing the load per hectare per year to literature estimates of land use type, Perro Creek's phosphorus load of .26 kg/ha/yr (0.23 lb/ac/yr) falls within the range of export naturally found in precipitation, as well as in the pastureland use category. It can be observed from the 2009 loading data that there was a significant increase in TP loading value of almost triple, and a TSS loading value of more than double at the monitoring site from the previous year.

Changes in discharge and load in Perro Creek (Figure 9) are related to precipitation, 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 July 2009 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.

E.coli is a bacteria that can be characterized by it's ability to grow at elevated temperatures. E. coli data have shown numerous samples where values were above what the MPCA has set as a water quality standard. The standard states that E. coli values should "Not 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". MPCA water quality standards for class 2B waters can be found at https://www.revisor.leg.state.mn.us/rules/?id=7050.0222. Although three of the five samples that were taken are above the value listed, the standard has not technically been

exceeded because of a lack of samples, but should be of concern. These high values could be attributed to animal waste (most likely household pets), waterfowl excrement (possibly from Perro Pond), and possibly failing septic systems (if any still exist).

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. Results from this monitoring can be found in Table 11. This tributary drains the area south of McKusick Lake including the outlet of Lily Lake, some wetlands, and a residential area. In the future Meadowlark and Myrtle Street sites should continue to be monitored for any additional loading that is coming into McKusick Lake from that tributary. Table 12 shows the difference in results at the Meadowlark Dr. site (downstream location) compared to those collected at the Myrtle St. site. TSS and VSS show little difference between sites, both TKN and flow show increases and decreases, and TP is reduced for all samples. Few conclusions can be made from these results at the present time; future years of monitoring should provide a better insight to the system.

Table 11: Myrtle Street and Meadowlark Drive 2009 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.	3/18/09 14:15	Snowmelt Grab	7	5	3.1	0.326	0.33575	**0.59**	**12.68**
Myrtle St.	7/24/09 12:24	Storm Grab	16	~3	7.7	0.23	0.10675	**0.13**	**9.21**
Myrtle St.	8/20/09 8:18	Storm Grab	4	~2	0.92	0.264	0.76025	**1.08**	**16.40**
Myrtle St.	10/2/09 9:32	Storm Grab	~2	~1	0.47	~0.038	0.90425	**0.19**	**9.76**
Myrtle St.	10/7/09 9:00	Storm Grab	~1	<1	0.74	0.117	NA**	**NA**	**NA**
Meadowlark Dr.	3/18/09 14:30	Snowmelt Grab	8	5	2.6	0.145	0.60075	**0.47**	**25.93**
Meadowlark Dr.	8/20/09 7:58	Storm Grab	4	3	1.3	~0.036	0.742	**0.14**	**16.01**
Meadowlark Dr.	10/2/09 9:18	Storm Grab	<1	~1	0.61	~0.033	0.4485	**0.08**	**2.42**
Meadowlark Dr.	10/7/09 8:00	Storm Grab	~1	~1	0.64	~0.01	1.71	**0.09**	**9.22**

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

** Total flow was too low to measure

Table 12: Myrtle Street and Meadowlark Drive Sample Comparison

Date	TSS (mg/L)	VSS (mg/L)	TKN (mg/L)	TP (mg/L)	Flow (cfs)	TP lb/day	TSS lb/day
3/18/09	1	0	(0.50)	(0.181)	0.265	**(0.12)**	**13.25**
8/20/09	0	1	0.38	(0.228)	(0.018)	**(0.94)**	**(0.39)**
10/2/09	(1)	0	0.14	(0.005)	(0.456)	**(0.11)**	**(7.34)**
10/7/09	0	0	(0.10)	(0.107)			

The Brown's Creek Diversion Structure Drainage data is extremely valuable for determining current impacts and future impacts to McKusick Lake. Although the total discharge and load

appears to be below regional averages for total phosphorus and within the forestland use category, it still has a significant impact on McKusick Lake compared to pre-diversion conditions. 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.
- Evaluate current erosion issues along the banks of Perro Creek for future Capital Improvement Project budgeting.
- 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 Meadowlark and Myrtle St. 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.

