2013 Water Quality Monitoring and TMDL Implementation Status Report

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Acronyms

BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
cfs	cubic feet per second
CFU/100 mL	colony forming units per 100 milliliters
Chlor-*a*	Chlorophyll-*a*
CRWD	Clearwater River Watershed District
District	Clearwater River Watershed District
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
lbs	Pounds
MDNR	Minnesota Department of Natural Resources
µg/L	micrograms per liter
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
NCHF	North Central Hardwood Forest
Ortho-P	Ortho-Phosphorus
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids

Executive Summary

This report was prepared by Wenck Associates, Inc. (Wenck) for the Clearwater River Watershed District (CRWD) to provide a description of the District's monitoring program, summarize and analyze 2013 monitoring data, and provide a progress report of TMDL Implementation activities in the District.

Significant findings in this report include the following:

1. Annual precipitation was below normal overall at monitored locations for the year in 2013 and ranged from 24.35 to 28.87 inches. Precipitation between February and June was above normal, July to September precipitation was far below normal.

2. Runoff over the District was below normal overall in 2013, 3.9 inches (compared to 7.9 inches in an average year). Runoff was highest during a period following a later than normal snowmelt in late April combined with above normal precipitation in April through June. Runoff was below normal during most of the period from July through September, when very little precipitation fell and many stream channels stopped flowing or dried up entirely.

3. Phosphorus loads from the Clearwater River were lower than those observed in recent years due to decreased runoff in 2013. The phosphorus load from the Clearwater River was estimated at 2,115 lbs at CR 10.5 (Grass Lake Dam). The upper watershed load measured at CR28.2 was 4,984 lbs. While this was a reduction from previous year's loads, it was still higher than the goals established for downstream Lake Betsy (2,280 lbs) and Clearwater Lake (4,000 lbs).

4. Flow-weighted average phosphorus concentrations were 24 µg/L and 252 µg/L at CR 10.5 and CR28.2, respectively. The concentration at CR10.5 was similar to concentrations seen in recent years, which demonstrates the good water quality in Clearwater Lake. The concentration observed at CR28.2 was lower than recent years and demonstrates a potential reduction in the export of phosphorus from the Kingston Wetland following the restoration of the original stream channel in 2013.

5. Phosphorus loading at Warner Creek station WR0.2 was 529 lbs in 2013, which was similar to recent phosphorus loads at the site, with the exception of 2011, when the load was far greater. Phosphorus concentrations were similar to 2012 and are far lower than elevated concentrations observed at the site from 2009 to 2011.

6. Ortho-phosphorus made up a large percentage of total phosphorus at monitoring stations downstream of some large wetland complexes in 2013, especially at County Ditch 20 near Watkins and the tributary stream north of Clear Lake. This indicates that

the export of soluble phosphorus from the wetlands contributes a significant portion of the phosphorus load at these locations during periods of normal or lower than normal runoff, as experienced in 2013. The District should continue to include components to reduce soluble phosphorus in implemented phosphorus reduction projects.

7. With the exception of the 11 lakes that are impaired in the District, the water quality of CRWD lakes is generally good and has generally improved or remained stable in the majority of the lakes in the District in recent years. While phosphorus concentrations remained above TMDL goals in several lakes in the District in 2013, phosphorus concentrations were generally improved from recent years in most lakes, most notably in Caroline, Louisa, Swartout, and Henshaw Lakes. Water clarity was extremely good in 2013 as the highest Secchi depths ever observed were measured in nine of the monitored lakes in 2013.

8. Lake monitoring efforts conducted in 2013 confirm the impact of internal loading of nutrients in some District lakes, as evidenced by monitoring data showing high bottom phosphorus concentrations that typically increase steadily throughout the summer, and periods of anoxia (dissolved oxygen concentrations < 2.0 mg/L) in some lakes. Monitoring data indicates that lakes especially susceptible to internal nutrient loading include Albion, Swartout, Henshaw, Augusta, Caroline, Louisa, Marie, Betsy, Scott, and Union. CRWD will continue to evaluate potential actions identified in the Watershed Restoration and Protection Plan (TMDL Implementation Plan) that address internal loading in future years.

9. Dissolved oxygen (DO) monitoring conducted in the District identified and confirmed sites with DO impairments. As observed in past years, most DO impairments were observed at sites downstream of large wetland complexes. This confirms conclusions drawn in previous years, that wetland sediment oxygen demand is the cause of low DO at these locations.

10. The completion of the Kingston Wetland Restoration project, which restores native hydrology to the system, resulted in increased DO concentrations downstream of the Kingston Wetland at a location that was impaired for DO during most of the year in previous monitoring years. DO in the impaired reach met state standards for most of the season.

11. Continued diagnostic and effectiveness monitoring as part of Cedar Lake Project #06-1 showed that the watershed phosphorus load in 2013 to Cedar Lake of approximately 773 lbs was below the project goal of 1,000 lbs. Summer average phosphorus and Chlorophyll-*a* concentrations in Cedar Lake were similar to previous years and are meeting minimum water quality standards established by the Minnesota Pollution Control Agency (MPCA). However, summer average phosphorus concentrations remain above the goal of 20 µg/L established through Project #06-01, indicating that additional

load reductions, additional actions, and time are necessary to meet lake water quality goals. Water clarity was similar to previous years in 2013 and was good overall except for periods following algal blooms in early summer.

12. The CRWD conducted rough fish removal in Segner Pond in 2013, removing close to what was removed in 2012, approximately 12,000 lbs, of carp in May and early June. Rough fish removal efforts will continue in the District in 2014.

13. The results of water quality monitoring and aquatic vegetation surveys conducted in Swartout, Albion, and Henshaw Lakes in 2013 continue to support the connection of lake water quality to the status of fish communities in these lakes. The reduction of rough fish populations through natural winterkill combined with the aggressive management leads to clear state shallow lakes in this system, as observed in Swartout Lake in recent years and Henshaw Lake in 2013. The response of the water clarity and aquatic vegetation coverage in Henshaw Lake to an expansive fish kill that occurred in early 2013 demonstrates how shallow lakes in the clear state foster rooted aquatic plant growth which, coupled with lower rough fish populations, stabilizes bottom sediments which can reduce internal loading and improve in lake water quality and reduce nutrient export to downstream lakes.

14. In 2013, the CRWD made progress towards water quality goals established in the Watershed Restoration and Protection Plan (WRPP/ TMDL Implementation Plan) by:
    - implementing additional monitoring tasks to fill data gaps identified in the TMDL. Collection of these data assist in achieving grants, final design of capital improvement projects and improved targeting of BMPs;
    - beginning work on two projects for which grant funding was received to protect and improve water quality in the Cedar Lake sub-watershed;
    - completing construction of the Kingston Wetland Restoration project;
    - continuing work on previously implemented projects, including:
        - completing design and permitting for the Phase II Kimball Stormwater Project
        - enrolling participants, conducting soil testing and GPS fertilizer application, and monitoring for the targeted fertilizer application reduction project in the upper watershed which is funded in part by a federal 319 grant,
        - conducting streambank restoration and stabilization project on the Clearwater River with the Minnesota Conservation Corps
    - Ongoing implementation of agricultural cost share BMPs
    - Rough fish management (removals and migration barriers)
    - AIS work with lake associations
    - continuing project development towards securing grant funding to implement projects identified in the WRPP:
        - Watkins impoundment, and
        - Lake Betsy hypolimnetic withdrawal

15. In 2014, the CRWD plans to continue progress towards TMDL goals by:
    - continuing monitoring water quality, hydrology and hydraulics to track water quality trends, project effectiveness and improve efficiencies of implementation projects,
    - conducting rough fish removal and migration management as necessary
    - continuing to implement the Soil Testing and GPS Fertilizer Application Project by enrolling landowners and continuing follow-up monitoring
    - continuing to monitor the Kingston Wetland Restoration Project,
    - constructing the Kimball Phase II project,
    - completing design and construction of the two components of the Cedar Lake Improvement Project,
    - identifying additional projects and continuing to apply for grant dollars to fund other CRWD projects, and
    - continuing education and outreach efforts, focusing on social media and schools

1.0 Introduction

The Clearwater River Watershed District (CRWD) has conducted a stream, precipitation, and lake monitoring program since 1980 (Appendix A). Ongoing monitoring is critical to establish baseline water quality and hydrologic data and to assess long-term water quality trends within the CRWD.

1.1 PURPOSE

The objectives of the monitoring program are:

1. Track progress towards water quality goals for impaired waters,
2. Fill data gaps identified in the TMDLs, and evaluate water quality through annual monitoring program,
3. Continue to provide baseline water quality data and calibration data sets to refine TMDL load reductions, and
4. Track long-term trends in all CRWD waters monitored ensuring early detection of declining trends.

Data collected through the monitoring program has documented dramatic improvements in lake water quality since the early 1980s, as well as significant reductions in stream nutrient and sediment loads (Appendix B and C). These improvements were largely the result of the CRWD's 1980 Chain of Lakes Restoration Project and other District initiatives. However, some water bodies do not meet state water quality standards for designated uses (aquatic habitat or recreation for example).

1.2 TMDL'S

The CRWD, in partnership with the Minnesota Pollution Control Agency (MPCA), began a Total Maximum Daily Load (TMDL) study in 2003 to address the District's impaired waters. The TMDL process establishes the amount of a given pollutant that the water body can assimilate while still meeting its designated uses. The TMDL studies were finalized in 2008 and the required nutrient, bacteria and oxygen demand load reductions have been quantified.

The status of TMDLs in the District is shown in Table 1.1. Many are complete and were approved by the MPCA, EPA and the public via a public comment period.

Through the TMDL process, the CRWD identified a suite of implementation strategies in the watershed needed to meet water quality goals for impaired waters and to protect water quality of all CRWD waters. These are documented in the Watershed Restoration and Protection Plan for the CRWD (TMDL Implementation Plan) which was approved by the MPCA in May of 2009.

Following the completion of the TMDLs, the CRWD undertook a revision of its Watershed Management Plan to reflect the recommendations in the TMDL and expand on them. The revised Watershed Management Plan was completed and approved by BWSR in 2011. TMDL reports can be found at the MPCA website at http://www.pca.state.mn.us/water/tmdl. The Watershed Management Plan is available at the CWRD web site www.crwd.org.

Another TMDL effort is underway for the larger 8-digit hydrologic unit code (HUC) 07010203, which includes CRWD as well as the Sauk and Elk River watersheds (Figure 1.1). This process began in 2009 under the MPCA's new approach to TMDLs called the watershed approach. The watershed approach is a 10-year rotation for assessing waters of the state on the level of Minnesota's major watersheds (8-digit HUCs). This process is scheduled to be completed in 2013, is being led by the Elk River Watershed Association (ERWSA) and Sherburne County Soil and Water Conservation District. Data collected through this project has resulted in the identification of new impairments and TMDLs needed within the CRWD based on indices of biotic integrity. These impairments are also listed in Table 1.1. Future funding for TMDL related efforts will also largely be controlled by this process; as such it is important for CRWD to remain strongly involved in this process.

Table 1.1 Impaired Waters in CRWD

Water	Impairment and Impaired Use	TMDL Status	Listing Date
Clear Lake (47-0095)	Nutrients, aquatic life and recreation	EPA Approved.	2008
Lake Betsy (47-0042)			2008
Union Lake (86-0298)			2008
Scott Lake (86-0297)			2008
Lake Louisa (86-0282)			2004
Lake Marie (73-0014)			2008
The Clearwater River, Clear Lake to Lake Betsy	Dissolved oxygen and bacteria, aquatic life & recreation		2004
Lake Caroline (86-0281)	Nutrients, aquatic life and recreation	EPA Approved.	2010
Lake Augusta (86-0284)			2010
Swartout Lake (86-0208)			2010
Lake Albion (86-0212)			2010
Henshaw Lake (86-0213)			2010

Water	Impairment and Impaired Use	TMDL Status	Listing Date
The Clearwater River, Grass Lake to the Mississippi	Dissolved oxygen, aquatic life and recreation	This listing was under consideration at MPCA as data collected during the 2007 TMDL study did not support the presence of an impairment, however, data collected in 2011 have indicated an impairment may exist under some high flow conditions. Currently this listing is slated to be addressed during the Mississippi St. Cloud Watershed TMDL.	2008
Clearwater River (Scott Lake to Lake Louisa)	Aquatic Life (Aquatic macroinvertebrates, fish)	Listed in 2012.	--
Clearwater River (Clearwater Lake to Mississippi River)	Aquatic Life (Fish)	Listed in 2012.	--
Fairhaven Creek (Headwaters to Lake Louisa)	*E. coli* bacteria	Listed in 2012.	--

Figure 1.1 Geographic Coverage of 8-Digit HUC Watershed TMDL Currently Underway

1.3 CURRENT PROJECTS

To meet lake water quality goals, nutrient loads must be managed from both watershed sources and internal nutrient cycling sources. Several of the watershed management strategies identified for lakes will also assist with meeting bacteria and dissolved oxygen goals for the Clearwater River. Projects and programs to achieve water quality goals were identified in the CRWD's Watershed Restoration and Protection Plan and are expanded upon in the CRWD's Watershed Management Plan which has been formally approved by BWSR.

The CRWD has also applied for grants since 2009 to fund several of the projects/ programs identified through the TMDL process and subsequent studies. Projects and their status are described in detail in Section 5 of this report. In 2013, the CRWD conducted work on the following grant funded projects:

- Streambank restoration of the Clearwater River in the upper watershed,
- Phase II of a municipal stormwater project to retrofit the city of Kimball, MN and provide stormwater treatment for its surrounding watersheds protecting a trout stream (Willow Creek) and reducing nutrient loads to several impaired lakes.
- Completed construction of a stream channel/ wetland restoration of the Kingston Wetland and conducted year 1 monitoring which showed a dramatic improvement in dissolved oxygen concentrations in the reach.
- Cedar Lake Watershed Protection and Improvement Project funded by a 2012 CWL grant. The project abstract follows: In 2002 citizens began to notice severe algal blooms in Cedar Lake, a high value recreational lake with exceptional clarity and fisheries habitat. Those observations, coupled with a sharp rise in average summer phosphorus and Chlorophyll-*a* raised a red flag over the future of the lake. Clearwater River Watershed District began an intensive monitoring program in 2003 to identify nutrient sources and protect Cedar Lake. Through intensive lake and watershed monitoring, CRWD identified the major source of nutrients to the lake: three nutrient impaired shallow lakes (Swartout, Albion and Henshaw Lakes) in the upper watershed and impaired wetlands discharged excess amounts of soluble phosphorus. CRWD also identified a suite of in-lake and watershed BMPs to improve water quality in the impaired shallow lakes to protect Cedar Lake. Implementation of these projects began in 2007. A TMDL for the three upstream lakes was approved by EPA in 2009 and MPCA approved a Watershed Wide Implementation plan also in 2009. Since 2007, CRWD has implemented as many capital and programmatic BMPs as possible with current funding and landowner participation, but additional load reductions are needed to meet water quality goals in all the lakes. The project targets reductions to the largest watershed sources of nutrient to Cedar and Swartout Lakes by installing iron sand filters to remove soluble phosphorus currently exported from degraded wetlands and lakes. The target is to size sand filters to treat baseflow and the 1.25-inch event to provide the maximum cost/ benefit while preserving upstream hydrology. The projects target reductions from the largest watershed sources of nutrients to each lake providing 80% of the necessary watershed load reductions to Swartout Lake (800 lbs/yr), and 40% of the necessary watershed load reductions to Cedar Lake (480 lbs/ yr). Conceptual plans and project designs were completed in 2013.

1.4 CURRENT MONITORING

The 2013 CRWD monitoring plan is found in Appendix A, and summarized below. Figure 1.2 shows locations that were monitored in 2013. Figure 1.3 shows locations of impaired water bodies in the CRWD.

- Fourteen lakes were monitored in 2013 to track long-term trends. The lakes monitored by CRWD in 2013 included Clearwater Lake East, Bass Lake, Lake Augusta, Lake Louisa, Lake Caroline, Scott Lake, Marie Lake, School Section Lake, Lake Betsy, Nixon Lake, Clear Lake, Union Lake, and Grass Lake. Pleasant Lake was monitored by the Pleasant Lake Association in 2013. Long-term Clearwater River monitoring stations CR-28.2, located upstream of Lake Betsy, and CR 10.5, located at the Grass Lake Dam, were sampled in 2013. The long-term monitoring station on Warner Creek near its inflow to Clearwater Lake at WR 0.2 was also sampled in 2013.

- Citizen Precipitation Recorders (CPRs) maintained precipitation records in Watkins, Kimball, and Annandale. Additional monitoring was conducted on Willow Creek and on tributary streams to Clear Lake in 2013. Water quality and flow were monitored at two additional stations on Willow Creek (WC 2.5 and WC 3.0) in Kimball, two tributary streams to Clear Lake.
- Tile inlets and tributary streams receiving agricultural drainage were monitored as part of the Fertilizer Application grant project.
- Continuous Clearwater River water levels were monitored upstream and downstream of the Kingston Wetland and at the Grass Lake Dam in 2013.
- Monitoring continued in the Cedar Lake sub-watershed in 2013 to track progress on the Cedar Chain of Lakes Improvement Project #06-1. Samples were collected from Albion Lake, Cedar Lake, Henshaw Lake, and Swartout Lake as well as from four tributary streams in the sub-watershed and the outlet of Cedar Lake. Vegetation surveys were also conducted on Swartout, Albion, and Henshaw Lakes.

Figure 1.2 2013 Monitoring Locations

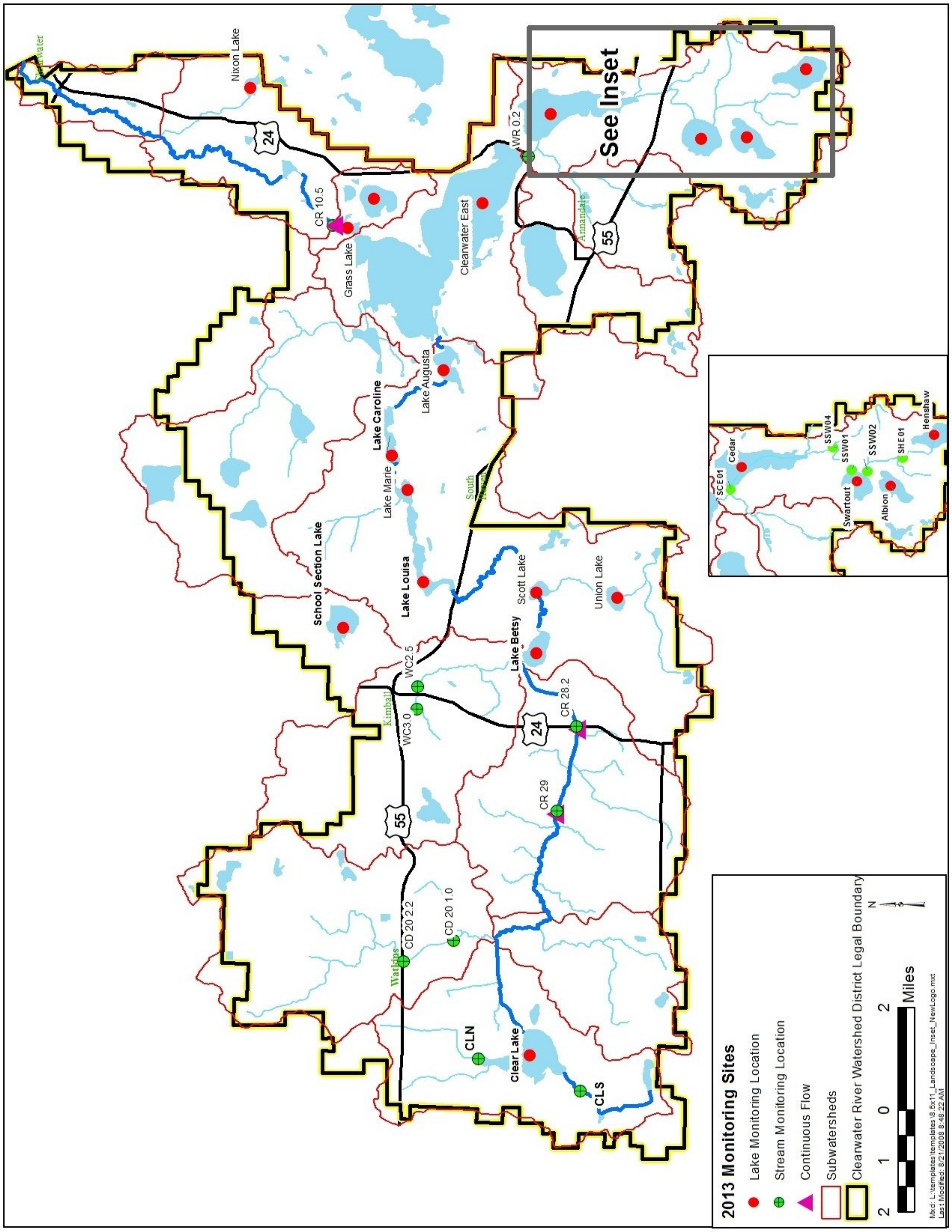
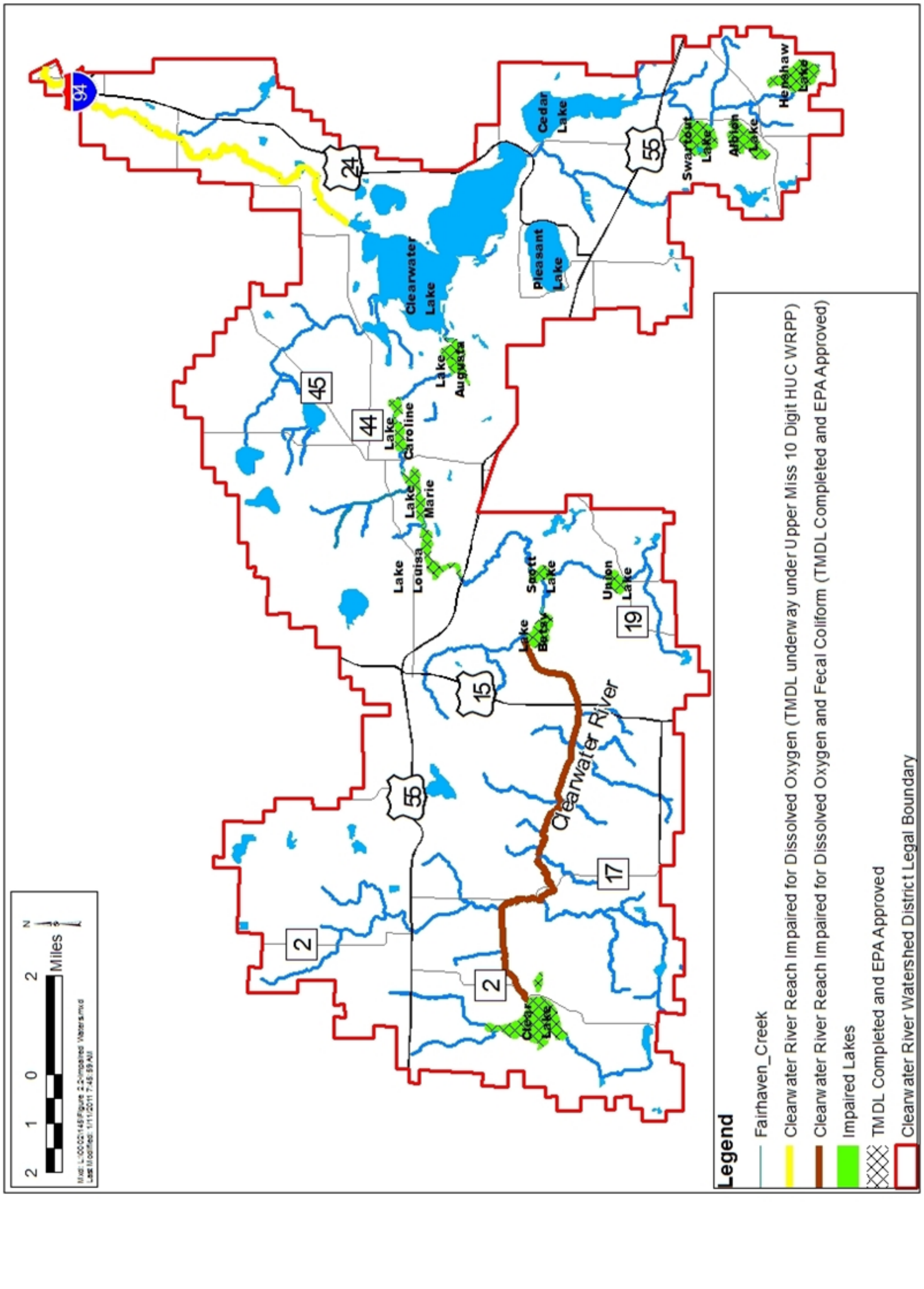


Figure 1.3 Impaired Water Bodies in CRWD



2.0 Hydrology

2.1 PRECIPITATION

Total annual precipitation measured in 2013 was below normal for the year at three of the four monitoring locations across the District. Precipitation was above normal in the early part of the year during most of the period from February to June at all stations. Precipitation received in February through April was primarily received in the form of snowfall. Precipitation was well below normal at all stations during the period from July to September, until above average precipitation amounts fell in October. Table 2.1 summarizes 2013 precipitation levels and Appendix D contains summary charts for each station.

Table 2.1 Clearwater River Watershed District 2013 Precipitation Records and Normals (inches)

	2013 St. Cloud (Saint Cloud WSO Airport)	1981-2010 Normal (St. Cloud)	2013 Watkins1 (Meeker)	2013 Kimball (Meeker)	1981-2010 Normal (Litchfield)	2013 Annandale/ Corinna (Wright)	1981-2010 Normal (Cokato)
January	0.45	0.65	0.41	0.09	0.70	0.37	0.77
February	1.33	0.59	1.25	1.93	0.64	1.68	0.70
March	2.63	1.55	2.31	1.57	1.46	1.81	1.63
April	2.90	2.57	2.95	2.29	2.60	2.95	2.97
May	4.98	2.95	4.22	3.50	3.22	4.66	3.39
June	5.76	4.17	3.75	5.01	4.99	5.73	4.57
July	1.43	3.31	1.98	1.73	3.83	2.38	3.70
August	0.85	3.79	1.79	0.35	3.86	1.21	4.23
September	1.87	3.46	2.27	2.31	3.39	2.35	3.25
October	4.34	2.49	5.18	3.59	2.42	3.89	2.50
November	0.53	1.38	0.75	0.52	1.32	0.56	1.61
December	1.68	0.82	1.44	1.46	0.87	1.28	0.94
Total	**28.75**	**27.73**	**28.30**	**24.35**	**29.30**	**28.87**	**30.26**

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Below Normal Precipitation

Above Normal Precipitation

2.2 RUNOFF AND DISCHARGE

The melt of the snowpack from above average snowfall that occurred in the winter of 2012-2013 and above average precipitation through June led to the heaviest runoff occurring in spring and early summer in 2013. In general, streams began flowing later than normal due to a late spring and frozen conditions persisting into mid to late April across the District. Below normal precipitation through the summer months caused most streams to stop flowing or dry up completely by late August or early September. Runoff over the upper watershed was 2.9 inches upstream of Lake Betsy at CR 28.2 and 3.9 inches at the outlet of Clearwater Lake

(CR10.5), which was lower than the long-term average runoff at CR 10.5 of 7.9 inches and similar to other years with similar precipitation.

Average flows in the Clearwater River were below the long-term average at CR 28.2 and CR10.5; at 19.38 cfs and 76.50 cfs, respectively. Table 2.2 summarizes the runoff volumes and average flows for the monitoring stations. Table B-1 in Appendix B compares the long-term precipitation to runoff for the CRWD as recorded at CR 10.5. Figure B-1 in Appendix B compares historic annual runoff and precipitation in the CRWD. Total runoff over the District is shown in Table B-2 in Appendix B.

Table 2.2 2013 Runoff Volume and Average Flow

Station	Tributary Sub-watershed Area (acres)	Runoff Volume (ac-ft)	Runoff Over Watershed (inches)	Average Flow (cfs)
CR 10.5	99,200	32,319	3.9	76.50
CR 28.2	33,977	8,151	2.9	19.38
WR0.2	16,992	3,720	2.6	17.37

Continuous Flow Monitoring Sites

In 2013, stream levels were monitored continuously at three sites on the Clearwater River to develop a continuous flow record at the sites, which allows for better quantification of seasonal runoff and annual phosphorus loads. Pressure transducers recorded the stream surface elevation at 15 minute intervals upstream of the Kingston Wetland at CR29.0 and downstream of the Kingston Wetland at CR28.2 while the Clearwater River was flowing from April to October. A pressure transducer was also installed at the Grass Lake Dam from April to October in 2013 (site locations shown on Figure 1.2).

Continuous water elevations at the stations near the Kingston Wetland are shown in Figure 2.1. 2013 continuous flows at CR28.2 and CR 10.5 are shown in Figure 2.2 and Figure 2.3, respectively. The figures demonstrate that flows at all three sites peaked in early July and declined for the rest of the summer, before recovering slightly following a precipitation event in October.

Figure 2.1 2013 Clearwater River Continuous Water Level Elevations (Kingston Wetland)

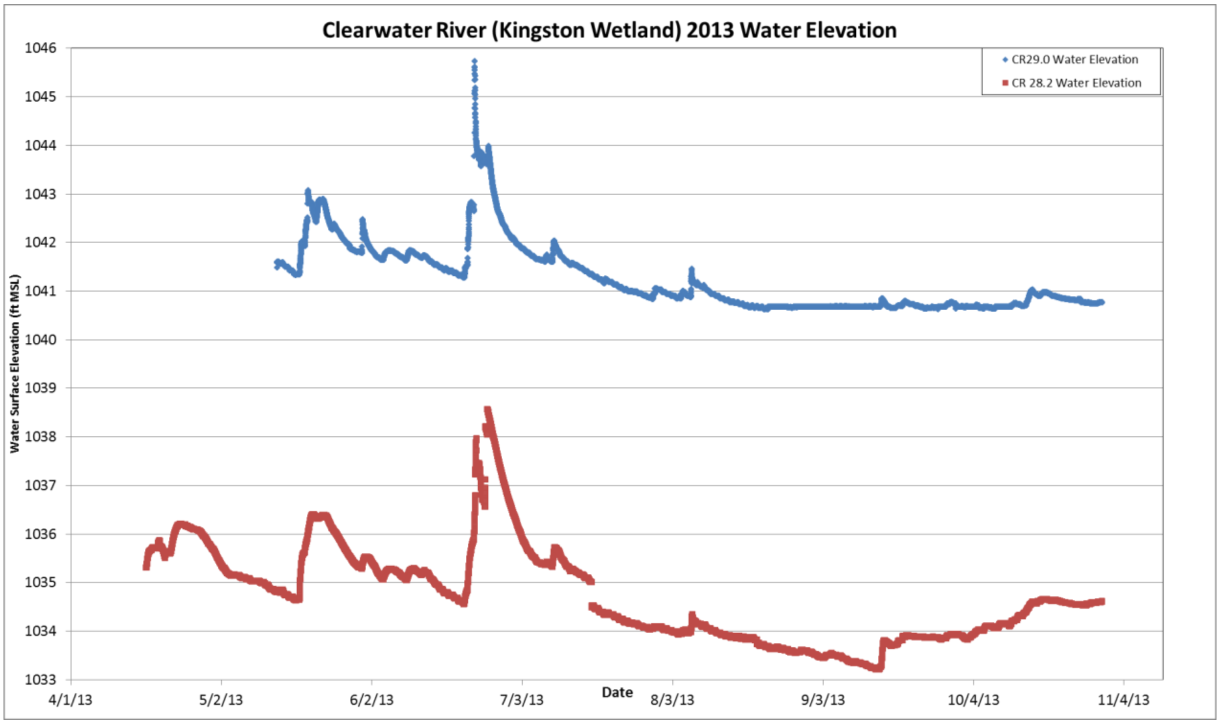


Figure 2.2 2013 Clearwater River Continuous Flow at Kingston Wetland

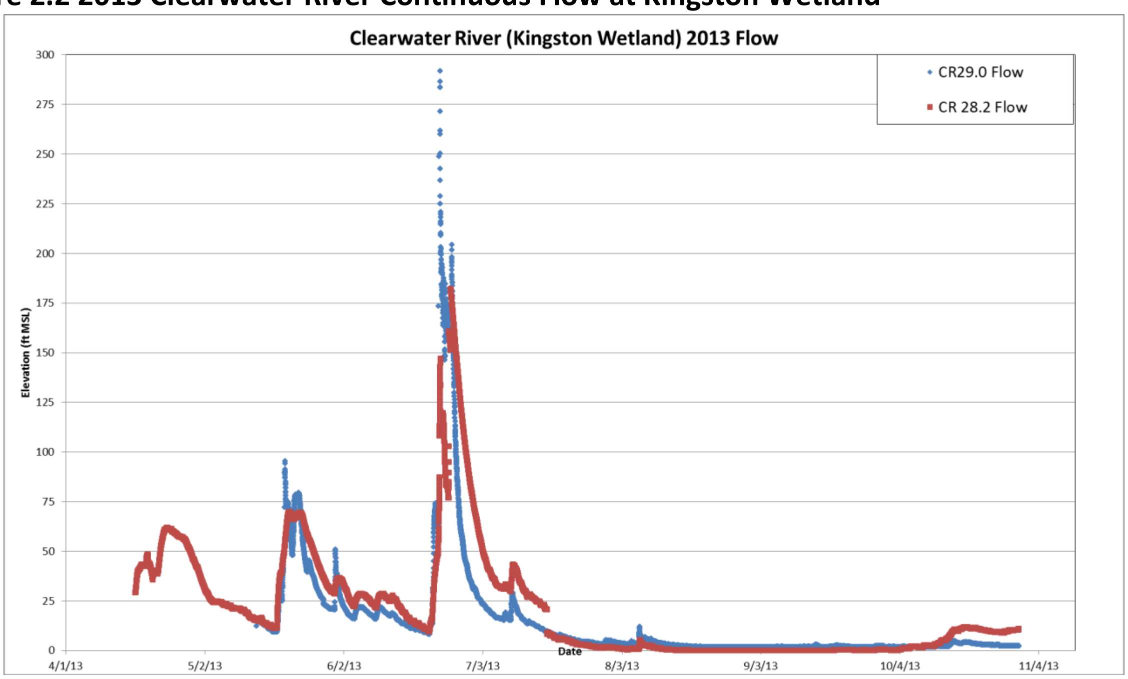
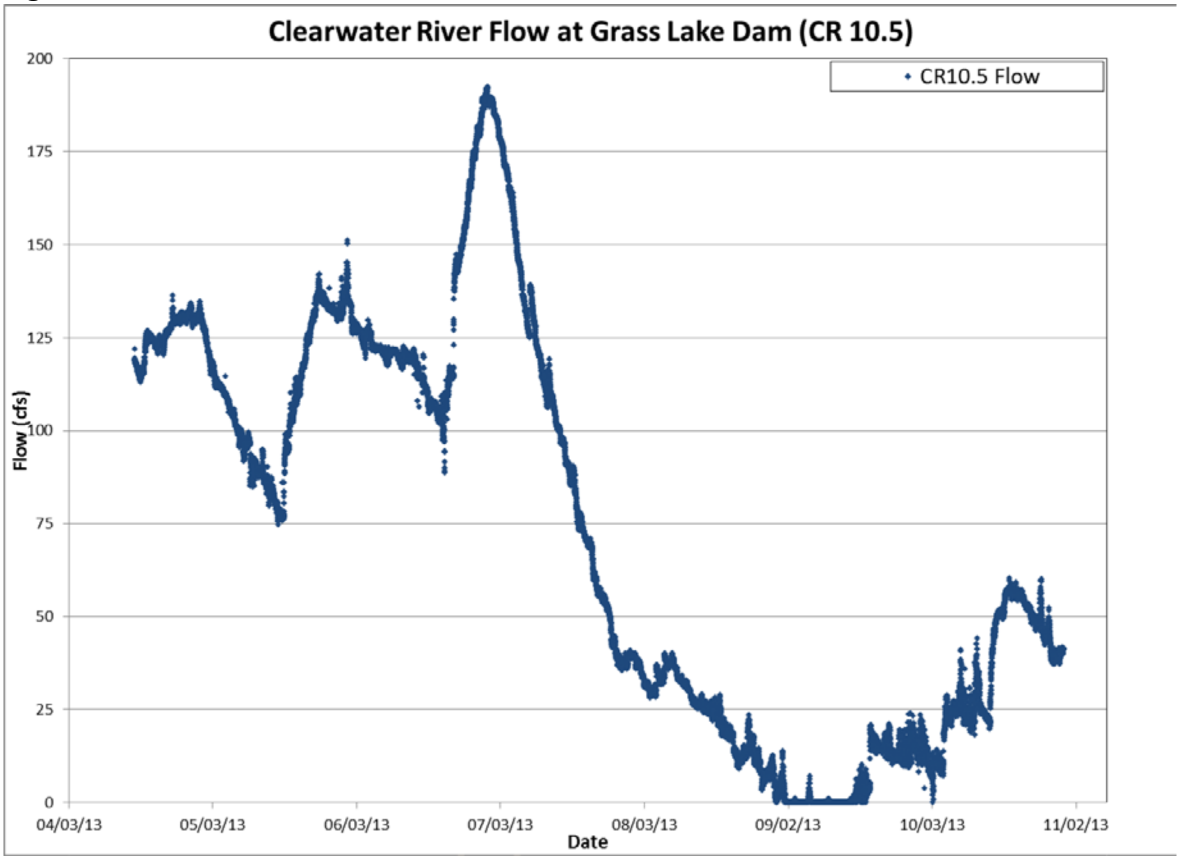


Figure 2.3 2013 Clearwater River Continuous Flow at CR10.5



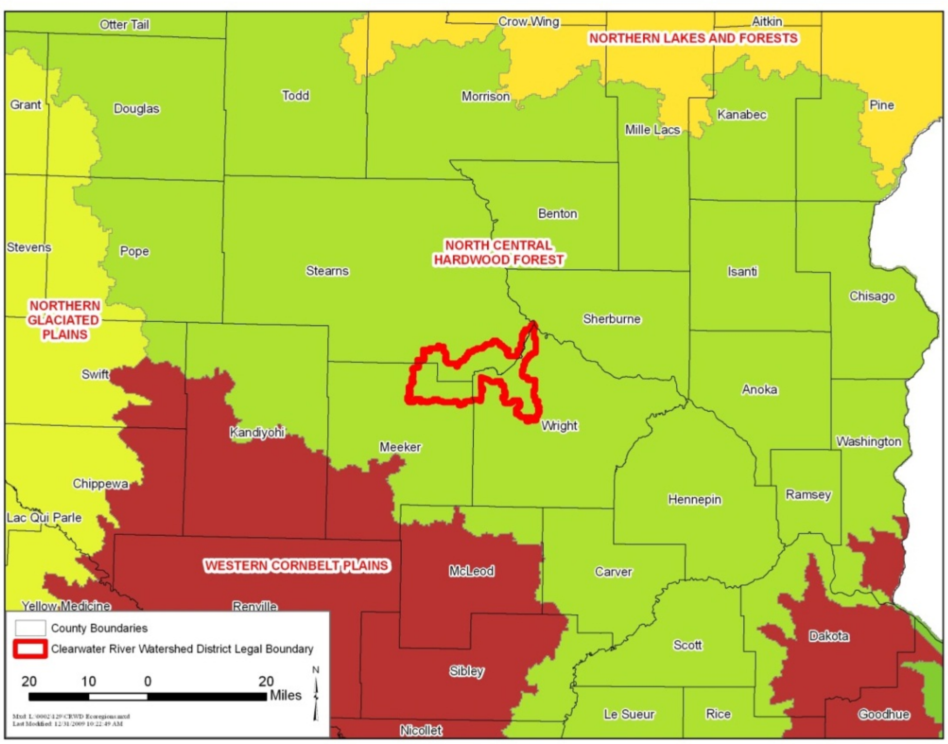
3.0 Water Quality

3.1 STREAM WATER QUALITY

Stream water quality was monitored at two long-term stations on the Clearwater River and one long-term station on Warner Creek in 2013. Stream water quality was also monitored at additional stations on Willow Creek upstream and downstream of Clear Lake, and on County Ditch 20 near Watkins. Water quality samples were collected monthly or bi-monthly while the streams were flowing from April to October. The water quality samples were analyzed for total phosphorus, ortho-phosphorus, and total suspended solids concentrations. Field data collected during monitoring visits included water temperature, dissolved oxygen, water level, and flow.

Annual mean concentrations were calculated for comparison to typical concentration ranges and state water quality impairment standards, which are organized by ecoregion across the state. CRWD liesentirely in the North Central Hardwoods Forest NCHF Ecoregion but is close to the border with the Western Corn Belt Plains (WCBP) Ecoregion as demonstrated in Figure 3.1. The watershed's tributary to station CR28.2 have characteristics similar to the nearby WCBP ecoregion. For this reason, typical concentrations from both ecoregions are provided for comparison to mean concentrations at CRWD stream monitoring stations.

Figure 3.1 Clearwater River Watershed District Ecoregions



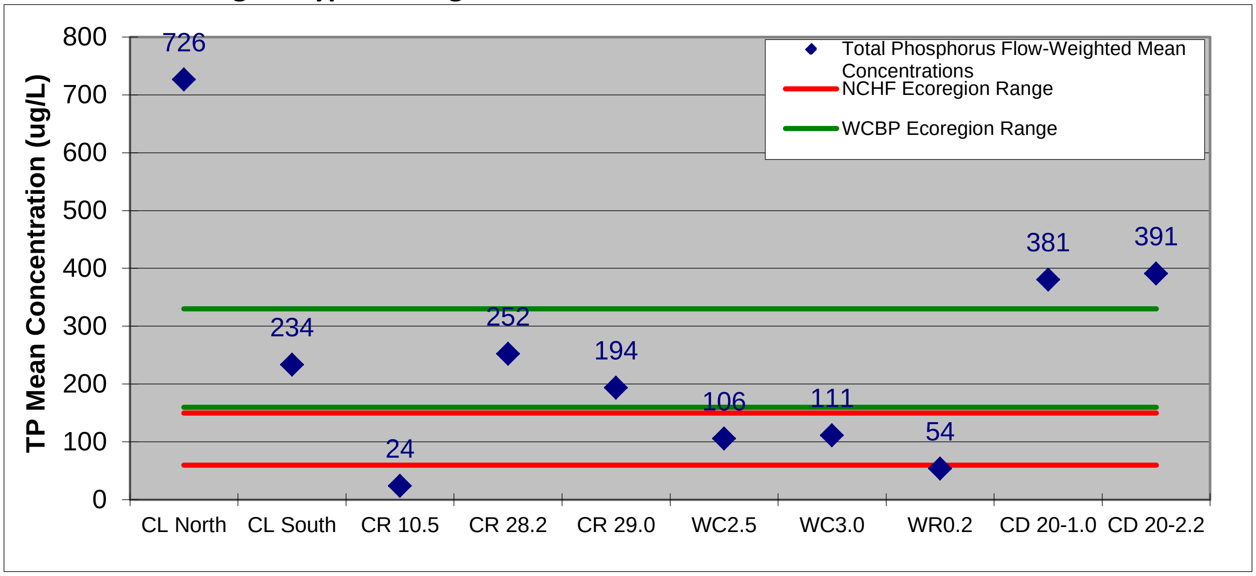
3.1.1 Phosphorus Concentrations and Phosphorus Loads

Stream loads and mean phosphorus concentrations were calculated at each monitoring station on the Clearwater River, Warner Creek, Willow Creek, Clear Lake tributary streams, and County Ditch 20 in 2013 to track the health and integrity of the streams with respect to state standards and to monitor loads to the lakes which drive water quality. Tributary streams were also monitored in the Cedar Lake sub-watershed and are discussed in Section 6.0.

Mean phosphorus concentrations were also calculated for each site and are compared to previous year's concentrations as well as a range of typical concentrations in the NCHF and WCBP ecoregions in Figure 3.2. At the long-term monitoring stations, flow-weighted mean phosphorus concentrations at WR0.2 and CR 10.5 were below the typical range for the NCHF Ecoregion. Mean concentrations at CR28.2 were within the range of the WCBP Ecoregion.

Phosphorus concentrations measured in Willow Creek were within the typical range for the NCHF Ecoregion. Phosphorus concentrations at Clear Lake South were within the WCBP Ecoregion, but concentrations at Clear Lake North and both sites on County Ditch 20 (CD 20-1.0 and CD 20.2.2) were well above than the Ecoregion ranges.

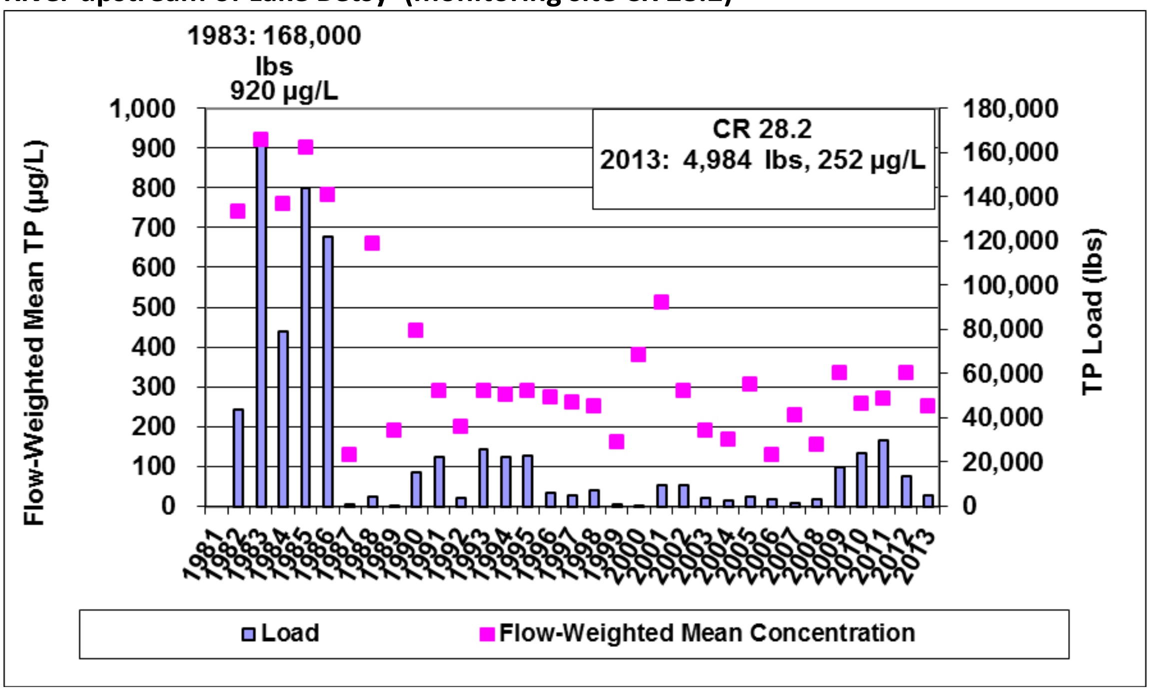
Figure 3.2 Clearwater River Watershed District 2013 Mean Phosphorus Concentrations in Runoff and Ecoregion Typical Range



Baseline total phosphorus (TP) concentrations in the Clearwater River remain low as compared with conditions monitored in the early 1980s. Flow-weighted mean total phosphorus concentrations at CR 28.2, just upstream of Lake Betsy, ranged from 740 to 920 μg/L in the early 1980s. The 2013 concentration was 252 μg/L, which was lower than 2012 and within the range of concentrations observed in recent years and far lower than concentrations seen in the early 1980s.

The TP load at CR28.2 was calculated using the continuous flow record data collected at CR28.2. The TP load at CR 28.2 in 2013 was 4,984 lbs, which is lower than loads observed in recent years and comparable to years with similar precipitation. Phosphorus loads at CR28.2 are still far below the high TP loads observed in the early 1980s, but remain higher than loads necessary to meet state water quality standards. Figure 3.3 shows the historical phosphorus load and flow-weighted mean concentration at CR 28.2.

Figure 3.3 Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River upstream of Lake Betsy (monitoring site CR 28.2)



Flow-weighted mean TP concentrations and phosphorus loads at CR 10.5 were calculated using flows over the dam that were calculated using continuous level data collected upstream of the Grass Lake Dam. The estimated mean phosphorus concentration at CR 10.5 in 2013 was 24 µg/L, which was much lower than concentrations measured in the later 1980s and similar to most recent years. Mean phosphorus concentrations at this station appear to be exhibiting a stable and decreasing trend, which is reflective of improving water quality in Clearwater Lake. The 2013 estimated total phosphorus load was 2,115 lbs (Figure 3.4), which is lower than loads observed in recent years and comparable to other years with similar runoff.

Figure 3.4 Historical Total Phosphorus Loading and Mean Concentration in the Clearwater River at the outlet of Clearwater Lake (monitoring site CR 10.5)

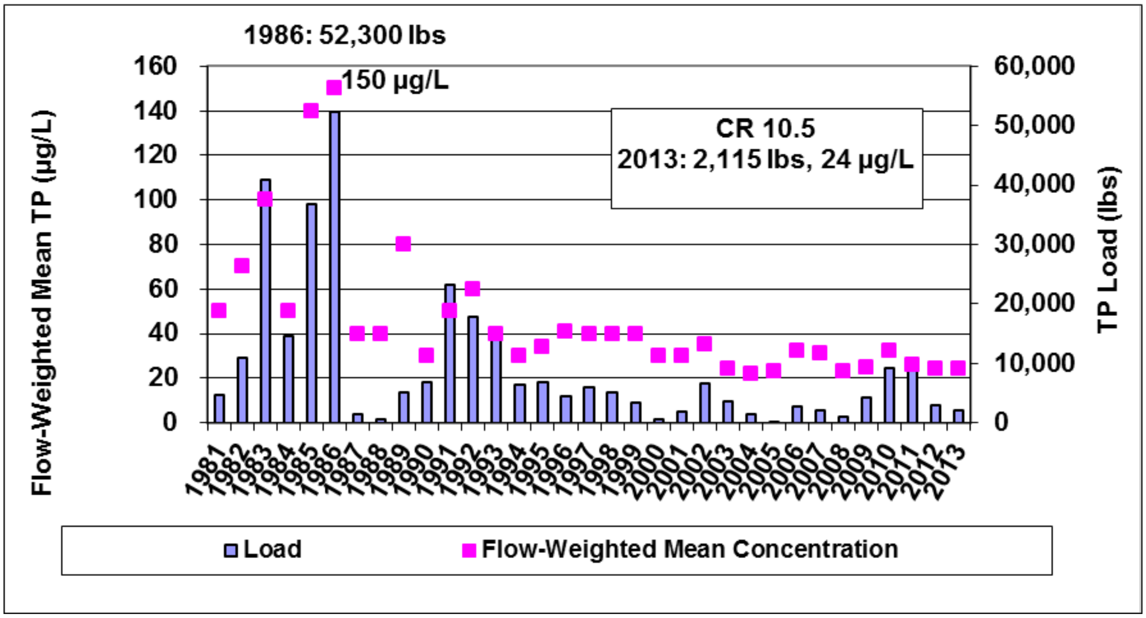
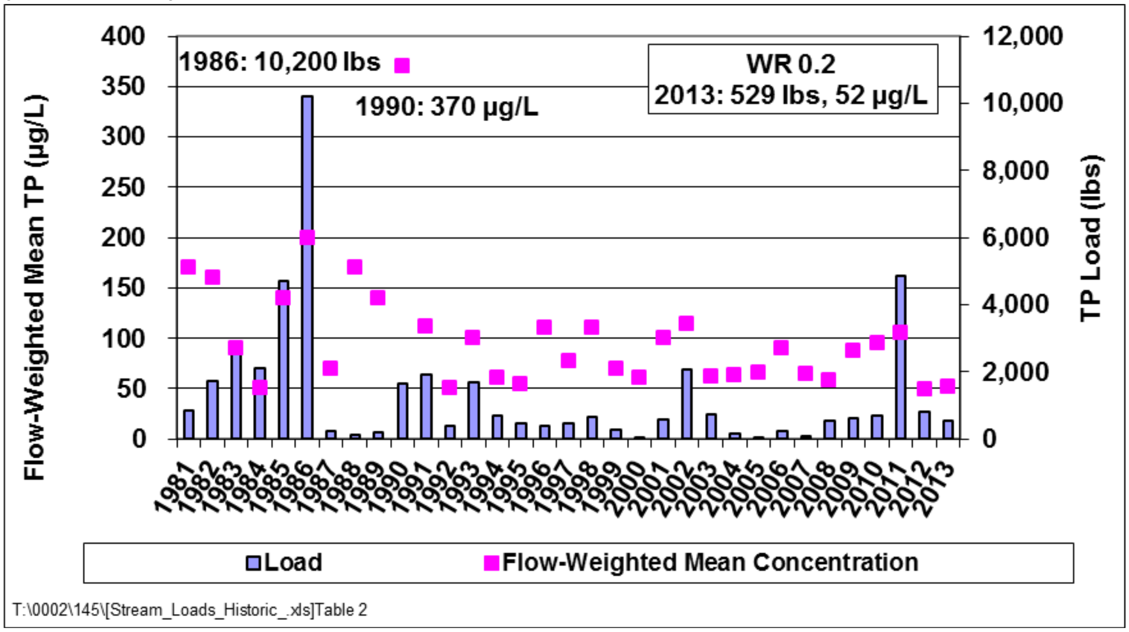


Figure 3.5 compares historical total phosphorus loads and mean phosphorus concentrations in Warner Creek as observed at monitoring station WR0.2. The flow-weighted mean TP concentration at Warner Creek in 2013 was 52 µg/L, which was similar to 2012 and much lower than concentrations observed at this site during the time period from 2008 to 2011. The total phosphorus load in 2013 was 529 lbs, similar to 2012 and to loads observed in other recent years with similar runoff.

Figure 3.5 Historical Total Phosphorus Loading and Mean Concentration at Warner Creek (Site WR-0.2)



Willow Creek has been monitored at two locations upstream and downstream of the City of Kimball since 2012 in order to monitor the effectiveness of projects constructed in the City. As shown in Table 3.2, concentrations decreased slightly from upstream to downstream, while loads increased slightly from upstream to downstream proportionately with the increase in flow. Phosphorus concentrations were similar in 2012 and 2013, while runoff and phosphorus loads were less in 2013 than in 2012. Phase II of the Kimball Stormwater Project which will be constructed in 2014 will further reduce hydraulic and nutrient loads to Willow Creek and downstream lakes. Monitoring will continue at these sites on Willow Creek to continue to track the effectiveness of these projects.

Table 3.2 Willow Creek Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)		Mean TP Concentration (ug/L)		Runoff (in)	
	2012	2013	2012	2013	2012	2013
WC2.5	713	452	90	101	5.11	2.89
WC3.0	619	415	126	119	3.65	2.59

Two tributaries to Clear Lake were also monitored in 2013. 2013 mean phosphorus concentrations were similar to 2012. Phosphorus loads were significantly less in 2013, primarily due to a significant decrease in runoff over the watershed. Monitoring will continue at these two locations in future years to track the progress of District projects implemented in the subwatershed tributary to Clear Lake.

Table 3.3 Clear Lake Tributaries Phosphorus Concentrations and Phosphorus Loads

Site	Phosphorus Load (lbs)		Mean TP Concentration (ug/L)		Runoff (in)	
	2012	2013	2012	2013	2012	2013
CLN	1,796	475	512	495	14.73	4.01
CLS	1,013	123	221	190	14.42	2.04

As shown in Figure 3.6, County Ditch 20 was also monitored in 2013 at two locations upstream and downstream of the Watkins wetland. As shown in Table 3.4, total phosphorus concentrations were similar and high at both sites with slightly higher concentrations observed at downstream station CD 20-1.0. The phosphorus load was over twice as high at the downstream monitoring location. The proportion of total phosphorus comprised of soluble phosphorus was very high at both sites, indicating potential export of soluble phosphorus from wetlands in this subwatershed as a significant source of phosphorus.

Figure 3.6 County Ditch 20 Monitoring Locations

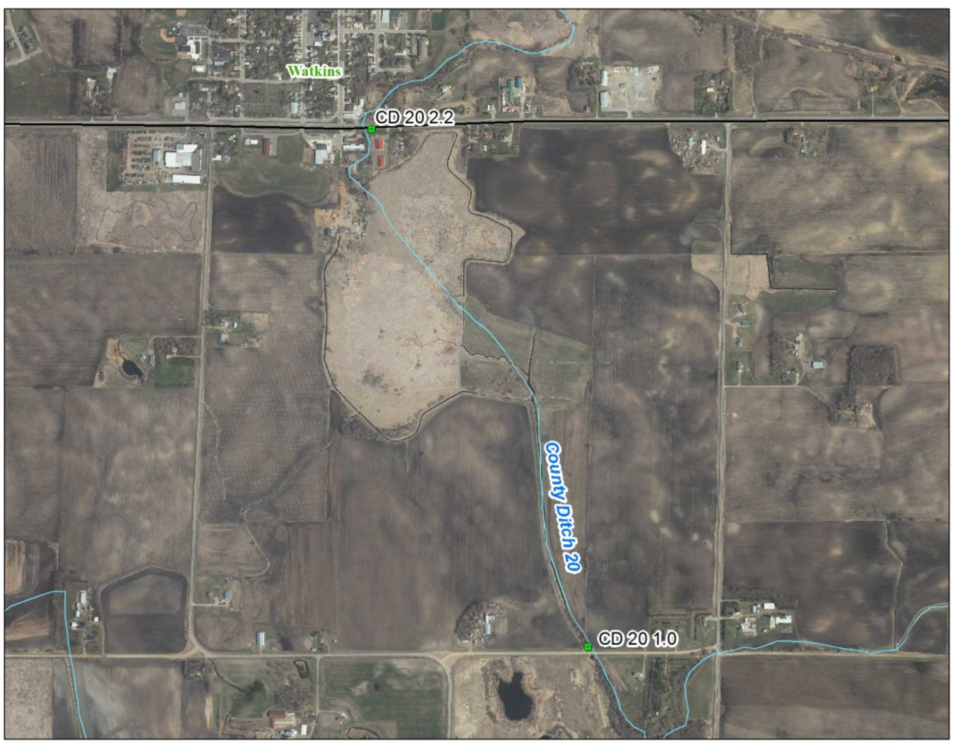


Table 3.4 2013 County Ditch 20 Phosphorus Concentrations and Phosphorus Loads

Site	Watershed Area (acres)	Phosphorus Load (lbs)	Mean TP Concentration (ug/L)
CD20-1.0	8,247	1,477	376
CD20-2.2	7,152	633	341

As demonstrated in Table 3.5, phosphorus loading rates varied throughout the District in 2013 and were generally lower than those observed in 2012 across the watershed. Phosphorus loading rates were lowest at sites in the lower watershed, 0.02 lbs/acre at CR 10.5 and 0.03 lbs/acre at WR0.2. Loading rates at upper watershed stations were generally higher as the loading rate was 0.15 lbs/acre at CR28.2, and 0.18 lbs/acre at CD20-1.0 and 0.45 lbs/acre at Clear Lake North.

It is notable that the loading rate at CR28.2 was similar and slightly less than the loading rate at CR29.0 upstream of the Kingston Wetland, demonstrating a decrease of phosphorus export from the Kingston Wetland in 2013 following the construction of the Kingston Wetland Restoration project. Loading rates for the upper most portion of the District likely are the truest measurement of watershed phosphorus export as loading data collected downstream reflects the sedimentation of phosphorus in District Lakes.

Table 3.5 2013 Phosphorus Loading Rates by Tributary Watershed

Site	Watershed Area (acres)	Phosphorus Load (lbs)	Phosphorus Loading Rate (lbs/acre)
CR10.5	99,200	2,115	0.02
WR0.2	16,992	529	0.03
WC2.5	6,838	452	0.07
WC3.0	5,926	415	0.07
Clear Lake South	1,404	123	0.09
CD 20-2.2	7,152	633	0.09
CR28.2	33,977	4,984	0.15
CR29.0	27,695	4,527	0.16
CD 20-1.0	8,247	1,477	0.18
Clear Lake North	1,055	475	0.45

Ortho-phosphorus (OP) is measured in streams because it is the dissolved form of phosphorus which is more readily used by algae. Relative fractions of ortho-phosphorus to total phosphorus provide valuable insight into the sources of nutrients in the District and potential solutions. Table 3.6 shows the ratio of the flow-weighted means of OP to total phosphorus (TP) as a percentage at each monitoring site.

As expected, OP made up a high percentage of TP in some monitoring stations in 2013, especially those downstream of large wetland complexes, as anoxic conditions developed in these basins during periods of low flow and OP was released from wetland sediments. Specifically, this was observed at the monitoring sites on County Ditch 20 and Clear Lake North. Results from tile monitoring conducted as part of the GPS Fertilizer Application Project demonstrate a high proportion of OP in water draining from subsurface tiles, which may be contributing to elevated fractions of OP at some monitoring sites.

In 2013, the percentage of OP in the TP at the Kingston Wetland monitoring stations indicate that OP is actually higher upstream of the wetland than downstream. This is a change from most previous years of monitoring results that demonstrated an increase in OP downstream of the wetland assumed to be caused by an export of OP from the Kingston Wetland. OP typically makes up a larger percentage of the total phosphorus during years with extended periods of low flows as was experienced during the summer months in 2013.

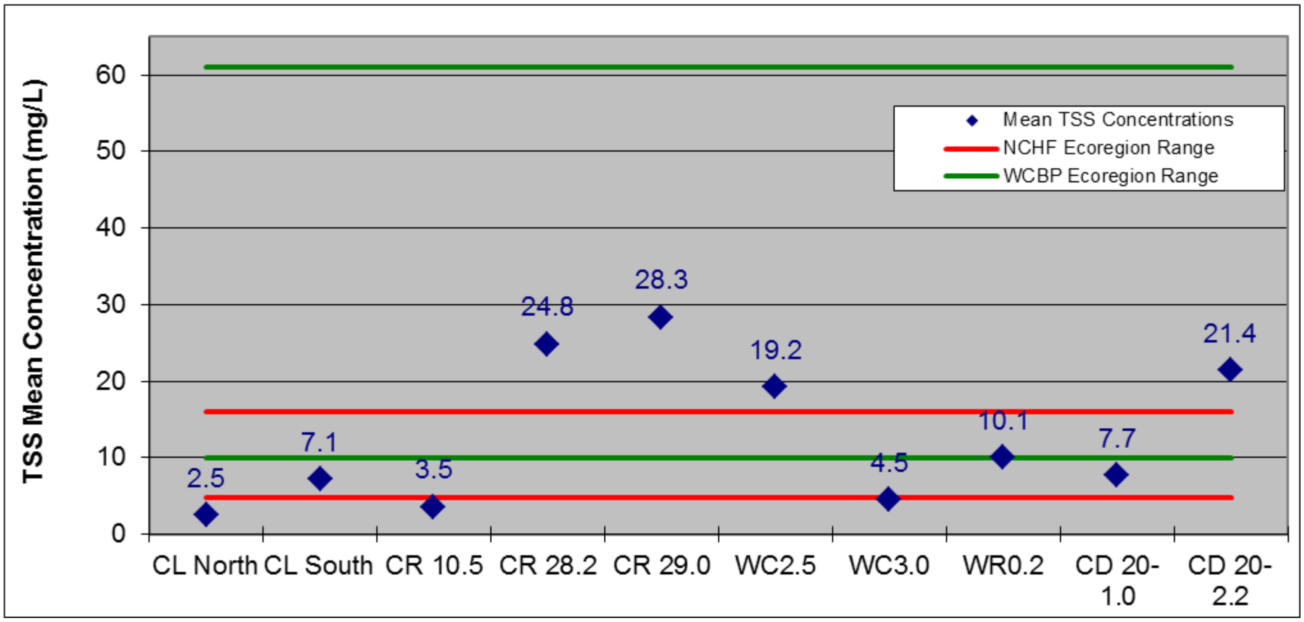
Table 3.6 Comparison of Ortho-Phosphorus to Total Phosphorus Concentrations in 2013

Site	%TP as Ortho-P
WC3.0	12%
WR0.2	20%
CR10.5	25%
WC2.5	29%
Clear Lake South	35%
CR28.2	46%
CR29.0	56%
CD20-2.2	74%
Clear Lake North	79%
CD20-1.0	80%

3.1.2 Total Suspended Solids

Samples were also analyzed for total suspended solids (TSS) in 2013. Mean concentrations of TSS are compared to typical Ecoregion concentrations in Figure 3.7. Mean concentrations of TSS were higher than those observed in previous years and were outside of the typical concentrations in the NCHF Ecoregion at some sites in 2013. The increase in TSS observed in 2013 at these sites was driven by high TSS concentrations observed during early season high flow events. It is likely that an accelerated melt that occurred later in the season due to extended cold temperatures in the spring of 2013 may have resulted in increased sedimentation into surface water bodies during the early part of 2013 which contributed to increased TSS concentrations.

