2016 Annual Report

Prepared for:

Clearwater River Watershed District

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Responsive partner.
Exceptional outcomes.

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Acronyms

BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BWSR	MN Board of Water & Soil Resources
cfs	cubic feet per second
CFU/100 mL	colony forming units per 100 milliliters
Chlor-*a*	Chlorophyll-*a*
CREP	Conservation Reserve Enhancement Program
CRWD	Clearwater River Watershed District
CWP	Clean Water Partnership
District	Clearwater River Watershed District
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
lbs	Pounds
MDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
μg/L	micrograms per liter
mg/L	milligrams per liter
NCHF	North Central Hardwood Forest
Ortho-P	Ortho-Phosphorus
RIM	Reinvest in Minnesota
SOD	Sediment Oxygen Demand
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
WMP	Watershed Management Plan

Executive Summary

This report has been prepared by Wenck Associates, Inc. (Wenck) in conjunction with Clearwater River Watershed District's (CRWD) staff to both satisfy the annual reporting requirements set forth in Minnesota Statutes Chapter 103D.351, as well as to provide a progress report of the Clearwater River Watershed District's Watershed Management Plan (WMP) Implementation activities. In addition, this report summarizes 2016 hydrologic, hydraulic and water quality monitoring data and provides an analysis of progress towards goals in the context of the District's watershed management activities.

In 2016, the CRWD made progress towards goals established in the Watershed Management Plan by doing the following:

- Completed construction on the Swartout Lake Component of the Cedar Lake Watershed Protection & Improvement Project in spring of 2016.
- Continued work on maintenance of District projects.
- Completed the technical analysis for the total suspended solids (TSS) and bacteria study.
- Completed the final report for the Targeted Fertilizer Application Project in the upper watershed, which is funded in part by a federal Section 319 grant.
- Continued targeted implementation of agricultural cost share best management practices (BMPs) in high priority locations that were identified through the total maximum daily load (TMDL) study and other grant funded studies including a Section 319 grant to install alternate tile intakes and a Clean Water Partnership grant to target TSS and bacteria load reductions in the upper watershed.
- Continued to implement rough fish management (removal and migration barriers). The District also evaluated costs and benefits of the use of newer tracking technology.
- Continued to monitor water quality, hydrology and hydraulics to track water quality trends and effectiveness of management strategies.
- Progressed on design for the Watkins Area Stormwater Treatment Project.
- Continued Aquatic Invasive Species (AIS) work with lake associations as initiated by lake associations.
- Administrator Loewen actively participated in the Stearns County AIS Committee and advised both Meeker and Wright County's AIS Task Forces.
- Conducted various civic engagement activities, including focused outreach to district school via partnership with the Sauk River Watershed District.

In 2017, the CRWD plans to continue progress towards Watershed Management Plan and TMDL goals by:

- Continuing to monitor water quality, hydrology and hydraulics to track water quality trends and the effectiveness of existing management strategies. These actions help to improve efficiencies of implementation projects.
- Conducting rough fish removal and migration management as necessary.
- Constructing the Watkins Area Stormwater Project.
- Continuing enrollment in the alternative tile intake project, and recruit project participants to reduce sediment and bacteria load in the upper watershed.
- Completing maintenance on existing projects as noted in annual project inspections.
- Continuing education and outreach efforts.

- ▲ Conducting the annual strategic planning session in March to evaluate WMP implementation, perform adaptive management and identify additional needs. This includes identifying additional projects and continuing to apply for grant dollars to fund other CRWD projects.
- ▲ Continuing discussions for update of the 10-year comprehensive plan.

Significant hydrologic, hydraulic and water quality findings in this report include the following:

1. Overall, annual precipitation and runoff was above normal at monitored locations for the year in 2016. Precipitation ranged from 41.42 inches in Kimball to 33.85 inches in St. Cloud. Runoff near the watershed outlet was below average at 7.55 inches (compared to 7.9 inches in an average year).
2. Phosphorus loads from the Clearwater River are stable to declining, but still above water quality target loads.
3. Lake water quality is stable to improving in all CRWD lakes based on long-term trends. Water quality in both Cedar Lake and Lake Betsy- lakes directly downstream of intensive District water quality improvement activities- is stable to improving. Lake Betsy water quality has improved dramatically since implementation activities began in 2009; water quality in Cedar Lake has stabilized near the water quality goal since work began in 2007.
4. Lakes Louisa and Marie have improving trends between 2013 and 2016.
5. Lake Augusta, impaired for nutrients, met the water quality total phosphorous (TP) standard 4 of last 8 years.
6. Clear Lake saw a record low concentration of 73 ug/L TP, just above it 60ug/L state standard.
7. Lake Caroline saw a dramatic Secchi depth improvement in 2016 and chlorophyll-*a* concentration improvement during the last four years.
8. Union Lake, temporarily high in TP is back down below the 40 ug/L TP standard.
9. Clearwater Lake West documented the lowest average summer surface TP concentration on record, <20 ug/L.

Information on the status of existing CRWD projects can be found by referring to the CRWD's Annual Project Inspection Report, located online at http://www.crwd.org/.

1.0 Introduction

1.1 MISSION STATEMENT

The District's mission is to promote, preserve and protect water resources within the boundaries of the CRWD in order to maintain property values and quality of life.

1.2 DISTRICT HISTORY

The area encompassed by the CRWD is rich in soil and water resources. The presence of those resources has encouraged the growth of two economic mainstays in this Central Minnesota territory – farming and tourism. Around these basics have grown the communities that support their needs. As population and industry grow, those priceless resources, which we often take for granted, may deteriorate.

In the 1960s and early 1970s, those who fished and enjoyed the waters of the Clearwater River Chain of Lakes began to notice a decrease in the clarity of those waters, an increase in the number of rough fish (bullheads and carp), and an increase in the growth of algae on the surface of the water. Property owners sought new tests from scientists interested in water quality. Those tests revealed that the nutrient content of the water had increased substantially since 1946 – phosphorus was coming into the Clearwater Lake at a rate almost double the rate considered damaging.

The lakes through which the Clearwater River flowed were aging much too quickly. That process, which is a natural phenomenon called "eutrophication," was being helped along at an alarming rate via pollution entering the river system from cities, farmland, private property, and industry.

Further reports concluded that the rate of phosphorus input could be reduced by as much as 50% if the cities of Watkins, Kimball, and Annandale, and the Modern Craftsmen's Milk Association of Watkins installed on-land waste treatment systems instead of discharging sewage and industrial effluents into the Clearwater River and Warner Creek. In addition, if the phosphorus input from all non-point sources (such as septic tanks, agricultural wastes, storm water runoff, and soil erosion) could be significantly reduced, water quality in the watershed could be restored to an acceptable level.

After a lengthy series of meetings and legal research, those concerned came to the conclusion that only a watershed district, with its powers of enforcement and its abilities to assess and to obtain federal and state funding, could tackle the pollution problem in the Chain of Lakes. The CRWD was the culmination of years of hard work and the beginning of many more years of work aimed at undoing some of the damage done over a long period of time to one of our most important resources – our lakes and streams.

The CRWD was established as a unit of local government on April 9, 1975, through citizen petition by order of the Minnesota Water Resources Board, acting under authority of Chapter 112, MSA (the Minnesota Watershed Act). Though the original thrust of the CRWD and its five-member Board of Managers was the improvement of water quality in the Clearwater River Chain of Lakes, its scope has grown into a complete program of water management within its boundaries.

1.3 DISTRICT INFORMATION

Mailing Address	75 Elm Street East PO BOX 481 Annandale, MN 55302
Website	www.crwd.org
Office hours	8am-4pm M-F (in field frequently, call ahead)
Board meeting schedule	Regular meetings are held monthly on the 3rd Wednesday at 6:00pm at City Hall in Annandale, MN. Special meetings are called on an as-needed basis.

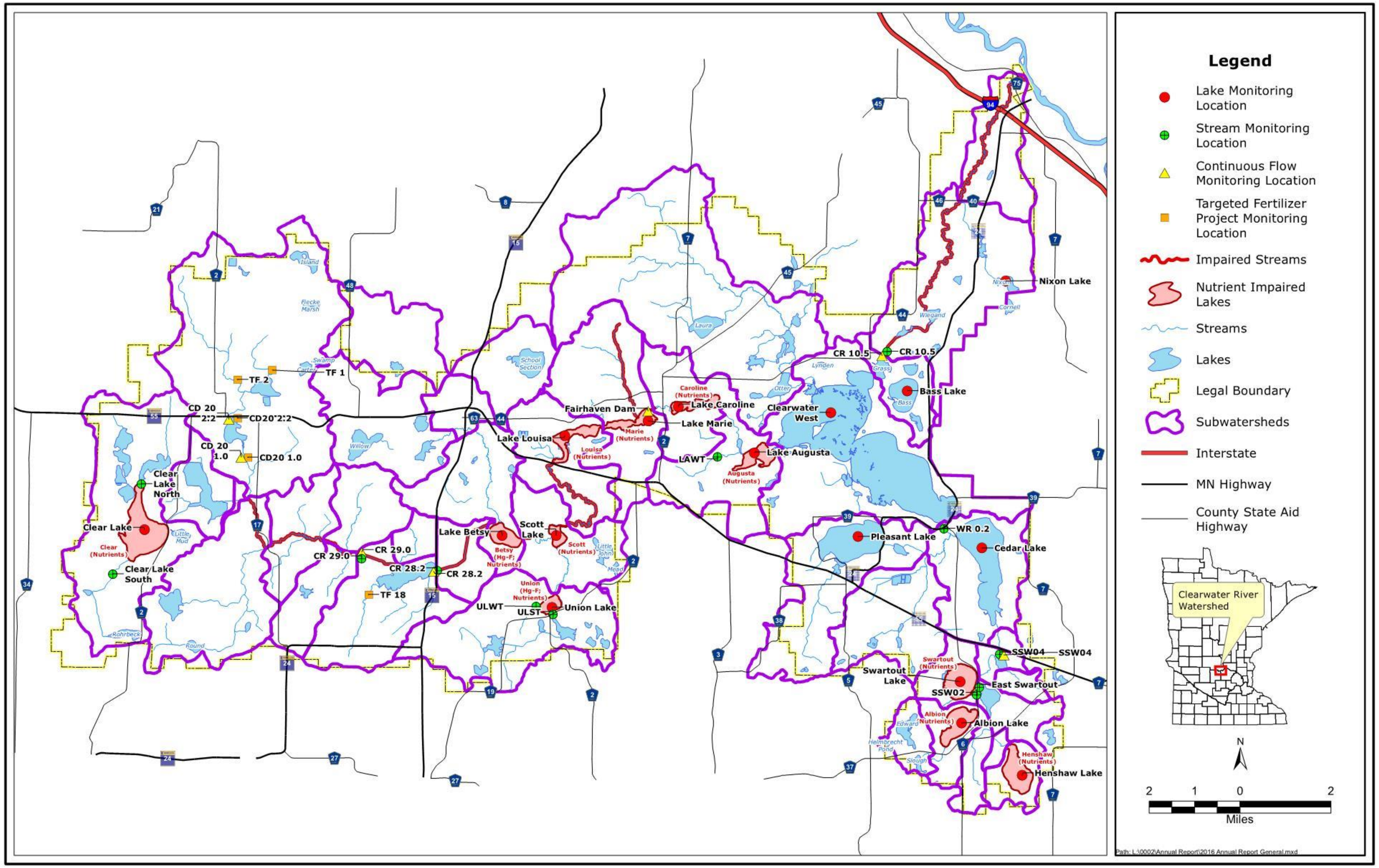
1.4 MONITORING & REPORT OBJECTIVES

The Clearwater River Watershed District's 9CRWD's) ongoing monitoring program– started in 1980- is critical to track long term water quality and hydrologic trends. This report summarizes data to evaluate progress towards water quality goals through program/ project implementation. This allows the CRWD to optimize costs and benefits of natural resource protection programs within the District. The 2016 monitoring plan is summarized in Appendix A, monitoring locations and impaired waters are summarized in Figure 1-1.

The objectives of the Water Quality Monitoring and Watershed Management Plan Implementation Status program are:

1. Track progress towards water quality goals for impaired waters by:
   a) Measuring water quality trends in lakes and streams and pollutant loads.
   b) Tracking programs and projects implemented.
   c) Evaluating water quality in the context of programs/ projects implemented.
2. Fill data gaps identified in the TMDLs.
3. Continue to provide baseline water quality data and calibration data sets to refine TMDL load reductions.
4. Track long-term trends in all CRWD waters monitored ensuring early detection of declining trends. Appendix B and C summarize historical loading and water quality data.
5. Provide recommendations for ongoing programs, projects and watershed management strategies based on data.

Figure 1—1: Impairments and water quality monitoring locations in the Clearwater River Watershed District.



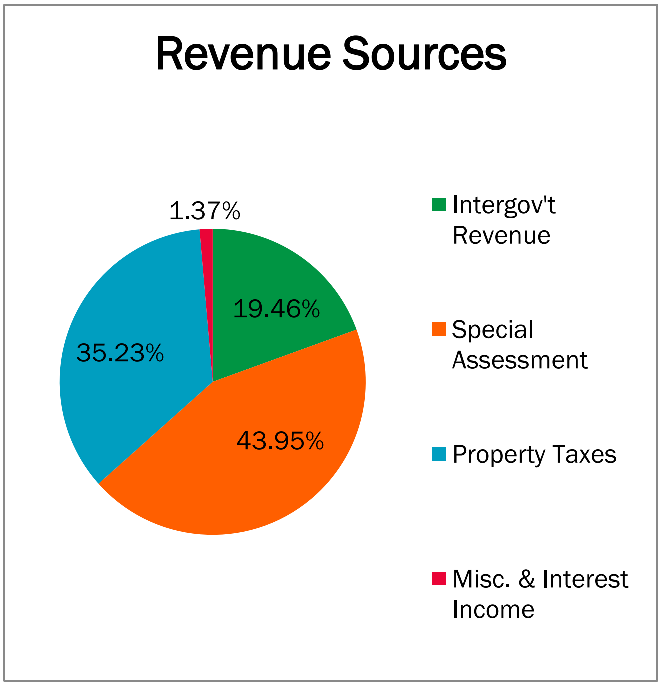
2.0 2016 Financial Condition of the CRWD

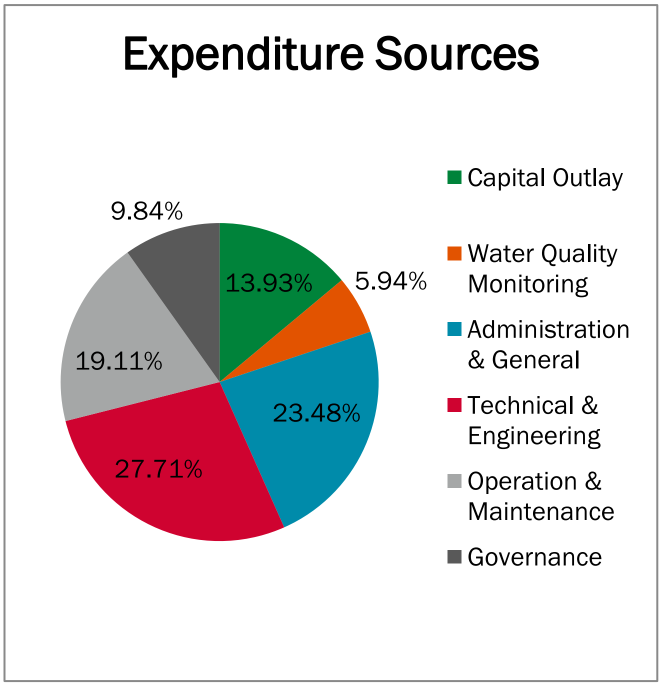
SUMMARY OF REVENUES

General Property Taxes	$250,852
Intergovernmental Revenue	$138,564
Special Assessments	$312,906
Misc. & Interest Income	$9,667
Total Revenue	$711,989

SUMMARY OF EXPENDITURES

Governance	$69,119
Administration & General	$164,867
Technical & Engineering	$194,570
Operation & Maintenance	$134,170
Water Quality Monitoring	$41,694
Capital Outlay	$97,829
Total Expenditures	$702,249
Fund Balances – January 1, 2016	$920,352
Fund Balances – December 31, 2016	$930,092





Note: The District conducts an independent audit annually; audited financial statements are available for public review at the District's office during normal business hours, at the Annandale Public Library, and online at: http://crwd.org/audit_reports.html. The above information can be found on pages 10-11 of said report.

The activities of the CRWD are funded by a combination of an ad valorem tax levy (based on property values within the CRWD), special assessments, and grants. Funds raised by special assessment can only be used for the specific purpose they were levied for. The CRWD budget, corresponding levies and special assessments are approved after public notice and hearing, as dictated by statute. This public hearing is normally held at the September regular meeting. A detailed budget is available for public review at the CRWD office.

3.0 Progress Towards Water Quality Goals | Status of CRWD Projects and Programs

The CRWD Watershed Management Plan (WMP) 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, water quality in upper watershed lakes like Clear Lake and Lake Betsy is the primary driver of water quality in downstream lakes like Clearwater Lake. Nutrient loads from 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 achieved for the lowest cost by initially focusing the efforts on improvements in the upstream end of the District and working downstream.

3.1 PROCESS

The CRWD WMP is specific in its focus: implement the identified projects and programs in high priority geographical areas. The District makes annual adjustments to further focus and refine management activities. The Board and staff review this report, compare findings to the WMP, and then prioritize projects and programs. They typically select one-three projects and programs to focus on in the coming year. The annual planning is based on remaining programs and projects identified in the Plan, water quality monitoring findings as well as other opportunistic projects identified during the year. This on-going strategic planning keeps the CRWD focused and efficient.

3.2 YEARLY SUMMARY OF PROGRESS | STATUS OF PROJECTS AND PROGRAMS

The following section summarizes year by year strategy as well as programs and projects undertaken since the plan was adopted:

2009

- ▲ Prioritized six 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 (Kimball Stormwater would eventually be broken into two phases, grant for Phase I was received in 2009).
- ▲ 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.
- ▲ Implement education program including watershed tours and outreach to lake associations, farmers and local government units.

2010

- ▲ Applied for and received Section 319 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, including collection of lake bottom samples and sediment phosphorus release analysis in Augusta and Scott Lakes.
- ▲ Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- ▲ Implemented Fertilizer Field Trial Project.

2011

- ▲ Constructed Kimball Stormwater Project (now known as Phase I).
- ▲ 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.
- ▲ Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- ▲ Implemented Fertilizer Field Trial Project.

2012

- ▲ Applied for and secured one 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.
- ▲ Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- ▲ Implemented Targeted Fertilizer Project.

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.
- Implement education program including watershed tours and outreach to lake associations, farmers and local government units.
- Began Kingston Wetland Restoration Project.
- Implemented Targeted Fertilizer Project.

2014

- Advanced implementation for priority projects:
  - Completed 90% of construction for Kimball Phase II stormwater retrofit.
  - Conducted Feasibility Study Betsy Lake Internal Load Management.
  - Completed design and permitting for two Cedar Lake watershed projects, construction to begin early in 2015
  - Continued implementation of Targeted Fertilizer Application Program, early reports from Co-Ops indicate enrollment is approaching goals.
- The Targeted Fertilizer Application Program was Awarded:
  - Minnesota Association of Watershed District Program of the Year
  - Environmental Initiative Natural Resources Award.
- Applied for both rounds of MN Board of Water and Soil Resources' (BWSR) Targeted Watershed Implementation Program to complete the plan implementation; CRWD was not selected for either grant.
- Applied for a Clean Water Legacy (CWL) grant for the Watkins Project.
- Applied for Section 319 funds for the Alternative Tile Intake Demonstration Program
- Measured and recorded positive results of the Kingston Wetland Restoration Project including reduced soluble phosphorus export from the wetland and improved dissolved oxygen concentrations downstream.
- 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.
- Implemented education program including watershed tours and outreach to lake associations, farmers and local government units.

2015

- Received a Clean Water Legacy Grant for the Watkins project and began design and permitting.
- Completed final project closeout for Kimball Phase II.
- Completed construction for the Highway 55 portion of the grant-funded Cedar Lake Watershed Protection and Improvement Project.
- Achieved substantial completion Swartout portion of the grant-funded Cedar Lake Watershed Protection and Improvement Project.
- Awarded 319 funds for the Alternative Tile Intake Demonstration Program and began program implementation.
- Continued to enroll landowners in the Targeted Fertilizer Application Program.
- Reported positive results of the Kingston Wetland Restoration Project in the final report and maintained sediment forebay.
- Continued to implement rough fish management (removal and migration barriers).
- Implemented agricultural best management practices via existing District cost-share and/or partnering with other entities (ex SWCDs).
- Conducted 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.

- Continued Aquatic Invasive Species (AIS) work with lake associations as initiated by lake associations. Actively participated with county-level AIS activities.
- Implemented education program including school district outreach via partnership with Sauk River Watershed District, watershed tours and outreach to lake associations, farmers and local government units.

Table 3—1: 2016 Summary of Progress | Status of Projects and Programs

Activity	Notes
Advisory Committee	Per MN Statute 103D, the CRWD Board of Managers has appointed an advisory committee. More information on the committee, include meeting minutes, can be found at: http://crwd.org/advisory_committee.html.
Annual Project Inspections	On an annual basis, the CRWD conducts a review of the operational status of all projects the CRWD owns, operates and/ or maintains on the landscape. At a minimum visual inspection of individual project's components are performed, with more in-depth inspections performed as warranted. From this, actions items needed to maintain operational effectiveness are determined. The results of these inspections are summarized annual in a Project Inspection Report, which serves to provide an annual status update to the CRWD Board of Managers. On July 20, 2016, the 2016 report was accepted by the CRWD Board of Manager. A copy of report can be viewed at: http://crwd.org/publications_reports.html. Status of projects and programs that do not physically exist on the landscape are covered below.
Aquatic Invasive Species (AIS) Treatment Programs	The CRWD has established four programs for the treatment of AIS in certain CRWD waters. These programs are funded by special assessments, and the lake associations on each lake undertake the management of the treatment programs via agreement with the CRWD; the CRWD acts as a fiscal agent on all projects. • Cedar Lake AIS Project ○ 8.8 acres of Curly-Leaf Pondweed chemically treated ○ 20.273 acres of Eurasian Watermilfoil chemically treated • Clearwater Lake Eurasian Watermilfoil Treatment Project ○ 73.8 acres of Eurasian Watermilfoil chemically treated • Lake Augusta AIS Project ○ 3.31 acres of Curly-leaf Pondweed chemically treated ○ 7 acres of Eurasian Watermilfoil were mechanically harvested • Lakes Louisa & Marie AIS Project ○ 13.83 acres of Curly-leaf Pondweed chemically treated on Lake Louisa ○ 14.78 acres of Curly-leaf Pondweed chemically treated on Lake Marie In addition, the CRWD actively participated with county-level AIS activities, principally by serving in an advisory role.
Bog Control Projects	In response to high water levels in the mid-1980s that caused severe floating bog problems on Augusta, Clearwater, and Grass Lakes, the CRWD set up two bog control projects with the cooperation of the lake property owners involved. These projects included acquisition and improvement of

Activity	**Notes**
	access areas for bog removal, and the funding (via assessment) and process for removal of floating bogs deemed harmful. The CRWD works in conjunction with the Minnesota Department of Natural Resources as well as other local authorities in removal of problematic bogs from choke points on these three lakes in order to ensure river flow is not restrict such that flooding could result. Bog removal by the CRWD is governed by CRWD Policy. Minimal bog activity was noted in 2016.
Education and Outreach Program	Program is a collection of activities, events, publications, etc. that fall under various projects and programs of the CRWD. Provides means to: • Inform citizens on CRWD activities • Encourage involvement and ownership of water-resource issues • Discover citizen concerns • Establish and test methods Activities completed in 2016 under this program include: • Multiple press releases, reports, and other publications. • Several CRWD advisory committee meetings. • Booth at both Annandale and Kimball Business Expos. • Attendance at multiple meetings and with individuals on a variety of circumstances. • Commented on variance and permit requests from Corinna Township, Meeker County, Stearns County and Wright County. • Engineering staff presented on a CRWD project at the 2016 Iowa Water Resource Conference. • Project signage installed at East Swartout and Old Highway 55 projects. • District-wide tour for interested citizens performed. • Multiple surveys of program enrollments and general citizens. • Partnership continued with Sauk River Watershed District to extend their school-age outreach programming to schools in the CRWD.
Incentive Program	**Agricultural Incentives** • No-till to spring incentive: 10.31 acres Visit: http://crwd.org/incentives.html to learn more about these incentive offerings.
Partnerships	**Mississippi River (St. Cloud) Watershed WRAPS** Collaborated with partners on this project where possible. The CRWD remains committed to working with its partners on the watershed restoration and protection strategies report process. **Opportunistic Partnerships** The CRWD will often work with other entities to accomplish water quality goals. • Norton Ave Erosion Issue: The CRWD was contacted by local residents regarding concerns with significant erosion along Norton Ave on the southern shore of Lake Augusta. The CRWD solicited the involvement of Wright County SWCD to develop a solution to this issue. Solution development continues into 2017. • Several other opportunities to partner on water quality improvement projects remain into 2017.
Project-specific	**Agricultural Cost-Share BMPs** Continued targeted implementation of agricultural cost-share best

Activity	Notes
	management practices (BMPs) in high priority locations identified in TMDL studies. • Included continuing to work on the federal Section 319-funded Alternative Tile Intake Project. • Included the completion of the analysis portion of the Clearwater River Restoration and Protection Phase II Project (Clean Water Partnership-funded), as well as imitating recruitment of landowners in the targeted area for BMP implementation. **Cedar Lake Watershed Protection & Improvement Project** Completed final project closeout for two Cedar Lake Subwatershed Projects which were funded in part through Clean Water Legacy Grants. **Targeted Fertilizer Application Reduction Project** Completed and submitted the final project report to the MN Pollution Control Agency. **Watkins Area Stormwater Treatment Project** Continued design and permitting work on the Clean Water Legacy Grant project for stormwater management in and around Watkins, MN.
Rough Fish Management Program	The CRWD continues to implement rough fish management strategies (principally removal and migration barriers) in areas of the CRWD where management funding has been established. In addition, several test net surveys were conducted to determine if lake seining was warranted in 2016. Open water seining was conducted on Lake Louisa in fall 2016 will low rough fish pull numbers. Under ice seining on Swartout Lake was planned for early winter 2017.
Water quality monitoring	Conducted water quality and hydrologic monitoring in accordance with recommendations of the WMP throughout the District to monitor project performance and better focus implementation efforts.

3.3 OTHER MATTERS AFFECTING THE INTERESTS OF THE CRWD

Listed below are several matters that occurred in 2016 that affected the CRWD's interests.

1. The Minnesota Pollution Control Agency, through its operating permit for the Clearwater Harbor and Hidden River Sanitary Sewer Systems, has required the institution of a Nitrogen Mitigation and Analysis Plan. At the end of 2016 the CRWD was in the process of finishing the investigation of alternatives to meet the requirements of the plan, and was seeking grant funding for implementation of an alternative to meet plan requirements.

3.4 SUMMARY OF PRIORITY PROJECTS

The CRWD has implemented several major projects to achieve water quality goals; status is shown below.

Table 3—2: Priority Implementation Projects

Project	TP Reduction (lbs/yr)	Expense	Learn more
Projects Recently Completed			
Cedar Lake Restoration (06-01 Original)	1,500	$295,000	http://crwd.org/cash_061.html
City of Kimball	244	$189,550	http://crwd.org/tmdl_willowcreek.html

Project	TP Reduction (lbs/yr)	Expense	Learn more
Stormwater Management (Phase I)			
Clear Lake Notched Weir	588	$80,000	http://crwd.org/clear_southnotch.html
City of Kimball Stormwater Reclamation and Reuse (Phase II)	1,175	$985,000	http://crwd.org/tmdl_kimball-stormwater-PHII.html
Kingston Wetland Feasibility Study and Wetland Restoration	1,955	$589,000	http://crwd.org/tmdl_kingston_restore.html
Conservation Corps Streambank Restoration	TP load reduction associated with sediment load reduction	$65,275	http://crwd.org/tmdl_ccmriparian.html
Cedar Lake Watershed Protection and Improvement Projects (06-01-Modified)	1,280	$583,000	http://crwd.org/cash_061_protectandimprove.html
GPS Fertilizer Application	3,200	$437,000	http://crwd.org/tmdl_targetedfertilizer.html
Expand Education Program	N/A	N/A	Incorporated in grant funded scopes of work are efforts to expand the CRWD's Education/ Outreach programs. The CRWD had a strong relationship with Lake Associations and hosts educational events that primarily target adults. The education program was expanded to include social media outreach as well as school age children in the community.
Projects In Progress			
Clearwater River Restoration & Protection Phase II	TBD	$144,000	Source inventory update complete. Design and implementation of best management practices at prioritized locations underway. http://crwd.org/tmdl_crr&pII.html.
Watkins Area Stormwater Treatment	796	$645,882	Land was acquired for this project in mid-2000s. 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. The District received grant award in 2015 and began design and permitting. Construction is planned for mid-2017. http://crwd.org/tmdl_watkins-area-stormwater.html.

Project	Potential TP Reduction (lbs/yr)	Estimated Expense	Status
Potential Future Projects			
Lake Betsy internal load management	1,300 – 6,500 lbs	$250,000-$600,000	A feasibility study was conducted in 2014 to support project development, alum treatment is under consideration.
Clear Lake soluble phosphorus load from watershed	TBD	TBD	Watershed soluble phosphorus loads to Clear Lake are a priority and needed to meet lake water quality goals. Investigate opportunities to retrofit existing project to incorporate soluble phosphorus removal.
CD 20 project	TBD	TBD	CD 20 is a major source of bacteria to the Clearwater River. Investigate sources and opportunities to mitigate loads.
Watkins soluble phosphorus load reduction project	TBD	TBD	Identify and develop projects to reduce soluble phosphorus loading in the watershed.
Other soluble phosphorus load reduction projects	TBD	TBD	Identify and develop projects to reduce soluble phosphorus loading.

4.0 Managers' Plan of Work for 2017

4.1 PLAN OVERVIEW

The CRWD Board of Mangers approved the following plan at their March 15th, 2017 regular meeting. The scope of this plan is limited to a high-level overview, providing a summary of work envision by the CRWD Board of Managers for the year. Throughout the year, new information and opportunities may arise; as such, implementation of the plan may be altered at any time. While focused only on 2017, the plan factors in long-term planning to ensure the District remains on task to accomplish its mission and purposes.

Many work items covered below are too complex to be completely covered in a single, all-encompassing work plan. As such, many of these items have their own stand-alone work plans.

Table 4—1: Plan Categories Summary

Categories	Work Item | Priority Level
General Administration	Policy Updates | **Priority:** High
	Order special assessment to replenish Pleasant Lake Outlet O&M Fund | **Priority:** High
	Special Assessment System Update | **Priority:** High
	Investigate opportunities with local partners to fund shared staff focused on ag BMP implementation | **Priority:** Medium
	Re-estimate phosphorus removal calculations | **Priority:** Medium
	Investigate technological opportunities to improve productivity | **Priority:** Low
Operation & Maintenance of Existing Infrastructure	Repairs at Annandale Wetland Treatment System| **Priority:** High
	Repairs at Lake Augusta Erosion Control | **Priority:** High
	Sanitary Sewer Systems, under professional management | **Priority:** High
	School Section Lake Outlet Project: complete re-establishment by October 2017, complete ice barrier in winter 2017-18 | **Priority:** High
Capital Project	Clearwater Harbor/ Hidden River NMAP Implementation: secure grant funding and complete design | **Priority:** High
	Lake Betsy Internal Load Reduction: submit grant applications in 2017 | **Priority:** High
	Watkins Area Stormwater Treatment Project: complete construction in 2017 | **Priority:** High
Programs	Agricultural Incentive Programs: implement ATI, CRR&PII, work with Wright SWCD on Cedar Lake Subwatershed, continue District-wide incentive offerings | **Priority:** High-Medium
	Aquatic Invasive Species Programs: continue fiscal agent role, continue to serve in advisory roles for county programs, assist lake associations considering District project | **Priority:** High-Medium
	Civic Engagement Program: attend various meetings, update fact sheet, attend Expos, make press releases, continue social media and school-age educational outreach | **Priority:** High-Medium
	Floating Bog Control Programs: continue to remove problem floating

Categories	Work Item | Priority Level
	bogs as needed | **Priority:** High
	Inspection Program: perform visual inspections of CRWD infrastructure and issue report | **Priority:** High
	Residential/ Commercial Incentive Programs: continue District-wide incentive offerings | **Priority:** Medium
	Rough Fish Management Programs: consider repairs/ modifications to existing migration barriers (as-needed), operate temporary trap at Segner Pond inlet, investigate seining from Betsy and Scott Lakes | **Priority:** High-Medium
	Vegetation Management Program: perform management at multiple CRWD sites, control woody and noxious species at sewer and wetland treatment projects | **Priority:** High
	Water Quality Monitoring Program: Refer to 2017 WQM Proposal| **Priority:** High
Potential Opportunities	CREP & RIM Opportunities: Work with local SWCDs to implement CREP & RIM in strategic locations within the CRWD | **Priority:** Medium
	Norton Ave Erosion Control Partnership Opportunity: As able, partner with Wright SWCD to bring this effort to fruition | **Priority:** High

4.2 PLAN DETAILS

Section 4.2 provides greater detail for each of the five categories that make up the Managers' Plan of Work for 2017.

Table 4—2: General Administration

Tasks		Description
1	Policy Updates	**Summary:** The CRWD Board has instructed its staff to compile all policies into a single "policy book," as well has draft several new policies and amend several current policies as part of this book creation. **Plan:** • Staff completes the compilation of policies into a policy book, as well as the drafting of new policies and amending of several existing policies by June 2017. **Priority:** High • Board review and approves policy book. **Priority:** High
2	Order Operation & Maintenance Assessment for Pleasant Lake Outlet Control Project	**Summary:** The Pleasant Lake Outlet Control Project's O&M is nearly below its targeted reserve level. As such, the CRWD Board plans to levy a special assessment to replenish the reserve. **Plan:** • Contact Pleasant Lake Improvement Association to ensure residents are aware of this upcoming assessment. **Priority:** High • Update assessment roll with new parcel ownership information, making reallocations as necessary due to parcel changes (splits, combinations, platting, etc.) **Priority:** High • Order special assessment at September 2017 budget hearing. **Priority:** High
3	Special Assessment System Update	**Summary:** The CRWD recently switched to a new accounting system to provide better services, decrease operational costs, comply with changing standards and provide more options for reporting and

Tasks		Description
		recordkeeping. **Plan:** Staff implements the new special assessment program by August 2017. **Priority:** High
4	Shared Staff Opportunities	**Summary:** From recent findings of personnel subcommittee, in 2017 the CRWD is to investigate opportunities with local partners to fund shared staff focused on ag BMP implementation in watershed. **Plan:** Hold meeting with Meeker and Stearns SWCD in summer 2017 to discuss shared staff opportunities. **Priority:** Medium
3	Re-estimate Phosphorus Removal Calculations	**Summary:** The CRWD has several legacy projects (ex. Annandale Wetland) that originally were calculated to contribute a significant nutrient load reduction. It has been some time since those projects were analyzed to determine whether they continue to provide said reductions, whether the projects have reached the end of their useful lives, and/or whether modifications are needed. **Plan:** Staff develops and Board approves an analysis schedule for legacy projects by end of year 2017. **Priority:** Medium
6	Technology Improvement	**Summary:** As previously directed by the Board, staff is investigating potential technological improvements to increase productivity **Plan:** • Investigate technology to improve data collection as part of annual inspections and water quality monitoring **Priority:** Low
Notes: Regularly recurring items, such as monthly claims processing, or levying of annual O&M special assessments, are not included.		