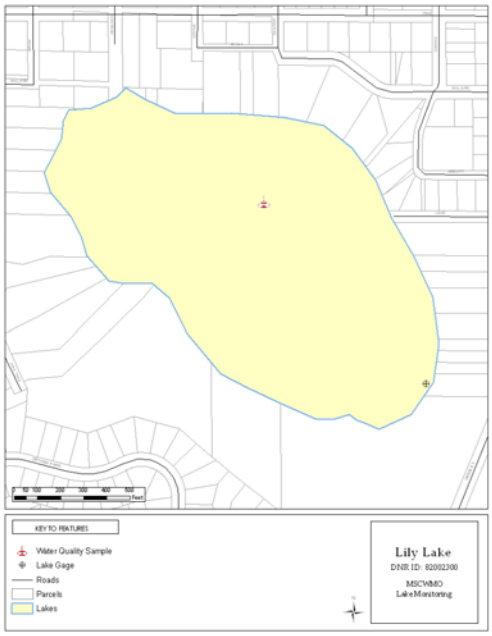
Appendix A

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

Lily Lake

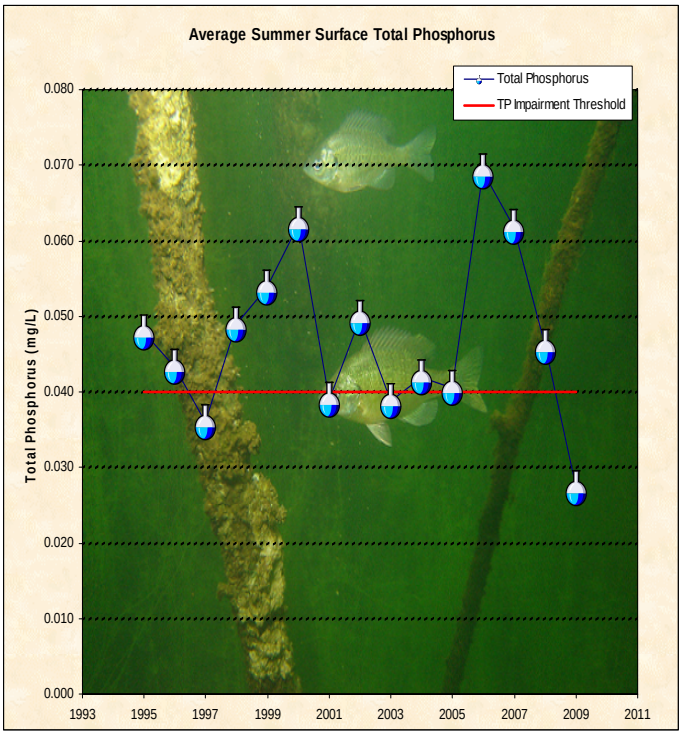
2009 Lake Grade: B+

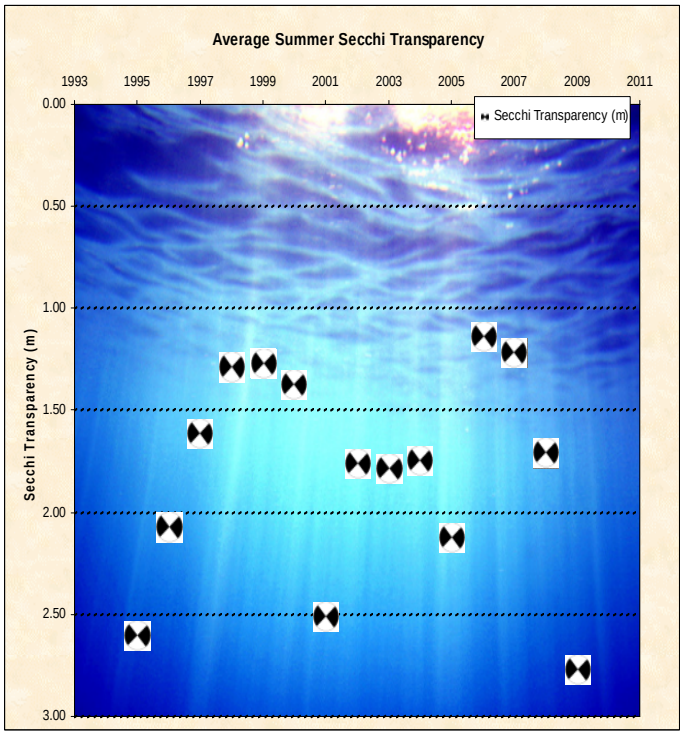
- DNR ID #: 820023
- Municipality: City of Stillwater
- Location: NE ¼ Section 32, T30N-R20W
- Lake Size: 35.90 Acres
- Maximum Depth: 51 ft
- Ordinary High Water Mark: 844.8 ft
- 55%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.
- Public access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



Summary Points

- Lily Lake was considered mesotrophic in 2009, 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 did stratify with the thermocline varying between 6 to 7 meters.
- Lily Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