Figure 3.7 2013 Total Suspended Solids Mean Concentrations in the District

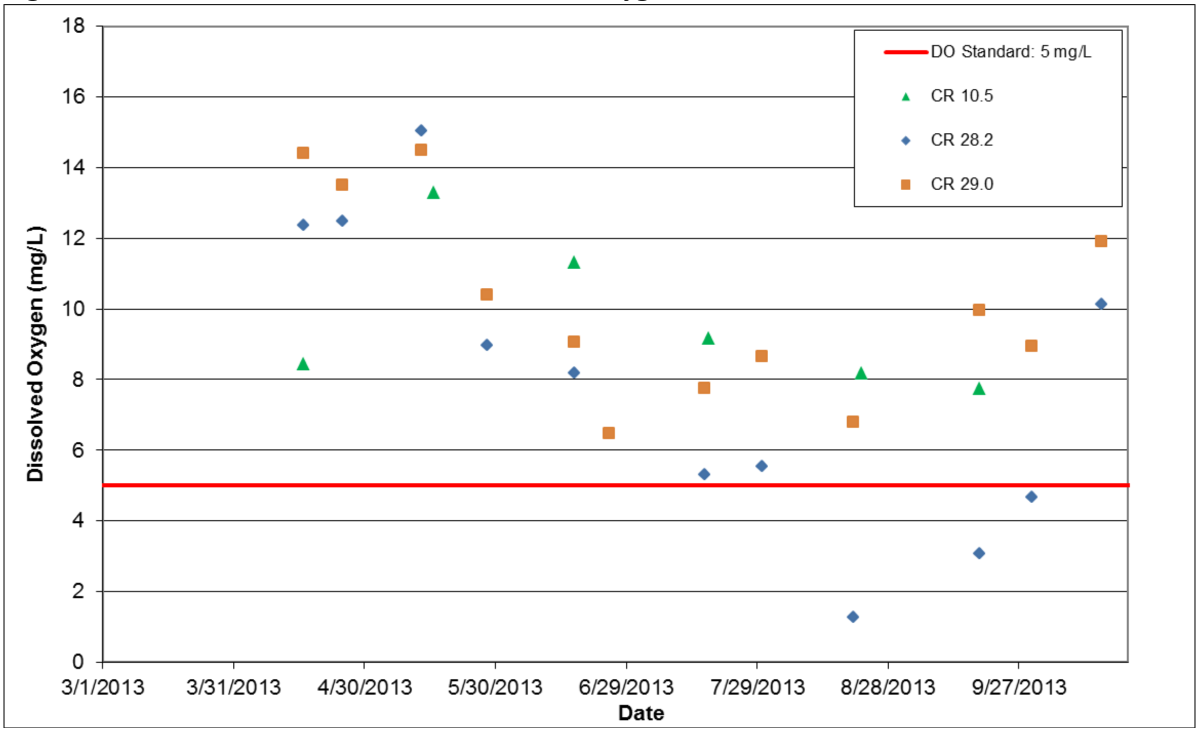


3.1.3 Dissolved Oxygen

Dissolved oxygen (DO) was also measured at each stream monitoring location because DO is essential to the survival of in-stream biota like fish and macroinvertebrates and the concentrations of DO are an indicator of the presence of suitable habitat. DO is also measured to track progress towards achieving the DO TMDL for the Clearwater River and to ensure that other streams in the CRWD meet the MPCA's water quality standard for DO of 5 mg/L or higher. Measured DO concentrations are compared to the MPCA standard for impairment of 5 mg/L in Figure 3.8 and Figure 3.9.

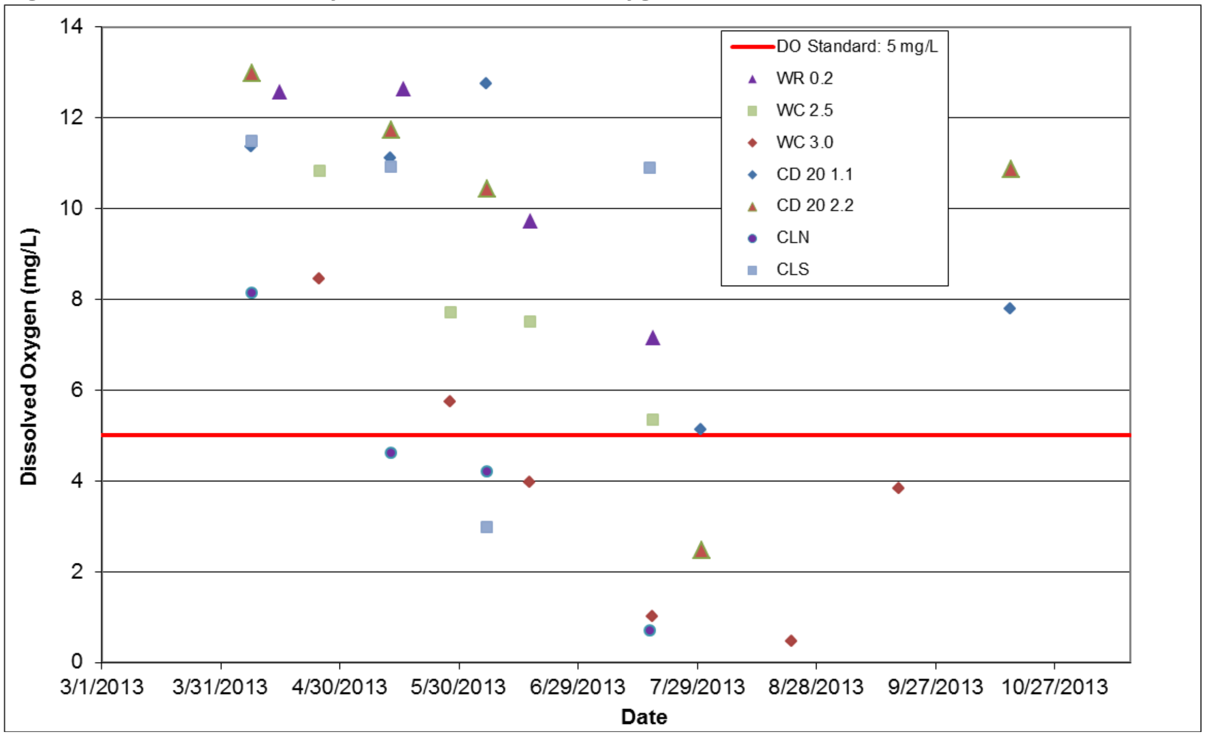
Figure 3.8 presents DO concentrations observed in the Clearwater River in 2013. Prior to the construction of the Kingston Wetland restoration project, data collected at CR28.2 demonstrated that low-flow DO violations occur downstream of Kingston Wetland for most of the year and are driven primarily by wetland sediment oxygen demand (SOD). The Kingston Wetland restoration project rerouted most of the flow of the Clearwater River through a restored meandering stream channel instead of through the Kingston Wetland in 2013. The DO concentrations observed in 2013 demonstrate that DO concentrations did not decrease significantly from those observed upstream of the Kingston Wetland, and the period during which DO concentrations are in violation of the DO standard was reduced to extreme low flow conditions (flows less than 2 cfs) in late summer.

Figure 3.8 2013 Clearwater River Dissolved Oxygen Concentrations



Dissolved oxygen data collected at tributary stream monitoring sites in 2013 is shown in Figure 3.9. DO concentrations were below the impairment standard during all monitoring events after May 1 at Clear Lake North, and WC 3.0.   DO concentrations were also near or below the impairment standard during midsummer at Clear Lake South and CD 20 2.2. The low DO concentrations at these stations are likely a result of increased water temperatures and lack of flow leading to anoxic conditions in wetlands upstream of these monitoring sites.

Figure 3.9 2013 Tributary Stream Dissolved Oxygen Concentrations



Additional stream water quality data is found in Appendix B, including summaries of historical phosphorus loads, stream flows, and flow-weighted mean concentrations. Appendix H shows phosphorus concentrations at each site monitored in 2013.

3.2 LAKE WATER QUALITY

The CRWD measures lake water quality to track progress towards meeting state standards, track long-term trends and identify potential areas where water quality is declining. To that end, The CRWDs 21 lakes are sampled on a rotating basis identified in the District's monitoring plan.

CRWD sampled seventeen lakes in 2013. One additional lake was monitored by a lake association. Parameters analyzed in 2013 included surface total phosphorus, ortho-phosphorus, Chlorophyll-*a*, and a field reading of Secchi depth. Surface samples characterize lake water quality. Samples for total phosphorus, ortho-phosphorus, and total iron were also collected near the lake bottom. Water temperature and dissolved oxygen profile data was also collected at each lake to better characterize lake stratification and the

CRWD Staff Collecting Lake Water Samples

period of anoxia which aids in quantifying internal loading.

3.2.1 2013 Monitoring Results

Summer average (June 1 to September 30) values were compared with the MCPA eutrophication standards for phosphorus, Chlorophyll-*a*, and Secchi disk depth, based on Ecoregion and lake type. The MPCA uses separate standards for shallow (less than 15 foot maximum depth or 80% of lake area less than 15 feet deep) and deep lakes (greater than 15 foot maximum depth). The appropriate standards for lakes monitored in the CRWD, which is in the North Central Hardwood Forest Ecoregion, are shown in Table 3.6. The MPCA standards are also used as the TMDL goals for summer average concentrations and Secchi depth in District lakes.

Table 3.6 MPCA Standards for Lakes in the North Central Hardwood Forest Ecoregion

	Total Phosphorus	Chlorophyll-*a*	Secchi Depth
Lake Category	**µg/L**	**µg/L**	**meters (not less than)**
Shallow Lakes	60	20	1
Deep Lakes	40	14	1.4
Source: Minnesota Pollution Control Agency			

Figures 3.10 and 3.11 compare the average total phosphorus concentrations in lakes sampled in 2013 to the TMDL goal.

Figure 3.10 2013 Summer Average Total In-Lake Phosphorus Concentrations (Deep Lakes)

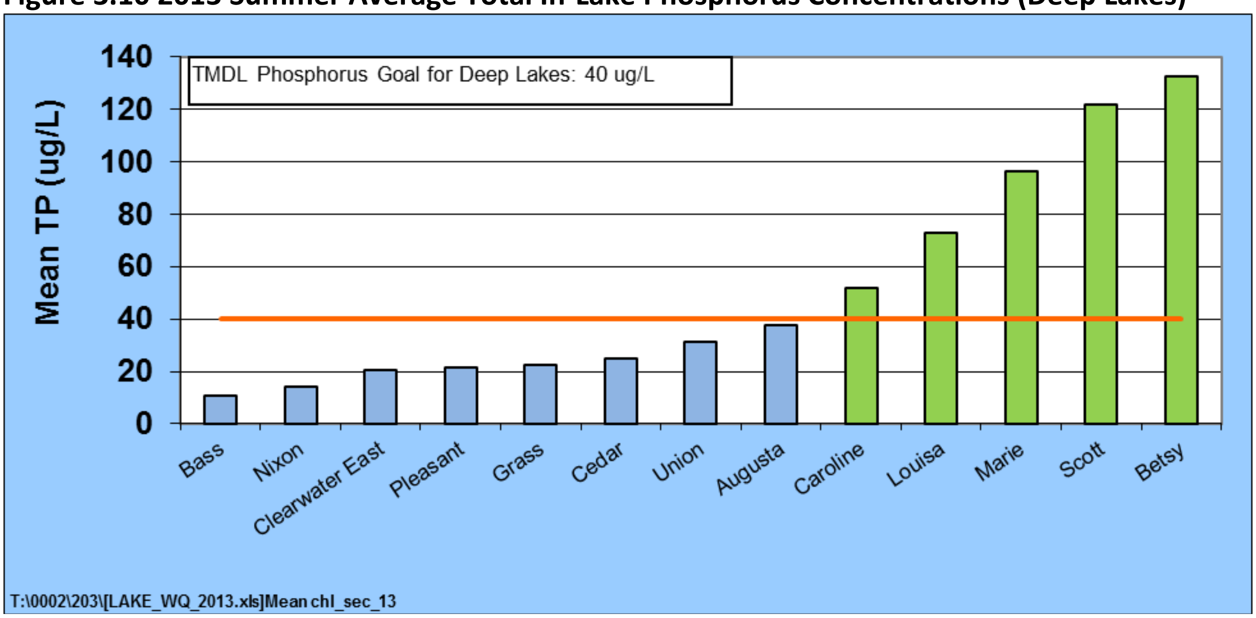
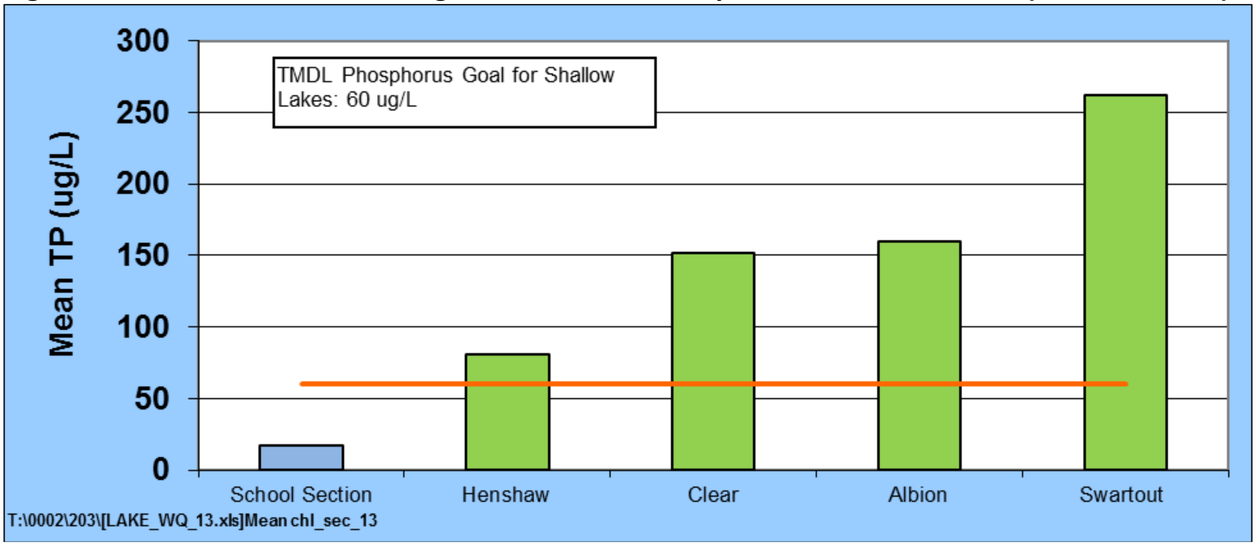


Figure 3.11 2013 Summer Average Total In-Lake Phosphorus Concentrations (Shallow Lakes)



In general, phosphorus concentrations were lower in most lakes in 2013 in comparison to recent years due to decreased runoff and loading from the watershed, with a few exceptions. Based on the 2013 monitoring data for each lake Caroline, Betsy, Louisa, Scott, Marie, Henshaw, Clear, Albion, and Swartout were above the TMDL goal for total phosphorus. Although phosphorus concentrations did not meet TMDL goals in these lakes, concentrations were dramatically improved in Caroline, Henshaw, Louisa, Marie, and Swartout Lakes. Phosphorus concentrations increased in Clear Lake in 2013.

Figures 3.12 and 3.13 compare the most recent summer average chlorophyll-a concentrations for sixteen CRWD lakes to the appropriate chlorophyll-*a* TMDL goal. In 2013, Betsy, Caroline, Marie, Louisa, Scott, Swartout, Clear, and Albion were above the TMDL goal for chlorophyll-*a*. Chlorophyll-a concentrations decreased significantly from recent years in Betsy, Caroline, Henshaw, and Union Lakes.

Figure 3.12 2013 Summer Average Chlorophyll-*a* Concentrations (Deep Lakes)

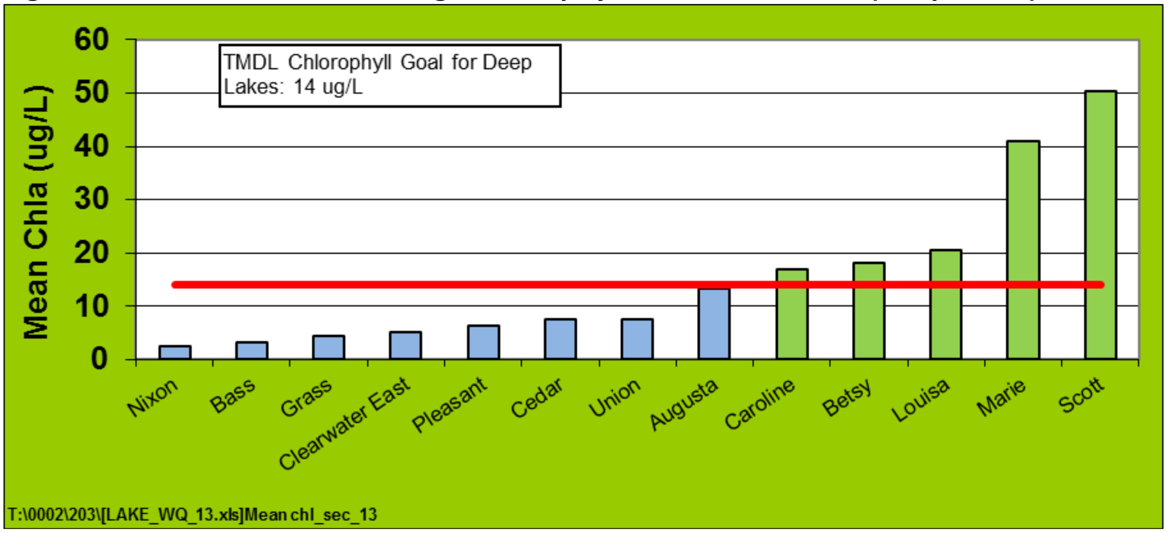
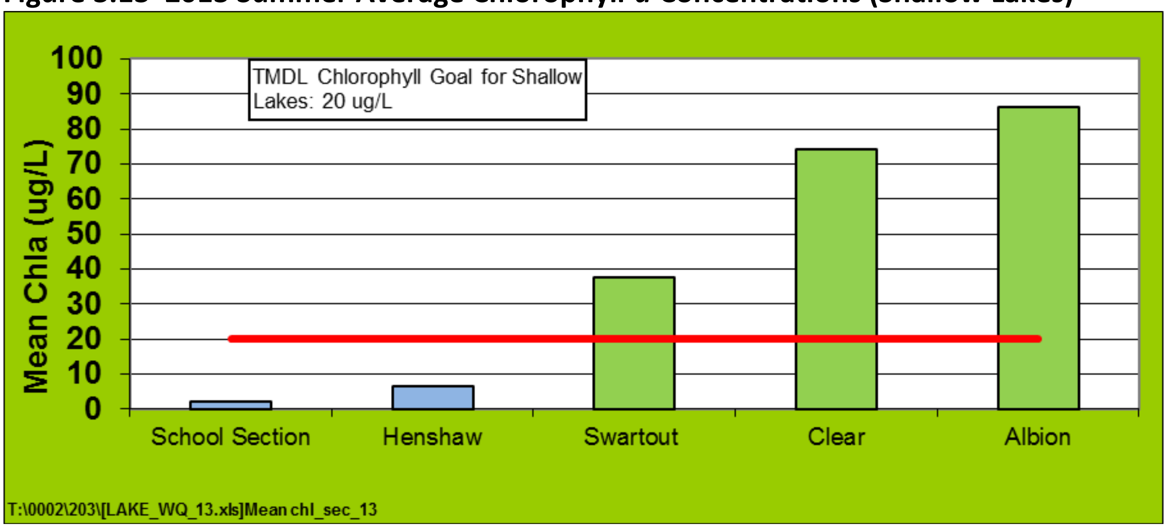


Figure 3.13 2013 Summer Average Chlorophyll-*a* Concentrations (Shallow Lakes)



Figures 3.14 and 3.15 compare the 2013 Secchi disk depth for CRWD lakes to the appropriate Secchi TMDL goal. Water clarity was good in the District lakes in 2013, as the TMDL goal was met for all lakes except for Albion and Clear.

Figure 3.14 2013 Summer Average In-Lake Secchi Depth (Deep Lakes)

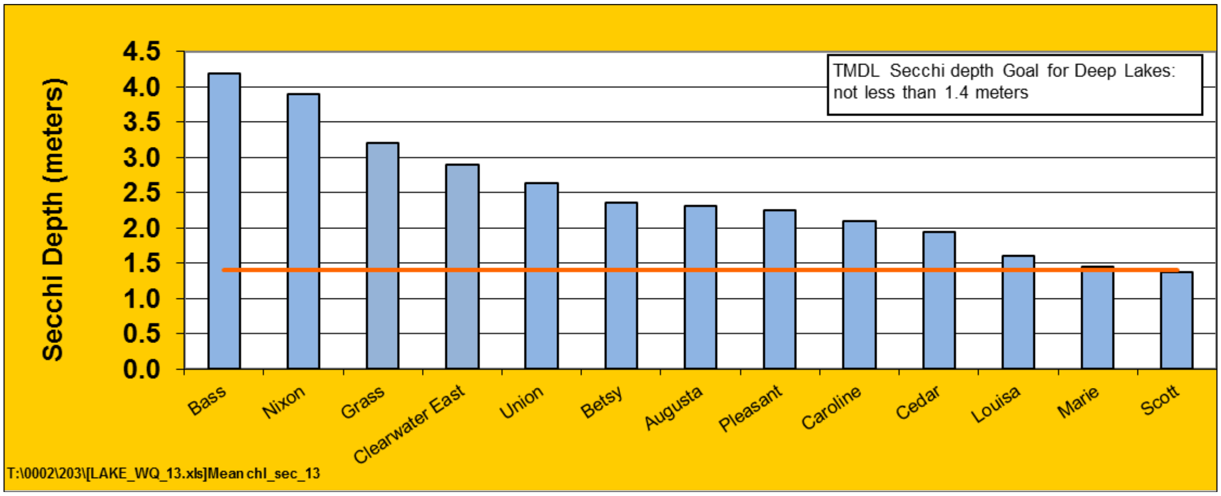
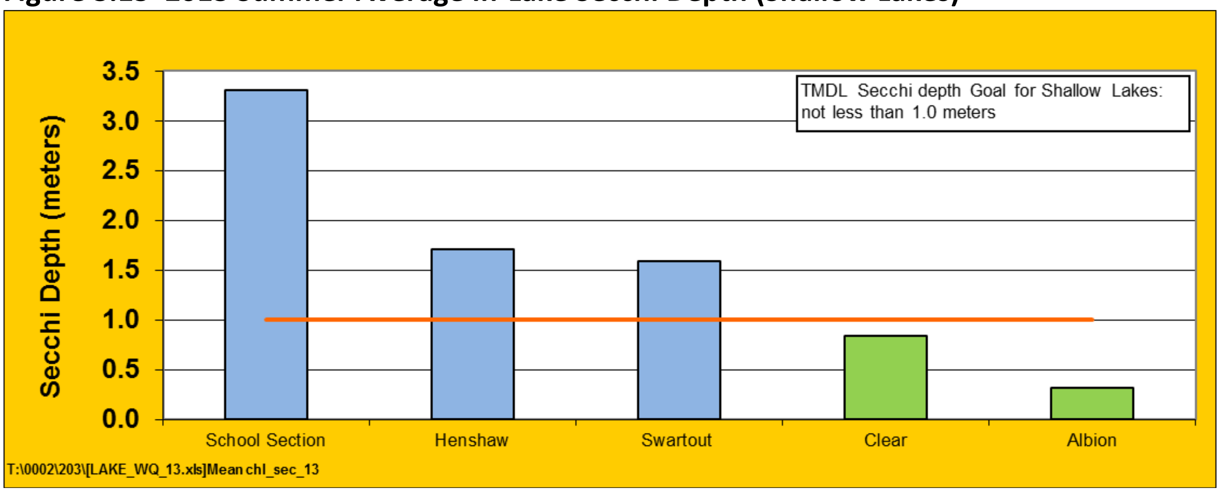


Figure 3.15 2013 Summer Average In-Lake Secchi Depth (Shallow Lakes)



As demonstrated in Table 3.7, phosphorus and Chlorophyll-*a* concentrations were near the low end of historic ranges in most lakes in 2013. Phosphorus concentrations at Bass and Nixon Lakes and Chlorophyll-*a* concentrations in Henshaw Lake were the lowest ever observed in these lakes. Secchi disk depths were near the low end of historic ranges in most lakes in 2013, with the highest Secchi readings ever observed at each lake being recorded at Betsy, Augusta, Bass, Caroline, Clearwater, Henshaw, Nixon, School Section, and Union Lakes. Conversely, the lowest Secchi reading ever observed at Albion Lake was recorded in 2013.

Table 3.7 2013 Mean In-Lake Total Phosphorus, Chlorophyll-*a*, and Secchi Depth, and Historical Ranges

	Total Phosphorus ug/l		Chlorophyll-a ug/L		Secchi Depth (meters)	
Lake	2013 Mean	Historical Range Mean	2013 Mean	Historical Range Mean	2013 Mean	Historical Range Mean
Albion	160	130-296	86	60-204	0.3	0.5-1.2
Augusta	38	28-300	13	4-73	2.3	1.1-1.9
Bass	11	13-28	3	2-5	4.2	3.1-4.2
Betsy	133	120-700	18	4-170	2.4	0.5-2.4
Caroline	52	36-300	17	3-55	2.1	0.8-1.9
Cedar	25	19-58	8	3-20	2.1	1.1-3.0
Clear	152	80-307	74	17-134	0.8	0.3-1.2
Clearw ater East	21	25-160	5	4-77	2.9	1.4-2.6
Grass	22	17-38	5	1-14	3.2	1.9-3.4
Henshaw	81	90-390	7	25-178	1.7	0.2-0.9
Louisa	73	33-440	20	4-101	1.6	0.6-2.1
Marie	96	69-360	41	4-153	1.5	0.6-2.3
Nixon	14	15-39	3	2-8	3.9	1.8-3.2
Pleasant	21	15-51	6	4-12	2.3	2.0-3.0
School Section	17	16-50	2	3-14	3.3	1.0-3.1
Scott	122	82-660	50	3-223	1.4	0.5-1.9
Sw artout	262	200-421	38	23-832	1.6	0.2-1.9
Union	32	25-88	8	7-39	2.6	1.0-2.3
Above TMDL Goal						
T:\0002\203_2013 Water Quality Monitoring\Water Quality Data\[Lake WQ 2013.xlsx]Historical Table						

Table 3.8 compares CRWD lakes to MPCA impairment standards and identifies phosphorus concentration trends in each lake. Water quality does not meet TMDL goals in 10 lakes. Overall, based on the most recent monitoring data for all lakes within CRWD, water quality in most lakes is generally good and appears to be remaining stable or improving. A recent increasing phosphorus trend observed in the three years prior to 2013 in the Clearwater Chain of Lakes including Louisa, Marie, Caroline, and Augusta corresponded to increased phosphorus loads in the Clearwater River in the upper watershed during that same time period. Lower runoff and resulting lower loads of phosphorus in 2013 resulted in decreased phosphorus concentrations in many of these lakes in 2013. Due to the flow-through nature of these lakes, the water quality is driven by the hydrology of the Clearwater River. During years with high runoff, phosphorus concentrations in the lake approach concentrations observed in the Clearwater River. During dry years, internal loading contributes a larger portion of the phosphorus load to the lakes.

Table 3.8 Lake Trend and Impairment Summary

Lake	Last Monitored	Phosphorus Trend	Use
Albion*	2013	Stable Trend	Impaired
Augusta*	2013	Recent Decreasing Trend	Full Use
Bass	2013	Stable Trend	Full Use
Betsy*	2013	Recent Decreasing Trend	Impaired
Caroline*	2013	Recent Decreasing Trend	Impaired
Cedar	2013	Recent Stable Trend	Full Use
Clear*	2013	Stable Trend	Impaired
Clearwater East	2013	Recent Stable Trend	Full Use
Clearwater West	2012	Recent Stable Trend	Full Use
Grass	2013	Decreasing Trend	Full Use
Henshaw*	2013	Recent Decreasing Trend	Impaired
Little Mud	2012	Decreasing Trend	Full Use
Louisa*	2013	Recent Decreasing Trend	Impaired
Marie*	2013	Recent Decreasing Trend	Impaired
Nixon	2013	Recent Stable Trend	Full Use
Otter	2012	Stable Trend	Full Use
Pleasant^	2012	Stable Trend	Full Use
School Section	2013	Stable Trend	Full Use
Scott*	2013	Recent DecreasingTrend	Impaired
Swartout*	2013	Recent Stable Trend	Impaired
Union*	2013	Recent Decreasing Trend	Impaired
Wiegand	2009	Decreasing Trend	Full Use

T:\0002\203_2013 Water Quality Monitoring\Water Quality Data\[Lake WQ 2013.xlsx]Summary

*TMDL Impaired

^ Monitored by lake association in 2013

Additional lake monitoring efforts that were conducted in 2013 are summarized in Section 5.0. Lake report cards provide a more detailed summary of present and historic water quality for each lake and are included in Appendix C. Water quality lab reports are in Appendix E, and field notes are in Appendix F.

4.0 Cedar Lake Project #06-1

4.1 INTRODUCTION

Segner Pond Limestone Berm Following Repairs

The Cedar Chain of Lakes Restoration Project #06-1 began in 2007 as a response to a petition by lakeshore residents to address the declining water quality and severe algae blooms in Cedar Lake. The goal of the project was to reduce the annual phosphorus load to Cedar Lake to 1,000 lbs which translates into an in-lake summer average phosphorus concentration in Cedar Lake of 20 µg/L. An additional goal of the project was to further reduce phosphorus loading from upstream lakes by reducing the carp population of the lakes.

Several projects were implemented between 2007-2013 to reduce in lake phosphorus concentrations in Swartout, Albion, Henshaw, and Cedar Lakes. Projects that have been implemented include rough fish management efforts, including the construction of five fish barriers (See photos below and Figure 4.3 for location) and rough fish removal. Other projects include the construction of the Segner Pond treatment wetland, and watershed BMPs such as tile inlet buffers and buffer strips.

Activities conducted in 2013 included ongoing maintenance of fish barriers, Segner Pond limestone berm repair, and rough fish removal..

Carp Removal at Segner Pond

Carp Removal at Segner Pond

Fish Barrier at Segner Pond

Fish Barrier at Swartout Lake Outlet

Fish Barrier at Illsley Ave.

Swartout Lake Inlet Fish Barrier

Fish Barrier at Henshaw Lake Outlet

4.2 MONITORING

Cedar Lake, Swartout Lake, Albion Lake, and Henshaw Lake were monitored four times from June to September in 2013. Streams tributary to the lakes were also monitored while they were flowing at five locations in 2013. Tributary streams are monitored to track annual loading to the lakes, which assists in determining progress towards meeting loading goals in addition with tracking the health of the streams.

4.2.1 Lake Monitoring

Cedar Lake

As shown on the Cedar Lake Report Card in Appendix C, the 2013 summer average total phosphorus concentration of 25 µg/L was below the minimum standard for impairment and is near the Project goal of 20 µg/L. Since Cedar Lake is a high value lake with water quality far better than the minimum standards for impairment, the project goal of 20 µg/L was set to protect water quality from decline. Chlorophyll-*a* concentrations were on the low end of ranges of concentrations observed in recent years and were below impairment standards in 2013. Secchi depth was in the range observed in recent years in 2013 and was better than the minimum standards for impairment.

Overall water quality appears to have stabilized or be slightly improving in Cedar Lake in recent years. However, episodic algal blooms remain a common occurrence in the lake, especially early in the growing season. A likely cause of these blooms is a pulse of nutrients to the lake that are incorporated by the algae.

Although internal loading of phosphorus is not suspected to make up a significant portion of the phosphorus load in Cedar Lake, it is likely that there is some internal loading of phosphorus in the lake. Elevated concentrations of phosphorus near the lake bottom observed during previous monitoring years indicate potential for internal loading. Temperature and dissolved oxygen profile data indicate that the lake is strongly stratified during most of the time period from June to November, which likely limits internal loading under normal conditions.

It is suspected that curly leaf pondweed may also contribute to internal loading in the lake by making phosphorus from buried lake sediment available in the water column during the growing season. Small areas of the lake containing curly leaf pondweed have been treated periodically with herbicides in recent years in an attempt to control the spread of the plant in the lake.

Swartout Lake

Swartout Lake water quality is summarized on the report card for the lake in Appendix C.

Summer average phosphorus concentrations were lower than those observed in recent years but remained well above TMDL goals in Swartout Lake in 2013. Chlorophyll-*a* concentrations remain above TMDL goals but continued to be well below the long-term range of Chlorophyll-*a* concentrations measured in the lake. Water clarity continued to be very good in 2013, relative to historical levels, as the summer average Secchi disk depth met the TMDL goal.

The trend of stable Chlorophyll-*a* concentrations that have been historically low since 2010 are likely the result of available light limiting the growth of algae. Prior to 2010, the lake had been very turbid due to the complete absence of rooted aquatic plants and the domination of the fishery by rough fish.

Clarity has increased dramatically in recent years due to a major reduction in the carp due to harvesting, migration management and extensive fish kill occurred in the late winter of 2010 The reduced carp and rough fish population allow for less disturbance to bottom sediments and resulting turbidity which allowed submergent vegetation growth in the lake in 2013 which anchor the sediments and provide habitat for other species.

However, as water clarity has increased, expected corresponding sustained algal blooms have not been documented. Algal blooms were limited to periodic episodes during mid-summer in 2013. While a small number of carp have been observed in the lake in 2012 and 2013, it does not appear that the population has increased dramatically in the lake to a level that has an impact on water quality, as observed prior to 2010.

In 2005, a vegetation survey in the lake found no rooted aquatic plants growing in the lake. Vegetation surveys conducted in 2010 through 2013 found submergent vegetation growing at approximately 30% of sample points across the lake (Figure 4.4). Figure 4.1 shows the water depth and typical areas of submergent and emergent vegetation coverage as inventoried from 2010 to2013.

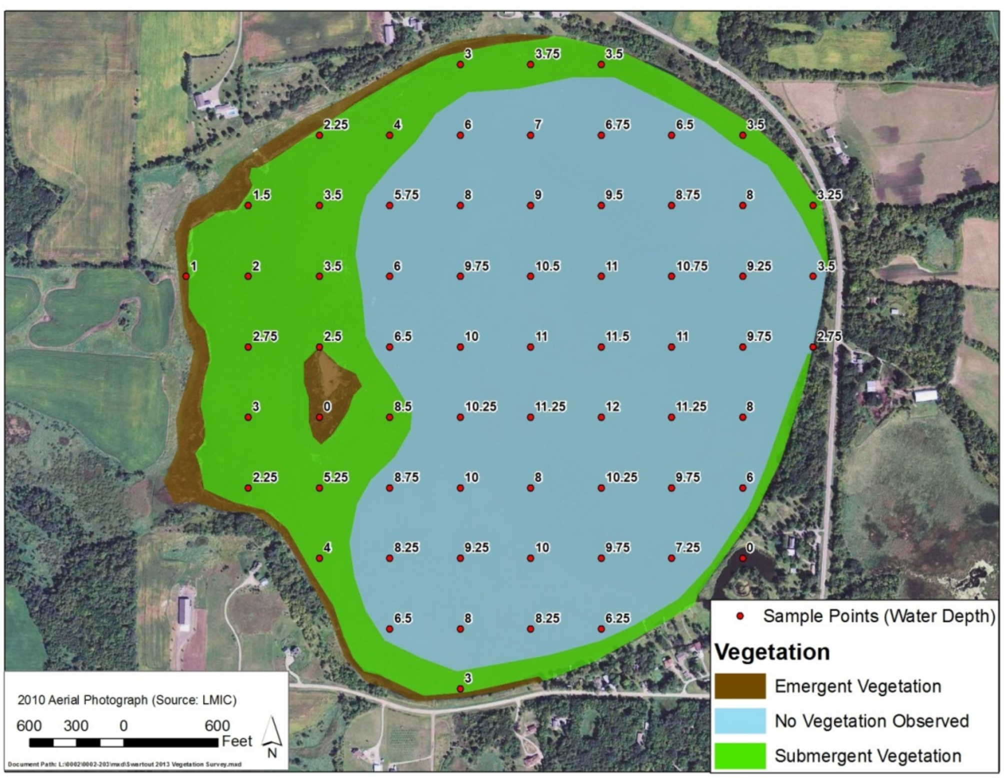
The 2013 vegetation inventory was conducted in early summer to survey the lake for curly leaf pondweed. There was no curly leaf pondweed observed at any of the sample points in 2013. Submerged aquatic vegetation growth appears to be limited by bottom substrate and not just water clarity as areas of the lake with mucky bottom sediments are vegetated with dense stands of native species. Many areas of the lake with similar depth with a sand/gravel substrate are not vegetated, even though water clarity would not appear to limit vegetation growth. Overall, submergent vegetation has been observed at most sample points less than five feet deep in the western portion of the lake. The submergent vegetation community is dominated by native species, with sago pondweed, narrow leaf pondweed, and leafy pondweed being the most common species observed. Overall vegetation density has increased and remained relatively stable since 2010, especially in the western bay of the lake near the island, where dense beds of sago pondweed growing to the surface are typically observed.

The current clear water condition of Swartout Lake represents the stable and healthy condition of a shallow lake. Clear water allows for abundant submergent vegetation growth, which stabilizes bottom sediments and provides food and cover for invertebrates, fish, and other aquatic animals. The abundant sago pondweed in the lake is also a preferred food source of many species of migratory waterfowl.

Aquatic Vegetation in Swartout Lake

The continued dramatic improvement in water clarity and submergent vegetation growth due to decreased rough fish populations over the last two years following an extensive winterkill of carp in the lake are an indication of the role that rough fish play in decreasing water quality in shallow lakes, especially in Swartout Lake. The reduction in the carp population in Swartout Lake in 2010 allowed for a drastic improvement to the ecological health of the lake.

Figure 4.1 Swartout Lake 2013 Aquatic Vegetation and Water Depth



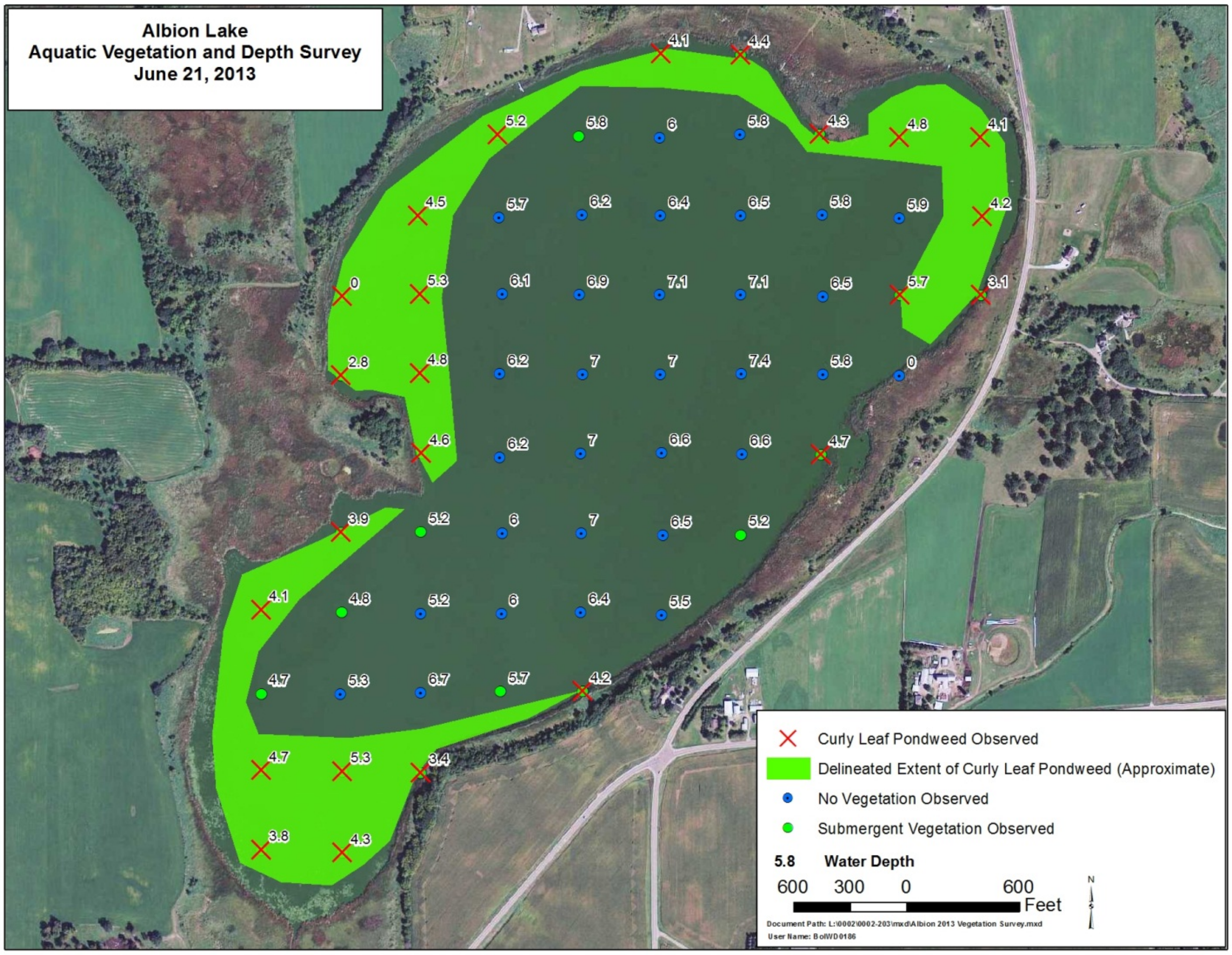
Albion Lake

As shown on the Albion Lake report card in Appendix C, summer average phosphorus and Chlorophyll- *a* concentrations observed in Albion Lake in 2013 remained above TMDL goals but were similar to concentrations observed in recent years. Water clarity continued to be poor in the lake as the summer average Secchi depth did not meet TMDL goals and was the lowest observed in the lake since monitoring began in 1996. Water clarity has generally been poor in the lake since 2010.

A review of 2013 water quality data indicates that phosphorus and Chlorophyll-*a* concentrations increased dramatically in August and September. The review of seasonal phosphorus concentrations in 2013 also demonstrates that total phosphorus throughout the summer was comprised almost entirely of particulate phosphorus with very little ortho-phosphorus. This is likely due to the re-suspension of bottom sediments in the lake from rough fish and wind, as well as algal uptake of ortho-phosphorous in the water column.

An aquatic vegetation survey was conducted early in the season in June 2013 in order to document the extent of curly leaf pondweed in the lake. Aquatic vegetation was observed at 50% of the survey points, as shown in Figure 4.2. Curly-leaf pondweed, sago pondweed, and flatstem pondweed were the most common species of submergent vegetation observed in the lake in 2013. The coverage and condition of submergent aquatic vegetation generally decreases as water clarity decreases throughout the season in Albion Lake. A fringe of emergent vegetation dominated by hardstem bulrush and cattail was also observed in portions of the lake. Curly leaf pondweed was observed at 39% of surveyed points and the approximate extent of curly leaf pondweed is shown in Figure 4.2. The extent of curly leaf pondweed and potential links to water quality in the lake will continue to be monitored in future years.

Figure 4.2 Albion Lake 2013 Aquatic Vegetation and Depth Survey



Henshaw Lake

Water quality improved dramatically in Henshaw Lake in 2013, following an extensive fish kill during the winter of 2012-2013. As summarized on the Henshaw Lake report card in Appendix C, summer average phosphorus concentrations in 2013 remained above the TMDL goal in the lake but were the lowest observed in the lake since monitoring began. Summer average Chlorophyll-*a* concentrations in 2013 were dramatically reduced and met the TMDL goal. Water clarity was also improved as the summer average Secchi depth of 1.7 meters met the TMDL goal and was the highest observed in the lake. The Secchi disk was visible on the bottom of the lake during most monitoring visits.

A winterkill of fish that occurred during the 2013 winter was confirmed by the MN DNR in April 2013. There was no evidence of rough fish in the lake in 2013. The dramatic improvement in water quality in 2013 demonstrates that the rough fish population is likely the main driver of water quality in Henshaw Lake.

Aquatic vegetation coverage, density, and diversity was also imporoved in Henshaw in 2013 as the lack of rough fish in the lake allowed for increased water clarity and optimal conditions for submerged vegetation growth. Vegetation surveys were conducted in the lake in June and August in 2013. The June survey was conducted to determine the extent of curly leaf pondweed in the lake. Curly leaf pondweed was found at 31% of sampled points during the June survey. The approximate delineated extent of curly leaf pondweed is shown in Figure 4.3. Overall, aquatic vegetation was found at 89% of surveyed points during the June survey.

An additional aquatic vegetation survey was conducted in August 2013 to document the extent of aquatic vegetation in the lake for comparison to previous years surveys. Vegetation was found at 63 of 64 sample stations (98%) during the August survey. The vegetation community was dominated by dense stands of sago pondweed, with leafy pondweed and narrow leaf pondweed also commonly observed. As demonstrated in Figure 4.4, aquatic vegetation surveys found vegetation at less than 20% of sampled points during surveys conducted in 2010 and 2012. The current state of the aquatic vegetation in Henshaw Lake is reflective of a healthy shallow lake in the clear water state and provides optimal habitat and food for fish, waterfowl, and other wildlife.

Figure 4.3 Henshaw Lake 2013 Aquatic Vegetation and Depth Survey

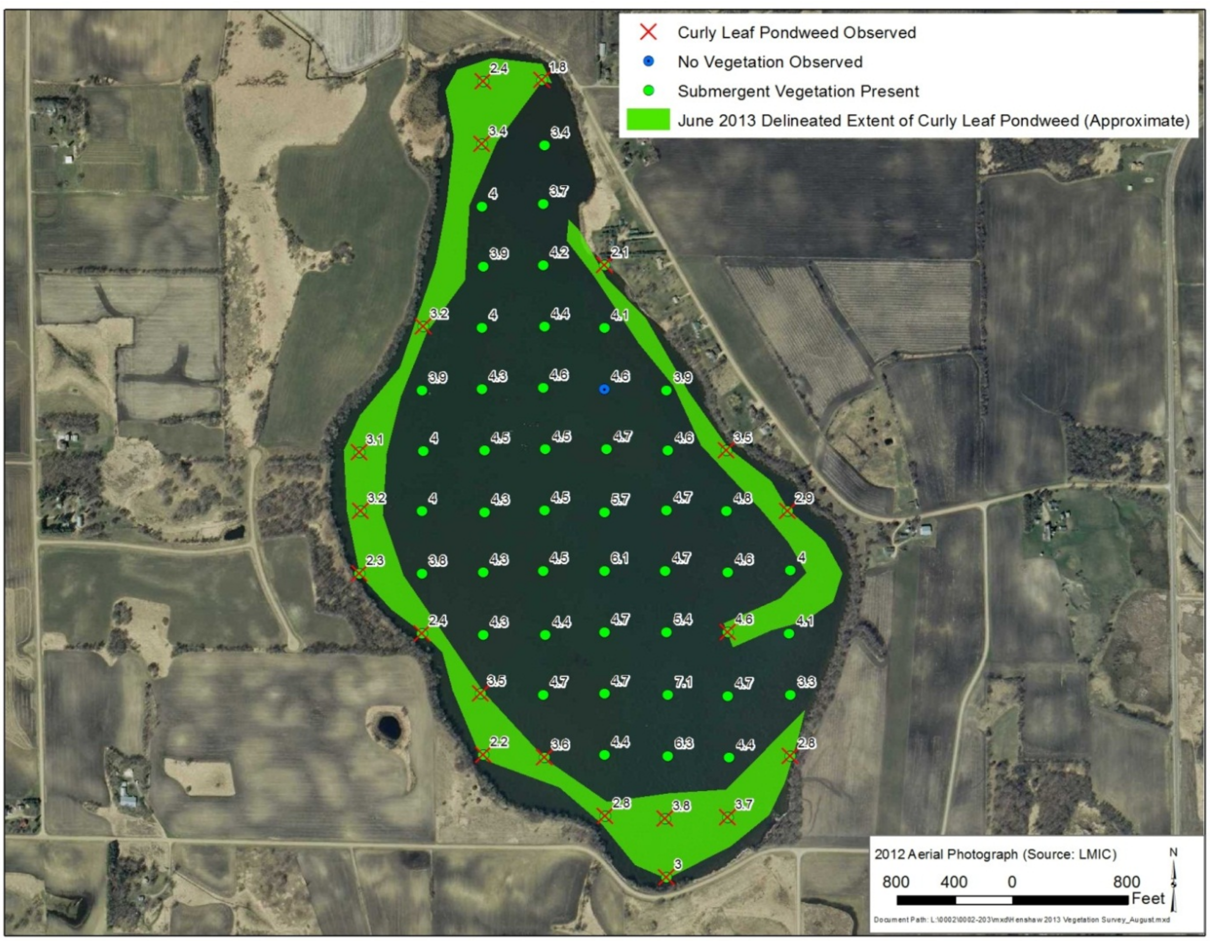


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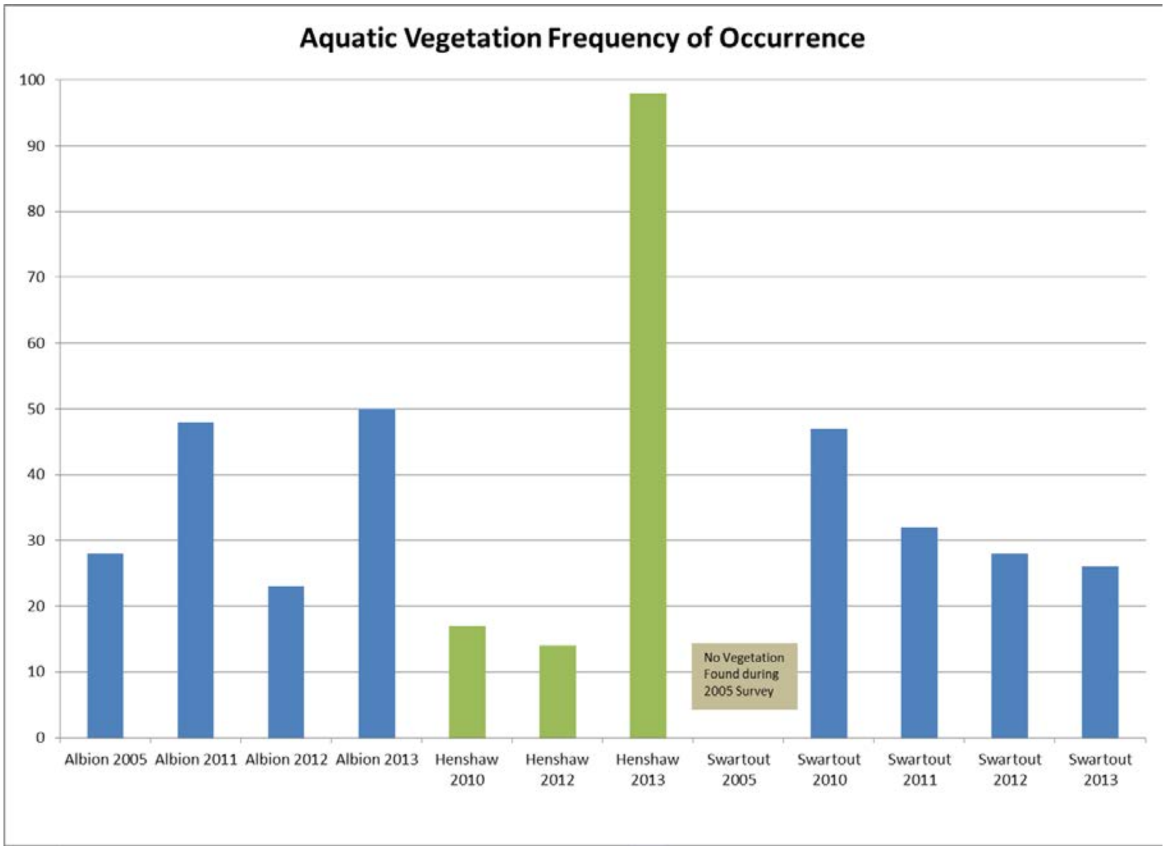
Figure 4.4 Aquatic Vegetation Frequency of Occurrence in Albion, Henshaw, and Swartout Lakes



4.2.2 Stream Monitoring

Five tributary streams in the Cedar Lake subwatershed were also monitored in 2013. Locations of the monitored tributary streams are shown on Figure 4.5. Annual runoff at each monitoring site from 2007 to 2013 is shown in Table 4.1 below. The calculated phosphorus loads from 2007 to 2013 are shown in Table 4.2 below. Mean total phosphorus concentrations are shown in Table 4.3 and phosphorus loading rates at each monitoring location are shown on Figure 4.4.

Table 4.1 Tributary Stream Flow Data 2007-2013

Runoff (in)							
Site	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
SCE01	1.60	3.60	2.00	2.47	12.26	6.49	3.98
SHE01	1.20	4.50	1.30	5.27	14.17	5.85	1.62
SSW01	0.70	7.00	3.50	5.95	14.78	3.68	2.10
SSW02	0.50	4.70	3.50	3.83	7.41	6.13	1.55
SSW04	1.20	4.00	1.50	3.66	10.76	5.49	2.48

Table 4.2 Tributary Stream Total Phosphorus Load 2007-2013

	TP Load (lbs)							
Site	2007	2008	2009	2010	2011	2012	2013	TP Load Goal
SCE01	121	199	136	160	791	395	225	
SHE01	81	247	61	198	424	272	37	
SSW01	98	698	602	839	4164	1121	581	
SSW02	292	858	739	624	2358	1342	300	
SSW04	870	1011	512	1149	3866	2543	773	1000

Table 4.3 Tributary Stream Mean Total Phosphorus Concentrations 2007-2013

	Mean TP Concentration (ug/L)						
Site	2007	2008	2009	2010	2011	2012	2013
SCE01	38	28	34	32	33	31	33
SHE01	283	222	195	153	122	189	95
SSW01	232	159	276	225	261	282	286
SSW02	96	301	345	267	522	359	329
SSW04	58	201	265	251	313	369	270

Overall, runoff in these tributaries was lower than in recent years due to a later than normal spring runoff and below normal precipitation in late summer through the remainder of the season. Mean TP concentrations were similar to those observed in most recent years at SCE01, SSW01, and SSW02 and were lower than in recent years at SSW04 and SHE01. Phosphorus loads were lower than normal at all tributary monitoring sites due to the lower runoff and decreased TP concentrations. The phosphorus load at SSW04 of 773 lbs was lower than the goal that was established for the watershed of 1000 lbs and lower than loads in most previous years.

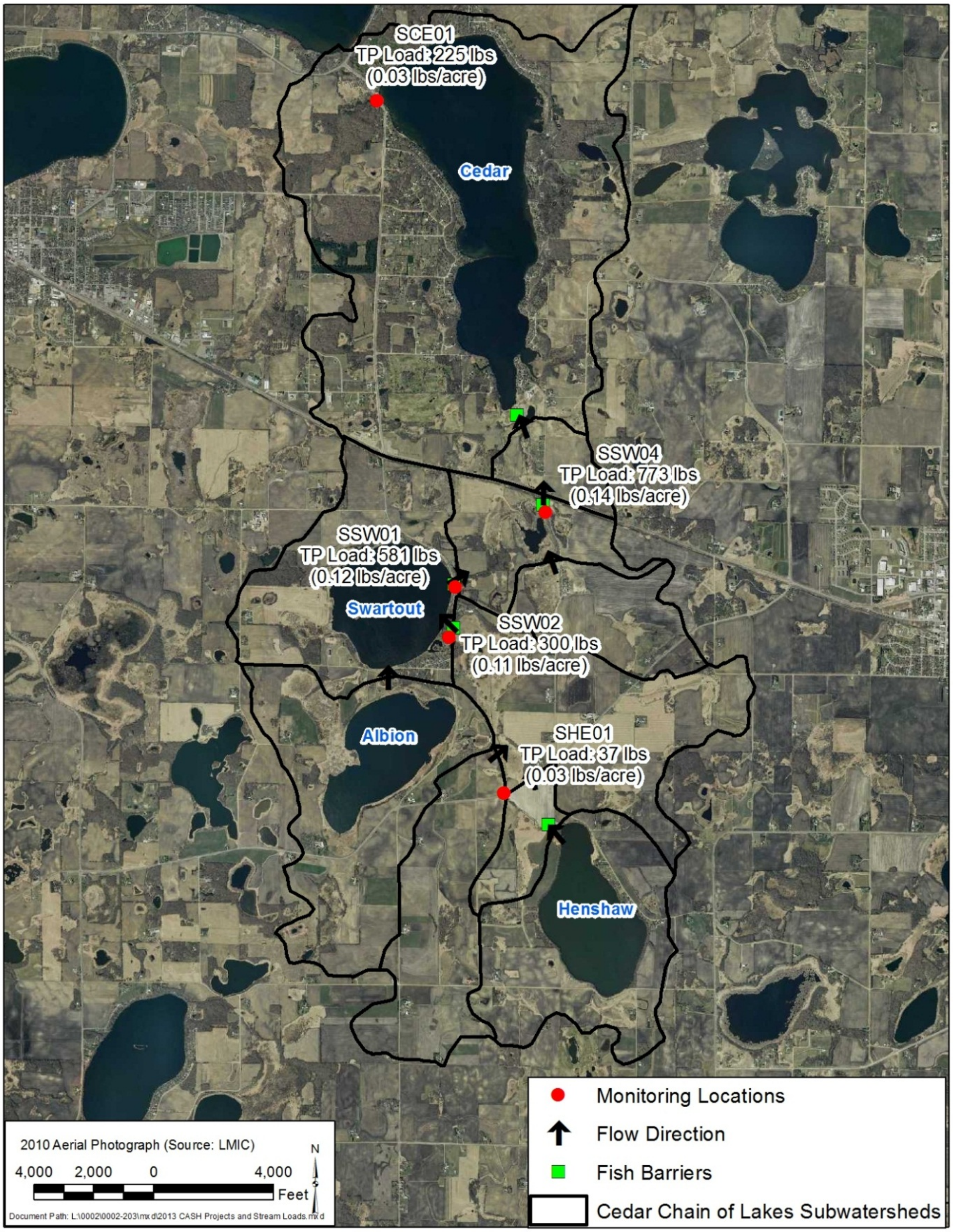
As demonstrated in Table 4.4, ortho-phosphorus made up a large proportion of the total phosphorus at SSW01, SSW04, and SSW02. This is an indication that the export of soluble phosphorus from wetlands and lakes in the sub-watersheds upstream of Cedar Lake is a significant contributor to the phosphorus load to Cedar Lake. Future proposed projects in this subwatershed target removal of ortho-phosphorus from wetland outflows.

Table 4.4 2013 Mean Phosphorus Concentrations and %TP as Ortho-P in Cedar Lake Sub-watershed

Site	Mean TP Concentration (ug/L)	Mean Ortho-P Concentration (ug/L)	%TP as Ortho-P
SHE01	95	28	29%
SCE01	33	6	18%
SSW04	286	152	53%
SSW02	329	126	38%
SSW01	270	151	56%

Phosphorus loads and phosphorus loading rates for the sub-watershed draining to each monitoring location are shown in Figure 4.5. This data demonstrates that the sub-watershed of the wetland draining into Swartout Lake at SSW02, Swartout Lake (SSW01), and the sub-watershed upstream of monitoring station SSW04 contributed the most phosphorus to the inflow to Cedar Lake in 2013.

Figure 4.5 2013 Stream Monitoring, Locations, Fish Barrier Locations, and Total Phosphorus Loads



4.2.3 Conclusions

Phosphorus loading from the subwatershed to Cedar Lake was lower than normal in 2013. A review of the 2013 phosphorus loading data demonstrates that a large proportion of the load to Cedar Lake is from Swartout Lake and the watershed of the wetland upstream of Swartout Lake to the southeast. The wetland downstream of Swartout Lake also appears to contribute phosphorus load to the inflow to Cedar Lake. Two projects are proposed to target the removal of soluble phosphorus in 2014 upstream of monitoring location SSW02 at the outlet of the wetland tributary to Swartout Lake and downstream of monitoring station SSW04.

The overall external phosphorus load to Cedar Lake, as measured at monitoring site SSW04, was 773 lbs in 2013, which is below the project goal of 1,000 lbs. Summer average phosphorus and Chlorophyll-*a* concentrations in Cedar Lake were similar to previous years and water quality was good throughout most of the summer in 2013. The continued improvement or stability of water quality in Cedar Lake demonstrates that the Project has been effective in recent years in reducing the external load of phosphorus to Cedar Lake during normal years and reducing the impacts on water quality of Cedar Lake during periods of high runoff. Proposed additional projects in 2014 target additional phosphorus removal necessary to reach the in lake phosphorus goal of 20 μg/L.

The monitoring results for this project over the last several years continue to highlight the connection of lake water quality to the status of fish and plant communities in Swartout, Albion, and Henshaw Lakes. This project has demonstrated that when addressing impairments in shallow lakes it is necessary to address the health of the biological communities in the lake. To improve the quality of shallow lakes, it is beneficial to restore the health of biological communities in the lake, including fish, plants, and zooplankton. Ideally, shallow lake management plans incorporating water level management to promote vegetation growth, and more intensive fish community management strategies, such as lake drawdowns or the application of Rotenone to promote rough fish kills, would be implemented. Efforts to implement some of these strategies have been met with some resistance on the part of land owners so the implementation strategies have been limited thus far to use of rough fish migration barriers and harvesting, and limited watershed BMPs.

The District received a grant in 2012 to construct iron sand filters at two locations in the watershed upstream of Cedar Lake to remove ortho-phosphorus from the flow to Cedar Lake. Plans were developed for these projects in 2013 and construction is proposed to begin on one of the projects upstream of Cedar Lake in 2014. The goal of these projects are to further reduce TP loads and address the high percentage of ortho-phosphorus observed in monitoring data in the watershed in 2013 and previous monitoring years.

5.0 Progress towards TMDL Water Quality Goals

The CRWD TMDL addresses water quality impairments in lakes and streams and identifies load reduction goals necessary to meet water quality standards. The CRWD Watershed Restoration and Protection Plan (WRPP/ TMDL Implementation Plan) was developed and approved by the MPCA in May of 2009. The 10-year plan identifies strategies and sets priorities to meet water quality goals in impaired waters.

The plan identifies the upper watershed (upstream of Lake Betsy) as the highest priority for implementing both capital projects and programmatic BMPs. Because of the flow-through nature of the Clearwater Chain of Lakes, the water quality in upper watershed lakes like Clear Lake and Lake Betsy are primary drivers of water quality in downstream lakes like Clearwater Lake. The loads from these upper watershed lakes and their tributary watersheds drive impairments in lakes further downstream. Clear Lake, Lake Betsy, and the tributary watersheds are targeted for intensive BMPs to not only improve water quality in those lakes, but to also reduce the load to downstream water bodies. All lakes will eventually be targeted, but the greatest impact will be made by initially focusing the efforts on improvements in the upstream end of the District and working downstream.

Each year, the Board and staff review this report, then conducts an annual planning session where the direction is set for the coming year. The planning session is based on projects identified in the comprehensive plan, as well as other opportunistic projects identified during the year. The following section summarizes implementation strategies undertaken since the plan was adopted year by year:

2009

- Prioritized 6 projects from the overall TMDL Implementation Plan
    - City of Kimball Stormwater Retrofit
    - Lake Betsy Internal Load Management
    - Watkins treatment area
    - Targeted Fertilizer Application Project
    - Kingston Wetland Restoration
    - Clear Lake South Sand Filter/ Weir
- Applied for grants for each of prioritized projects, received grant for Kimball stormwater
- Implemented agricultural BMPs identified in the TMDL Implementation Plan in upper watershed
- Conducted additional monitoring, including collection of lake bottom samples and sediment phosphorus release analysis in Clear and Betsy Lakes
- Education

2010

- Applied for received grant for Kingston Wetland Restoration and Targeted Fertilizer Application Project
- Applied for Watkins Area Restoration Grant and Lake Betsy Internal Load, grants not funded
- Applied for and received CCM funding for streambank restoration.
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted additional monitoring to fill in data gaps and continue to assess internal loading in District lakes
- Education

2011:

- Applied for and secured a grant for Kimball Stormwater Phase II
- Implemented BMPs identified in the TMDL Implementation Plan
- Applied for and received CCM funding for streambank restoration.
- Conducted supplemental water quality and hydrologic monitoring in accordance with recommendations of the implementation plan throughout the District to track progress and focus implementation efforts.
- Education

2012:

- Applied for and secured funding for 1 grant for two projects in the Cedar Lake Subwatershed:
    - Highway 55 project
    - Swartout Wetland Project
- Completed Clear Lake South Sand Filter/ Weir
- Implemented BMPs identified in the TMDL Implementation Plan
- Applied for and received CCM funding for streambank restoration.
- Conducted supplemental water quality and hydrologic monitoring in accordance with recommendations of the implementation plan throughout the District to monitor project performance and better focus implementation efforts.
- Education

2013

- Advanced implementation for priority projects
    - Completed design of Kimball Phase II stormwater retrofit; worked to complete permitting
    - Further developed feasibility for Betsy Lake Internal Load Management
    - Feasibility study of Lake Augusta Internal Load management options
    - Lake Augusta AIS Project

- Applied for and received CCM funding for streambank restoration.
- Secured funding for 20 CCM crew hours for stream bank stabilization for 2014.
- Implemented BMPs identified in the TMDL Implementation Plan
- Conducted supplemental water quality and hydrologic monitoring in accordance with recommendations of the implementation plan throughout the District to monitor project performance and better focus implementation efforts.
- Education

5.1 TMDL IMPLEMENTATION PROJECTS AND PROGRAMS

Through the process of implementation, priority projects and programs are identified and implemented. In 2009, five priority projects were developed to the concept stage in order to apply for grants. Project development was advanced on 2 priority projects: Lake Betsy and Clear Lake internal load management and Watkins Treatment area. Internal load management was also investigated on Lake Augusta due to landowner pressure. The alternatives reviewed were not favorable, no project was advanced from these efforts. Table 5.1 provides summary information for these projects and selected projects are described in more detail below.