Table 4—3: Operation & Maintenance of Existing Infrastructure

Projects		Description	Purpose
1	Annandale Wetland Treatment System Repairs	**Summary:** Constructed in 1980s to address nutrient loading from City of Annandale, including the former wastewater treatment plant, this project is estimated to provide phosphorous load reduction of ~750 lbs. annually. 2016 inspections noted the need for repairs to multiple sections of the projects west channel and berm in order to maintain operational effectiveness. **Plan:** The Board will direct its engineer to develop a quote package in Fall 2017, with quotes to be solicited and chosen winter 2017-18 and repairs to be made in the same period. **Priority:** High	Watershed nutrient load reduction
2	Lake Augusta Erosion Control	**Summary:** Constructed in 1980s to alleviate a large erosion problem on the southwest side of Lake Augusta due to groundwater action, this project is estimated to provide phosphorus load reduction of ~42lbs./ yr. In winter 2017-18 it was discovered that a portion of the project was in need of additional repairs. **Plan:** The CRWD Board has already directed its staff to develop repair designs, with the goal of joining with Wright County's planned road reconstruction work on nearby County Road 3. Repairs should be completed by fall 2017. **Priority:** High	Watershed nutrient load reduction
3	Sanitary Sewer Systems	**Summary:** Completed in 00s, the CRWD owns and operates four communal wastewater treatment systems that were petitioned either by developers or Stearns County. **Plans:** See capital projects for large project for two systems. All four systems are managed by a professional firm. Maintenance schedule has been established and is followed for system components. **Priority:** High	Wastewater treatment, groundwater and surface water protection
4	School Section Lake Outlet Control Structure	**Summary:** Instituted in mid-1980s to address high water on this lake and minimize erosion caused by high water. Currently, this project is undergoing re-establishment to install a robust ice barrier and to establish a new benefits structure for future assessments. **Plans:** • Complete process to re-establish project by October 2017. **Priority:** High • Install new ice barrier system Winter 2017-18. **Priority:** High	Local flood control
Note: Projects in need of minor work (defined as less than $2.5K), or work that is non-construction in nature are not listed			

Table 4—4: Capital Projects

Projects		Description	Purpose
1	Clearwater Harbor/ Hidden River Sewer Systems' NMAP Implementation	**Summary:** The MN Pollution Control Agency, as part of its operating permit for these two sewer systems, has mandated a nitrogen mitigation and analysis plan (NMAP) be implemented by permit expiration in 2019. Plan: • Secure grant funding from state to implement summer 2018. **Priority:** High • Complete design Fall/ Winter 2017. **Priority:** High	MPCA permit required, protect local groundwater
2	Lake Betsy Internal Load Reduction	**Summary:** The CRWD lists addressing internal load in lake Betsy as one of five priority activities in is current watershed management plan. In preparation, the CRWD has completed a feasibility study along with additional water monitoring. **Plan:** • Staff completes one-of-one meetings with regulatory authorities and granting entities by summer 2017. **Priority:** High • Staff submits grant application late summer 2017. **Priority:** High	Internal load reduction, improve lake ecology
3	Watkins Area Stormwater Treatment	**Summary:** The CRWD was awarded a $351,906 Clean Water Legacy Grant from BWSR to address dissolved phosphorus from both an urban and agricultural watershed around Watkins, MN. **Plan:** Complete construction by winter 2017. **Priority:** High	Watershed nutrient load reductions, restore native hydrology

Table 4—5: Programs

Projects		Description	Purpose
1	Agricultural Incentive Program	**Summary:** The CRWD has a long history of leading, partnering and encouraging the installation and adoption of best management practices (BMPs) of agricultural lands to mitigate nutrient exportation to downstream waters. Today the CRWD has multiple efforts underway to continue this effort. **Plans:** • Continue to implement the Alternative Tile Intake Project, partnering with Meeker and Stearns SWCDs to implement in the upper Clearwater River watershed. **Priority:** High* • Continue to implement the Clearwater River Restoration & Protection Phase II Project, partnering with Meeker and Stearns SWCDs to implement in the upper Clearwater River Watershed. **Priority:** High* • Form partnership with Wright SWCD to accelerate BMP adoption in the Cedar Lake watershed. **Priority:** Medium • Continue district-wide incentive offering, focusing on leveraging existing offerings from outside groups (ex. RIM/ CREP/ CRP, state cost-share, EQUIP) for implementation in prioritized areas. **Priority:** Medium	Watershed nutrient load reduction
2	Aquatic Invasive Species Programs	**Summary:** The CRWD is addressing AIS in three ways: 1) acting as a fiscal agent via establishment of projects to control existing and new AIS infestations on lakes were residents have petitioned for projects, 2) serve in advisory roles on county-established AIS committees and task forces and 3) encourage local groups and governments, along with state groups and governments, in their AIS efforts and provide support as needed/ as able. **Plans:** • Continue to act fiscal agent for established projects, following policy. **Priority:** High • Work with other lake associations considering petitioning the CRWD to undertake their own projects. **Priority:** High • If brought forward by residents, consider amending and/or replacing existing AIS project to incorporate AIS prevention measures, along with control measures. **Priority:** High • Continue to serve in advisory roles for county AIS committees/ task forces. **Priority:** Medium	Maintain lake ecology and mitigate consequences of AIS infestations

Projects		Description	Purpose
3	Civic Engagement Program	**Summary:** A program to create & increase public awareness, develop ownership & buy-in among citizens in water quality improvement efforts, provide useful information & encourage decision makers and improve adoption of conservation on the landscape. **Plans:** • Continue to attend various civic groups and LGU meetings as able. Priority: Medium • Update brochure/ fact sheet. **Priority:** High • Attend Annandale & Kimball business expos. **Priority:** High • Complete multiple press release. **Priority:** High • Continue to implement social media outreach. **Priority:** Medium Continue to implement school-age educational program. **Priority:** High	Increase public awareness, create buy-in, provide information to decision makers, accelerate conservation adoption
4	Floating Bog Control Program	**Summary:** Instituted in the 1980s to control floating bogs that could potentially cause flooding problems by blocking flow at key choke points, namely the Grass Lake Dam, the channel between Grass and Clearwater Lake and the channel between Augusta and Clearwater Lake. Can also remove problem floating bogs below Grass Lake Dam if deemed necessary. **Plans:** continue to remove floating bogs that threaten to block flow at noted points as needed. **Priority:** High	Maintain river flow to avoid localized flooding
5	Inspection Program	**Summary:** The CRWD has implemented an annual inspection program of its existing infrastructure as part of its commitment to ensuring all projects are operationally effective. **Plan:** Staff will perform visual inspections of each CRWD infrastructure project during the months of April-June 2017. All inspections will be summarized in a report to the CRWD Board by July 2017. The Board will hold discussions in July/ August 2017 on the results of the inspections and prioritize necessary repairs and modifications. **Priority:** High	Maintenance of existing infrastructure
6	Residential/ Commercial Incentive Program	**Summary:** The CRWD has a long history of leading, partnering and encouraging the installation and adoption of best management practices (BMPs) in areas where residential/ commercial development resulted in land alterations such that stormwater runoff is or can cause negative impacts to receiving waters. These efforts continue today. **Plans:** Continue district-wide incentive offering, focusing on leveraging offerings from outside groups in prioritized areas. **Priority:** Medium	Watershed nutrient load reduction

Projects		Description	Purpose
7	Rough Fish Management Program	**Summary:** Fish seining has been performed on multiple lakes in the CRWD to improve lake ecology and maintain water quality. Multiple fish traps and migration barriers have been installed in the CRWD to improve management. **Plans:** • Make repairs and modifications to multiple fish migration barriers. **Priority:** Low, hold till end of 2017 to allow time to test new barrier design at Swartout Inlet. • Highway 55 Fish Trap will not be operated in 2017. • A temporary fish trap will be operated at Segner Pond inlet Spring/Summer 2017. **Priority:** High Investigate seining from Lake Betsy and Scott as an effective means to control rough fish. **Priority:** Medium	Manage internal loading of nutrients, improve lake ecology
8	Vegetation Management Program	**Summary:** Several CRWD projects require various levels of vegetation management. For maintaining native plantings to controlling invasive and noxious species, this program ensures the work is completed. **Plan:** • The CRWD Board will consider quotes for vegetation management at several CRWD project no later than April 2017. **Priority:** High • Control of woody vegetation and noxious species at the three sewer systems' treatment areas will be performed by June 2017. **Priority:** High Control of woody vegetation and noxious species at the three wetland treatment systems and the isolation unit will be performed by June 2017. **Priority:** High	Maintenance of existing infrastructure, promotion of native habitat
9	Water Quality Monitoring Program*	**Summary:** Program to collect water quality data (primarily chemistry and hydrology) to establish trends, assist with setting goals, determine projects, practices, and programs to implement and evaluate effectiveness of completed projects, practices and programs. **Plans:** The CRWD Board annually establishes a work plan for this program. Please refer to this work plan.	Track long term trends, assist with determining project effectiveness and adaptive management measures
	Notes: *These projects/ programs have existing, stand-alone work plans. These should be referred to as needed.		

Table 4—6: Potential Opportunities

Project	Description	Purpose
CREP Opportunities	Opportunity: Based on data and recent field reconnaissance work, the CRWD has several areas of opportunity to implement buffers and/or water storage areas that could be good candidates for the upcoming Conservation Reserve Enhancement Program (CREP) funding opportunity. **Plan:** • Work with Meeker, Stearns and Wright County SWCDs to implement CREP in strategic locations within the CRWD (ex. DWSMA, riparian area, loss wetland areas, sediment source inventory, etc.) • Determine level of involvement of CRWD in CREP opportunities (ex. funding, leadership, technical assistance, etc.)	Watershed nutrient load reduction
Norton Ave Erosion Control Partnership Opportunity	**Opportunity:** Wright County SWCD is in the process of making changes to this area to provide additional practices to slow water flow and protect the downstream gully from further erosion. The CRWD may assist in this effort.	Watershed nutrient load reduction

5.0 Hydrology

5.1 PRECIPITATION

Total annual precipitation measured in 2016 was above normal at all four monitoring locations across the District. Table 5-1 summarizes 2016 precipitation; Appendix D contains summary charts for each station.

Table 5—1: Clearwater River Watershed District 2016 Precipitation Records and Normals (inches)

Month	2016 St. Cloud (Saint Cloud WSO Airport)	1981-2010 Normal (St. Cloud)	2016 Watkins (Meeker)	2016 Watkins1 (Meeker)	2016 Kimball (Meeker)	1981-2010 Normal (Litchfield)	2016 Annandale /Corinna (Wright)	1981-2010 Normal (Cokato)
January	0.31	0.65	0.16	0.02	0.52	0.70	0.53	0.77
February	0.63	0.59	0.56	0.42	1.15	0.64	0.91	0.70
March	1.50	1.55	1.48	1.39	1.64	1.46	1.62	1.63
April	1.74	2.57	1.35	1.92	2.02	2.60	2.71	2.97
May	2.17	2.95	4.03	3.96	4.28	3.22	3.87	3.39
June	3.37	4.17	3.01	3.97	3.95	4.99	3.13	4.57
July	6.74	3.31	9.27	10.64	5.68	3.83	4.55	3.70
August	8.36	3.79	5.71	5.58	9.76	3.86	6.19	4.23
September	3.08	3.46	7.04	5.70	6.74	3.39	4.68	3.25
October	2.68	2.49	3.02	2.63	1.95	2.42	2.65	2.50
November	1.69	1.38	2.08	2.77	2.07	1.32	2.13	1.61
December	1.58	0.82	1.63	2.37	1.65	0.87	1.63	0.94
Total	**33.85**	**27.73**	**39.34**	**41.37**	**41.42**	**29.30**	**34.60**	**30.26**

Below Normal Precipitation

Above Normal Precipitation

5.2 CONTINUOUS FLOW MONITORING

In 2016, stream levels were monitored continuously at four sites on the Clearwater River to develop a continuous flow record at those sites, allowing for better quantification of seasonal runoff and annual phosphorus loads. The four sites from up to downstream are: CR29.0, CR28.2, Fairhaven Dam, and CR10.5 (Grass Lake Dam). Pressure transducers were also installed upstream of Cedar Lake (SSW04) and along County Ditch 20 at 1.0 (CD20 1.0). Pressure transducers recorded the stream surface elevation at 15 minute intervals at each location while the Clearwater River was flowing from April to October.

Water elevations were converted to flow using unique stage-discharge relationships (rating curves). The rating curves for each monitoring station were developed using stage and flow measured in the field over several monitoring seasons. 2016 continuous flows are shown in Figures 5-1. 2016 had higher flow rates at each station compared to 2015.

For the Kingston sites (CR28.2 and CR29.0), high flow rates may not be accurately predicted. This is due to the lack of high stage flow records at both sites to calibrate the rating curve. On the curves below, high flow rates were predicted by extrapolation of the regression equation.

Figure 5—1: 2016 Clearwater River Continuous Flow.

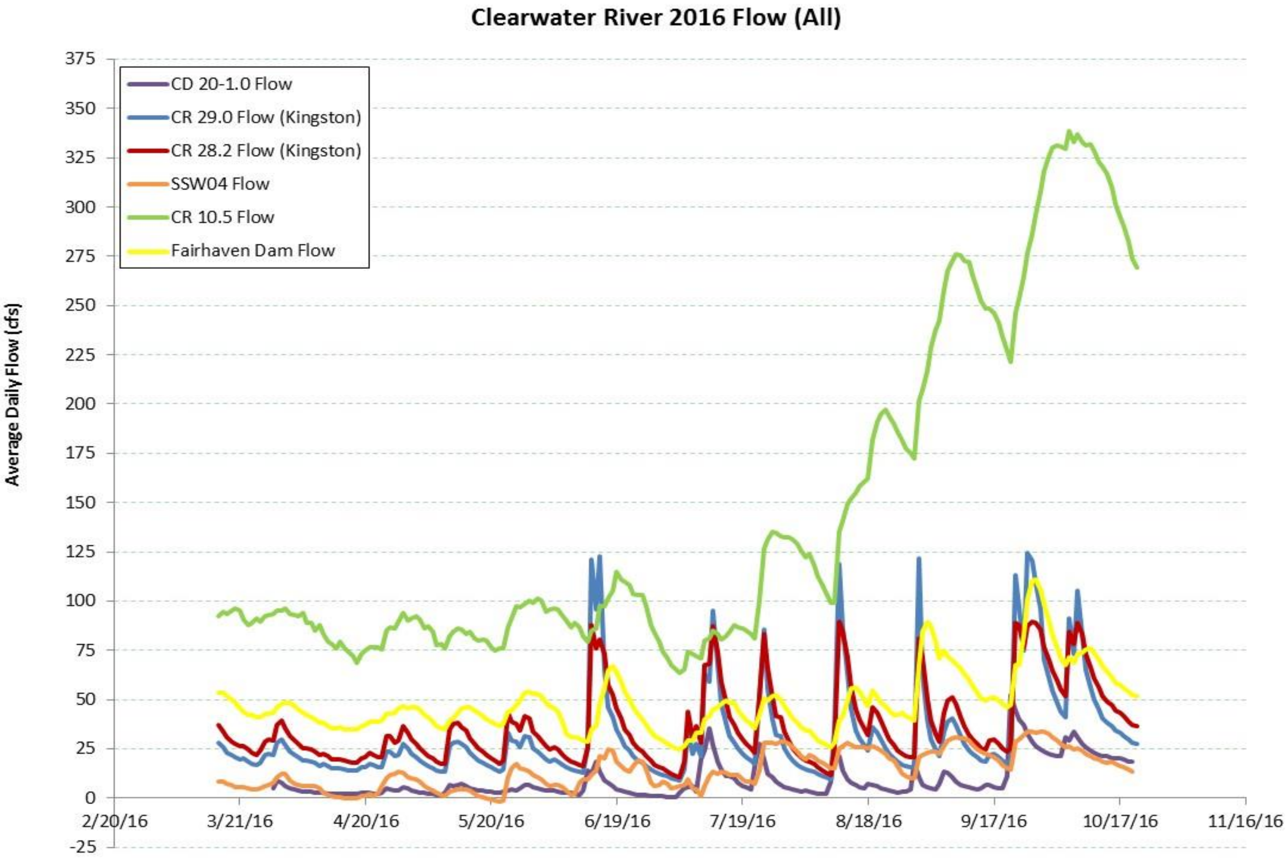
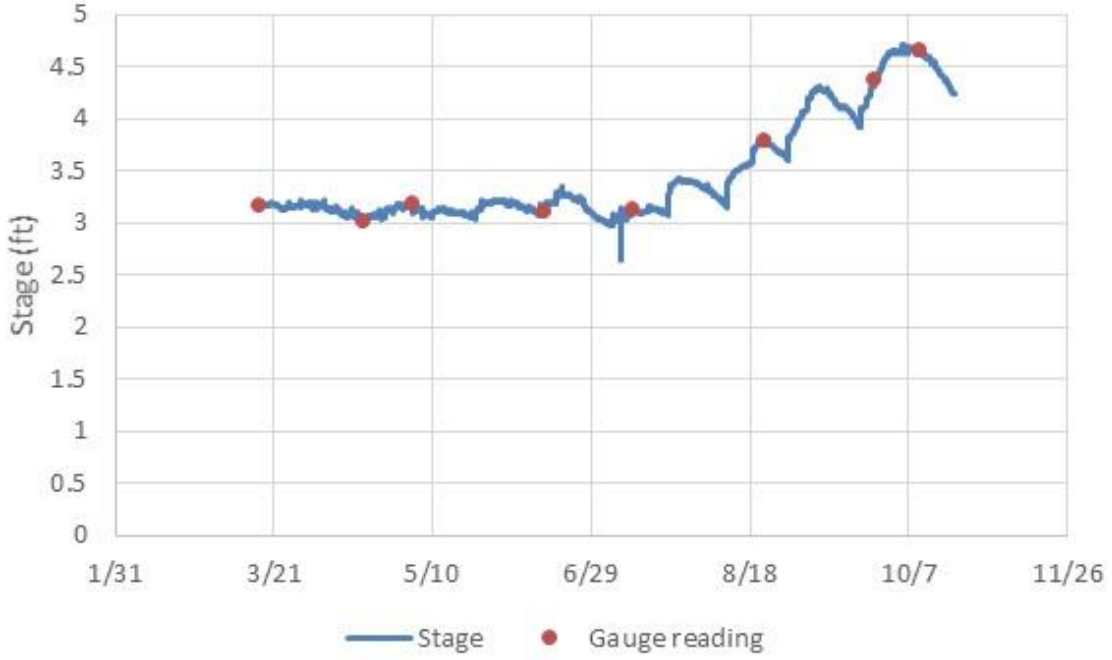


Figure 5—2: 2016 CR10.5 Transducer Stage and Gauge Reading.



5.3 AVERAGE DISCHARGE

Average flows in the Clearwater River at CR 28.2 and CR10.5 were 38 cfs and 141 cfs, respectively. Table 5-2 summarizes the 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 5—2: 2016 Average Flow

Station	Tri Tributary Sub-watershed Area [acres]	Average Flow [cfs]
CD20-1.0	8,247	9.08
CR29.0	27,695	57.29
CR28.2	33,977	38.01
SSW04	5,532	11.98
CR10.5	99,200	141.04

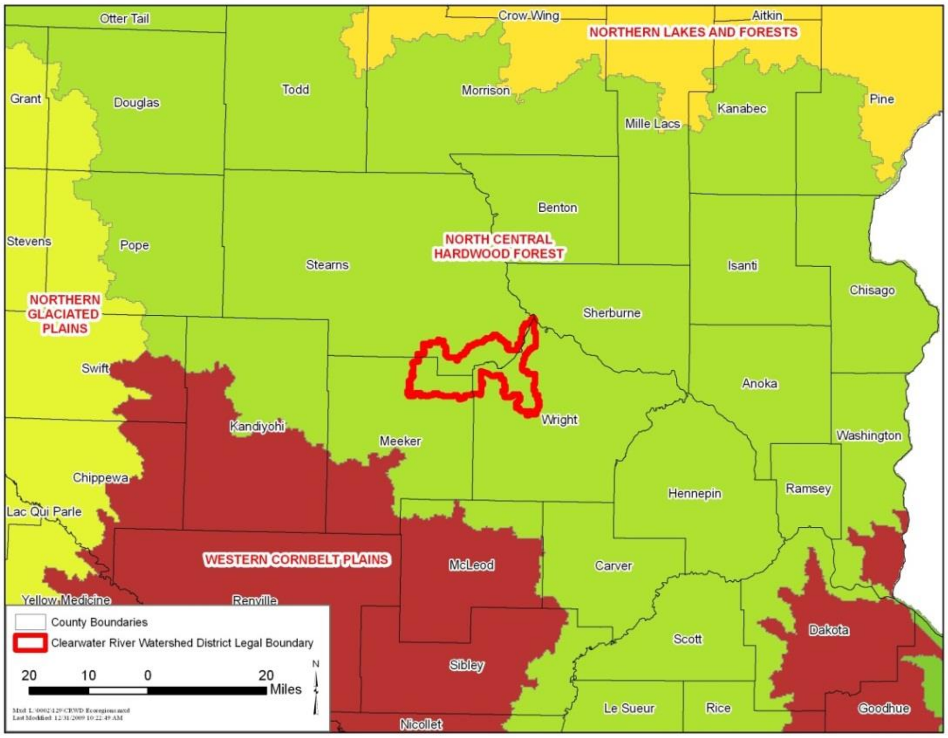
6.0 Stream Water Quality

6.1 OVERVIEW

Stream water quality was monitored at several locations in the CRWD, including two long-term stations on the Clearwater River and one long-term station on Warner Creek in 2016. Stream water quality was also monitored at additional stations (Figure 1-1). 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 (nitrogen was also sampled for select stations). 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 lies entirely 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 6-1. The watershed tributary to station CR28.2 has characteristics similar to the nearby WCBP ecoregion. The new Central River Region Standard reflects this and is shown in Figure 6-2 for comparison with measured values.

Figure 6—1: Clearwater River Watershed District Ecoregions.

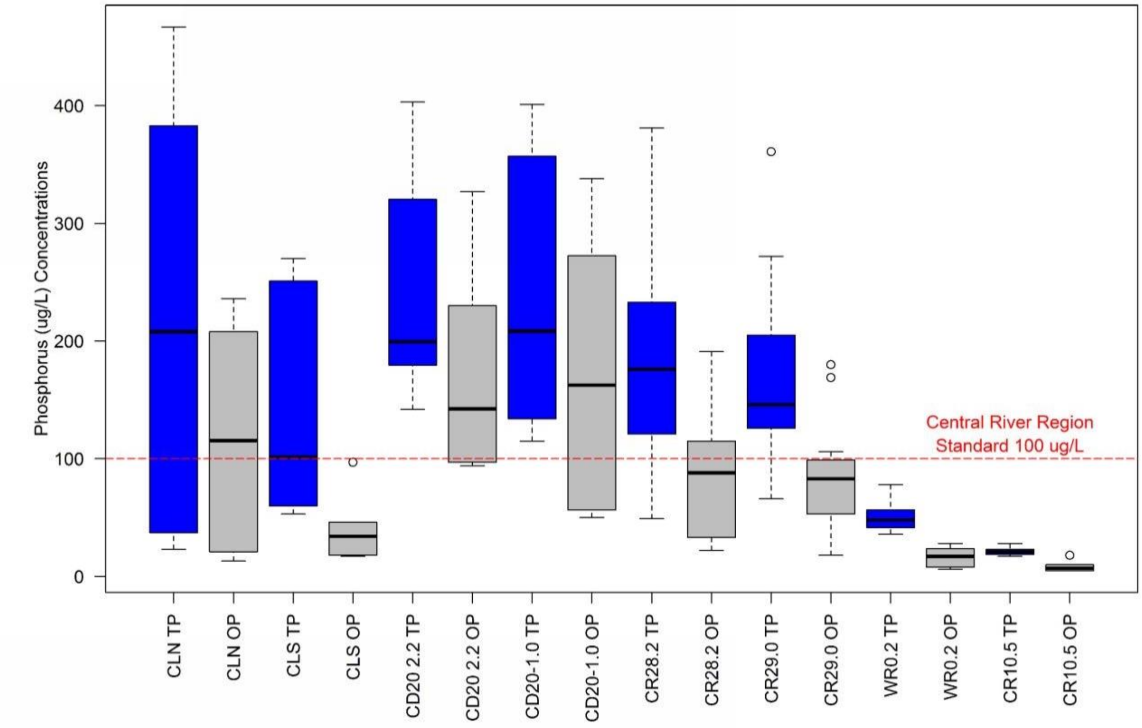


6.2 PHOSPHORUS

Stream phosphorus concentrations were monitored and loads were estimated at each monitoring station on the Clearwater River, Warner Creek, Willow Creek, Clear Lake tributary streams, and County Ditch 20 in 2016. Tributary streams were also monitored in the Cedar Lake sub-watershed.

Mean phosphorus concentrations were calculated for each site for comparison to the newly adopted river eutrophication standards (Figure 6-2). At the long-term monitoring stations, mean phosphorus concentrations at CR10.5 and WR0.2 were below the central river region eutrophication standard. Mean phosphorus concentrations measured at all other stations were well above the eutrophication standard.

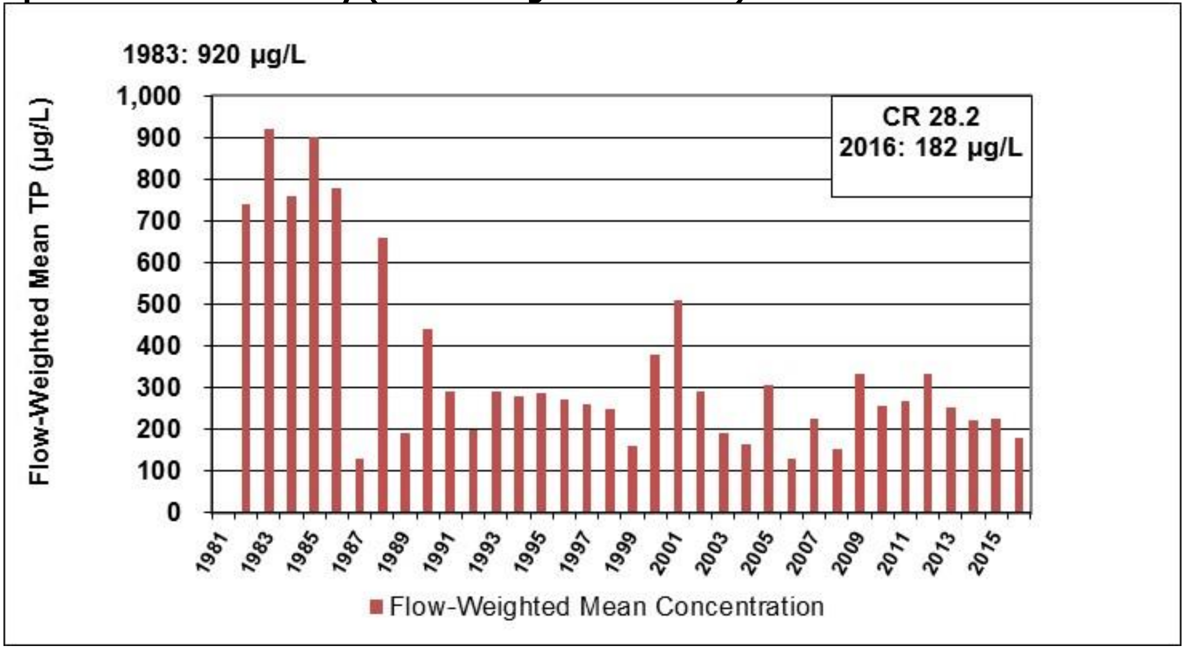
Figure 6—2: Clearwater River Watershed District 2016 Phosphorus Concentrations Boxplot.



Note: horizontal lines above and below the box are maximum and minimum of the data. The upper and lower limit of the box is, by default, the 75th and 25th quantile. The thick line in the box represents the median of the data. The open circles are data points that fall out of the range and could be considered outliers.

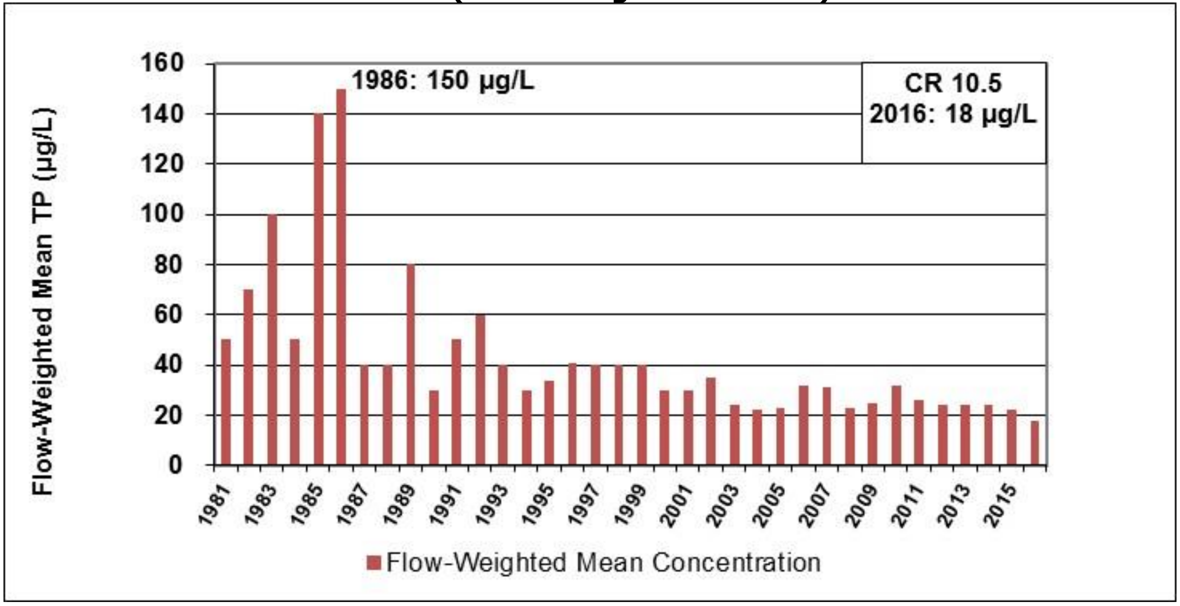
Figure 6-3 through 6-5 show historical flow-weighted TP concentration at stations CR28.2, CR10.5, and WR0.2. Baseline TP concentrations in the Clearwater River remain low compared with conditions monitored in the early 1980s. Flow-weighted TP concentrations at CR 28.2, just upstream of Lake Betsy, ranged from 740 to 920 μg/L in the early 1980s. The 2016 concentration was 182 μg/L and is showing a decreasing trend. TP concentration was lower in 2016 compared to 2015. However, TP concentration at CR28.2 is still exceeding the central river eutrophication standard.

Figure 6—3: Historical Flow-weighted TP Concentration in the Clearwater River upstream of Lake Betsy (monitoring site CR 28.2).



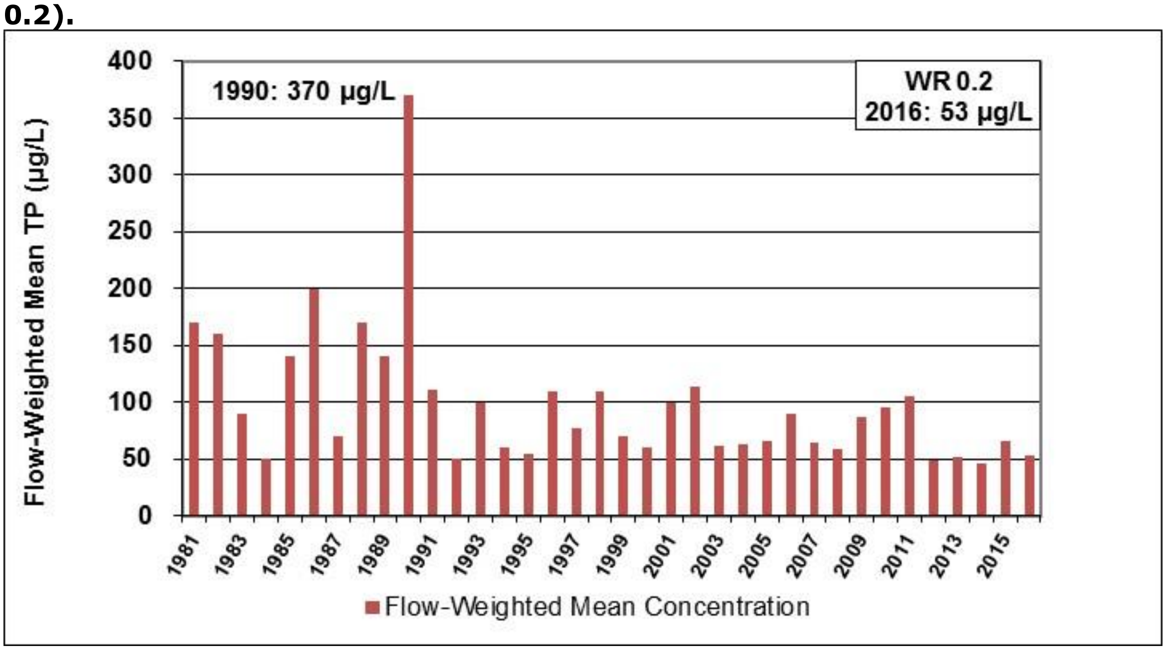
Flow-weighted TP concentrations at CR 10.5 were estimated using flows over the dam that were calculated using continuous level data collected upstream of the Grass Lake Dam. The estimated TP concentration at CR 10.5 in 2016 was 18 µg/L, which is significantly lower than concentrations measured in the 1980s. Flow-weighted TP concentrations at this station appear stable over the past 6 years, which is reflective of water quality conditions in Clearwater Lake.

Figure 6—4: Historical Flow-weighted TP Concentration in the Clearwater River at the outlet of Clearwater Lake (monitoring site CR 10.5).



Flow-weighted TP concentrations in Figure 6-5 compare historical flow-weighted TP concentrations in Warner Creek at monitoring station WR0.2. The 2016 flow-weighted TP concentration at WR0.2 was 53 μg/L, which is lower than 2015.

Figure 6—5: Historical Flow-weighted TP Concentration at Warner Creek (Site WR-0.2).



Two tributaries to Clear Lake were also monitored in 2016 (Table 6-1). 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. The flow-weighted TP concentrations at both CLN and CLS were lower in 2016 than 2015. TP load calculation is biased due to the biased flow sampling each year. In 2015, flow was sampled from April to September; while in 2016, flow was sampled from April to July.

Table 6—1: Clear Lake Tributaries Flow-weighted TP Concentrations and Phosphorus Loads

Year	Runoff [inches]		Flow-weighted TP [µg/L]		TP Load [lbs]	
	CLN	CLS	CLN	CLS	CLN	CLS
2012	14.73	14.42	512	221	1,796	1,013
2013	4.01	2.04	495	190	475	123
2014	13.87	7.97	296	145	981	367
2015	14.23	7.75	351	258	1,194	636
2016	4.12	3.43	256	156	252	170

As shown in Figure 6-6, County Ditch 20 was also monitored in 2016 at two locations upstream and downstream of the Watkins wetland. As shown in Table 6-2, TP concentration and load both decreased in 2016 for CD20-2.2. But for CD20-1.0, TP concentration decreased while TP load increased. This is because of the increased runoff in 2016 at the site. The phosphorus load was still over twice as high at the downstream monitoring location. The proportion of TP comprised of soluble phosphorus was very high at both sites, indicating release of soluble phosphorus from wetlands. Grab sample results from both sites are reported here.

Table 6—2: County Ditch 20 Flow-weighted TP Concentrations and Phosphorus Loads

Year	Runoff [inches]		Flow-weighted TP [µg/L]		TP Load [lbs]	
	CD20-1.0	CD20-2.2	CD20-1.0	CD20-2.2	CD20-1.0	CD20-2.2
2013	2.10	1.15	376	341	1,477	633
2014	4.23	2.26	341	144	3,185	1,384
2015	4.21	2.94	357	370	2,809	1,766
2016	5.44	2.54	326	341	3,061	1,401

Figure 6—6: County Ditch 20 Monitoring Locations.

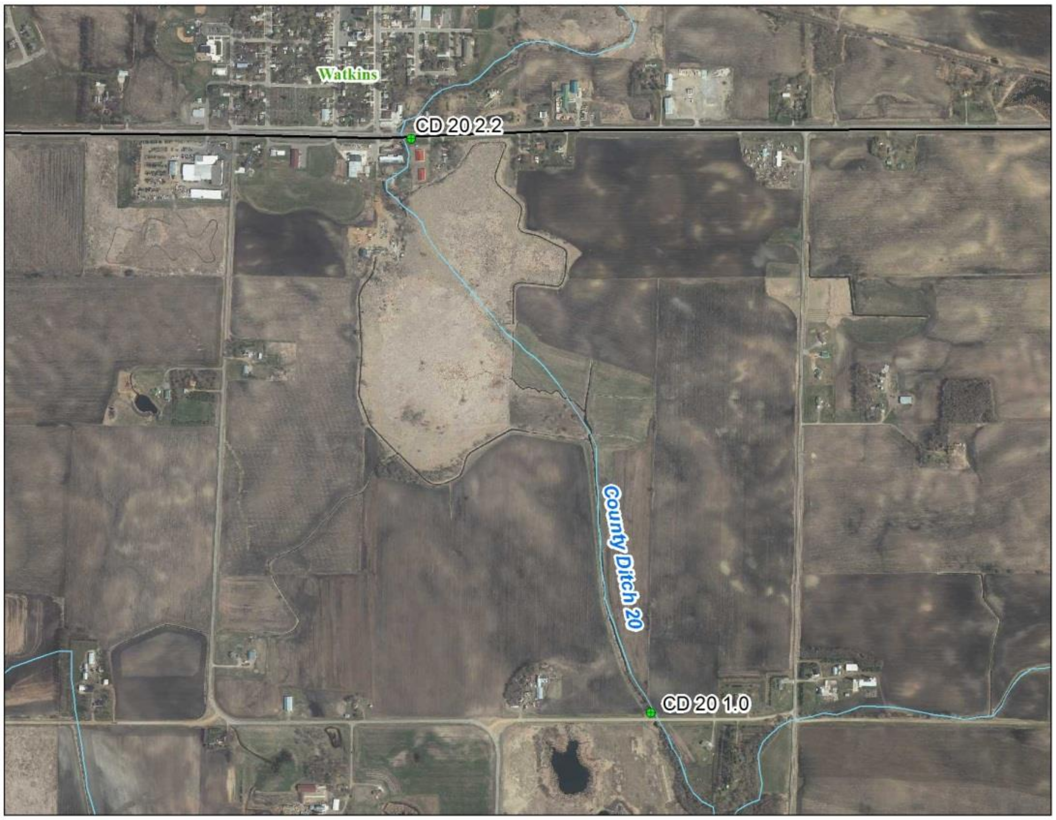


Table 6-3 shows flow-weighted TP concentrations throughout the District in 2016. Ortho-phosphorus (OP) is measured in streams because it is the dissolved form of phosphorus which is more readily used by algae. Relative fractions of ortho-phosphorus to total phosphorus provide valuable insight into the sources of nutrients in the District and potential solutions. Table 6-3 also shows the ratio of the mean OP to TP as a percentage at each monitoring site.