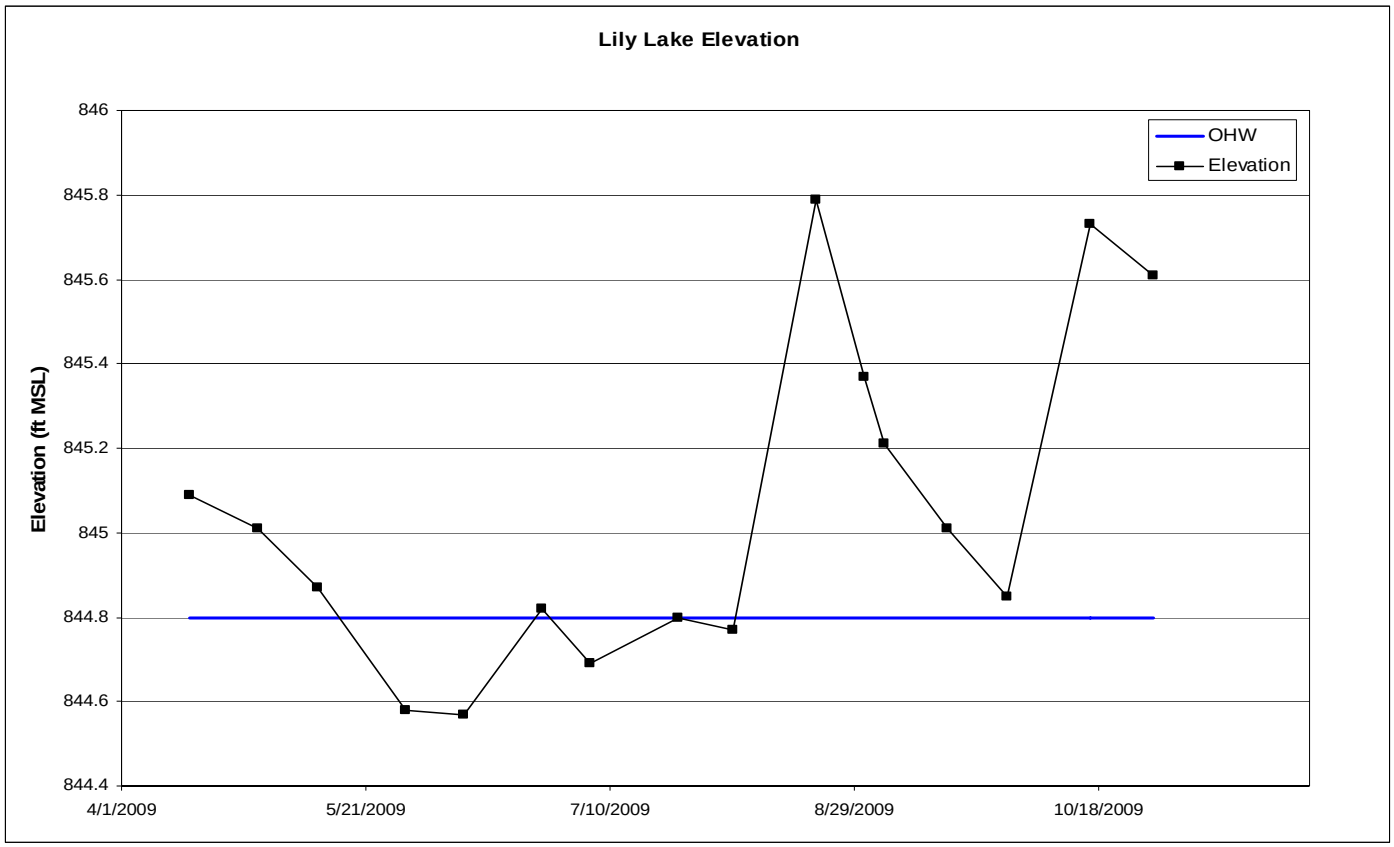
Date	Total Phosphorus (mg/l)	Chlorophyll-*a* (ug/l)	Total Kjeldahl Nitrogen (mg/L)	Iron (mg/L) (Hypolimnion)	Total Phosphorus (mg/L) (Hypolimnion)	Total Ortho-P (mg/L) (Hypolimnion)	Total Kjeldahl Nitrogen (mg/L) (Hypolimnion)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/l)	Surface Temperature Levels (Celsius)
4/13/2009	0.050	30	1.3	27.6	0.608	0.341	5.2	1.52	14.52	9.4
5/3/2009	0.027		0.6					2.10		13.8
5/11/009	0.041	6.7	1.2	12.8	0.428	0.098	3.3	2.59	9.14	15.0
5/31/2009	0.021	4	0.9					4.10		19.4
6/10/2009	0.028	4.3	0.6	10.9	0.346	0.384	2.8	3.66	8.59	17.1
7/1/2009	0.024	7.6	0.5					2.10		21.5
7/6/2009	0.032	5.1	1.2	9.49	0.409	0.026	2.9	3.20	8.62	23.4
8/4/2009	0.029	7.8	1.0	12	0.544	0.306	3.4	2.74	8.52	23.4
8/9/2009	0.023	14	1.1					1.60		25.8
8/30/2009	0.026	6.1	1.1					2.20		22.6
8/31/2009	0.033	9.4	1.1	12.6	0.735	0.262	3.5	3.20	5.55	21.3
9/29/2009	0.029	14	1.0	0.101	0.627	0.376	3.6	2.13	5.93	14.5
2009 Average	0.030	10	1.0	12.21	0.528	0.256	3.5	2.60	8.70	18.9
2009 Summer Average	0.027	8	0.9	9.02	0.532	0.271	3.2	2.77	7.44	21.0