To date, the CRWD has won grants for several major projects including:

- Kimball Stormwater Management Phase I & II
- Kingston Wetland and Clearwater River Feasibility Study and Wetland Restoration
- Protection and restoration of several stretches of the Clearwater River through MCC
- Gridded soil testing and GPS aided fertilizer applications for 16,000 acres in CRWD
- Cedar Lake Watershed Protection and Improvement Project

Table 5.1 Priority Implementation Projects

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
Watkins Impoundment	796	$645,882	Hold for grant funds: Land was acquired for this project. An initial grant application for $351,906 scored highly but was not selected in 2009 due to amount requested. Conducted additional feasibility work and completed another grant application which was not awarded. Will continue to seek grant funding for implementation in 2014.
City of Kimball Stormwater Management (Phase I)	244	$189,550	Secured grant funds and partner contribution from the City of Kimball. Construction of the project was substantially completed November 2010. Final grading, planting, and stabilization were completed in 2011. Follow up monitoring was conducted in 2012 and 2013.

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
City of Kimball Stormwater Reclamation and Reuse (Phase II)	118	$738,000	Secured grant funds in 2011. Completed design and permitting for project in 2013. Project scheduled to be constructed in 2014.
GPS Fertilizer Application	3,200	$871,000	Implemented field trial in 2010 on approximately 1,400 acres using District funds. Completed analysis of data gathered in 2010. Implemented on an additional 567 acres in 2011. Grant funding secured in 2011 for project to be conducted on 16,000 acres in the District. Contract was executed in 2012 and approximately 4,000 acres were enrolled in the project. 8,841 acres have been enrolled to date. Monitoring was conducted on tile outlets and tributary streams and ditches in the project area. Application of this program is recommended for expansion to the remainder of the watershed.
Lake Betsy Hypolimnetic Withdrawal	480	$315,000	Grant application was denied in 2011. Future grant applications are scheduled, as well as discussions with the department of agriculture.
Clear Lake Notched Weir	588	$75,000	Easement was secured for project in 2011. Permit applications were completed and submitted in December 2011. Project was constructed in 2012. Monitoring conducted in 2013.
Kingston Wetland Feasibility Study and Wetland Restoration	1,970	$739,000	A $404,300 grant was secured for this project. Stream monitoring and other data collection tasks began in Spring 2011. Data collection, modeling, and design were completed in 2012. The project was constructed in 2013 and monitoring was conducted to measure the success of the project.
Conservation Corps Streambank Restoration	TP load reduction associated with sediment load reduction	$65,275	Originally implemented in 2010 when work was Conducted along 2,800 linear feet of streambank. CRWD secured a $28,875 grant for the project from Conservation Corps Minnesota. Additional grant funding was secured in 2011 and work on 6,700 linear feet of stream channel was completed between 2011 and 2013.
Cedar Lake Watershed Protection and Improvement Projects	1,280	$554,200	The project targets reductions to the largest watershed sources of nutrient to Cedar and Swartout Lakes by installing iron sand filters to remove soluble phosphorus currently exported from degraded wetlands and lakes. The target is to size sand/iron filters to treat baseflow and the 1.25-inch event to provide the maximum cost/ benefit while preserving upstream hydrology. The projects target reductions from the largest watershed sources of nutrients to each lake providing 80% of the necessary watershed load reductions to Swartout Lake (800 lbs/yr), and 40% of the necessary watershed load reductions to Cedar Lake (480 lbs/ yr).

5.1.1 Watkins Impoundment

The proposed project is the construction of an impoundment on a 20-acre CRWD-owned parcel of land northeast of the city to treat runoff discharged from the city's storm drainage system. The impoundment would be created by constructing an earthen dike across the creek that runs west to east across the parcel. Two sub-watersheds totalling 740 acres of urban and agricultural land drains through this creek to a nearby ditch. A sheet pile weir with a V-notch outlet point would control discharge from the impoundment. The impoundment is sized to store runoff from the 0.5 inch event, which would provide an annual nutrient removal efficiency of 25%. The impoundment would also potentially provide some removal of bacterial load from the agricultural land and biological oxygen demand currently stressing the Clearwater River.

The filter consists of 3/4 inch to 3 inch diameter limestone wrapped in geotextile fabric and staked in place at the outlet of the structure. As the water passes through the filter, the phosphorus comes in contact with and binds to the calcium in the limestone, and is removed from the water.

No grant funds have been awarded for this project. CRWD will continue to develop the project and seek grant funding for this project.

5.1.2 City of Kimball Stormwater (Phase I)

This project targets phosphorus removal for Lake Betsy and protection of the Willow Creek trout habitat by collecting and infiltrating/ reusing stormwater runoff from 428 acres in and around the City of Kimball. Stormwater runoff from the City of Kimball drains untreated into Willow Creek, a trout stream. Willow Creek is tributary to Lake Betsy, which is impaired by excess nutrients.

It is estimated that this project will reduce phosphorus discharged to Willow Creek and Lake Betsy by 244 pounds annually, or about 3 percent of the 8,300 pound annual load reduction required for Lake Betsy. Kimball is one of two urban areas tributary to Lake Betsy, making it a targeted area for load reduction in the TMDL.

Completed Basin

A grant was awarded for this project in 2009 and construction began on the project in 2010, with substantial completion of construction that year. Final grading, planting, and stabilization of the basin and raingarden was completed in 2011. The project consists of a shallow basin to collect stormwater for irrigation of a near-by baseball field and infiltration to recharge shallow groundwater. The project also includes a rain garden with native plantings. Education and outreach curriculum centered on the project will be developed and implemented by the school district with support of CRWD staff.

CRWD staff conducted maintenance to improve the quality of the vegetation in the raingarden on the site. Continued vegetation maintenance in the raingarden and basin is planned for 2014.

5.1.3 City of Kimball Stormwater (Phase II)

This project is Phase II of the CRWD's plan to manage stormwater from the City of Kimball and reduce nutrient loading to impaired downstream waters. The project proposes to enhance water quality treatment and promote infiltration to recharge shallow groundwater by constructing shallow basins and an off-line filtration ditch to treat previously untreated stormwater from the City of Kimball before it flows into Willow Creek. The project will also recharge shallow groundwater and more closely mimic the area's natural hydrology, and will improve water quality and temperature in Willow Creek and reduce nutrient loadings to downstream lakes.

Phase I treated a portion of the City of Kimball's runoff. Phase II provides treatment for the 1.25 inch event for the remainder of the drainage areas from the City of Kimball to Willow Creek. It is estimated that this project will remove 118 lbs of phosphorus per year over a 35 year life cycle of the project. This project will also enhance the function of Phase I by allowing it to treat a higher volume from a smaller drainage area. The project will also improve the quality of wetlands to enhance the hydrology and habitat in the area and will convert upland areas to wetland to provide retention, filtration, and infiltration.

A grant was awarded for this project in December 2011. A conceptual project design was put together in 2012. Design and permitting was completed in 2013. The project is scheduled to be constructed in 2014.

5.1.4 GPS Fertilizer Application

Using grant funds secured in 2011, this project has a goal of enrolling up to 16,000 acres in the target watershed in a gridded soil testing and GPS fertilizer application project. The project includes systematic soil tests to determine nutrient concentrations and the proper amount of fertilizer to be applied in each field. The fertilizer is applied using GPS to apply the correct amount of fertilizer in each grid of the fields based on the results of the soil tests.

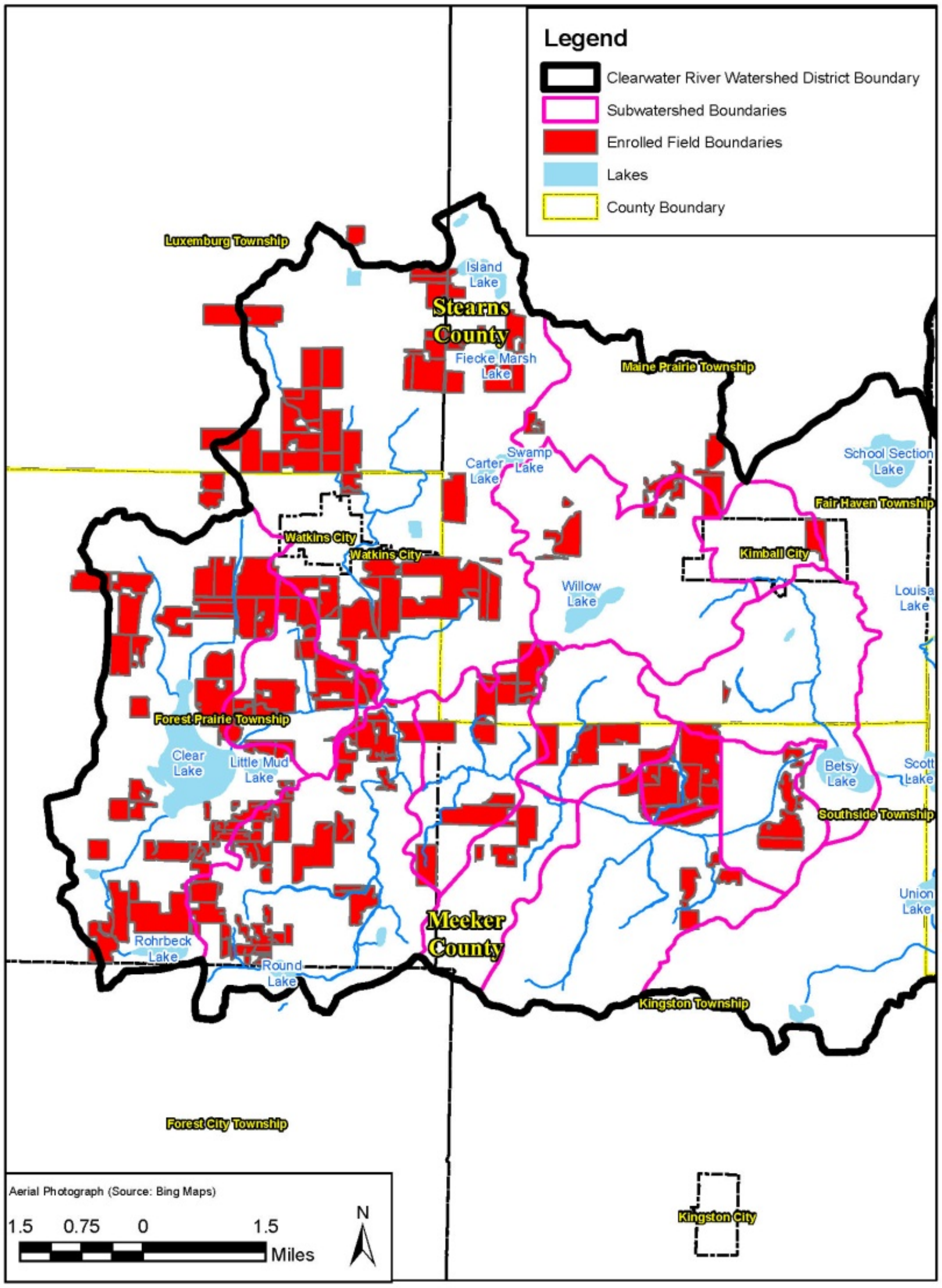
Prior to the implementation of the grant project, a field trial was conducted in 2010 in cooperation with the Litchfield Consumers Co-op and other partners on approximately 1,400 acres of priority cropland in the western portion of the District tributary to Clear Lake and Lake

Betsy. The priority cropland was identified by CRWD based on the proximity to water bodies, slope, and soil type. This field trial demonstrated the feasibility and utility of systematic soil testing in reducing fertilizer application and thus phosphorus load in agricultural runoff. A workplan was approved and a contract was executed for the grant in 2012. The CRWD began enrolling landowners in the program in 2012 and enrolled more landowners in 2013. Soil testing and fertilizer application was conducted in fall of 2012 and 2013.

The goal of the program is a 10% reduction in fertilizer application rates on selected priority cropland in the District resulting in a potential 3,200 lb annual reduction of phosphorus load in the watershed tributary to Lake Betsy. It is estimated that the program could potentially translate into a 10% to 50% reduction in phosphorus runoff from the watershed.

To date, 7,414 acres have been enrolled in the program, representing 54% of cropland in the watershed tributary to lake Betsy (See Figure 5.1), with an additional 8,000 acres scheduled for enrollment in 2014.

Figure 5.1 Enrolled Fields through 2013



In 2013, water quality monitoring was conducted at drain tile outlets and drainage ditches from enrolled fields as well as in non-enrolled fields. Automated sampling equipment was installed at one site that was enrolled in the program and at a non-enrolled site. The automated sampling equipment was used to collect composite samples during precipitation events and to record continuous water level.

Monitoring data collected in 2013 will be further analyzed to compare results from different sites using variables such as program enrollment in the watershed tributary to the monitoring site, watershed area, flow, and soil types. The CRWD will also continue to monitor in-lake water quality and watershed loads in the Clearwater River to further track the success of the project. The results will be publicized to encourage wider application of this technique.

Although all application data from the project has not been received and compiled, data from 55% of the project was compiled in 2013. Overall, review of the fertilizer application data indicated that the GPS application of fertilizer based on gridded soil testing did not result in a significant overall reduction in fertilizer applied. However, the GPS application of fertilizer resulted in the fertilizer being applied at the appropriate rates and not overapplied in sensitive areas shown to have high soil phosphorus concentrations by the gridded soil testing conducted as part of the project. Conclusions drawn from this initial review of the data indicate that there was a 46 ton reduction in phosphorus fertilizer application in sensitive areas, which are those areas often associated with farmed wetlands or adjacent to topographically low areas where soil testing found higher soil phosphorus concentrations.

5.1.5 Lake Betsy Hypolimnetic Withdrawal

This proposed project would pump nutrient-rich water from the lake hypolimnion and use it to irrigate a nearby farm field. A field trial including intensive monitoring is proposed to be completed to evaluate the effectiveness of the BMP in reducing internal load. Lake inflows and outflows will be monitored for flow and quality, while weekly temperature and dissolved oxygen profiles and bi weekly nutrient profiles will be taken to evaluate impact on lake water quality. Volume and timing of withdrawals will be tracked to estimate load reduction.
The proposed project will assess the cost-effectiveness of lake hypolimnetic withdrawal and irrigation as an internal phosphorus load management BMP, and evaluate its transferability to lakes in the Clearwater River Watershed District and elsewhere.

This project has not received grant funding to date. The CRWD continued to conduct monitoring on Lake Betsy to better quantify internal nutrient loading in the lake in 2012 and 2013. This project was re-evaluated for implementation in 2013 and grant applications will continue to be submitted.

5.1.6 Clear Lake Notched Weir/ Iron Sand Filter

The project detains water at a notched weir on a Clear Lake tributary stream south of the lake. This will allow particulate phosphorus to settle out of agricultural runoff before discharging to Clear Lake and a portion of the water to filter through in iron/ sand filter. Since monitoring data indicated that a large proportion of the total phosphorus consists of soluble phosphorus, it was recommended that a soluble phorphorus filter be included with the project. As a result of this recommendation, a sand-iron filter was included in the project design to remove soluble phosphorus from the tributary inflow. The targeted load reduction for this project is 588 pounds of phosphorus annually. The phosphorus load removed through the proposed project represents a significant component of the required load reduction from watershed sources to Clear Lake. The imoundment temporarily detains and filters water from smaller runoff events while allowing controlled overflow of stormwater during larger storm events.

The District secured an easement on the property in 2011. The District also completed the design and permit applications were approved by local, state, and federal regulatory agencies in January 2012. The project was constructed in December 2012. Monitoring was conducted in the tributary stream downstream of the project in 2013. Backwater conditions in the channel between the project site and Clear Lake in 2013 may have reduced filtration during a portion of the year. Monitoring results collected at this site indicate that phosphorus concentrations were lower in 2013 than in previous years.

5.1.7 Kingston Wetland Feasibility Study and Restoration

The Kingston Wetland Feasibility Study and Restoration Project was desiged to restore main channel dissolved oxygen concentrations in the Clearwater River and reduce the seasonal export of soluble phosphorus to impaired lakes while maintaining particulate phosphorus sequestering capacity, and improve stream and wetland habitat and ecology.

Data collected in year 1 following construciton show improvements in DO were achieved by mitigating sediment oxygen demand in the wetland complex. The project also targets a 1,970 lb/year phosphorus reduction to downstream lakes by preventing soluble phosphorus export from the riparian wetland.

A feasibility study was prepared in June of 2012 and permit applications were prepared and submitted to local, state, and federal agencies for approval. Construction began on the project in late January 2013 and was completed in March 2013. Wenck and District staff observed the construction and documented that the construction was completed according to plans.

Photographs of the project area prior to construction, during construction, and following the completion of construction are found in Appendix I. As docmented in the field and shown in the photographs, the meandering channel was constructed as designed and was sufficiently restored following the completion of construction. Erosion control measures that were installed along the constructed banks were sufficient to prevent significant erosion from the streambanks. The banks were seeded and mulched following the completion of construction and vegetation cover was successfully established within the entire reach of the project area by early summer 2013.

A comparison of the project area prior to construction and after construction is shown below in Figure 5.2 and Figure 5.3

Figure 5.2 Post-Construction View of Kingston Wetland Project Area (2013 Aerial Photograph)

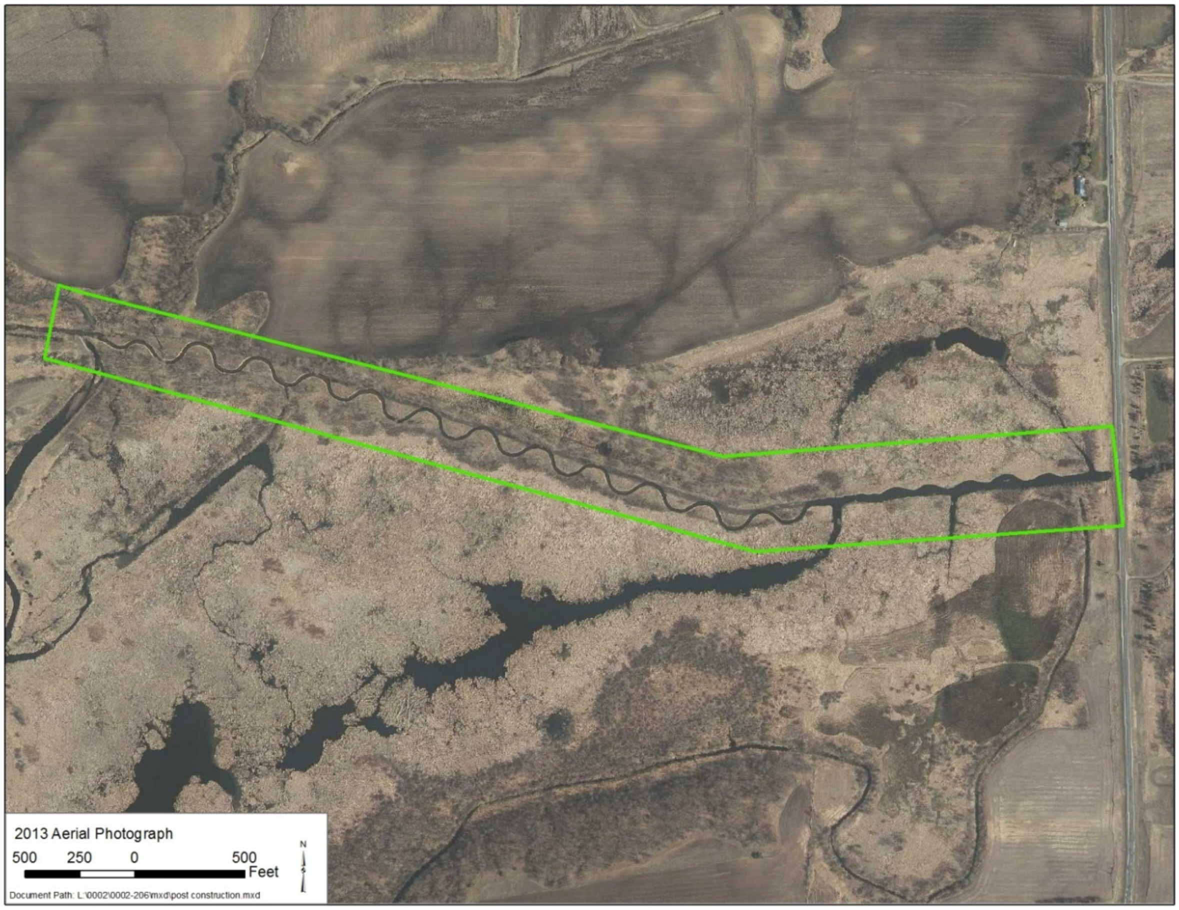
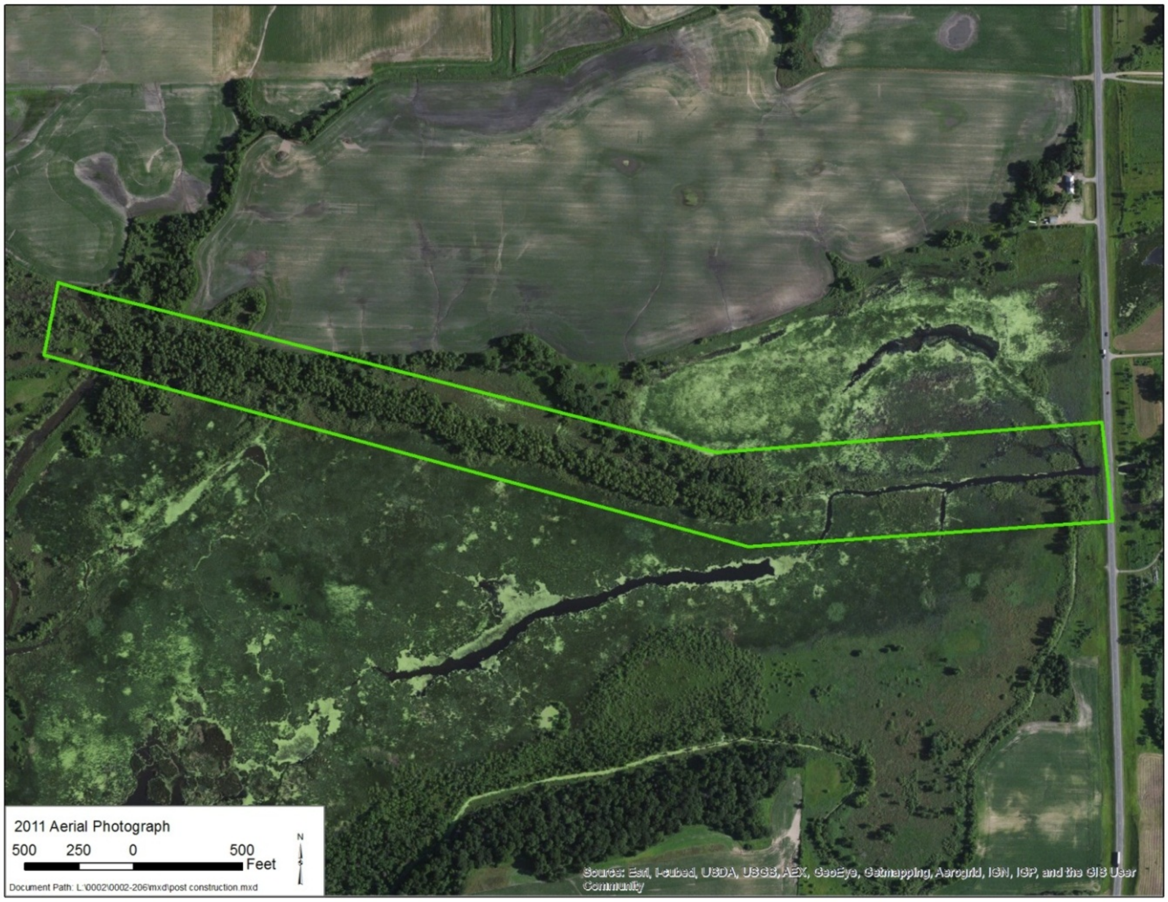


Figure 5.3 Pre-Construction View of Kingston Wetland Project Area (2011 Aerial Photograph)



Water quality monitoring was conducted upstream of the project area at monitoirng site CR29 and downstream of the project area at monitoring site CR28.2 in 2013. The monitoring results were compared to monitoring results from 2006 and 2011 at CR29 and 2006, 2011, and 2012 at CR28.2. A summary of monitoring data for comparison is found in Appendix J.

Monitoring data was evaluated to measure the success of the goal of the project of reducing the export of soluble phosphorus from the wetland and improving dissolved oxygen concentrations in the Clearwater River. In general, TP concentrations at the downstream monitoring location were lower in 2013 than in most previous years with similar flows. TP concentrations and the proportion of TP comprised of ortho-phosphorus were similar from upstream of the wetland to downstream, indicating a reduction in phosphorus export from the Kingston wetland to the Clearwater River in comparison to previous years.

Dissolved oxygen concentrations were improved in the Clearwater River downstream of the Kingston Wetland in 2013, as DO concentrations remained above the impairment standard for most of the year, with the exception of late summer, when zero flow conditions and warm water contributed to a sag in DO concentrations. This is in comparison to 2011 and 2012, when DO concentrations were below the impairment standard for the entire period from June to October across ranges of high and low flows.

Monitoring will be conducted in 2014 to evaluate the improvement of aquatic habitat within the restored stream reach. Macroinvertebrate samples will be collected and analyzed for comparison to samples that were collected prior to the restoration. Water quality monitoring will continue to be conducted upstream and downstream of the project area to continue to track the progress of reaching the project goals.

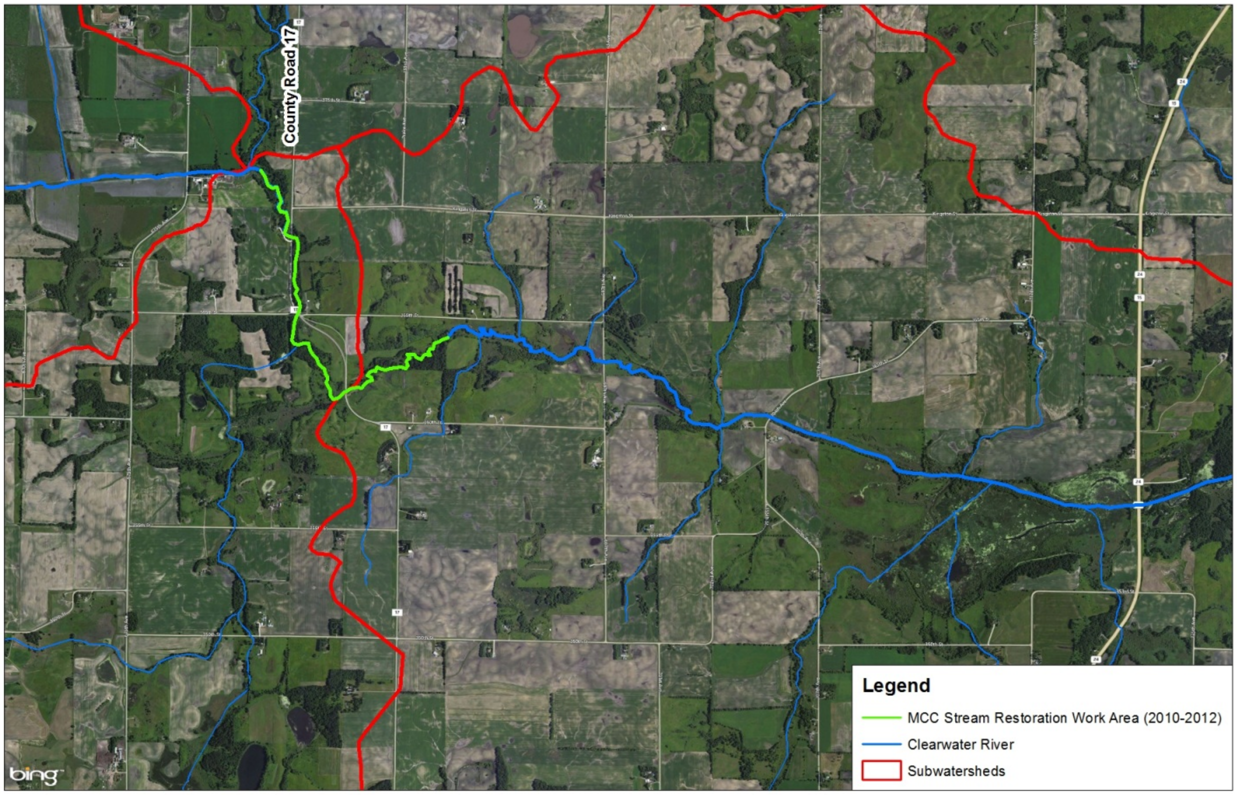
5.1.8 Clearwater River Channel Stabilization

The purpose of this project, which began in 2010, is to stabilize the channel and banksof the Clearwater River. The CRWD has prioritized areas for restoration with extensive tree canopy which does not allow for the growth of stabilizing ground vegetatation.These areas are subject to sloughing and incision of the channel banks. The outcomes of the project are to stop soil loss from the bank area by restoring vegetation, stop soil loss from the channel by installing bank toe protection and grade control, and installing grade control structures that will aerate water.

The Conservation Corps crews began work in 2010 and were responsible for thinning trees, building and installing brush bundles, fabricating grade control structures from felled logs, live stake harvesting and installation, seeding slopes, and installing erosion control fabric along approximately 2,800 linear feet in the project area. The CRWD conducted similar work in 2011 on an additional 6,700 linear feet of stream channel of the Clearwater River. In 2012, the CRWD continued working in the same general area by working on an additional 1,800 linear feet of channel and repairing damaged areas within the reaches worked on in previous years. Figure 5.4 shows the channel stabilization project area since 2010. Reference photos showing a representative of the streambank before and after the work was completed were taken and are shown below.

The project has given the CRWD the opportunity to work with willing landowners along the Clearwater River. CRWD plans to continue finding additional landowners to continue this project with the CCM in future years.

Figure 5.4 CCM Channel Stabilization Project Area



5.1.9 Expanded Lake Water Quality Monitoring

Samples were collected near the bottom at Augusta, Caroline, Louisa, Marie, Scott, and Union Lakes in 2013 and analyzed for total phosphorus, ortho-phosphorus, and total iron. A summary of surface and bottom phosphorus concentrations, bottom iron concentrations, and a DO/temperature profile at each lake for each monitoring date is found in Appendix G. A summary of bottom phosphorus data collected at each lake since 2009 is found in Appendix K. A summary of current and historical lake data is also found on the lake report cards in Appendix C.

Analysis of these parameters in bottom samples is helpful in estimating internal nutrient cycling in lakes. In-lake nutrient cycling is an important component of the whole lake nutrient budget. Phosphorus builds up in lake-bottom sediments due to increases in phosphorus load export from the tributary watershed.

Lake profile data, in which temperature and dissolved oxygen were recorded at 1 meter increments in each lake helps to identify the period of stratification in lakes. This data also allows quantification of the period of anoxia, defined as dissolved oxygen levels less than 2 mg/L, in each lake. Internal loading can be a result of sediment anoxia, where weakly bound phosphorus is released into the water column in a form readily available for phytoplankton production.

Review of the lake profile data collected in 2013 demonstrates that most lakes that typically stratify were stratified in early June and remained stratified through September.

Table 5.2 provides a summary of conditions in CRWD lakes which can be used to determine the potential for in-lake nutrient cycling in each lake sampled in 2013. Generally, lakes which have high bottom phosphorus concentrations and periods of anoxia from stratification are susceptible to internal nutrient cycling. Lake stratification patterns identified in Table 5.2 vary between water bodies. Lake stratification can drive anoxia, which can drive internal loading in deeper lakes. Identifying the stratification and anoxic period can guide design of efforts to reduce internal loading.

Table 5.2 2013 Summer Average Concentrations and Lake Stratification Patterns

Lake Name	Surface Summer Average TP (µg/L)	Surface Summer Average OP (µg/L)	Bottom Summer Average TP (µg/L)	Bottom Summer Average OP (µg/L)	Lake Stratification Pattern
Albion	160	5	Not Sampled		Mixed
Augusta	38	10	763	626	Strongly Stratifies
Bass	11	5	Not Sampled		Strongly Stratifies
Betsy	124	65	Not Sampled		Weakly Stratifies
Caroline	52	13	1963	1518	Strongly Stratifies
Cedar	25	6	Not Sampled		Strongly Stratifies
Clear	152	45	Not Sampled		Polymictic
Clearwater East	21	6	Not Sampled		Strongly Stratifies
Grass	22	8	Not Sampled		Stratifies
Henshaw	81	34	Not Sampled		Mixed
Louisa	73	21	979	714	Strongly Stratifies
Marie	96	11	1925	1598	Stratifies
Nixon	14	6	Not Sampled		Stratifies
Pleasant	21	Not Sampled			Stratifies
School Section	17	6	Not Sampled		Polymictic
Scott	122	22	217	88	Polymictic
Swartout	262	132	Not Sampled		Polymictic
Union	32	7	636	139	Strongly Stratifies

Mixed and Polymictic: In mixed water bodies, water temperature is fairly uniform from top to bottom in the lake. As a result, oxygen enriched water from near the surface is able to mix throughout the water column, and anoxia is typically not present. Polymictic lakes are lakes that develop a weak stratification and mix periodically throughout the growing season. As a result of the frequent mixing, anoxic conditions would likely occur infrequently.

Stratified: In stratified lakes a warm surface layer forms during summer months and the lake maintains a cooler lower layer in the lake and prevents mixing between the two layers. This does not allow oxygen enriched water to reach the bottom layer and anoxia can develop below the thermocline.

Lakes with high bottom phosphorus concentrations that experience anoxic conditions during periods when the lake is stratified have a high potential for internal loading. Lakes with the highest bottom concentrations of phosphorus in 2013 include Caroline, Louisa, Marie, and Union. Based on the presence of high bottom phosphorus concentrations, lake stratification patterns, and associated periods of anoxia during a given year, these lakes have a high potential for internal loading. Shallow lakes such as Henshaw, Albion, Swartout, and Clear can load internally throughout the season based on disturbance of bottom sediments from wind and rough fish.

As shown on the Lake Report Cards in Appendix C and in Lake Phosphorus and Profile Data in Appendix G, the bottom phosphorus concentrations in most lakes generally increased throughout the summer in 2013 as anoxic conditions developed in these lakes in early summer. This is especially evident in Augusta, Louisa, Marie, and Union Lakes. The bottom phosphorus concentrations in these lakes typically decrease after mixing with the entire water column during fall turnover. This pattern of seasonal increase in bottom phosphorus concentrations is evident in most years as shown in Appendix K, which compares bottom phosphorus concentrations in District Lakes since 2009.

Appendix A

2013 Water Quality Monitoring Program

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Business Professionals

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TECHNICAL MEMORANDUM

TO: Clearwater River Watershed District Board of Managers

FROM: Norman C. Wenck, Engineer for the District

DATE: February 13, 2013

SUBJECT: Proposed 2013 Water Quality Monitoring Program

Introduction

The Clearwater River Watershed District conducts its annual water quality monitoring at selected lakes and locations on streams. The proposed 2013 program is intended to assess District progress towards water quality goals and to track long-term water quality trends. The monitoring program also tracks the performance of water quality improvement projects implemented by the District.

Please note that additional sites will be monitored in the upper watershed in 2013 as part of the GPS Fertilizer Application Project and Kingston Wetland post-construction monitoring.

The 2013 proposed monitoring stations are shown on Figure 1. The 2013 proposed lake monitoring follows the long-term plan as shown in Table 1. The proposed monitoring sites together with a proposed schedule and laboratory and field parameters are shown in Table 2.

Lake Monitoring

It is recommended that the District's 2013 lake monitoring include the 13 lakes shown on Table 1, including Clearwater East, Augusta, Louisa, Caroline, Scott, Marie, School Section, Nixon, Union, and Grass Lakes. Surface water samples should be collected at all of the sampled lakes. Bottom samples should be collected in Augusta, Louisa, Marie, Caroline, Scott, and Union Lakes to track internal loading in these lakes.

The proposed stations and the parameters to be monitored are shown on Table 2.

Clear Lake and Lake Betsy will be monitored from May to September as part of the Fertilizer Application Project.

Stream Monitoring

The Clearwater River will also be monitored once a month from March-October at long –term monitoring station CR 10.5 at the Grass Lake Dam. Warner Creek will be monitored once a month at long-term monitoring station WR 0.2 from March-October.

These stations will be monitored for water quality and flow. Water quality parameters are total phosphorus, ortho-phosphorus, and total suspended solids.

The Clearwater River will be monitored twice a month from March-October at long-term monitoring station CR28.2 and CR 30.0 as part of the Kingston Wetland Restoration Project. As shown in Figure 1, several other stream locations in the upper watershed will be monitored as part of the Fertilizer Application Project in 2013.

Cedar Lake Subwatershed Monitoring
Monitoring conducted in the Cedar Lake Subwatershed will continue in 2013. Surface water quality samples and temperature/dissolved oxygen profile data should be collected from Cedar, Albion, Henshaw, and Swartout Lakes in 2013. Tributary streams in the Cedar Lake subwatershed will also be monitored in five locations while they are flowing from March to October.

It is also recommended that the District continue to conduct aquatic vegetation surveys in Albion, Henshaw, and Swartout Lakes in 2013. The vegetation surveys should be conducted in early summer in order to quantify the extent of curly leaf pondweed in these lakes, as well as track the overall vegetation coverage and species in each lake to compare to surveys conducted in previous years.

Estimated Cost
The proposed basic monitoring program is estimated to be funded by an estimated $11,500 from the 1980 Project and $8,500 from the Data Acquisition Fund. An estimated 240 hours of CRWD staff time will be required to complete these monitoring tasks. The Cedar Lake Subwatershed monitoring is estimated to cost $5,200 plus an estimated 80 hours of CRWD staff time.

Recommended Supplemental Monitoring
In addition to the basic program, it is recommended that supplemental monitoring efforts be considered in 2013. The proposed supplemental monitoring efforts would allow the District to track the success of individual projects or to investigate specific water quality concerns.

Supplemental Monitoring Task 1: Maintain continuous level measurement station at Grass Lake Dam.
It is recommended that the District continue the continuous level measurements of the Clearwater River at the Grass Lake Dam. The collection of this data, which began at this site in Summer 2012, will enable the calculation of continuous flows over the dam and allow for better characterization of runoff in the watershed. The approximate cost of this task which includes installation of the equipment and data management is $500 plus 20-24 hours of CRWD staff time.

Supplemental Monitoring Task 2: Additional monitoring at Willow Creek.
It is recommended that the District continue to collect samples and monitor flow in Willow Creek at two locations, one upstream and one downstream of the City of Kimball. This monitoring will allow the quantification of the water quality benefits of Phase I and Phase II of the City of Kimball stormwater projects. The sites should be monitored monthly from March-October with an additional 2 events during storms. The cost of this task is approximately $1,200 plus an additional 20-24 hours of CRWD staff time.

Supplemental Monitoring Task 3: Contingency stream monitoring.

This supplemental monitoring task would involve collecting up to 2 additional samples from routine monitoring stations CR 28.2, CR 10.5, and WR 0.2 during high runoff periods following significant precipitation events. Flows would also be monitored during these events. This task also includes the budget to collect up to 4 additional samples in the watershed to document unique events observed by CRWD staff, such as runoff from feedlots or other discharges to water bodies that have previously gone unmonitored. The approximate cost of this task would be $750 plus 18-24 hours of CRWD staff time.

Summary

The proposed monitoring program continues the program in place since 1981, coordinates with other programs, and reflects input from the Board and citizens. Please feel free to call me at 763-479-4201 or Rebecca Kluckhohn at 763-479-4224 with any questions or comments that you may have.

TABLE 1
PROPOSED LONG-TERM WATER QUALITY MONITORING PLAN FOR CRWD LAKES

LAKE STATIONS	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Clearwater Lake:										
Clearwater East	DNR		X		X		X		X	
Clearwater West	DNR	X		X	X	X		X		X
Main Stem Lakes:										
Augusta	DNR		X		X	X*	X	X	X	X
Louisa	TMDL/ DNR	TMDL*	X		X	X	X	X	X	X
Caroline	DNR	X		X	X	X	X	X	X	X
Scott		X		X	X	X*	X	X	X	X
Marie	DNR	X*		X	X	X	X	X	X	X
Betsy	X		X		X*	X	X	X	X	X
Other Lakes:										
Cedar	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Pleasant	MPCA		X	X(3)	X	X		X		X
School Section			X		X		X		X	
Nixon			X	X	X		X		X	
Otter			X		X			X		
Bass	MPCA/ DNR	X		X(3)	X		X		X	
Clear	X			X	X*	X	X	X	X	X
Union	MPCA			X	X	X	X	X	X	X
Henshaw	X		X	X(2)	X(2)	X(2)	X(2)	X	X	X
Little Mud		X			X			X		
Wiegand	X				X			X		X
Swartout	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Albion	X	X		X(2)	X(2)	X(2)	X(2)	X	X	X
Grass	DNR			X	X		X		X	X
Number of Lakes Monitored W/ CRWD Funding	17	10	9	14	22	14	17	17	17	16

Note:

(2) Part of Project #06-1

(3) Added to assess trends

* Lake bottom sediment cores collected and analyzed

TABLE 2
Proposed 2013 CRWD Monitoring Plan Summary

Category	2012 Schedule	Station	Parameters
Lakes:	June 3-7, July 8-12, August 5-9, September 2-6 Note: (Lake sampling to be completed by September 15)	The CRWD will monitor Clearwater (East), Augusta, Louisa, Caroline, Scott, Marie, School Section, Nixon, Bass, Union, Grass. Cedar, Albion, Swartout, and Hensaw Lakes will be monitored under Project #06-1. Clear and Betsy will be monitored under the Fertilizer Application Project.	Field: Secchi depth, DO and temperature profiles.
			Lab: surface samples for total phosphorus, ortho phosphorus, and chlorophyll-a Bottom samples for total phosphorus, ortho phosphorus, and total iron in selected lakes.
Streams:	Twice monthly March-October	CR 28.2 and CR 30.0 (monitored under Kingston Wetland Project)	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids, E. coli
	Monthly March-October	CR 10.5	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids,
	Monthly March-October	Warner Creek at WR0.2; Willow Creek at WC 2.5 and WC 3.0	Field: flows, DO and temperature Lab: total phosphorus, ortho phosphorus, total suspended solids,
	Monthly March-October	Clear Lake North, Clear Lake South, CD 20 1.1 and CD20 1.2 (monitored under Fertilizer Application Project)	
	Continuous Water Level	River Stage at CR10.5, CR28.2, and CR30.0	
Precipitation:	Daily	Corinna, Kimball, Watkins	
Cedar Lake Tributaries	Monthly while streams are flowing from March-October	The CRWD will monitor stream tributary sites SSW01, SSW02, SSW04, SCE01, and SHE01	Tributaries Field: DO, temperature, conductivity, pH ; Lab: total phosphorus, ortho phosphorus, TSS
		Flows will also be gauged at lake outlet sites (SSW01, SHE01, and SCE01) on days when lake samples are collected in Swartout, Henshaw, and Cedar Lakes.	

Appendix B

Historical Mean Flow and Phosphorus Loading

APPENDIX B Table B-1
Historical Mean Flow and Phosphorus Loading

Clearwater River Watershed District

2013 Annual Report

Station Main Stem:	Year	Average Stream Flow (cu m/sec)	(cfs)	Flow-Weighted Average Total Phosphorus Concentration (mg/L)	Total Phosphorus Load (kg)	(lb)	µg/L
CR 28.2	1981 (1)	--	--	1.400	--	--	1,400
	1981						
(Actual River	1982 (1)	0.93	32.8	0.740	19,700	43,500	740
Mile 27.2)	1983	2.62	92.6	0.920	76,000	168,000	920
	1984	1.49	52.6	0.760	35,700	78,800	760
	1985	2.32	81.9	0.900	65,500	144,000	900
	1986	3.20	113	0.780	55,200	122,000	780
	1987	0.11	3.90	0.130	460	1,020	130
	1988	0.09	3.12	0.660	1,850	4,080	660
	1989	0.02	0.72	0.190	120	260	190
	1990	0.51	18.0	0.440	7,040	15,500	440
	1991	1.11	39.1	0.290	10,200	22,500	290
	1992	0.26	9.30	0.200	1,660	3,650	200
	1993	1.28	45.2	0.290	11,600	25,600	290
	1994	1.17	41.2	0.280	10,100	22,300	280
	1995	1.15	40.4	0.288	10,400	22,900	288
	1996	0.33	11.7	0.274	2,860	6,300	274
	1997	0.27	9.36	0.260	2,170	4,790	260
	1998	0.41	14.4	0.250	3,190	7,020	250
	1999	0.08	2.78	0.160	400	870	160
	2000	0.02	0.72	0.380	240	530	380
	2001 (4),(5)	0.27	9.46	0.510	4,309	9,500	510
	2002	0.47	16.50	0.291	4,290	9,460	291
	2003	0.28	9.92	0.190	1,710	3,770	190
	2004	0.48	17.04	0.166	1,248	2,751	166
	2005 (6)	1.11	39.28	0.306	1,862	4,105	306
	2006	0.31	11.10	0.130	1,328	2,928	130
	2007	0.14	5.02	0.228	767	1,692	228
	2008	0.64	22.53	0.155	1,333	2,938	155
	2009	1.15	40.60	0.333	7,982	17,597	333
	2010	1.55	54.60	0.258	10,866	23,955	258
	2011	2.62	92.66	0.269	13,593	29,967	269
	2012	1.01	35.72	0.335	6,096	13,440	335
	2013	0.55	19.38	0.252	2,261	4,984	252
CR 10.5	1981 (1)	1.15	40.6	0.050	2,060	4,550	50
	1982 (1)	2.20	77.8	0.070	4,990	11,000	70
	1983	5.64	199	0.100	18,500	40,800	100
	1984	4.28	151	0.050	6,620	14,600	50
	1985	3.88	137	0.140	16,700	36,800	140
	1986	5.52	195	0.150	23,700	52,300	150
	1987	0.46	16.2	0.040	600	1,320	40
	1988	0.23	7.95	0.040	260	580	40
	1989	0.97	34.2	0.080	2,340	5,150	80
	1990	3.77	133	0.030	3,060	6,750	30
	1991	6.68	236	0.050	10,500	23,200	50
	1992	4.16	147	0.060	8,090	17,800	60
	1993	5.01	177	0.040	6,330	14,000	40
	1994	2.92	103	0.030	2,850	6,290	30
	1995	2.83	100	0.034	3,040	6,710	34
	1996	1.53	54.2	0.041	1,970	4,350	41
	1997	2.06	72.8	0.040	2,690	5,940	40
	1998	1.78	63.0	0.040	2,330	5,120	40
	1999	1.25	44.1	0.040	1,520	3,350	40
	2000	0.31	10.8	0.030	280	610	30
	2001 (4),(5)	0.90	31.7	0.030	850	1,873	30
	2002	2.46	87.0	0.035	2,950	6,500	35
	2003	2.11	74.6	0.024	1,590	3,500	24
	2004	1.66	58.8	0.022	639	1,409	22
	2005 (6)	3.05	107.6	0.023	59	130	23
	2006 (6)	1.76	62.2	0.032	1,263	2,785	32
	2007	0.97	34.1	0.031	933	2,057	31
	2008	1.27	44.8	0.023	452	997	23
	2009	3.99	141.0	0.025	1,949	4,297	25
	2010	6.16	217.5	0.032	4,150	9,149	32
	2011	9.20	325.1	0.026	4,645	10,240	26
	2012	2.59	91.37	0.024	1,365	3,009	24

APPENDIX B Table B-1
Historical Mean Flow and Phosphorus Loading

Clearwater River Watershed District

2013 Annual Report

Station Main Stem:	Year	Average Stream Flow (cu m/sec)	(cfs)	Flow-Weighted Average Total Phosphorus Concentration (mg/L)	Total Phosphorus Load (kg)	(lb)	µg/L
CR10.5 (cont.)	2013	2.16	76.50	0.024	959	2,115	24
WR 0.2 (2)	1981 (1)	0.07	2.60	0.170	390	860	170
	1982 (1)	0.23	8.20	0.160	780	1,720	160
	1983	0.47	16.50	0.090	1,270	2,800	90
	1984	0.60	21.20	0.050	950	2,100	50
	1985	0.48	17.10	0.140	2,130	4,700	140
	1986	0.86	30.40	0.200	4,630	10,200	200
	1987	0.04	1.50	0.070	100	230	70
	1988	0.01	0.40	0.170	60	130	170
	1989	0.03	1.19	0.140	80	180	140
	1990	0.06	2.28	0.370	750	1,660	370
	1991	0.26	9.22	0.111	860	1,900	111
	1992	0.11	4.02	0.050	170	370	50
	1993	0.24	8.59	0.100	760	1,670	100
	1994	0.18	6.34	0.060	320	700	60
	1995	0.12	4.27	0.054	210	460	54
	1996	0.05	1.78	0.110	180	380	110
	1997	0.09	3.15	0.077	220	480	77
	1998	0.09	3.11	0.110	290	650	110
	1999	0.06	2.03	0.070	130	280	70
	2000 (3)	0.01	0.44	0.060	25	56	60
	2001 (4),(5)	0.08	2.88	0.100	257	567	100
	2002	0.26	9.17	0.114	930	2,060	114
	2003	0.16	5.79	0.062	320	710	62
	2004	0.07	2.6	0.063	78	172	63
	2005	0.58	20.6	0.066	22	48	66
	2006	0.06	2.1	0.090	102	224	90
	2007	0.03	0.9	0.064	34	76	64
	2008	0.31	11.1	0.058	246	542	58
	2009	0.15	5.3	0.087	273	602	87
	2010	0.16	5.6	0.095	311	685	95
	2011	1.12	39.47	0.105	2,202	4,854	105
	2012	0.48	17.08	0.049	371	818	49
	2013	0.49	17.37	0.052	240	529	52

NOTES:

Flow values are time-weighted averages unless otherwise noted.

Total phosphorus values are flow- and time-weighted averages unless otherwise noted.

(1) Values in 1981 and 1982 are arithmetic means
(2) Station WR 0.2 was designated Station WC 0.2 in 1981-1983
(3) Phosphorus values in 2000 are flow-weighted and adjusted per log-log regression on flow so as to correspond to annual mean flows.
(4) 2001 Flow and total phosphorus values are arithmetic averages.
(5) 2001 total phosphorus loads estimated from arithmetic averages of flow and total phosphorus values.
(6) Values in 2005 and 2006 were calculated using supplemental flow data from CSAH 40 near Clearwater

T:\0002\203_2013 Water Quality Monitoring\Water Quality Data\[Stream_Loads_Historic_13.xls]Table 2

Appendix B-TABLE B-2

YEARLY PRECIPITATION AND RUNOFF TOTALS

Clearwater River Watershed District

2013 Annual Report

Precipitation (inches of water)

YEAR	Watkins	Kingston	Maine Prairie	Corinna	Area-Weighted Precipitation Average	Runoff (inches)
1981	--	--	--	--	19.76	(1) 3.6
1982	--	--	--	--	24.58	(1) 6.8
1983	46.54	--	42.32	35.02	41.78	17.4
1984	32.23	30.13	32.37	36.07	32.95	13.3
1985	40.72	39.49	45.28	--	42.22	12.0
1986	40.02	35.63	39.68	33.40	37.26	16.0
1987	18.97	15.40	19.41	16.16	17.52	1.4
1988	16.57	18.98	15.96	15.01	16.48	0.7
1989	22.13	22.68	21.80	16.96	20.68	3.0
1990	40.35	39.18	41.36	32.18	37.94	11.7
1991	41.30	45.11	43.41	36.28	41.01	20.7
1992	23.06	18.41	20.47	24.35	22.01	12.9
1993	40.17	35.27 (2)	37.54 (2)	33.33	36.71	15.5
1994	34.77	--	30.13	30.26	31.98	9.0
1995	33.80	--	33.65	28.66	32.21	8.8
1996	31.31	--	24.32 (2)	26.13 (2)	27.59	4.8
1997	24.18	--	21.90	27.37	24.43	6.3
1998	30.03	--	29.39	27.43 (2)	29.05	5.5
1999	22.08	--	22.31 (2)	27.71	23.84	3.9
2000	23.83	--	20.56	19.91	21.22	1.0
2001	31.00	--	33.56	29.57	31.28	2.8
2002	37.50	--	40.27	44.72	40.57	7.6
2003	22.63	--	21.34	26.77 (2)	23.02	6.5
2004	33.58	--	33.58	31.67	33.10	2.8
2005	32.30 (2)	--	--	41.47	36.89	8.6
2006	20.95	--	--	23.38	22.17	4.2
2007	26.58	--	--	27.82	27.20	3.0
2008	26.19	--	--	25.00	25.58	2.0
2009	28.86	28.06*	--	27.65	28.26	7.6
2010	34.36	36.56*		32.94	33.65	13.1
2011	30.87	33.61*		30.61	30.74	18.8
2012	27.42	27.50		28.50	27.81	5.6
2013	28.30	24.35		28.87	27.17	3.9
				Mean	29.35	7.9
				Std. Dev.	7.6	5.5

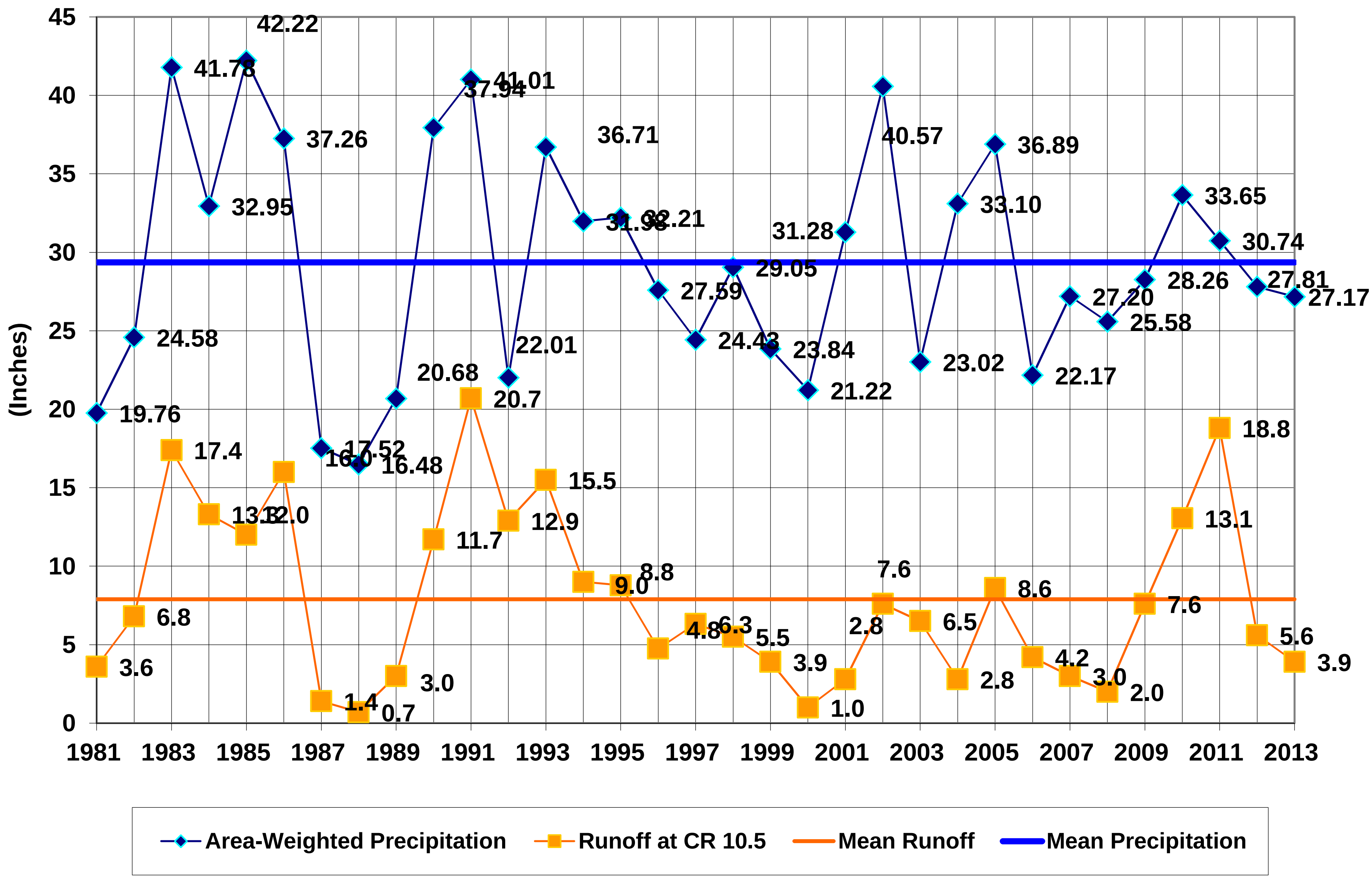
NOTES:

Whole watershed runoff is based on time-weighted average flow at Clearwater Lake outlet (station CR 10.5), and total drainage area of 155 square miles.

(1) Data for single gauge in east-central part of watershed (Camp Heritage on Lake Caroline).

(2) Average values of other stations in District were used to fill in missing data.
* Value from Kimball Station

Appendix B Figure B- 1
Clearwater River Watershed District
2013 Annual Report

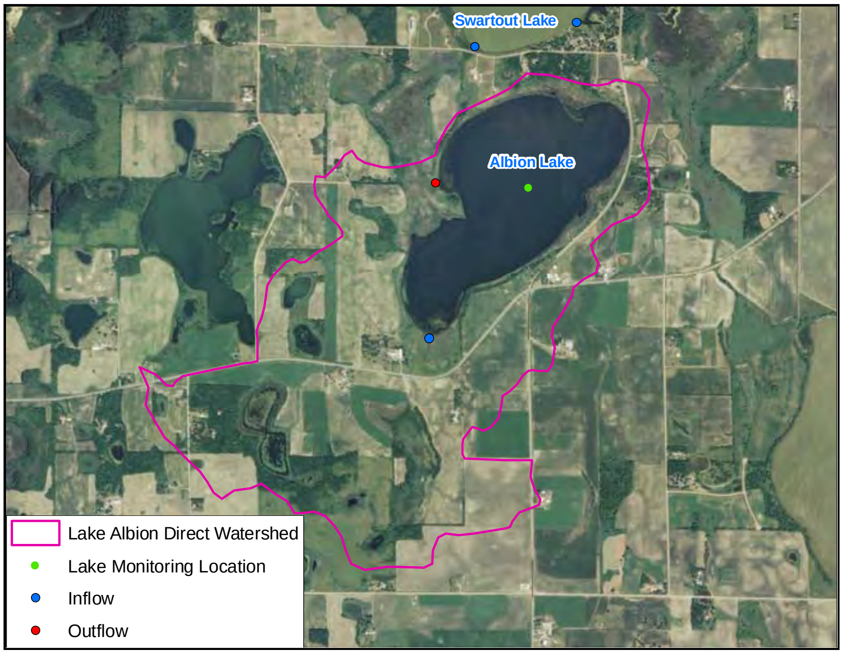


T:\0002\203_2013 Water Quality Monitoring\Water Quality Data\Stream_Loads_Historic_13Precip_Runoff_Graph_07

Appendix C

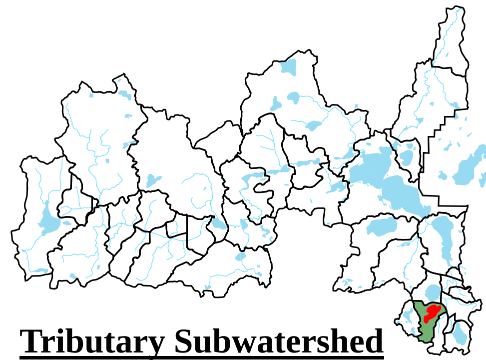
2013 Lake Report Cards

2013 Albion Lake Report Card

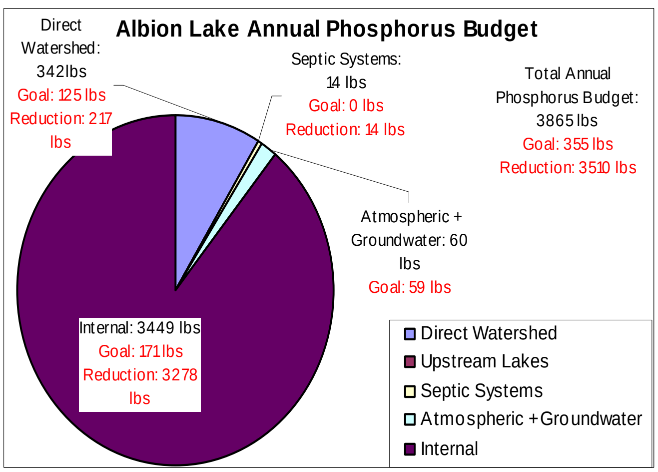


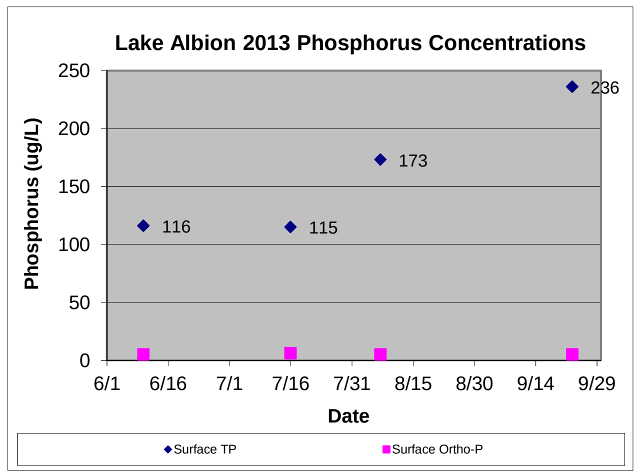
Lake Data

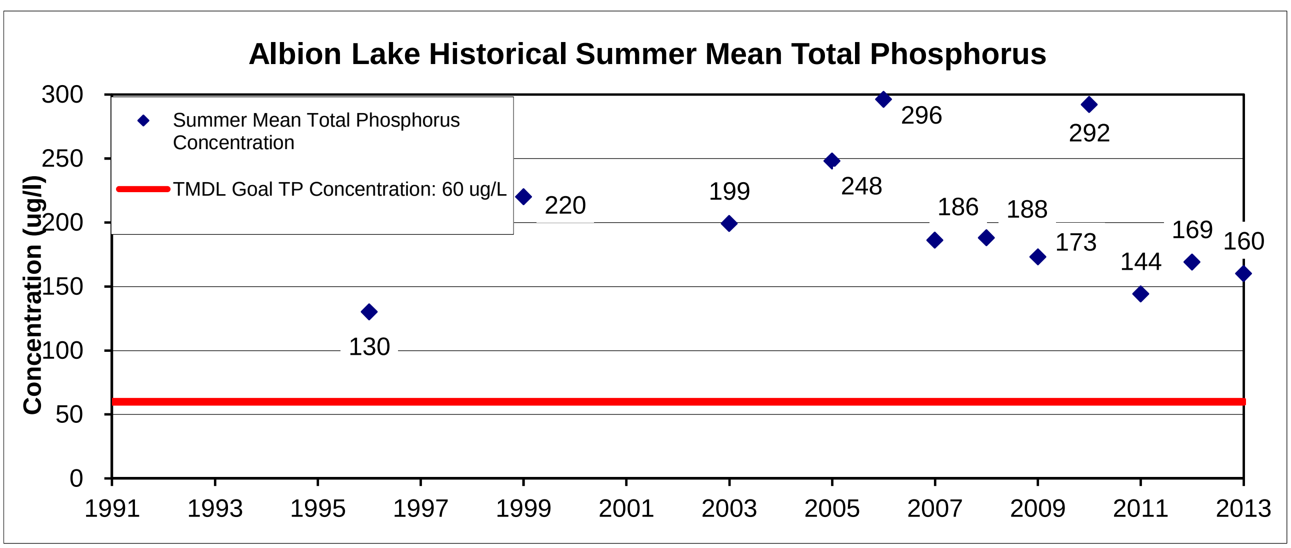
Surface Area:	251 Acres
Maximum Depth:	9 Feet
Contributing Subwatershed Area:	1,094 acres



Tributary Subwatershed (shaded)

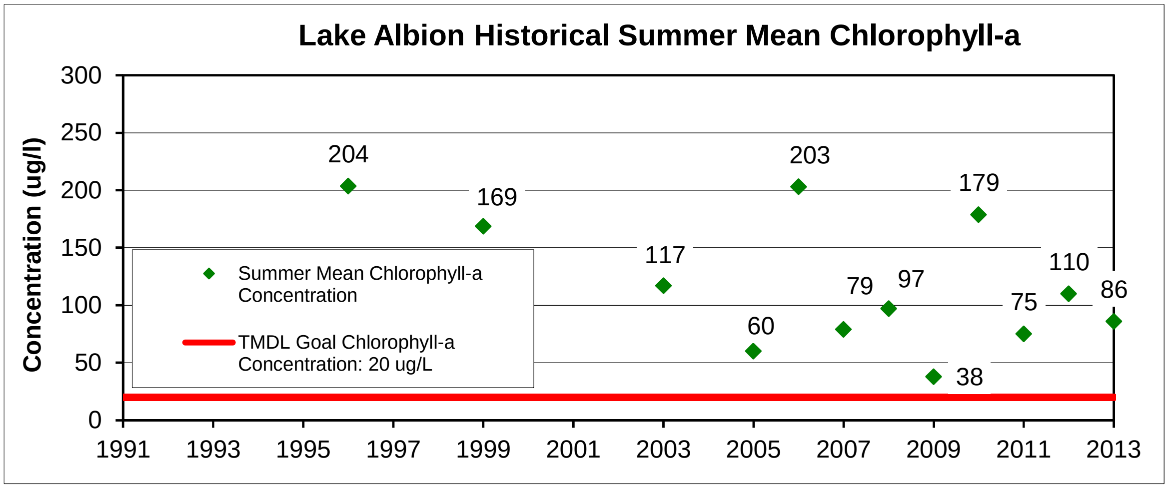


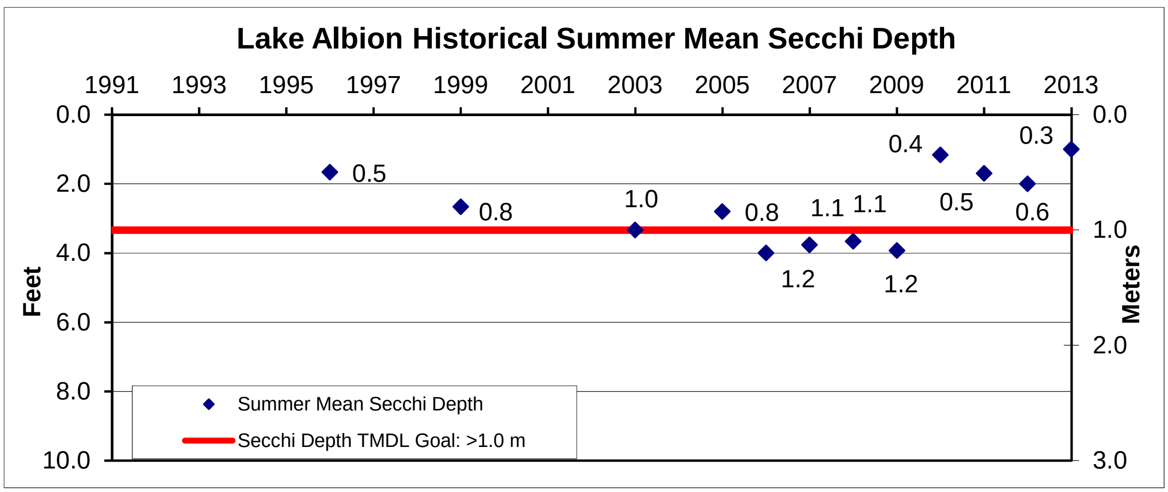




Albion Lake
2013 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





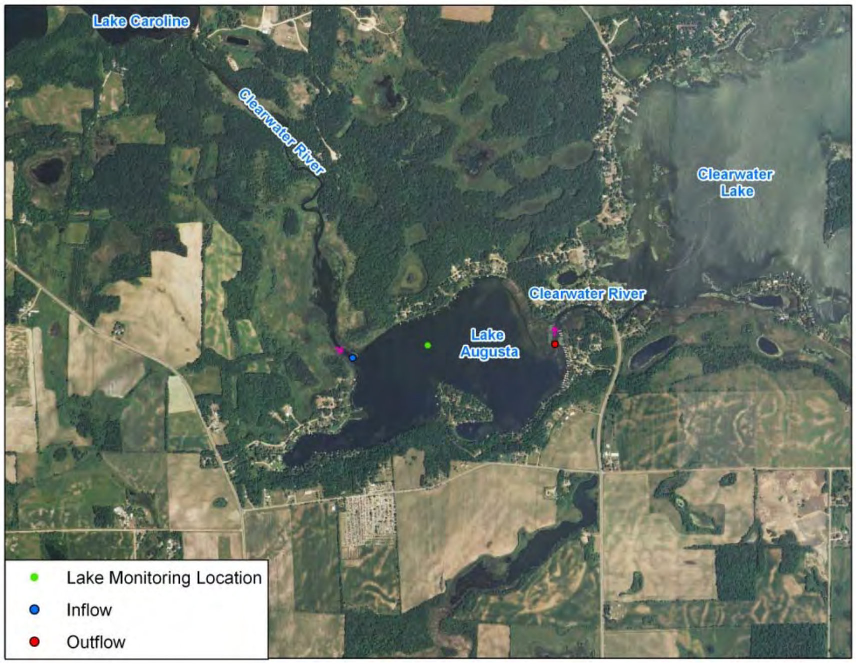
Summary

- TP and Chlorophyll-a concentrations were similar to those observed in previous years and remained above TMDL water quality goals.
- Water clarity was poor in 2013 and remained lower than the TMDL goal.
- Carp were observed to be abundant in the lake in 2013, which is likely contributing to poor water clarity and increased phosphorus concentrations due to resuspension of sediments and internal nutrient loading.
- An aquatic vegetation survey conducted in 2013 found submerged vegetation at 50% of sampled points. Curly leaf pondweed was abundant and was observed at 39% of sampled points. Sago pondweed was the most common native vegetation species observed during the 2013 survey, as it was observed at 29% of sampled points.