OP continues to make up a high percentage of TP in some monitoring stations in 2016. This is especially true of monitoring locations 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 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.

Table 6—3: 2016 Flow-weighted TP Concentration by Tributary Watershed

Site	Location	Watershed Area [acres]	Flow-weighted TP Conc. [ug/L]	TP as ortho-P [percent]
CD20-2.2	Clearwater River	7,152	341	70%
CD20-1.0	Clearwater River	8,247	326	69%
CLS	Clear Lake	1,404	156	35%
CLN	Clear Lake	1,055	256	50%
CR29.0	Clearwater River	27,695	183	44%
CR28.2	Clearwater River	33,977	182	54%
WR0.2	Clearwater West	16,992	53	32%
CR10.5	Clearwater River	99,200	18	39%

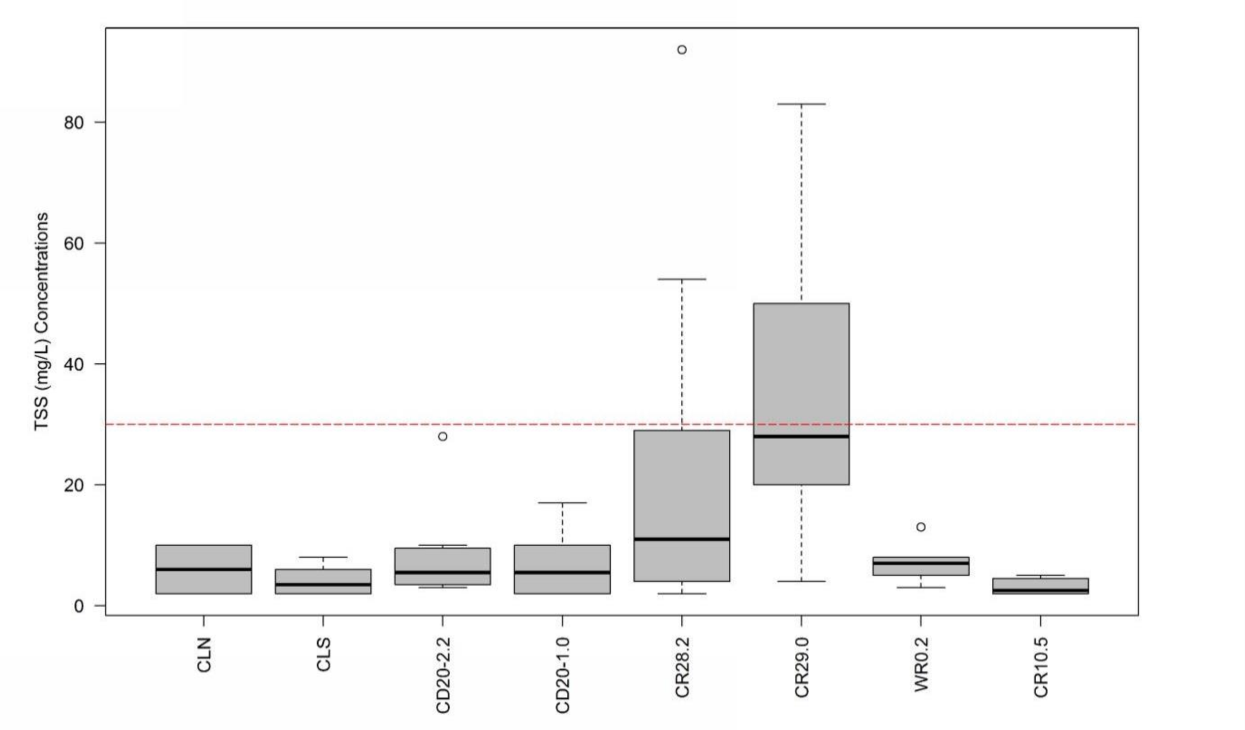
6.3 TOTAL SUSPENDED SOLIDS

Stream water quality samples were also analyzed for total suspended solids (TSS) in 2016. Mean TSS concentrations for all monitoring sites were compared to the newly adopted 30 mg/L TSS standard for rivers and streams in the North Central Hardwood Forest (NCHF) Ecoregion (Figure 6-7). Per impairment listing criteria, the TSS standard must not be exceeded more than 10% of the time over a multiyear data window. Among all the sites sampled, CR 28.2 and CR 29.0 had more than 10% exceedance from 2004 to 2016. LAWT (monitoring station upstream of Lake Augusta) had more than 10% exceedance of the standard in 2016.

Table 6—4: 2016 Total Suspended Solids Mean Concentrations by Tributary

Site	Location	Mean TSS Conc. [mg/L]	Number of Samples	% Exceedance
CD20-2.2	Clearwater River	9	7	0%
CD20-1.0	Clearwater River	6	8	0%
CLS	Clear Lake	3	5	0%
CLN	Clear Lake	6	5	0%
CR29.0	Clearwater River	28	5	20%
CR28.2	Clearwater River	17	8	25%
WR0.2	Clearwater West	7	8	0%
CR10.5	Clearwater River	3	8	0%

Figure 6—7: 2016 Total Suspended Solids Concentration Boxplots in the CRWD.



Note: horizontal lines above and below the box are maximum and minimum of the data. The upper and lower limit of the box is, by default, the 75th and 25th quantile. The thick line in the box represents the median of the data. The open circles are data points that fall out of the range and could be considered outliers.

6.4 NITROGEN MONITORING

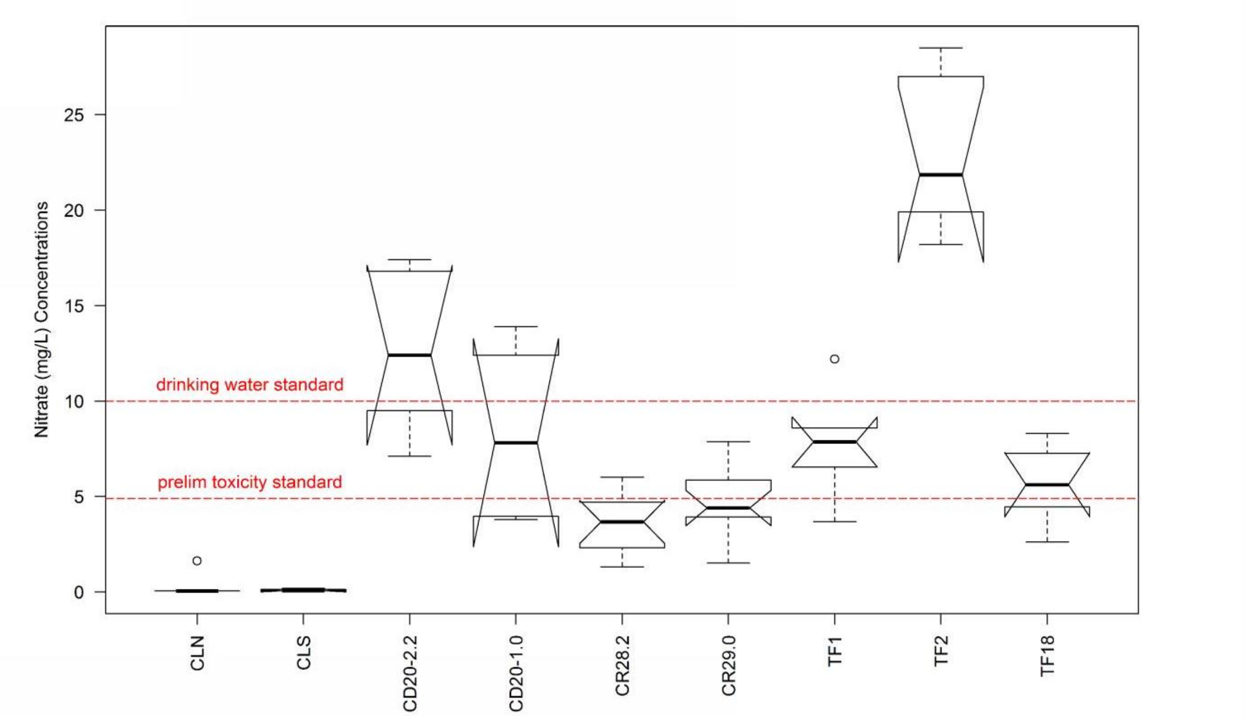
CRWD expanded its stream monitoring in 2013 to include nitrogen (N) series monitoring at several stations in the upper watershed (Figure 1-1). Concern about N in surface water has grown in recent decades due to: 1) increasing studies showing toxic effects of nitrate on aquatic life, 2) increasing N concentrations and loads in the Mississippi River combined with nitrogen's role in causing a large oxygen-depleted zone in the Gulf of Mexico, and 3) the discovery that some Minnesota streams exceed the 10 mg/l standard established to protect potential drinking water sources. In 2013, the Minnesota Pollution Control Agency (MPCA) published the Nitrogen in Minnesota Surface Waters Report which discusses the sources, trends and potential ways to reduce nitrogen in Minnesota's surface waters. In 2014, the State of Minnesota released The Minnesota Nutrient Reduction Strategy Report which calls for a N reduction of 45% throughout the Mississippi River Basin. Additionally, the MPCA is currently in the process of developing nitrate water quality standards based on aquatic life toxicity for surface waters throughout the state. The CRWD recognizes these efforts and the increased awareness and concern of nitrogen loading to surface waters in the state of Minnesota.

Nitrogen enters water in numerous forms, including both inorganic and organic. The primary inorganic forms of N are ammonia, ammonium, nitrate, and nitrite. Organic-nitrogen (Organic-N) is found in proteins, amino acids, urea, living and dead organisms (i.e., algae and bacteria) and decaying plant material. Organic-N is usually determined from the laboratory method called total Kjeldahl nitrogen (TKN), which measures a combination of organic N and ammonia+ammonium. Since N can transform from one form to another, it is often considered in its totality as total nitrogen (TN). The relative amounts of the different forms of N in surface waters depends on many factors, including: proximity to point and nonpoint pollution sources; influence of groundwater baseflow discharge; abundance and type of wetlands; reservoirs and lakes in the pathway of flowing streams; as well as other natural and anthropogenic factors. Temperature, oxygen levels, and bio-chemical conditions each influence the dominant forms of N found in a given soil or water body.

Nitrate (NO_3) is very soluble in water and is negatively charged, and therefore moves readily with soil water through the soil profile, where it can reach subsurface tile lines or groundwater. Nitrate pollution of shallow groundwater is common among agriculturally dominated watersheds with coarse textured soils. Upon application to a field, nitrogen not utilized by plants can leach into the ground and moves into nearby lakes, streams, and wells or be carried by tile drainage directly into a stream. Minnesota rules have an existing nitrate standard for the protection of human health at 10 mg/l, which applies to surface waters designated for drinking water uses (class 2A and class 2Bd). Minnesota is currently in the process of developing nitrate standards for aquatic life toxicity. In 2010, the MPCA published a draft technical support document that proposed a nitrate standard of 4.9 mg/l to address aquatic life toxicity. However, because the Environmental Protection Agency (EPA) is currently carrying out supplemental aquatic life toxicity tests for nitrate, the MPCA put these proposed standards on hold.

Nitrate was monitored at 9 stations in the upper watershed in 2016. The nitrate monitoring data are presented as box plots in Figure 6-8. Results indicate the stream locations where tile drainage collects (TF1, TF2, and TF18) were consistently above the proposed toxicity standard, and occasionally exceeded the drinking water standard. Nitrate levels in County Ditch 20 were also high, particularly at CD20-2.2. County Ditch 20 is an agricultural watershed with significant tile drainage. Nitrate concentrations were consistently lower at CD20-1.0 compared to CD20-2.2 likely due to denitrification in the wetland south of Watkins (Figure 1-1). The mainstem (CR28.2 and CR29.0) and Clear Lake (CLN and CLS) monitoring stations displayed relatively low nitrate concentrations compared to the other sites in the upper watershed.

Figure 6—8: 2016 Nitrate concentrations in the upper Clearwater River watershed.



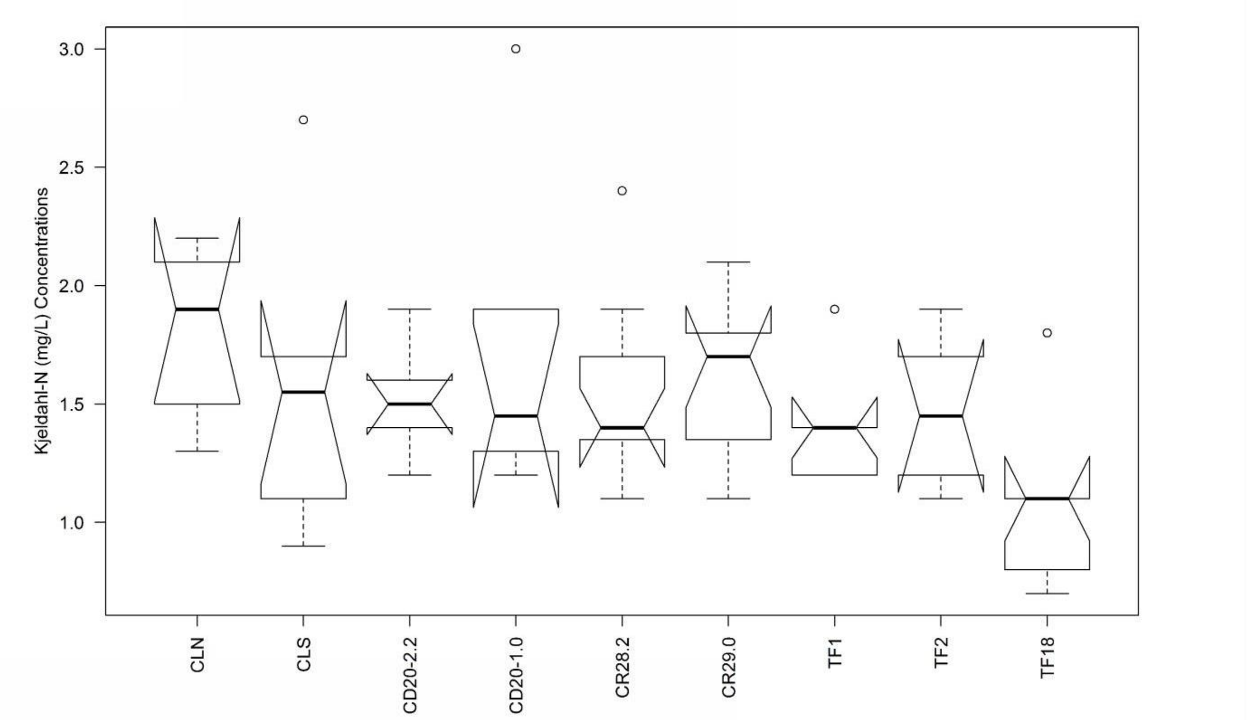
Note: horizontal lines above and below the box are maximum and minimum of the data. The upper and lower limit of the box is, by default, the 75th and 25th quantile. The thick line in the box represents the median of the data. The open circles are data points that fall out of the range and could be considered outliers.

TKN is the sum of ammonia+ammonium plus organically bound N. Ammonia (NH_3) is toxic to fish and other aquatic organisms. Ammonium (NH_4), the predominant form in the pH range of most natural waters, is less toxic to fish and aquatic life as compared to NH_3. Common sources of ammonia/ammonium include human and animal wastes, as well as certain fertilizers and industrial wastes. Ammonia and ammonium most commonly enter surface waters through overland runoff or direct discharges from wastewater sources.

The second component of TKN is organically bound N. The organic component can be determined by subtracting ammonia+ammonium from TKN. Common sources of organic nitrogen include plant and animal waste or decomposing organisms. Organic forms of nitrogen are typically unavailable for plant and animal growth and assimilation. Of the TKN components, ammonia+ammonium break down quickly in natural systems and are rapidly converted to nitrate by nitrifying bacteria, a process which consumes oxygen. Organic nitrogen can also be broken down and converted to nitrate, but it is usually a slower process. Because of its abundance in waste products and the potential for oxygen depletion (nitrification), WWTP effluent is often monitored for TKN.

TKN was measured at 9 stations in the upper watershed in 2016. Results show TKN levels were relatively low and consistent at all 9 stations in the upper watershed (Figure 6-9). TKN at the tile monitoring sites were similar to those measured at the Clear Lake, County Ditch 20, and Clearwater River mainstem sites. These results suggest nitrate is the dominant form of nitrogen in the upper portion of the watershed and TKN loading should not be viewed as a major concern.

Figure 6—9: 2016 TKN concentration in the upper Clearwater River watershed.



Note: horizontal lines above and below the box are maximum and minimum of the data. The upper and lower limit of the box is, by default, the 75th and 25th quantile. The thick line in the box represents the median of the data. The open circles are data points that fall out of the range and could be considered outliers.

6.5 DISSOLVED OXYGEN

Dissolved oxygen (DO) was measured at each stream monitoring location in 2016 to track progress toward 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 (5 mg/L or higher as a daily minimum). Dissolved oxygen is essential to the survival of in-stream biota like fish and macroinvertebrates and is therefore an indicator of the presence of suitable habitat.

Figure 6-11 shows DO data collected at tributary stream monitoring sites in 2016. DO concentrations fell below the impairment standard at most tributaries monitored. In some cases, low DO is the result of oxygen demand in upstream wetlands. In others, low summer flow and increased temperatures contributes to low DO.

Figure 6—10: 2016 Clearwater River Dissolved Oxygen Concentrations.

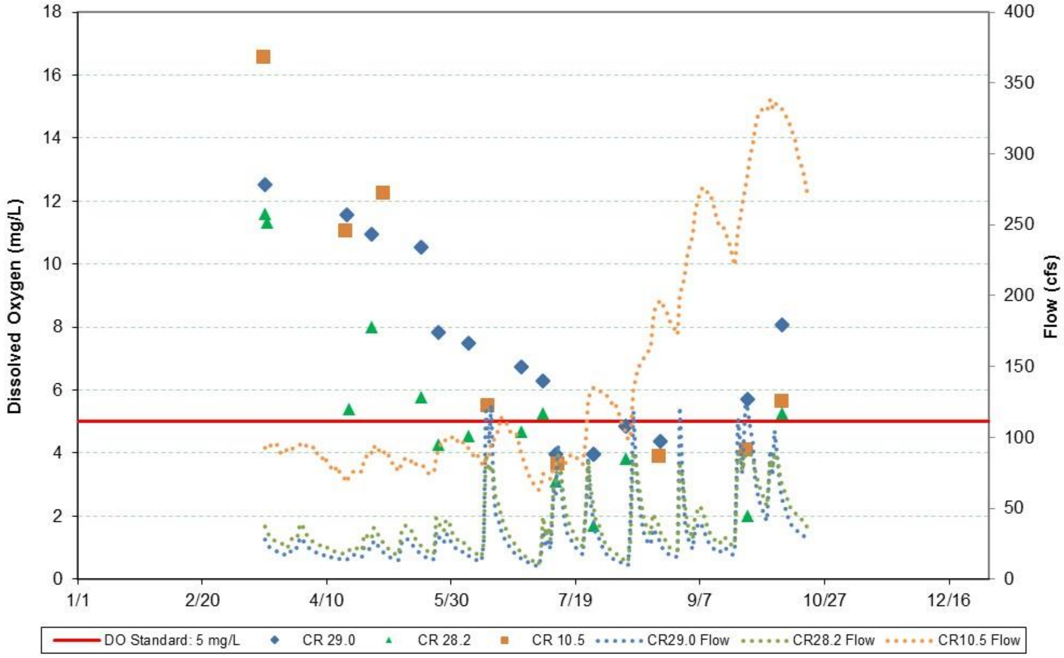
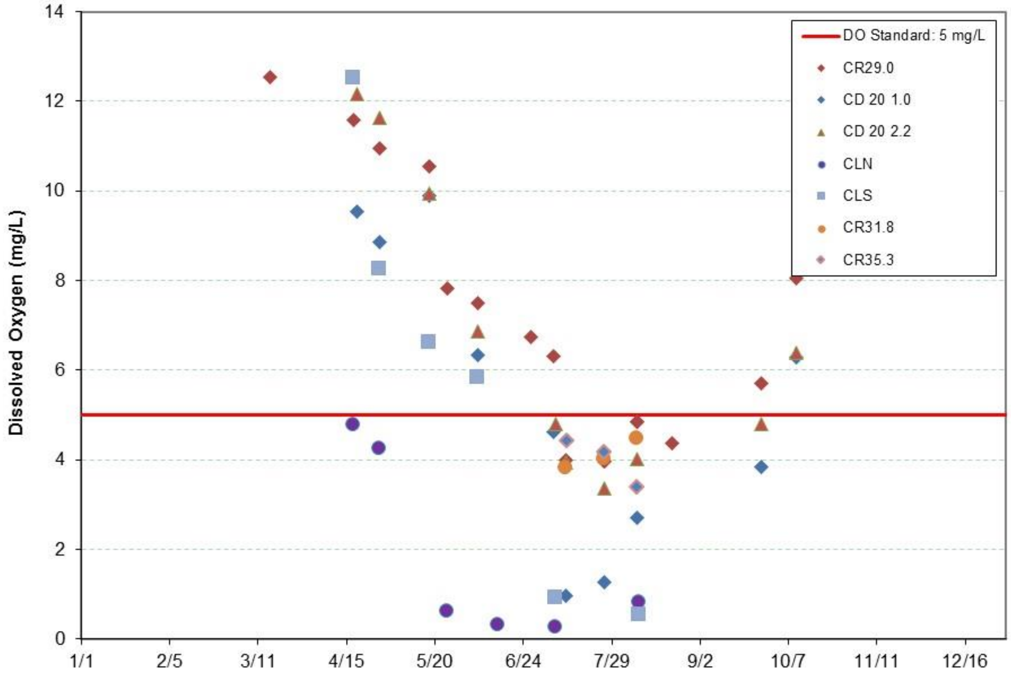


Figure 6—11: 2016 Tributary Stream DO Concentrations.



Additional stream water quality data is found in Appendix B, including summaries of historical phosphorus loads, stream flows, and flow-weighted mean concentrations. Appendix F shows phosphorus concentrations at each site monitored in 2016.

6.6 *E. COLI* BACTERIA

Bacteria is measured in CRWD to track progress towards meeting the CRWDs bacteria TMDL, and to ensure that other areas within the District meet the state standards and to evaluate bacteria sources throughout the District.

Measurements of most probable number (MPN) of colony forming units (CFU) per 100 mL of *E. coli* were taken at two locations on the Clearwater River (CR29.0 and CR28.2). Data collected at those two sites are used to track TMDL implementation progress. Table 6-5 shows the monthly reported values of *E. coli* at CR 29.0 and CR 28.2.

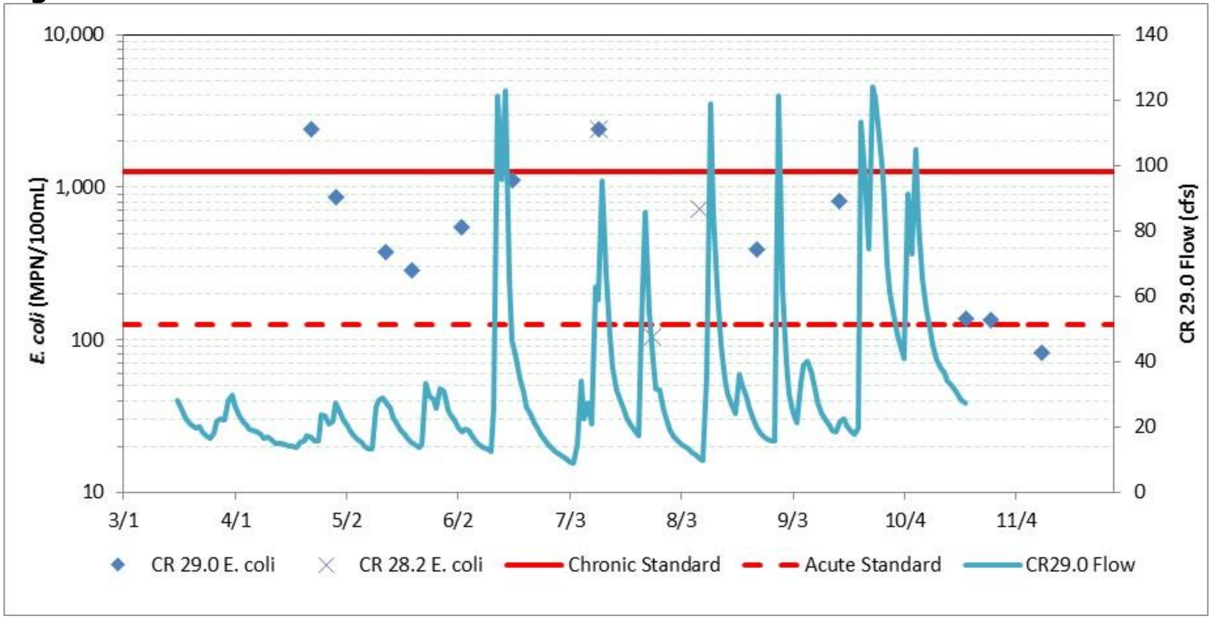
Table 6—5: E. coli Monthly Reported Values in the Clearwater River

Month	CR 29.0 *E. Coli* Reported Value [MPN/100mL]	CR 29.0 # of Measurements	CR 28.2 *E. Coli* Reported Value [MPN/100mL]	CR 28.2 # of Measurements
April	1448	2	-	0
May	326	2	-	0
June	780	2	-	0
July	2420	1	502	2
August	387	1	727	1
September	816	1	-	0
October	136	2	-	0

Nearly all samples collected at CR29.0 from May through September exceeded the acute standard in 2016 (Figure 6-12). Two of the samples exceeded the chronic standard. Depending on the sources of bacteria in the watershed, this may indicate the need for additional projects to target and control bacteria concentrations. Such projects may include limiting and controlling livestock access to the river and its tributaries.

In 2015, the CRWD received a Clean Water Partnership (CWP) grant to identify and implement agricultural BMPs and/or other projects to reduce sediment, phosphorus, and bacteria loads to the Upper Clearwater River. Through this project, the CRWD updated the existing 2008 field reconnaissance of high priority sediment and bacteria sources through desktop review/analysis and field visits. Sites with the highest potential export were prioritized for implementation projects. Combinations of agricultural BMPs and/or stream stabilization techniques are recommended to reduce sediment, phosphorus, and bacteria loads to the Clearwater River.

Figure 6—12: 2016 E. coli Measurements at CR29.0 and CR28.2.



*Chronic Standard: Not to be exceeded by the monthly reported value
**Acute Standard: Maximum not to be exceeded by 10% of samples taken in a calendar month

7.0 Lake Water Quality

7.1 OVERVIEW

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. The CRWDs 21 lakes are sampled on a rotating basis identified in the District's monitoring plan.

CRWD sampled sixteen lakes in 2016. Parameters analyzed in 2016 included surface TP, ortho-phosphorus, Chlorophyll-a, and a field reading of Secchi depth. Surface samples characterize lake water quality. Samples for TP, ortho-phosphorus, and total iron were also collected near the lake bottom for selected lakes. Water temperature and DO profile data was also collected at each lake to better characterize lake stratification and periods of anoxia which helps determine the potential for internal loading from lake sediments.

7.2 2016 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 7-1. The MPCA standards are also used as the TMDL goals for summer average concentrations and Secchi depth in District lakes.

Table 7—1: MPCA Standards for Lakes in the North Central Hardwood Forest Ecoregion

Lake Category	TP [µg/L]	Chlorophyll-a [µg/L]	Secchi Depth [meters]
Shallow Lakes	60	20	1.0
Deep Lakes	40	14	1.4

Source: Minnesota Pollution Control Agency

Figures 7-1 and 7-2 compare the average total phosphorus concentrations in lakes sampled in 2016 to the TMDL goal.

Figure 7—1: 2016 Summer Average Total In-Lake Phosphorus Concentrations (Deep Lakes).

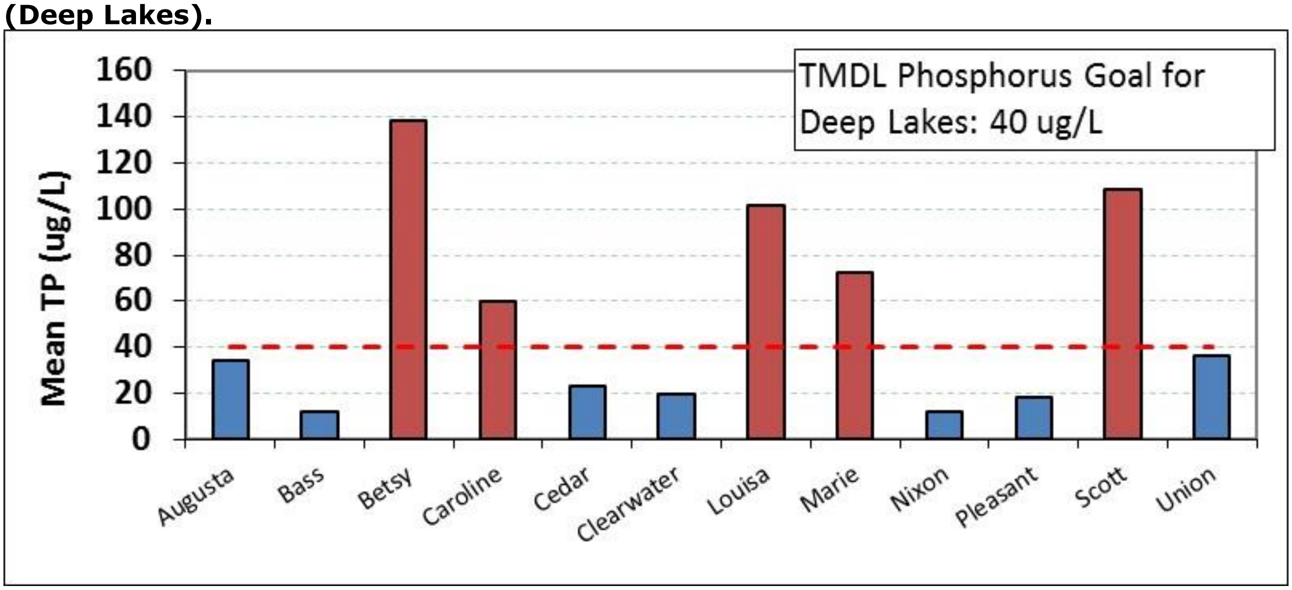
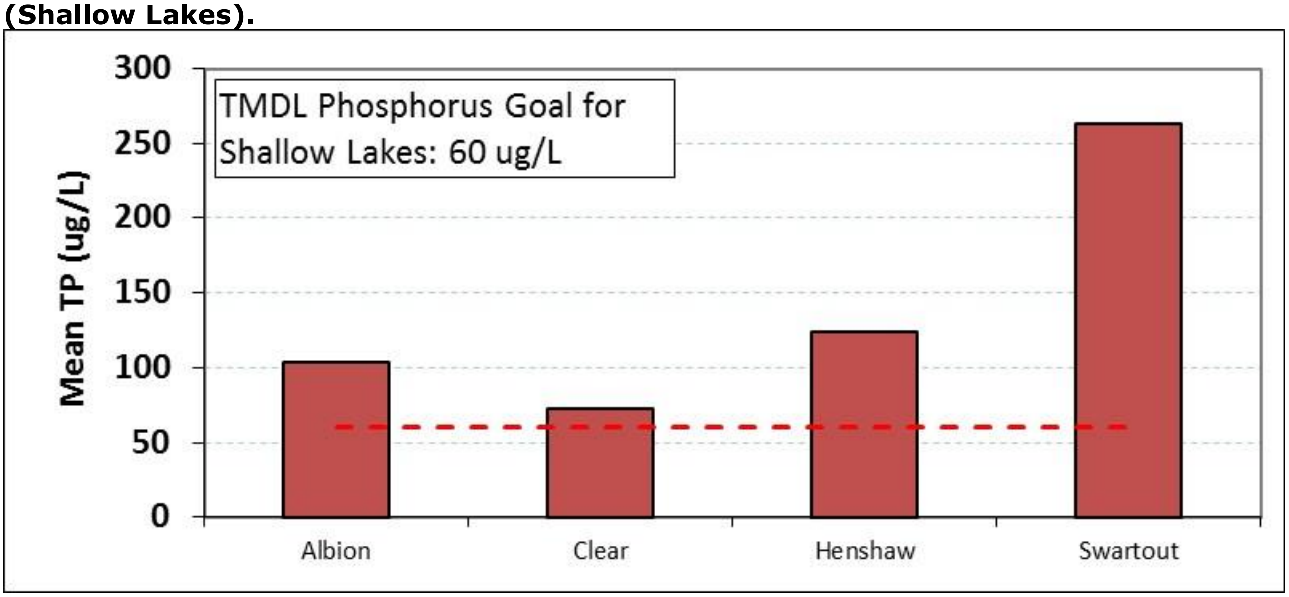


Figure 7—2: 2016 Summer Average Total In-Lake Phosphorus Concentrations (Shallow Lakes).



In general, most lakes showed a decreasing trend in phosphorus concentrations in 2016. Based on the 2016 monitoring data, Albion, Besty, Caroline, Clear, Henshaw, Louisa, Marie, Scott, and Swartout Lakes were above state standards for TP. Although phosphorus concentrations did not meet TMDL goals in these lakes, concentrations decreased in Albion, Besty, Caroline, Clear, Henshaw, Marie, and Scott Lakes in 2016 compared to 2015.

Figures 7-3 and 7-4 compare the most recent summer average chlorophyll-a concentrations for fourteen CRWD lakes to the appropriate chlorophyll-a TMDL goal. In 2016, Besty, Augusta, Caroline, Scott, Clear, Swartout, Albion and Henshaw Lakes were above the TMDL goal for chlorophyll-a. It is interesting to note that Marie Lake did not meet TP standards in

2016 but did meet chlorophyll-a standards. This suggests something other than phosphorus may be limiting algae growth in these lakes. A recent trend of decreasing chlorophyll-a concentrations continued in 2016 in Albion, Cedar, Marie, and Union Lake.

Figure 7—3: 2016 Summer Average Chlorophyll-a Concentrations (Deep Lakes).

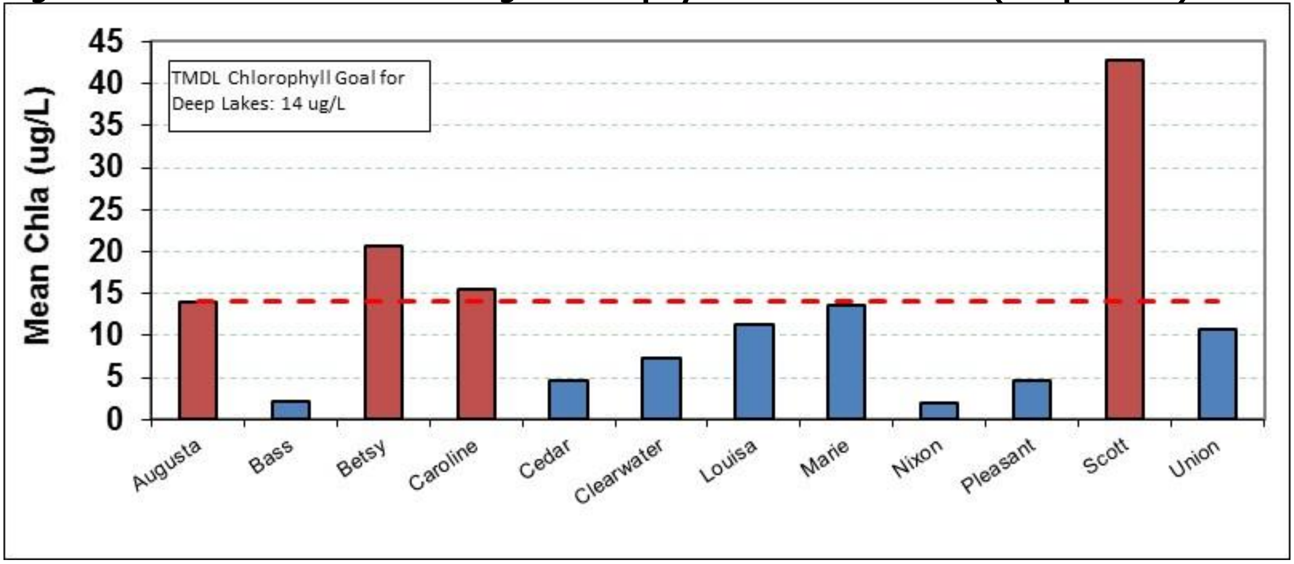
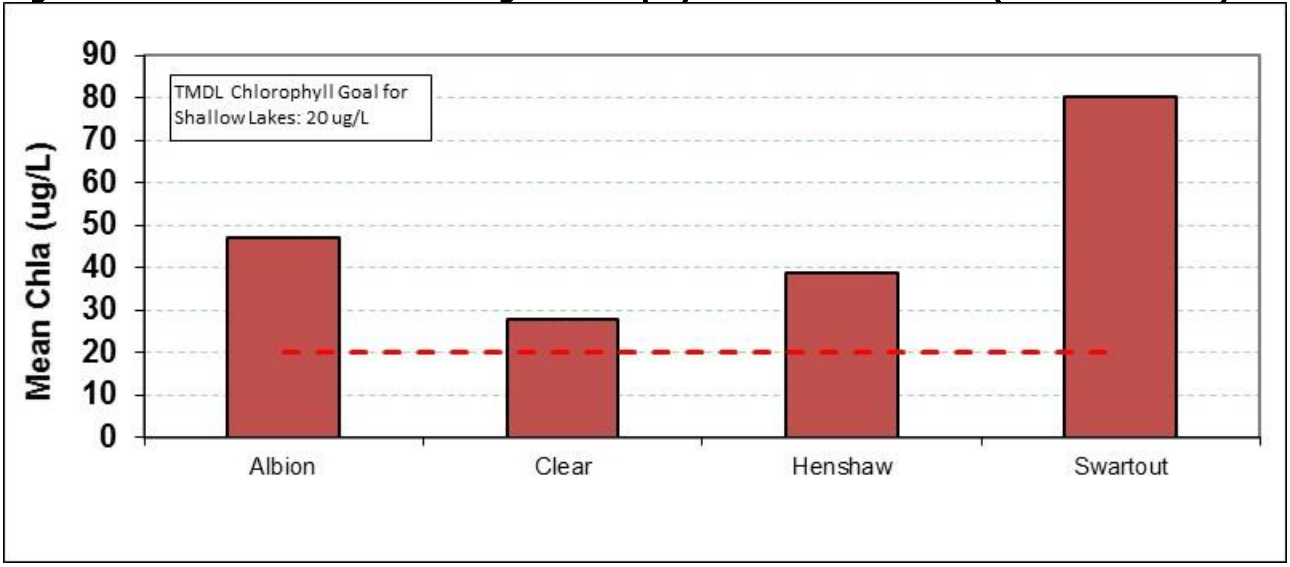


Figure 7—4: 2016 Summer Average Chlorophyll-a Concentrations (Shallow Lakes).