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
2009 Elevation (ft)	845.79	8/21/2009	844.57	6/10/2009	845.05

*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."

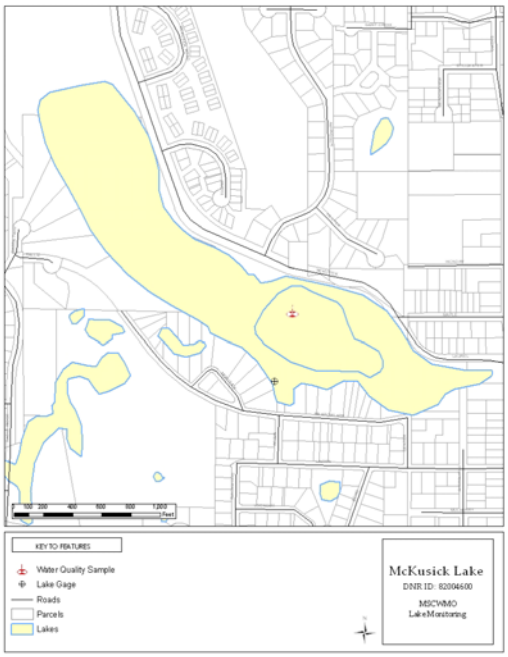


Lake Water Quality Summary											
	Trophic Status	Summertime Lake Grades									
	2009	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Mesotrophic	B	C	C	D	C	C	C	C	C	C
Chlorophyll-*a* (ug/l)	Mesotrophic	A	C	C	C	B	B	B	B	A	C
Secchi depth (ft)	Mesotrophic	B	C	C	D	C	C	C	C	B	C
Overall	Mesotrophic	B+	C	C	D+	C+	C+	C+	C+	B	C