TMDL Activities

- Due to Lake Albion's small tributary watershed, the reduction of watershed loads alone will not be sufficient to achieve water quality goals for the lake. A significant reduction in the internal nutrient source will be required to meet water quality targets in the lake.
- The lake was surveyed for curly leaf pondweed in June 2013.
- Management strategies including rough fish management should be implemented carefully in order to establish a state of high ecological integrity in the lake.
- Nutrient reduction strategies implemented as part of the Cedar Lake Improvement Project have included watershed BMPs and rough fish management.
- A shallow lake management plan should be developed for the lake in the future.

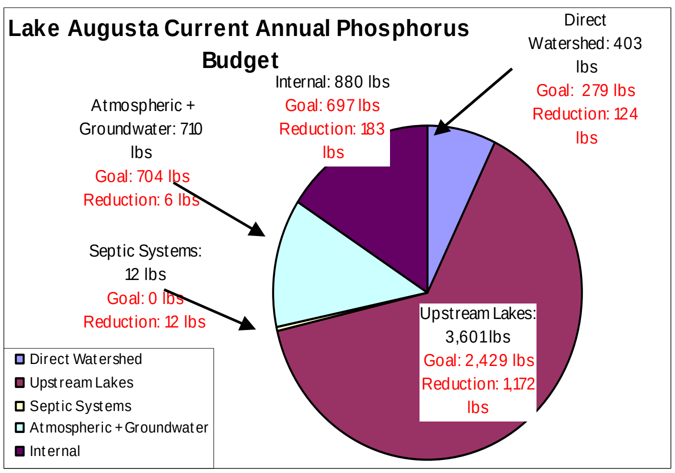
2013 Lake Augusta Report Card

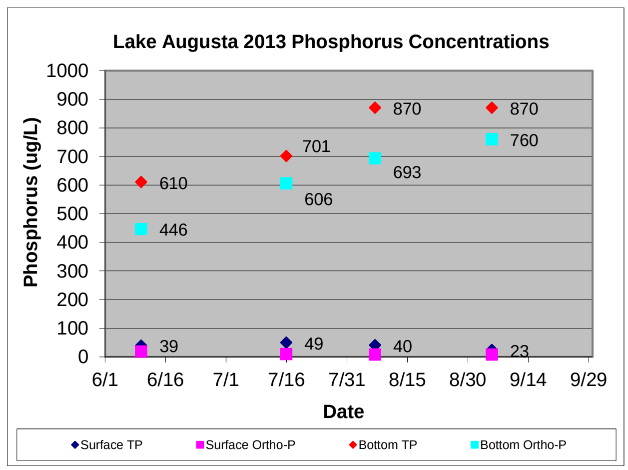


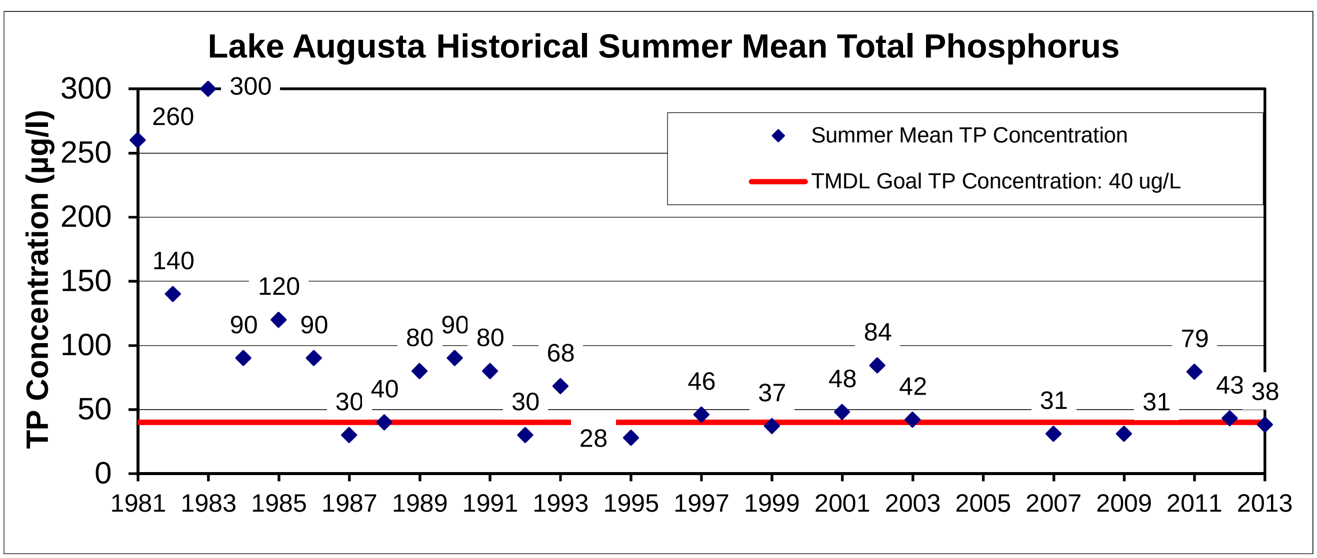
Lake Data

Surface Area:	177 Acres
Maximum Depth:	82 Feet
Subwatershed Area:	62,936 acres

Tributary Subwatershed (shaded)



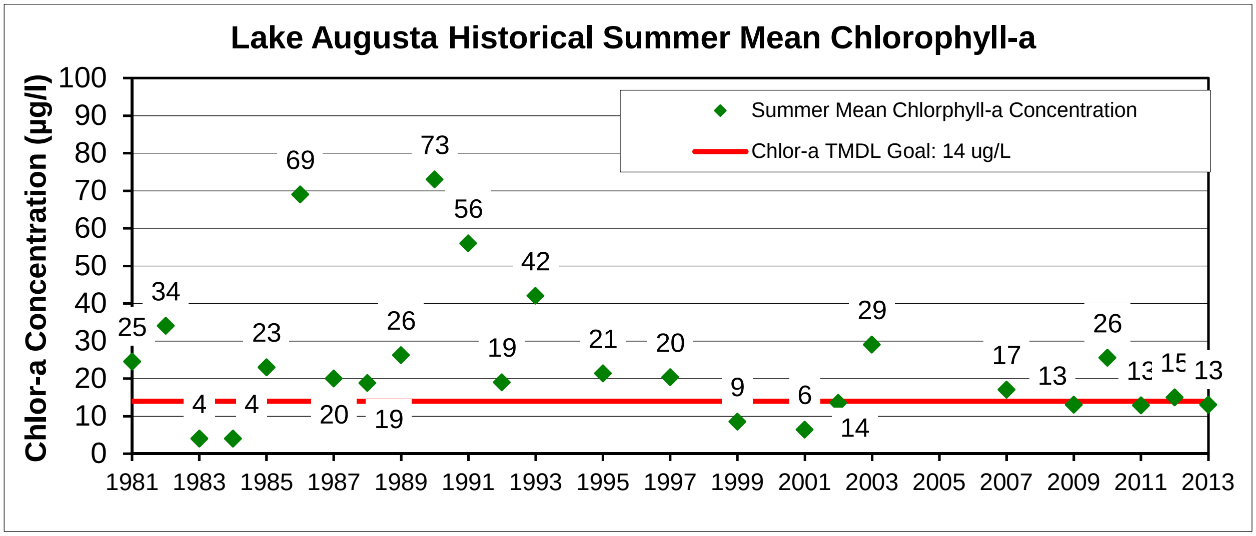


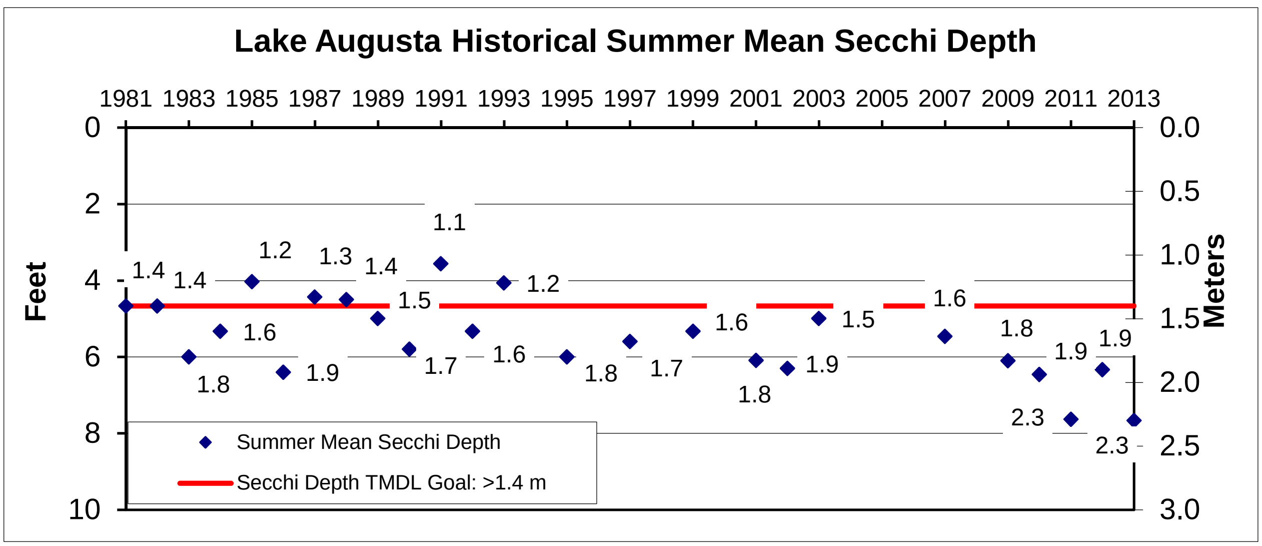


Clearwater River Watershed District	Wenck	January 2014
Lake Augusta	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix C

Lake Augusta
2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





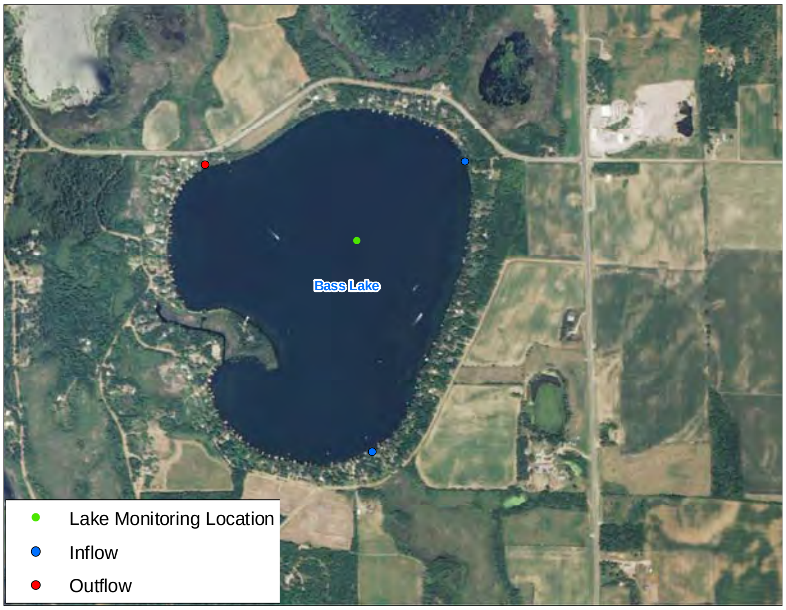
2013 Summary

- Phosphorus concentrations decreased in 2013 and were below TMDL goals.
- Chlorophyll-a concentrations were similar to recent years and were below TMDL goals.
- Water clarity was slightly improved in 2013 as Secchi disk depth was slightly higher than observed in most recent years and met TMDL goals.
- Water quality is dominated by loads from the Clearwater River and is buffered by upstream lakes.
- Monitoring data indicates a potential for high internal loads in the lake as bottom phosphorus concentrations are high in the lake.

TMDL Activities

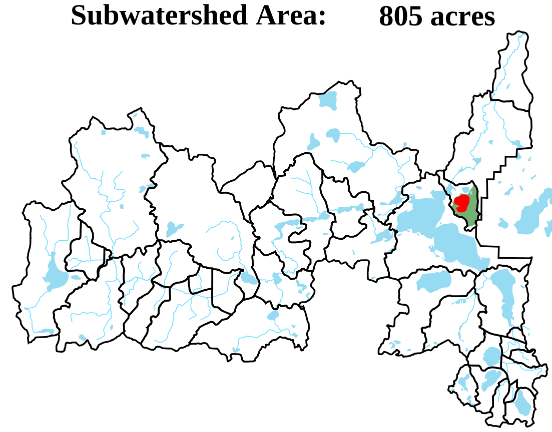
- TMDL calls for a combination of watershed load reductions and internal load reductions in order to meet water quality goals.
- Activities implemented in the upstream watersheds (Clear Lake and Lake Betsy) will have a cumulative impact on downstream lakes.
- Phosphorus reduction activities identified for implementation by the TMDL Implementation Plan in the watersheds tributary to Lake Betsy and Clear Lake include BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds.

2013 Bass Lake Report Card

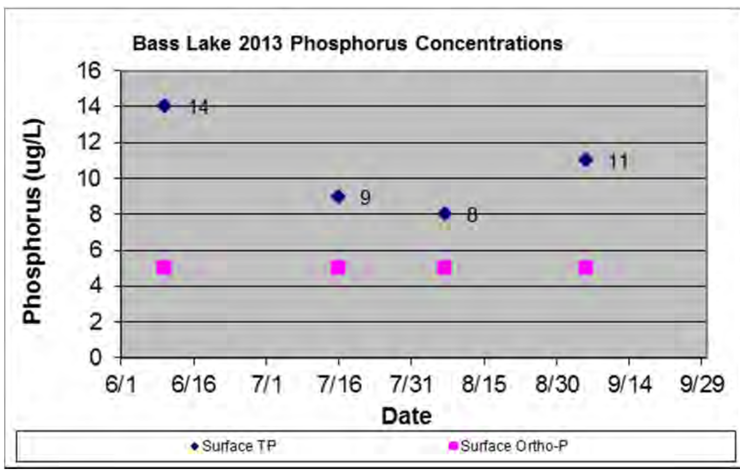


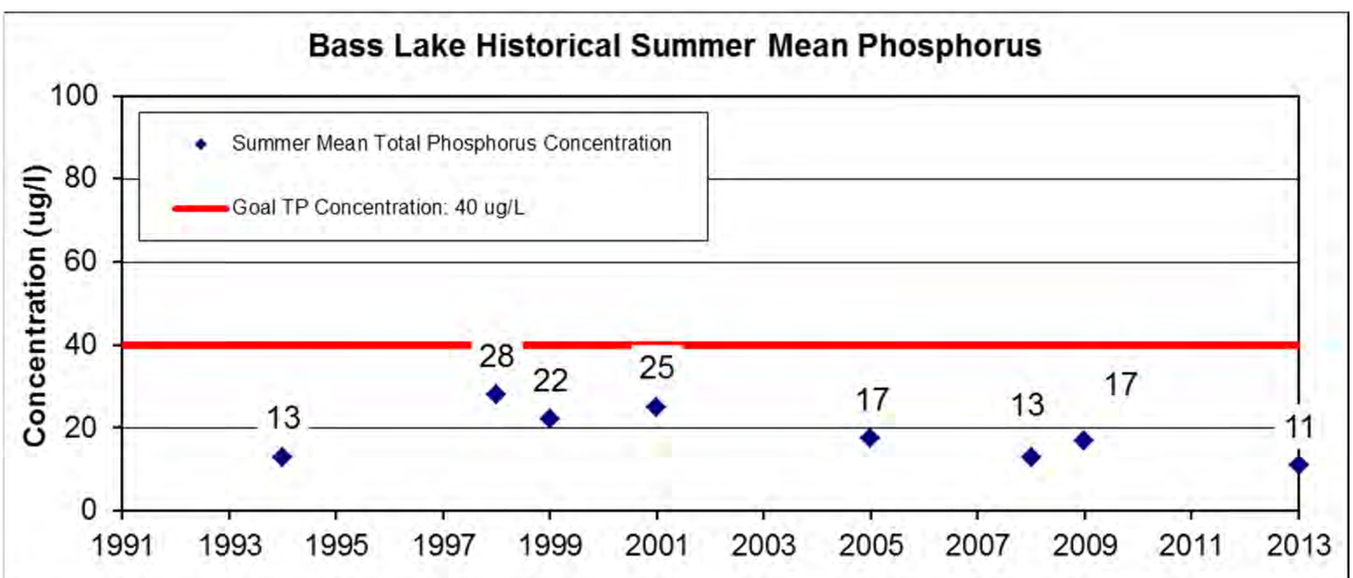
Lake Data

Surface Area:	**218 Acres**
Maximum Depth:	**34 Feet**
Subwatershed Area:	**805 acres**



Tributary Sub watershed (shaded)

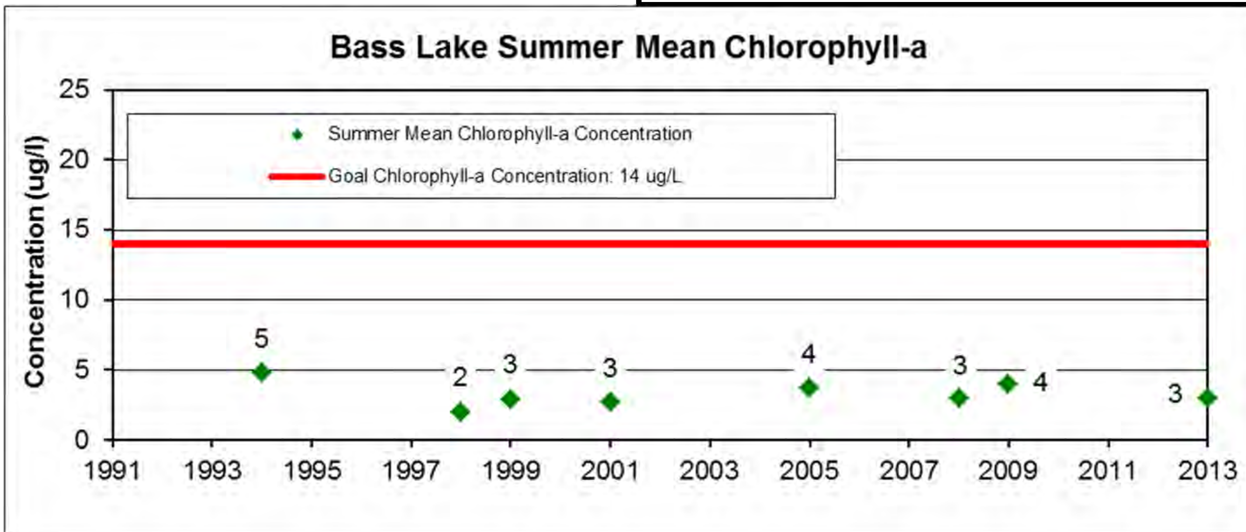


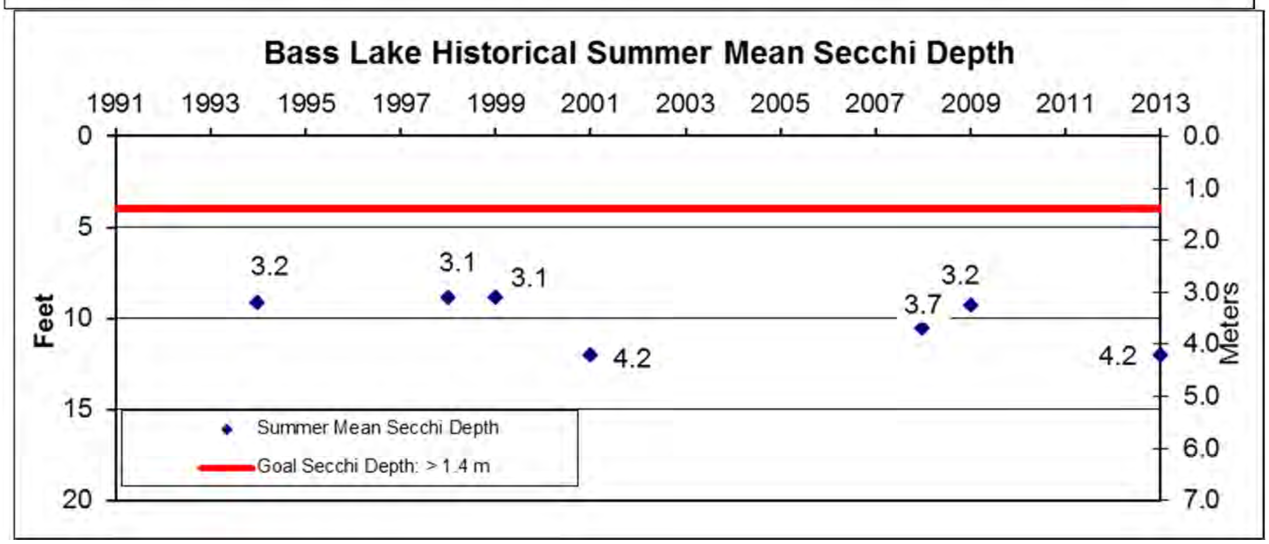


Bass Lake

2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

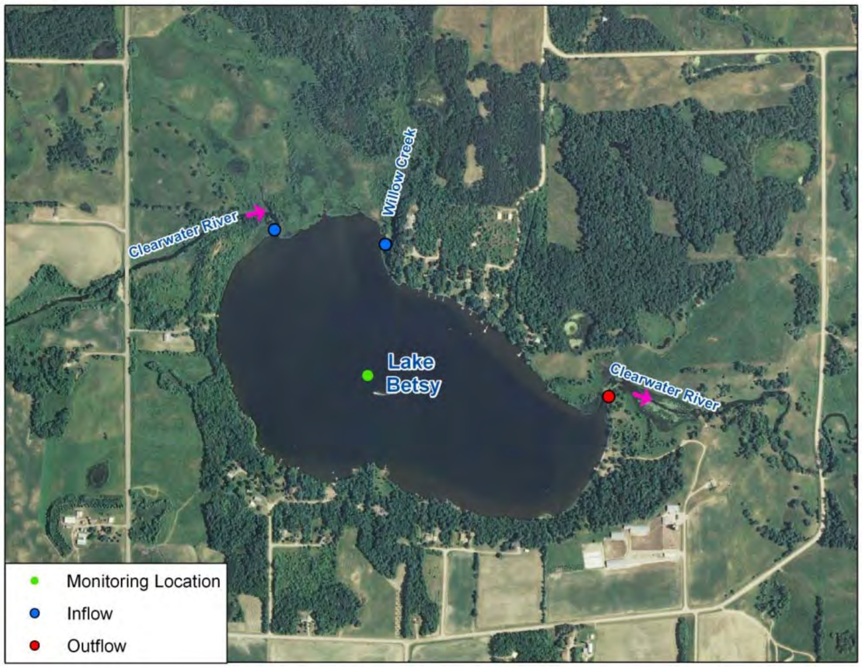
- Current water quality is good in Bass Lake as phosphorus concentrations, chlorophyll-a, and Secchi depth have met MPCA standards since monitoring of the lake began in 1994.
- Bass Lake is managed by the DNR for largemouth bass, northern pike, and bluegill.

Water Quality Improvement Activities

- Good land management practices adjacent to the lakeshore and in the upstream watershed will help to maintain the good water quality in Bass Lake.

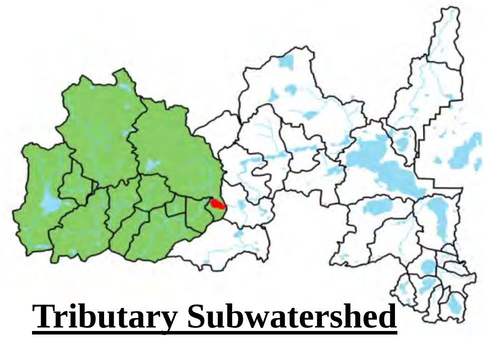
Wenck
Wenck Associates, Inc. 1800 Pioneer Creek Center
Environmental Engineers Maple Plain, MN 55359

2013 Lake Betsy Report Card

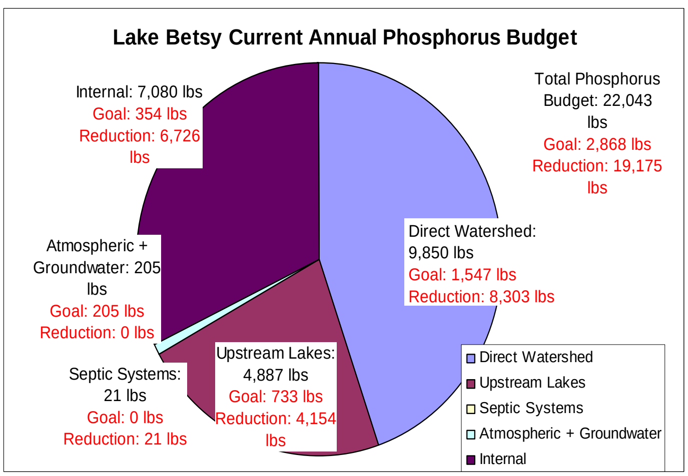


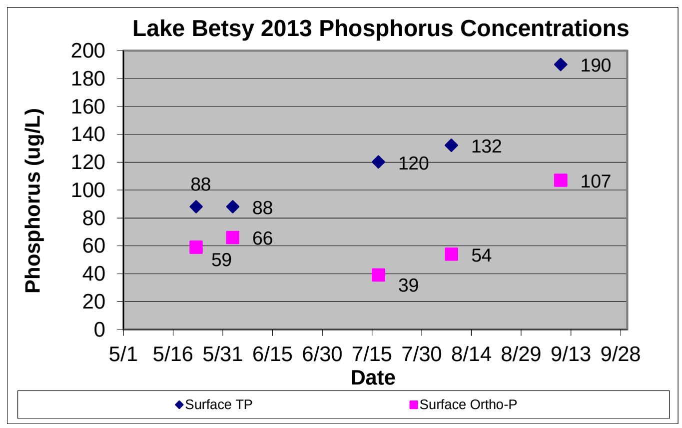
Lake Data

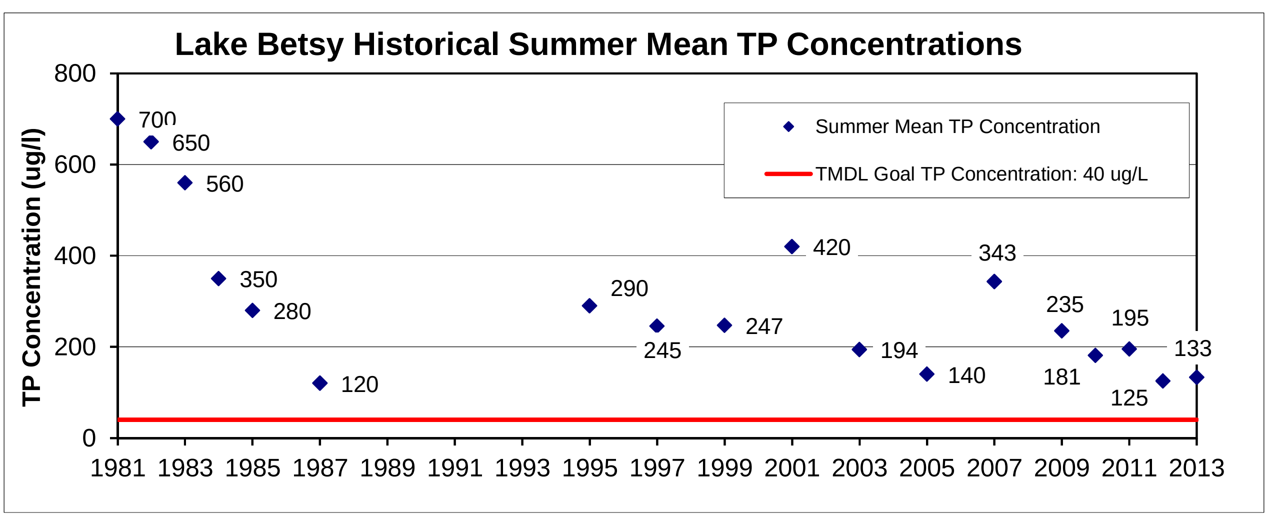
Surface Area:	153 Acres
Maximum Depth:	23 Feet
Subwatershed Area:	43,789 acres
Mean Depth:	10 Feet



Tributary Subwatershed (shaded)





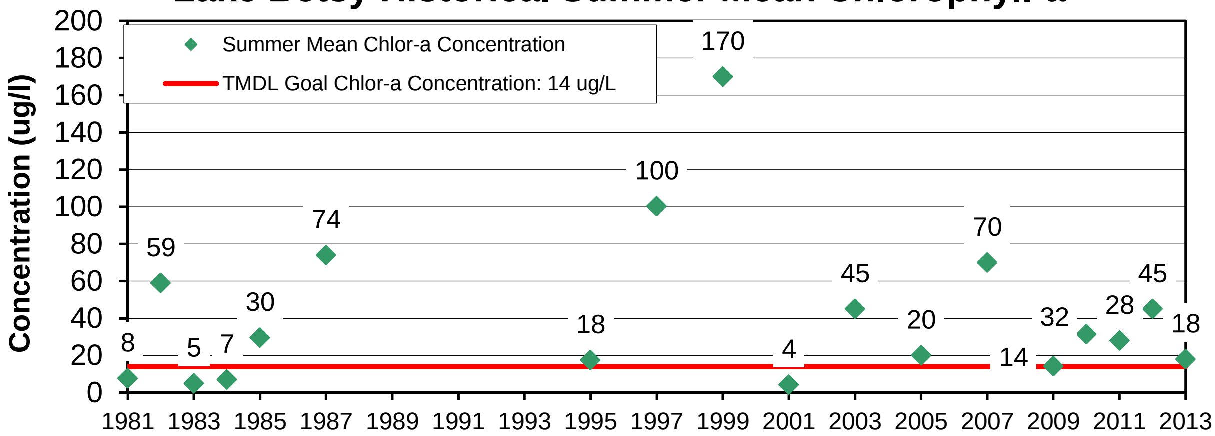


Clearwater River Watershed District	Wenck Associates, Inc. Environmental Engineers · 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2014
Lake Betsy		Appendix C

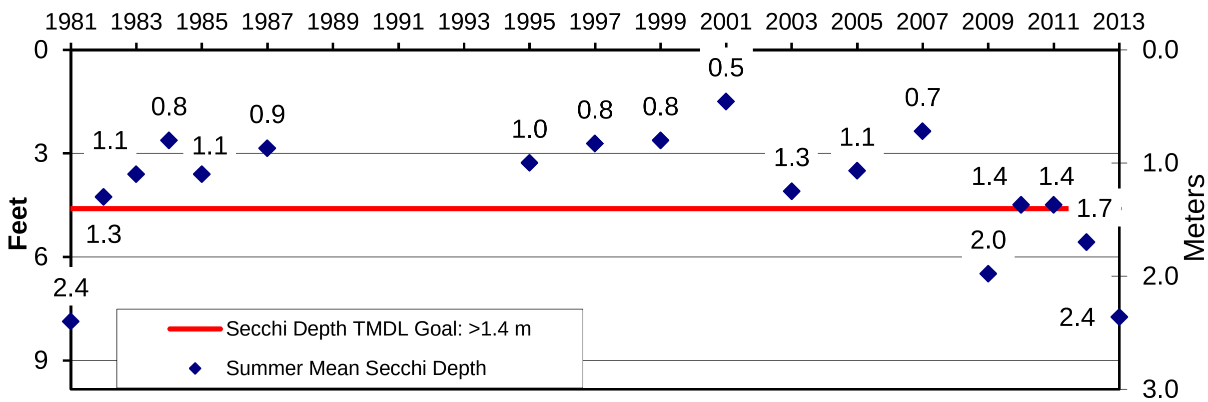
Lake Betsy
2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter

Lake Betsy Historical Summer Mean Chlorophyll-a



Lake Betsy Historical Summer Mean Secchi Depth



2013 Summary

- Recent TP concentrations have been stable and generally decreasing since 2007. TP concentrations remain below those of the early 1980's but are still well above the TMDL goals.
- Water clarity has improved recently as Secchi depth continued to increase in 2013 and has met TMDL goals in recent years.
- Water quality is dominated by loads from the Clearwater River.
- Phosphorus release rates from sediment were measured in 2009 and internal loading of phosphorus was found to be well above the TMDL allocation for the lake.
- Bottom phosphorus concentrations are extremely high in the lake, which is a further indication of high potential for internal loading.

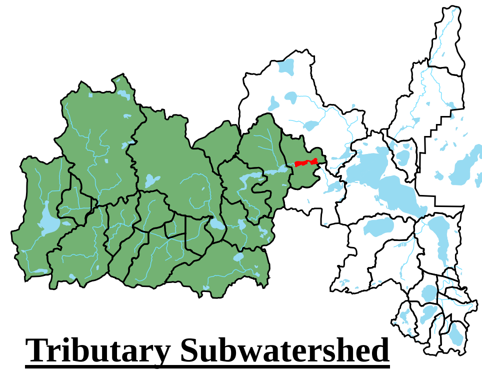
TMDL Activities

- TMDL calls for significant phosphorus reductions in watershed runoff and internal loading in order for Lake Betsy to meet state standards.
- The TMDL Implementation Plan identifies activities to be implemented in the watershed tributary to Lake Betsy, including BMPs, hypolimnetic withdrawal (potential 480 lb reduction), Kingston Wetland restoration (potential 1,970 lb reduction) and targeted soil testing and GPS fertilizer application (potential 600 lb reduction).
- Implementation activities in the watershed in 2013 included the completion of the Kingston Wetland Project, streambank restoration, and GPS fertilizer application and testing.

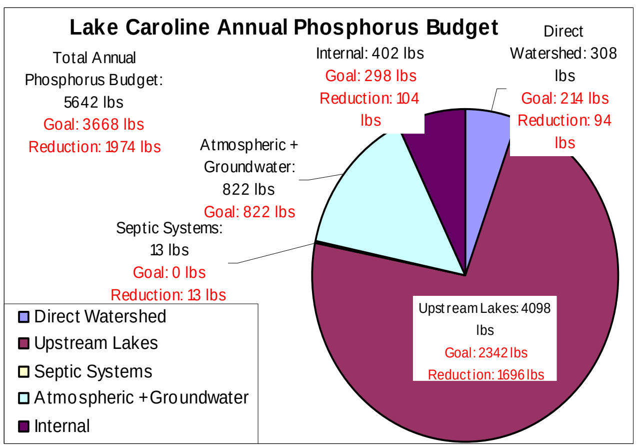
2013 Lake Caroline Report Card

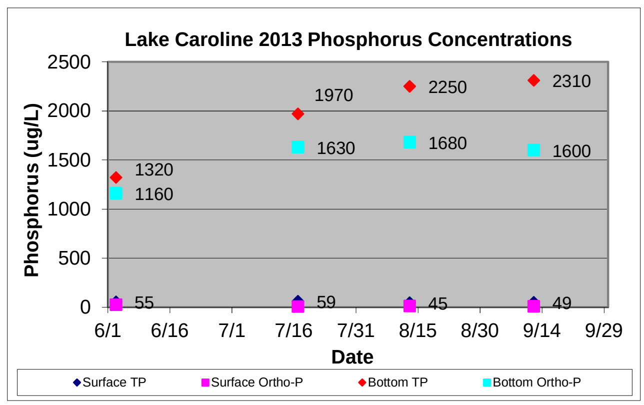
Lake Data

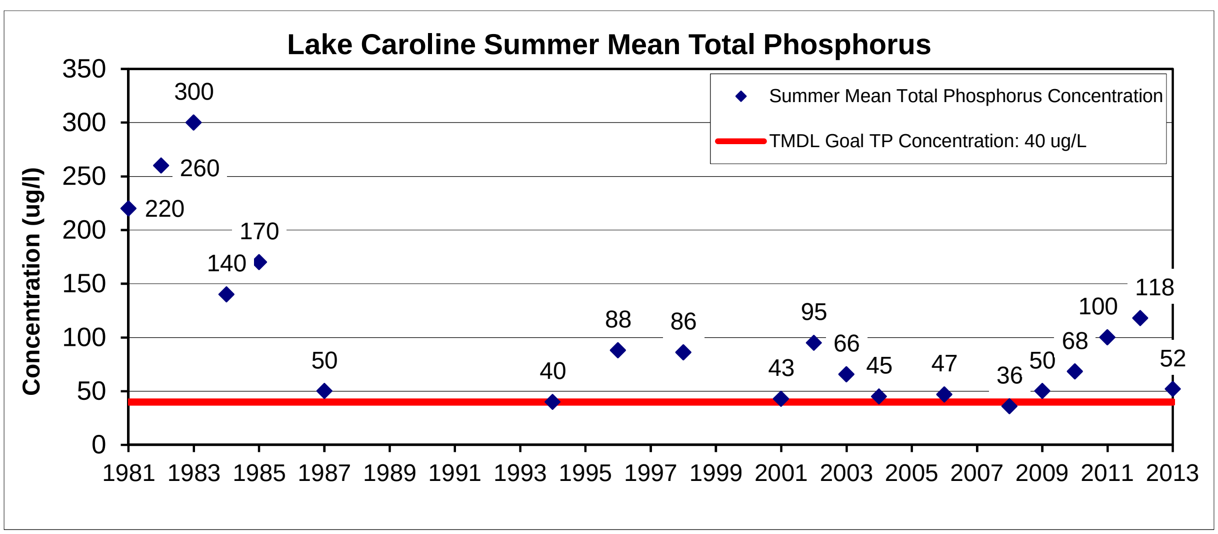
Surface Area: 126 Acres
Maximum Depth: 45 Feet
Subwatershed Area: 60,132 acres



Tributary Subwatershed (shaded)



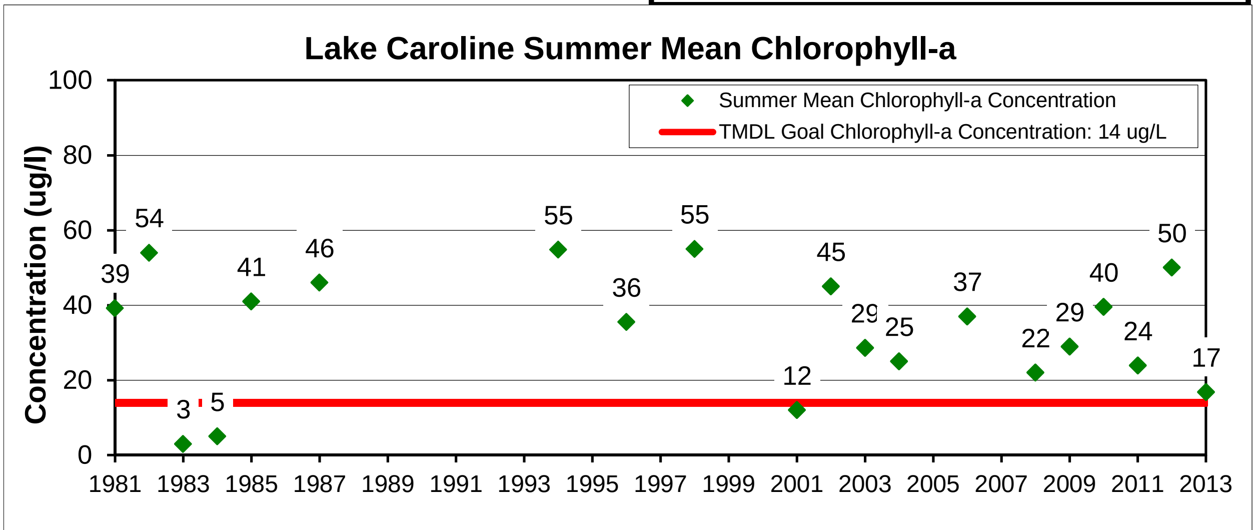


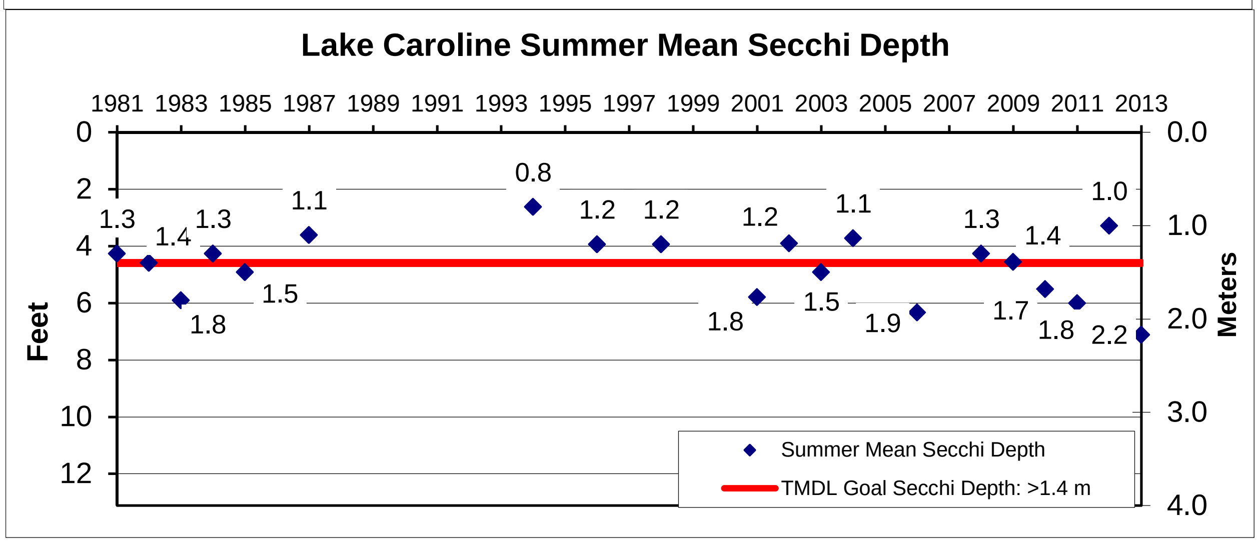


Clearwater River Watershed District	Wenck Associates, Inc. Environmental Engineers — 1800 Pioneer Creek Center, Maple Plain, MN 55359	January 2014
Lake Caroline		Appendix C

Lake Caroline
2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- TP concentrations decreased to a level that was near TMDL goals after increasing steadily since 2008.
- Chlorophyll –a concentrations decreased and were near TMDL goals in 2013.
- Water clarity improved in 2013 as the summer mean Secchi depth was the highest observed in the lake.
- Water quality is dominated by loads from the Clearwater River and Lake Marie.
- While they decreased slightly from concentrations observed in previous years, bottom phosphorus concentrations observed in 2013 remained high and indicate that internal loading may contribute significant phosphorus to the lake during years with low runoff.

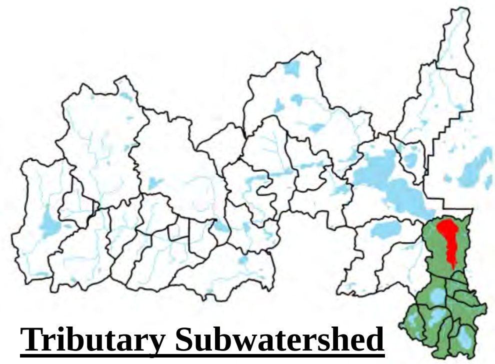
TMDL Activities

- Measures recommended by the TMDL Implementation Plan for the upper watershed will help decrease the load of phosphorus to Lake Caroline.
- Water quality goals can be met through a combination of watershed management and internal load reductions.

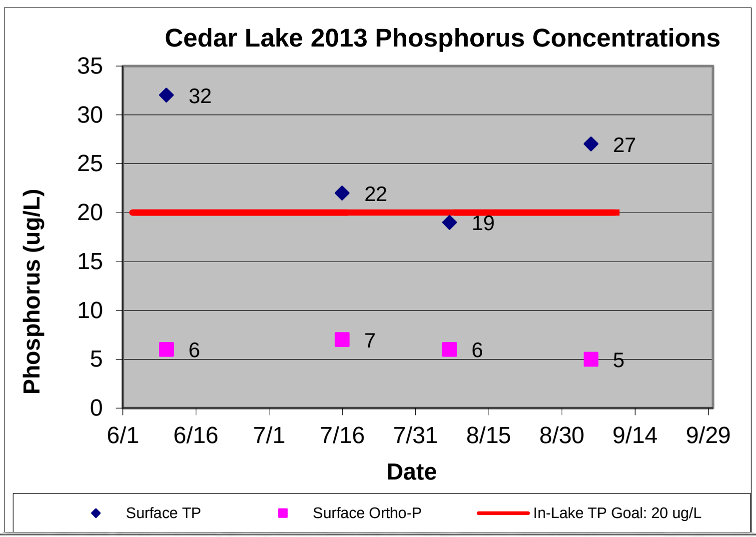
2013 Cedar Lake Report Card

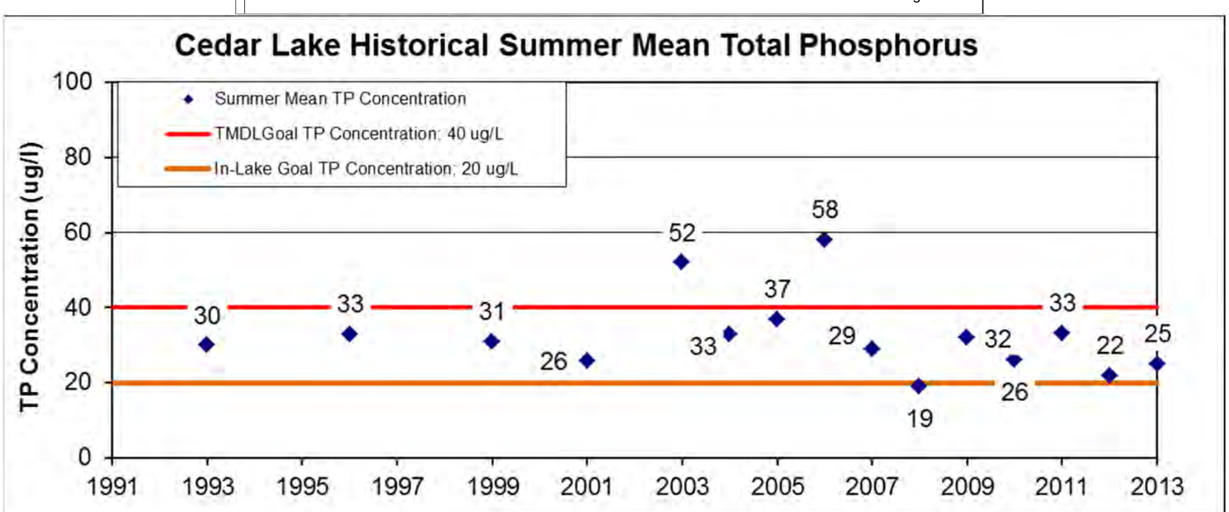
Lake Data

Surface Area:	783 Acres
Maximum Depth:	108 Feet
Subwatershed Area:	9.715 acres



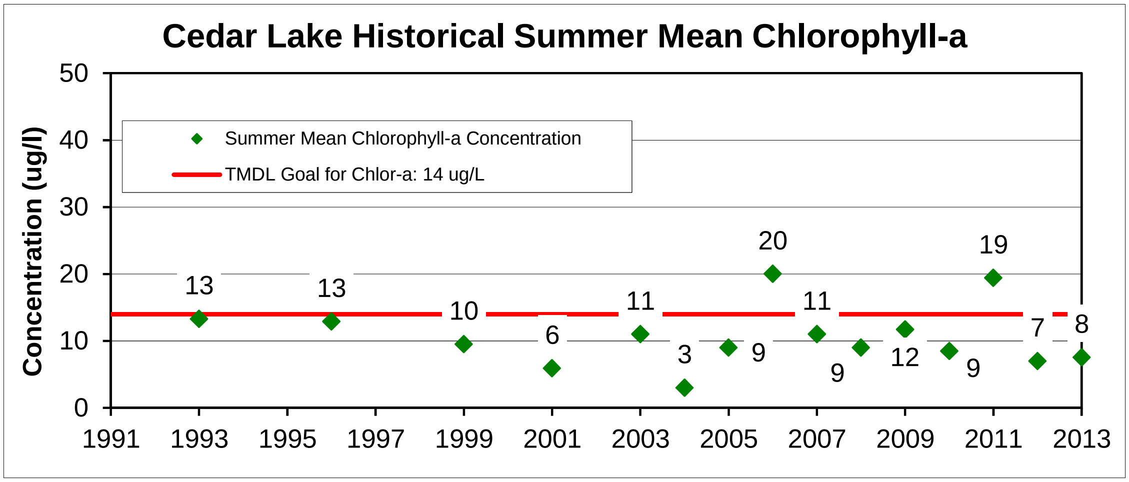
Tributary Subwatershed (shaded)

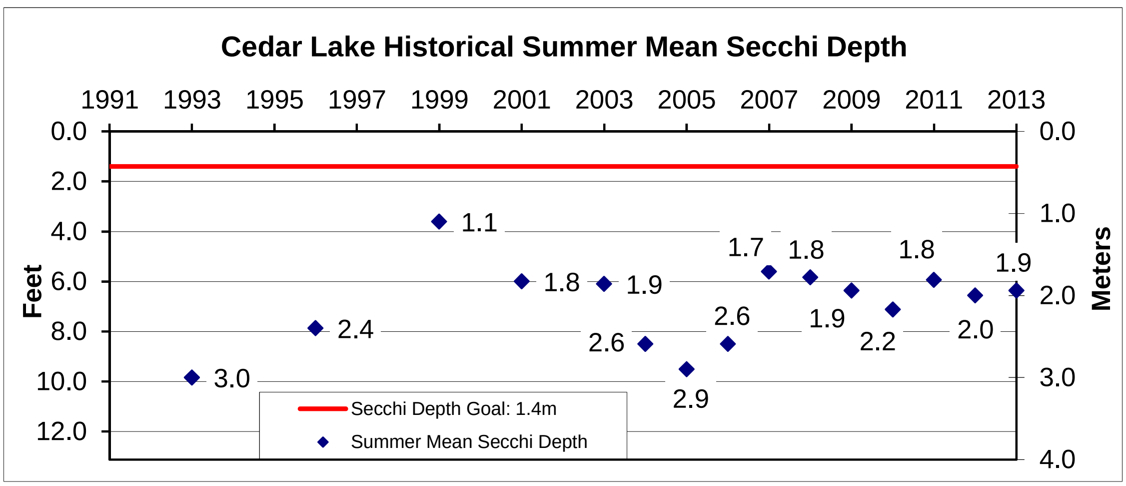




Cedar Lake
2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- 2013 average phosphorus concentrations were below TMDL goals and near the goals established for the lake at the start of Project #06-1 in 2007.
- 2013 average chlorophyll-a concentrations were on the low end of most other years since 2007 and were below the impairment standard.
- Although periodic algal blooms have been common early in the summer in recent years, overall water clarity remains good in the lake, as Secchi depth is better than the TMDL goal.
- The primary source of phosphorus is from the upper watersheds and Swartout, Albion, and Henshaw Lakes.

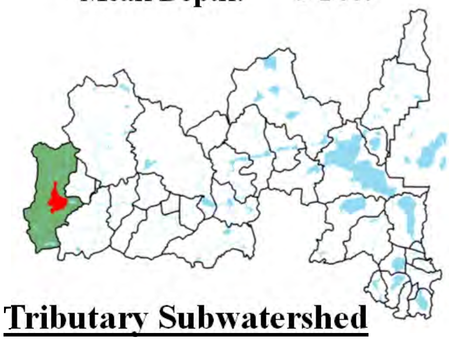
TMDL Activities

- Since 2007, the Cedar Lake Restoration Project has implemented fish barriers, buffers, tile inlet replacement, and the construction of Segner Pond, a wetland treatment basin. The goal of the project is to reduce the phosphorus load to Cedar Lake from the upper watershed.
- Additional projects geared towards reducing phosphorus are proposed to be implemented in 2014 and future years on the inflow to Cedar Lake upstream of Segner Pond and in the outflow from the tributary wetland upstream of Swartout Lake.
- Measures recommended by the TMDL Implementation Plan for the impaired Swartout, Albion, and Henshaw Lakes will serve to improve water quality in Cedar Lake.

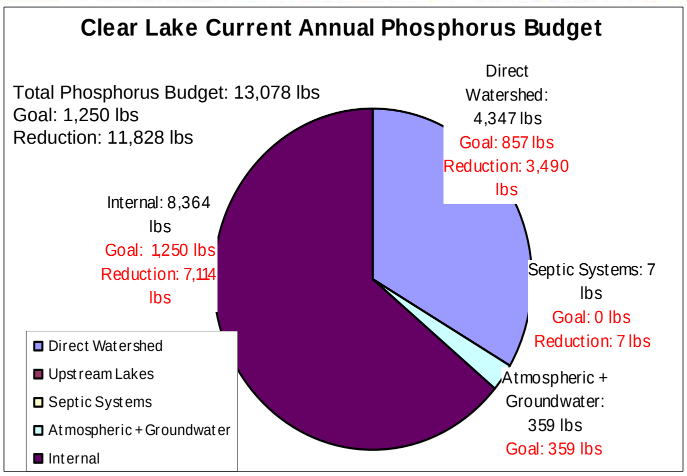
2013 Clear Lake Report Card

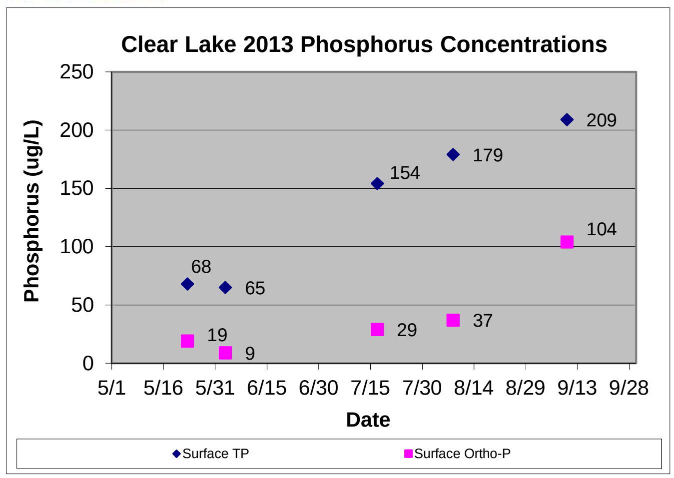
Lake Data

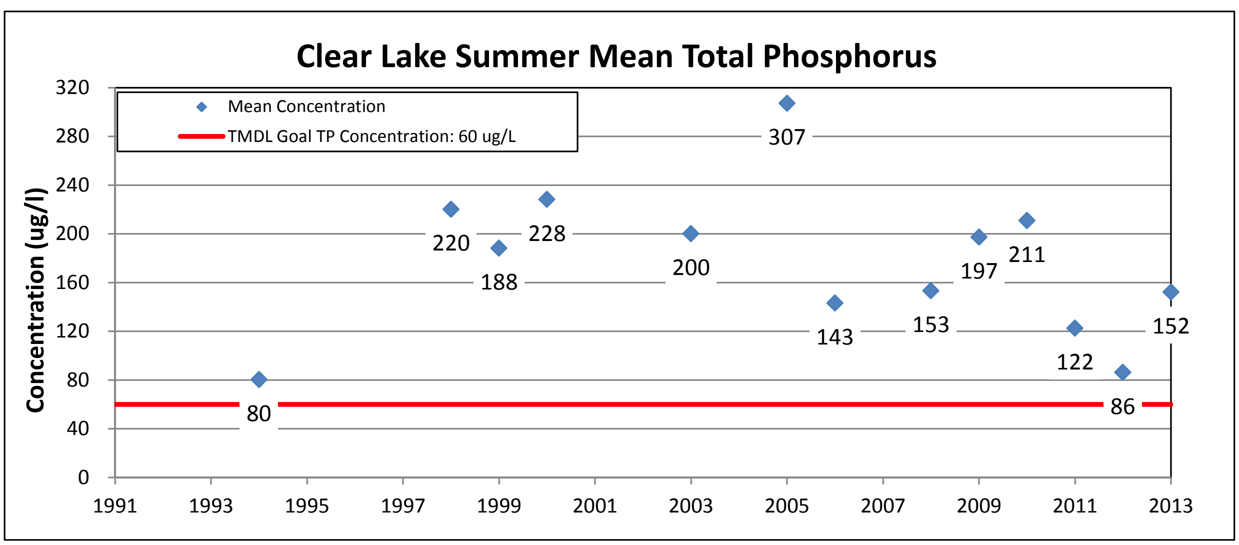
Surface Area:	515 Acres
Maximum Depth:	17 Feet
Subwatershed Area:	6,801 acres
Mean Depth:	9 Feet



Tributary Subwatershed (shaded)



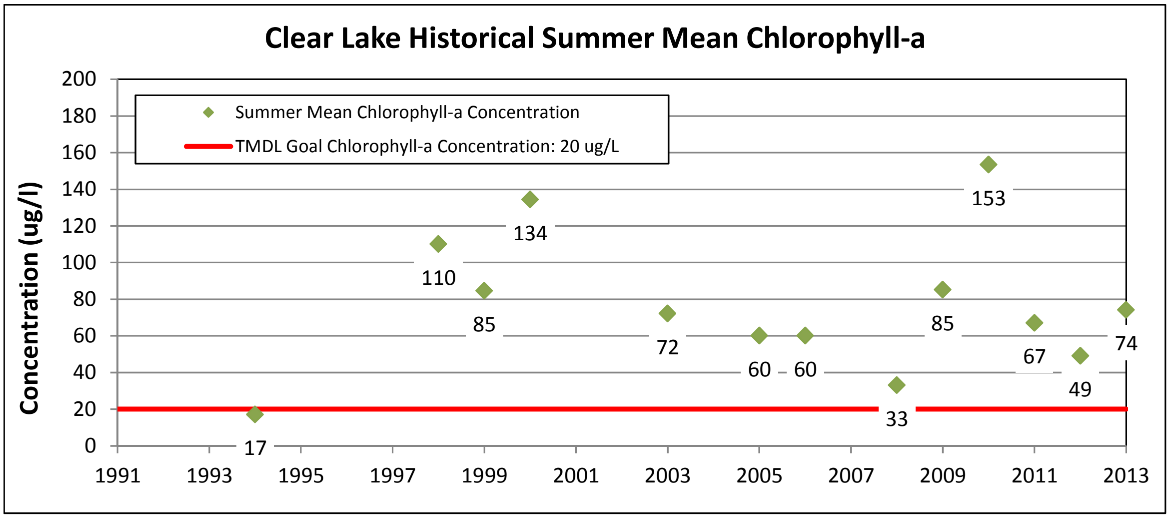


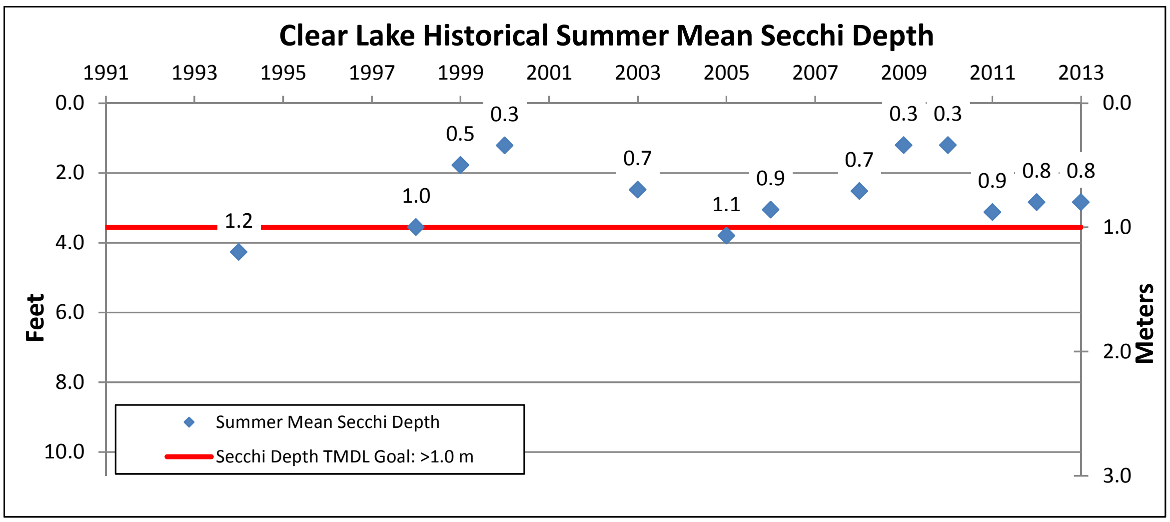


Clearwater River Watershed District	Wenck	January 2013
Clear Lake	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	Appendix C

Clear Lake
2013 Lake Report Card

MPCA Shallow Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





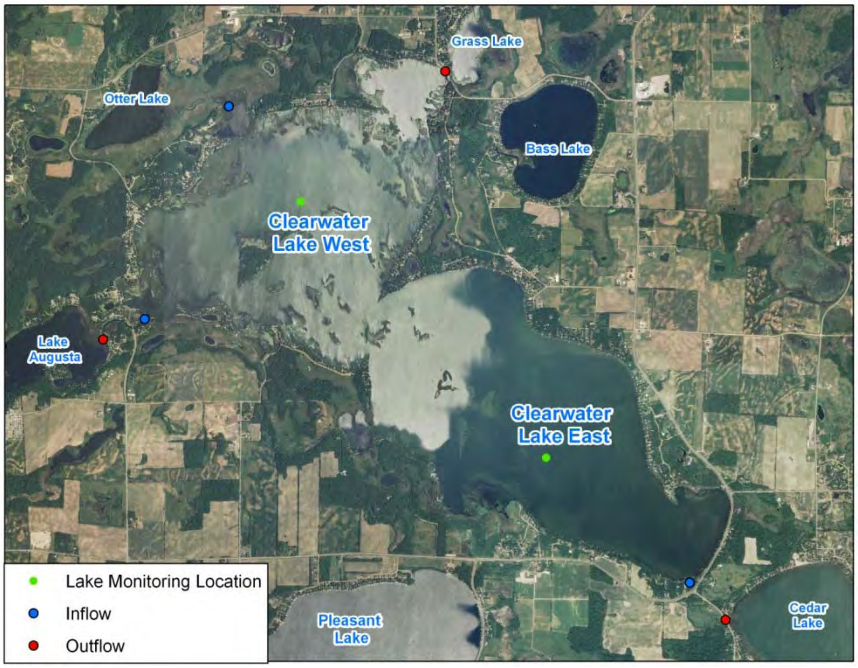
2013 Summary

- Clear Lake is located at the headwaters of the Clearwater River.
- Phosphorus and chlorophyll-a concentrations remained above TMDL goals in 2013 and increased slightly from recent years.
- Secchi depth did not meet the TMDL goal but remained similar to recent years.
- Periodic poor water quality and nuisance algal blooms have been common in Clear Lake.
- High bottom phosphorus concentrations along with the lake's nature of becoming stratified and mixing throughout the summer indicates that internal loading of phosphorus from the lake's bottom sediments occurs throughout the year.