Figures 7-5 and 7-6 compare the 2016 Secchi disk depth for CRWD lakes to the appropriate state standards. In general, water clarity improved in many District lakes in 2016 likely due to the decreased algae growth as seen in the chlorophyll-a data. State standards were met for all lakes except Swartout, Albion, and Henshaw. Swartout and Albion did not meet the goal in 2015.

Figure 7—5: 2016 Summer Average In Lake Secchi Depth (Deep Lakes).

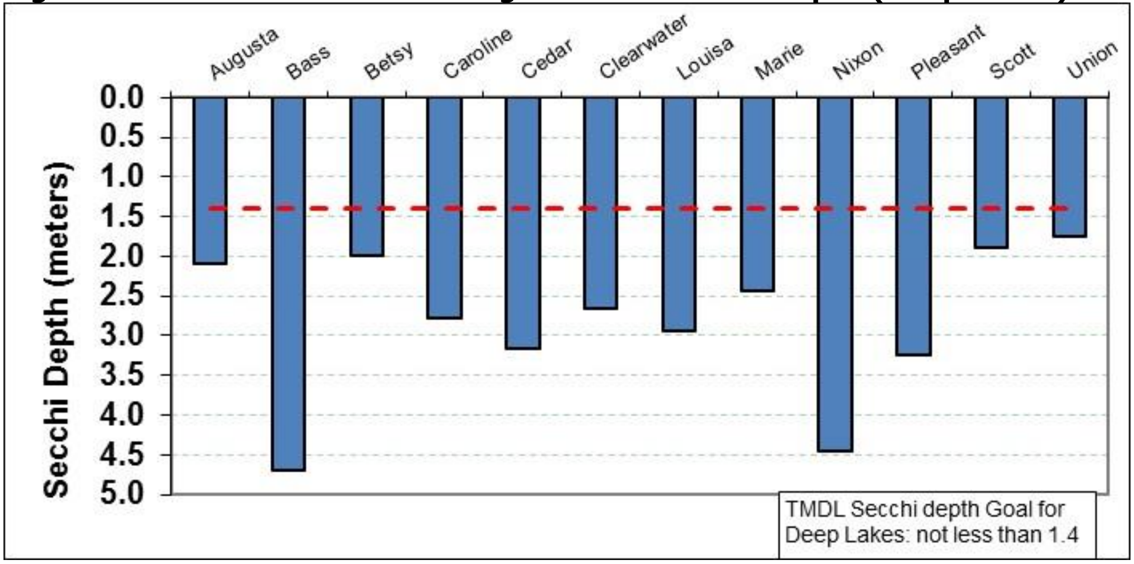
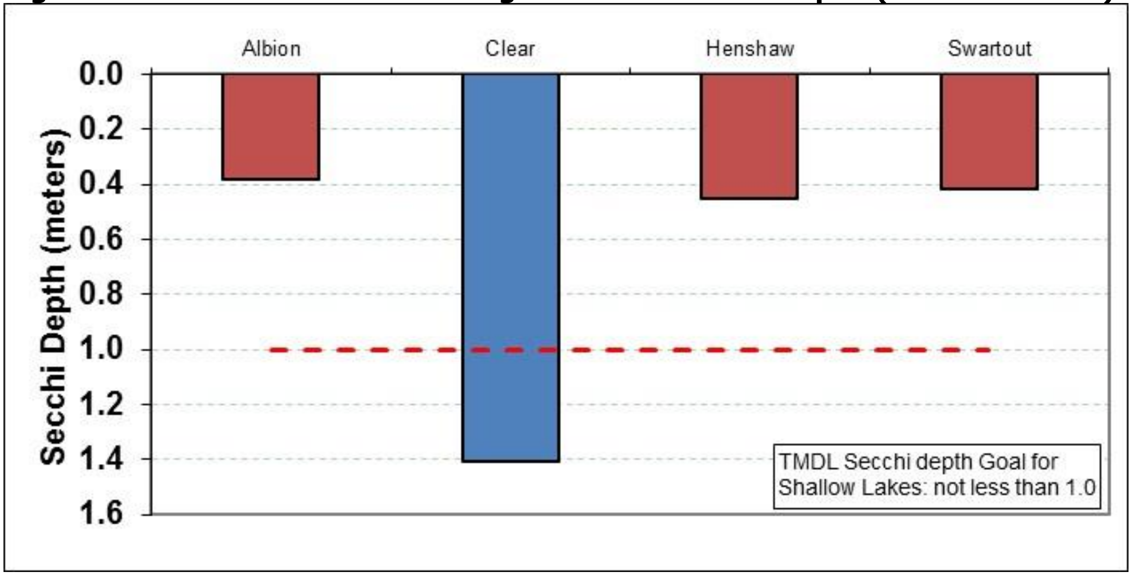


Figure 7—6: 2016 Summer Average In-Lake Secchi Depth (Shallow Lakes).



As demonstrated in Table 7-2, phosphorus and Chlorophyll-a concentrations were mostly near the low end of historic ranges in most lakes in 2016. Secchi disk depths were near the midpoint of historic ranges in most lakes in 2015, with the best Secchi readings ever observed in Augusta, Cedar, Clear and School Section Lakes. Secchi depth was near the low end of the historic range in only Albion and Union Lakes 2015.

Table 7—2: 2016 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	2016 Mean	Historical Range Mean	2016 Mean	Historical Range Mean	2016 Mean	Historical Range Mean
Albion	104	104-296	47	37-204	1	0.3-1.2
Augusta	35	28-300	14	4-73	7	1.1-2.3
Betsy	138	120-700	21	4-170	7	0.5-2.4
Caroline	60	36-300	15	3-55	9	0.8-2.1
Cedar	23	19-58	5	3-20	10	1.1-3.2
Clear	73	80-307	28	17-153	5	0.3-1.8
Clearwater West	20	18-130	7	3-85	9	1.2-3.0
Grass	-	17-38	-	1-14	-	1.9-3.4
Henshaw	124	81-390	39	7-278	1	0.2-1.7
Little Mud	-	25-62	-	5-83	-	1.6-3.4
Louisa	102	33-440	15	4-101	10	0.6-2.1
Marie	72	69-360	14	4-153	8	0.4-2.3
Otter	-	13-34	-	1-8	-	1.9-3.0
School Section	-	14-50	-	2-14	-	1.0-4.2
Scott	109	82-660	57	3-223	6	0.5-1.9
Swartout	263	166-438	80	11-832	1	0.2-2.1
Union	36	25-88	11	7-39	6	1.0-2.6
Weigand	-	28-61	-	3-12	-	1.4-3.7

Exceeds state standards

Table 7-3 summarizes phosphorus concentration trends in each lake. Again, phosphorus concentrations did not meet state standards in nine lakes in 2016. Overall, based on the most recent monitoring data for all lakes within CRWD, water quality is generally good and remaining stable or improving. During years with high runoff, phosphorus concentrations in certain lakes approach concentrations observed in the Clearwater River. During dry years, internal loading contributes a larger portion of the phosphorus load to the lakes.

Table 7—3: Lake Trend and Impairment Summary

Lake	Last Monitored	Phosphorus Trend	Use
Albion*	2016	Recent Stable Trend	Impaired
Augusta	2016	Recent Stable Trend	Full Use
Bass	2016	Recent Stable Trend	Full Use
Betsy*	2016	Recent Stable Trend	Impaired
Caroline*	2016	Recent Stable Trend	Impaired
Cedar	2016	Recent Stable Trend	Full Use
Clear*	2016	Recent Decreasing Trend	Impaired
Clearwater East	2013	Recent Stable Trend	Full Use
Clearwater West	2016	Recent Decreasing Trend	Full Use
Grass	2015	Decreasing Trend	Full Use
Henshaw*	2016	Recent Stable Trend	Impaired
Little Mud	2015	Decreasing Trend	Full Use
Louisa*	2016	Recent Stable Trend	Impaired
Marie*	2016	Recent Stable Trend	Impaired
Nixon	2016	Recent Decreasing Trend	Full Use
Otter	2015	Stable Trend	Full Use
Pleasant	2016	Recent Stable Trend	Full Use
School Section	2015	Stable Trend	Full Use
Scott*	2016	Recent Stable Trend	Impaired
Swartout*	2016	Recent Stable Trend	Impaired
Union	2016	Recent Stable Trend	Impaired
Wiegand	2015	Decreasing Trend	Full Use

*Exceeded TP standard in 2016

7.3 ADDITIONAL MONITORING EFFORTS

Union Lake Intensive Monitoring

Intensive monitoring was performed in 2016 on Union Lake in order to help explain perceived shifts in water quality by the District in recent years. Two tributary locations were monitored in 2016 to evaluate phosphorus concentration/loading to Union Lake, which assists in determining progress towards meeting TMDL goals in addition to tracking the health of the streams. In-lake water quality was monitored four times from June to September in 2016.

In addition to the water quality monitoring, the District conducted a point intercept plant survey on June 17th to assess submerged vegetation in the lake. During this survey, Lowrance HDS sonar technology and ciBioBase was used to map bathymetry, bottom (sediment) composition and evaluate vegetation location between monitoring points and relative vegetation bio-volume.

Locations of the two Union Lake tributary monitoring locations are shown on Figure 1-1. Annual runoff at each monitoring site was not calculated due to the lack of flow monitoring data. Mean TP and Ortho-P concentrations for each site and year are shown in Table 7-4. These data indicate TP was considerably lower at site ULST in 2016 compared to 2007. Average summer in-lake phosphorus concentrations in Union Lake have also shown an improving trend in recent years as described below.

Table 7—4: Union Lake tributary monitoring summary

Site	Year	Samples	Watershed Size [acres]	Mean TP Concentration [ug/L]	Mean Ortho-P Concentration [ug/L]	TP as Ortho-P [percent]
ULWT	2016	6	397	108	67	62%
ULST	2016	7	3,917	59	43	73%
	2007	7		180	50	28%

Since 2012, average summer Secchi depth, total phosphorus and chlorophyll-a have met state standards four out of five years (See Appendix C). Between 1995 and 2011, TP and chlorophyll-a concentrations consistently exceeded state water quality standards.

The June 17, 2016 vegetation inventory showed that submerged vegetation growth was robust throughout the littoral zone (less than 15 feet deep). Submerged aquatic vegetation was observed around the entire lake from the shoreline to areas with water depths of approximately 17 feet. Overall, submerged vegetation was observed at 85% of sample points in 2016. However, only three submerged vegetation species were observed during the June survey: curly-leaf pondweed (82% occurrence), coontail (20%), and sago pondweed (13%).

Curly-leaf pondweed is a non-native plant species that can out-compete native plant species and disrupt lake ecosystems by changing the dynamics of internal phosphorus loading. Survey results clearly indicate curly-leaf pondweed is the dominant species during early summer in Union Lake. Curly-leaf pondweed has the ability to grow slowly throughout the winter, even under thick ice and snow cover. Thus, by the time other species start growing in the spring, curly-leaf plants are large enough to block light penetration to the bottom. By late spring, curly-leaf pondweed can form dense surface mats which interfere with recreation activities. By mid-summer, these dense mats senesce and die back, releasing nutrients that may contribute to undesirable algae blooms.

Coontail was the second most abundant plant species observed in Union Lake. Coontail is a native plant species to Minnesota lakes and wetlands. Coontail and other native species have a more typical life cycle compared to curly-leaf pondweed. They typically begin growing in late spring and peak during the warm summer months before gradually dying back when water temperatures decrease in the fall. As a result, these species are not considered a source of nutrients or a water quality concern during the summer growing season. Coontail thrives in nutrient rich environments and can reproduce rapidly to form thick stands of tangled stems and vegetation mats at or below the water's surface. In shallow areas, these vegetative mats can interfere with water recreation such as boating, fishing, and swimming. In high abundance, coontail can crowd out less-aggressive native species which can lead to lower species diversity.

As shown in Figure 7-7, the vegetation biovolume was highest in 2016 in the eastern and southeastern portions of the lake in depths less than eight feet. Overall, the intensive monitoring indicates phosphorus runoff concentration from the watershed was relatively low and water clarity and submerged vegetation growth in Union Lake were good in 2016. The vegetation community, however, is dominated by curly-leaf pondweed and coontail, which are less desirable, aggressive species. Union Lake would benefit from a late season survey to assess the vegetation community once curly-leaf pondweed has died off. Future management of Union Lake should focus on maintaining current water quality conditions and managing the vegetation community to decrease curly-leaf pondweed and support native vegetation growth.

Figure 7—7: Union Lake vegetation biovolume during June 17, 2016 survey.

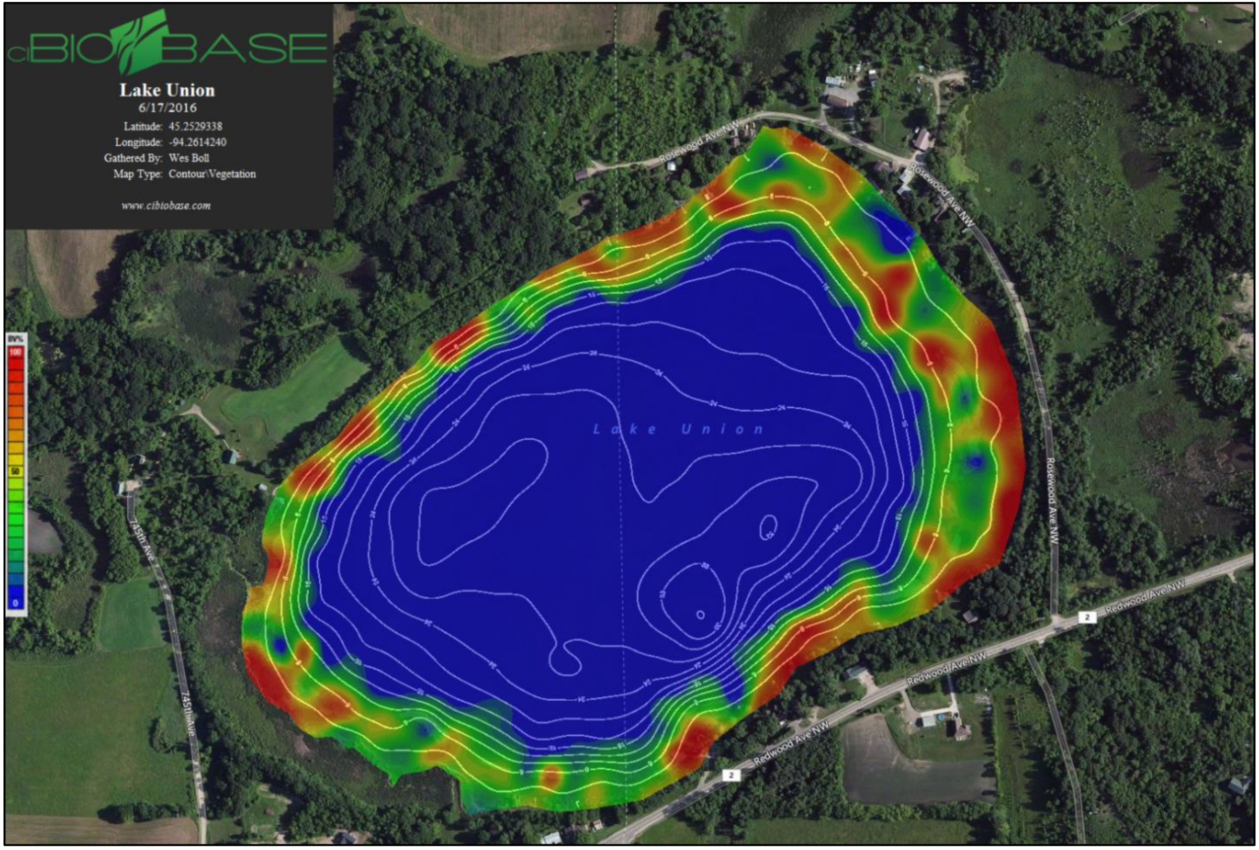
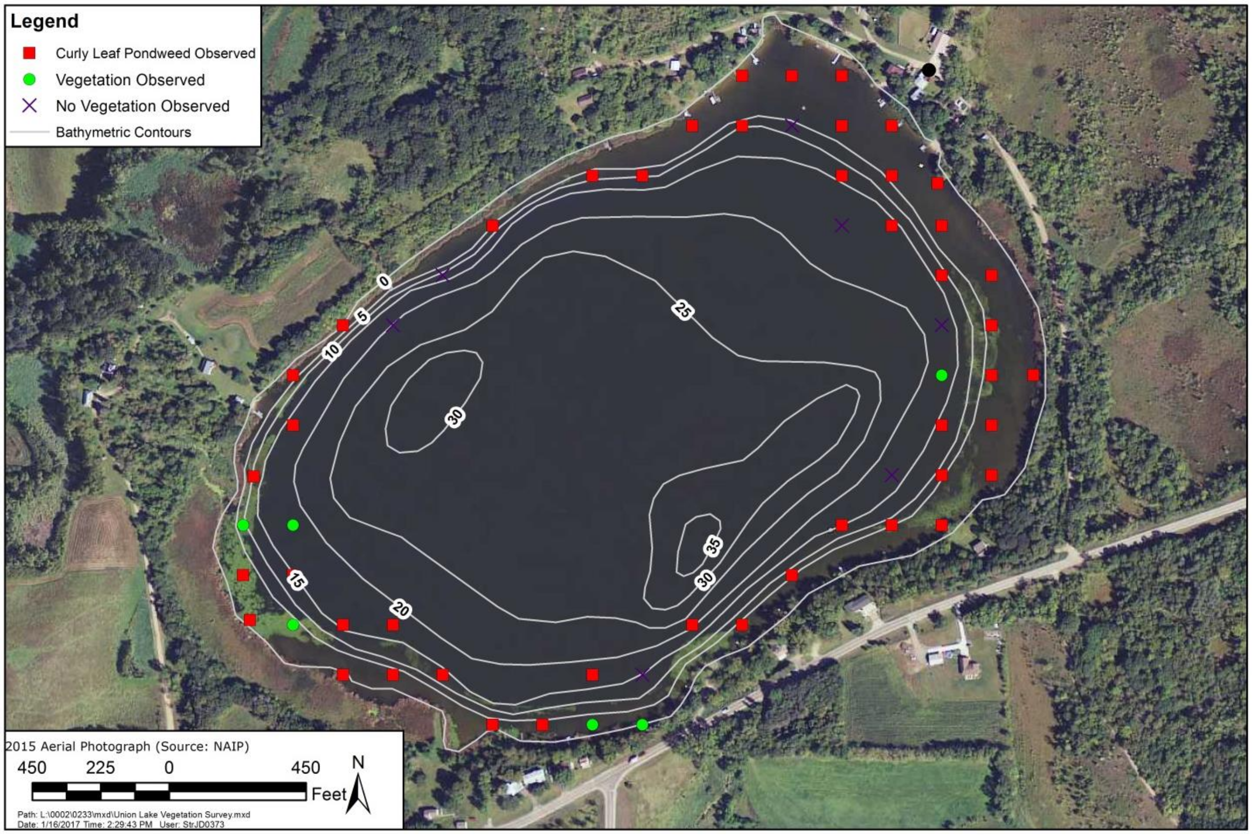


Figure 7—8: Union Lake vegetation sampling points and curly-leaf pondweed abundance.



Hypolimnion Lake Sampling

Samples were collected near the bottom at Betsy Lake in 2016 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 E. A summary of bottom phosphorus data collected at Betsy Lake since 2009 is found in Appendix H. 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 one 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 2016 demonstrates that most lakes that typically stratify were stratified in early June and remained stratified through September.

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OFFICE MEMORANDUM

TO: BOARD OF MANAGERS

FROM: ADMINISTRATOR LOEWEN

DATE: 03/02/2016

SUBJECT: PROPOSED 2016 WATER QUALITY MONITORING PROGRAM

Introduction

The Clearwater River Watershed District has conducted an annual water quality monitoring program at selection locations throughout the watershed since 1981 in an effort to assess District progress towards water quality goals, track long-term water quality trends, and evaluate effectiveness of existing water quality improvement projects and programs. The proposed 2016 program is intended to continue this effort.

The water quality monitoring program is divided into four categories: lake monitoring, stream monitoring, data MAR (management, analysis, reporting), and supplemental monitoring. The 2016 proposed monitoring stations are shown on Figure 1. The 2016 proposed lake monitoring follows the long-term lake monitoring plan as shown in Table 1. The 2016 proposed stream monitoring follows the long-term stream monitoring plan as shown in Table 2. The proposed monitoring sites together with a proposed schedule and laboratory/field parameters are show in Table 3. The proposed budget for the three water quality monitoring categories is shown in Tables 4 and 5.

Lake Monitoring

The recommended 2016 lake monitoring includes the 16 lakes shown on Table 1.

- Clearwater West, Augusta, Caroline, Marie, Louisa and Scott will be monitored June – September as part of ongoing operation and maintenance of the Clearwater River Chain of Lakes (1980) Restoration Project.
- Bass, Nixon, Pleasant and Union lakes will be monitored June – September as general fund tasks.
- Cedar, Albion, Swartout, and Henshaw lakes will be monitored from June - September as part of ongoing operation and maintenance of Project #06-1.
  - **REJECTED** It is also recommended the District continue to conduct aquatic vegetation surveys in Albion, Swartout, and Henshaw lakes in 2016. The vegetation surveys should be conducted in late summer to track the overall vegetation coverage and species in each lake to compare to surveys conducted in previous years. The lakes would also be mapped using sonar equipment during the survey to provide aquatic vegetation biomass, lake contours, lake volume, and bottom hardness data.
  - A nitrogen suite will be sampled from the surface waters of Albion, Swartout and Henshaw this year to better determine factors influencing lake ecology.

- Clear and Betsy lakes will be monitored from May to September as part of the Targeted Fertilizer Application Reduction Project. A nitrogen suite will be sampled from the surface water for these two lakes.

Surface water samples and profiles of field parameters should be collected at all of the sampled lakes. Bottom samples should be collected from only Betsy; staff feels trend are well establish for bottom concentrations in lakes, and bottom sampling should be skipped this year to save on costs. The proposed stations and the parameters to be monitored are shown on Table 3.

Stream Monitoring

The recommended 2016 stream monitoring includes the 15 streams shown on Table 2.

- The Clearwater River will be monitored once a month at station CR 10.5. Stations CR 28.2 and CR 29.0 will be monitored twice per month as part of the Targeted Fertilizer Project. Time period for all three sites is March – October. A nitrogen suite will be sampled twice per month from CR 28.2 and CR 29.0.
- Warner Creek will be monitored at WR 0.2 once a month from March – October.
- Willow Creek will not be monitored this year, and has been moved to a three-year sampling rotation
- For the Cedar Lake subwatershed, only sites SSW02 and SSW04 will be monitored from March – October this year. The other three sites (SSW01, SHE01 and SCE01) will be dropped as past years' sampling indicates that these sites characteristics closely match the lakes upstream of the sites. As such, monitoring the lakes is sufficient, and these sites can be dropped to save on costs.
    - One monitoring station will be established at the East Swartout component of the Cedar Lake Watershed Protection & Improvement Project (tentatively station ES1). SSW02 will be pulled from above the constructed stream weir instead of it's currently location in the highway culvert.
- Continuous water level monitoring will be recorded using pressure transducers at stations CD 20-2.2, CD 20-1.0, CR29.0, CR28.2, and CR10.5. If the Board authorizes the expenditure of funds for an additional pressure transducer, site SSW04 would be added to this list.

All stream stations will be monitored for water quality and flow. Water quality parameters are total phosphorus, ortho-phosphorus, and total suspended solids. Samples will be collected to be analyzed for E-coli at CR 29.0.

As shown in Figure 1, several other stream locations in the upper watershed will be monitored as part of the Targeted Fertilizer Application Reduction Project in 2016. These include TF 1, TF 2, TF 18, CD 20 2.2, CD 20 1.0, CLN and CLS. In addition to the standard parameters, a nitrogen suite will be sampled as well from these locations.

Targeted Fertilizer Tile Monitoring

Three tile outlets are monitored as part of the Targeted Fertilizer Application Reduction Project. Field staff time for monitoring these tile outlets is estimated at 18 hours. This activity is required and funded through this project's grant.

Data Management, Analysis and Report

Data drives decisions, and the 2016 water quality monitoring program is designed to provide high-quality data to assist the CRWD in its work. The objectives of the monitoring program are:

1. Track progress towards water quality goals for impaired waters by:
    a. Measuring water quality trends in lakes and streams and pollutant loads
    b. Tracking programs and projects implemented
    c. Evaluating water quality in the context of programs/ projects implemented
2. Fill data gaps identified in the TMDLs
3. Continue to provide baseline water quality data and calibration data sets to refine TMDL load reductions
4. Track long-term trends in all CRWD waters monitored ensuring early detection of declining trends
5. Provide recommendations for ongoing and new programs and projects.

The hydrologic, hydraulic and water quality monitoring data (field and laboratory) collected under this proposal will be maintained in the MPCA's online database and evaluated to determine progress towards water quality goals. The CRWD will publish results annually.

Supplemental Monitoring

In addition to the two categories listed above, it is recommended that supplemental monitoring efforts be considered in 2016. The proposed supplemental monitoring efforts would allow the District to track the success of individual projects or to investigate specific water quality concerns.

REJECTED Supplemental Monitoring Task 1: CD20-2.2 Pressure Transducer Purchase

The placement of a pressure transducer above the Watkins Wetland Isolation Unit as well as below at CD20-1.0 will help the CRWD in determining the effect of said wetland on water quality. Purchase of pressure transducer with installation components is ~$1,500.00. Set up, installation, and operation is estimated at 4 hours of staff time.

REJECTED Supplemental Monitoring Task 2: Additional Lake Betsy Monitoring – Internal Load

The results of the Lake Betsy Internal Load Management Study indicate that a whole –lake alum treatment may be a more cost effective alternative to Hypolimnetic Withdrawal. In order to provide better data for future internal load reduction work in Lake Betsy, the Board of Managers may want to consider an alum dosing study. This task involves collecting sediment from the lake bottom and conducting lab tests to determine optimum alum dosing and develop an estimate of probable cost. The lab costs for this are ~$5,500 with an additional 8 hours of staff time.

ACCEPTED Supplemental Monitoring Task 3: Monitor inlet tributary above Lake Augusta

Wright County is planning to realign CO RD 136, located just west of Lake Augusta. Now would be a good opportunity to quantify pollutant loading from the tributary stream this road crossing just northwest of Lake Augusta to determine if a water quality improvement should be sought as part of the planned realignment. The estimate cost for this task is $350.00, plus 6 hours of field staff time.

ACCEPTED Supplemental Monitoring Task 4: Contingency Monitoring

This task involves collecting up to 2 additional samples from routine monitoring stations 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 collecting 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 estimated cost for this task is $750.00 plus 6.75 hours of field staff time.

ACCEPTED Supplemental Monitoring Task 5: Targeted Monitoring in Lake Union Subwatershed

This task involves developing and implementing a targeted water quality monitoring effort in the Lake Union Subwatershed to better quantify potential reasons for past two-years of declining water quality trends in Lake Union. Staff would develop a plan that could contain the following elements: tributary stream monitoring, lake vegetation survey, land use change analysis, wetland analysis. Costs have not been defined for this effect, but rough estimates are as follows:

Activity	**Hours**	**Costs**
Tributary stream monitoring	23 hours, ~$750	~$1,250
Lake vegetation survey	8 hours, ~$750	~$1,500
Land use change analysis	4 hours, ~$600	~$100

Table 1: Proposed Long-Term Water Quality Monitoring Plan for CRWD Lakes

LAKE STATIONS	'06	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Clearwater Lake:											
Clearwater East		X		X		X		X		X	
Clearwater West	X		X	X	X		X		X		X
Main Stem Lakes:											
Augusta		X		X	X^{*}	X	X	X	X	X	X
Caroline	X		X	X	X	X	X	X	X	X	X
Marie	X^{*}		X	X	X	X	X	X	X	X	X
Louisa	X^{*}	X		X	X	X	X	X	X	X	X
Scott	X		X	X	X^{*}	X	X	X	X	X	X
Betsy		X		X^{*}	X	X	X	X	X	X	X
CASH Lakes:											
Cedar	X		$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	X	X	X	X	X
Albion	X		$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	X	X	X	X	X
Swartout	X		$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	X	X	X	X	X
Henshaw		X	$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	$X^{\wedge}$	X	X	X	X	X
Other Lakes:											
Bass	X		X^{+}	X		X		X			X
Clear			X	X^{*}	X	X	X	X	X	X	X
Grass			X	X		X		X		X	
Little Mud	X			X			X			X	
Nixon		X	X	X		X		X			X
Otter		X		X			X			X	
Pleasant		X	X(3)	X	X		X		X		X
School Section		X		X		X		X		X	
Union			X	X	X	X	X	X	X	X	X
Wiegand				X			$X^{\#}$			$X^{\#}$	
No. lakes monitored by CRWD	10	9	14	22	14	17	17	17	14	18	16

Notes: $^{\wedge}$Part of Project #06-1; $^{+}$Added to assess trends, *Lake bottom sediment cores collected and analyzed, $^{\#}$ Monitored from Nordell Bridge

Table 2: Proposed Long-Term Water Quality Monitoring Plan for CRWD Streams

STREAM STATIONS	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Cedar Subwatershed[^]											
SCE 01[#]			X	X	X	X	X	X	X	X	
SHE 01[#]			X	X	X	X	X	X	X	X	
SSW 01[#]			X	X	X	X	X	X	X	X	
SSW 02			X	X	X	X	X	X	X	X	X
SSW 04			X	X	X	X	X	X	X	X	X
Clearwater River											
CR 10.5	X	X	X	X	X	X	X	X	X	X	X
CR 28.2	X	X	X	X	X	X[+]	X[+]	X[+]	X[+]	X[+]	X[+]
CR 29.0	X					X[+]	X[+]	X[+]	X[+]	X[+]	X[+]
Other Streams:											
CLN					X		X[*]	X[*]	X[*]	X[*]	X[*]
CLS	X				X		X[*]	X[*]	X[*]	X[*]	X[*]
CD 20 - 1.0	X			X				X[*]	X[*]	X[*]	X[*]
CD 20 - 2.2	X							X[*]	X[*]	X[*]	X[*]
WC 2.5[*]							X	X	X	X	
WC 3.0[*]							X	X	X	X	
WR 0.2	X	X	X	X	X	X	X	X	X	X	X
No. streams monitored by CRWD	7	3	8	9	10	9	13	15	15	15	10

Notes: ^ part of project #06-1, + part of Targeted Fertilizer Project, * three-year rotation, # dropped to save cost and deemed no longer needed

Notes: [^]Part of Project #06-1; [+]Part of Kingston Wetland Project, [*]Part of Targeted Fertilizer Project

Table 3: Proposed 2016 CRWD Monitoring Plan Summary

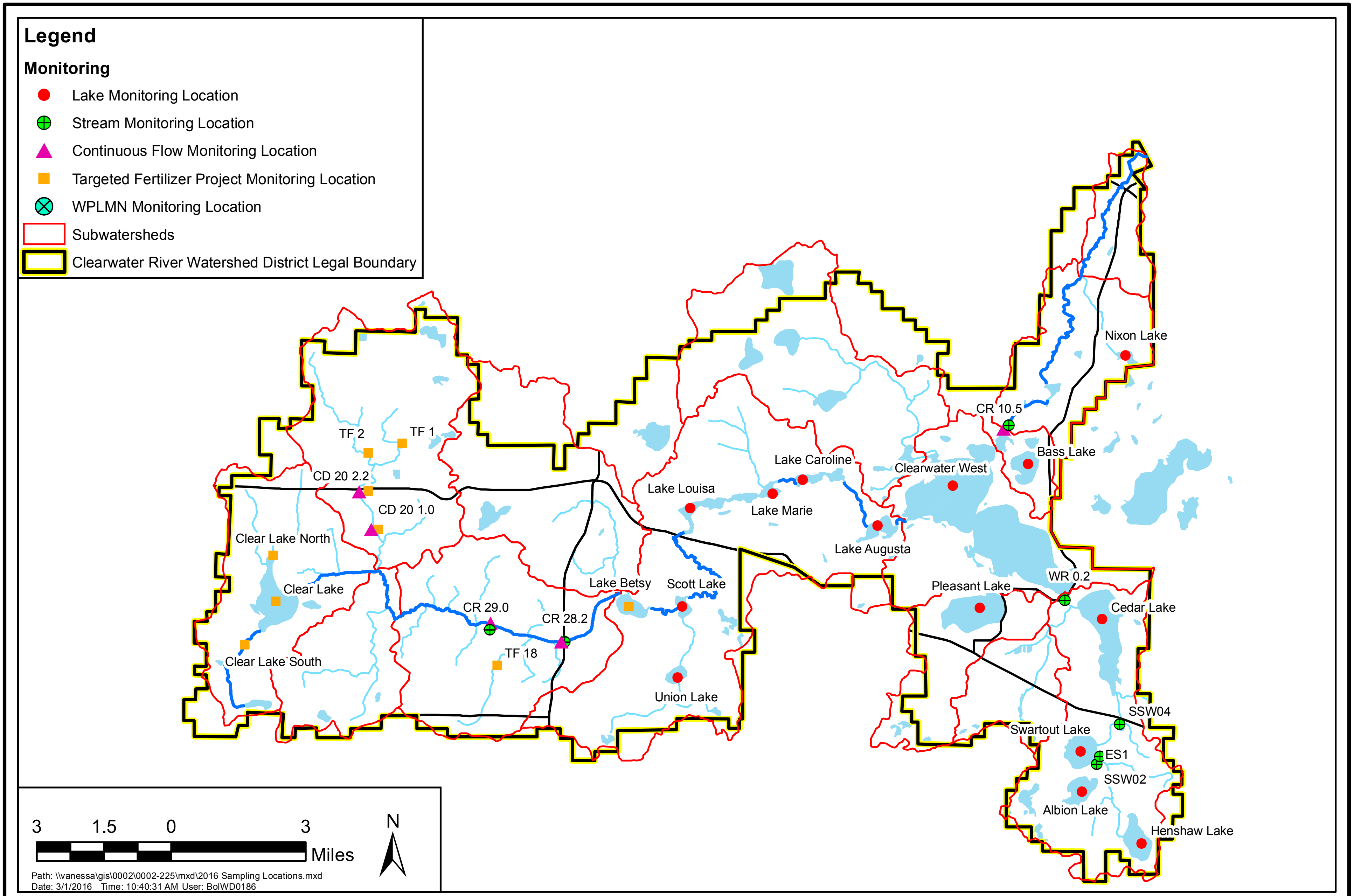
Category	2014 Schedule	Station	Parameters
Lakes:	June 3-7, July 8-12, August 5-9, September 2-6 Note: (Lake sampling to be completed by September 15)	*Clearwater (West), Augusta, Caroline, Marie, Louisa and Scott monitored under the Chain of Lakes (1980) Project. *Bass, Nixon, Pleasant and Union monitored under the general fund. *Cedar, Albion, Swartout, and Henshaw monitored under Project #06-1. *Clear and Betsy monitored under the Targeted Fertilizer Project (start in May).	*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 Betsy.
Streams:	Twice monthly March-October -Preferred before 8:00am	CR 28.2 and CR29.0 monitored under Targeted Fertilizer Project	Field: DO, temperature, conductivity, pH Lab: total phosphorus, ortho phosphorus, TSS; E-coli at CR 29.0
	Monthly March-October	CR 10.5 and Warner Creek at WR0.2 monitored under the general fund	Field: DO, temperature, conductivity, pH Lab: total phosphorus, ortho phosphorus, TSS
	Monthly March-October	Clear Lake North, Clear Lake South, CD 20-1.0, CD20-2.2, TF 1, TF 2, TF 18 monitored under Fertilizer Application Project	Field: DO, temperature, conductivity, pH Lab: total phosphorus, ortho phosphorus, TSS
	Monthly March-October	SSW02, SSW04 monitored under Project #06-1	Field: DO, temperature, conductivity, pH Lab: total phosphorus, ortho phosphorus, TSS
	Continuous: March-October	CR 10.5 & Fair Haven Dam(general fund) CR 28.2 & CR 29.0 (Targeted Fertilizer) CD 20-2.2 &CD 20-1.0 (Targeted Fertilizer)	Place pressure transducers after ice-out, check throughout year, pull in October
Precipitation:	Daily	Corinna, Kimball, Watkins	Rain gauge stations (4)

Table 4: Proposed 2016 Water Quality Monitoring Cost Sheet, per category and funding source

Funding Source	Estimated Field Staff Costs ($32.50/hr.)	Laboratory Costs	Other Costs	Total Costs
Lake Monitoring				
General [100]	$1,300.00	$720.00	$64.00	$2,084.00
Chain of Lakes [210]	$1,950.00	$1,080.00	$48.00	$3,078.00
Project #06-1 [215]	$1,300.00	$1,029.60	$64.00	$2,393.60
Veg. Surveys [215]	$390.00	$0.00	$1,600.00	$1,990.00
Targeted Fert. [247]	$812.50	$898.00	$40.00	$1,750.50
			TOTAL	$11,296.10
Stream Monitoring				
General [100]	$455.00	$579.20	$64.00	$1,098.20
Chain of Lakes [210]	$1,040.00	$1,344.00	$48.00	$2,432.00
Project #06-1 [215]	$390.00	$579.20	$96.00	$1,065.20
Targeted Fert. [247]	$3,282.50	$7,688.00	$496.00	$11,466.50
Tile Monitoring [247]	$585.00	$2,232.00	$144.00	$2,961.00
CLWP&I [215]	$195.00	$289.60	$128.00	$612.60
			TOTAL	$19,635.50
Data Analysis & Reporting				
General [100]	$0.00	$0.00	$15,000.00	$15,000.00
Chain of Lakes [210]	$0.00	$0.00	$2,000.00	$2,000.00
Project #06-1 [215]	$0.00	$0.00	$2,000.00	$2,000.00
Kingston Wetland [246]	$0.00	$0.00	$1,000.00	$1,000.00
Targeted Fert. [247]	$0.00	$0.00	$2,000.00	$2,000.00
			TOTAL	$22,000.00
			SUBTOTAL (lake, stream, analysis)	$52,931.60
Supplemental Monitoring				
Supplemental #	**Funding Source**			**Total Cost**
1	Data Acquisition [205]			$1,630.00
2	Chain of Lakes [210]			$6,210.00
3	General [100]			$545.00
4	General [100]			$969.38
5	Data Acquisition [205]			$3,873.75
			TOTAL	$13,228.13
			GRAND TOTAL	$66,159.73
Notes: Mileage to and from sampling site, or delivering samples to lab and/or shipper are not included				

Table 5: Proposed 2016 Water Quality Monitoring Budget, per funding source

Funding Source	Proposal Amount	Amount Budgeted
Monitoring, No Supplemental Monitoring		
General [100]	$18,182.20	$31,775.00
Chain of Lakes [210]	$5,126.00	$7,170.00
Project #06-1 [215]	$7,933.40	$8,775.00
CWR&PII [210]	$3,512.00	$0.00
Targeted Fertilizer [247]	$18,178.00	$10,550.00
TOTAL	$52,931.60	$58,270.00
Only Supplemental Monitoring		
General [100]	$1,514.38	N/A
Data Acquisition Fund [205]	$5,503.75	N/A
Chain of Lakes [210]	$6,210.00	N/A
TOTAL	$13,228.13	N/A
All Monitoring		
General [100]	$19,696.58	$31,775.00
Data Acquisition Fund [205]	$5,503.75	$2,500.00
Chain of Lakes [210]	$11,336.00	$7,170.00
Project #06-1 [215]	$7,933.40	$8,775.00
CWR&PII [210]	$3,512.00	$0.00
Targeted Fertilizer [247]	$18,178.00	$10,550.00
TOTAL	$66,159.73	$60,770.00
Note: Previous years instituted Water Quality Monitoring Program Totals are: 2015: $47,604.15 2014: $47,050.00 2013: $38,626.00 2012: $47,714.00 2011: $53,706.00		



CLEARWATER RIVER WATERSHED DISTRICT

2016 Monitoring Locations

WENCK ASSOCIATES

Responsive partner. Exceptional outcomes.