McKusick Lake

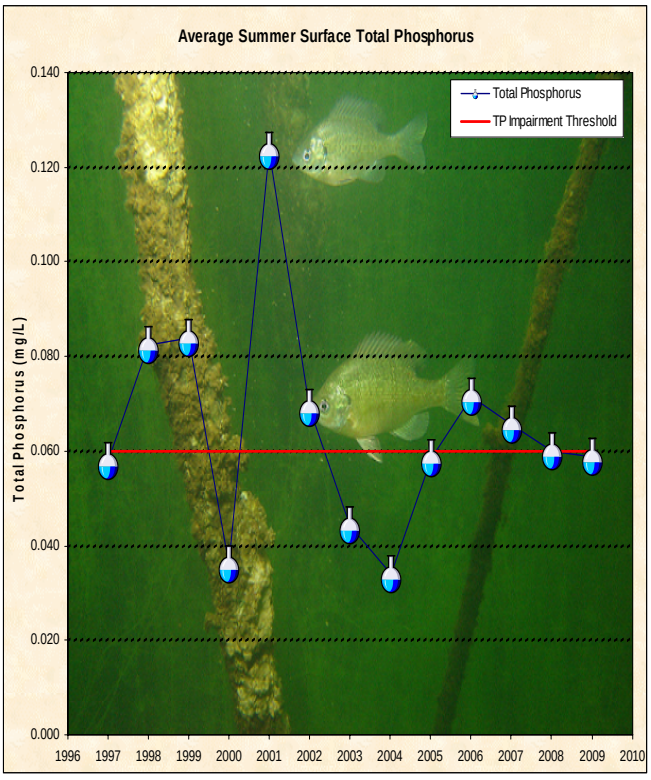
2009 Lake Grade: B

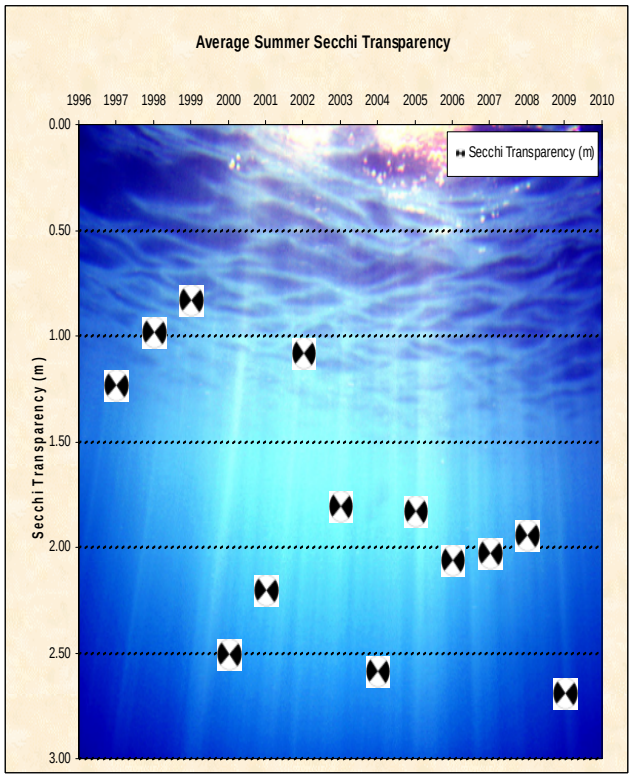
- DNR ID #: 820020
- Municipality: City of Stillwater
- Location: NE ¼ Section 29, T30N-R20W
- Lake Size: 46 Acres
- Maximum Depth: 12.5 ft
- Ordinary High Water Mark: 853 ft
- 100%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- McKusick Lake was considered mesotrophic in 2009, 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 not stratify in 2009.
- McKusick Lake is listed as impaired for nutrients on the Minnesota Pollution Control Agency's Impaired Waters List.