TMDL Activities

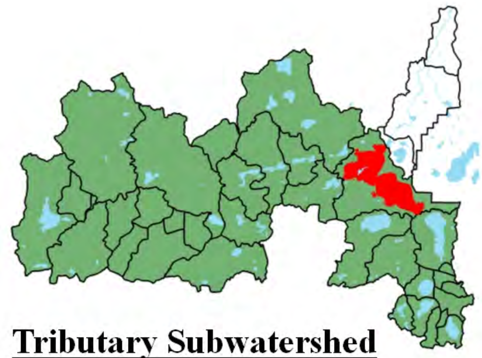
- The TMDL Implementation Plan calls for significant reductions in phosphorus from direct watershed runoff and internal loading in order for Clear Lake to meet state standards
- All but 7 of the ISTSs on the lake have been routed to the City of Watkins WWTP, resulting in approximately 100 lbs. of TP reduction to the lake.
- Sedimentation ponds were installed at two inlets to the lake.
- Clear Lake Association has implemented curly leaf pondweed treatment and rough fish removal.
- GPS Fertilizer application project was implemented in the Clear Lake Subwatershed in 2011 and continued in 2013.
- Additional sedimentation ponds and watershed BMPs have been recommended as potential TP reduction strategies.
- The CRWD constructed a notched weir on a tributary stream south of the lake in 2012 to address phosphorus loads from the subwatershed.

2013 Clearwater Lake Report Card

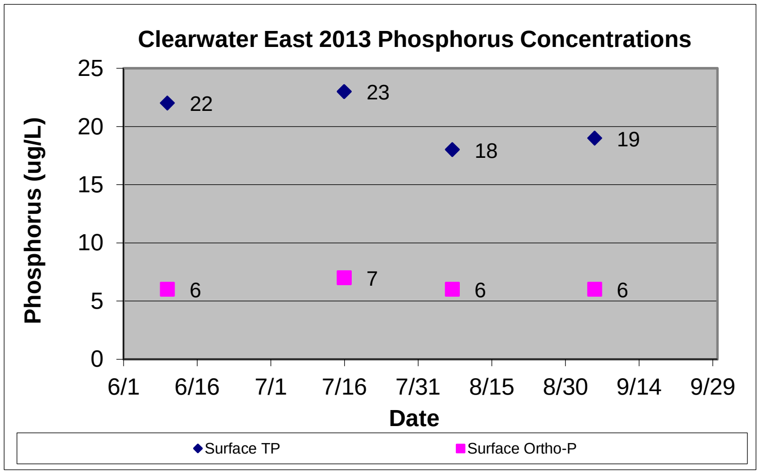


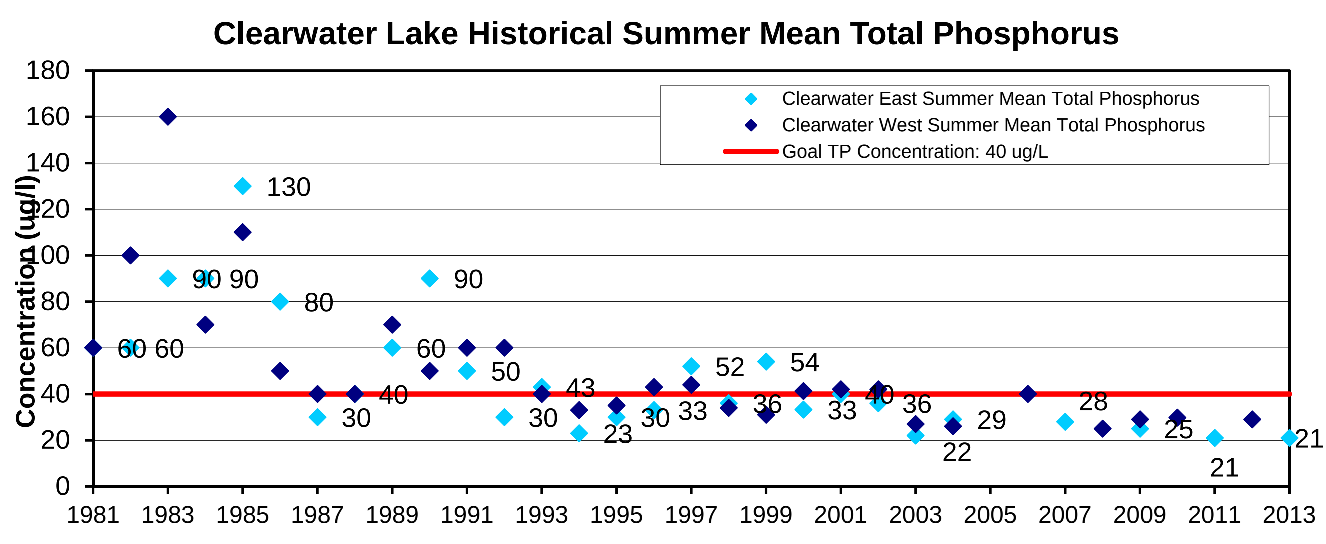
Lake Data

Surface Area:	**3,158 Acres**
Maximum Depth:	**73 Feet**
Subwatershed Area:	**100,232 acres**



Tributary Subwatershed (shaded)

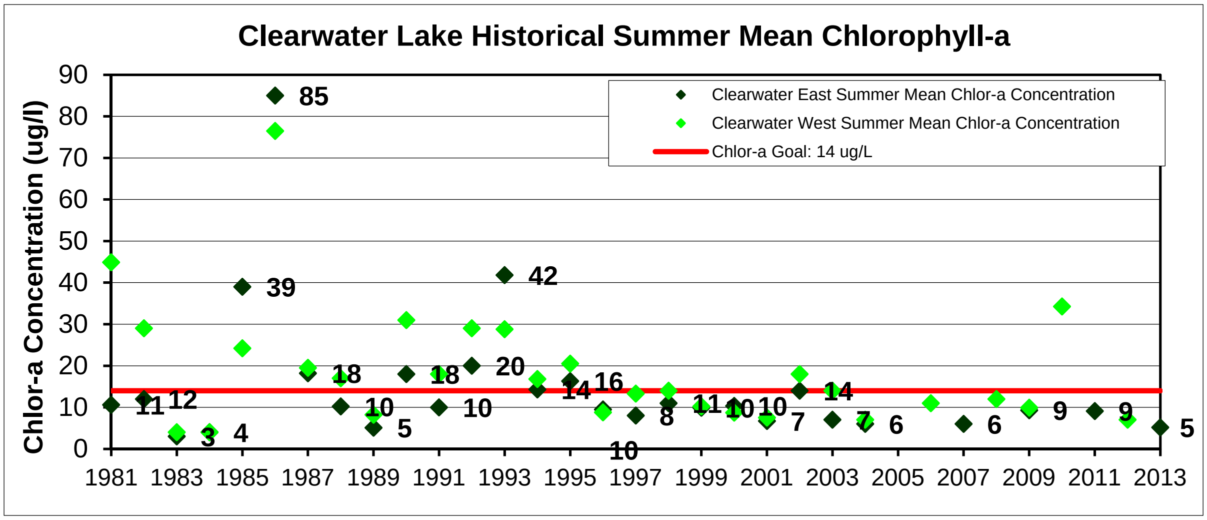


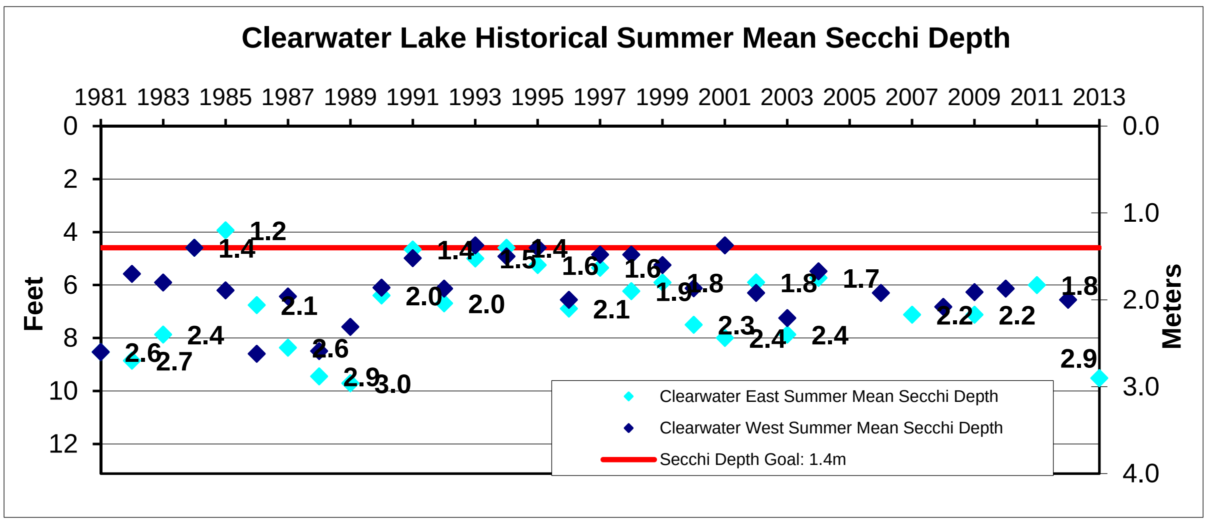


Clearwater River Watershed District	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2014
Clearwater Lake		Appendix C

Clearwater Lake
2013 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- Water quality has improved significantly in Clearwater Lake since the early 1990s, as summer mean phosphorus and chlorophyll-a concentrations have decreased significantly and the lake meets recreational water quality goals.
- Water quality measurements have been stable over recent years and meet TMDL goals.
- The majority of the phosphorus load to Clearwater Lake comes from the upstream watersheds.

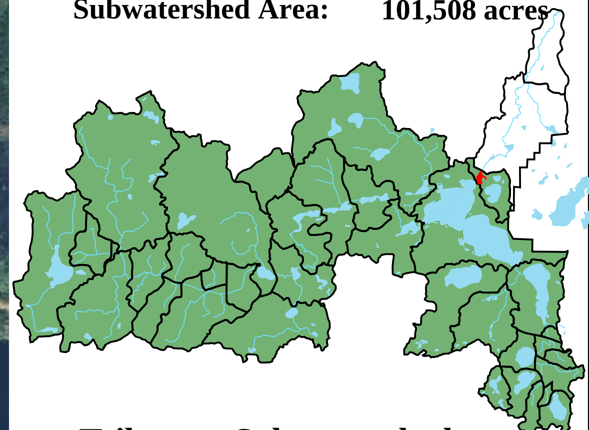
Lake Management Activities

- Watershed loads to Clearwater Lake have been below the established phosphorus loading goals of 5,000 lbs. in most recent years.
- Measures that are put in place in the upper watershed as part of the TMDL Implementation Plan will also help to maintain or improve water quality in Clearwater Lake in the future. Specifically, BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified for implementation in the upstream watersheds.

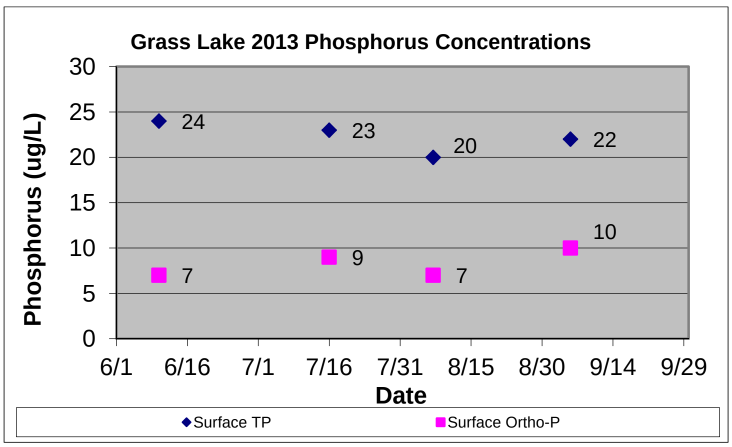
2013 Grass Lake Report Card

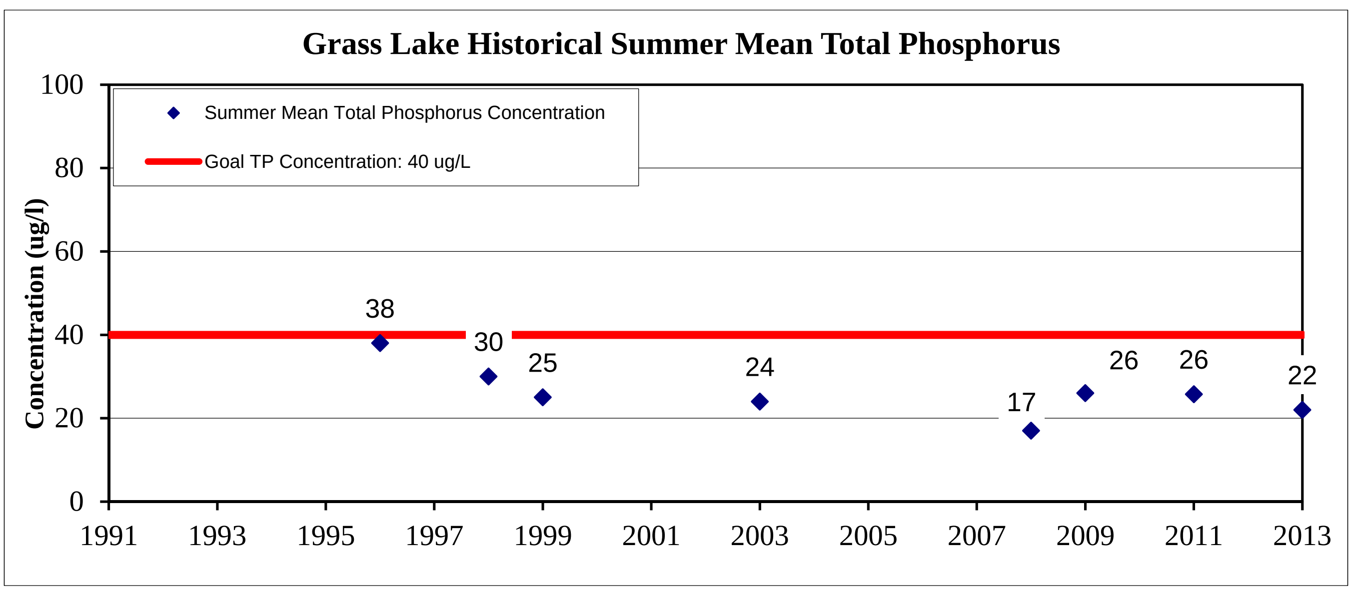
Lake Data

Surface Area:	92 Acres
Maximum Depth:	35 Feet
Subwatershed Area:	101,508 acres



Tributary Sub watershed (shaded)

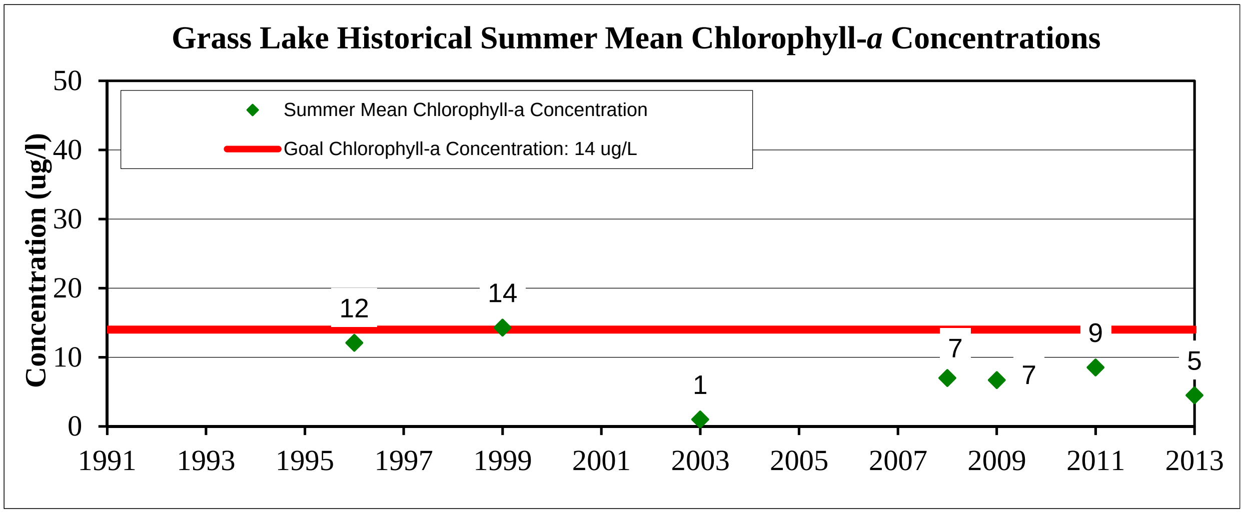


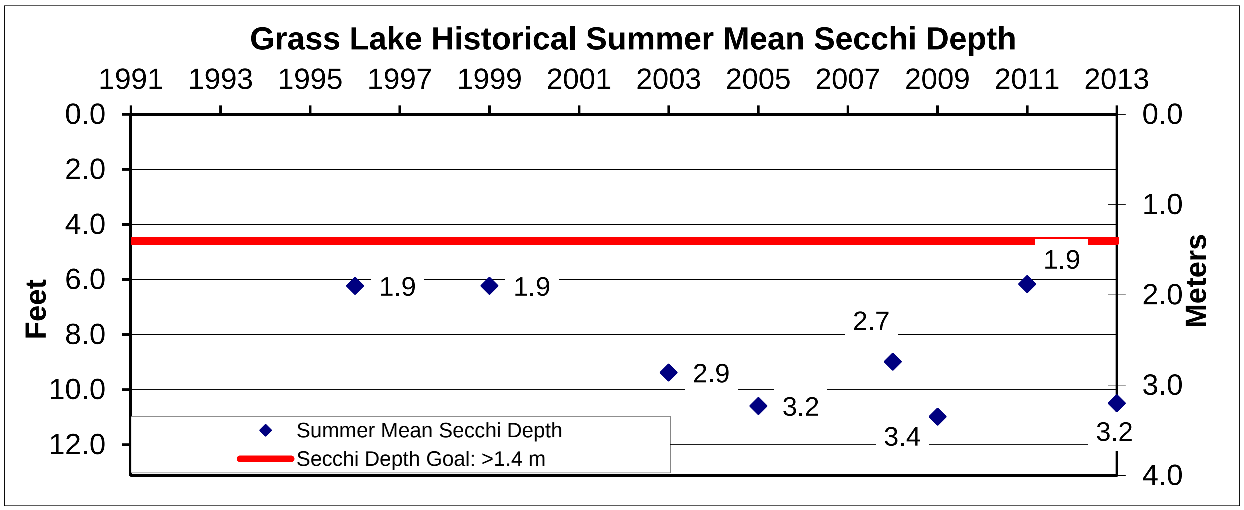


Grass Lake

2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





Summary

- Current water quality is good in Grass Lake as phosphorus concentrations, chlorophyll-a, and Secchi depth have met TMDL Goals since monitoring of the lake began in 1994.

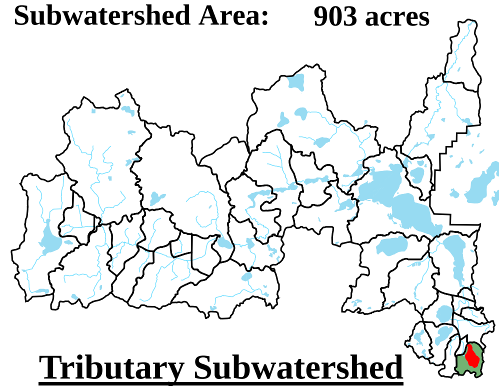
Water Quality Improvement Activiities

- Good land management practices along the lakeshore and in the upstream watershed that are implemented to improve the water quality in upstream lakes and the Clearwater River will also help to maintain the good water quality in Grass Lake.

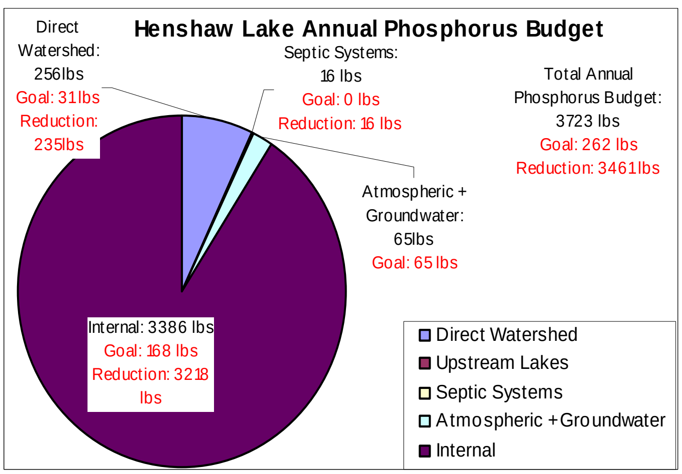
2013 Henshaw Lake Report Card

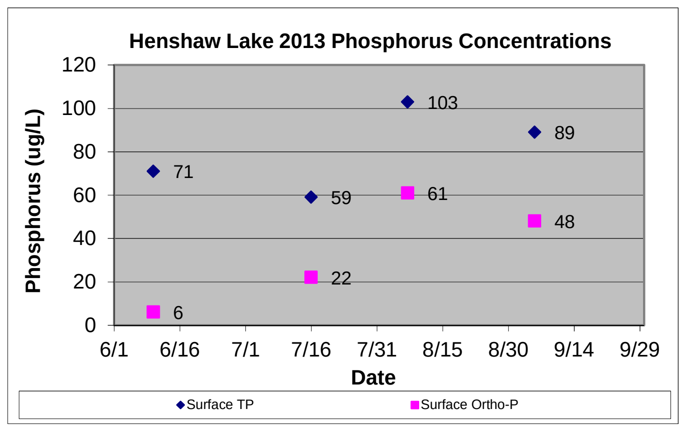
Lake Data

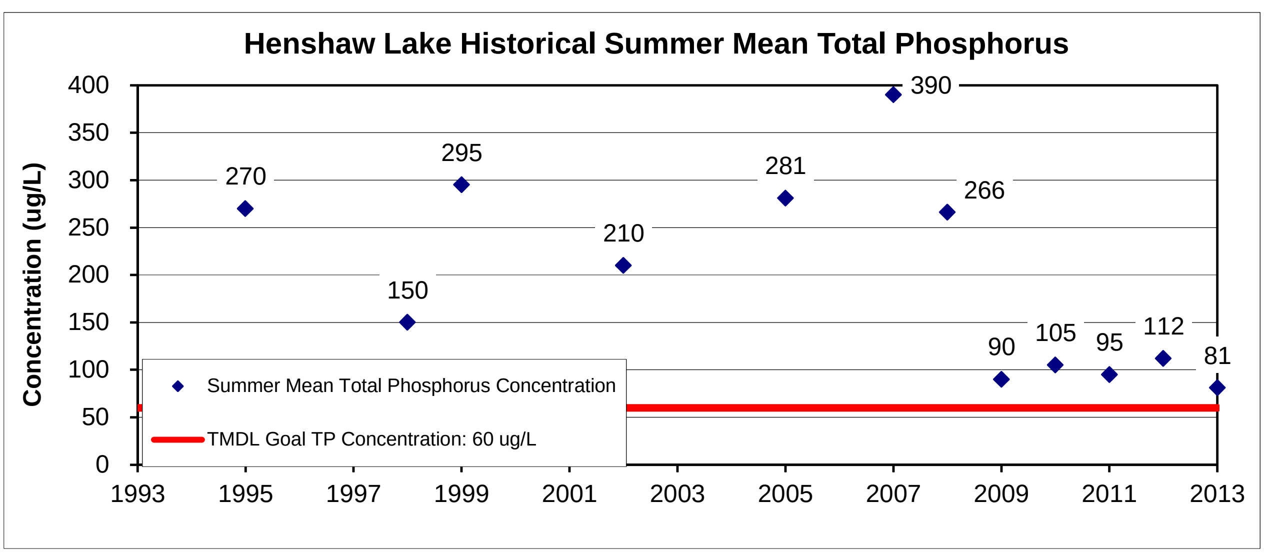
Surface Area:	271 Acres
Maximum Depth:	8 Feet
Contributing Subwatershed Area:	903 acres



Tributary Subwatershed (shaded)

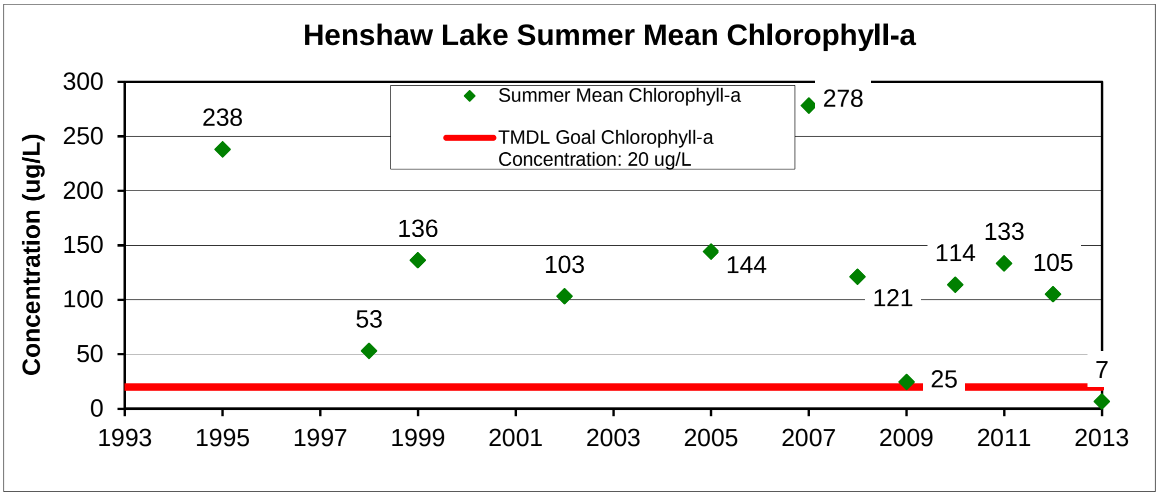


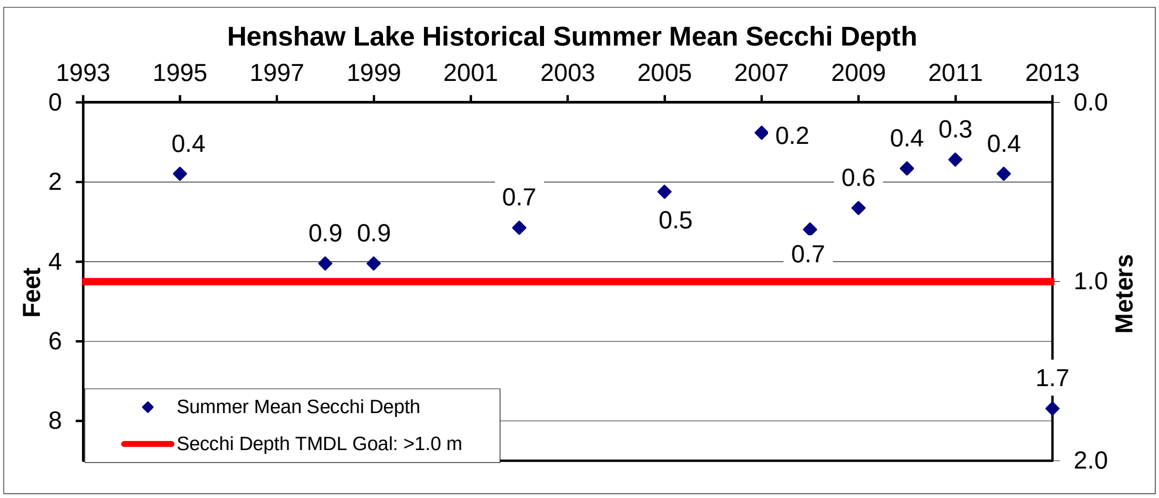




Henshaw Lake
2013 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





2012 Summary

- In-lake phosphorus concentrations exceeded TMDL goals in 2013 but were the lowest observed in the lake since monitoring began.
- Water clarity was extremely good in 2013, as Secchi depths were the highest observed in the lake and met TMDL goals. The Secchi disk was visible on the bottom of the lake during most monitoring trips in 2013.
- Vegetation surveys conducted in June and August 2013 found aquatic vegetation at nearly every sample point compared to less than 20% coverage in previous surveys. Sago pondweed was the dominant native species observed in the lake. Curly leaf pondweed was also observed at 31% of sample points in June 2013.
- The improved water clarity and vegetation community is attributed to an extensive winterkill of rough fish in early 2013, demonstrating the impact that rough fish have on the water quality in the lake.

TMDL Activities

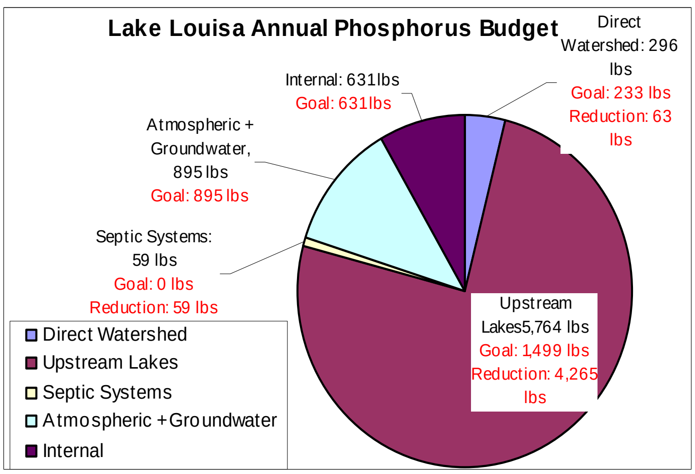
- Due to its small tributary watershed, the reduction of watershed loads alone will not be sufficient to achieve water quality goals. A significant reduction in the internal nutrient source will be required to improve water quality in the lake.
- Hydrologic and ecological restorations, especially the permanent management of rough fish populations, will be required to improve water quality in the lake. The lakes rapid rebound to a clear water state in the absence of rough fish is a demonstration of the important role that rough fish populations play in the water quality and ecological integrity of the lake.
- Nutrient reduction strategies implemented as part of the Cedar Lake Improvement Project as well as activities recommended by the TMDL Implementation Plan will help improve water quality in Henshaw Lake.

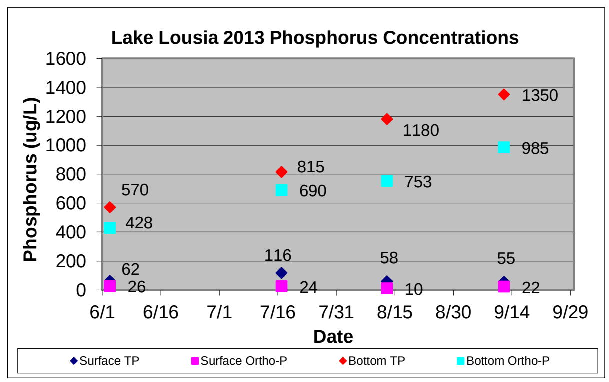
2013 Lake Louisa Report Card

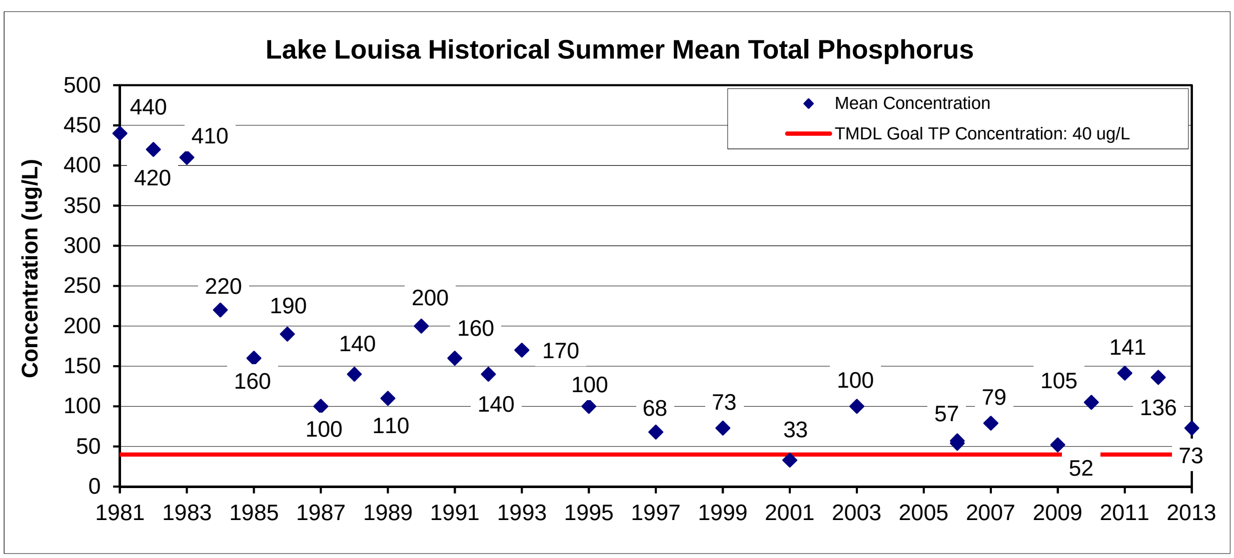
Lake Data

Surface Area:	**193 Acres**
Maximum Depth:	**44 Feet**
Subwatershed Area:	**53,881 acres**

Tributary Subwatershed (shaded)

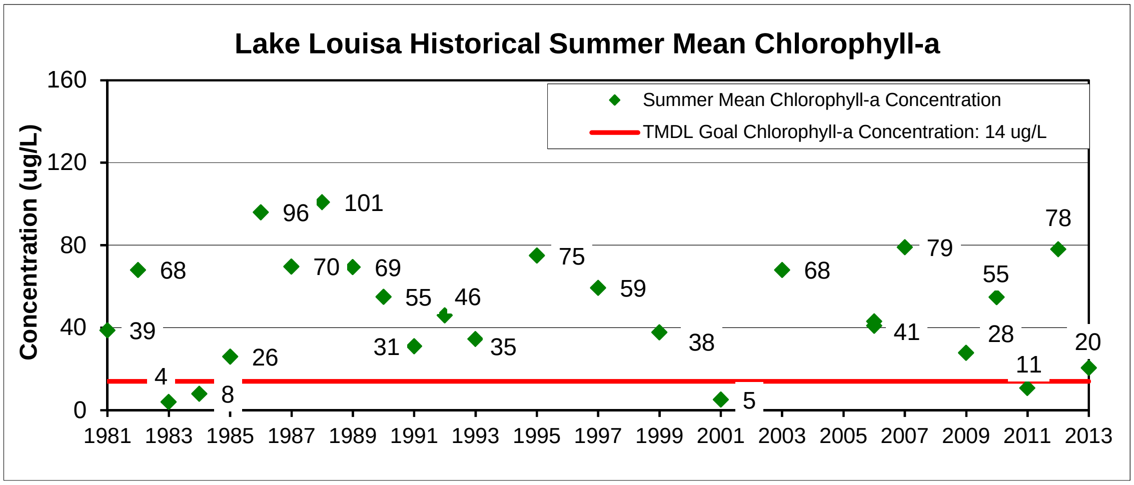


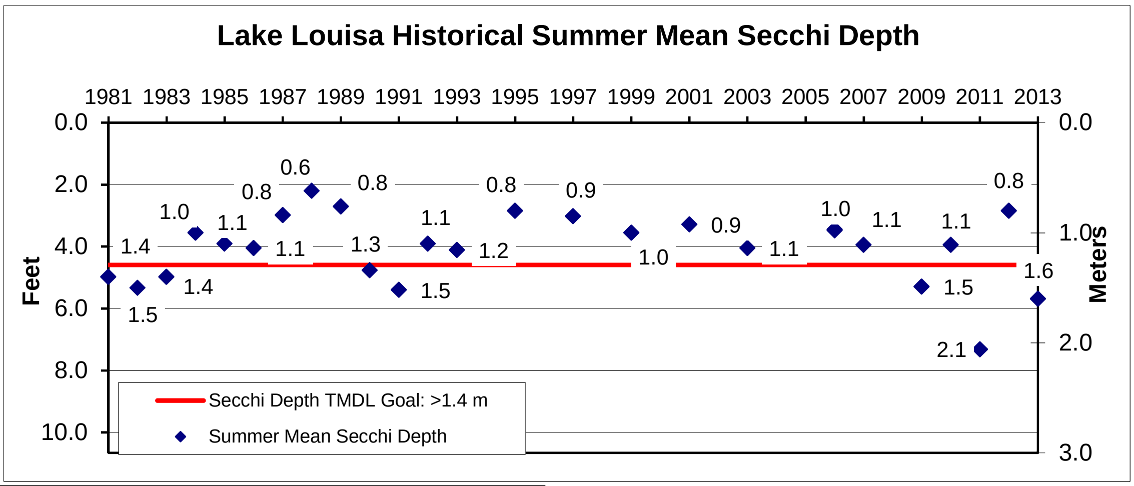




Lake Louisa
2013 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- Summer average phosphorus concentrations decreased in 2013 after increasing steadily since 2009 but remain above TMDL goals. Phosphorus concentrations in the lake are driven primarily by phosphorus loads from the Clearwater River and upstream lakes.
- 2013 Chlorophyll-a concentrations decreased from previous years and were near TMDL goals in 2013.
- Secchi depth increased in 2013 and met TMDL goals.
- Monitoring data indicates the potential for high internal loads in the lake as periods with high bottom phosphorus concentrations coupled with extended periods of bottom anoxia are observed in late summer and early fall. 2013 bottom phosphorus concentrations decreased significantly from previous years but reamined high.

TMDL Activities

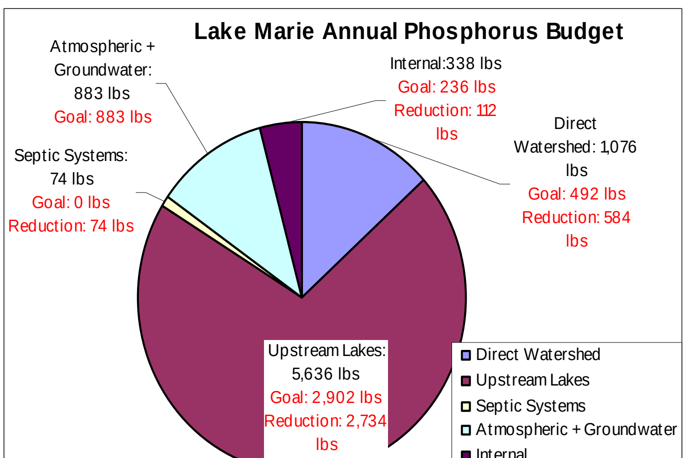
- Reducing phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving water quality in Lake Louisa.
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for the upstream watersheds
- Lake management strategies have included rough fish removal since 1984 and aerators from 1985 to 1995.

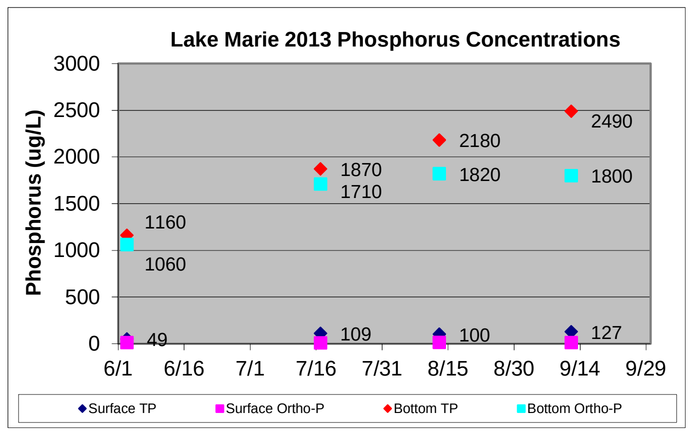
2013 Lake Marie Report Card

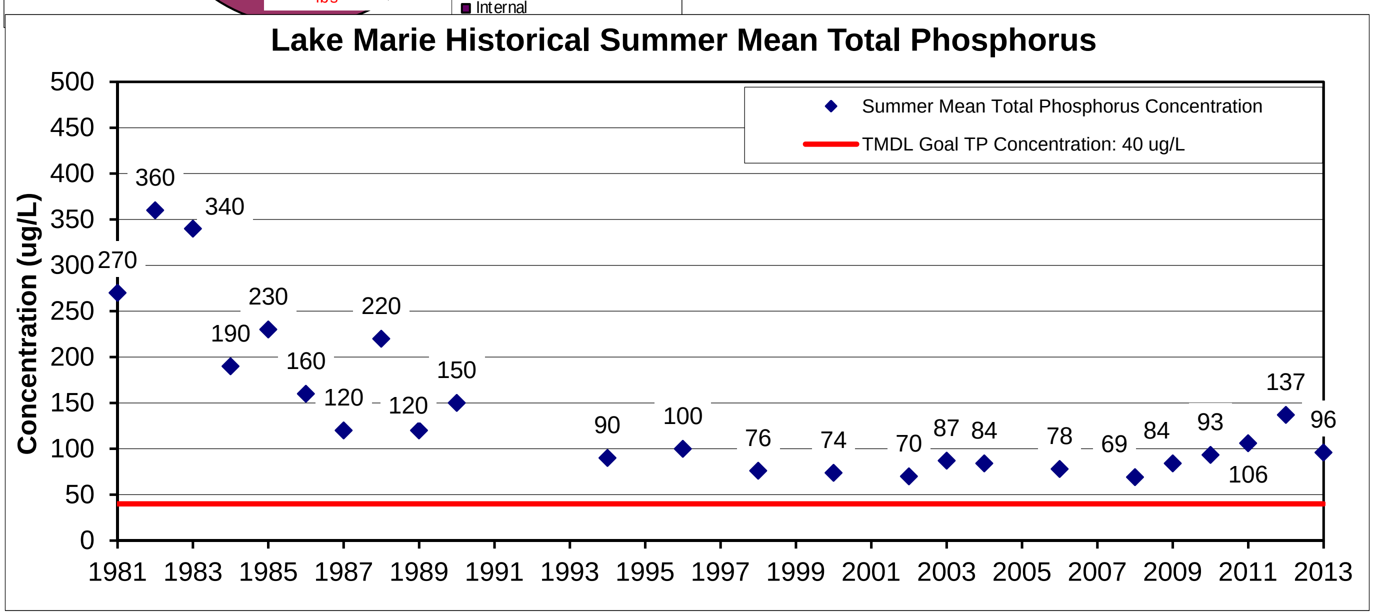
Lake Data

Surface Area:	140 Acres
Maximum Depth:	36 Feet
Subwatershed Area:	59,837 acres

Tributary Subwatershed (shaded)

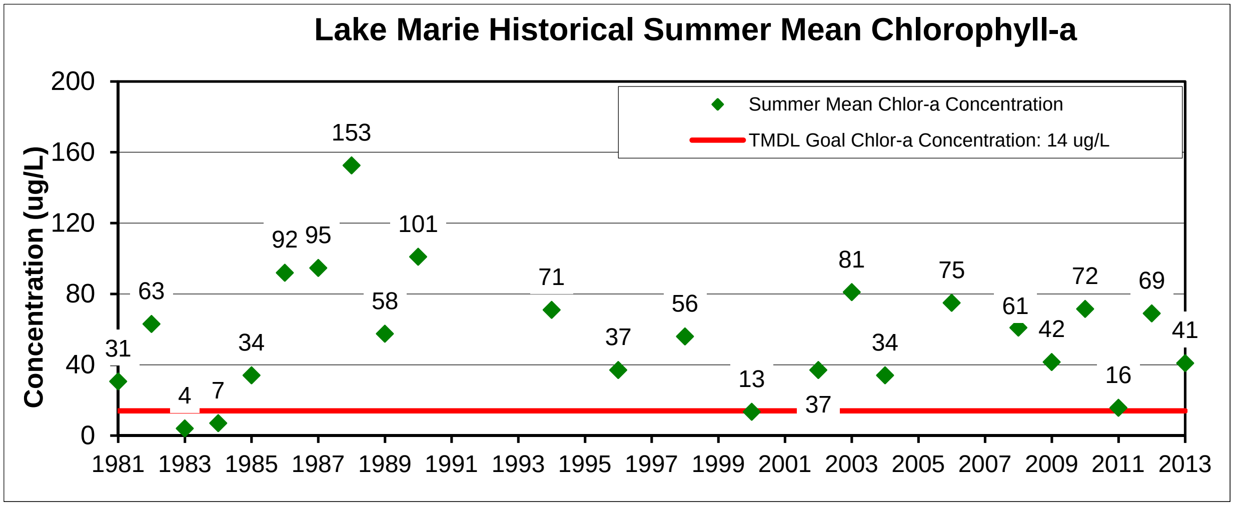


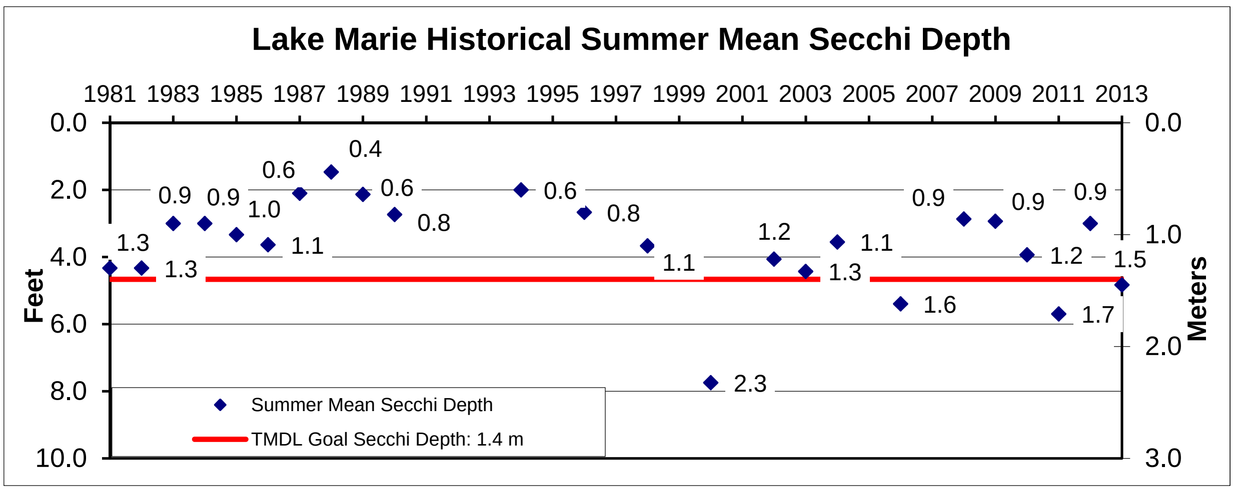




Lake Marie
2013 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- Phosphorus concentrations decreased in 2013 after increasing steadily since 2008. Although water quality has improved significantly since the early 1990s, phosphorus concentrations remain above TMDL goals.
- Chlorophyll-a concentrations decreased compared to 2012, but were similar to most other recent years.
- Water clarity improved slightly in 2013 as Secchi depth increased compared to 2012, exceeded the TMDL goal, and was similar to most recent years.
- Monitoring data continued to demonstrate extremely high bottom phosphorus concentrations throughout the season in the lake in 2013.
- High bottom phosphorus concentrations and extended periods of anoxia demonstrates the potential for high internal loads in the lake.

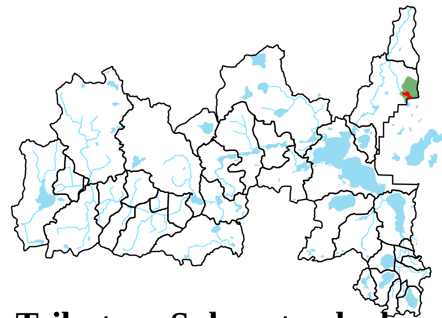
TMDL Activities

- The reduction of phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving lake water quality.
- Lake management strategies have included rough fish removal since 1984 and aeration from 1985 to 1995.
- Phosphorus reduction activities identified for implementation by the TMDL Implementation Plan in the upstream watersheds tributary to Lake Betsy and Clear Lake include BMP's, hypolimnetic withdrawal, Kingston Wetland restoration, soil testing and GPS fertilizer application, and the construction of sedimentation ponds.

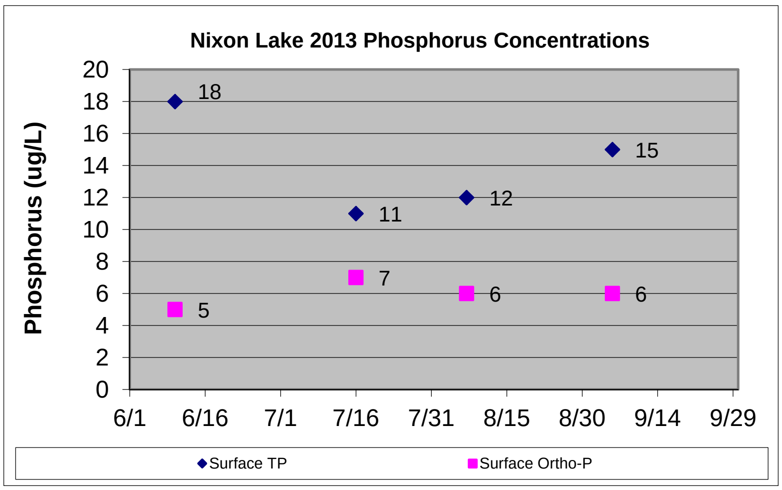
2013 Nixon Lake Report Card

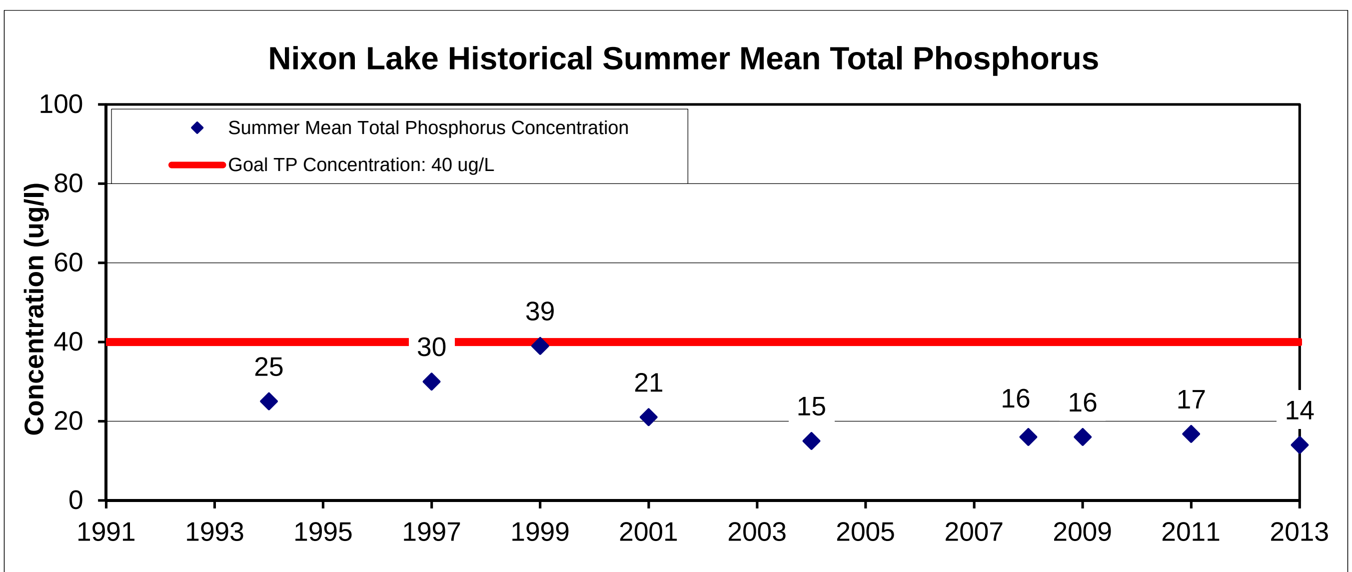
Lake Data

Surface Area:	56 Acres
Maximum Depth:	67 Feet
Subwatershed Area:	570 acres



Tributary Sub watershed (shaded)



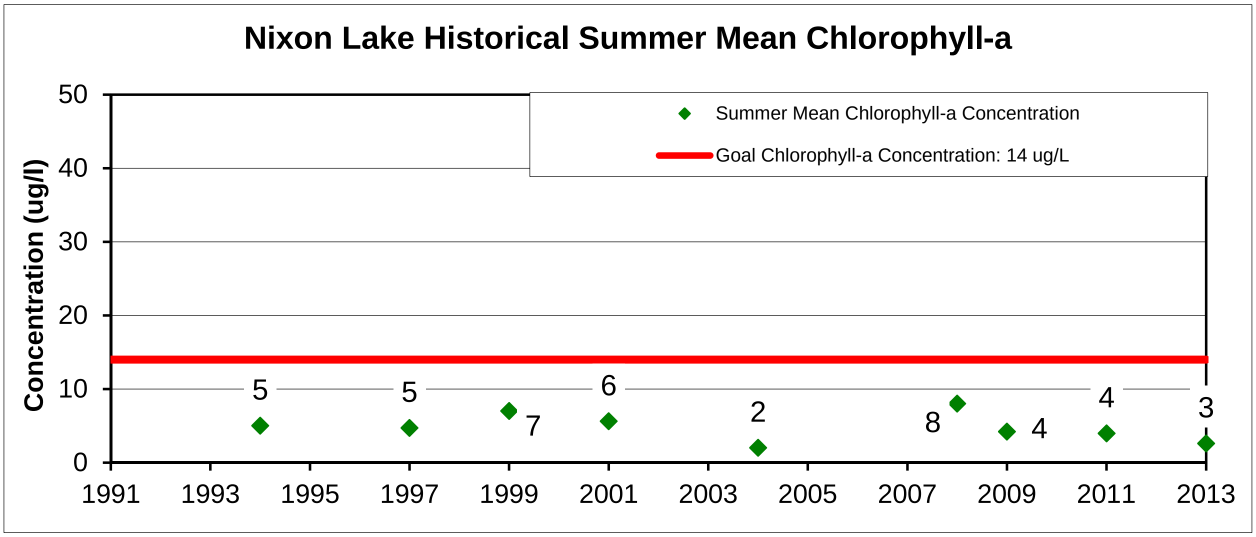


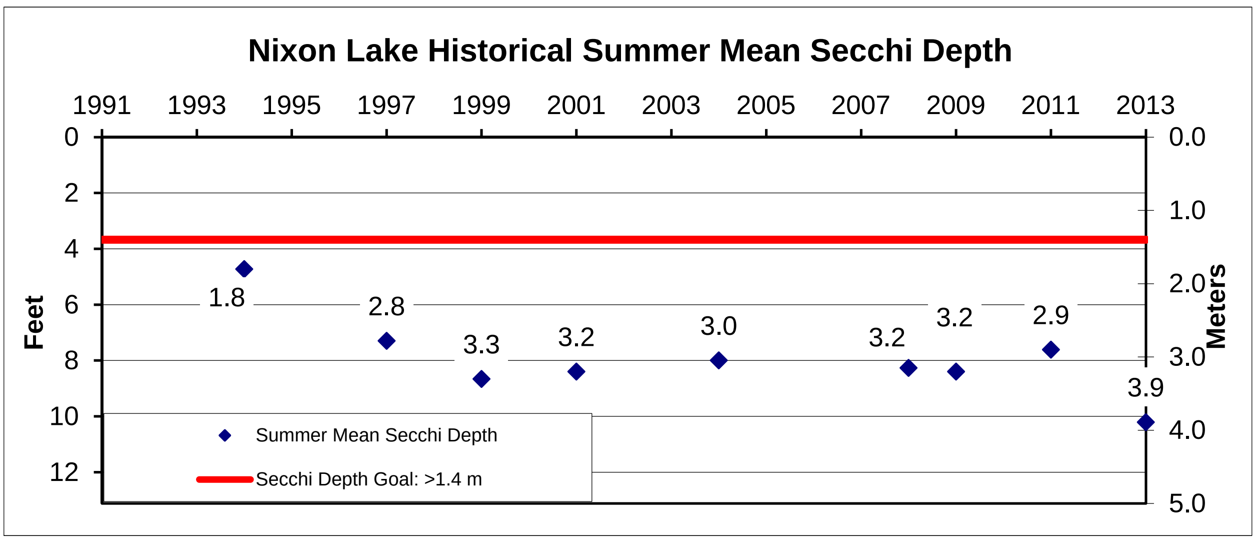
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2014
Nixon Lake		Appendix C

Nixon Lake

2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- Current water quality is good in Nixon Lake as phosphorus concentrations, chlorophyll-a, and Secchi depth have met MPCA standards since monitoring of the lake began in 1994.
- The 2013 Secchi depth was the highest recorded in the lake since monitoring began in 1994.
- A small watershed with limited development contribute to good water quality in the lake.
- Nixon Lake has a diverse aquatic plant community and wetlands and cattail fringe surround most of the lake.

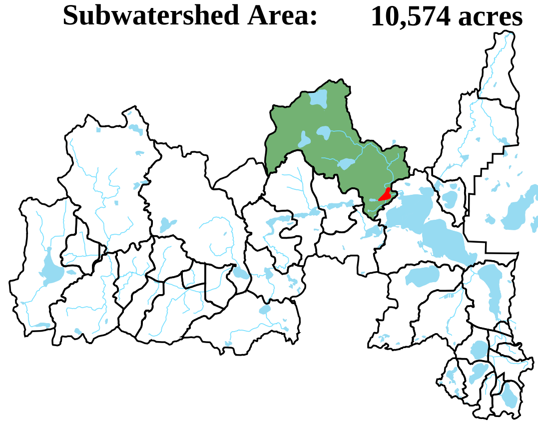
TMDL Activities

- Good land management practices along the lakeshore and in the lake's small watershed will help to maintain the good water quality in Nixon Lake.