FEB 2016

Figure 1

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

Clearwater River Watershed District

2016 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
	2014	1.04	36.83	0.222	3,358	7,404	222
	2015	0.84	29.75	0.225	3,374	7,438	225
	2016	1.08	38.01	0.182	3,777	8,326	182
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
	2013	2.16	76.50	0.024	959	2,115	24
	2014	4.57	161.31	0.024	2,000	4,409	24

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

Clearwater River Watershed District

2016 Annual Report

Station		Average Stream Flow		Flow-Weighted Average Total Phosphorus Concentration	Total Phosphorus Load		
Main Stem:	Year	(cu m/sec)	(cfs)	(mg/L)	(kg)	(lb)	µg/L
	2015	3.47	122.77	0.022	1,327	2,926	22
	2016	3.99	141.04	0.018	1,617	3,565	18
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
	2014	0.38	13.47	0.046	278	613	46
	2015	0.17	6.09	0.066	198	436	66
	2016	0.66	23.38	0.053	671	1,480	53

NOTES:

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

Appendix B-TABLE B-2

YEARLY PRECIPITATION AND RUNOFF TOTALS

Clearwater River Watershed District

2016 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
2014	29.49	29.70		28.48	29.22	8.1
2015	35.55	32.12		37.61	35.09	6.0
2016	39.34	41.42*		34.60	36.97	7.6
				Mean	29.72	7.8
				Std. Dev.	7.1	5.3

NOTES:

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

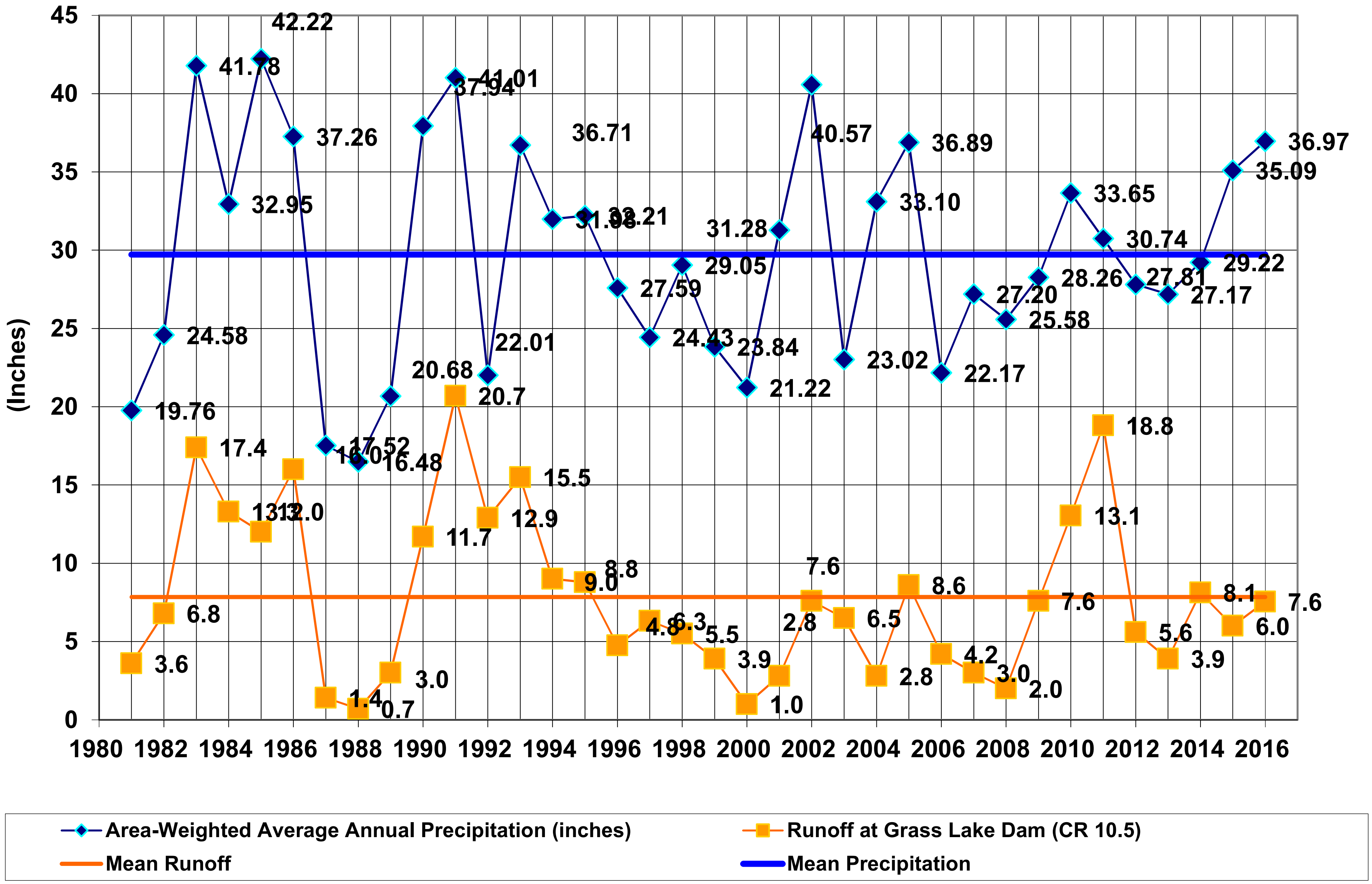
(1) Data for single gauge in east-central part of watershed (Camp Heritage on Lake Caroline).

(2) Average values of other stations in District were used to fill in missing data.

* Value from Kimball Station

V:\Technical\0002\2016 WQ Monitoring Data\2016 Spreadsheets\[Stream_Loads_Historic_15.xls]Table 2

Appendix B Figure B- 1
Clearwater River Watershed District
2016 Annual Report



V:\Technical\0002\2016 WQ Monitoring Data\2016 Spreadsheets\Stream_Loads_Historic_15.xlsPrecip_Runoff_Graph_07

METHODS FOR DETERMINING VEGETATION & FISH HEALTH

Overview

Biodiversity is important in maintaining a healthy lake ecosystem. Biodiversity is considered to be a principle driver of ecosystem function and critical to ecosystem resilience and stability. A diverse ecosystem provides a number of services such as nutrient recycling, improved water quality, and increased recreational opportunities. Human disturbances often lead to a decrease in species diversity resulting in a weakening and/or loss of support to the ecosystem services provided by healthy biotic community.

The development of health assessment indices have provided a means in which natural resources managers can evaluate and monitor the health of a lake's biological community to help focus restoration and preservation efforts. The species that make up a community vary in their tolerance to human disturbances, therefore, as the episodic and cumulative disturbances occur to a system a decrease in species richness and a shift to species that are very tolerant to disturbance. Assessment tools developed by the MnDNR use these tolerance differences to relate the relative health of a given lake. Specifically, different sets of tools have been developed to relate the health of the fish community (Fish IBI) and another set of tools for the vegetation community (FQI).

Floristic Quality Index

The Floristic Quality Index (FQI) is a vegetation health assessment tool that is based on a metric of species richness and a Coefficient of Conservatism (C), which is a score (0 -10) that relates a species site fidelity and tolerance to disturbance. Thus, species that have narrow habitat ranges and/or low tolerance to stress have high C-values. Therefore, the more species observed in a lake and the greater the C-values the greater the system health.

FQI assessment was designed to allow for health assessment from various community sampling techniques. Three different survey methods can be used: Minnesota Biological Survey methods, MnDNR transects or point intercept surveys (most common). All three methods have limitations yet all are relatively good at capturing and evaluating the health of the vegetation community.

Due to natural differences in species composition between deep and shallow lakes and ecoregions, two unique sets of thresholds were developed for FQI scoring for the North Central Hardwoods ecoregion (Table 1). The MnDNR has performed at least one survey and FQI assessment on all of the CRWD lakes presented in this appendix. Each lake report card shows the most recent FQI score for each lake and how it relates to the impairment thresholds presented in Table 1. It should be pointed out that the report cards only show FQI assessments conducted by the MnDNR, and therefore do not include any FQI assessments based on surveys performed by CRWD or other parties.

Table 1: Minnesota Department of Natural Resources North Central Hardwoods ecoregion point intercept and transect sampling FQI impairment thresholds for deep and shallow lakes.

Classification	Deep	Shallow
Exceptional	32.4	26.0
Impaired	18.6	17.7

Fish Index of Biotic Integrity

The Fish IBI is comprised of multiple metrics that integrate aspects of species richness, community assemblage, and trophic composition. The combining of all individual metrics results in a single score that relates the relative health of the fish community with healthier systems having greater overall scores. Low scores are typically associated to imbalanced communities filled with tolerant species and high scores are typically received when communities are balanced and filled with intolerant species.

Fish IBI sampling includes trap and gill net surveys along with nearshore backpack electrofishing and beach seining. Together these various sampling gears are able to capture information from various habitats throughout a lake and also target all fish species.

Minnesota lakes that fall within lake classes 20 - 43 (Schupp lake classification) have been partitioned into four distinct Fish IBIs. Lake class groups are clustered together using eight lake attributes that account for the expected variability of a fish community due natural phenomenon (Table 2).

Table 2: Minnesota Department of Natural Resources fish IBI tool classification.

IBI Tool	Schupp's Lake Class	Lake Classification Group Description
2	22, 23, 24, 25, 27	Generally, deep lakes with high shoreline complexity (SDI) that are typically less than 80% littoral.
4	28, 29, 30, 31, 32	Compared to LCG 2 these lakes on average are smaller, have intermediate littoral area, have less shoreline complexity (typically rounder basins). They also typically have a low trophic status, low phosphorus levels, and clearer water compared to LCG2.
5	33, 34, 35, 36, 37, 39	Central and Northern MN lakes of shallow to moderate depths (mostly littoral). Generally, naturally eutrophic lakes with lots of vegetation and soft sediment.
7	38, 41, 42, 43	Shallowest lakes typically consisting of > 80% littoral area. Primarily in the southern half of the state. Excludes winterkill lakes (w/in 10 years) and riverine lakes

Due to these expected differences and unique IBIs each tool has its own set of thresholds to generalize the relative health of a lake's fish community (Table 3).

Table 3: Minnesota Department of Natural Resources impairment thresholds for fish IBI tools.

Classification	Tool 2	Tool 4	Tool 5	Tool 7
Exceptional	64	59	61	NA
Impaired	44	38	24	36

The MnDNR has performed Fish IBI assessments on six lakes throughout the CRWD: Cedar, Betsy, Louisa, Clearwater, School Section, and Bass. The lake report cards for each of these lakes present the Fish IBI score and how it relates to the impairment thresholds presented in Table 3.

More information on Fish IBI methodology can be found on the MnDNR's website:

http://www.dnr.state.mn.us/waters/surfacewater_section/lake_ibi/index.html

ALBION LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 251 acres

Residence Time: 1,752 days

Surface Area: 251 acres

Subwatershed Area: 1,094 acres

Maximum Depth: 9 feet

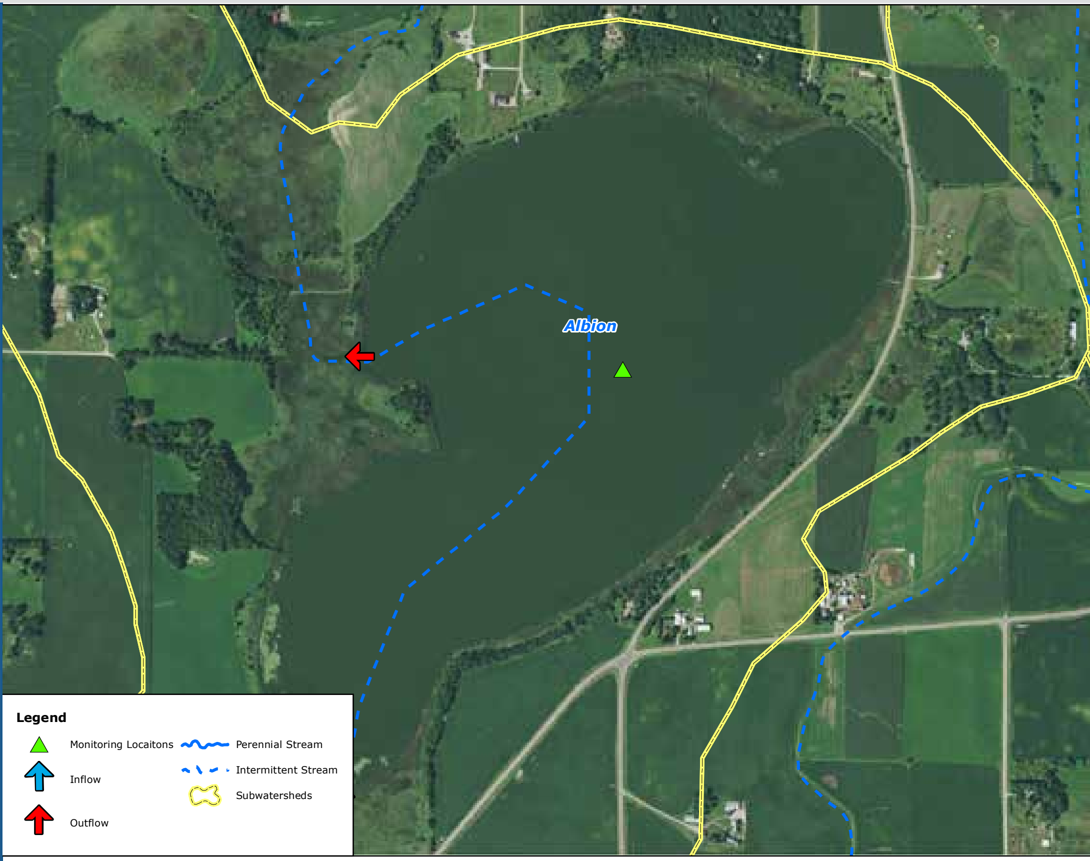
Upstream Waters: None

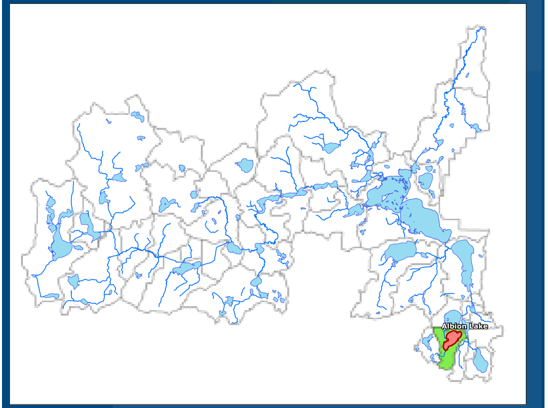
Common Fish — Common carp, black bullhead

Dominant Vegetation — Sago pondweed

Invasive Species — Curly-leaf pondweed

Status — Impaired; TMDL Completed 2010





TO DO LIST

- Rough fish management
- AIS management
- Manage upstream loads

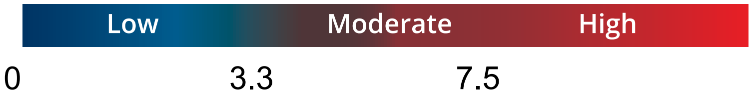
Fish Health (IBI)

*Fish IBI has not been assessed

Vegetation Health (FQI)

*Sample date: 8/16/2011

Sediment P Release (mg/m²/day)



*Sediment release rate has not been assessed

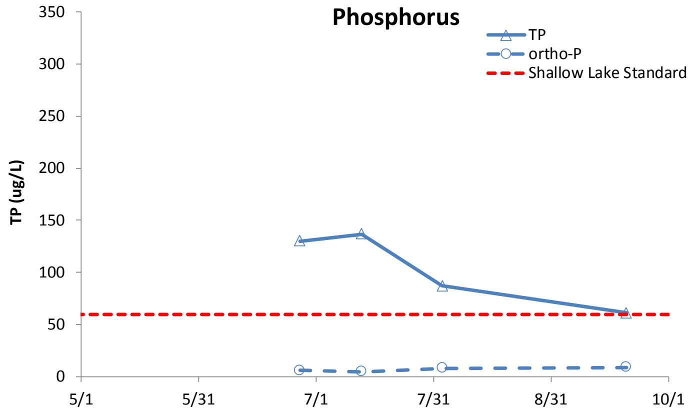
WENCK

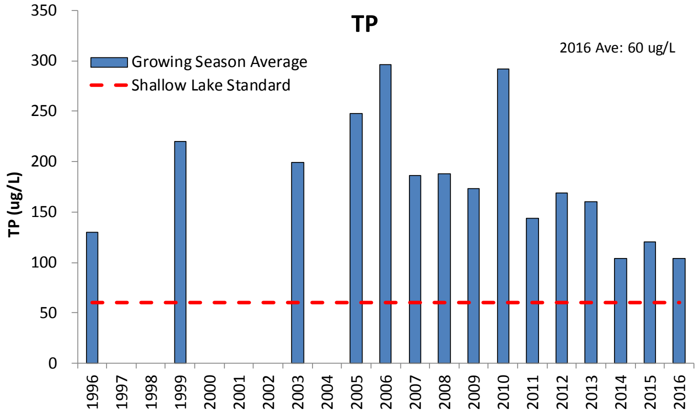
ALBION LAKE

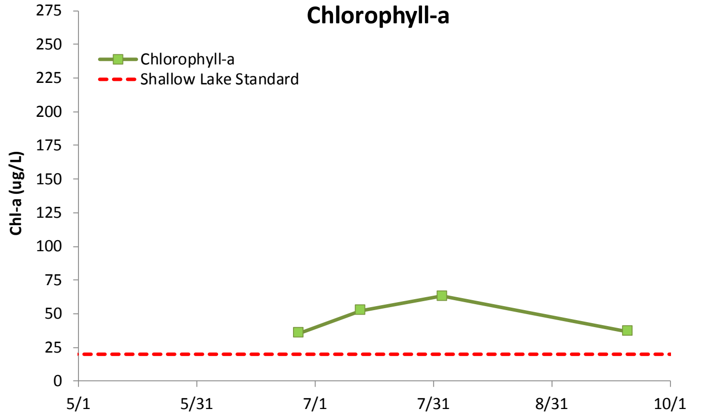
Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

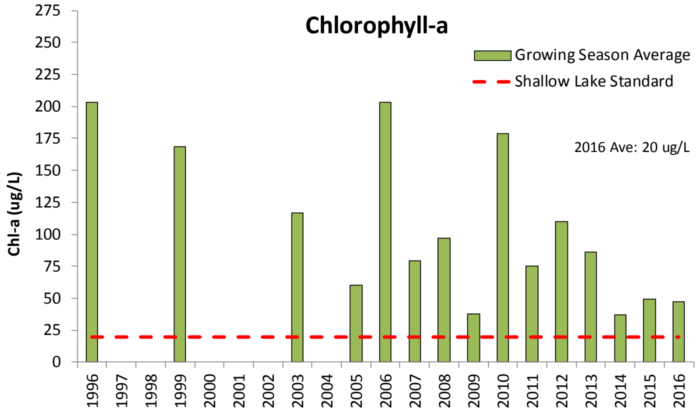
2016 Water Quality

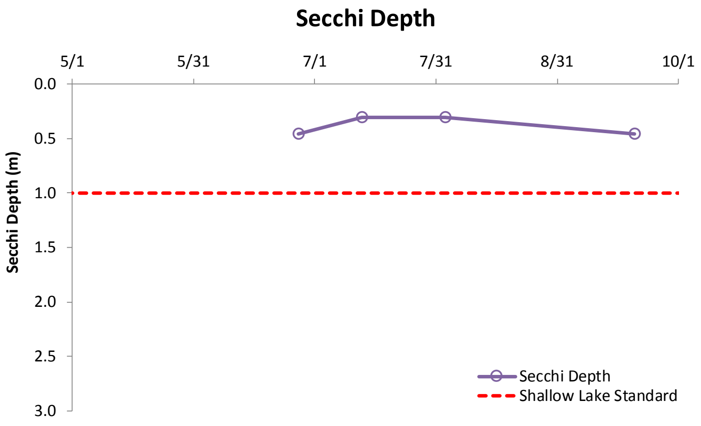
Historic Water Quality

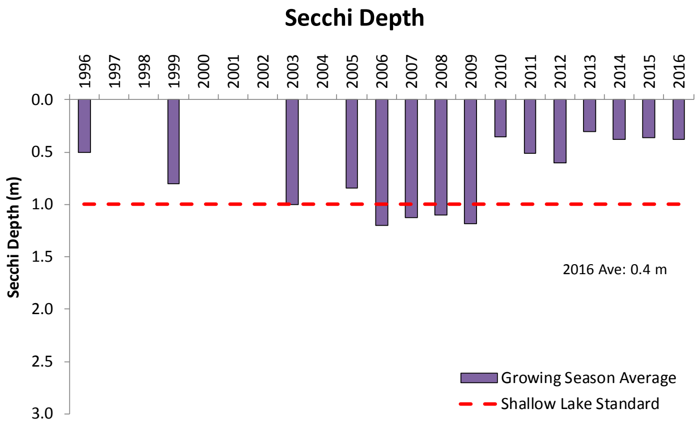












WENCK

BASS LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 96 acres

Surface Area: 222 acres

Subwatershed Area: 796 acres

Maximum Depth: 34 feet

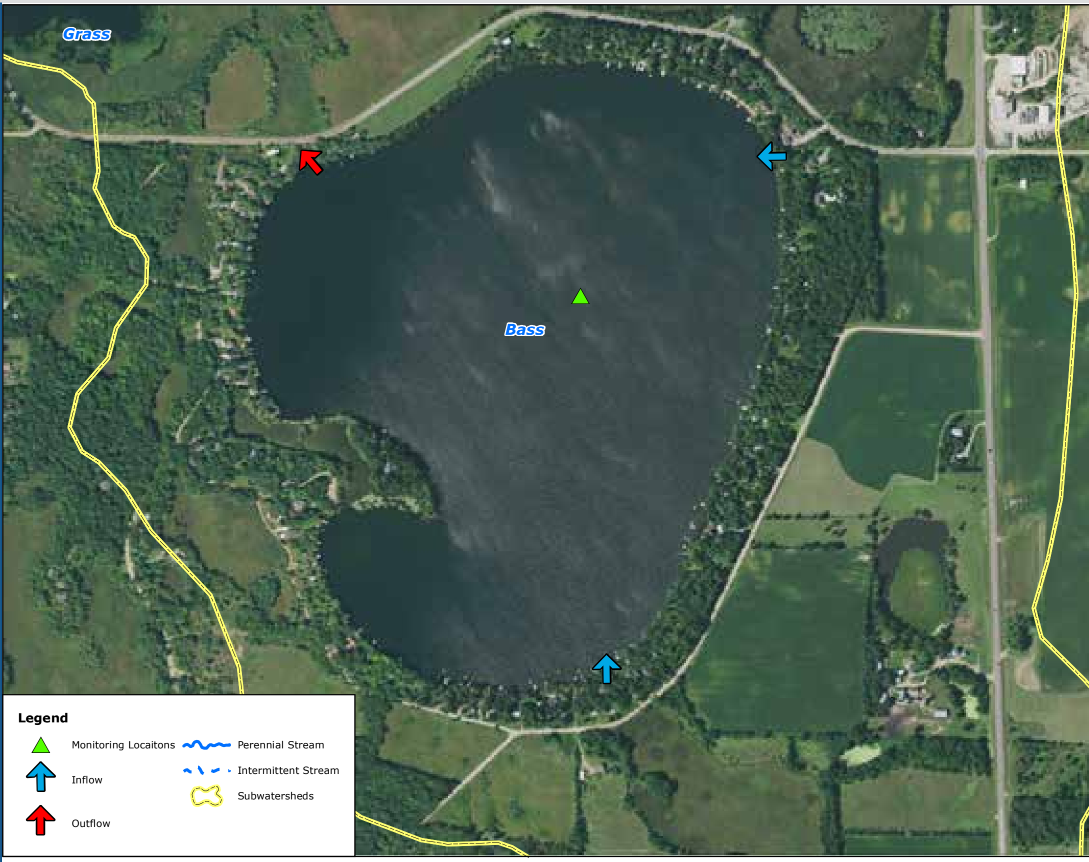
Upstream Waters: None

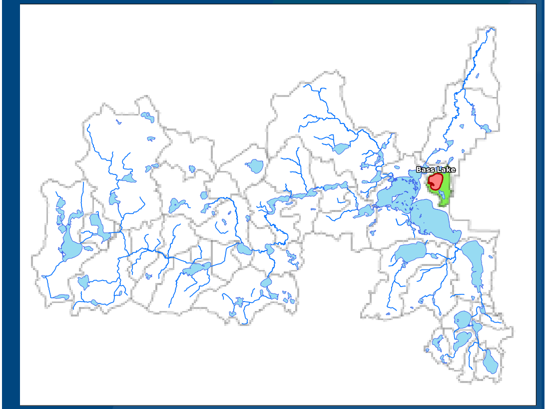
Common Fish: Bluegill, Northern Pike, Yellow Bullhead, Largemouth Bass

Dominant Vegetation: Currently obtaining vegetation info from DNR

Invasive Species: Currently obtaining vegetation info from DNR

Status: Not impaired

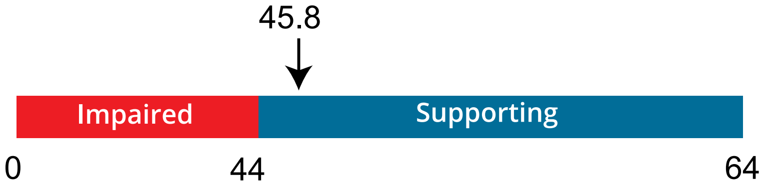




TO DO LIST

- Protect water quality
- Manage upstream loads
- AIS management and prevention

Fish Health (IBI)

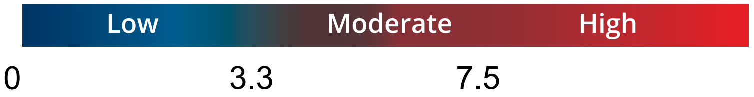


*Sample date: 6/11/2007

Vegetation Health (FQI)

*Sample date: 8/10/2015

Sediment P Release (mg/m²/day)



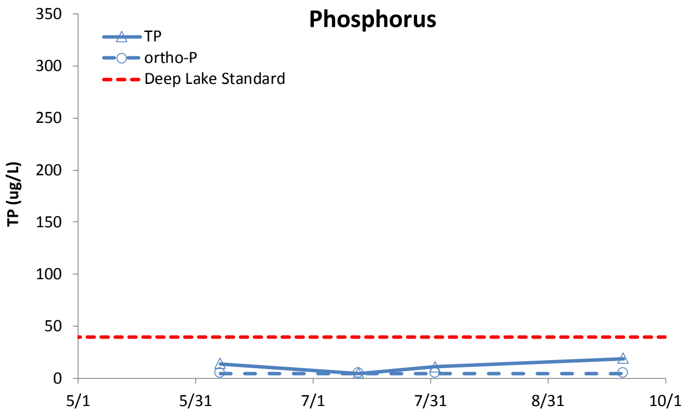
*Sediment release rate has not been assessed

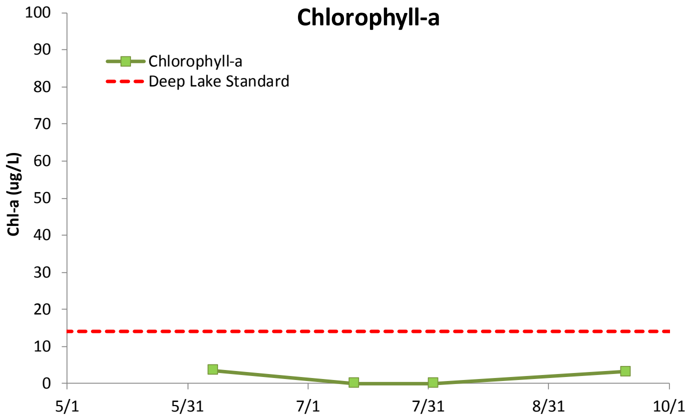
WENCK

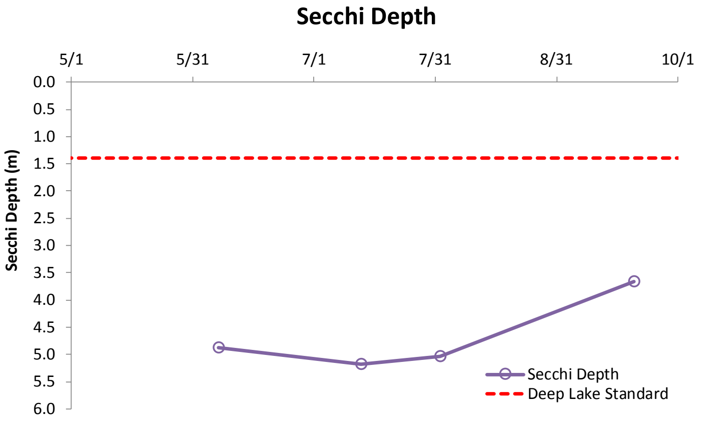
BASS LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

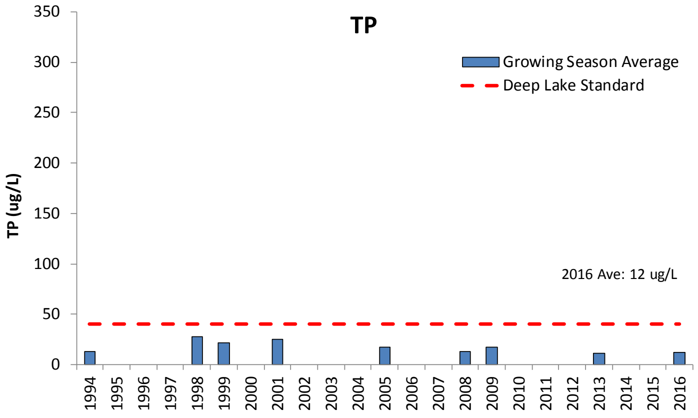
2016 Water Quality

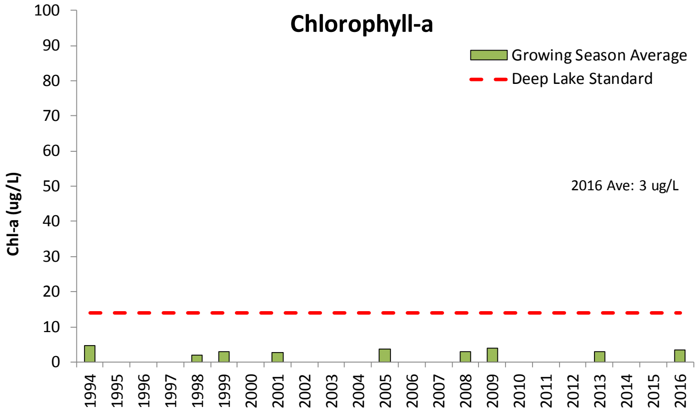


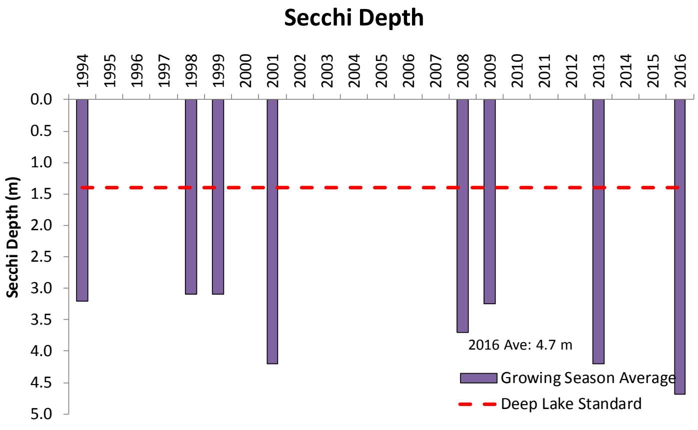




Historic Water Quality







WENCK

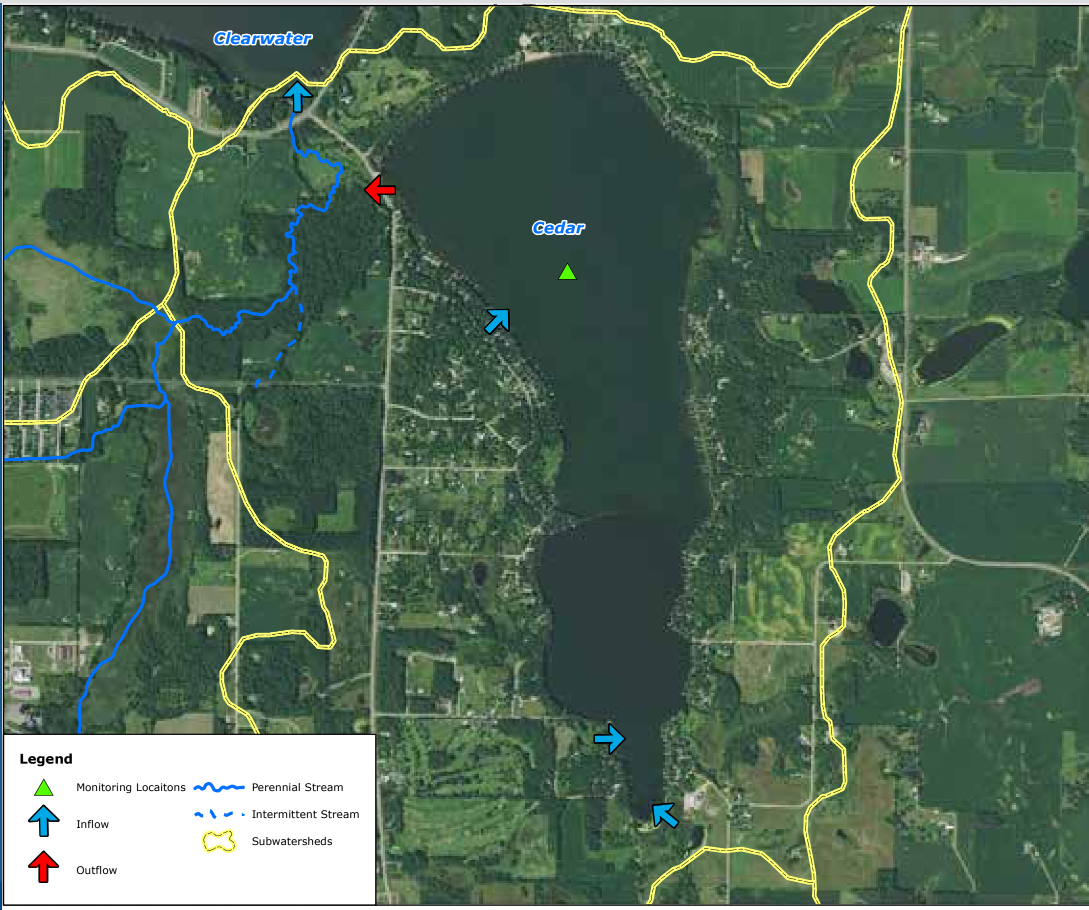
CEDAR LAKE

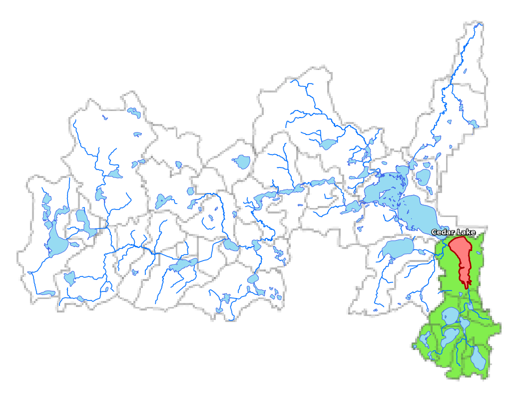
Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