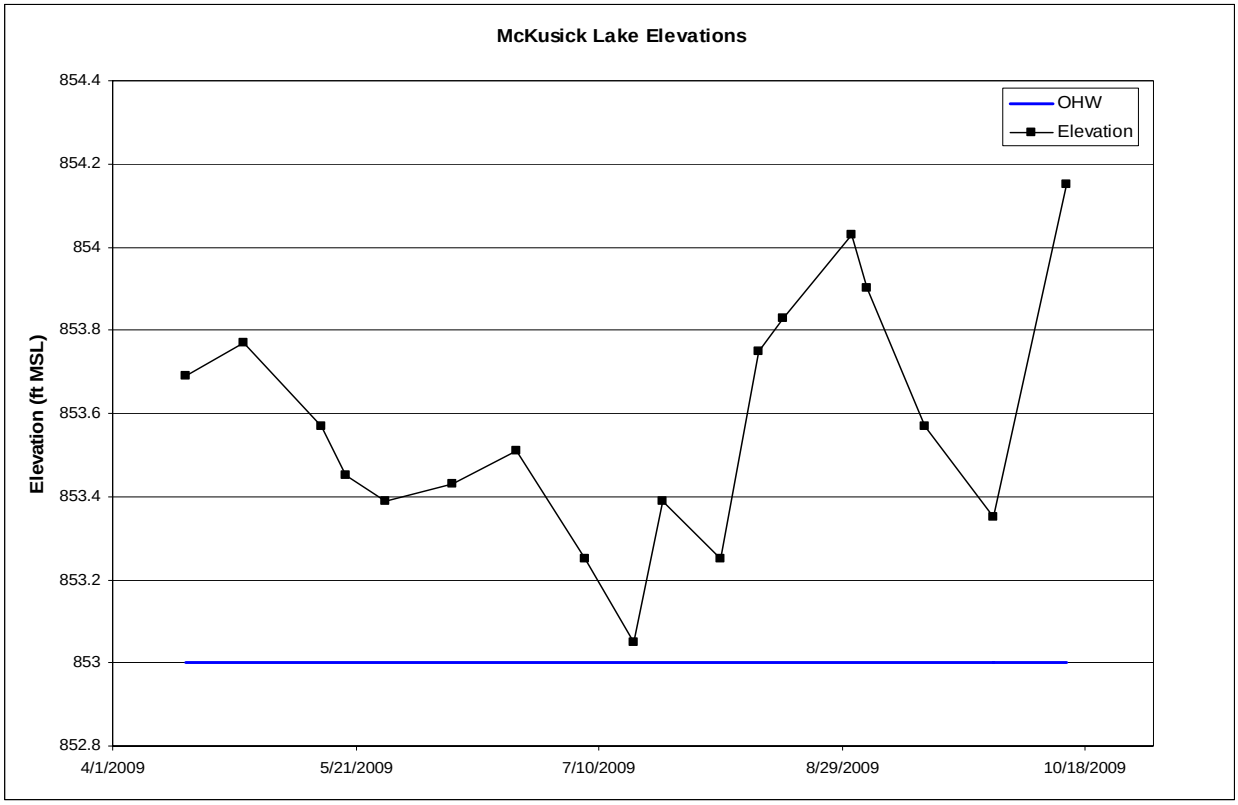
Date	Total Phosphorus (mg/l)	Chlorophyll-*a* (ug/l)	Total Kjeldahl Nitrogen (mg/L)	Secchi Disk Depths (m)	Surface Dissolved Oxygen Levels (mg/l)	Surface Temperature Levels (Celsius)
4/13/2009	0.057	16	1.2	2.29	10.39	11.9
4/28/2009	0.057	14	1.3	1.83	10.73	13.7
5/14/2009	0.059	13	1.2	1.68	8.46	14.6
5/27/2009	0.057	13	1.2	1.98	9.65	18.6
6/10/2009	0.055	15	1.5	2.13	8.95	17.0
6/23/2009	0.045	6.9	1.2	3.20	8.59	27.4
7/7/2009	0.038	7.3	1.1	3.05	11.92	25.2
7/23/2009	0.034	6.6	1.1	2.74	10.83	23.7
8/4/2009	0.091	5.1	1.7	3.05	9.97	24.3
8/17/2009	0.032	6	0.93	2.13	7.61	26.0
9/1/2009	0.110	8.4	0.95	2.44	9.26	20.6
9/15/2009	0.099	4.7	1.1	2.90	10.17	23.2
9/30/2009	0.027	9.5	0.94	3.35	9.66	14.4
10/14/2009	0.026	7.1	0.8	3.96	12.89	6.7
2009 Average	0.056	9	1.2	2.62	9.93	19.1
2009 Summer Average	0.059	8.3	1.2	2.70	9.66	22.0

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
2009 Elevation (ft)	854.15	10/14/2009	853.05	7/17/2009	853.57

*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."



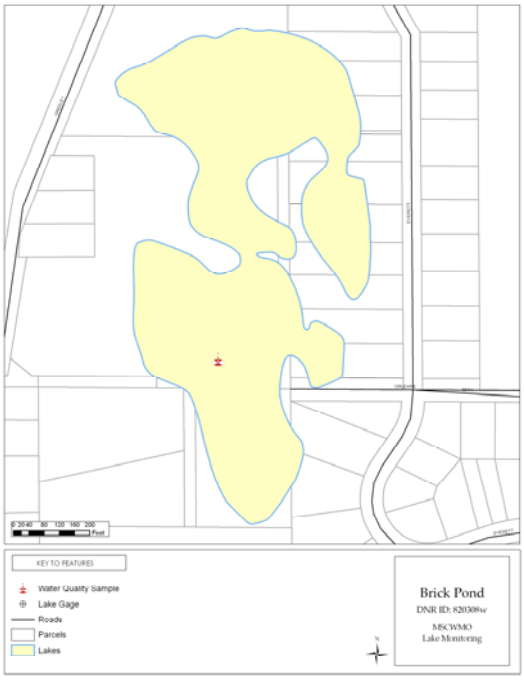
Lake Water Quality Summary

	Trophic Status	Summertime Lake Grades									
	2009	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Eutrophic	C	C	C	D	C	C	C	C	C	C
Chlorophyll-*a* (ug/l)	Mesotrophic	A	B	B	B	B	A	B	C	B	B
Secchi depth (ft)	Mesotrophic	B	C	C	C	C	B	C	D	B	B
Overall	Mesotrophic	B	C+	C+	C	C+	B	C+	C+	B-	B-