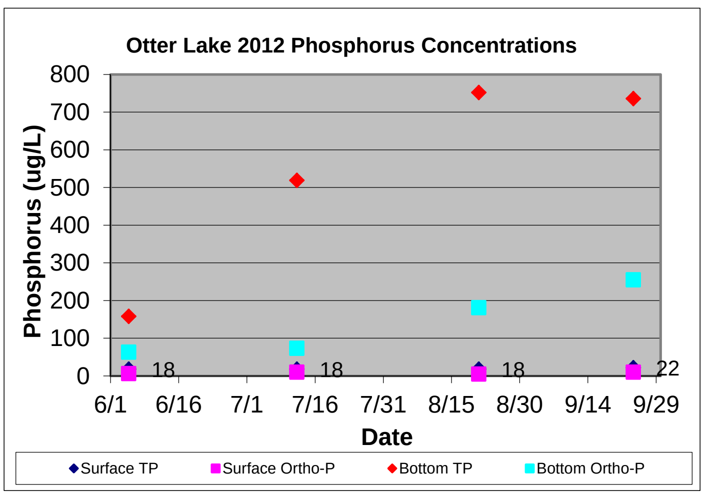
2012 Otter Lake Report Card

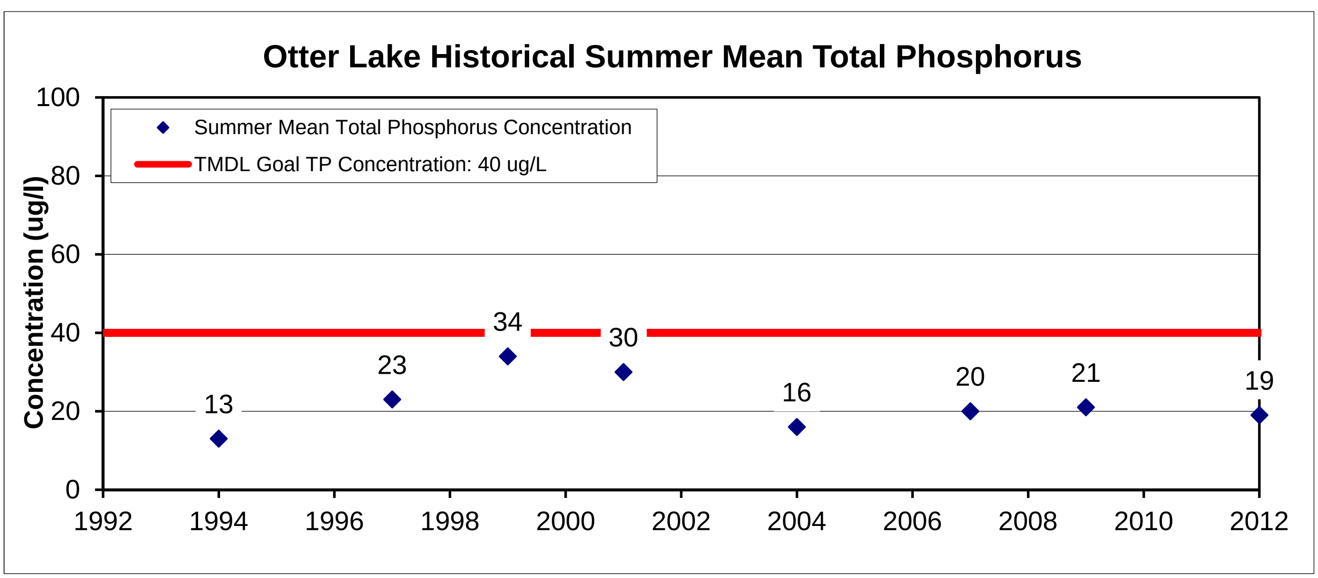
Lake Data

Surface Area:	**96 Acres**
Maximum Depth:	**51 Feet**
Subwatershed Area:	**10,574 acres**



Tributary Sub watershed (shaded)



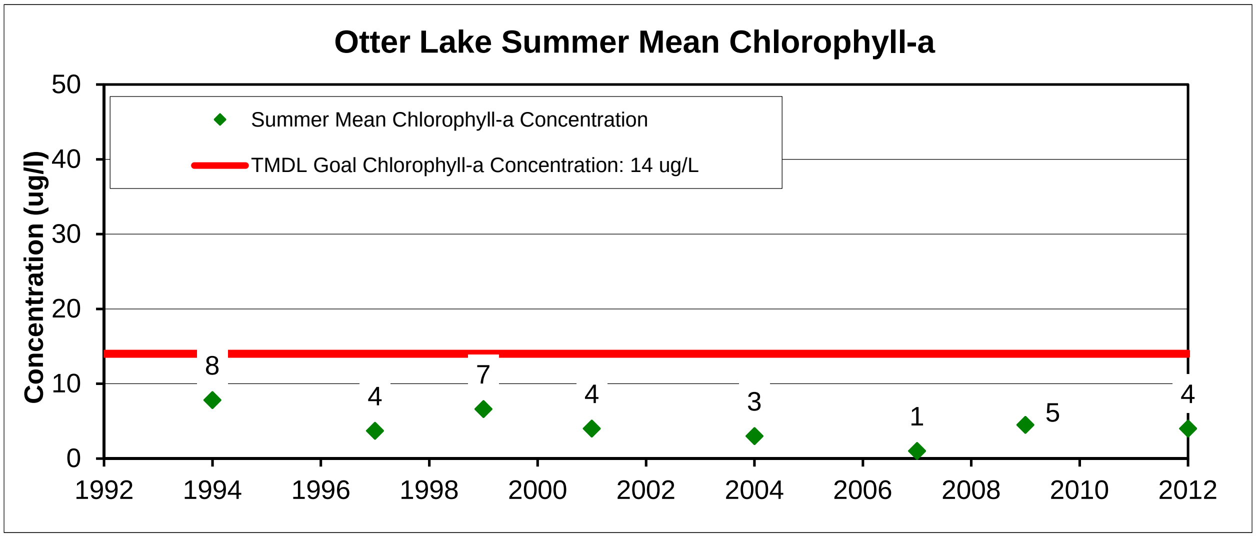


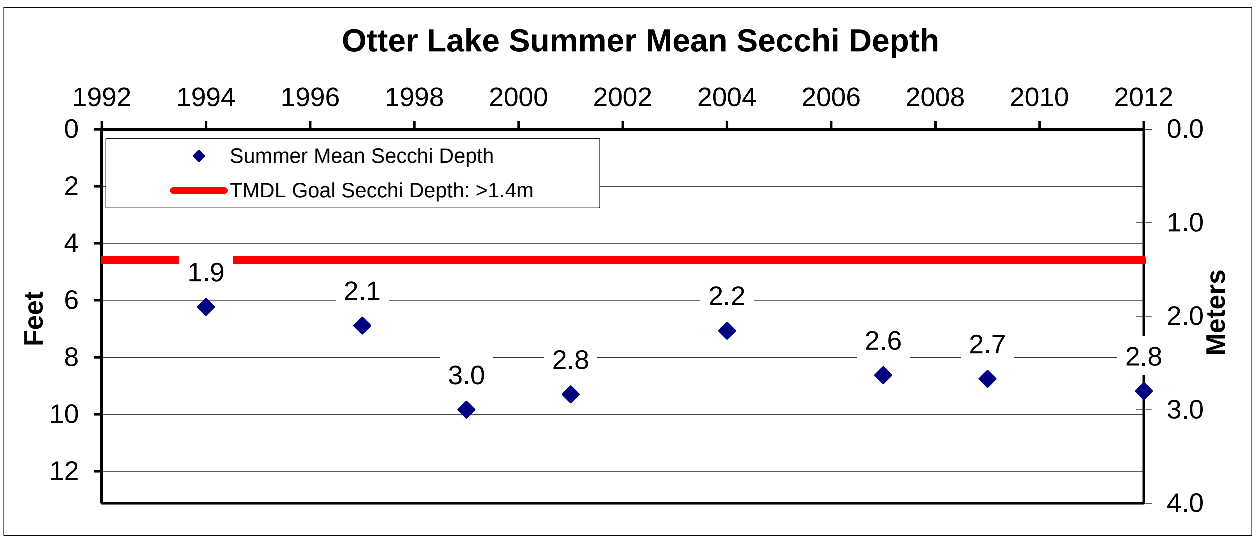
Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2013
Otter Lake		Appendix C

Otter Lake

2012 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





Summary

- Overall water quality is good in Otter Lake as phosphorus and chlorophyll-a concentrations, and Secchi depth have met TMDL goals since monitoring of the lake began in 1994.
- A small direct contributing watershed with limited development contributes to good water quality in Otter Lake.
- Otter Lake is connected to Clearwater Lake by a channel, and a high quality fishery exists for both northern pike and walleye in the lake.*

Water Quality Improvement Activities

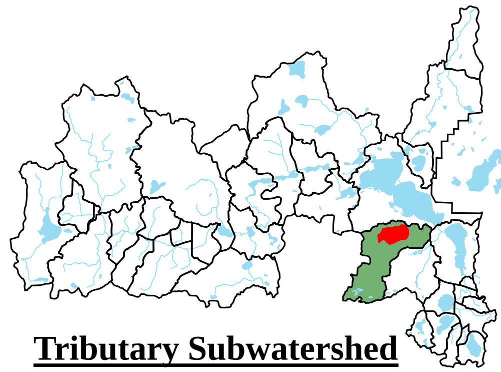
- Good land management practices adjacent to the lakeshore and thorughout the lake's watershed will help to maintain the good water quality in Otter Lake.
- A small direct contributing watershed with limited development contributes to good water quality in Otter Lake

*Source: MN DNR Lake Finder

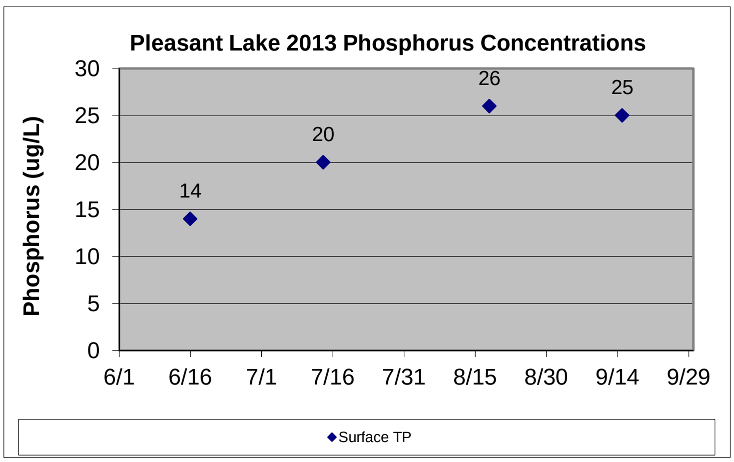
2013 Pleasant Lake Report Card

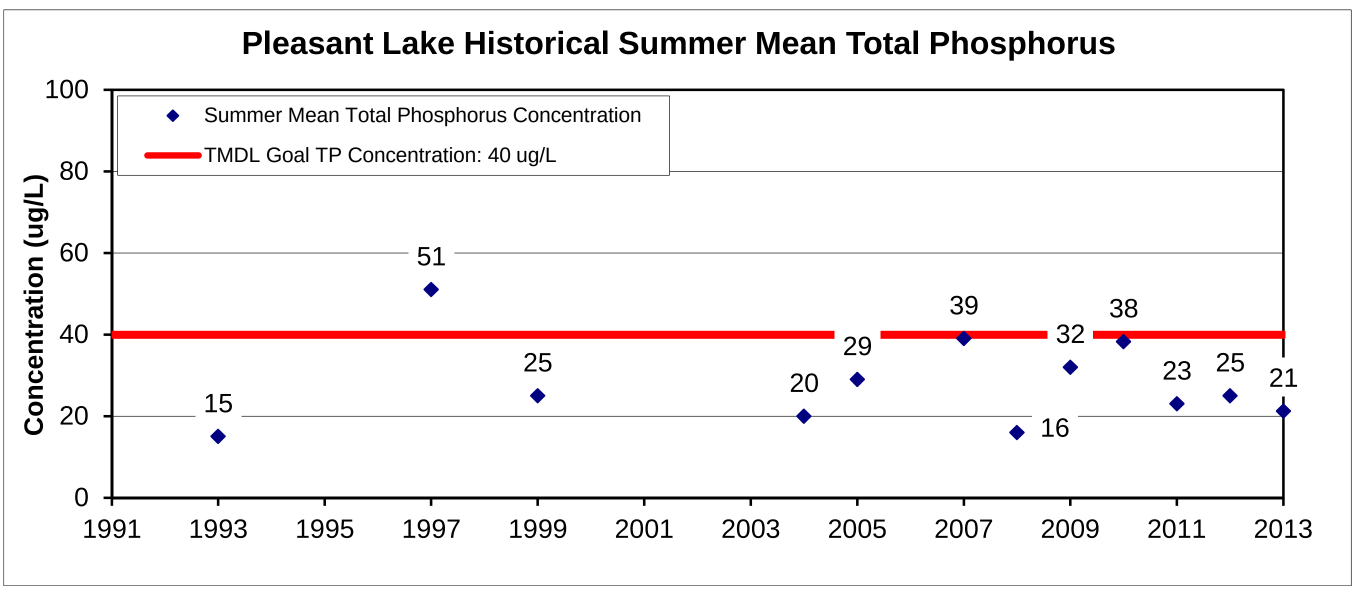
Lake Data

Surface Area: 571 Acres
Maximum Depth: 74 Feet
Subwatershed Area: 4,325 acres



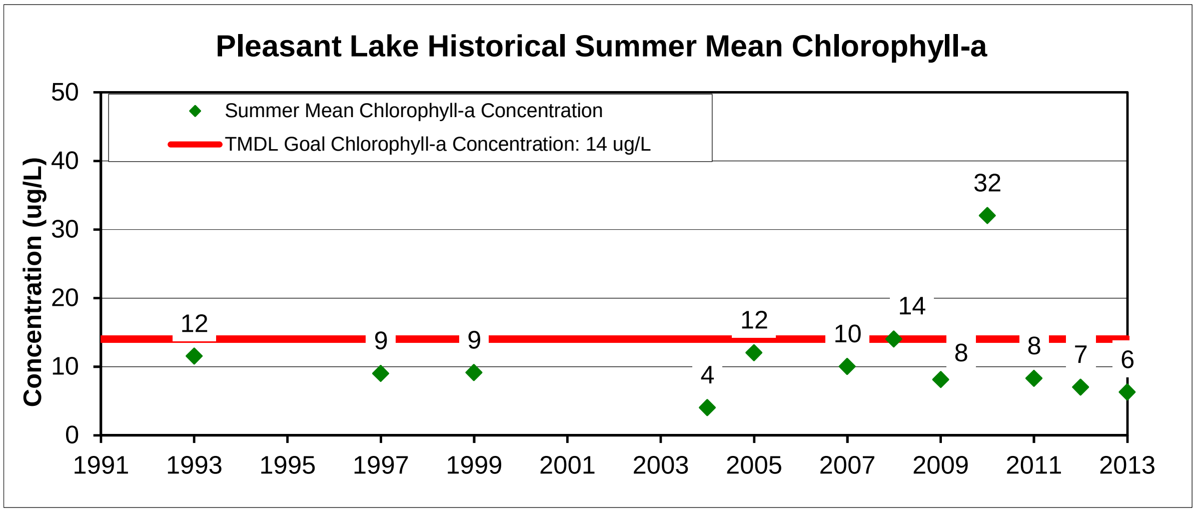
Tributary Subwatershed (shaded)

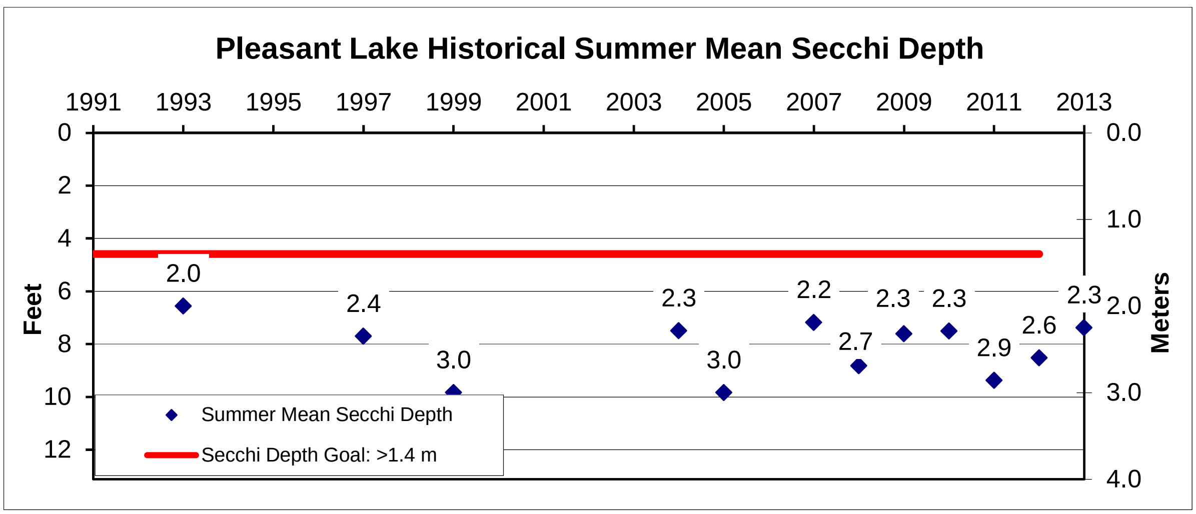




Pleasant Lake
2013 Lake Report Card

MPCA Proposed Deep Lake Standards for the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





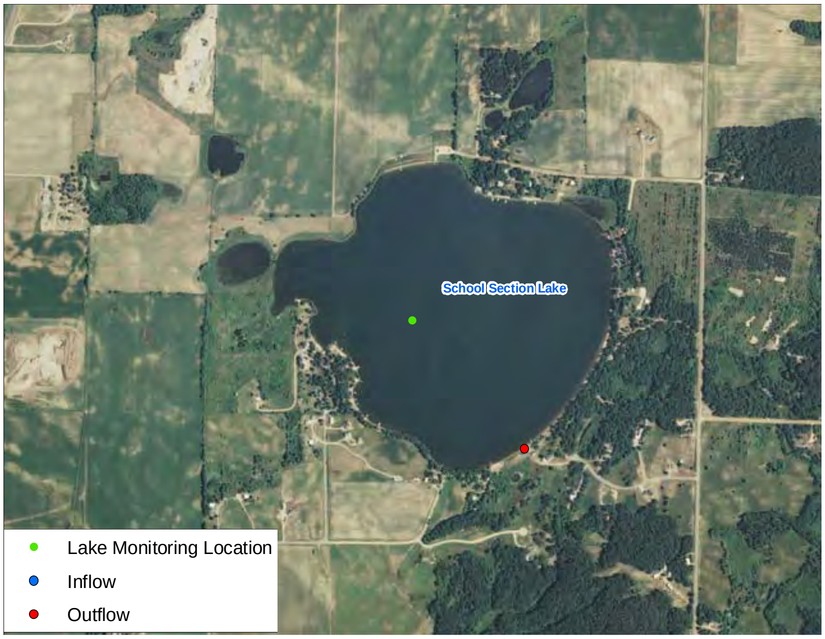
2013 Summary

- Current water quality is good in Pleasant Lake as phosphorus concentrations, chlorophyll-a, and Secchi depths have met TMDL goals since 1993.
- Phosphorus concentrations have decreased since slightly higher concentrations were observed in 2009 and 2010.
- Summer average phosphorus and chlorophyll-a concentrations as well as Secchi depths were similar to 2012.

Water Quality Improvement Activities

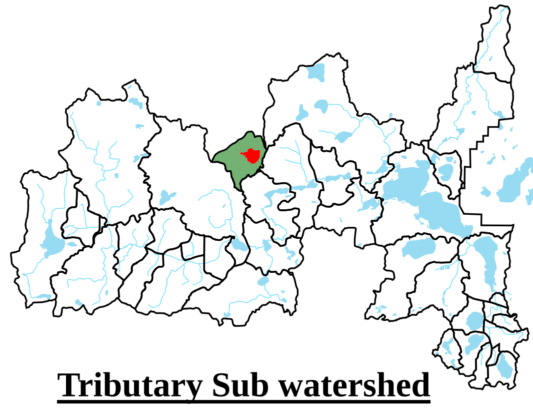
- Good land management practices adjacent to the lakeshore, the upstream watershed, and in the City of Annandale will help to maintain the good water quality in Pleasant Lake.
- The expansion of curly leaf pondweed in the lake in recent years does not seem to have negatively impacted water quality.

2013 School Section Lake Report Card

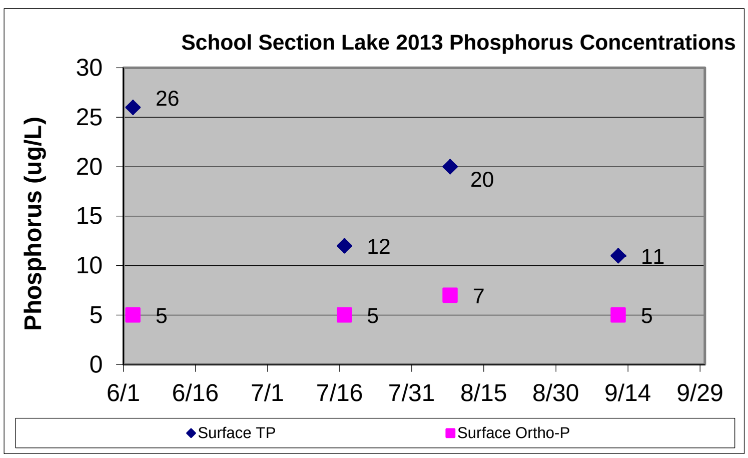


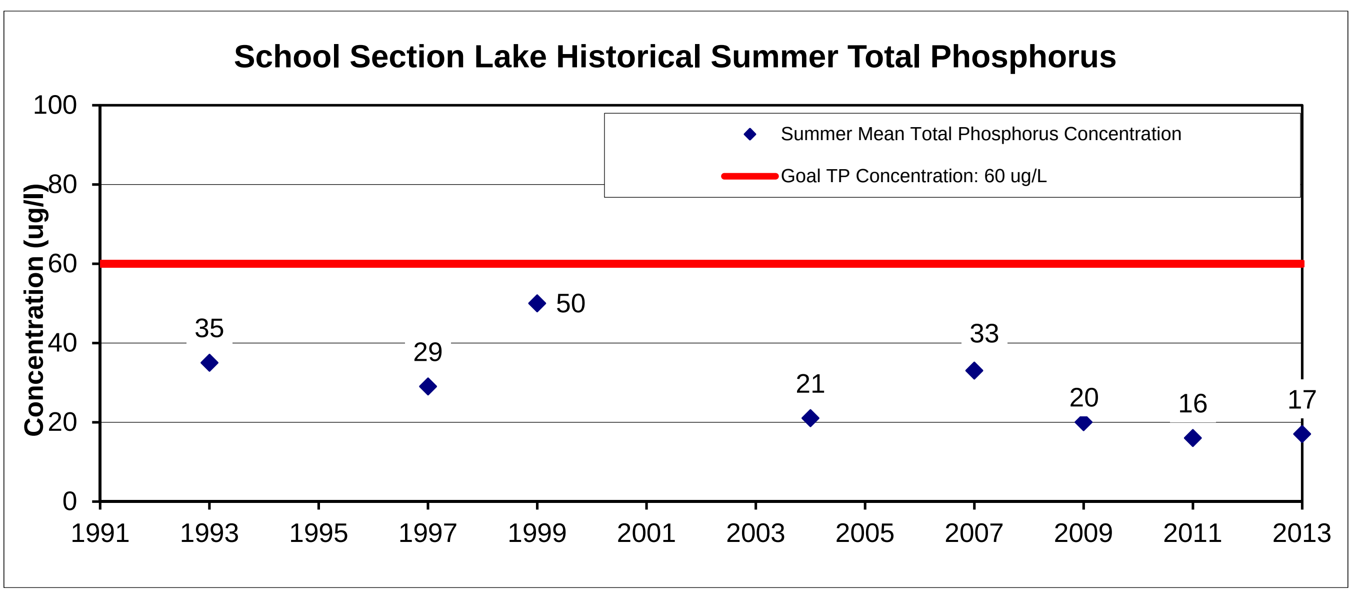
Lake Data

Surface Area:	**192 Acres**
Maximum Depth:	**12 Feet**
Subwatershed Area:	**1,843 acres**



Tributary Sub watershed (shaded)



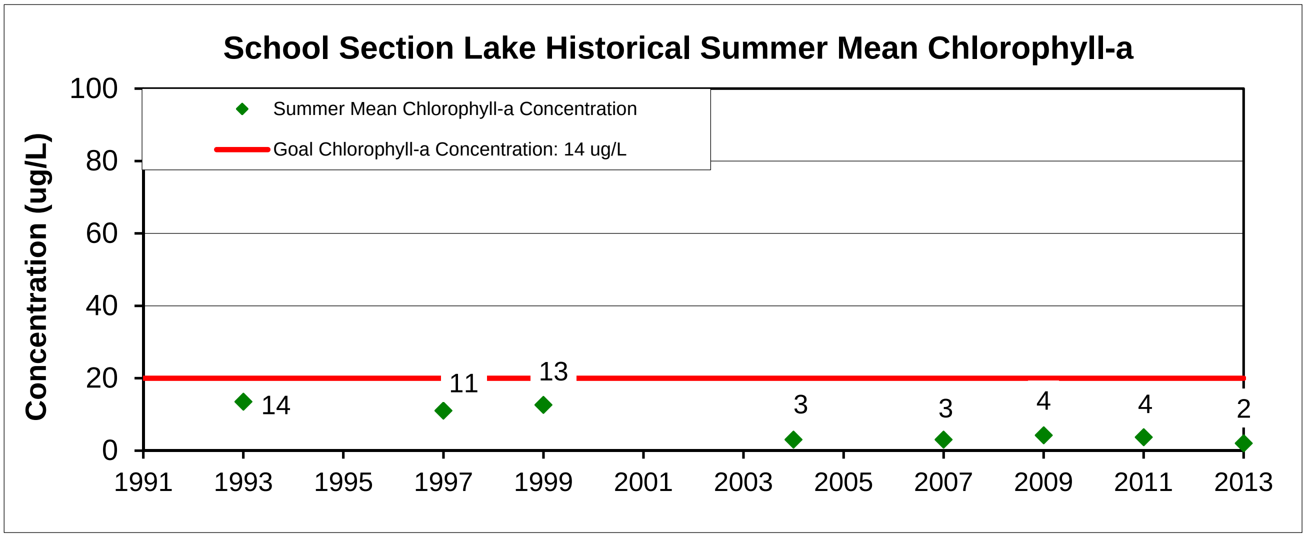


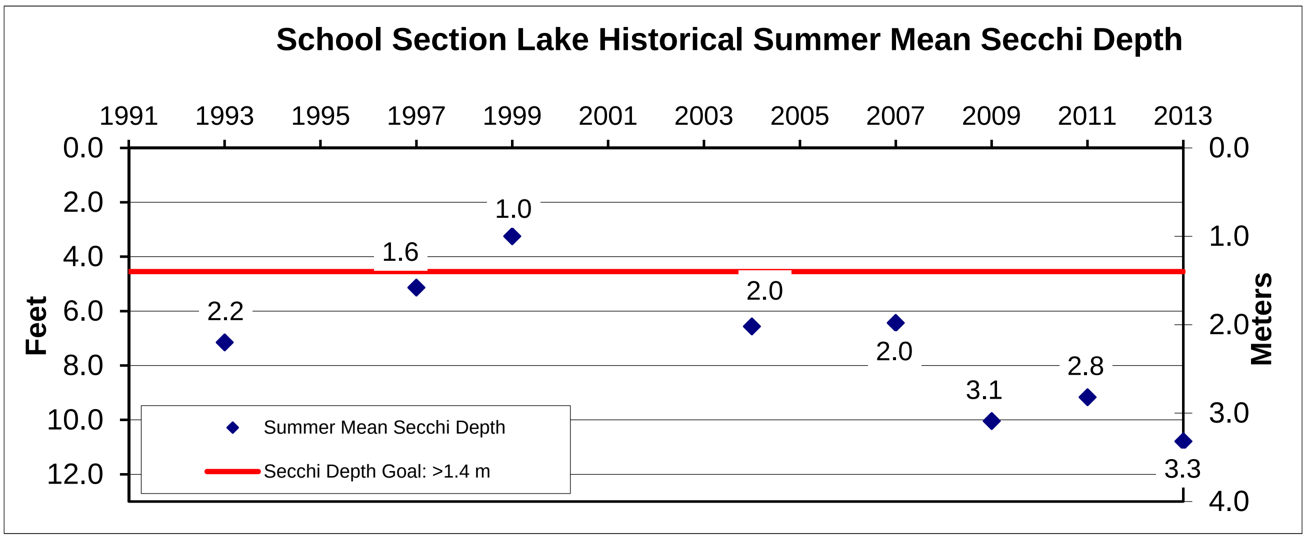
Clearwater River Watershed District	**Wenck** Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	January 2014
School Section Lake		Appendix C

School Section Lake

2013 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





2013 Summary

- Current water quality is good in School Section Lake as phosphorus concentrations, chlorophyll-a concentrations, and Secchi depth have met MPCA standards since monitoring of the lake began in 1993.
- Water clarity has improved and phosphorus concentrations have decreased since 2007, while chlorophyll-a concentrations have remained consistently low. Water clarity was the highest ever observed in 2013.
- School Section Lake is a shallow natural environment lake with a diverse aquatic plant community comprised primarily of native species. Invasive curly leaf pondweed was abundant in 1990 but was rare in 2008, covering less than one tenth of an acre over the lake.*
- An outlet structure is maintained and operated by the CRWD to control lake water elevations.

*Source: MN DNR Lake Finder

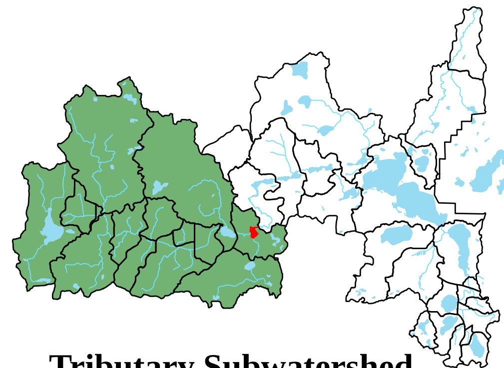
Water Quality Improvement Activities

- Good land management practices along the lakeshore and in the watershed will help to maintain the good water quality in School Section Lake.

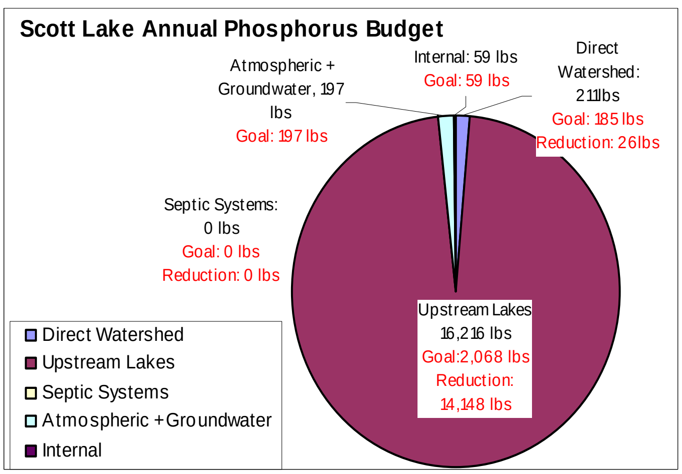
2013 Scott Lake Report Card

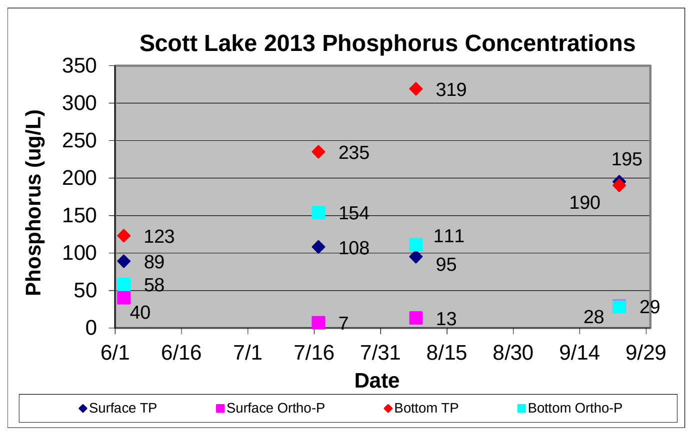
Lake Data

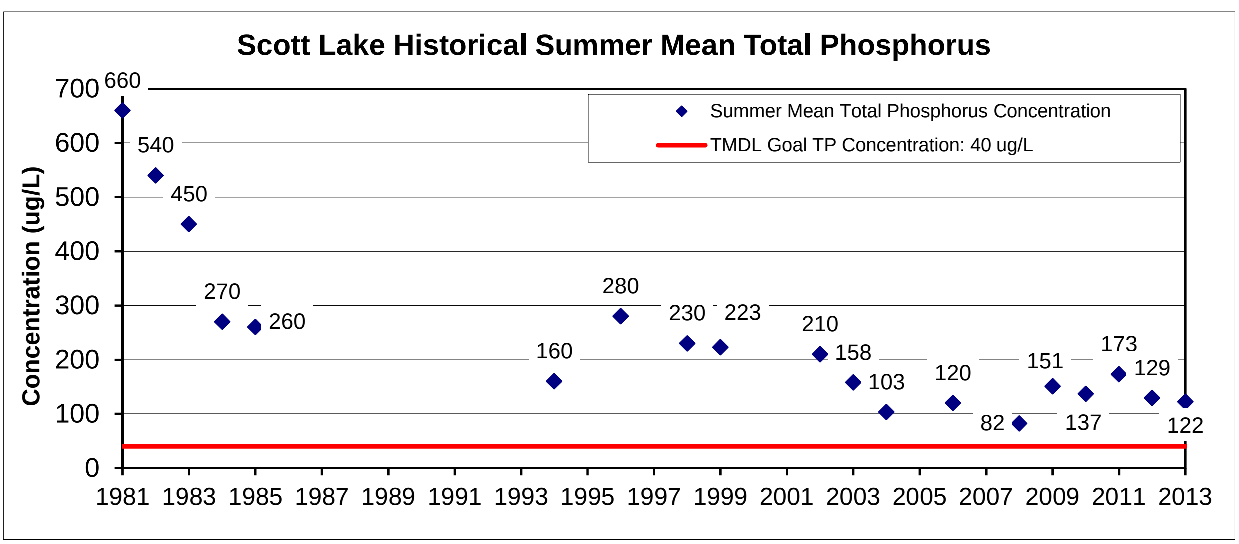
Surface Area: 80 Acres
Maximum Depth: 23 Feet
Subwatershed Area: 51,000 acres



Tributary Subwatershed (shaded)

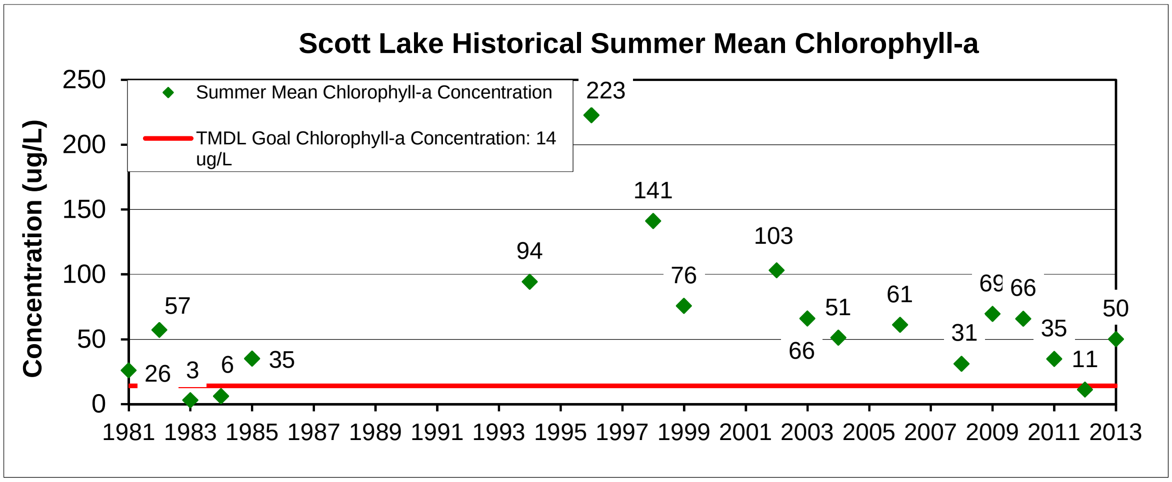


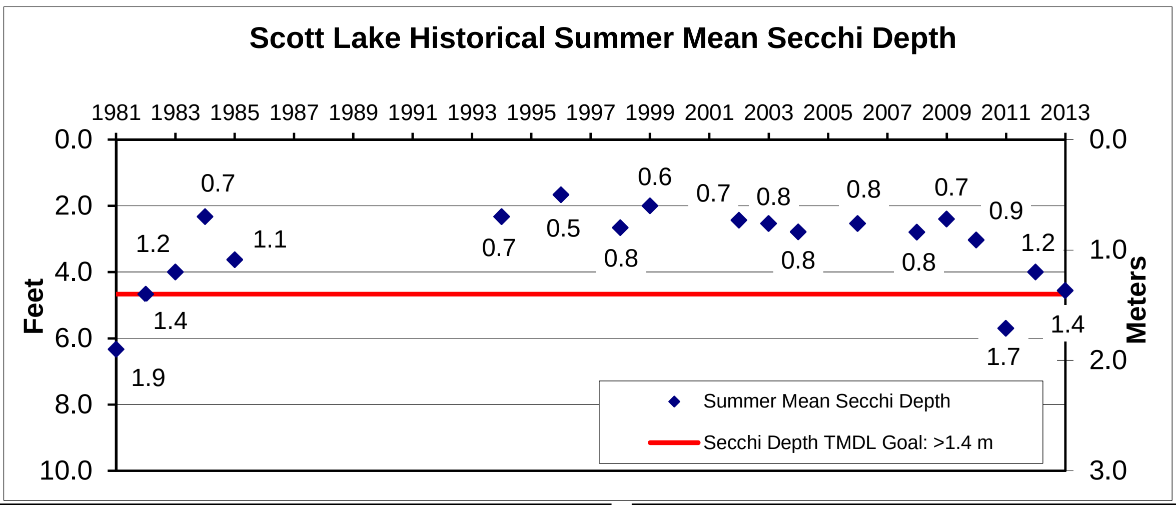




Scott Lake
2013 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





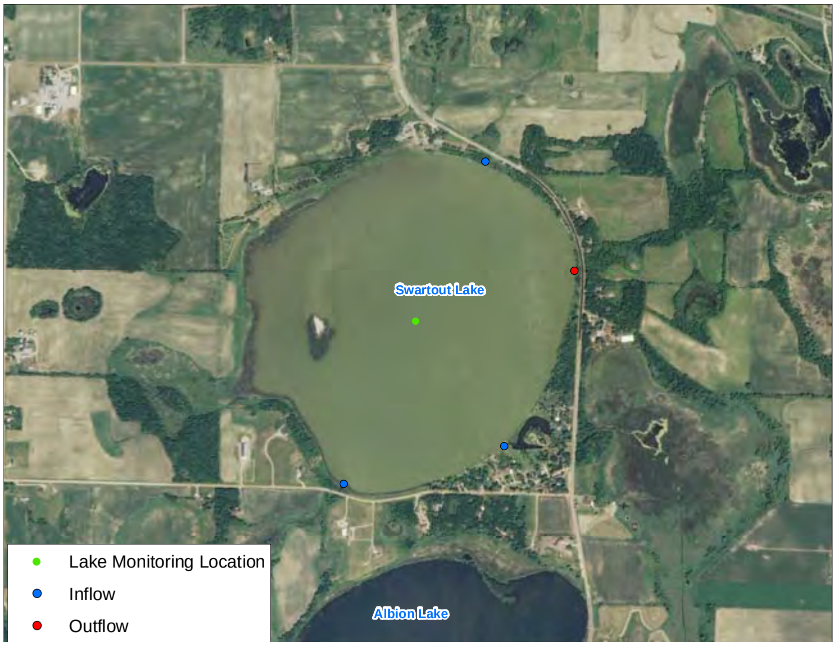
2013 Summary

- Phosphorus concentrations have decreased since 2011 following a period of increasing concentrations from 2008 to 2010. TP concentrations are similar to values seen in recent years and remain above TMDL goals.
- Secchi depth increased slightly in 2012 and was near the TMDL goal. Overall, Secchi depth has improved since the early 1990s.
- Chlorophyll-a concentrations increased from 2012 and did not meet TMDL goals, but was simlar to values seen in most recent years.
- Water quality in Scott Lake is dominated by the inflow from Lake Betsy. Recent bottom phosphorus concentration analysis and sediment phosphorus release analysis performed in 2010 indicate that Internal loading may represent a significant source of phosphorus to the lake during some years as well.

TMDL Activities

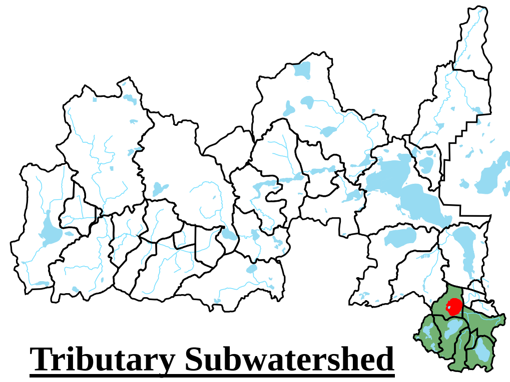
- Reducing phosphorus loads from upstream lakes and the direct tributary watershed will have the greatest impact on improving water quality in Scott Lake. Controlling loads in Lake Betsy is the key to improving water quality in Scott Lake
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, Kingston Wetland restoration, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for implementation in upstream watersheds.

2013 Swartout Lake Report Card

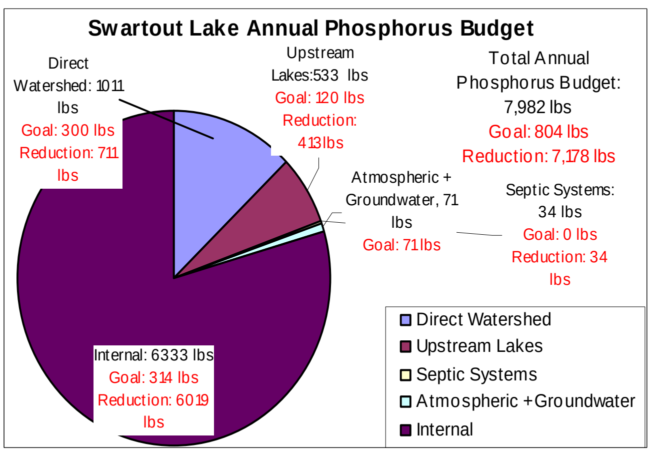


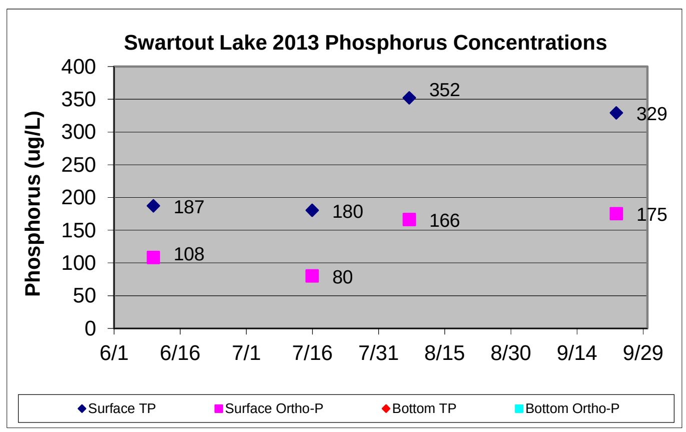
Lake Data

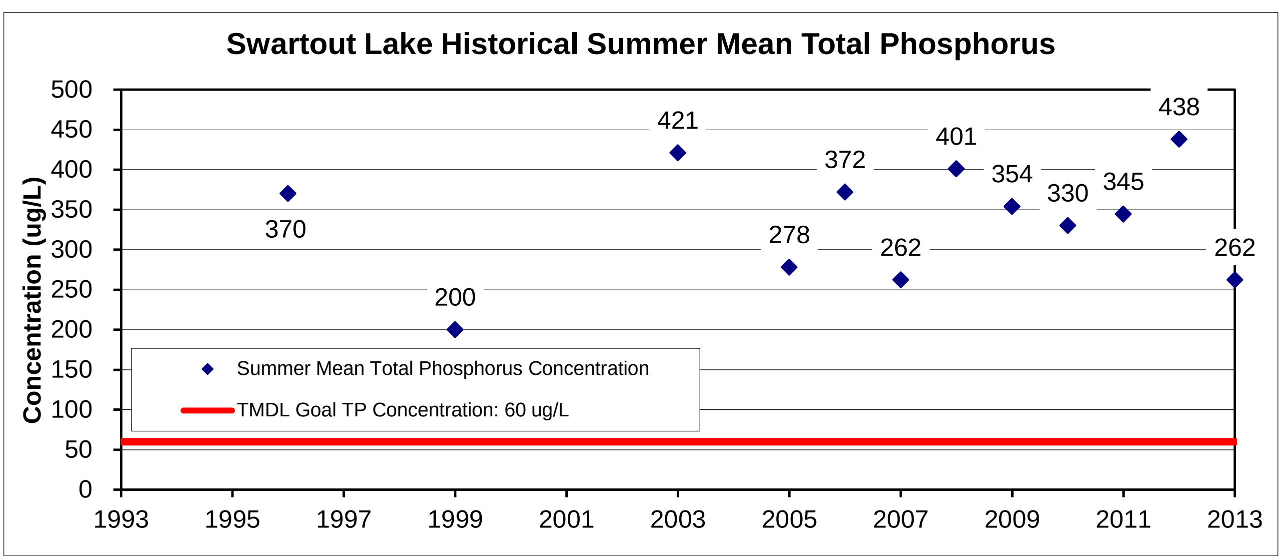
Surface Area:	**296 Acres**
Maximum Depth:	**12 Feet**
Subwatershed Area:	**5,551 acres**



Tributary Subwatershed (shaded)

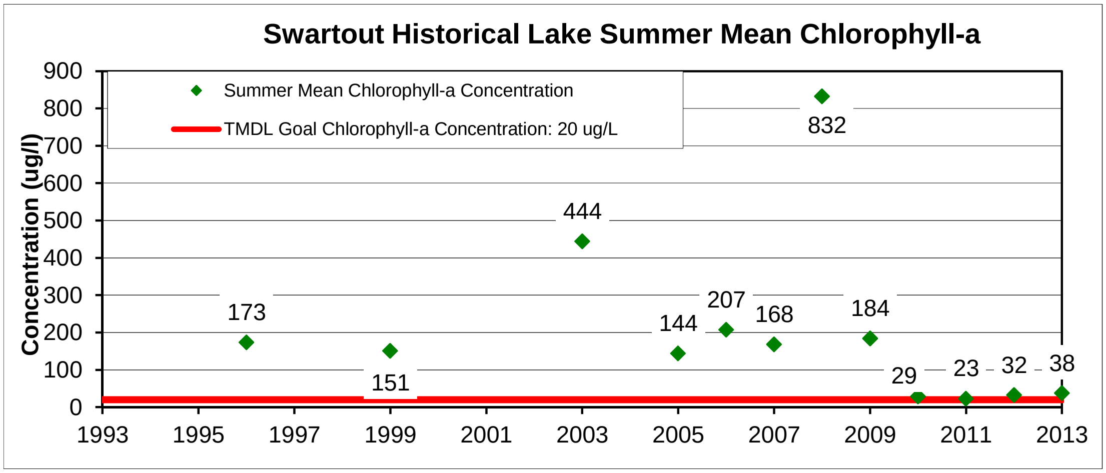


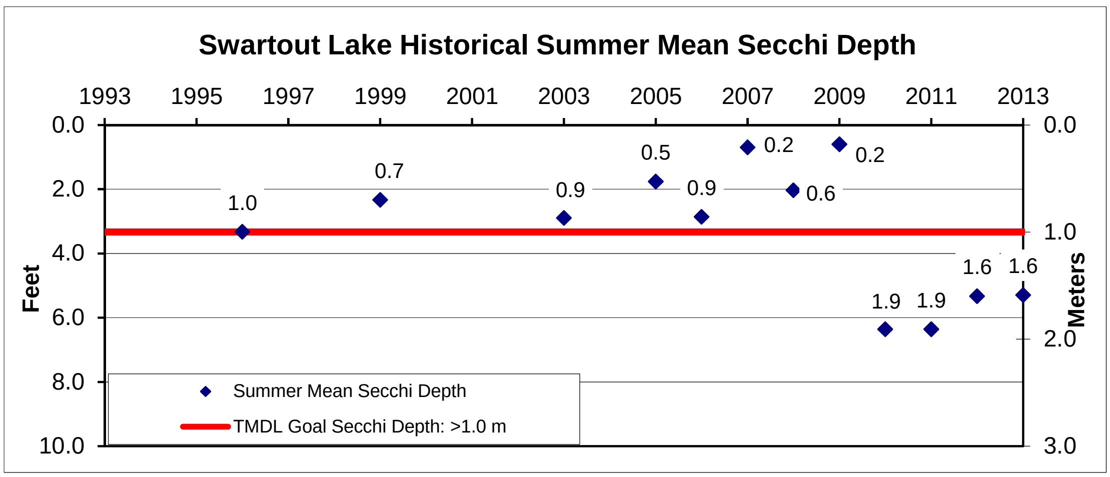




Swartout Lake
2013 Lake Report Card

MPCA Standards for Shallow Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 60 ug/L
Chlorophyll-a: ≤ 20 ug/L
Secchi Depth: ≥ 1.0 meter





Summary

- Phosphorus concentrations decreased significantly in 2013 and were the lowest observed since 2007 but remained well above TMDL goals. Phosphorus concentrations increased in late summer in 2013.
- Chlorophyll-a concentrations were similar to recent years since 2010 and remained near the TMDL goal.
- Secchi depth met the TMDL goal and water clarity continued to be very good in 2013 due to decreased numbers of rough fish in the lake since an extensive winter fish kill in 2010.
- An aquatic vegetation inventory conducted in June 2013 found similar results to vegetation surveys performed since 2010. Dense beds of native species of submergent vegetation were observed in shallow portions of the lake with a suitable substrate for aquatic vegetation growth. There was no curly leaf pondweed or other invasive species observed in 2013.
- Internal loads are the major source of nutrients to the lake.

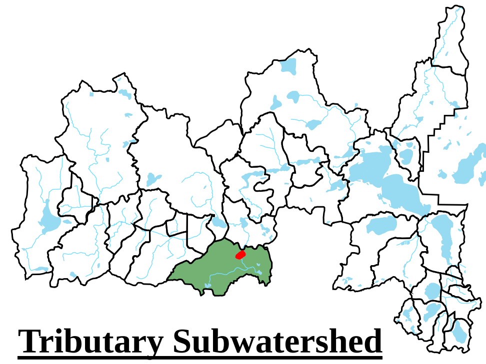
TMDL Activities

- Swartout Lake receives significant nutrient loads from upstream lakes Albion and Henshaw. A reduction in these external loads as well as a significant reduction in internal nutrient cycling will be required to meet TMDL goals in Swartout Lake.
- Rough fish migration control and removal is an important element of lake management. Fish barriers have been installed on tributary streams to inhibit carp from reaching spawning wetlands. Rough fish harvest has been conducted during the winter as well.

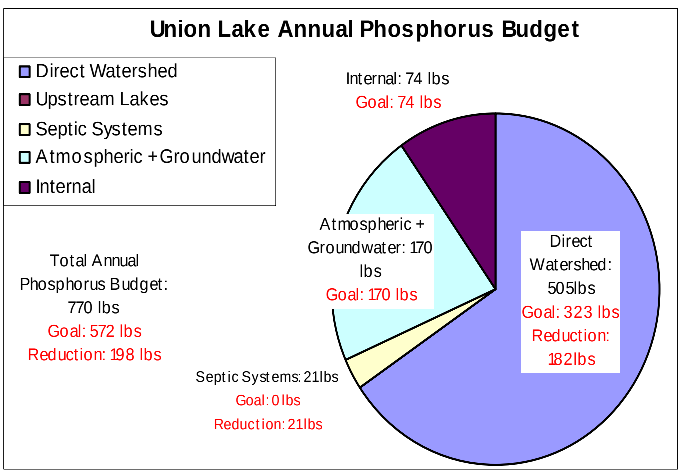
2013 Union Lake Report Card

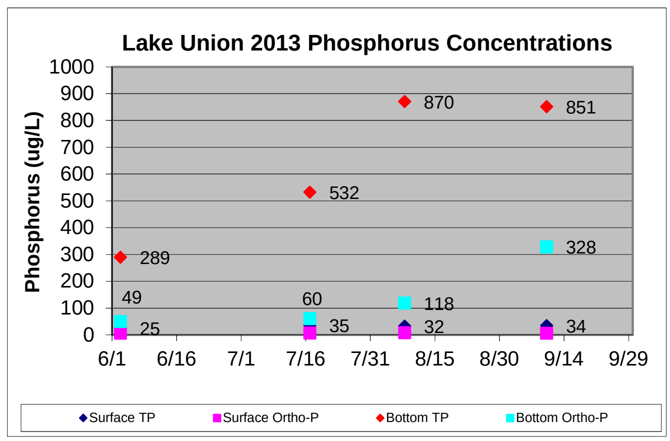
Lake Data

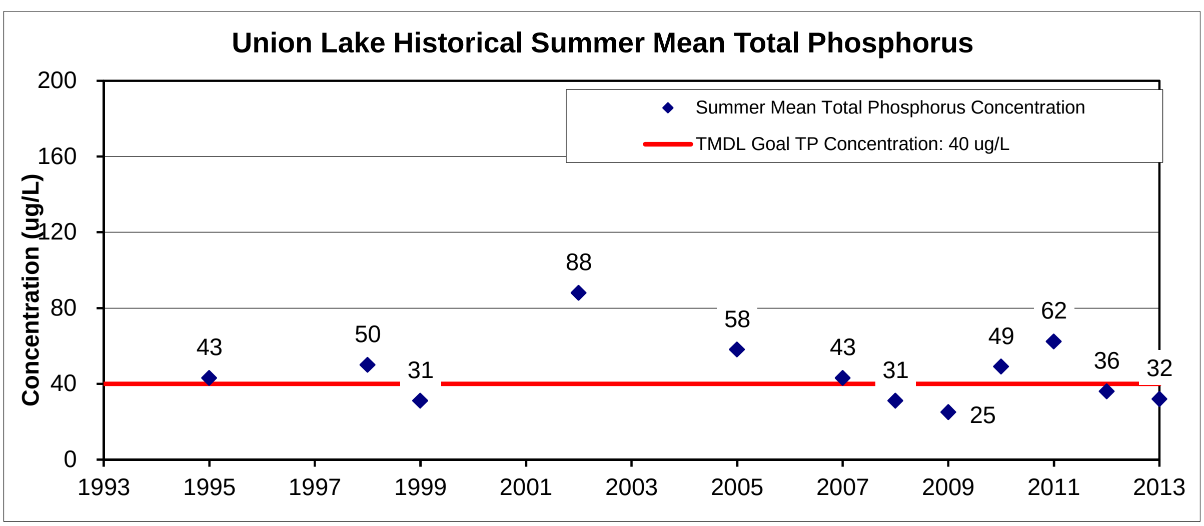
Surface Area: 93 Acres
Maximum Depth: 35 Feet
Subwatershed Area: 4,741 acres



Tributary Subwatershed (shaded)



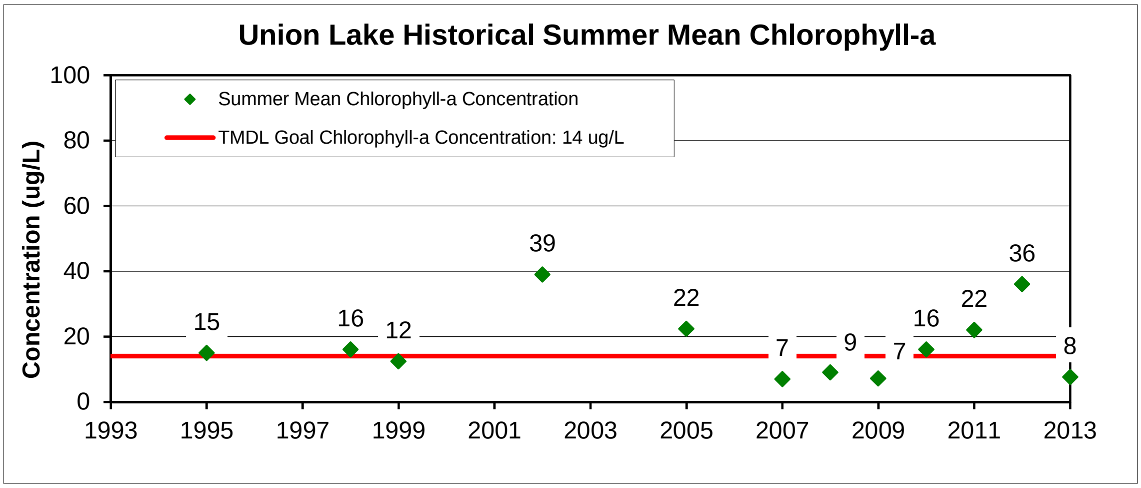


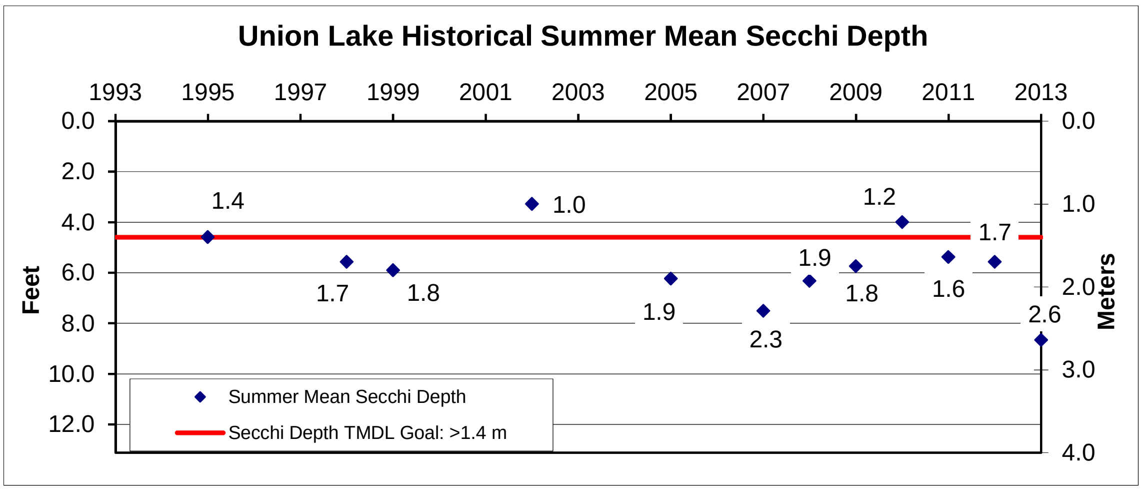


Clearwater River Watershed District	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	January 2014
Union Lake		Appendix C

Union Lake
2013 Lake Report Card

MPCA Standards for Deep Lakes in the North Central Hardwood Forest:
Total Phosphorus (TP): ≤ 40 ug/L
Chlorophyll-a: ≤ 14 ug/L
Secchi Depth: ≥ 1.4 meter





2013 Summary

- Total phosphorus concentrations have decreased since 2011 and met TMDL goals in 2013.
- Chlorophyll-a concentrations decreased in 2013 and met TMDL goals.
- Water clarity improved in 2013, as the Secchi disk depth was the highest observed in the lake and met TMDL goals in 2013.
- Bottom phosphorus concentrations, which can be an indicator for the potential for internal loading, were lower in 2013 than in recent years.

TMDL Activities

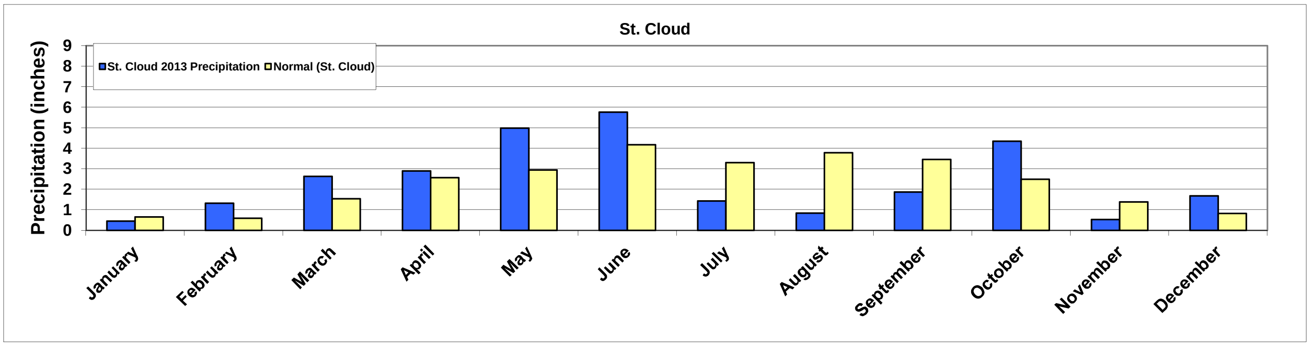
- Watershed loads appear to be the only reduction necessary for Union Lake to meet its water quality goals.
- Reducing phosphorus loads from the lake's direct tributary watershed will have the greatest impact on improving water quality in Union Lake.
- Phosphorus reduction strategies including BMPs, hypolimnetic withdrawal, targeted soil testing and GPS fertilizer application, and the construction of sedimentation ponds are identified by the TMDL Implementation Plan for implementation in upstream watersheds.