- **Littoral Area**: 315 acres
- **Surface Area**: 790acres
- **Subwatershed Area**: 9,715 acres
- **Maximum Depth**: 108 feet
- **Upstream Waters**: Swartout, Albion, Henshaw

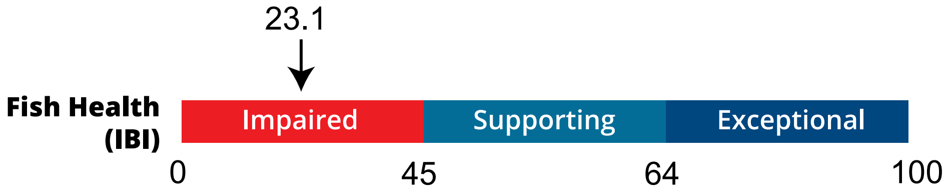
Common Fish	Bluegill, Northern Pike, Walleye, Largemouth Bass
Dominant Vegetation	Coontail, northern water milfoil, chara
Invasive Species	Eurasian water milfoil, curly-leaf pondweed
Status	Not Impaired



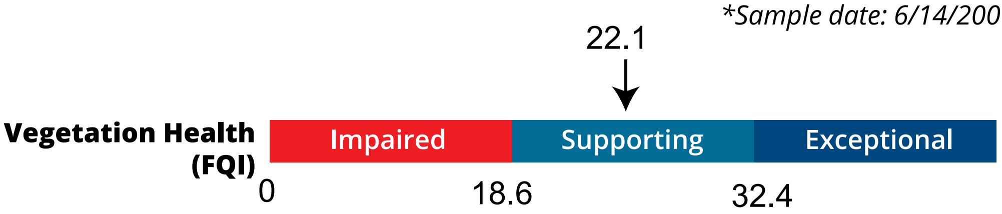


TO DO LIST

- AIS management
- Rough fish management in upstream lakes
- Internal load management study
- Manage upstream soluble P loads



*Sample date: 6/14/2006



*Sample date: 8/17/2015

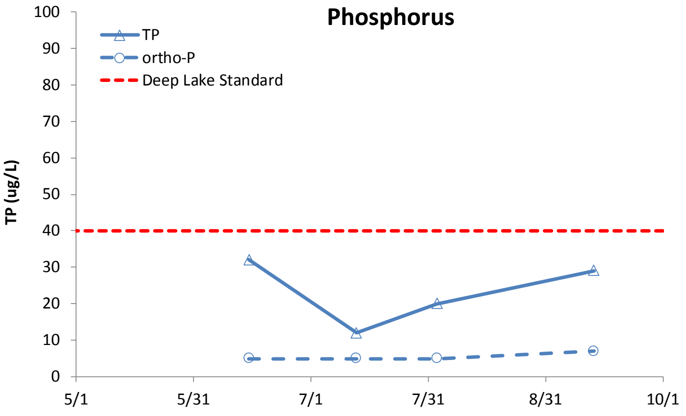
*Sediment release rate has not been assessed

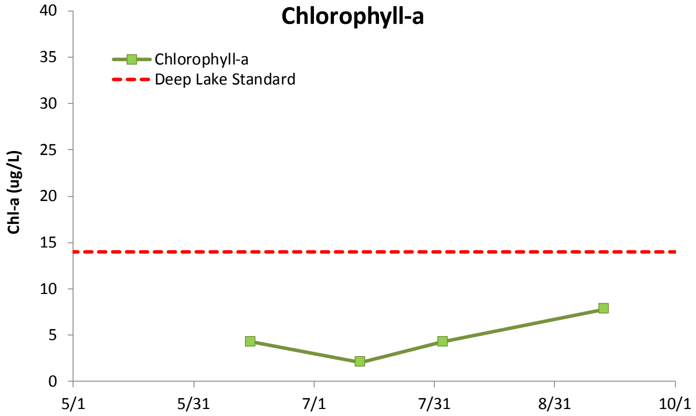
WENCK

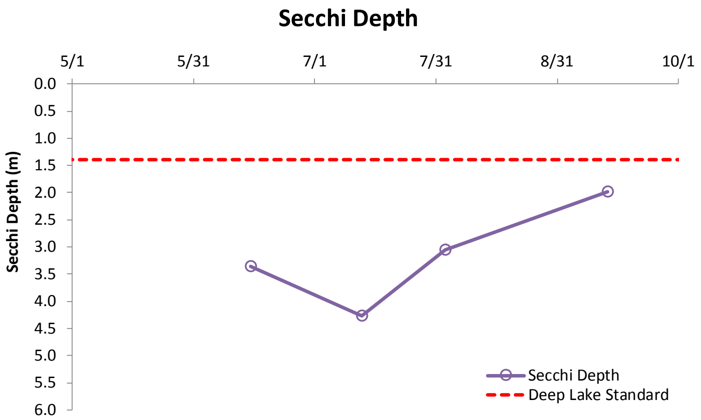
CEDAR LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

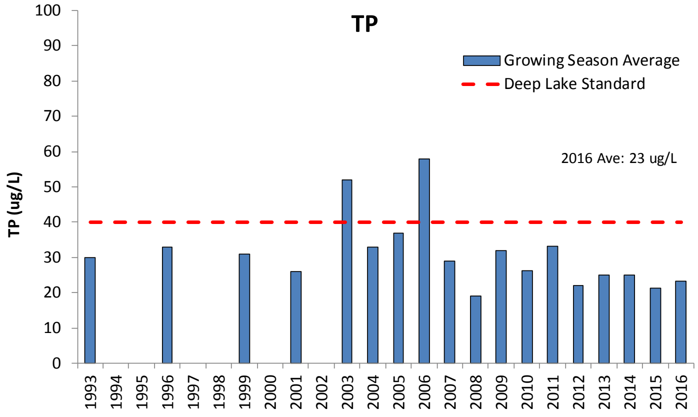
2016 Water Quality

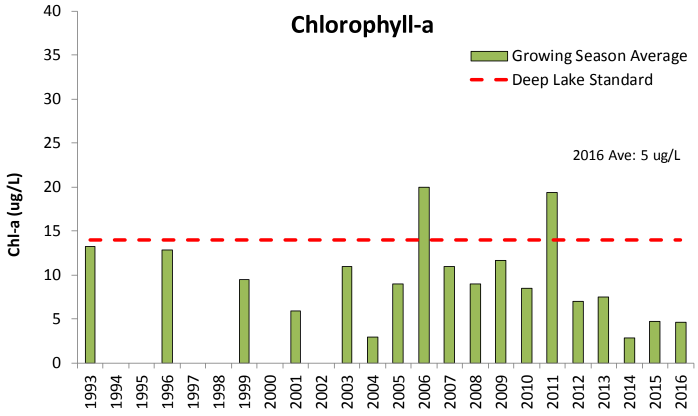


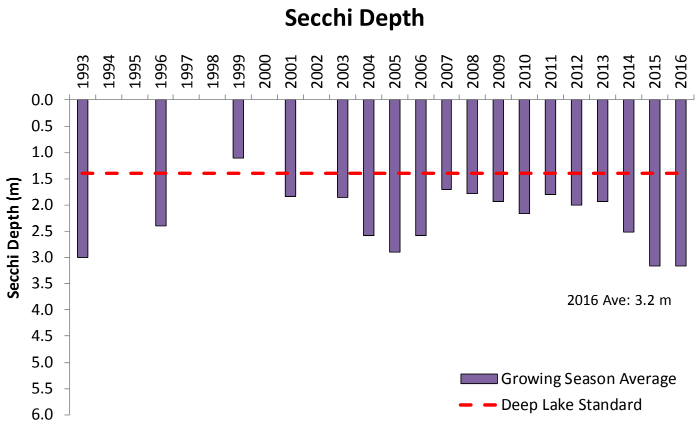




Historic Water Quality







WENCK

CLEAR LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 441 acres

Residence Time: 686 days

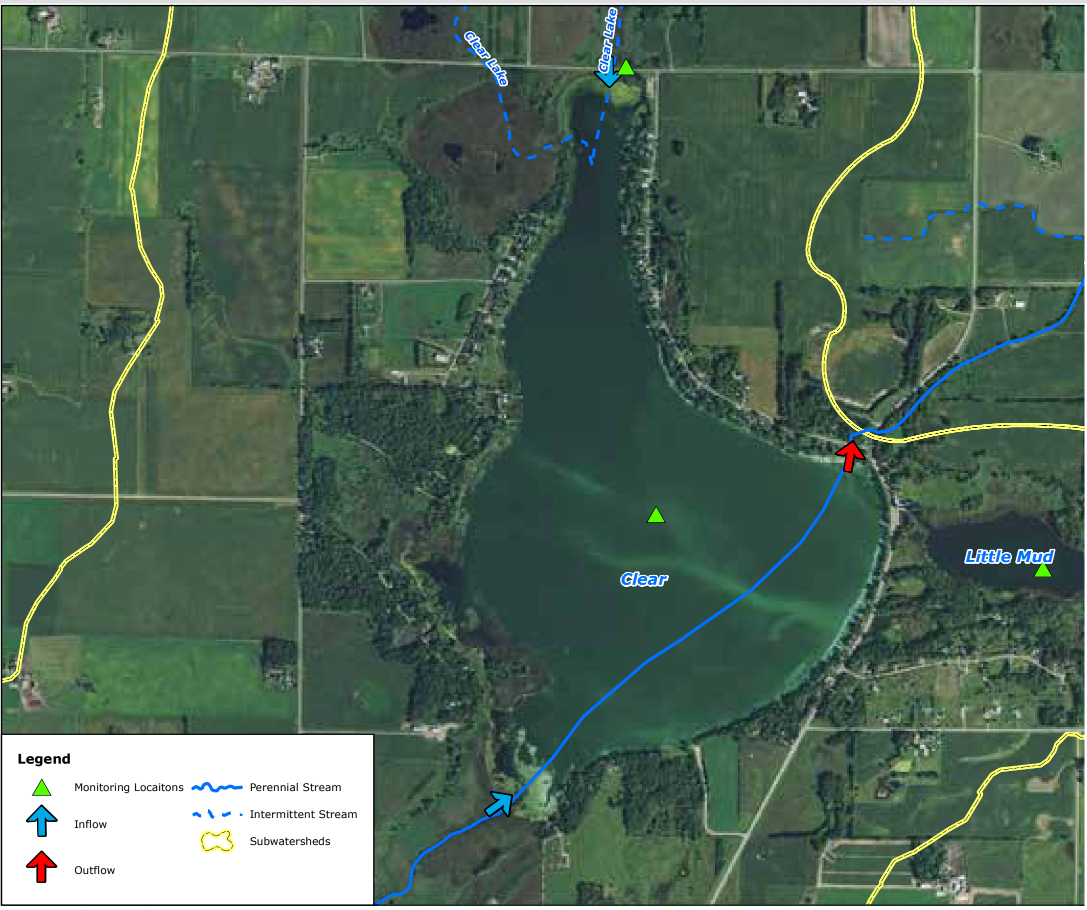
Surface Area: 529 acres

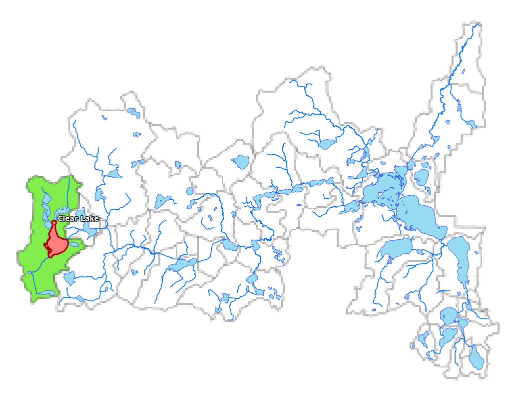
Subwatershed Area: 6,801 acres

Maximum Depth: 18 feet

Upstream Waters: None

Common Fish	Northern Pike, Black Crappie, Walleye, Bluegill
Dominant Vegetation	No Recent Survey
Invasive Species	Eurasian water milfoil, Curly-leaf pondweed
Status	Impaired, TMDL completed in 2009





TO DO LIST

- AIS Management
- Manage rough fish
- Manage upstream soluble P loads

Fish Health (IBI)

Impaired | Supporting

0 36 100

Fish IBI has not been assessed

19.3 ↓

Vegetation Health (FQI)

Impaired | Supporting | Exceptional

0 18.6 32.4

**Sample date: 7/31/2012*

2.4 ↓

Sediment P Release (mg/m²/day)

Low | Moderate | High

0 3.3 7.5

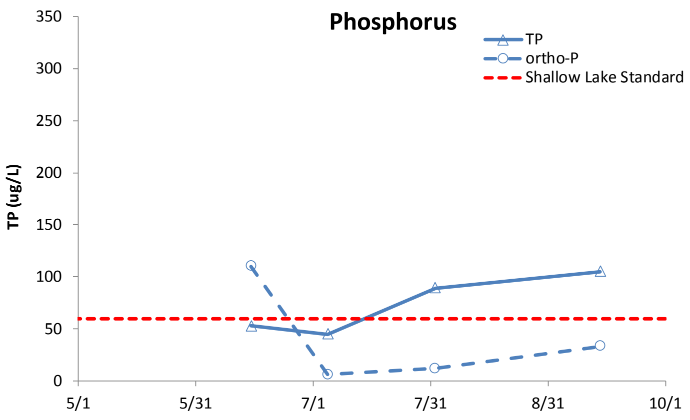
**Sample date: 2009*

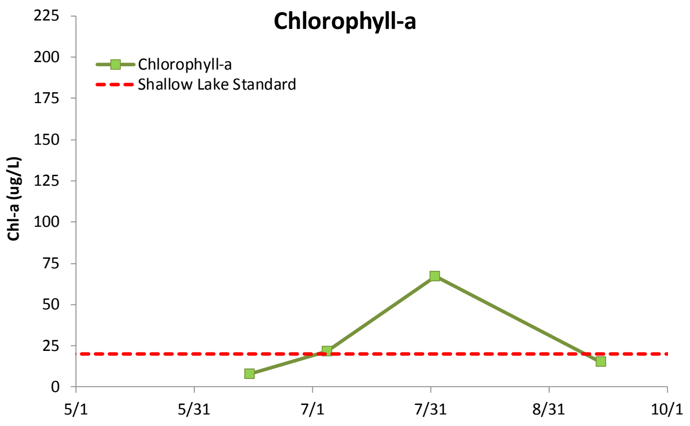
WENCK

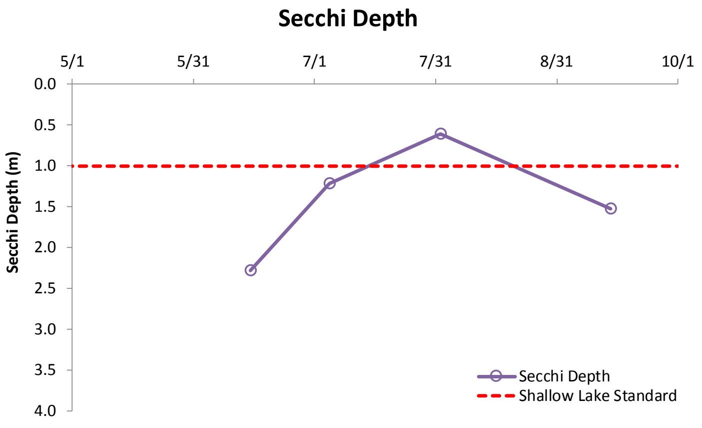
CLEAR LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

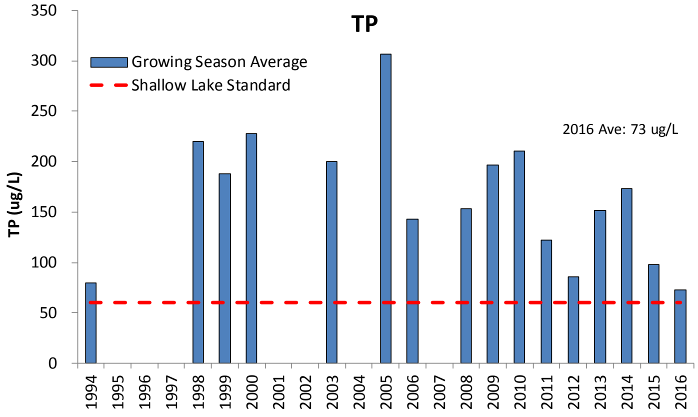
2016 Water Quality

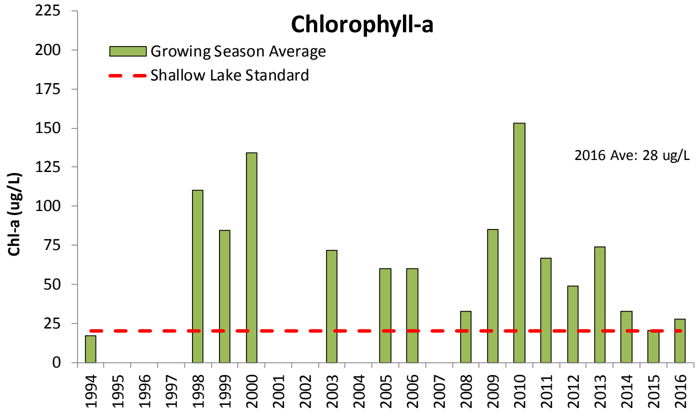


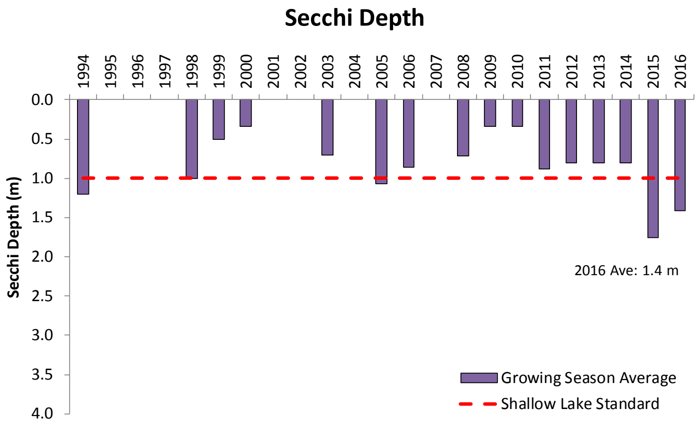




Historic Water Quality







WENCK

CLEARWATER LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 1,596 acres

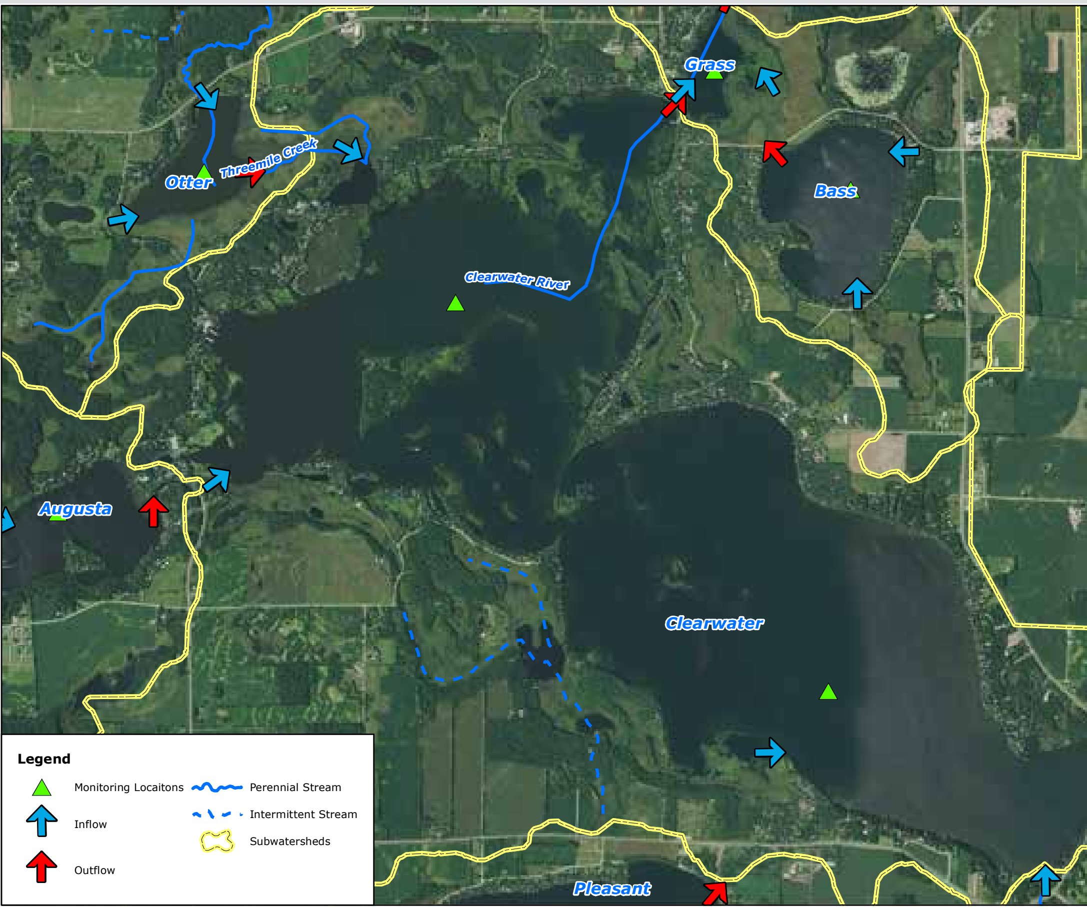
Surface Area: 3,158 acres

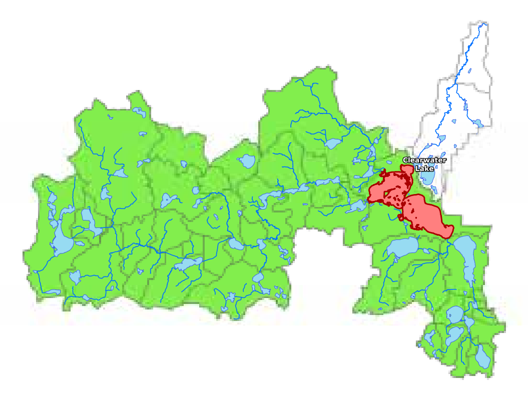
Subwatershed Area: 100,232 acres

Maximum Depth: 73 feet

Upstream Waters: Clearwater River, Augusta, Cedar, Otter, and Pleasant Lake

Common Fish	Bluegill, Northern Pike, Walleye, Largemouth Bass, Yellow Bullhead
Dominant Vegetation	Obtaining Recent Survey from DNR
Invasive Species	Eurasian water milfoil, curly-leaf pondweed, zebra mussels
Status	Not Impaired

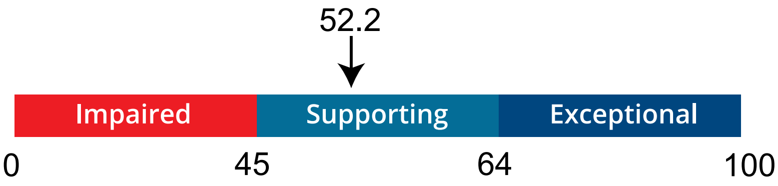




TO DO LIST

- Protect
- Manage upstream loads
- AIS management

Fish Health (IBI)

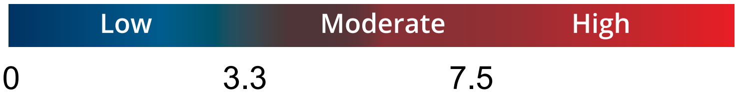


**Sample date: 7/15/2008*

Vegetation Health (FQI)

**Sample date: 8/10/2015*

Sediment P Release (mg/m²/day)

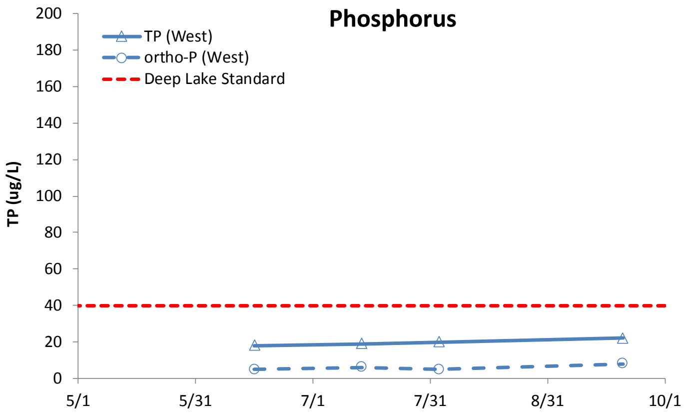


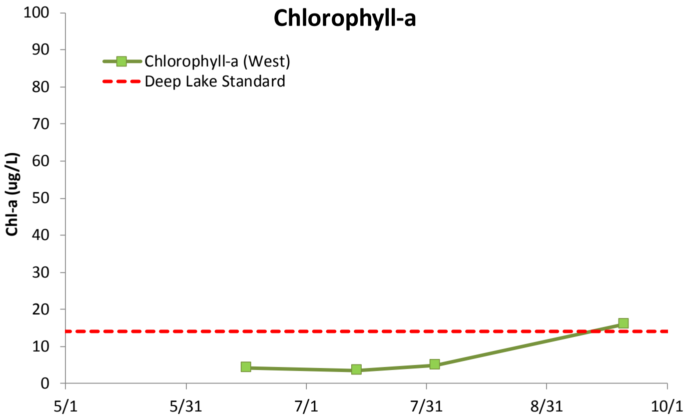
**Sediment release rate has not been assessed*

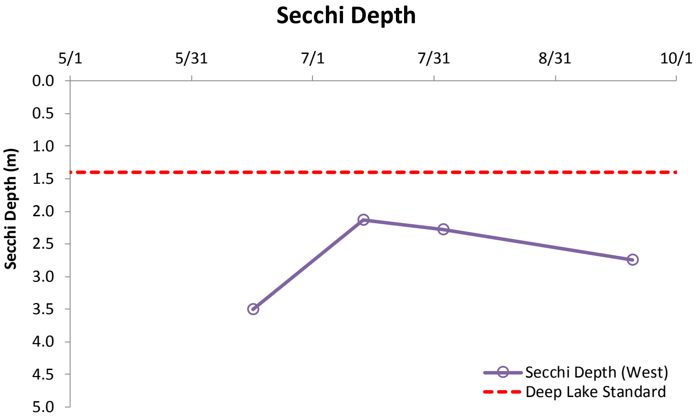
WENCK

CLEARWATER LAKE

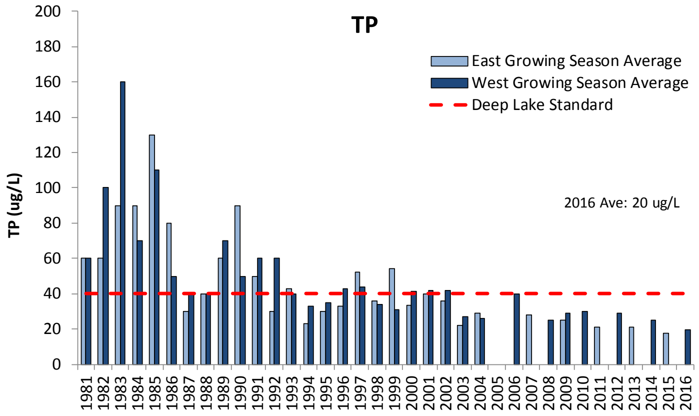
2016 Water Quality

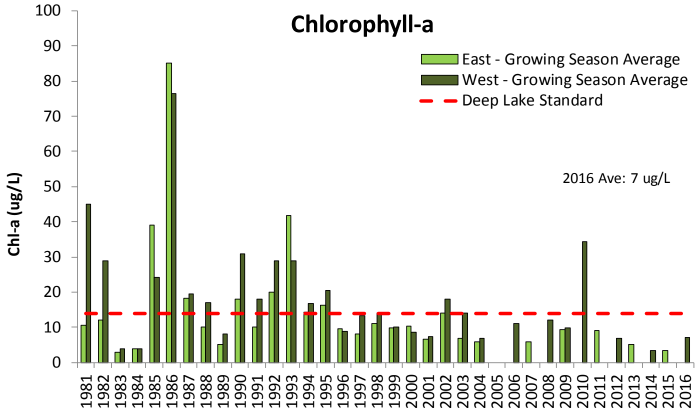


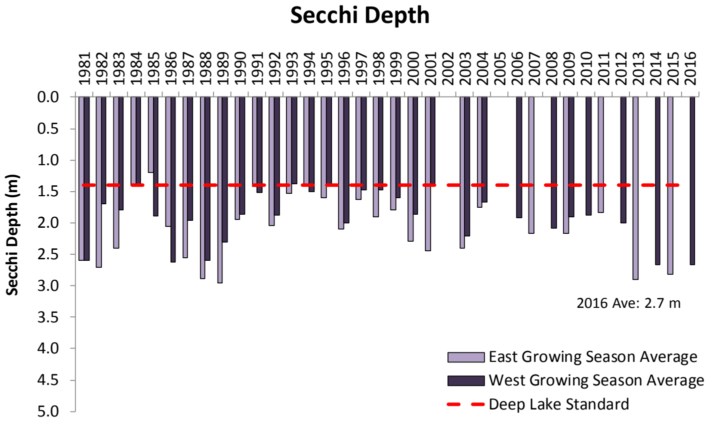




Historic Water Quality







GRASS LAKE

QUICK FACTS

Littoral Area: 62 acres

Surface Area: 71 acres

Subwatershed Area: 101,508 acres

Maximum Depth: 35 feet

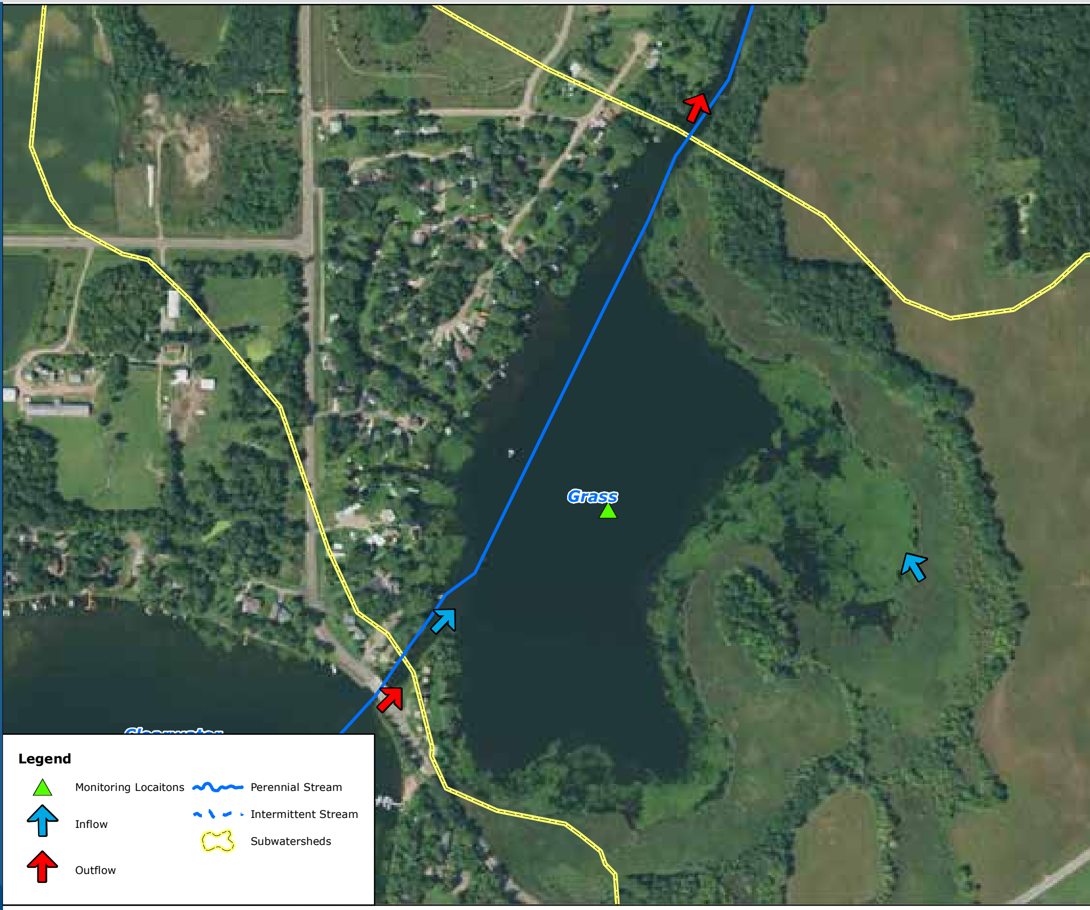
Upstream Waters: None

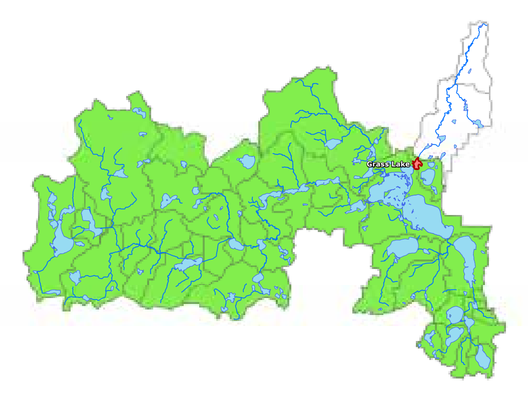
Common Fish: Bluegill, Northern Pike, Yellow Bullhead

Dominant Vegetation: No Recent Survey

Invasive Species: Zebra Mussells

Status: Not Impaired

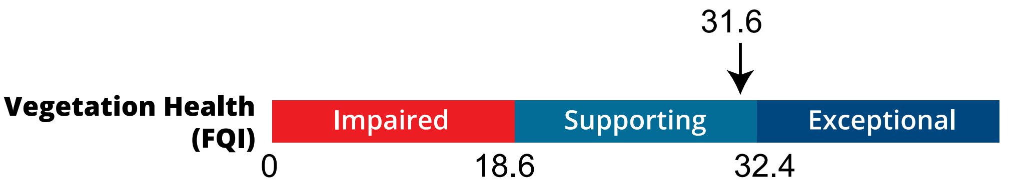




TO DO LIST

- Protect
- Manage upstream loads
- AIS Management

*Fish IBI has not been assessed



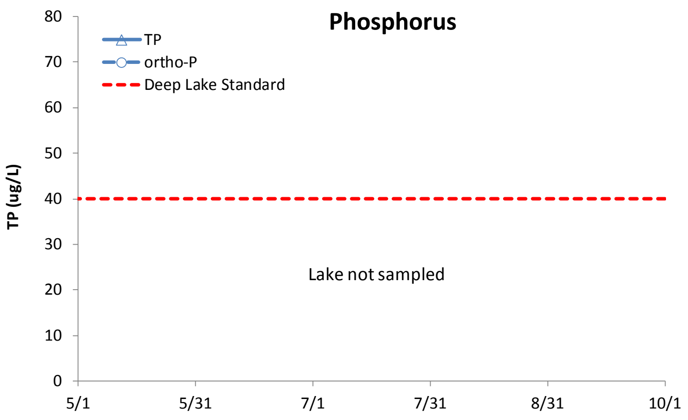
*Sample date: 8/1/2005

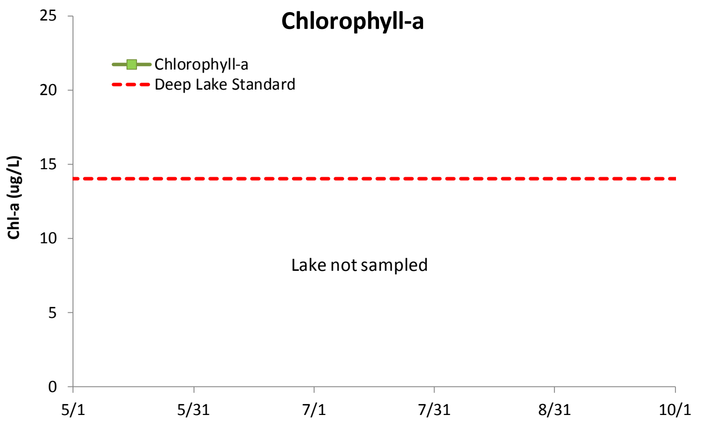
*Sediment release rate has not been assessed