Brick Pond

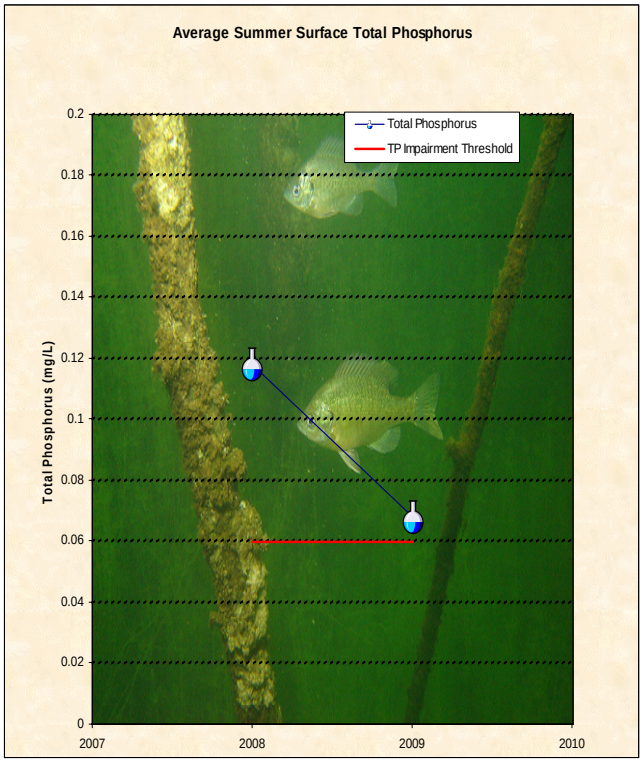
2009 Lake Grade: B-

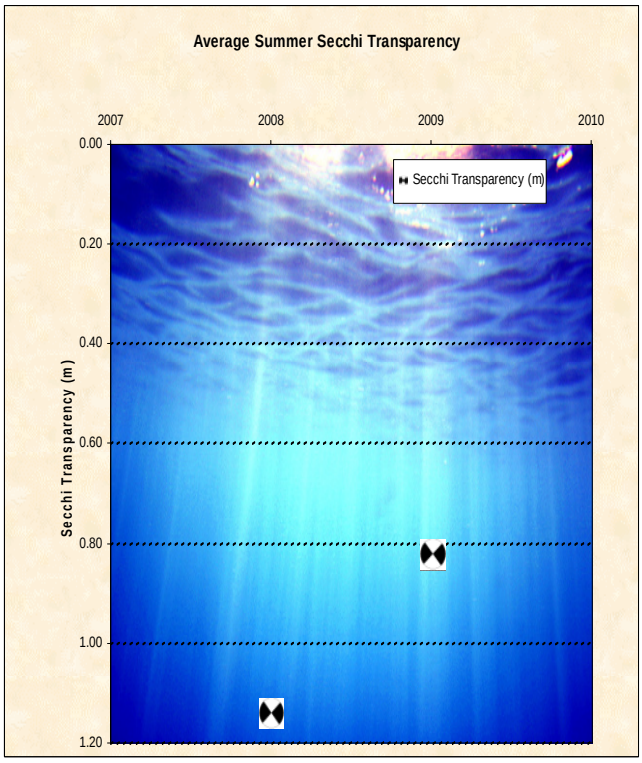
- DNR ID #: 820308
- Municipality: City of Stillwater
- Location: NW ¼ Section 33, T30N-R20W
- Lake Size: 12 Acres
- Maximum Depth: 5 ft
- Ordinary High Water Mark: N/A
- 100%Littoral
  Note: Littoral area is the portion of the lake <15 ft and dominated by aquatic vegetation.



Summary Points

- Brick Pond was considered eutrophic in 2009, 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 2009.





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)
4/13/2009	0.093	20	1.3	0.76	13.01	12.5
5/14/2009	0.079	9.3	1.2	0.61	9.72	15.0
6/10/2009	0.09	6.7	1	1.22	10.49	16.5
7/7/2009	0.092	6.7	1.1	1.07	13.25	26.5
8/5/2009	0.066	3.4	0.69	0.91	7.95	23.2
9/2/2009	0.055	5.4	0.55	0.46	11.01	20.1
9/30/2009	0.036	2.5	0.62	0.46	14.96	13.1
2009 Average	0.073	7.7	0.92	0.78	11.48	18.13
2009 Summer Average	0.068	4.9	0.79	0.82	11.53	19.88