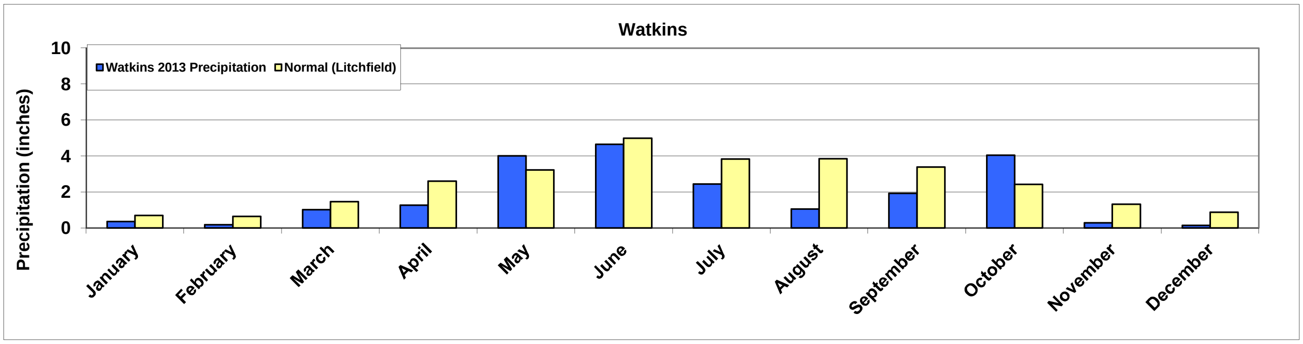
Wenck
Wenck Associates, Inc. Environmental Engineers
1800 Pioneer Creek Center Maple Plain, MN 55359

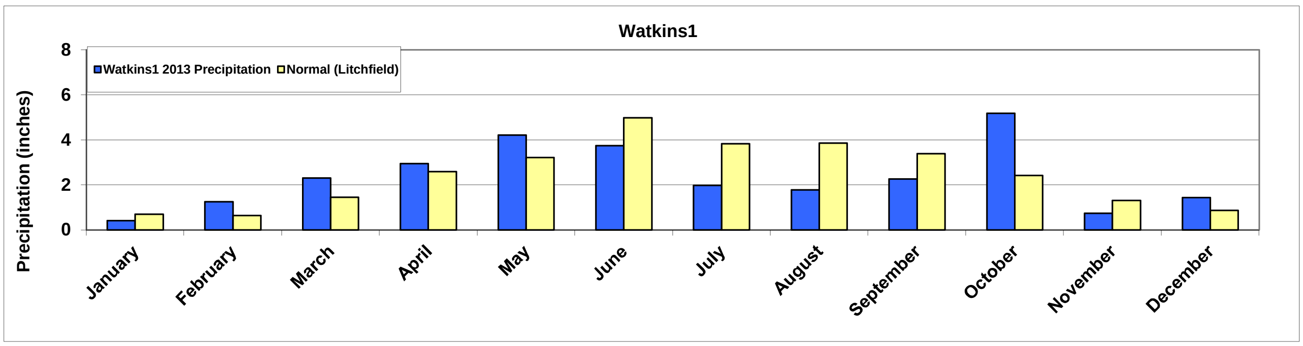
Appendix D

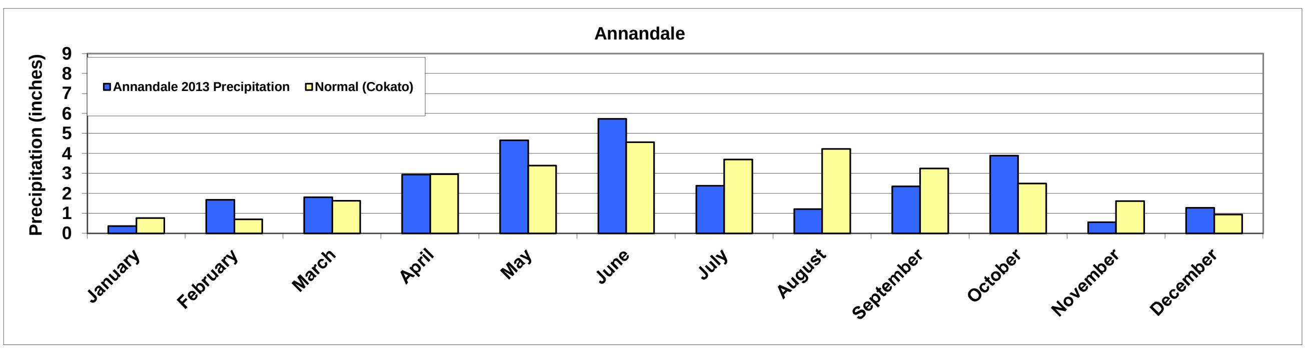
Citizen Precipitation Records Summary

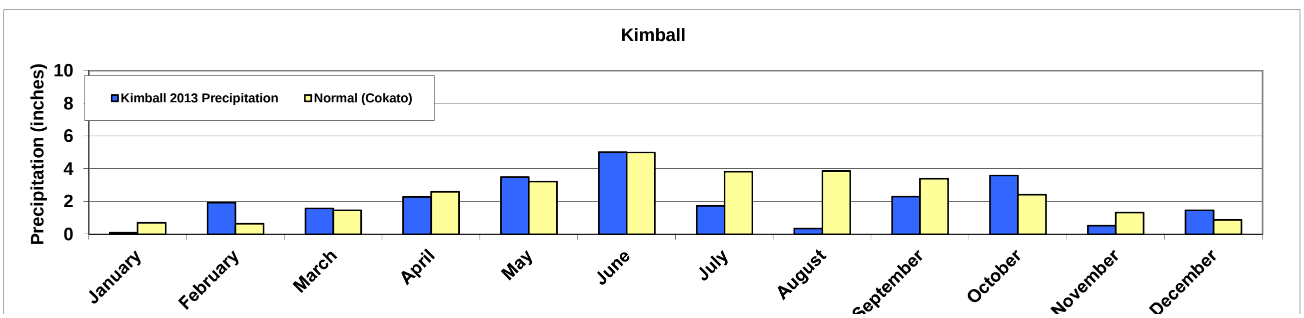
Appendix D
Figure 1
Clearwater River Watershed District
2013 Annual Report











Appendix E

2013 Lake Water Quality Field Notes and Lab Reports
(On Enclosed CD Only)

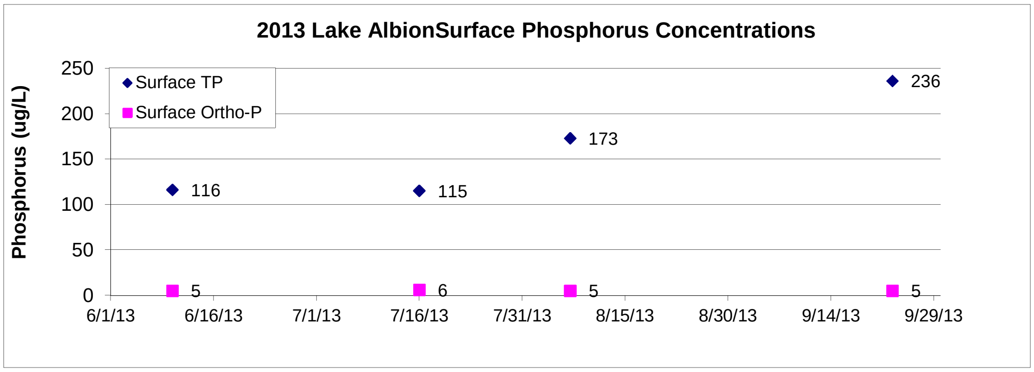
Appendix F

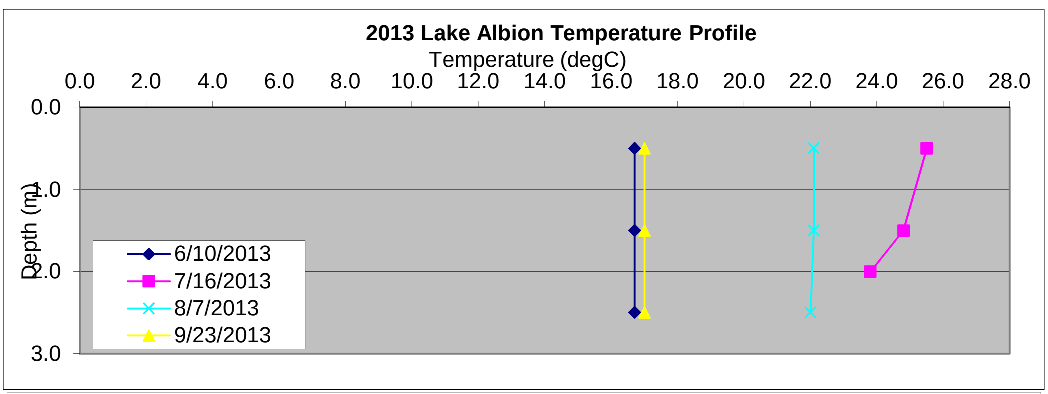
2013 Stream Water Quality Field Notes and Lab Reports
(On Enclosed CD Only)

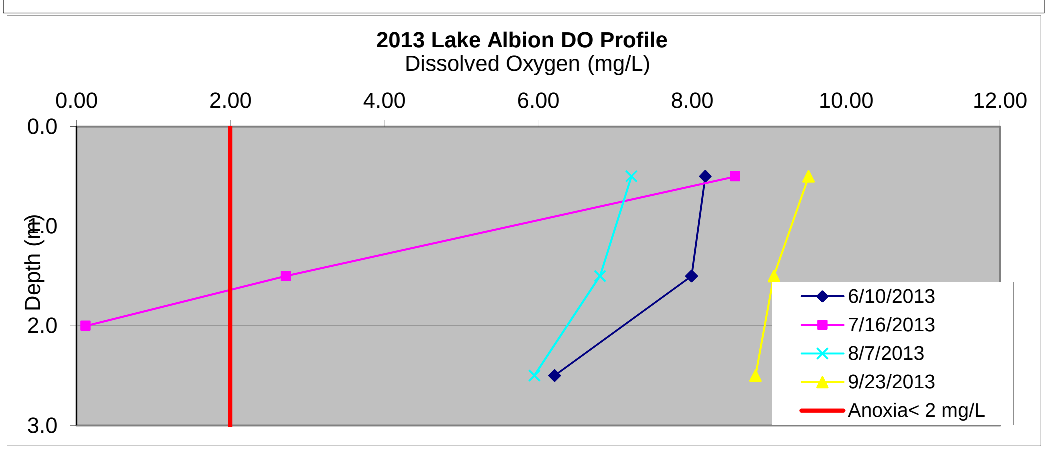
Appendix G

Lake Phosphorus and Profile Data

CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data







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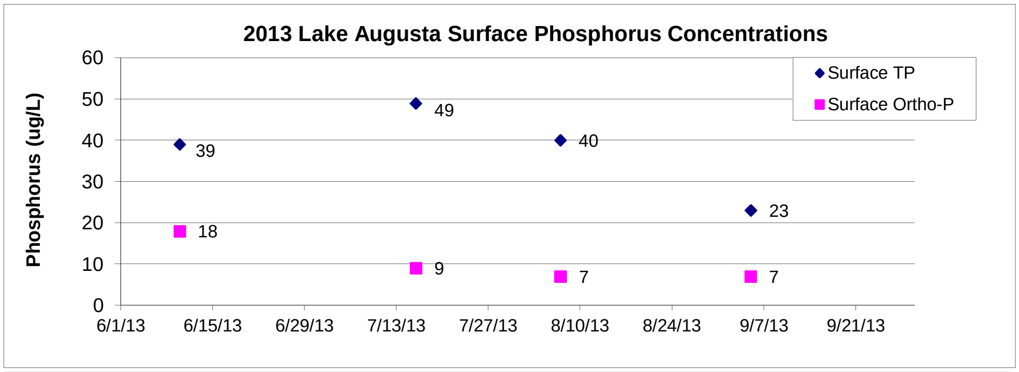
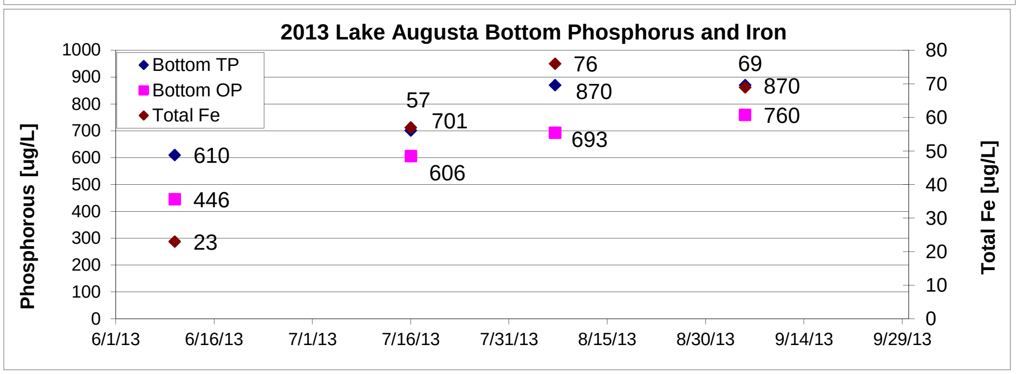
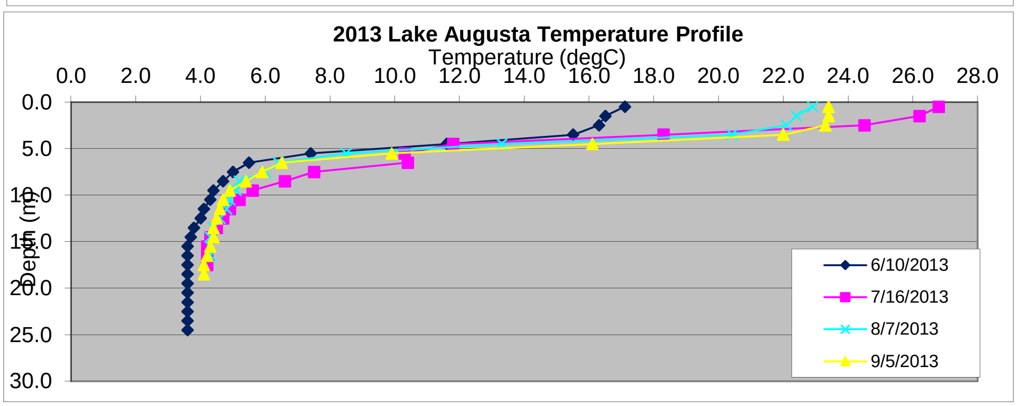
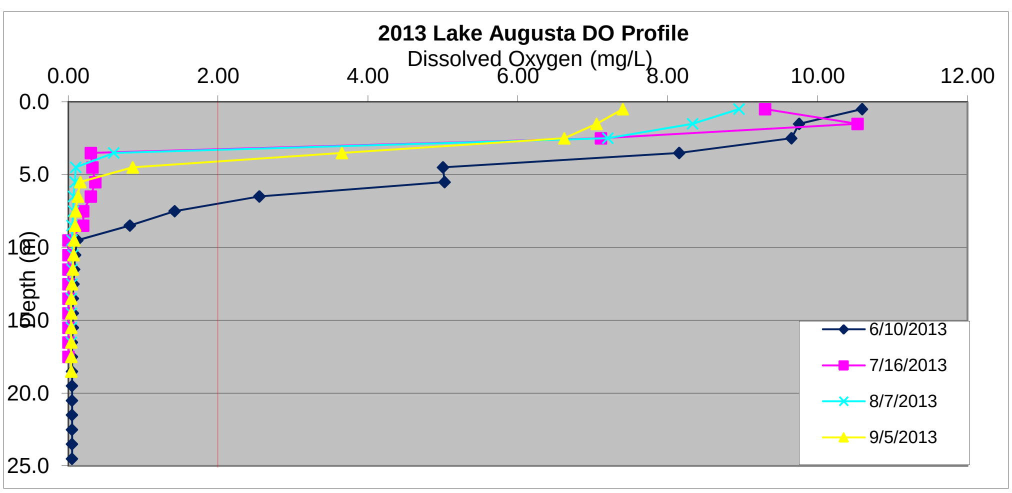
Appendix G-Lake Phosphorus
and Profile Data

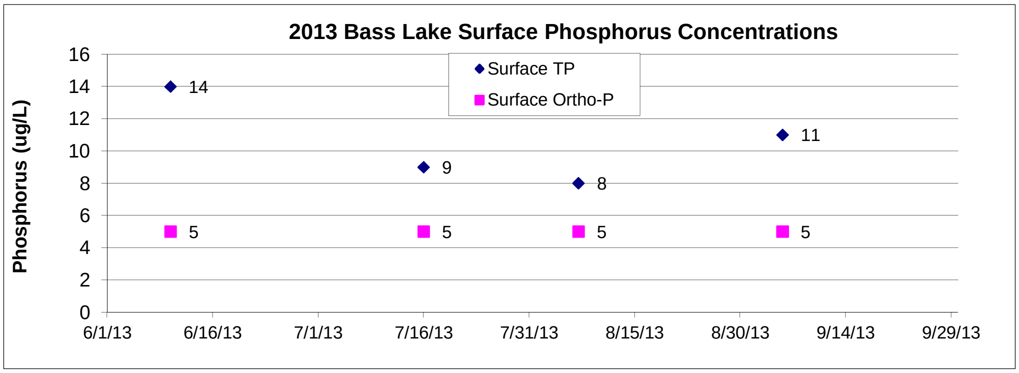


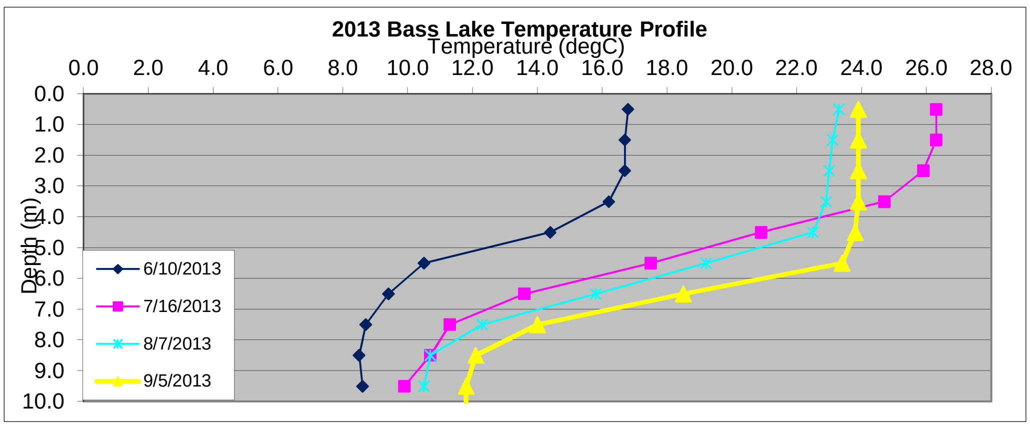


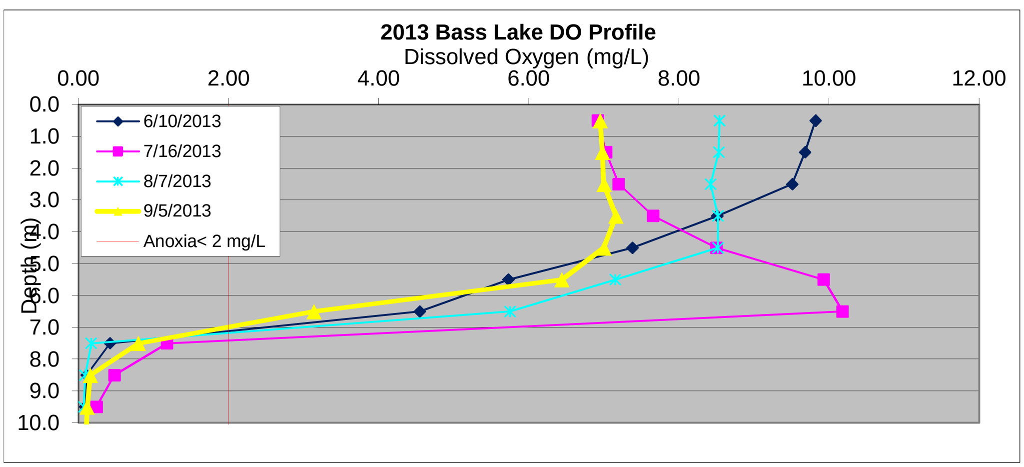




CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data







CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
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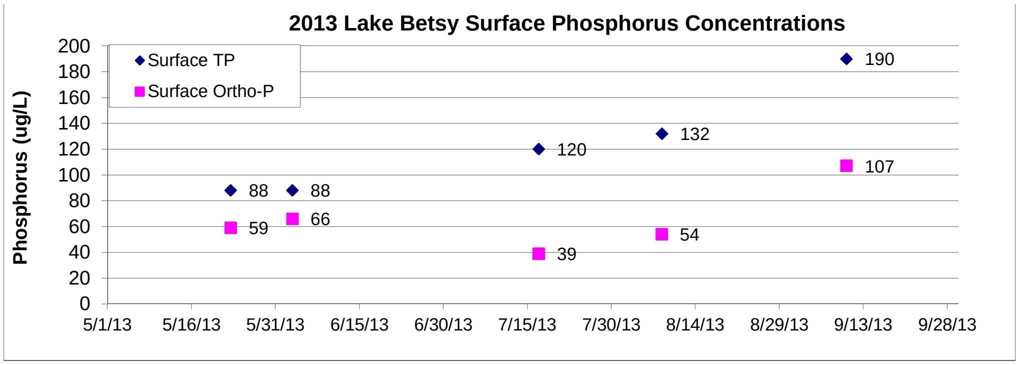

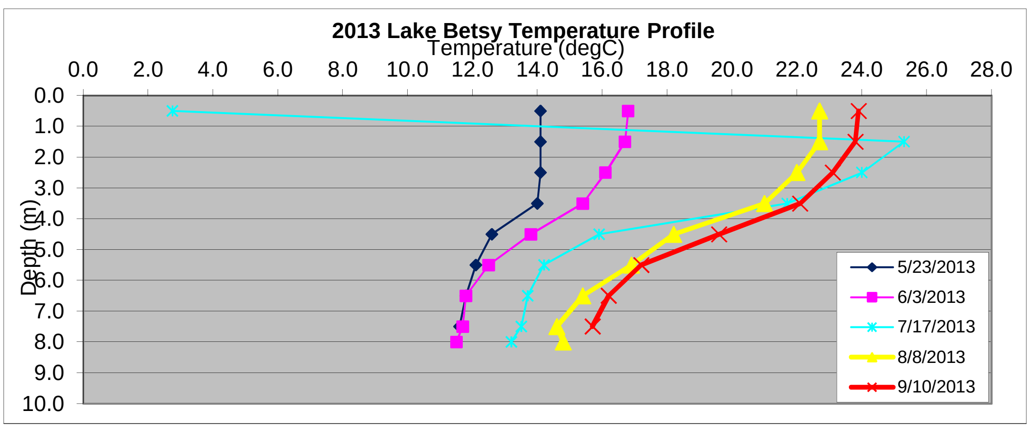

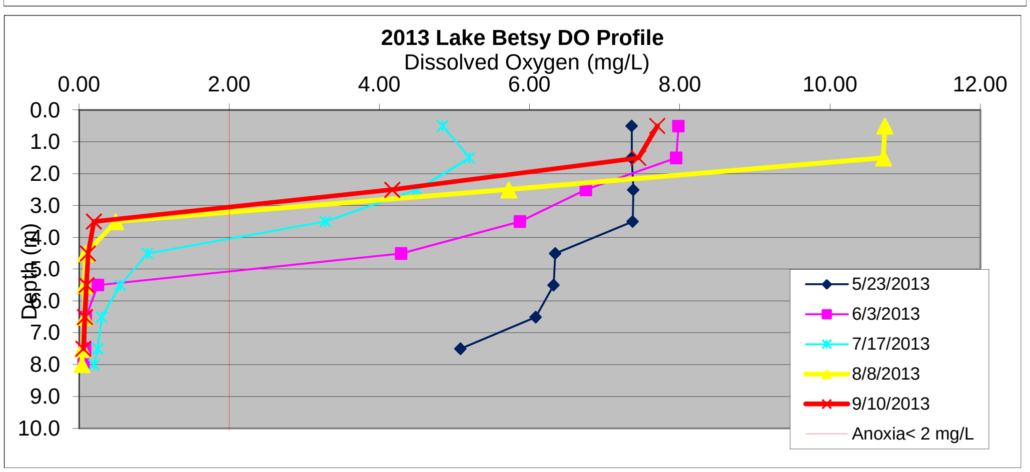

CRWD 2013 Water Quality Report
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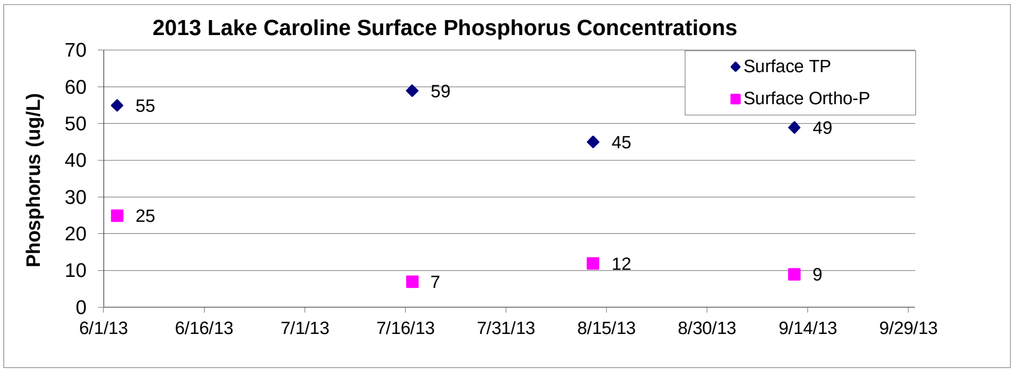

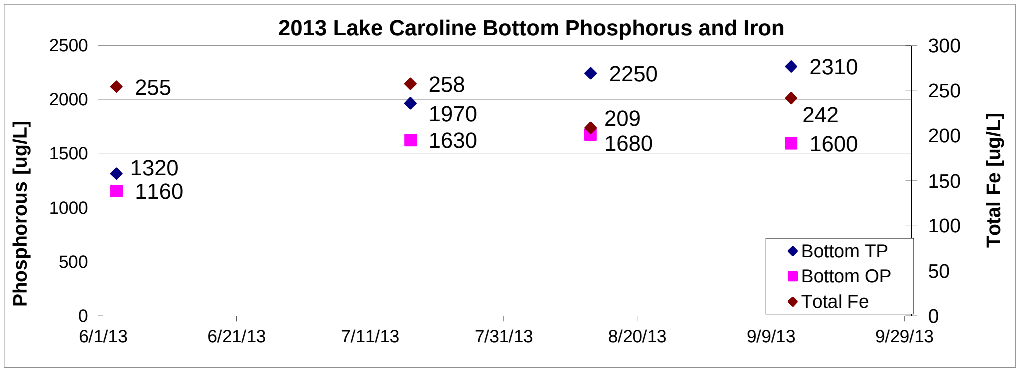

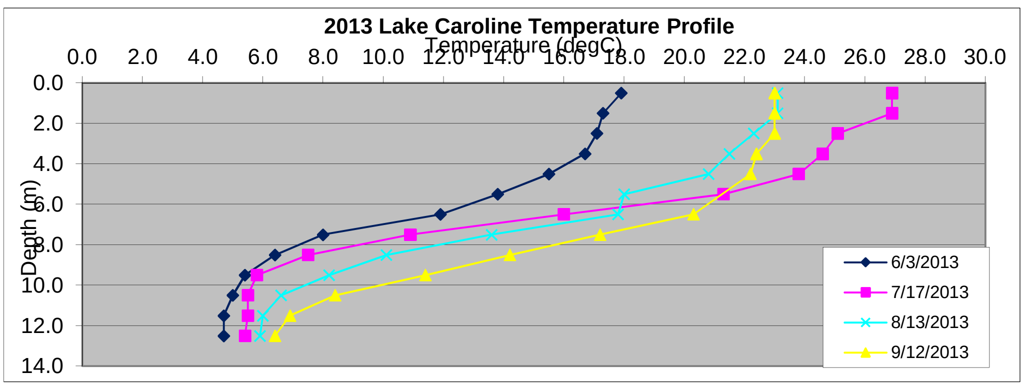

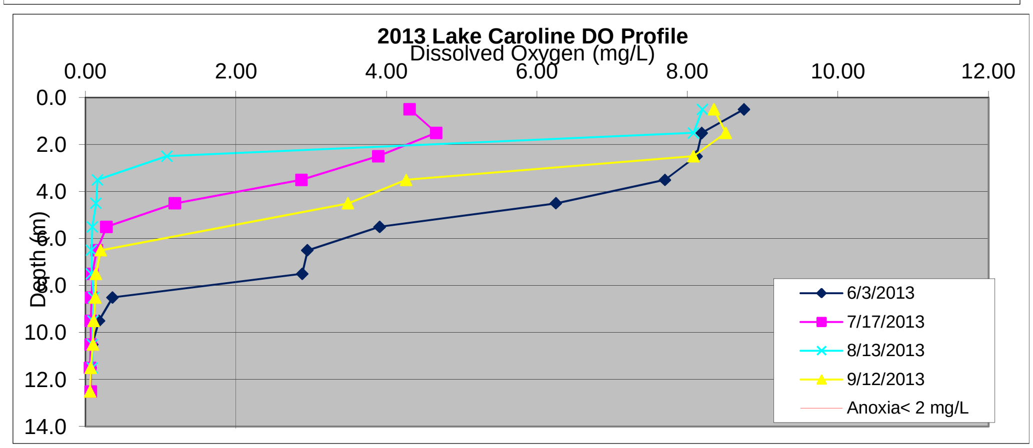

CRWD 2013 Water Quality Report
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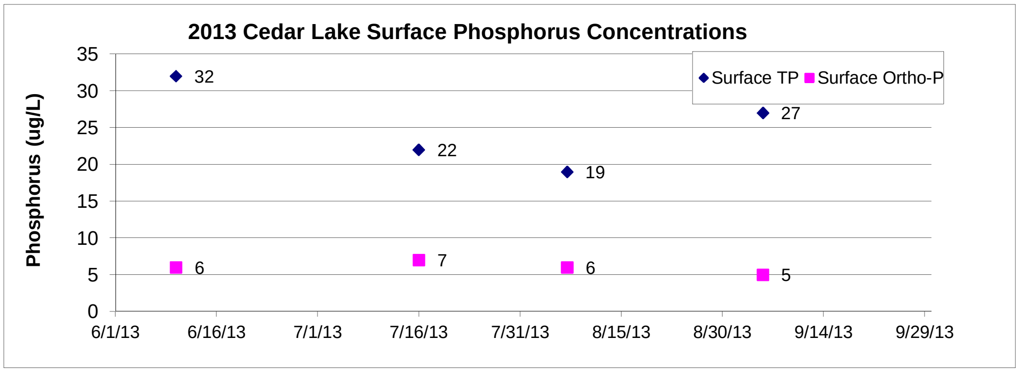
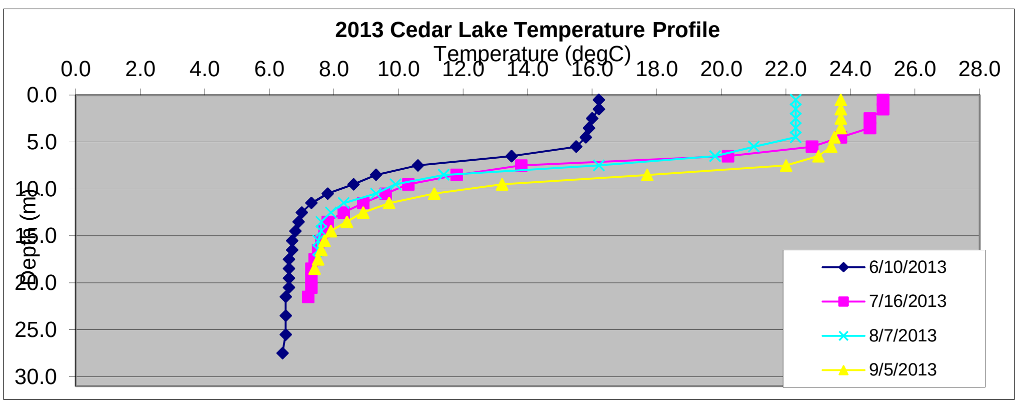
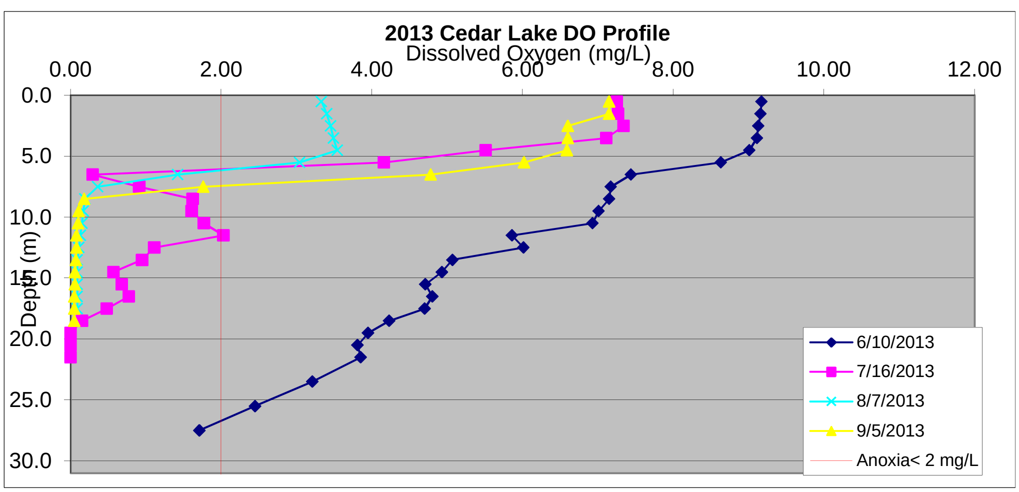
and Profile Data







CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
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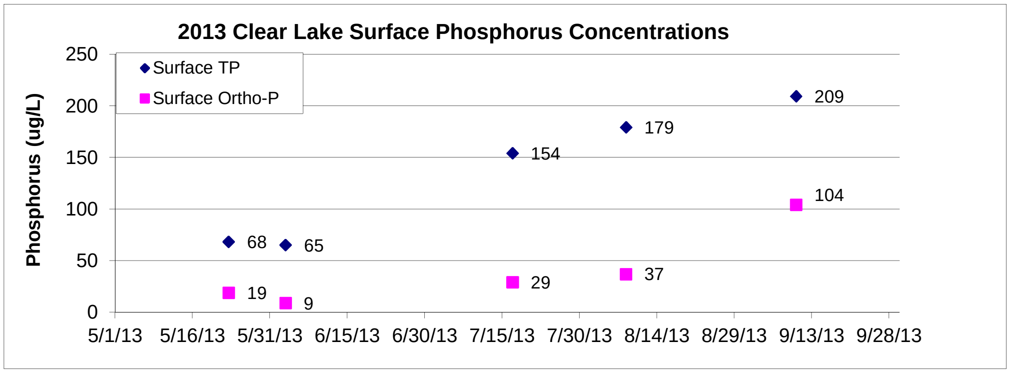

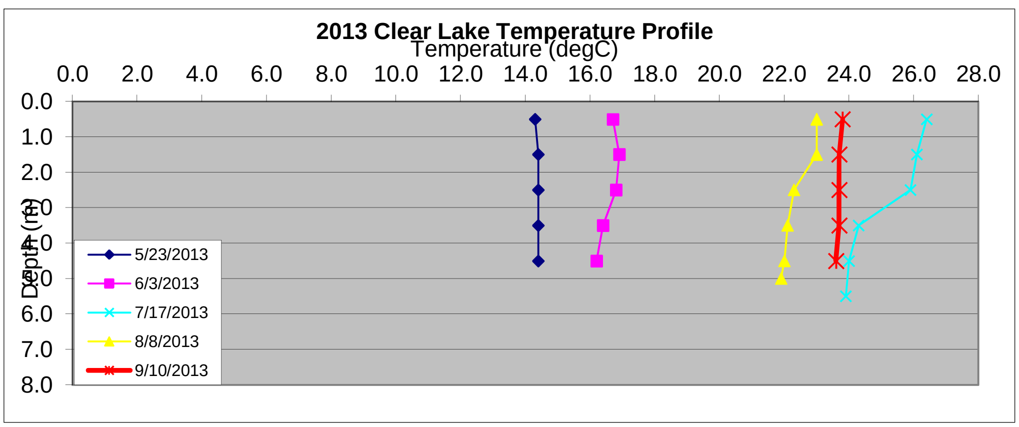

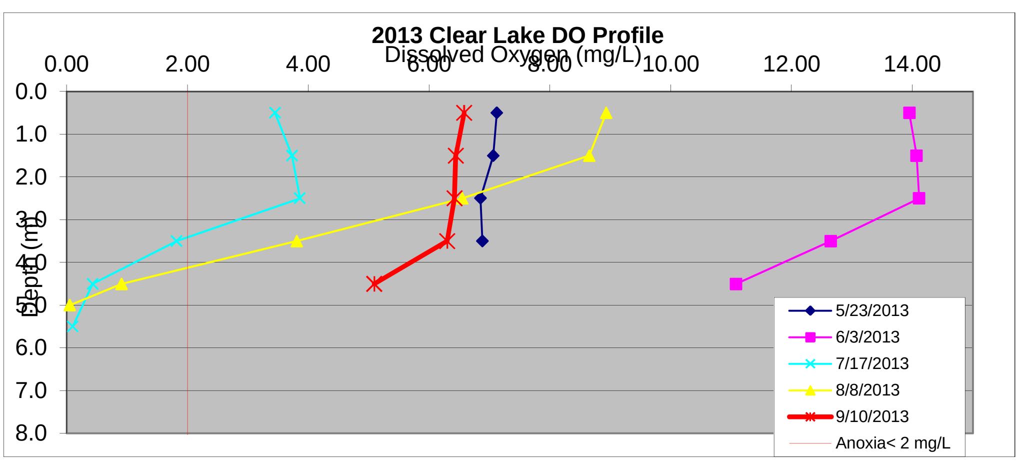

CRWD 2013 Water Quality Report
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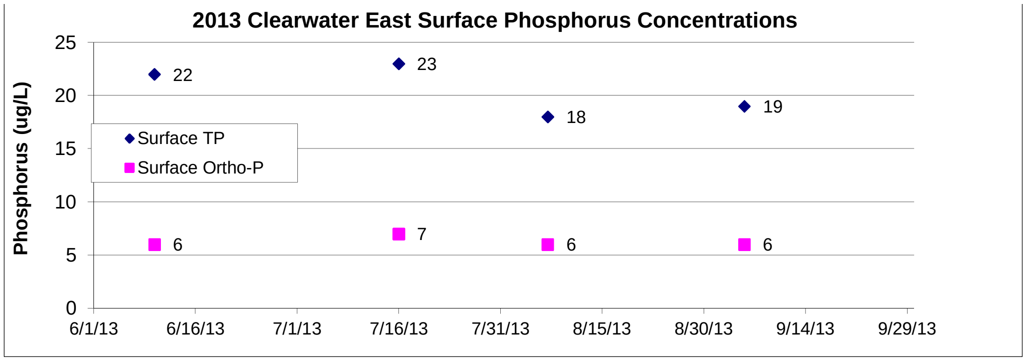

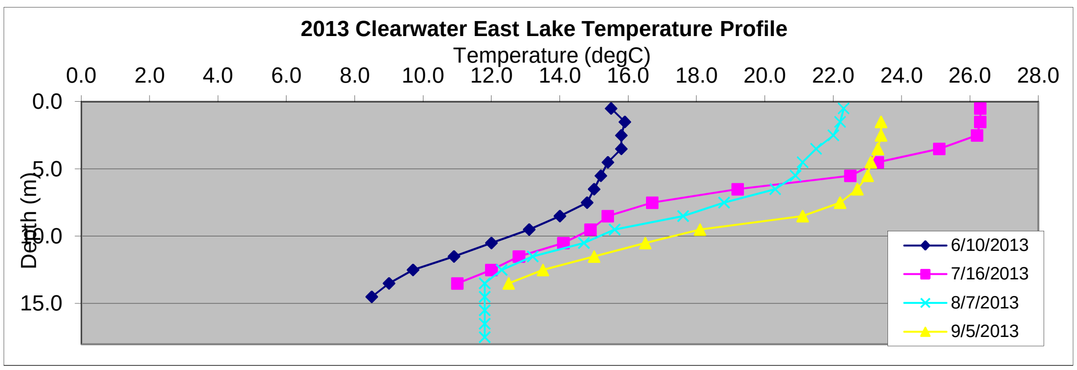

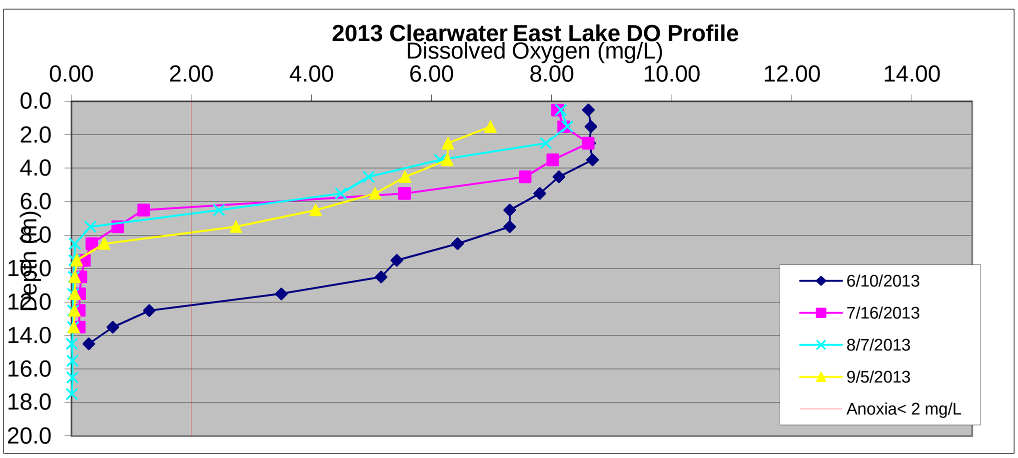

CRWD 2013 Water Quality Report
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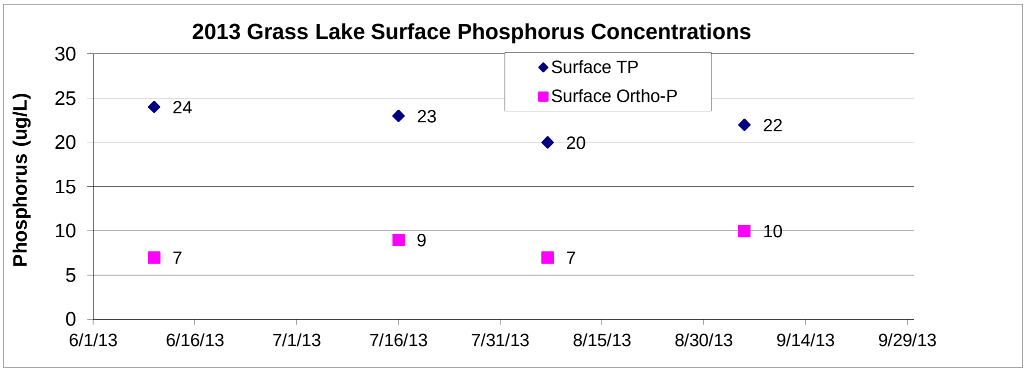

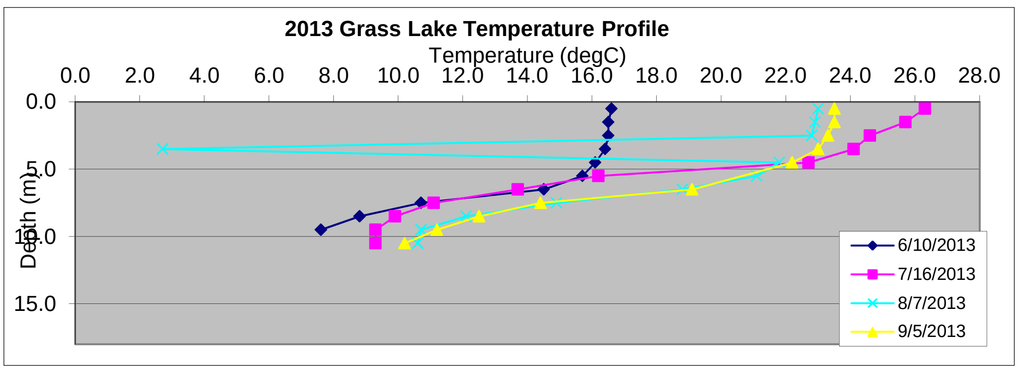

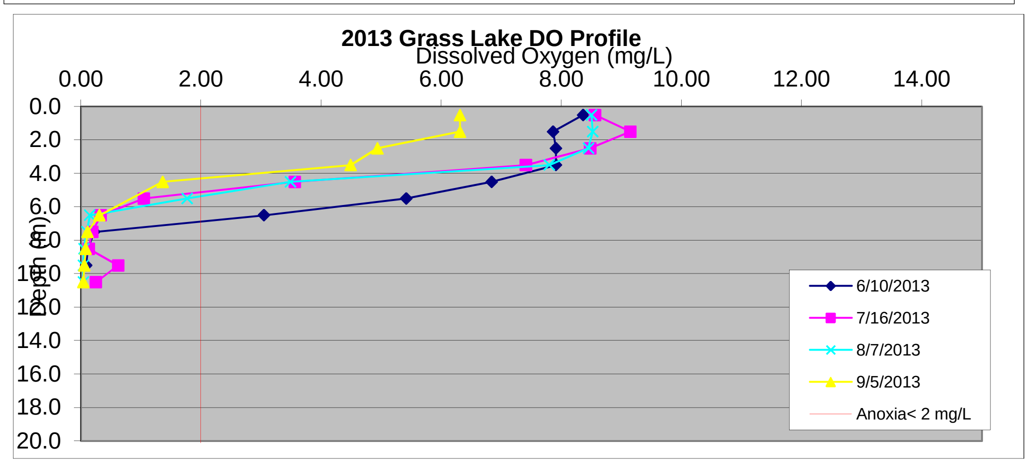

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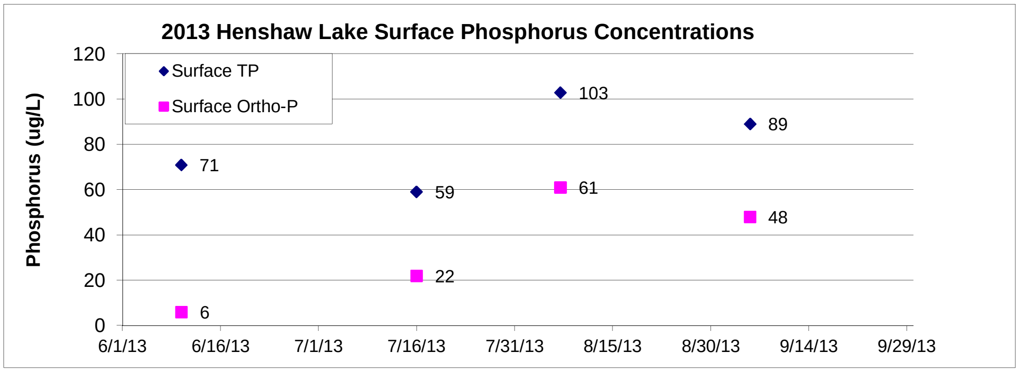
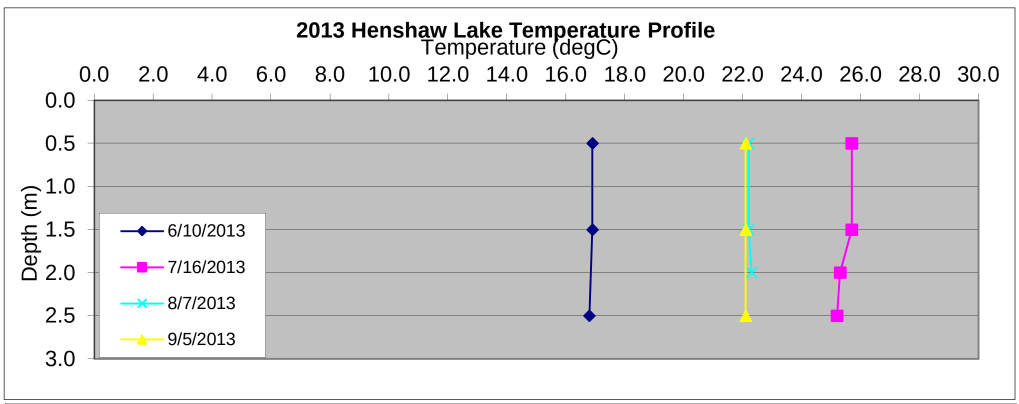
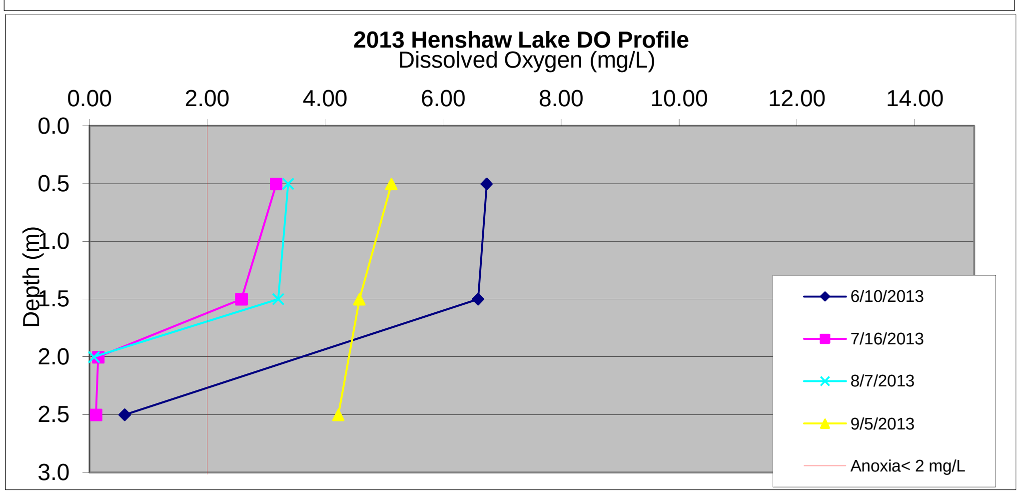
and Profile Data







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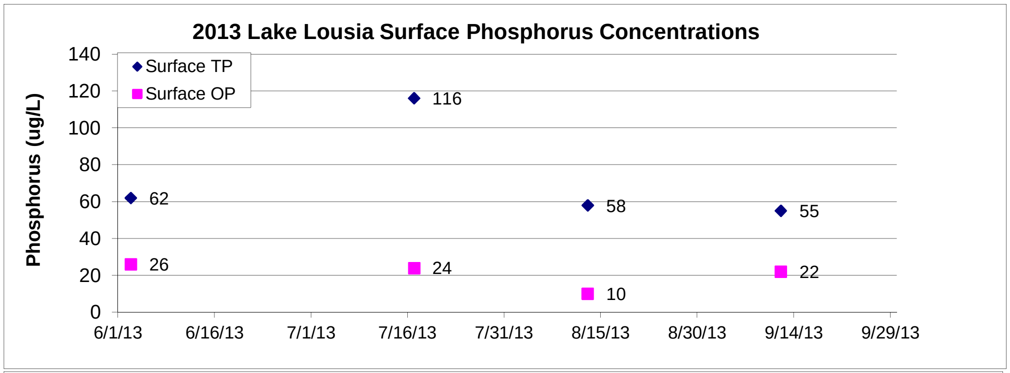

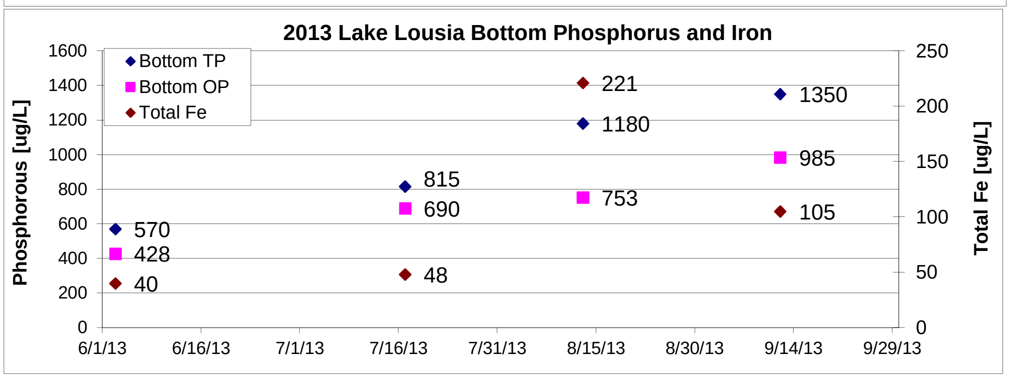

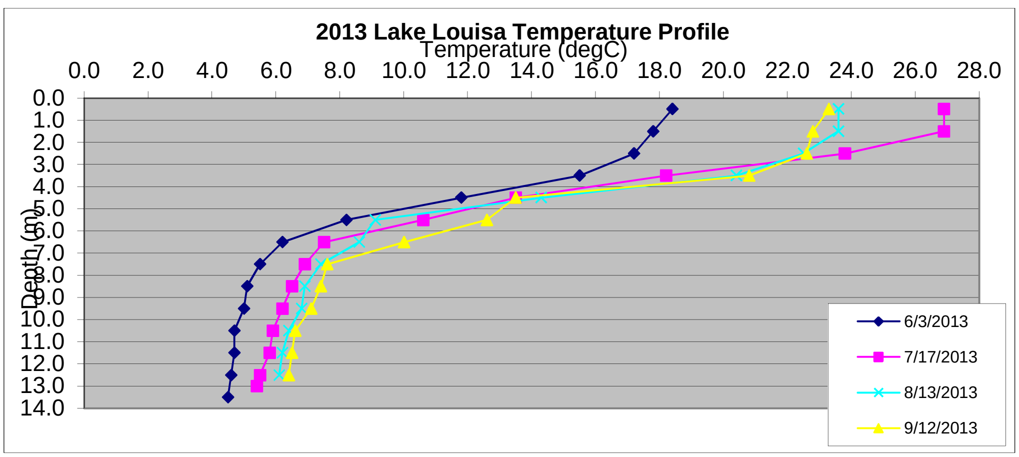

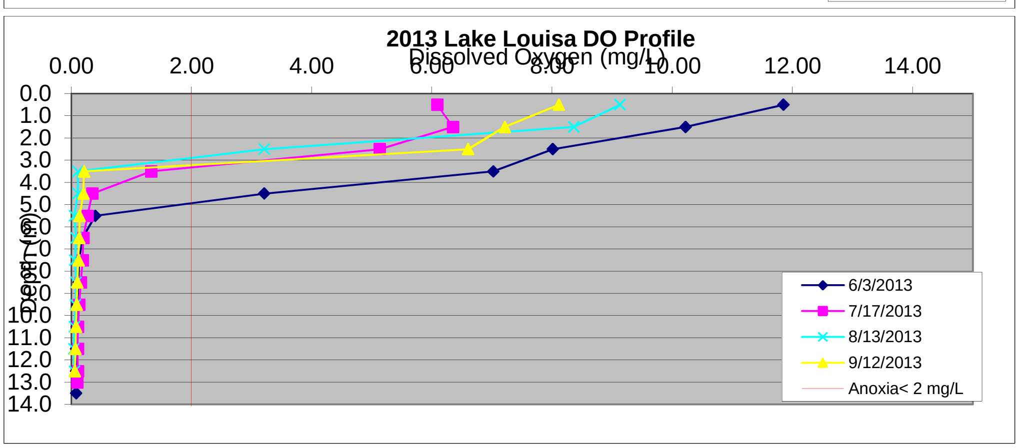

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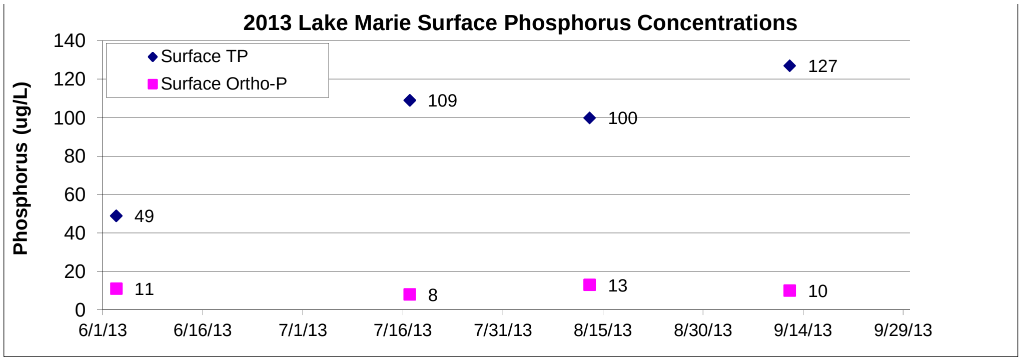
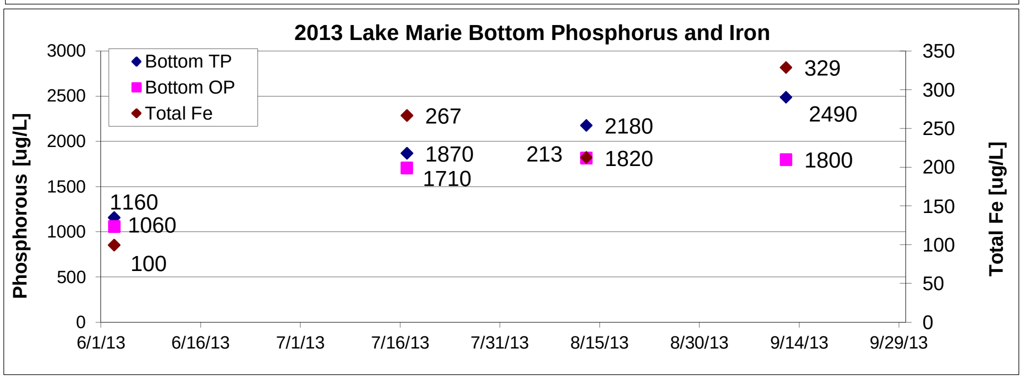
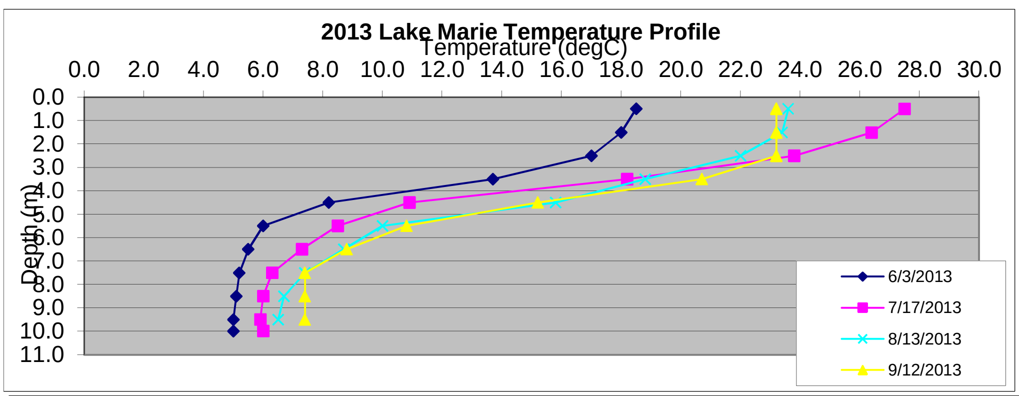
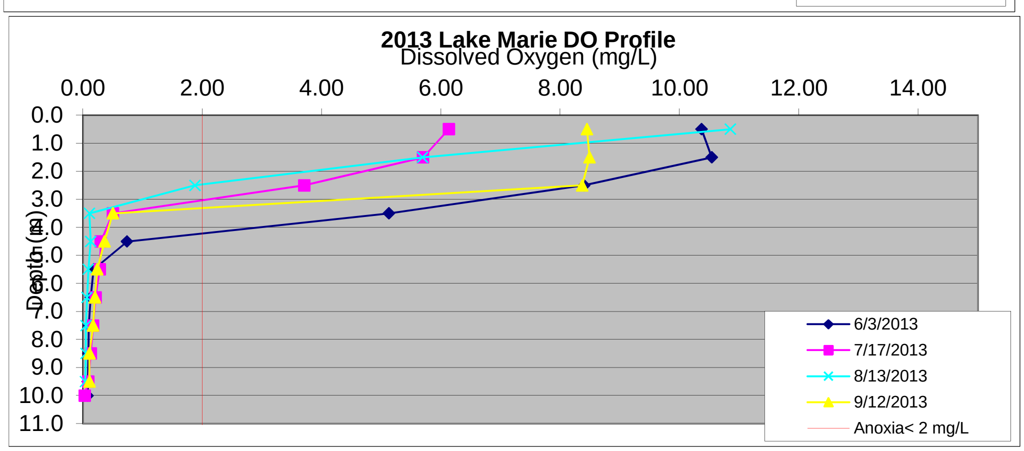
Appendix G-Lake Phosphorus
and Profile Data









CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
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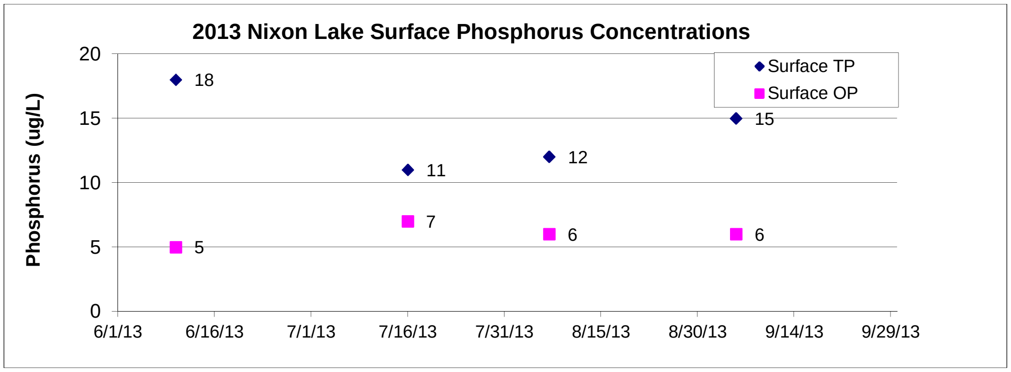
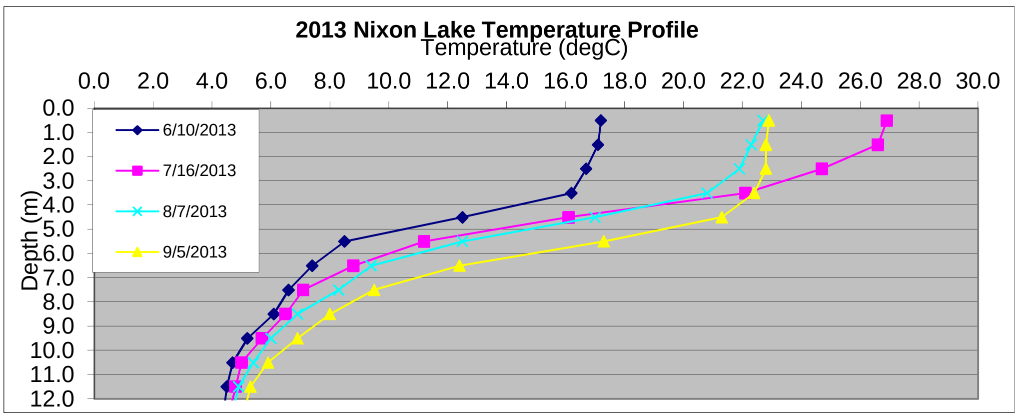
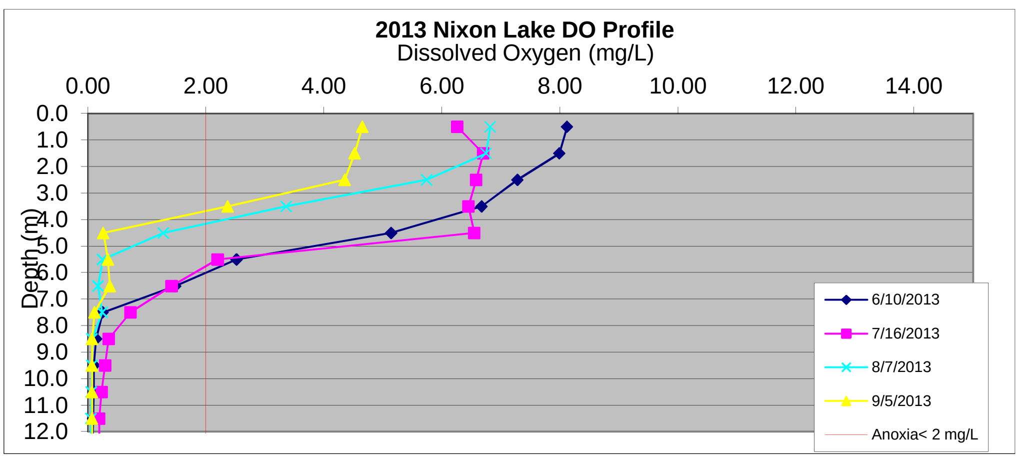
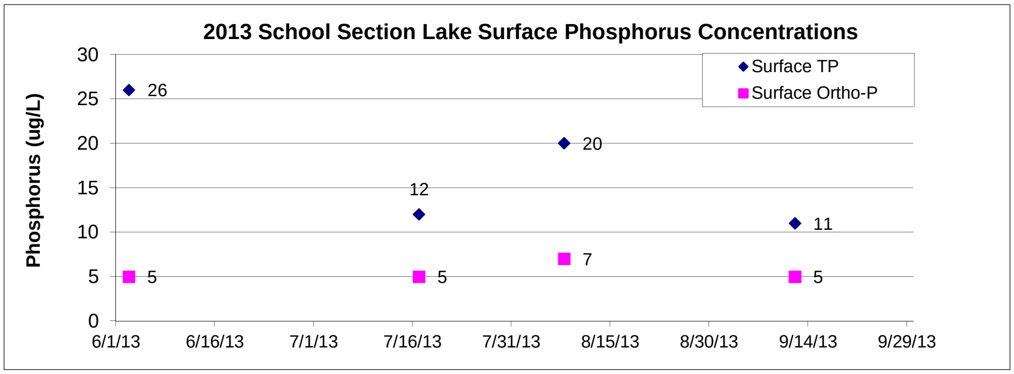
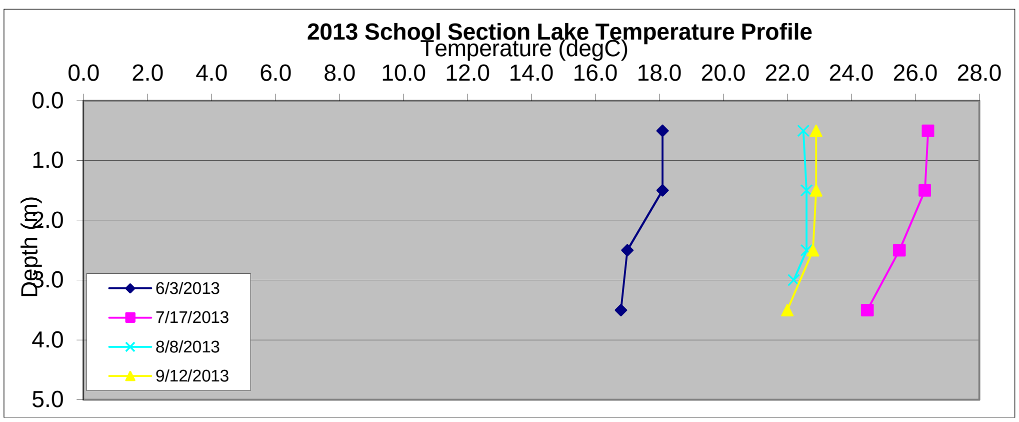


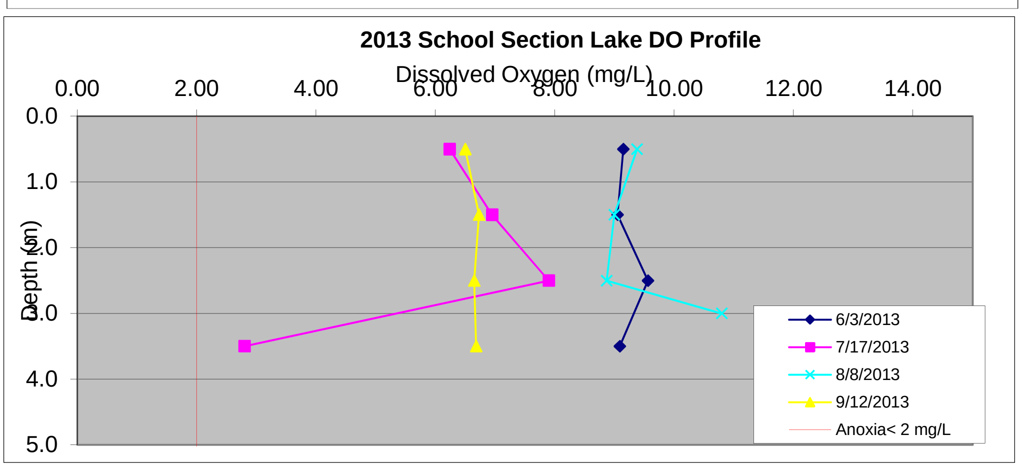




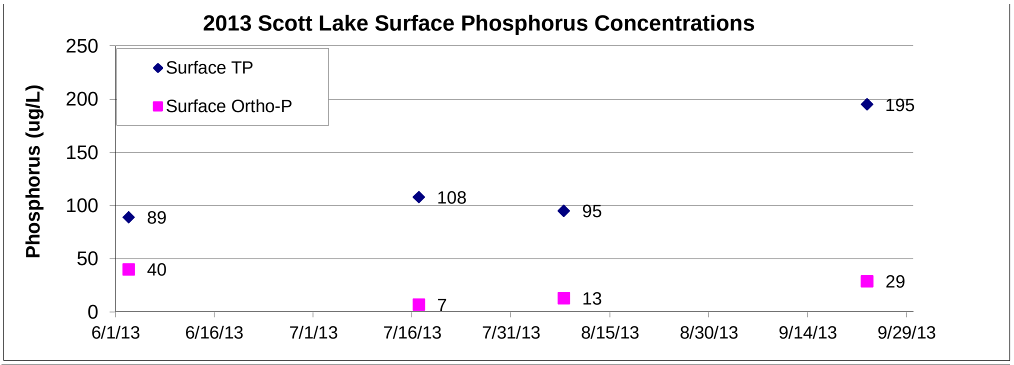
CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data