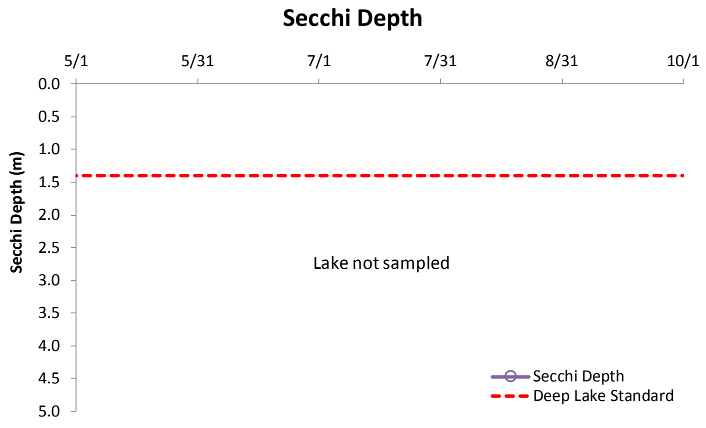
GRASS LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

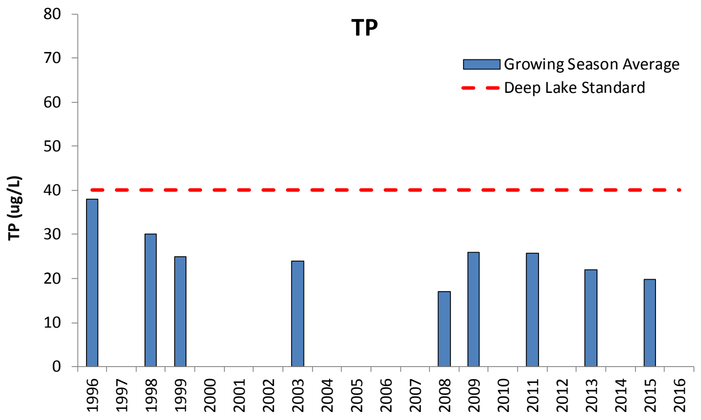
2016 Water Quality

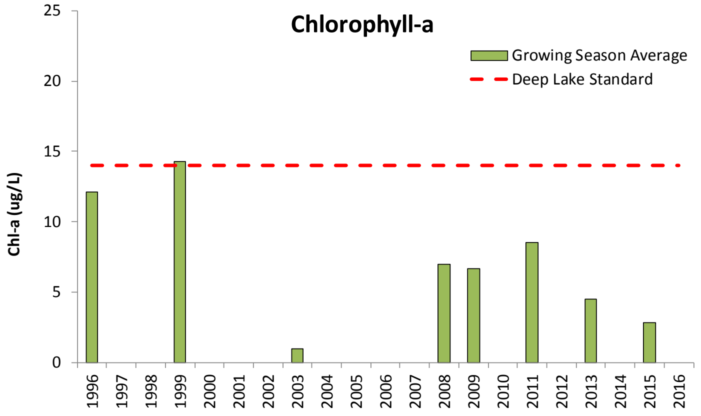


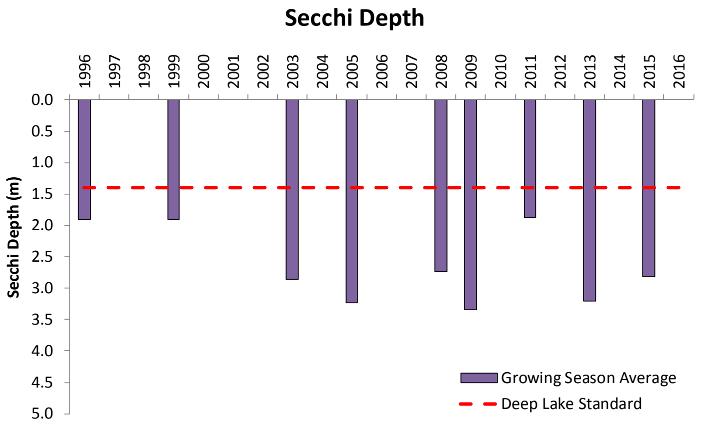




Historic Water Quality







HENSHAW LAKE

QUICK FACTS

Littoral Area: 271 acres

Residence Time: 1,697 days

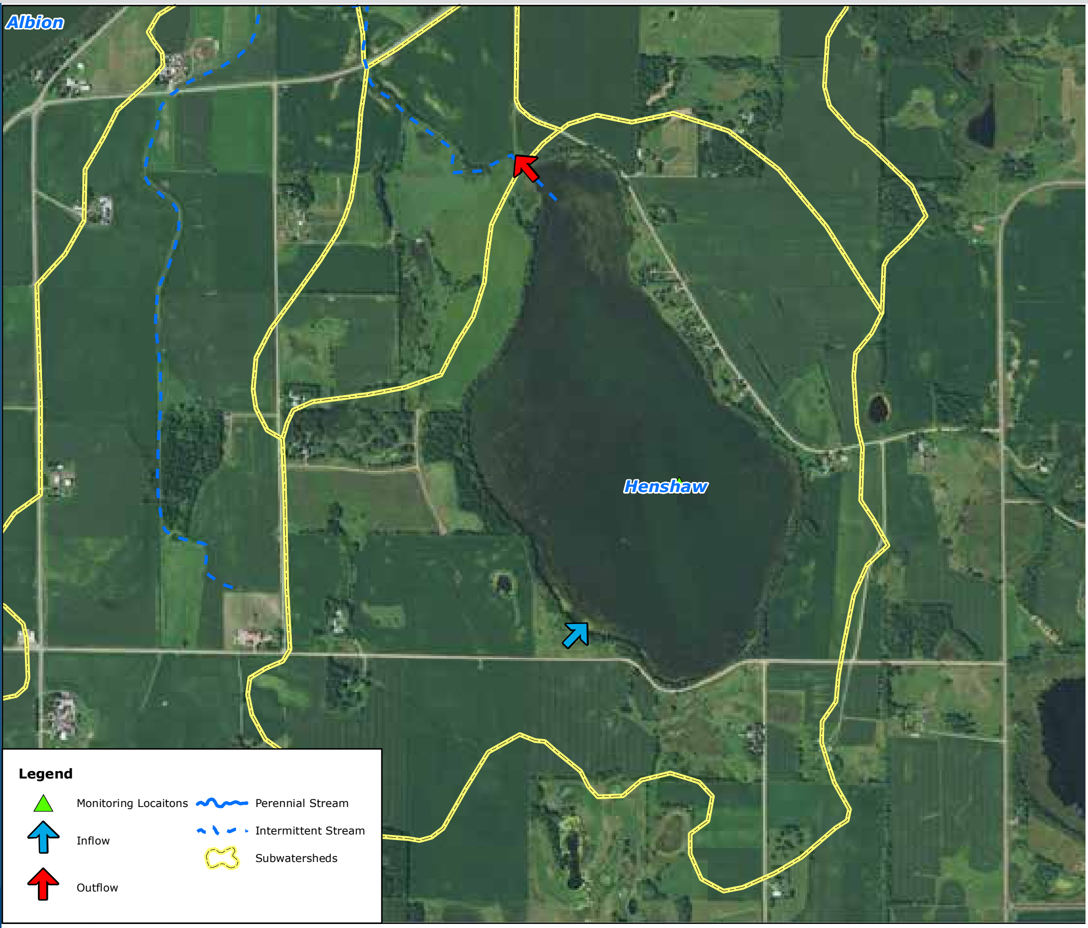
Surface Area: 903 acres

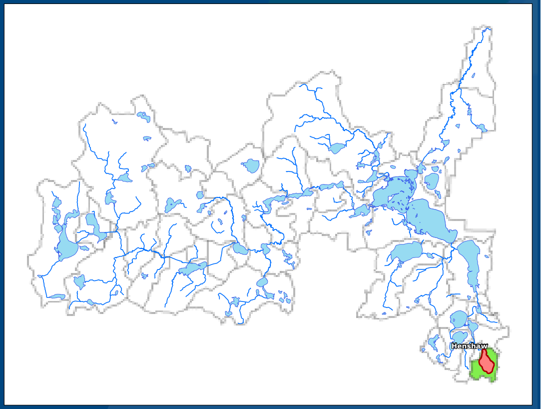
Subwatershed Area: 903 acres

Maximum Depth: 8 feet

Upstream Waters: None

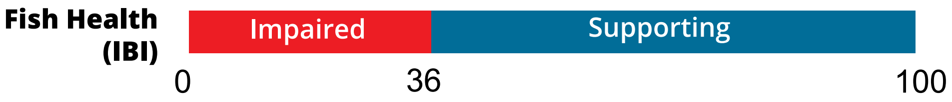
Common Fish	Black Bullhead, Common Carp
Dominant Vegetation	Sago pondweed, Coontail, Bushy pondweed
Invasive Species	Curly-leaf pondweed
Status	Impaired, TMDL Completed 2010



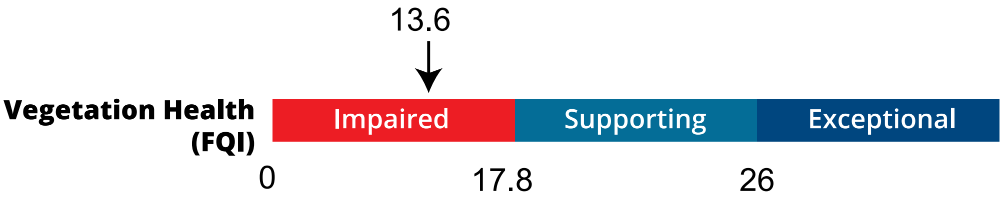


TO DO LIST

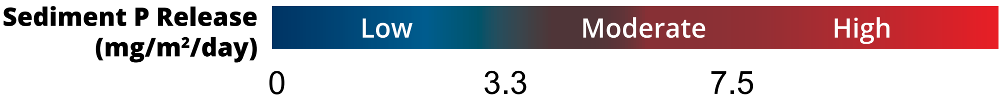
- Rough fish management
- AIS management
- Internal load management study
- Manage upstream load



*Fish IBI has not been assessed



*Sample date: 7/18/2013

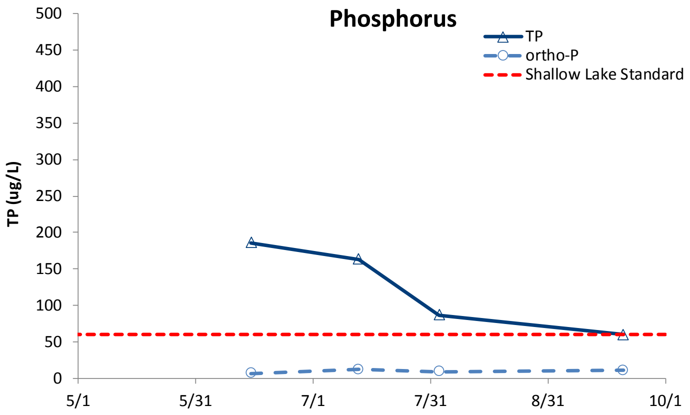


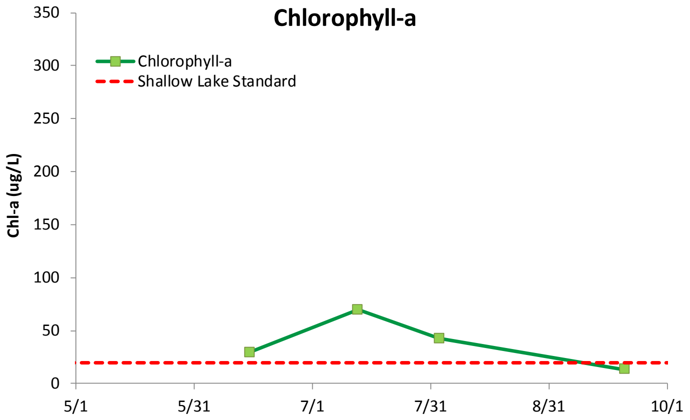
*Sediment release rate has not been assessed

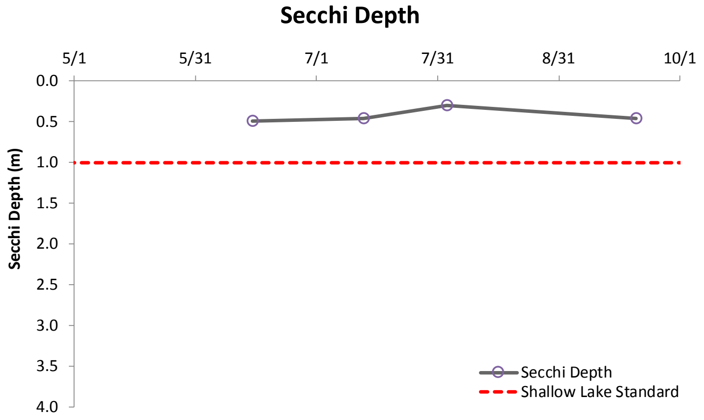
HENSHAW LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

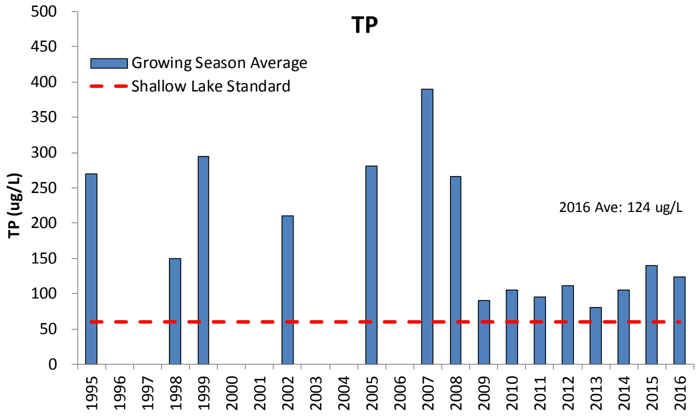
2016 Water Quality



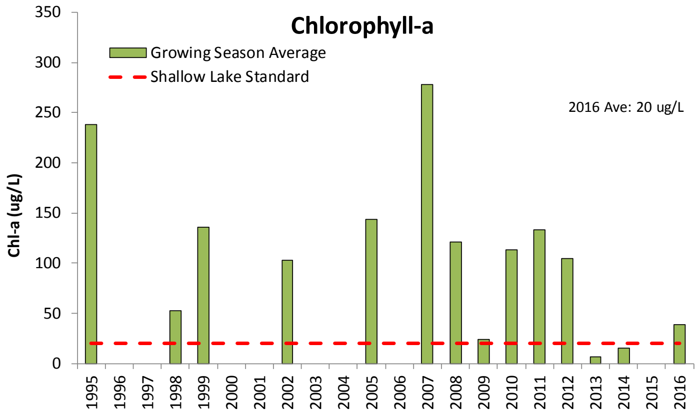




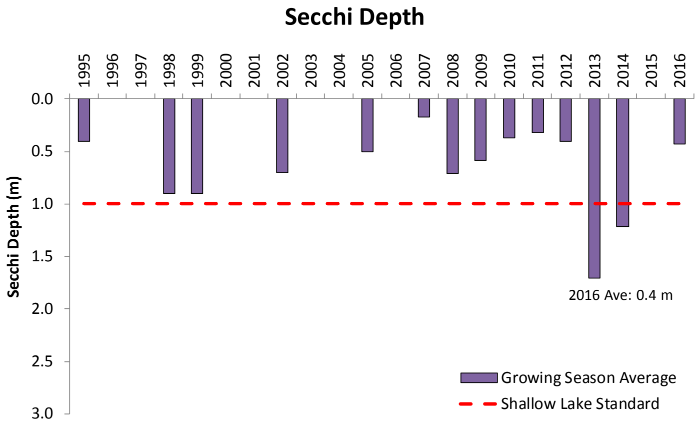
Historic Water Quality



2016 Ave: 124 ug/L



2016 Ave: 20 ug/L



2016 Ave: 0.4 m

WENCK

LAKE AUGUSTA

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 65 acres

Residence Time: 55 days

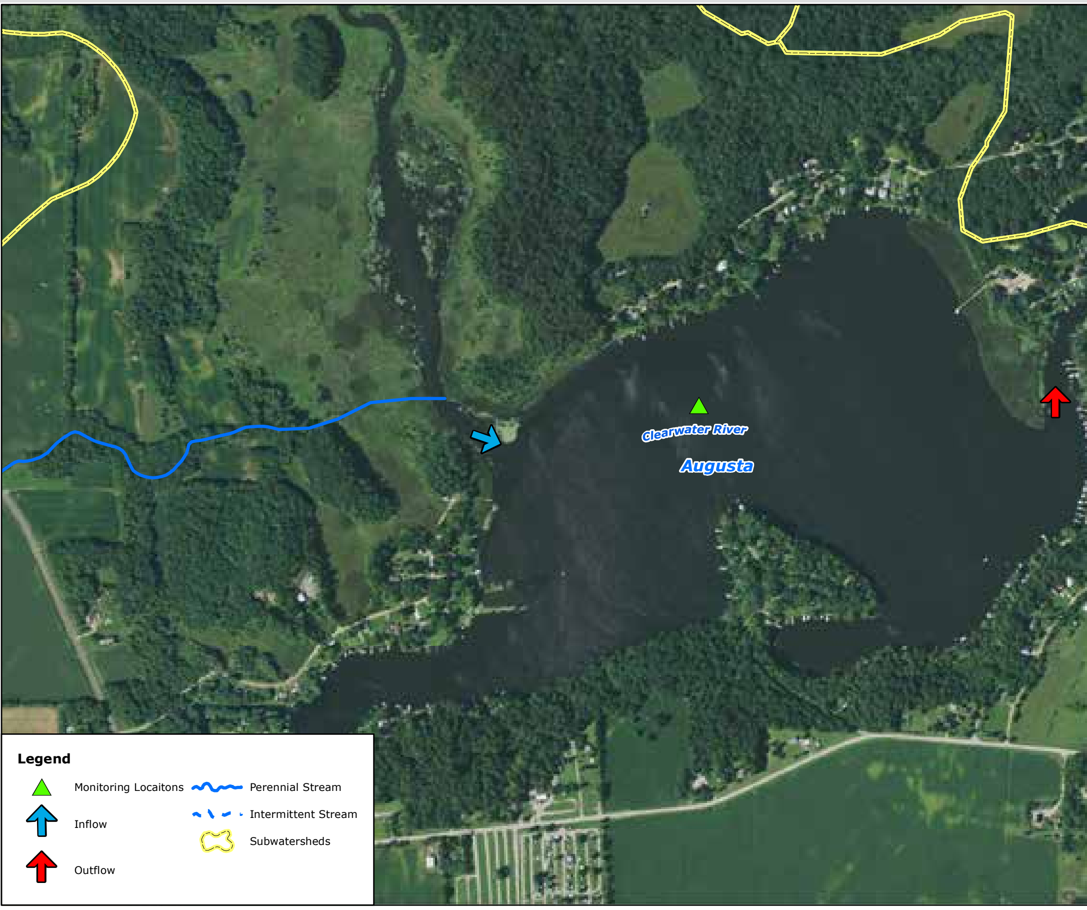
Surface Area: 187 acres

Subwatershed Area: 62,936 acres

Maximum Depth: 82 feet

Upstream Waters: Caroline, Louisa, Marie

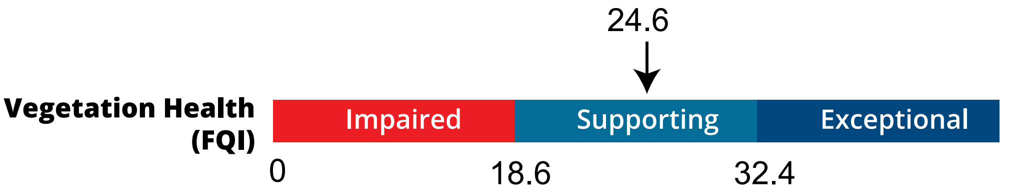
Common Fish	Bluegill, Northern Pike, Crappie, Yellow Bullhead, Common Carp
Dominant Vegetation	No Recent Survey
Invasive Species	Eurasian water milfoil, curly-leaf pondweed, zebra mussles
Status	Impaired, TMDL completed in 2010



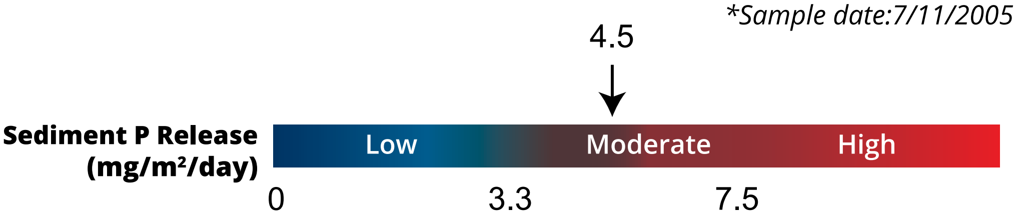
TO DO LIST

- Manage upstream loads
- AIS management

*Fish IBI has not been assessed



*Sample date:7/11/2005

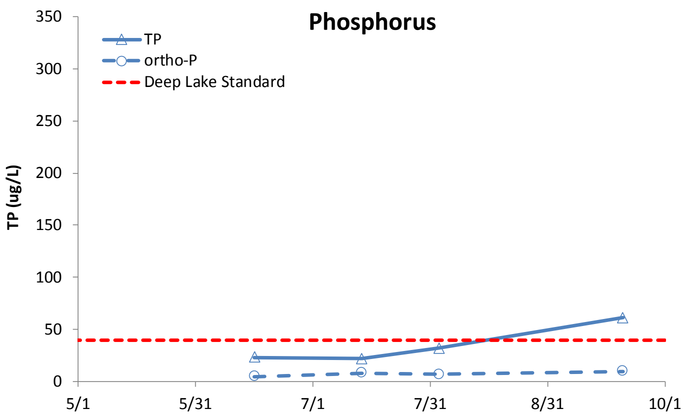


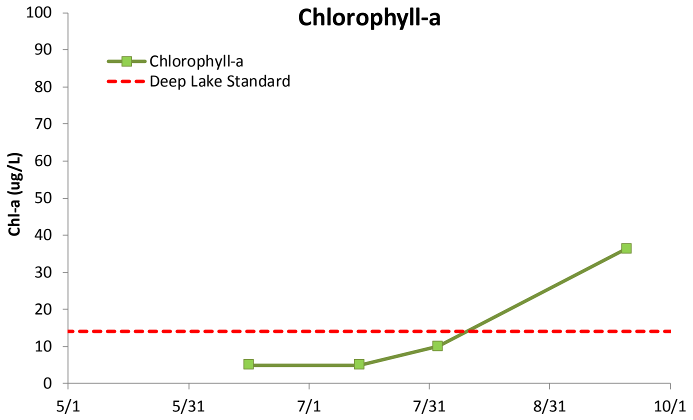
*Sample date: 2010

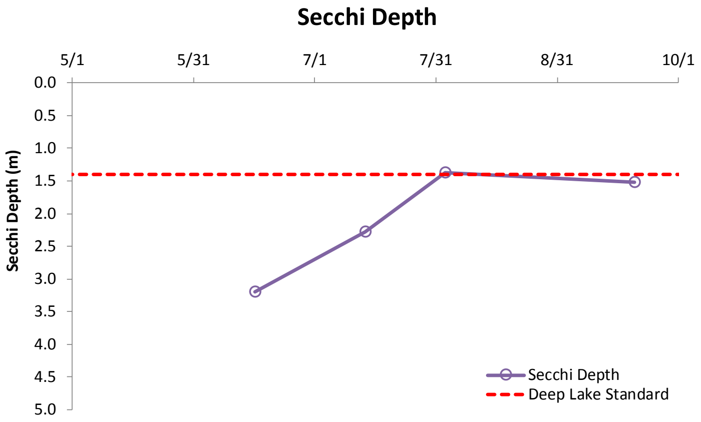
LAKE AUGUSTA

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

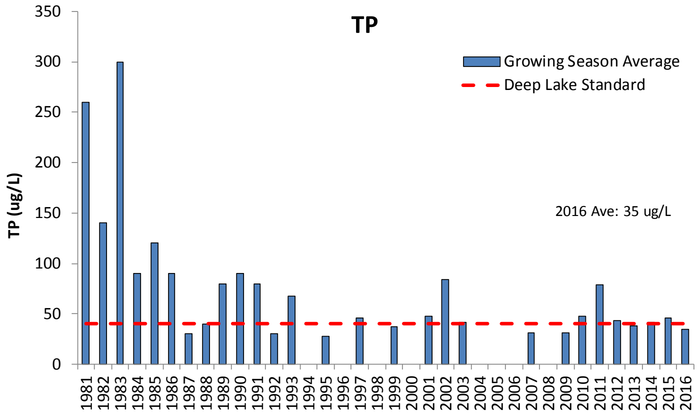
2016 Water Quality

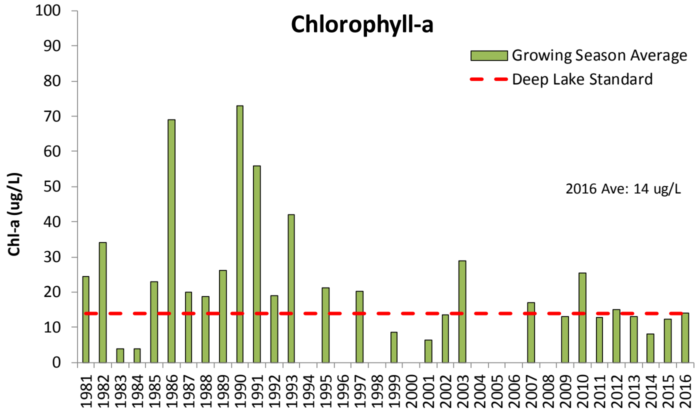


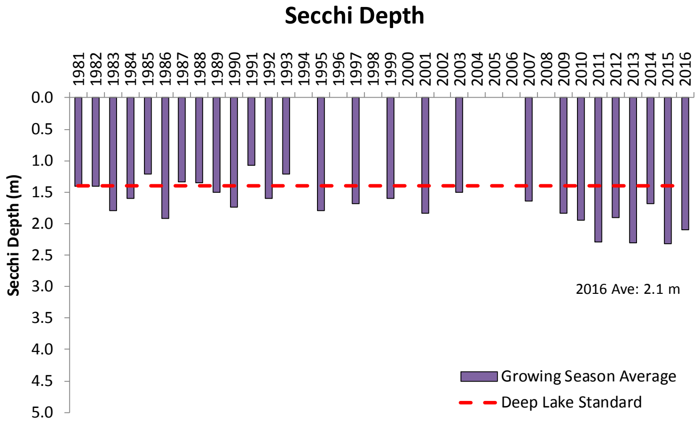




Historic Water Quality







WENCK

LAKE BETSY

QUICK FACTS

Littoral Area: 90 acres

Residence Time: 33 days

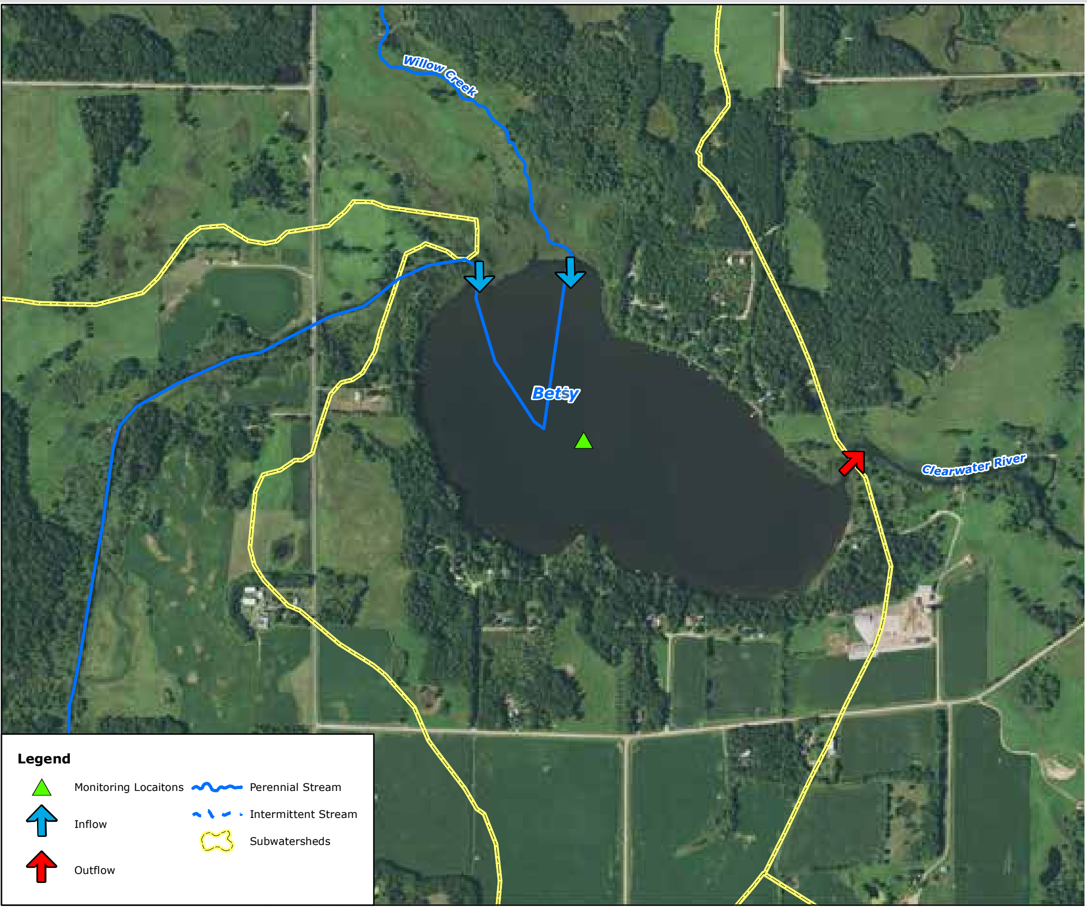
Surface Area: 154 acres

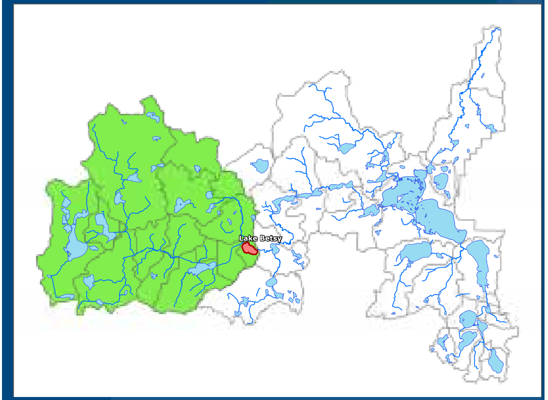
Subwatershed Area: 43,789 acres

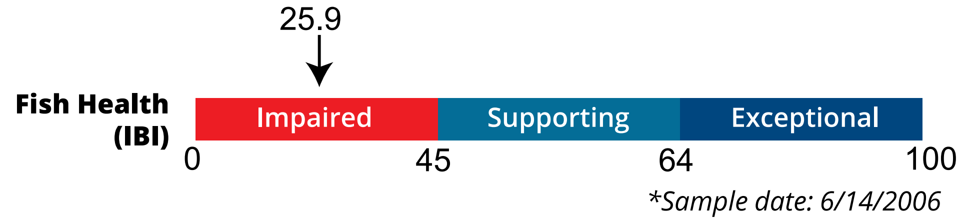
Maximum Depth: 29 feet

Upstream Waters: Clearwater River

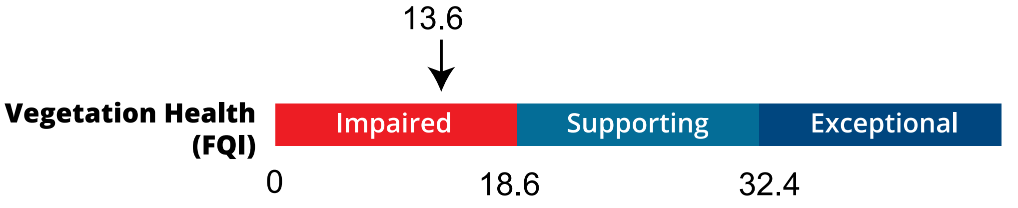
Common Fish	Channel Catfish, Northern Pike, Black Crappie, Bluegill, Common Carp
Dominant Vegetation	Coontail, Curly-leaf pondweed
Invasive Species	Curly-leaf pondweed
Status	Impaired, TMDL completed in 2009



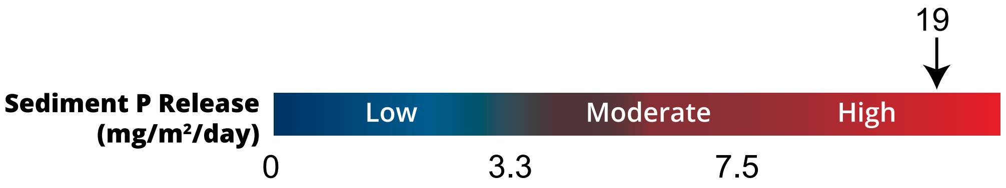




*Sample date: 6/14/2006



*Sample date: 7/30/2007



*Sample date: 2009

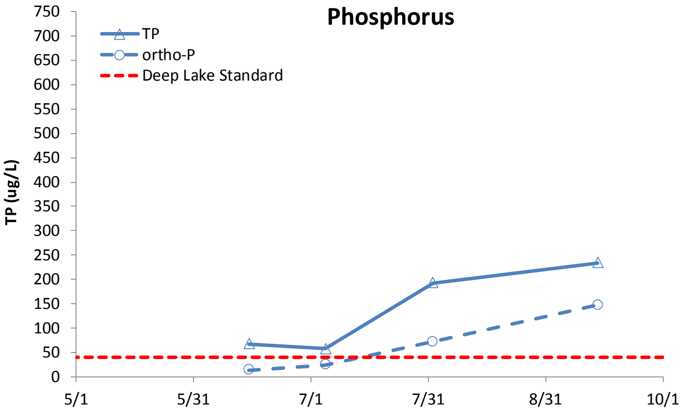
TO DO LIST

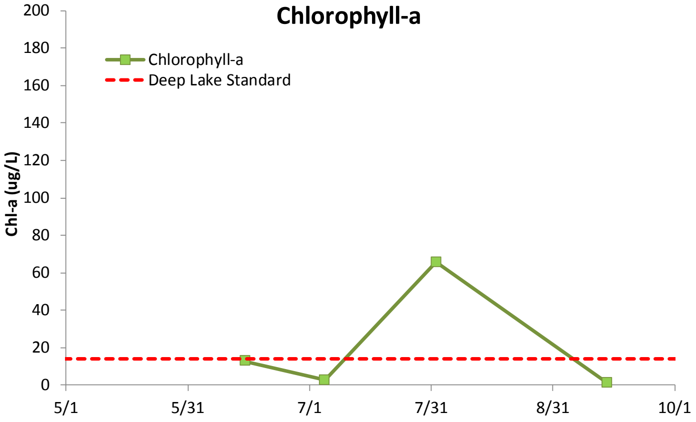
- Rough fish management
- Internal load reduction study and implementation
- Manage upstream loads
- AIS management