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*

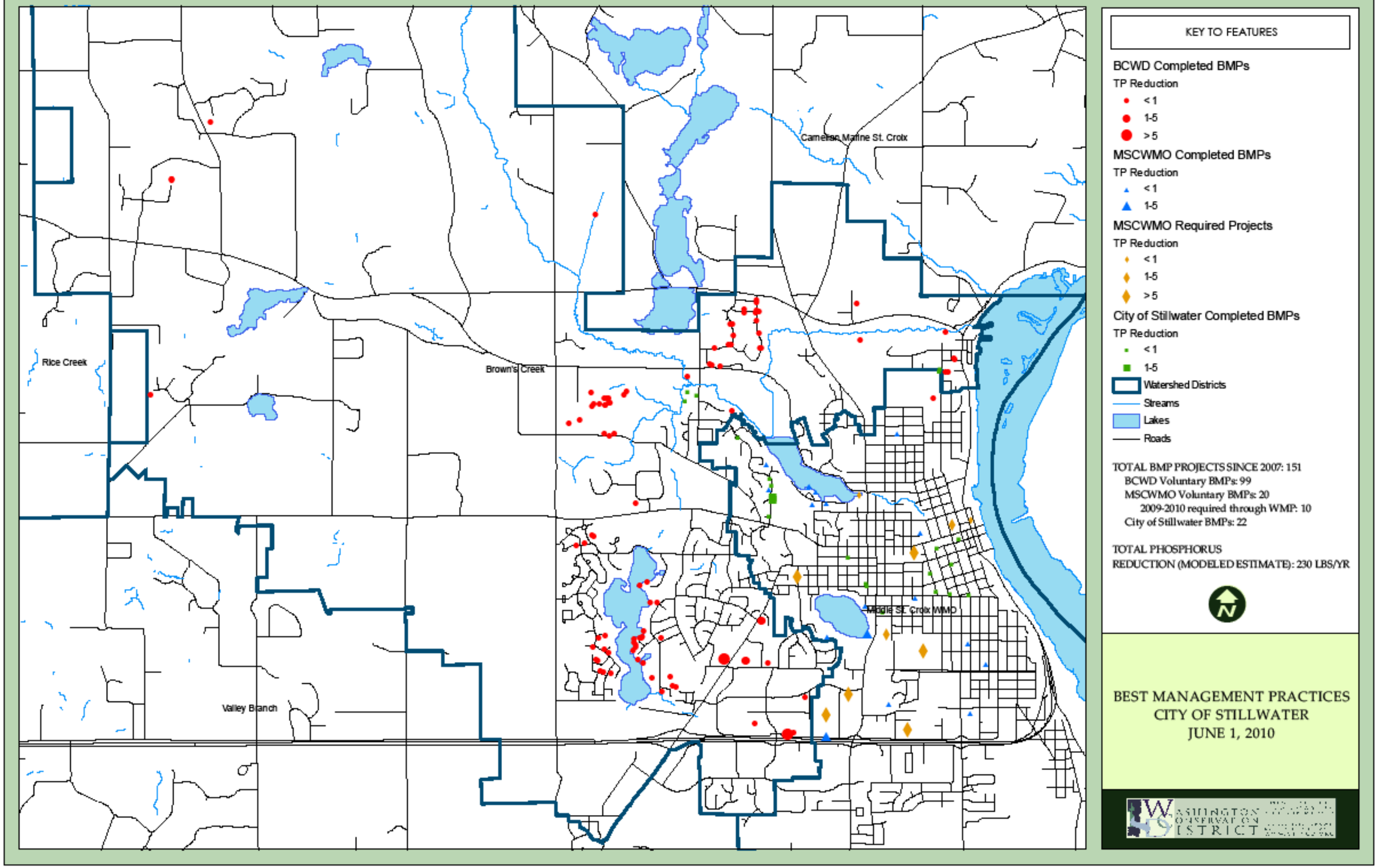
	High	High Date	Low	Low Date	Average
2009 Elevation (ft)	N/A	N/A	N/A	N/A	N/A

*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

Lake Water Quality Summary											
	Trophic Status	Summertime Lake Grades									
	2009	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Total Phosphorus (mg/l)	Hypereutrophic	C	D	NA	NA	NA	NA	NA	NA	NA	NA
Chlorophyll-*a* (ug/l)	Mesotrophic	A	A	NA	NA	NA	NA	NA	NA	NA	NA
Secchi depth (ft)	Eutrophic	C	C	NA	NA	NA	NA	NA	NA	NA	NA
Overall	Eutrophic	B-	C+	NA	NA	NA	NA	NA	NA	NA	NA

Appendix B

City Of Stillwater BMP Map


Rice Creek
Brown's Creek
Cameron Marine St. Croix
Valley Branch
Middle St. Croix WMD
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