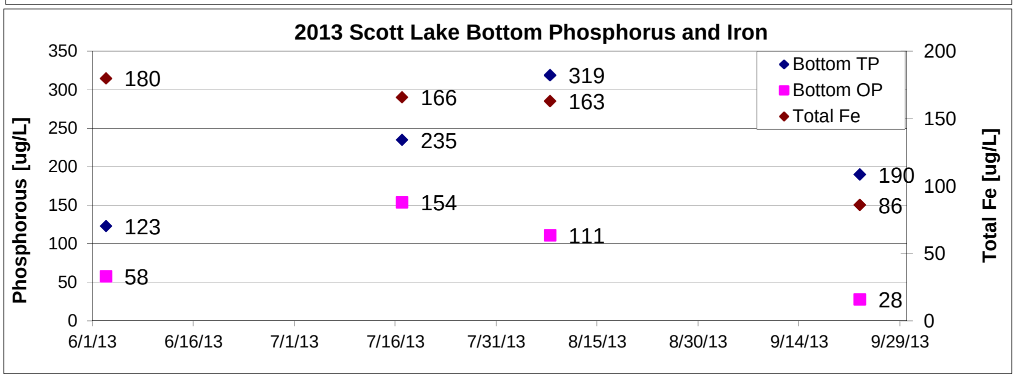


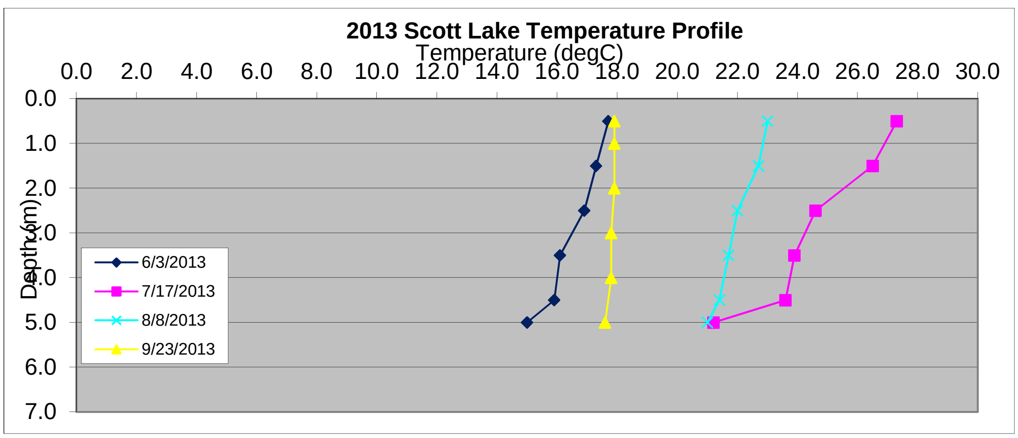


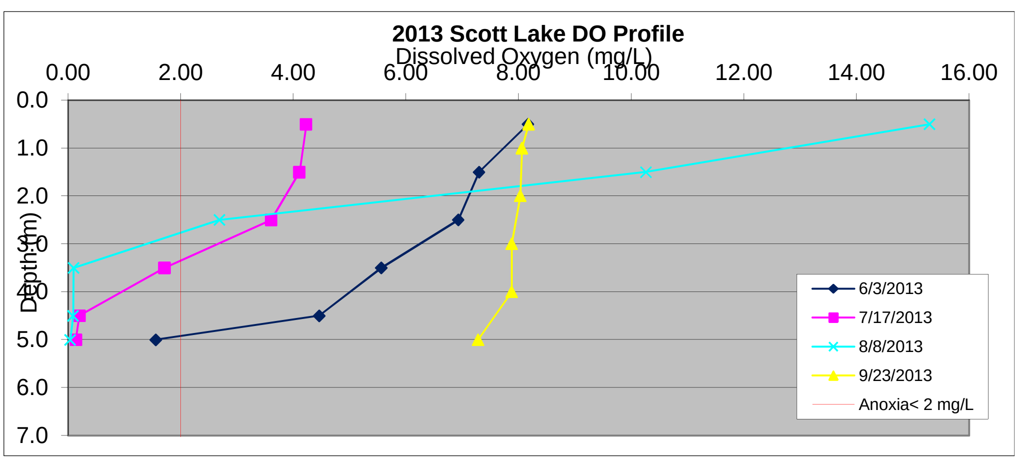


CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data

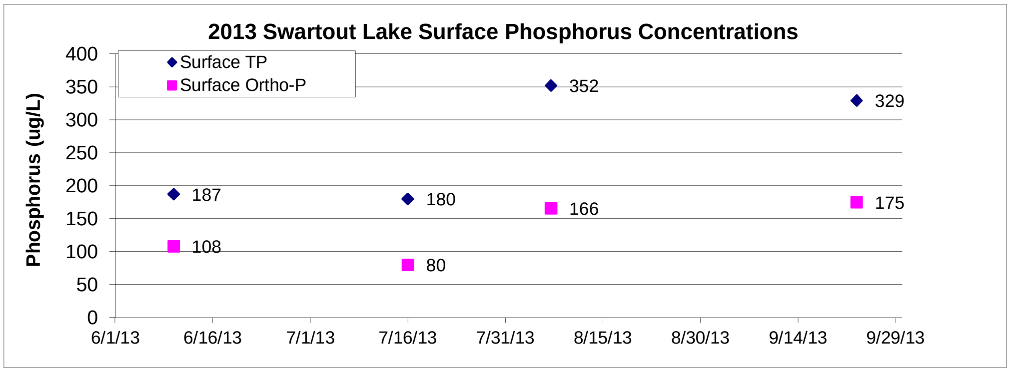


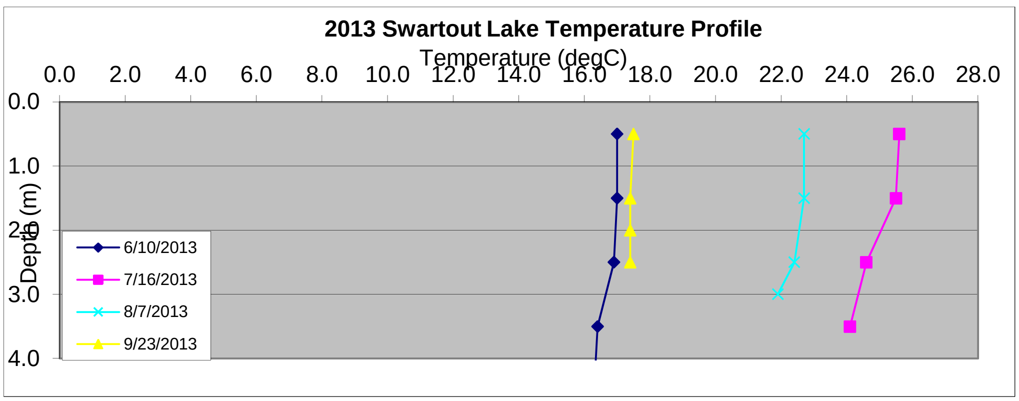


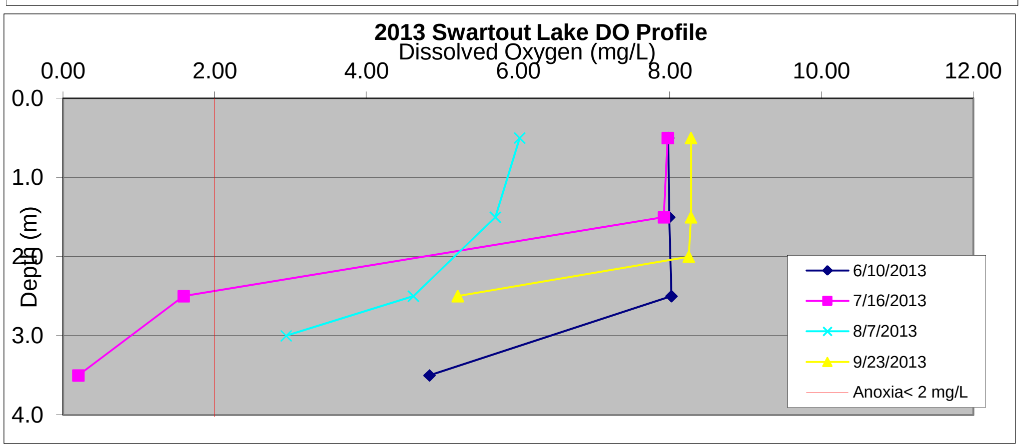




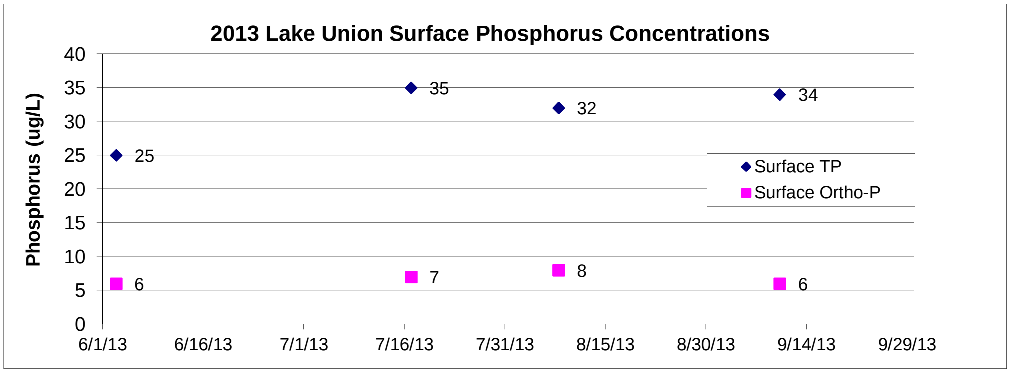
CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data

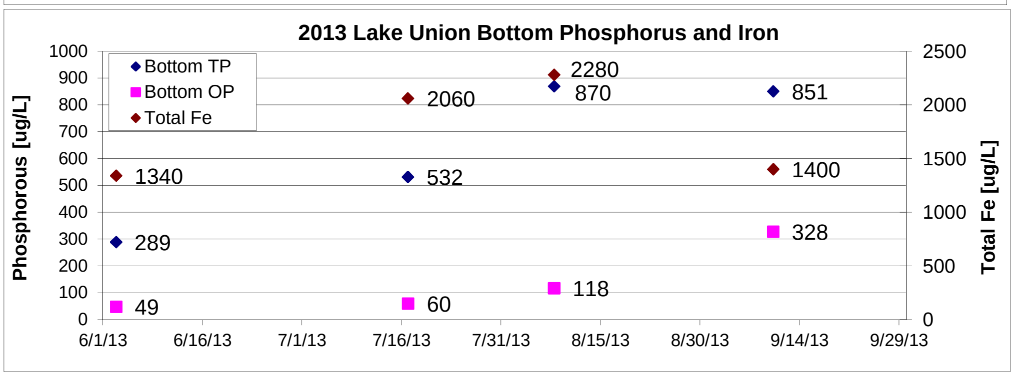


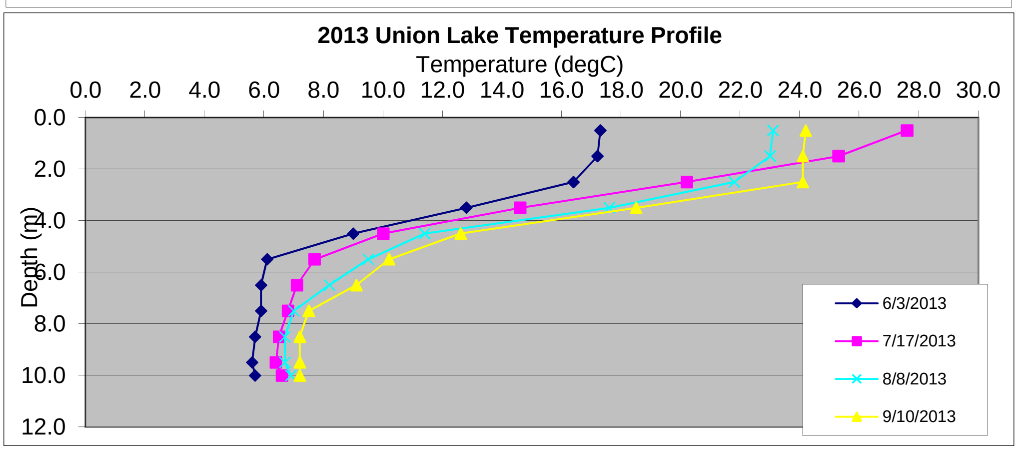


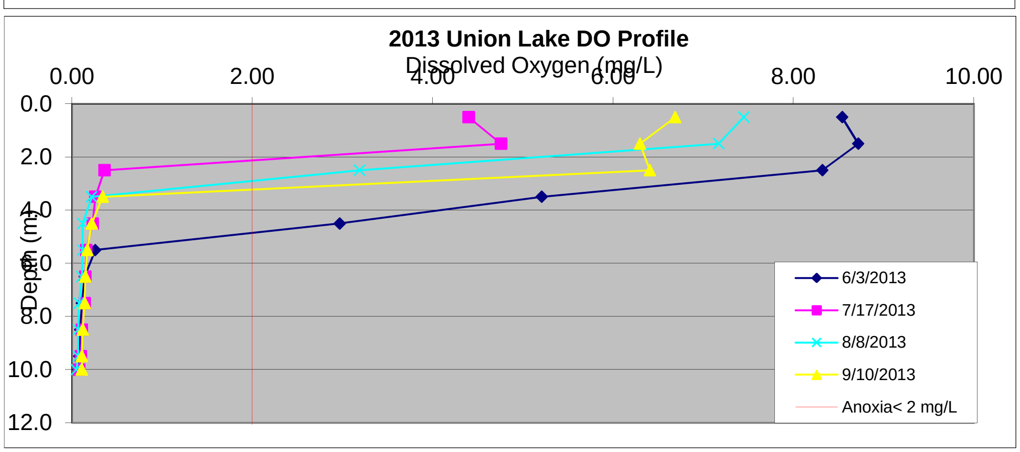


CRWD 2013 Water Quality Report
Appendix G-Lake Phosphorus
and Profile Data





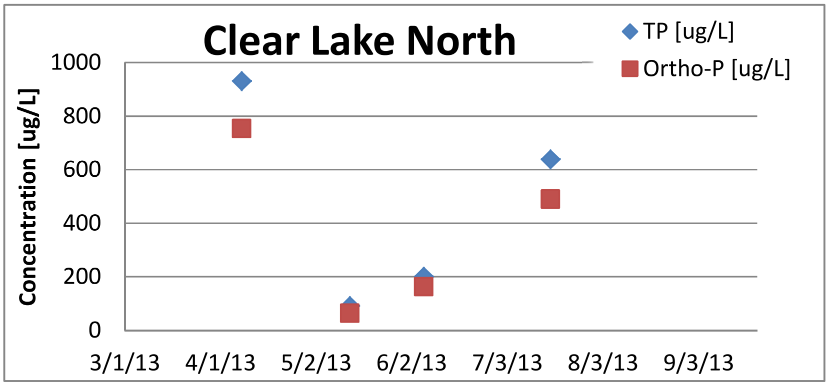


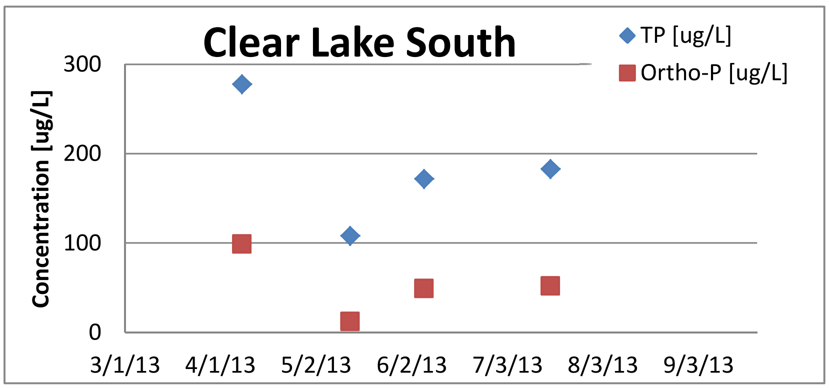


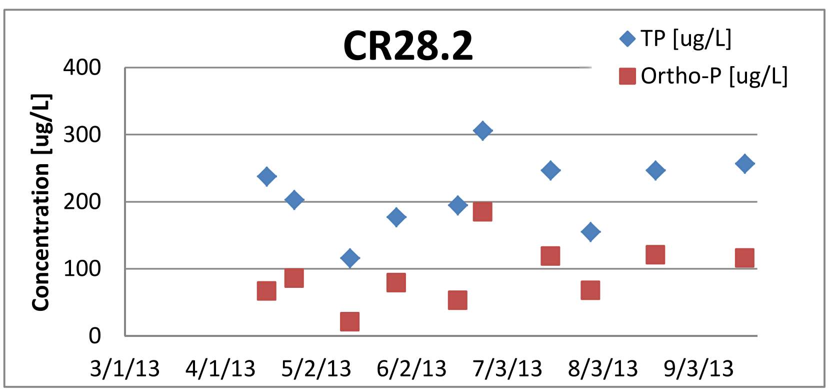
Appendix H

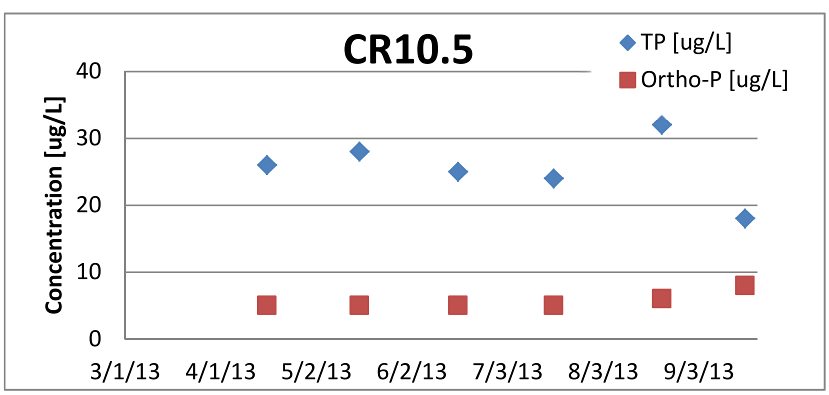
2013 Stream Phosphorus Concentrations

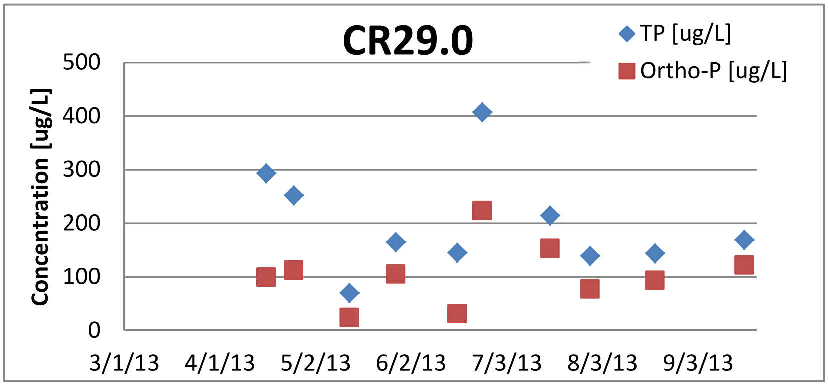
Clearwater River Watershed District
2013 Annual Report
Appendix H







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Ortho-P [ug/L]
Concentration [ug/L]
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400
300
200
100
0
3/1/13
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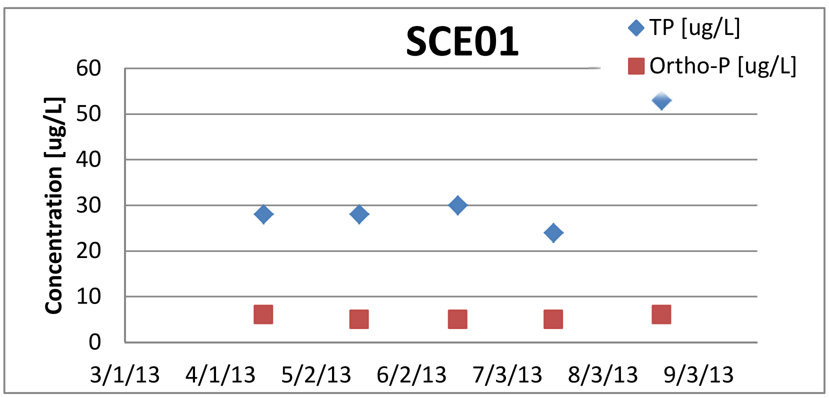
8/3/13
9/3/13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Ortho-P [ug/L]
Concentration [ug/L]
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50
40
30
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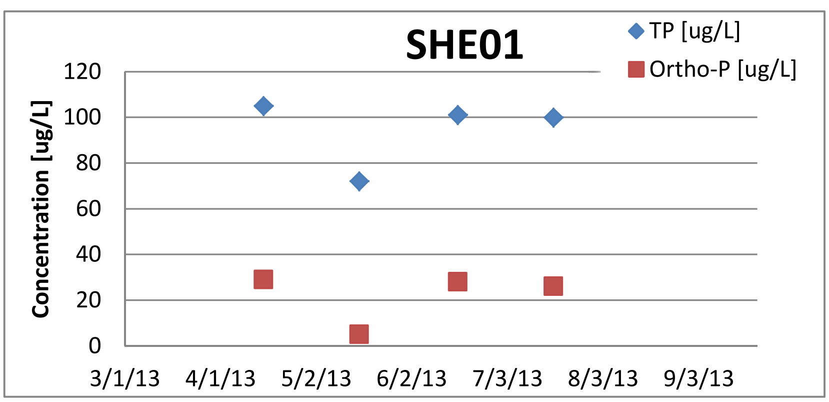
8/3/13
9/3/13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Ortho-P [ug/L]
Concentration [ug/L]
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100
80
60
40
20
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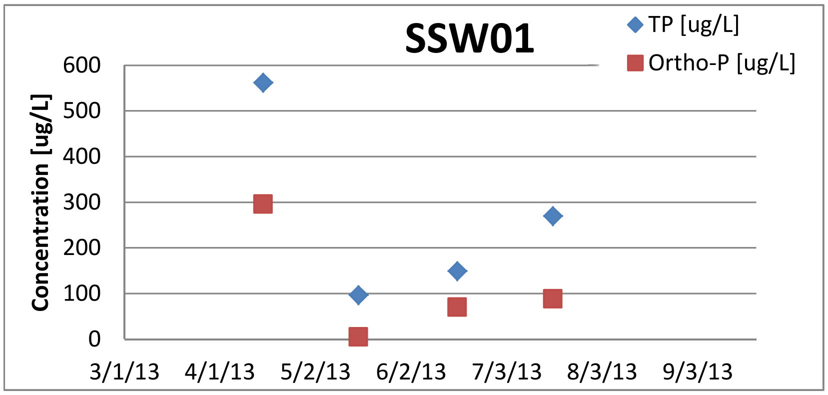
8/3/13
9/3/13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Ortho-P [ug/L]
Concentration [ug/L]
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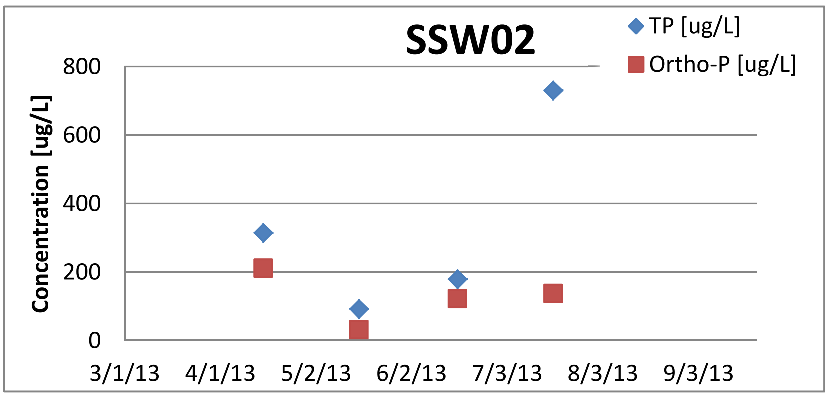
8/3/13
9/3/13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Concentration [ug/L]
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400
200
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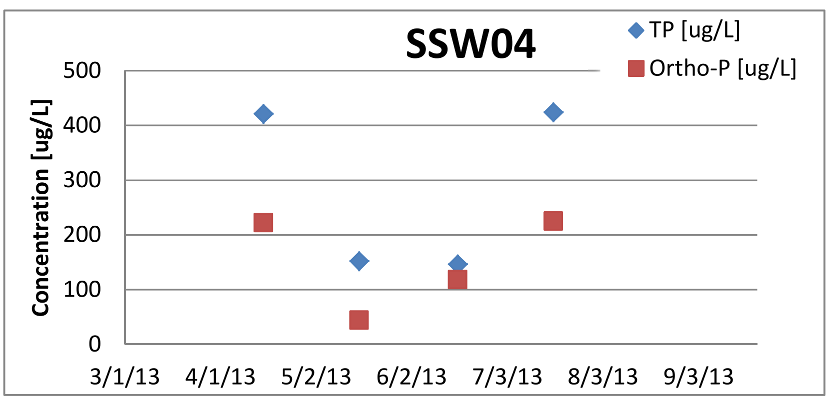
8/3/13
9/3/13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Ortho-P [ug/L]
Concentration [ug/L]
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300
200
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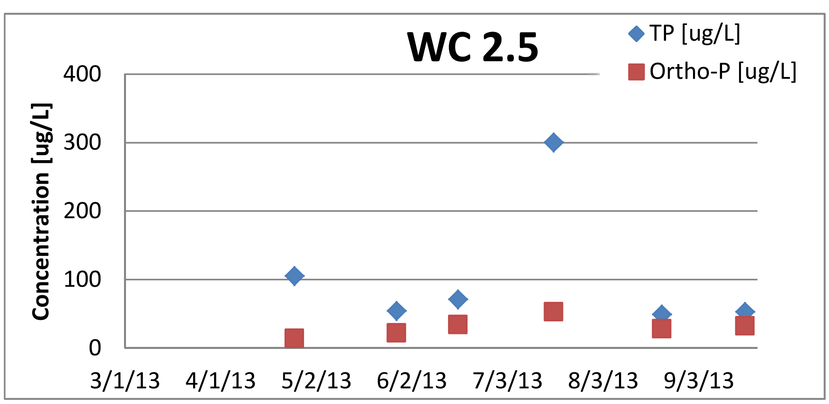
8/3/13
9/3/13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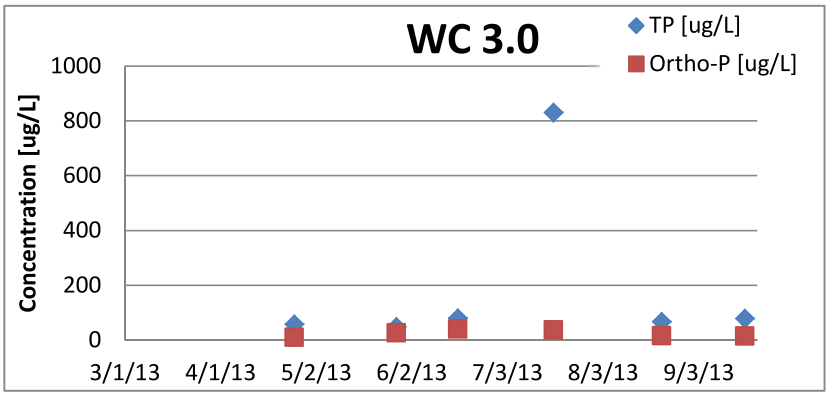
8/3/13
9/3/13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Concentration [ug/L]
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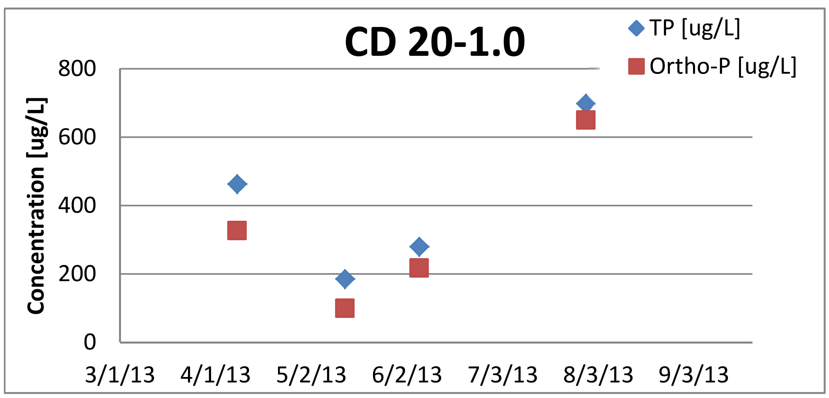
8/3/13
9/3/13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Ortho-P [ug/L]
Concentration [ug/L]
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600
400
200
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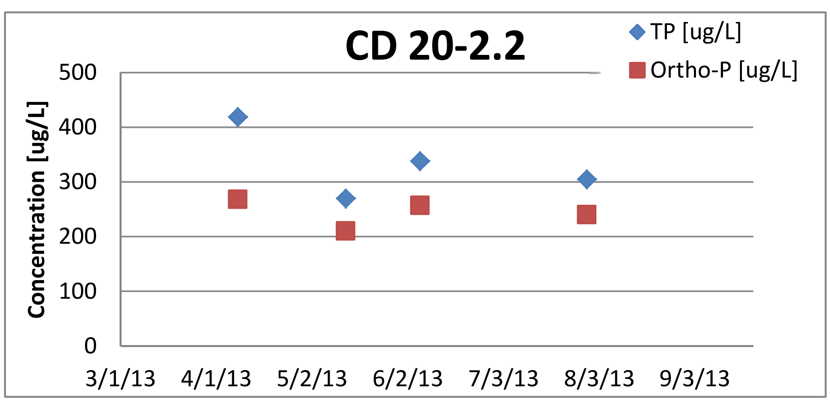
8/3/13
9/3/13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Concentration [ug/L]
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200
100
0
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4/1/13
5/2/13
6/2/13
7/3/13
8/3/13
9/3/13

Appendix I

Kingston Wetland Restoration Project Photos

Post Project (March 2013) Constructed and Restored Channel

Post Project (Aug 2013) Completed Revegetated Channel

Post Project-(Aug 2013) Looking Downstream near Hwy 15)

Post-Project (Aug 2013) Completed Channel

Post-Project (Aug 2013) Completed Revegetated Channel 3

Post-Project (Aug 2013) Completed Revegetated Channel in Wetland and Riprap

Post-Project (Aug 2013) Completed Revegetated Channel in Wetland

Post-Project (Aug 2013) Revegetated Banks

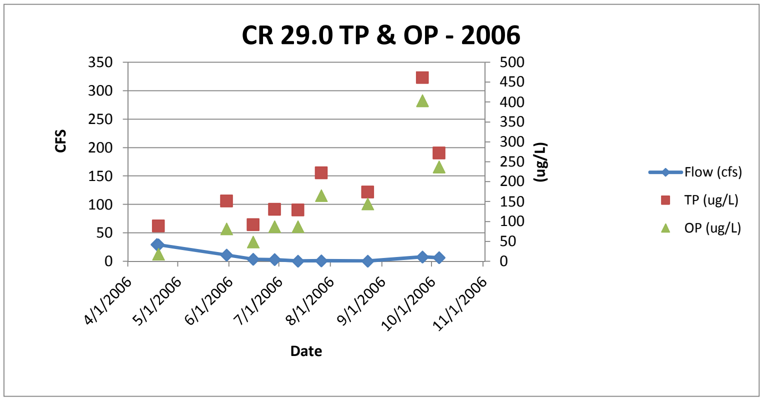
Pre-Project (Aug2012) Upstream of Hwy 15

Post-Project-(Aug 2013)Looking Upstream from Hwy 15

Post-Project (Feb 2013) Constructed and Restored Channel Upstream of Hwy 15

Appendix J

Kingston Wetland Monitoring Data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(ug/L)
Date
Flow (cfs)
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OP (ug/L)
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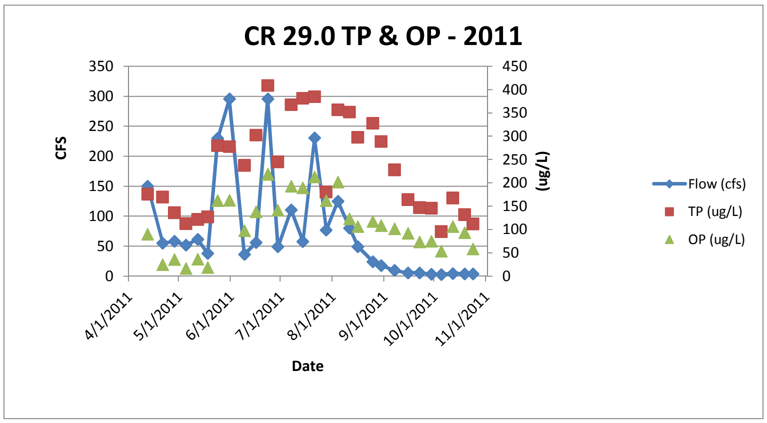
6/1/2006
7/1/2006
8/1/2006
9/1/2006
10/1/2006
11/1/2006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OP (ug/L)
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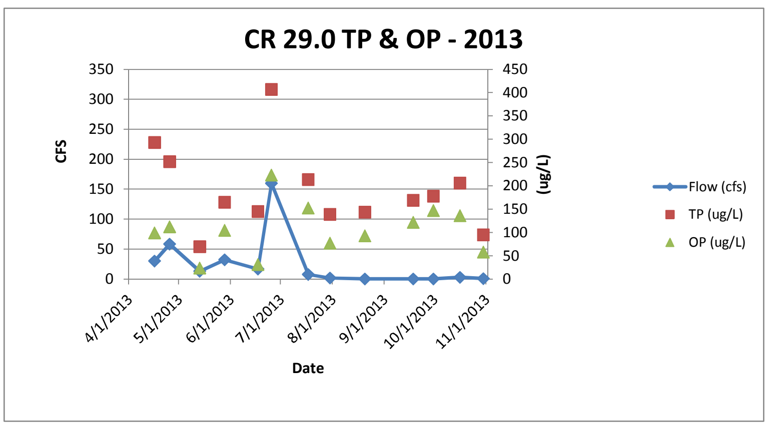
10/1/2011
11/1/2011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Flow (cfs)
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OP (ug/L)
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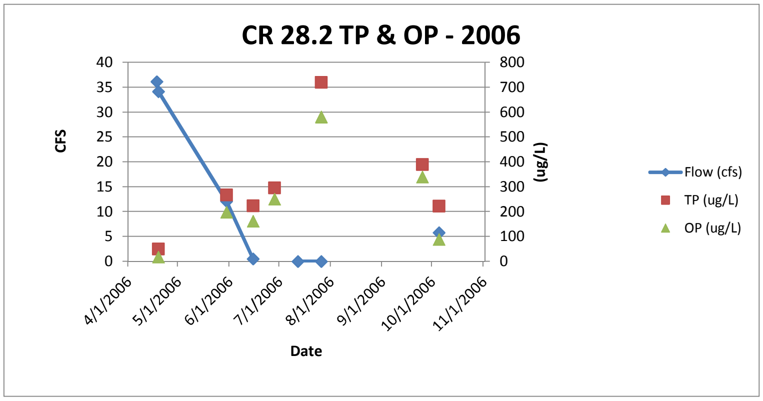
9/1/2013
10/1/2013
11/1/2013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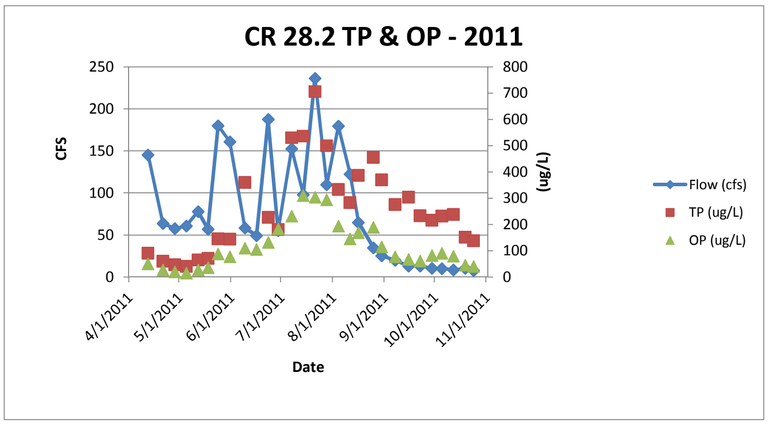
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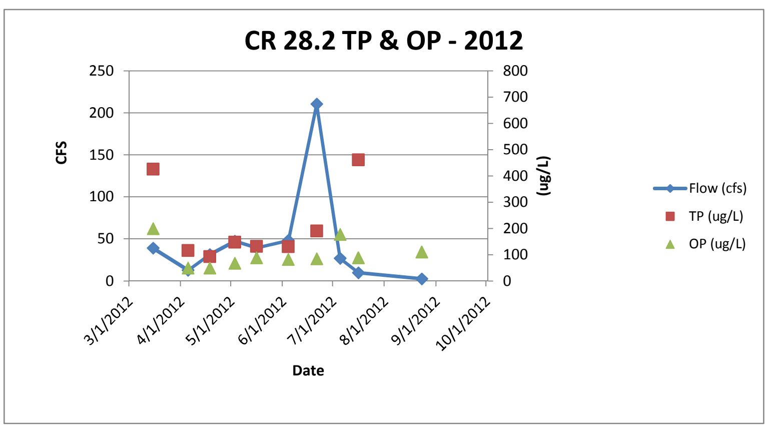
11/1/2011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CFS
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Date
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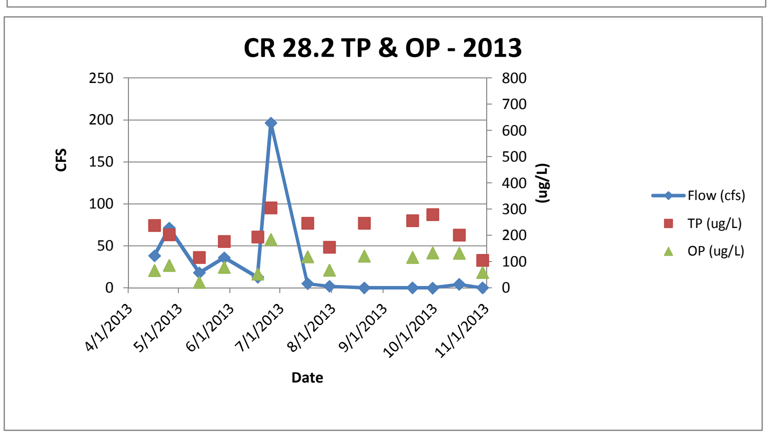
10/1/2012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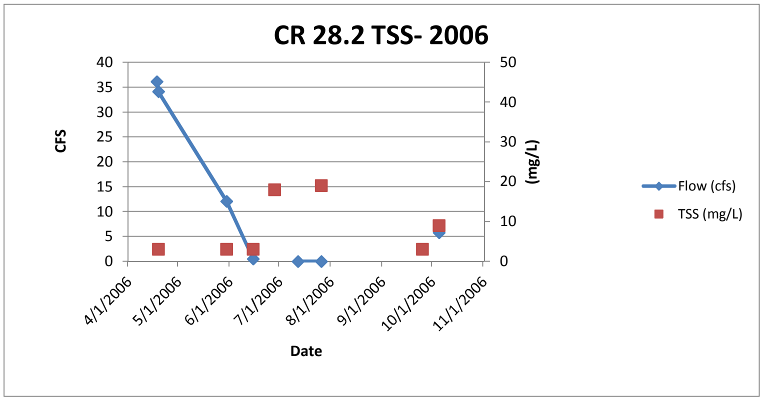
11/1/2013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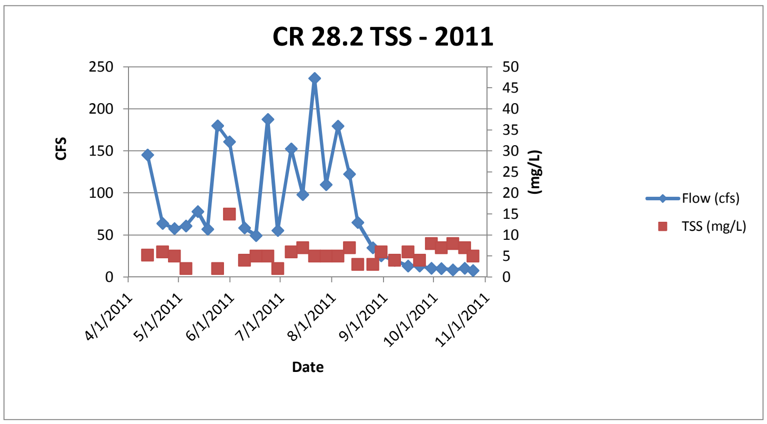
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(mg/L)
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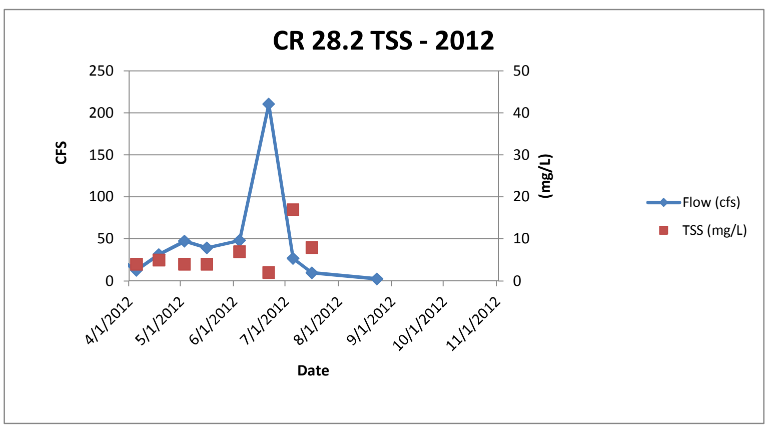
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Flow (cfs)
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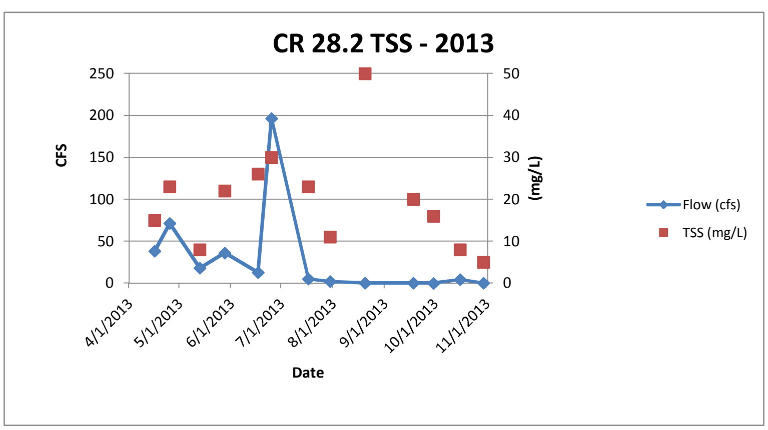
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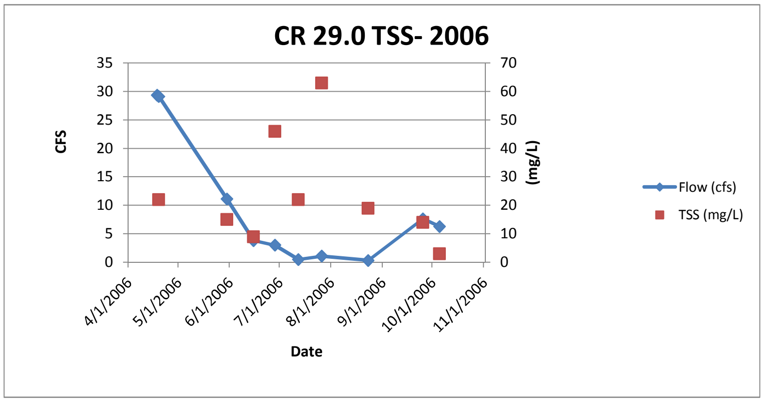
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(mg/L)
Date
Flow (cfs)
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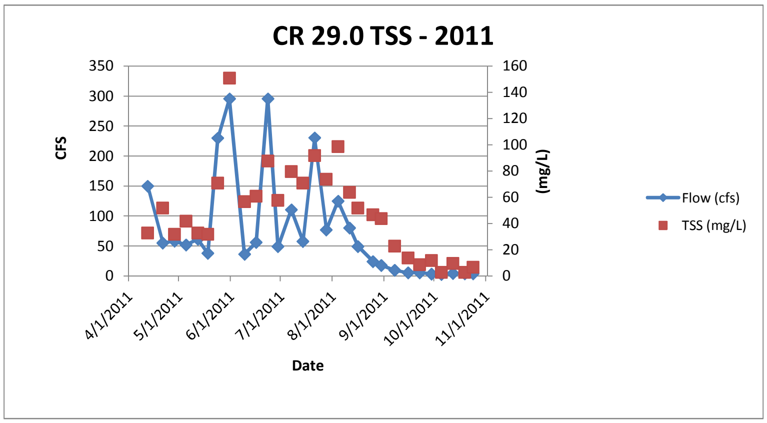
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(mg/L)
Date
Flow (cfs)
TSS (mg/L)
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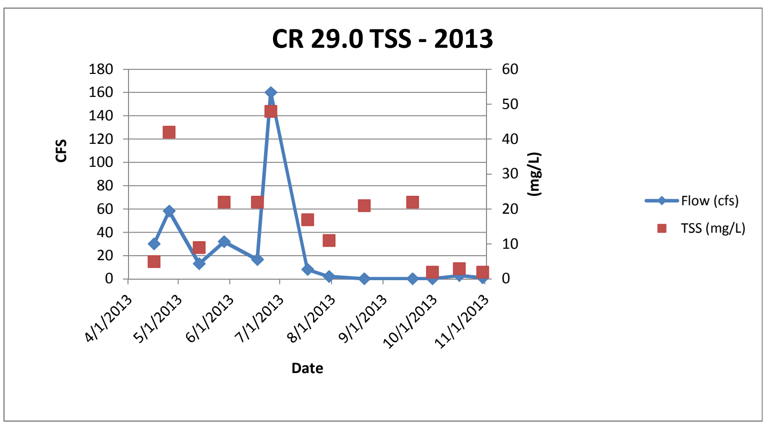
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CFS
(mg/L)
Date
Flow (cfs)
TSS (mg/L)
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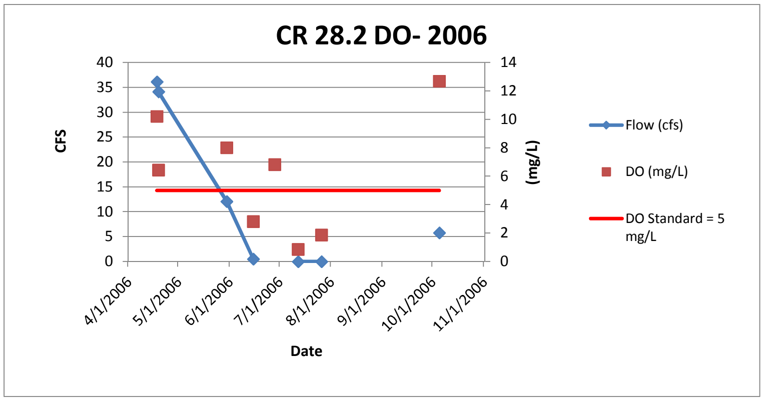
10/1/2013
11/1/2013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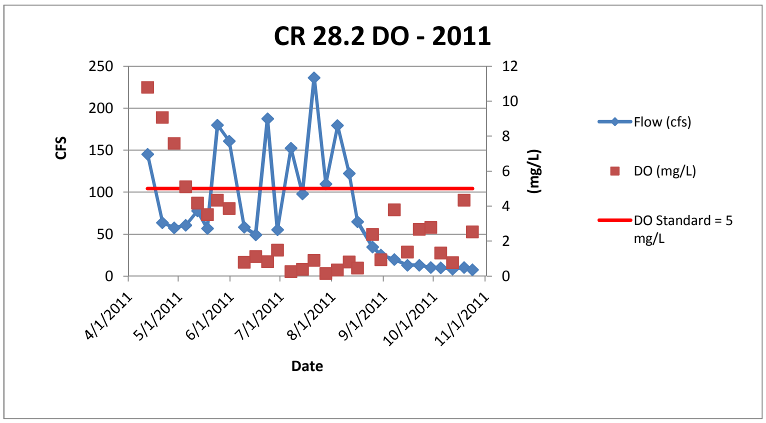
11/1/2006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Date
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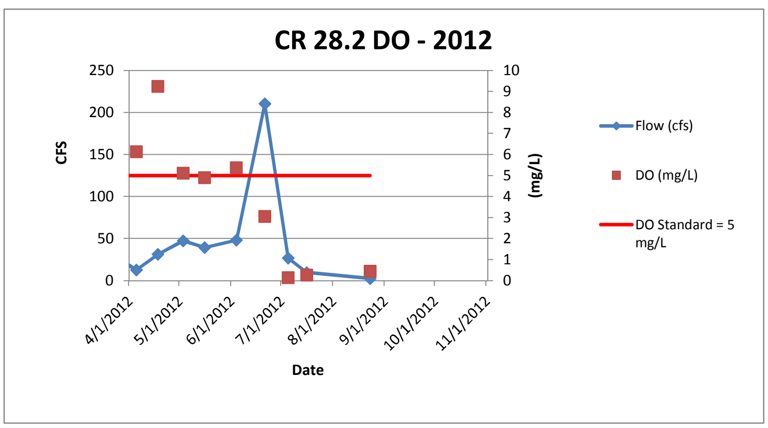
11/1/2011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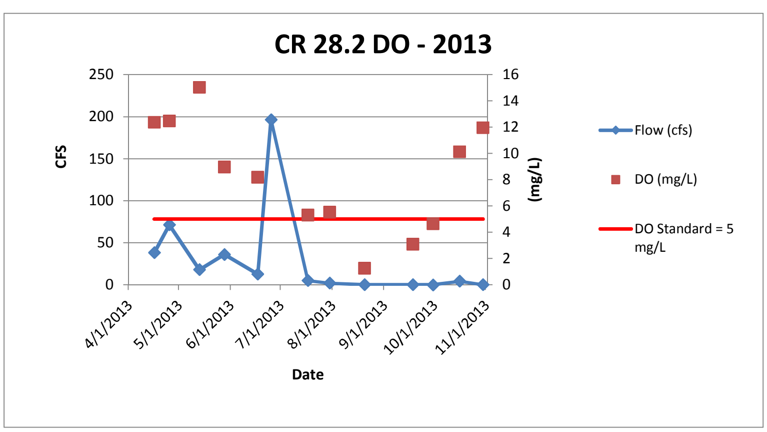
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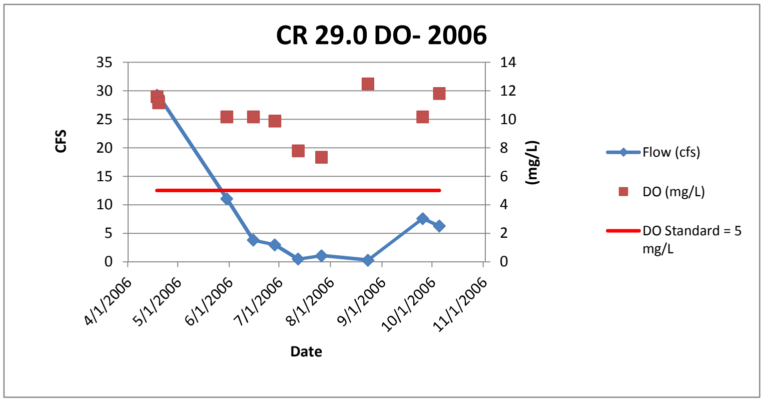
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5/1/2006
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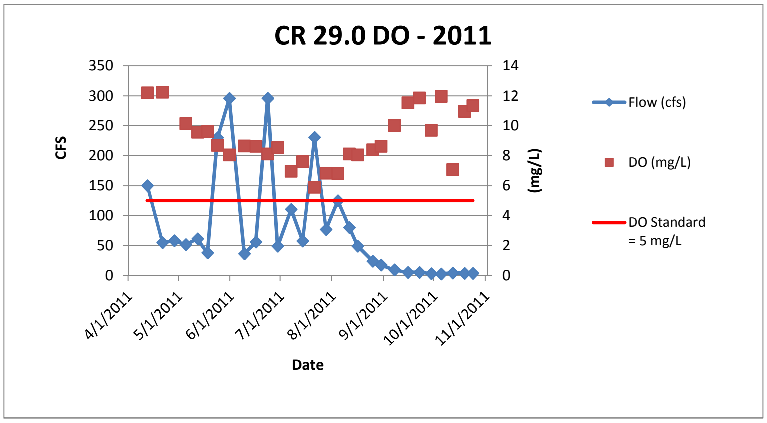
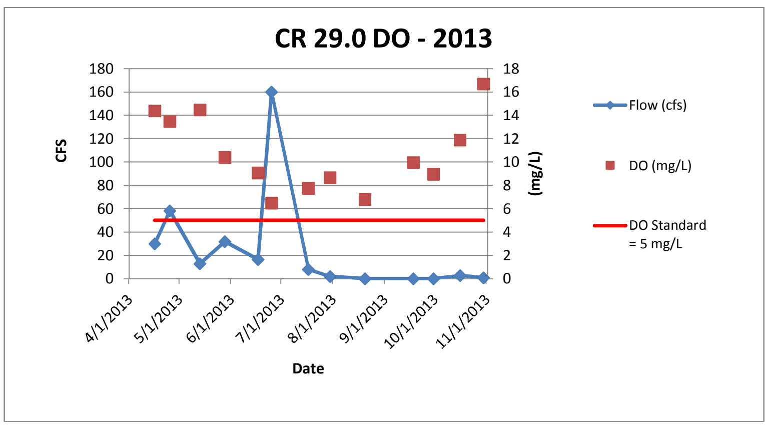
9/1/2006
10/1/2006
11/1/2006

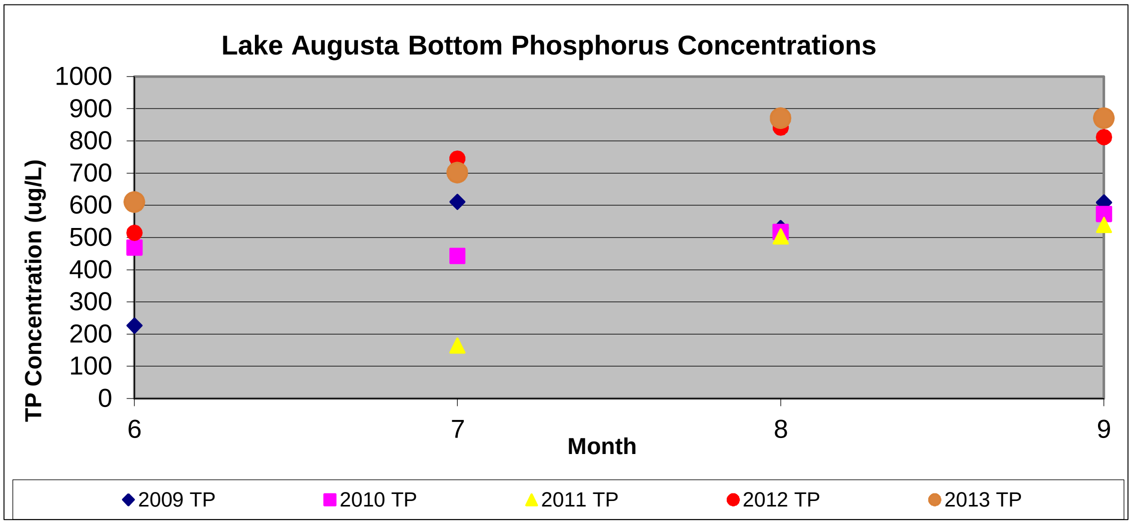

CR 29.0 DO - 2011
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2011
5/1/2011
6/1/2011
7/1/2011
8/1/2011
9/1/2011
10/1/2011
11/1/2011

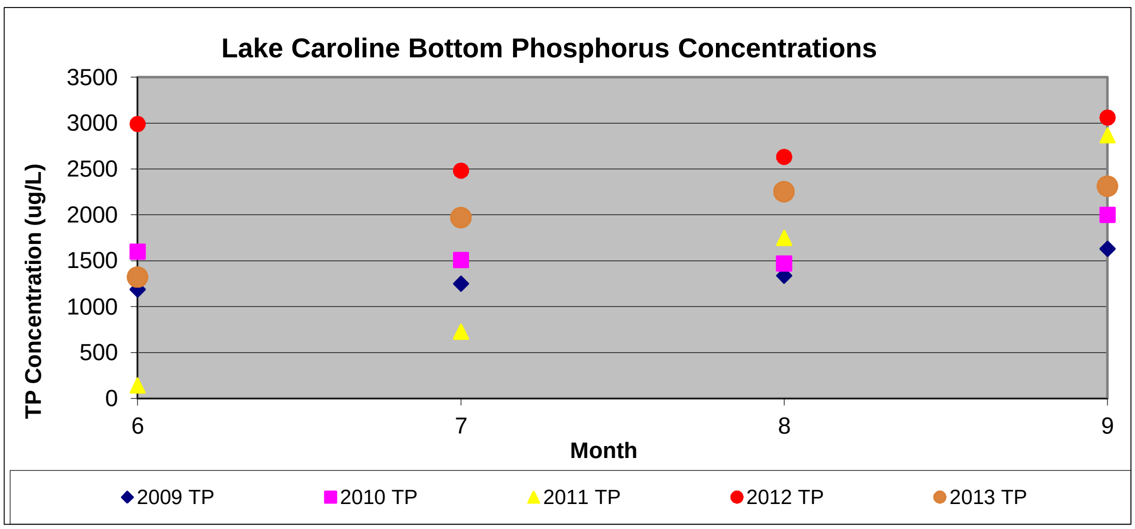

CR 29.0 DO - 2013
CFS
(mg/L)
Date
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013
11/1/2013

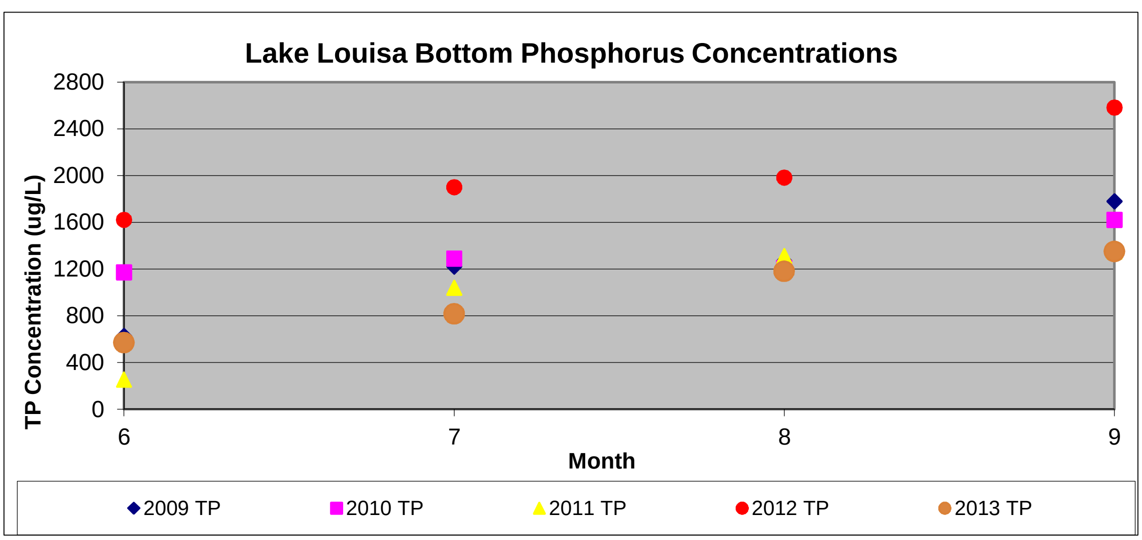
Appendix K

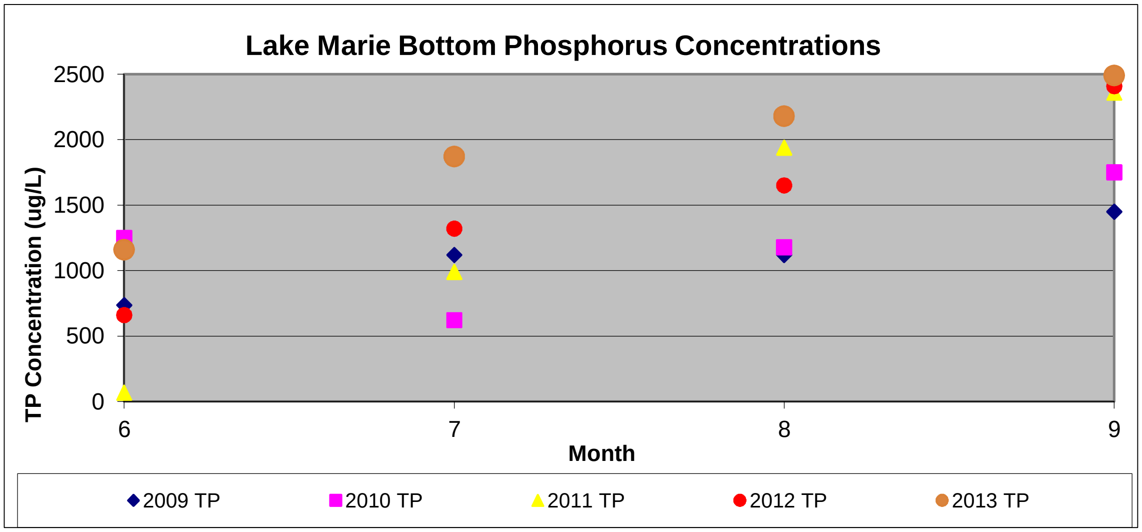
Lake Bottom Phosphorus Concentrations (2009-2013)

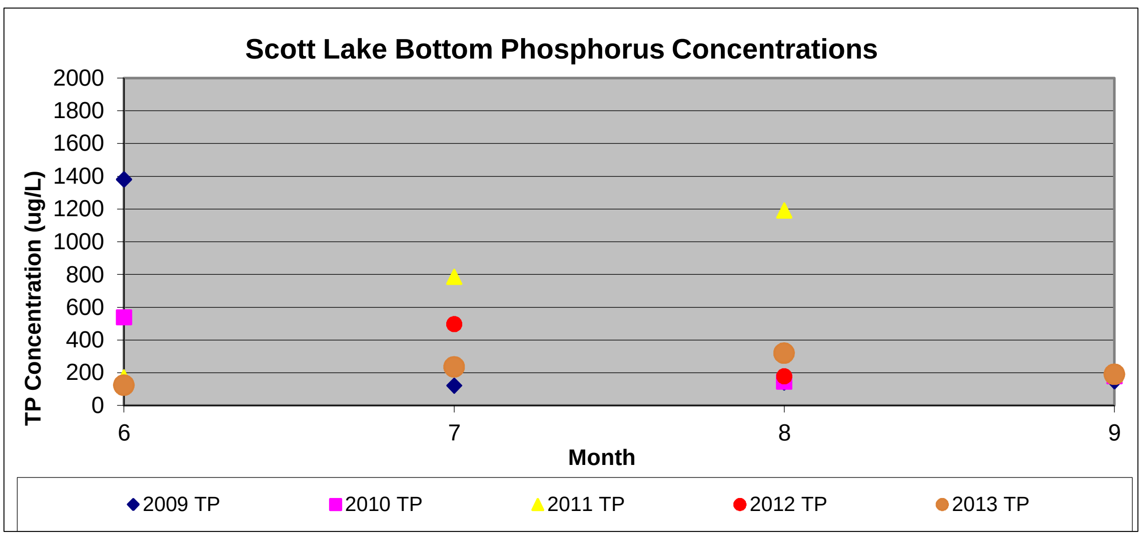
Clearwater River Watershed District
2013 Annual Monitoring Report
Appendix K

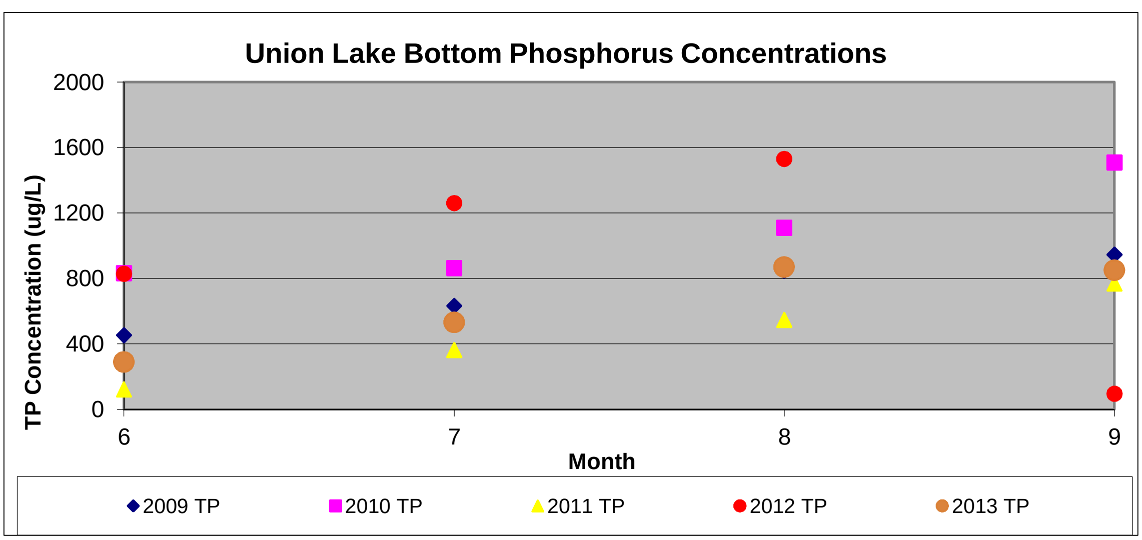







Lake Marie Bottom Phosphorus Concentrations
TP Concentration (ug/L)
2500
2000
1500
1000
500
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP


Scott Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP


Union Lake Bottom Phosphorus Concentrations
TP Concentration (ug/L)
2000
1600
1200
800
400
0
6
7
8
9
Month
2009 TP
2010 TP
2011 TP
2012 TP
2013 TP