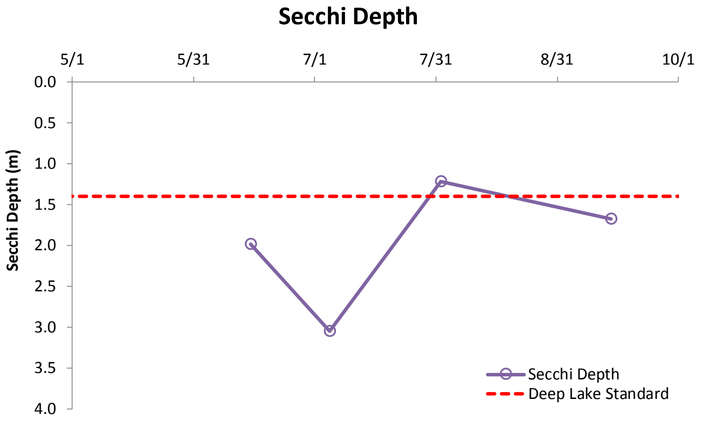
LAKE BETSY

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

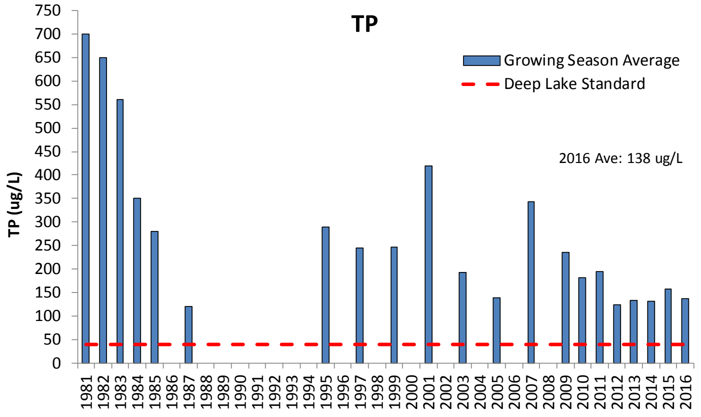
2016 Water Quality

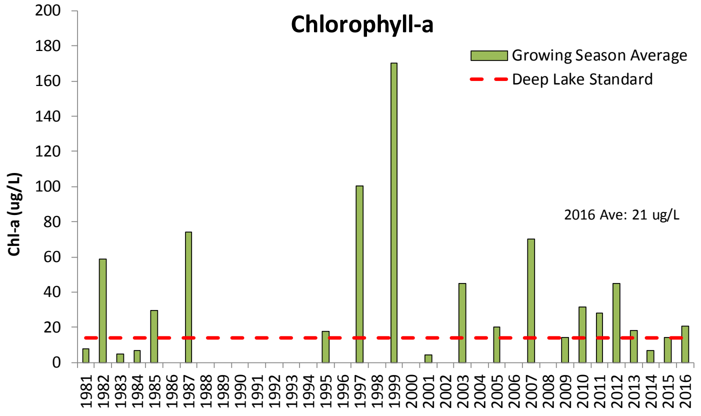


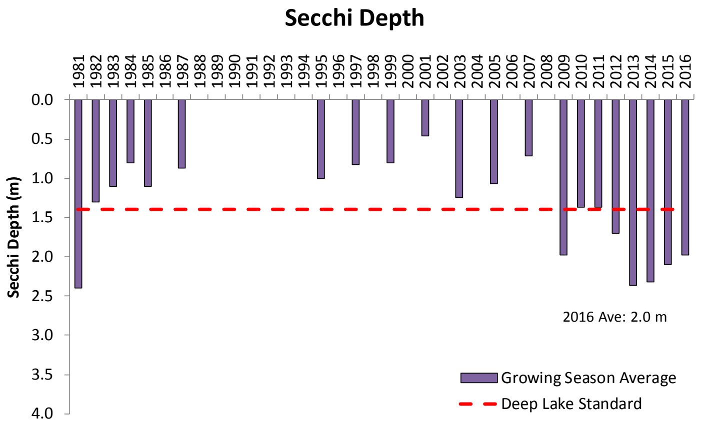




Historic Water Quality







WENCK

LAKE CAROLINE

QUICK FACTS

Littoral Area: 46 acres

Residence Time: 26 days

Surface Area: 135 acres

Subwatershed Area: 60,132 acres

Maximum Depth: 45 feet

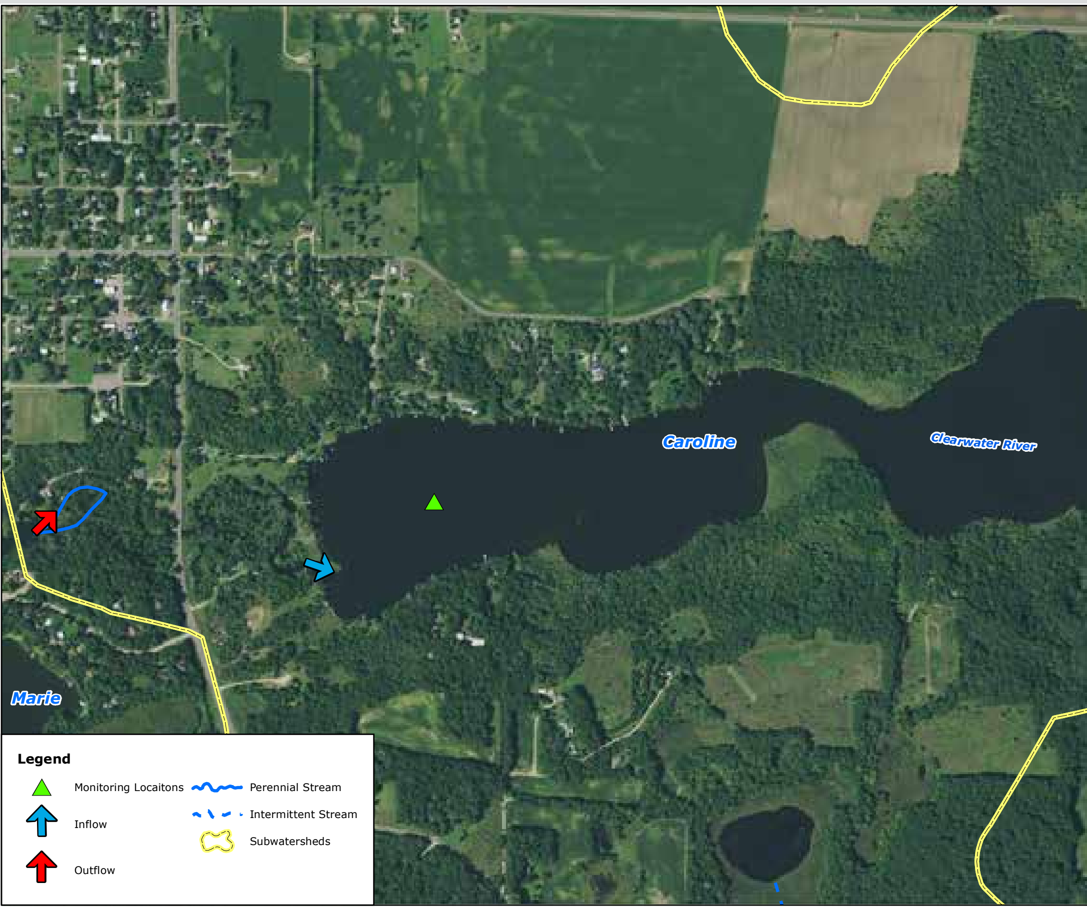
Upstream Waters: Louisa, Marie

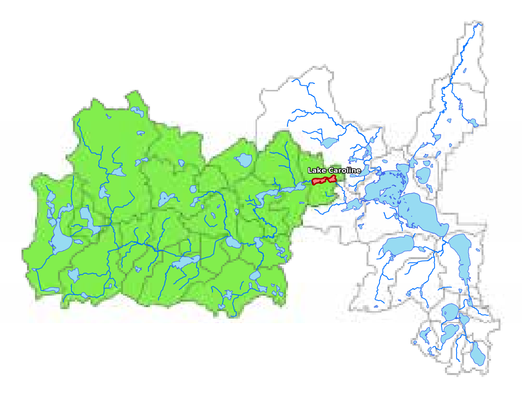
Common Fish: Black Crappie, Bluegill, Northern Pike, Largemouth Bass, Common Carp, Walleye, White Sucker

Dominant Vegetation: No Recent Survey

Invasive Species: Curly-leaf pondweed, Eurasian watermilfoil

Status: Impaired, TMDL completed in 2010

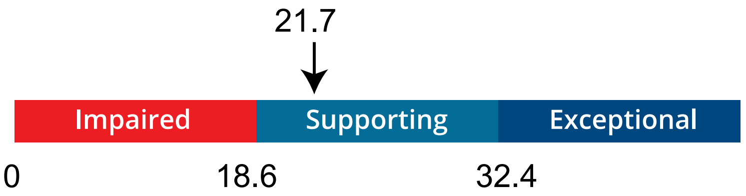




Fish Health (IBI)

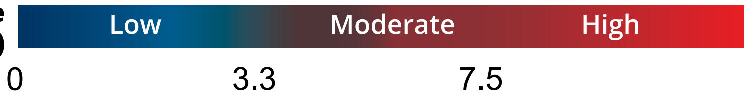
*Fish IBI has not been assessed

Vegetation Health (FQI)



*Sample date: 6/28/2005

Sediment P Release (mg/m²/day)



*Sediment release rate has not been assessed

TO DO LIST

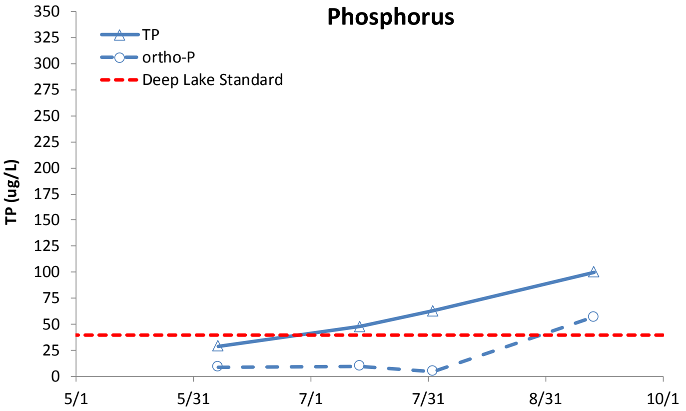
- Manage upstream loads
- AIS management
- Internal load management study

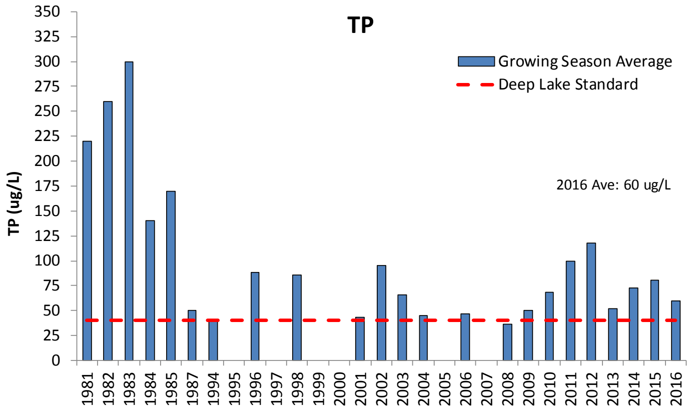
LAKE CAROLINE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

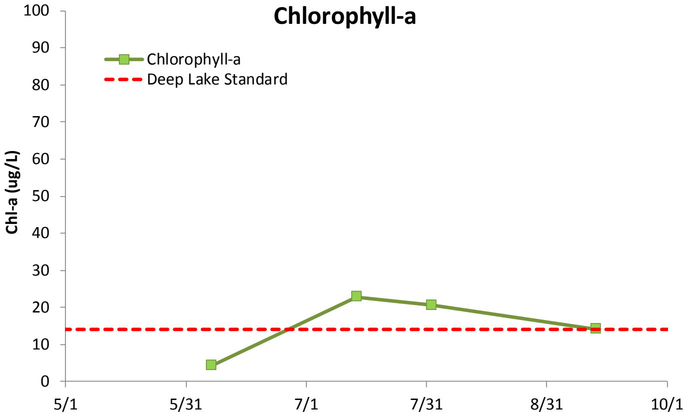
2016 Water Quality

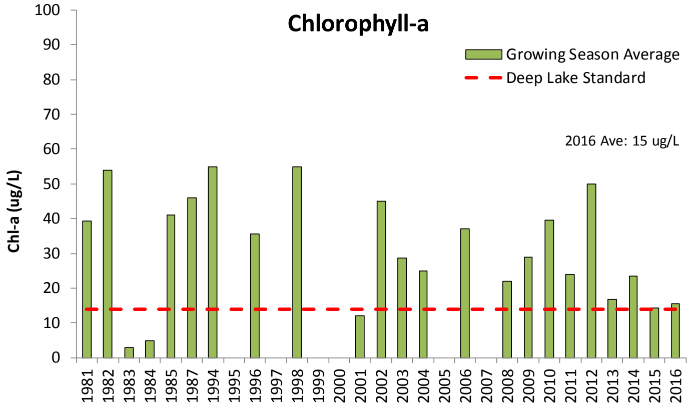
Historic Water Quality



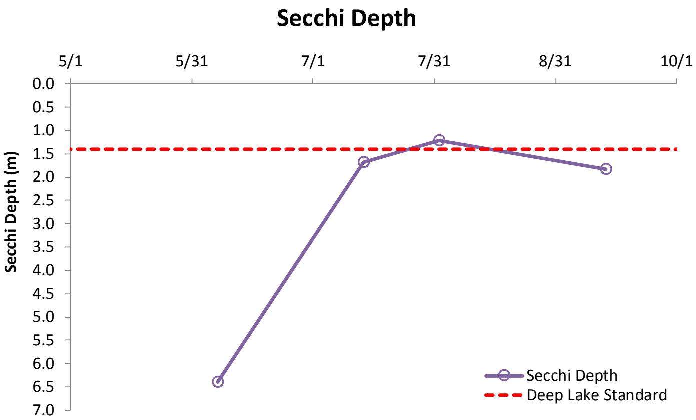


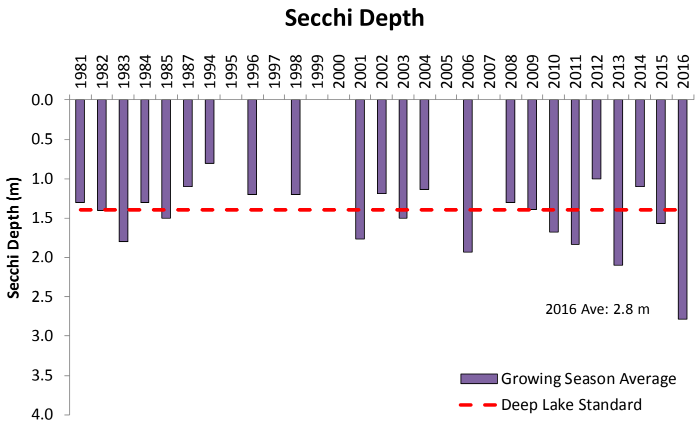
2016 Ave: 60 ug/L





2016 Ave: 15 ug/L





2016 Ave: 2.8 m

WENCK

LAKE LOUISA

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 122 acres

Residence Time: 17 days

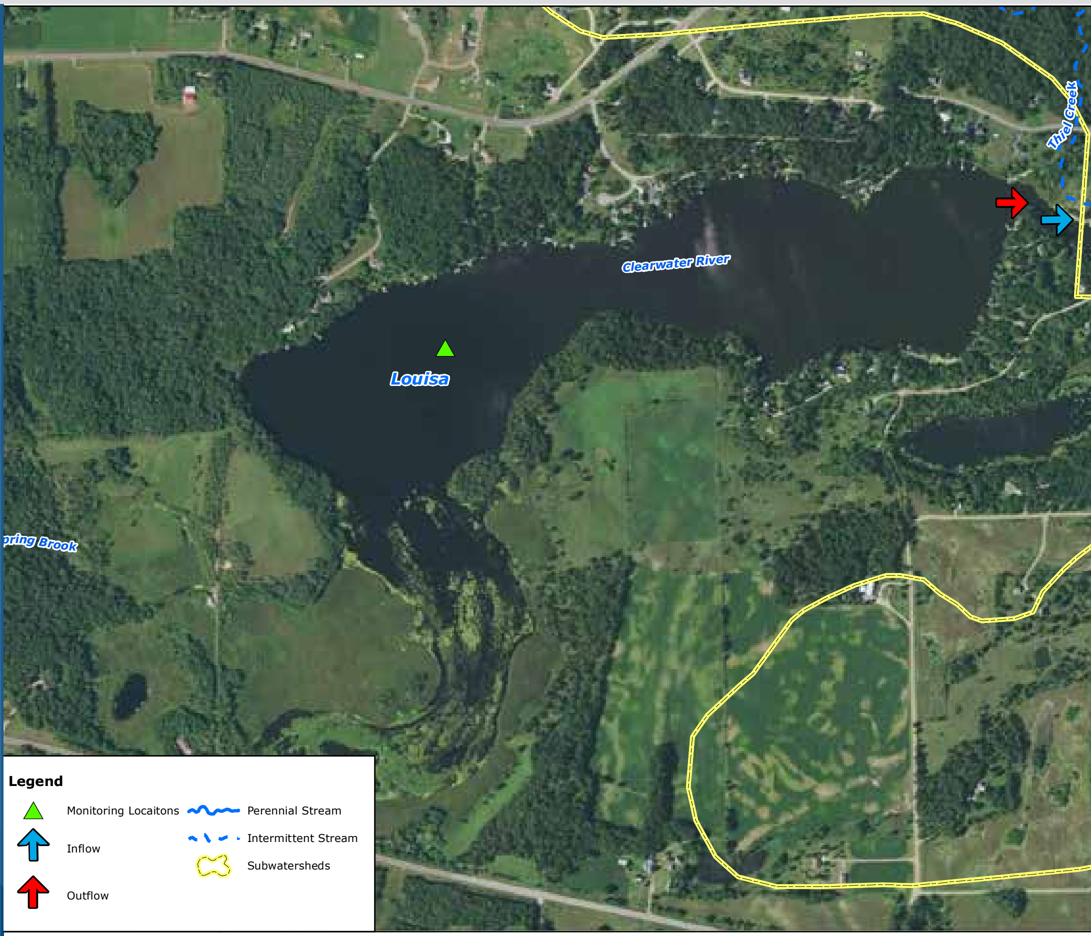
Surface Area: 189 acres

Subwatershed Area: 58,881 acres

Maximum Depth: 44 feet

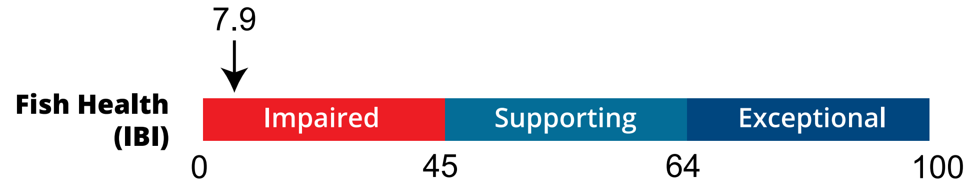
Upstream Waters: Clearwater River, Lake Betsy

Common Fish	Bluegill, Northern Pike, Largemouth Bass, White Sucker
Dominant Vegetation	No Recent Survey
Invasive Species	Curly-leaf pondweed
Status	Impaired, TMDL Completed 2009

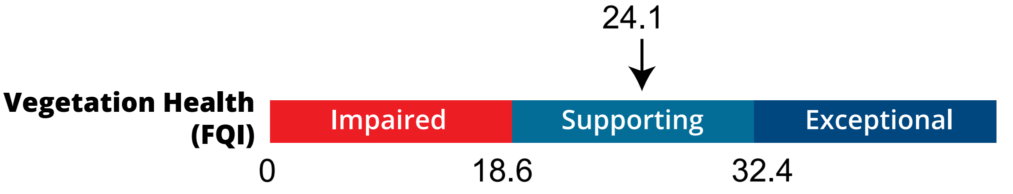


TO DO LIST

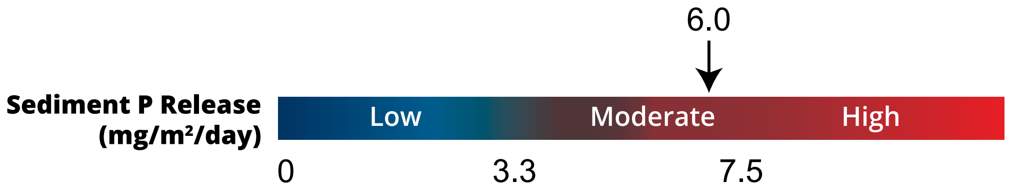
- Manage upstream loads
- AIS management
- Internal load management study



*Sample date: 8/17/2006



*Sample date: 6/20/2005



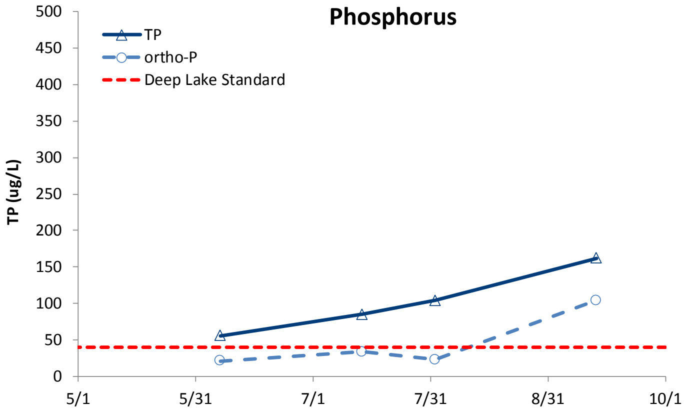
*Sediment release rate has not been assessed

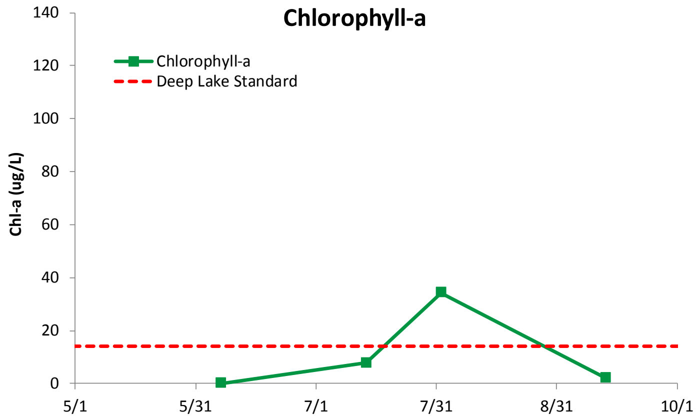
*Sample date: 2003

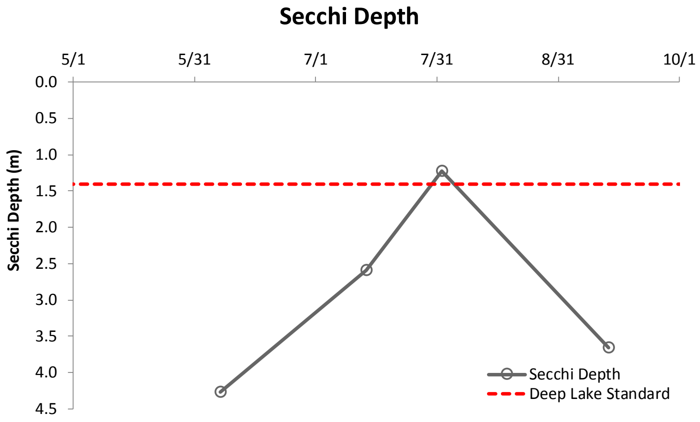
WENCK

LAKE LOUISA

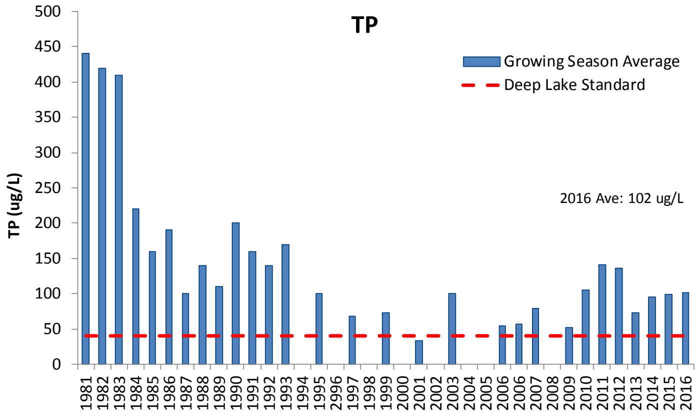
2016 Water Quality

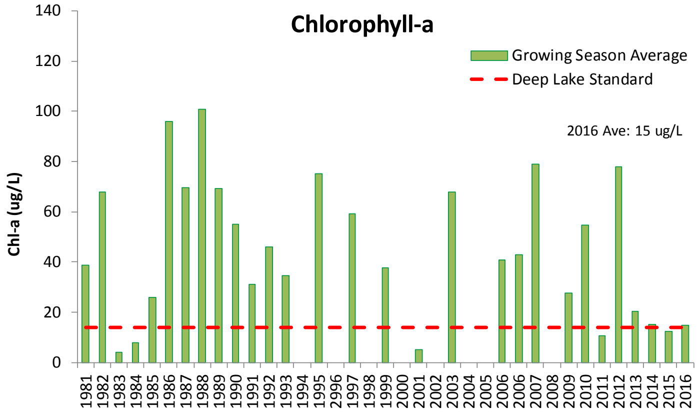


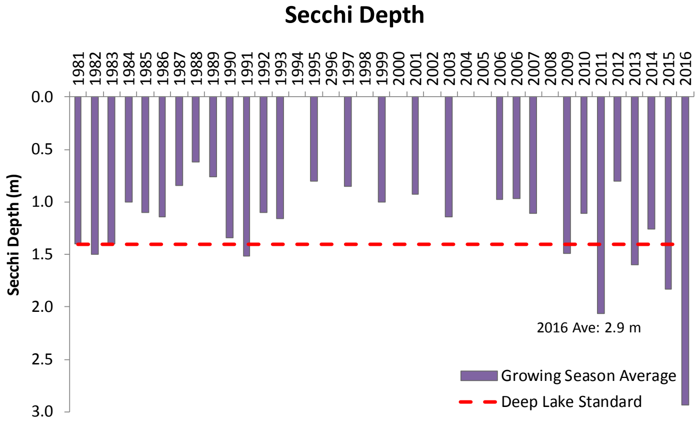




Historic Water Quality







LAKE MARIE

QUICK FACTS

Littoral Area: 107 acres

Residence Time: 24 days

Surface Area: 146 acres

Subwatershed Area: 59,837 acres

Maximum Depth: 36 feet

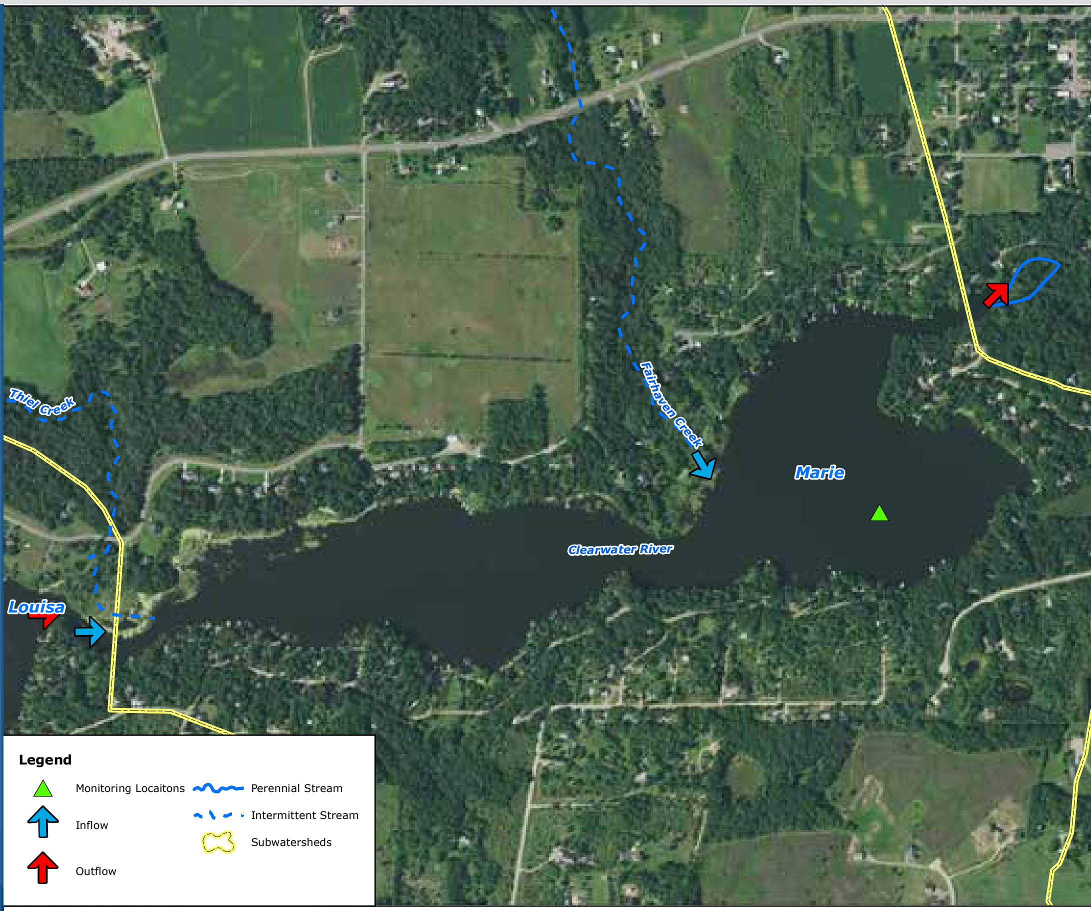
Upstream Waters: Clearwater River, Louisa

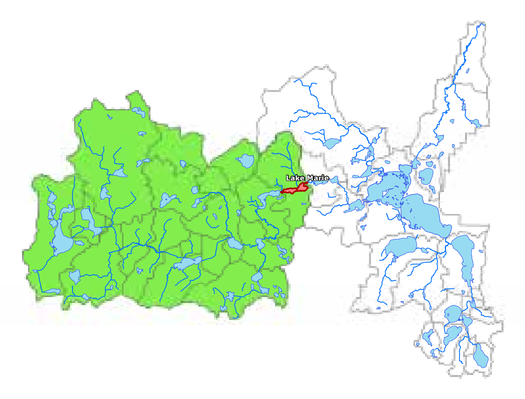
Common Fish: Black Crappie, Bluegill, Northern Pike, White Sucker, Yellow Perch

Dominant Vegetation: No Recent Survey

Invasive Species: Curly-leaf pondweed

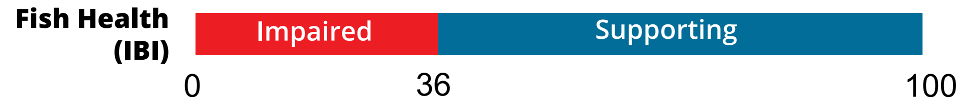
Status: Impaired, TMDL Completed 2009



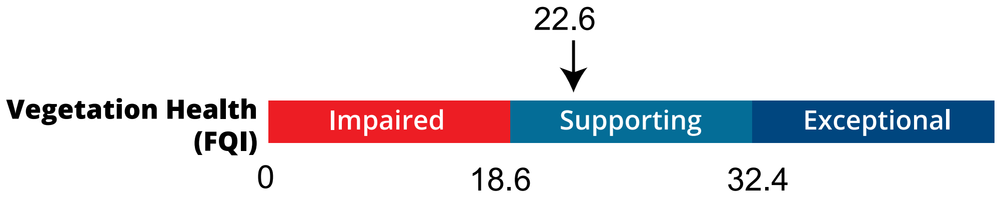


TO DO LIST

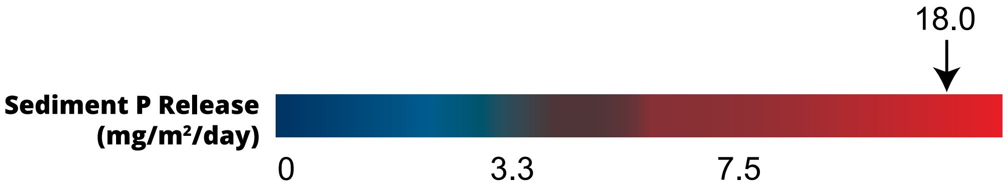
- Manage upstream loads
- AIS management
- Internal load management study



*Fish IBI has not been assessed



*Sample date: 6/23/2005

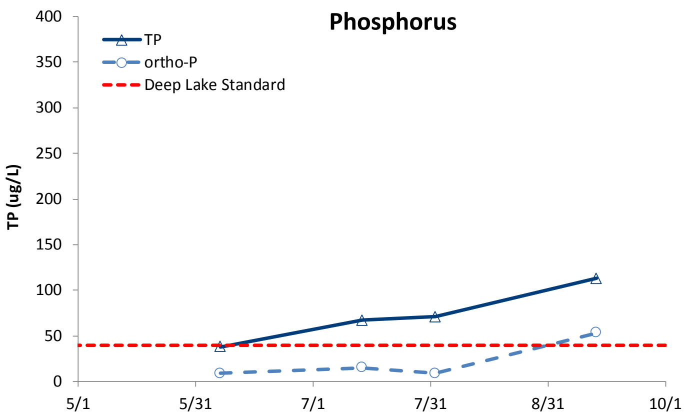


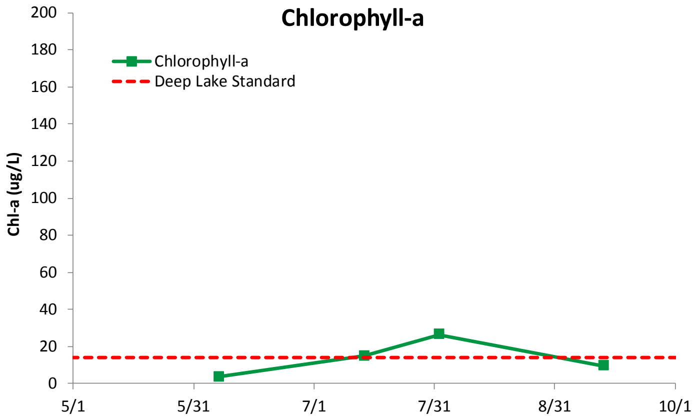
*Sediment release rate has not been assessed

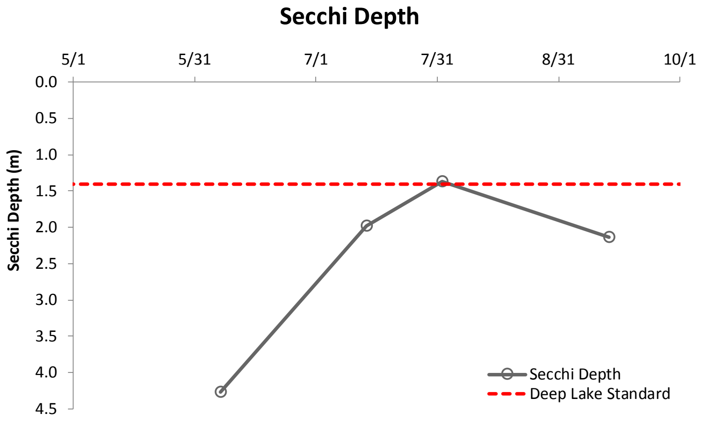
*Sample date: 2003

LAKE MARIE

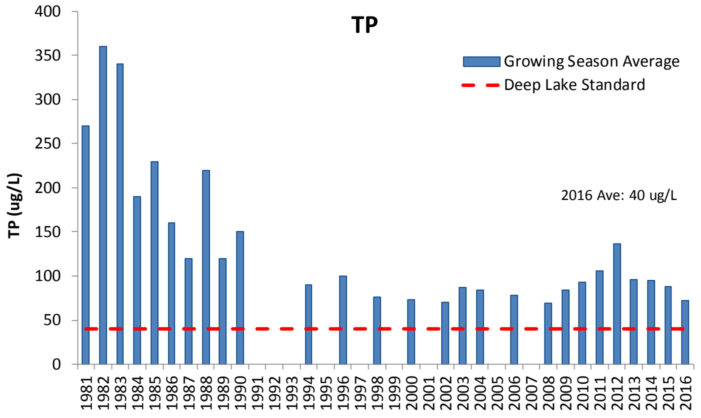
2016 Water Quality

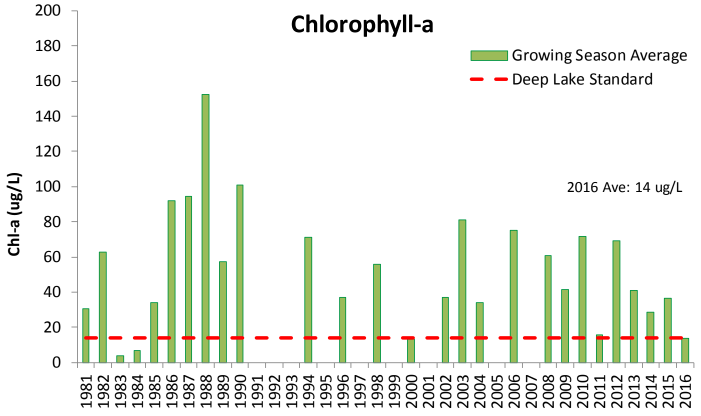


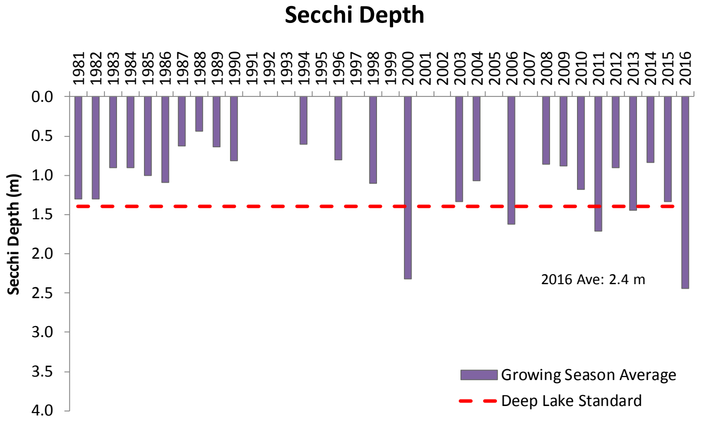




Historic Water Quality







NIXON LAKE

QUICK FACTS

Littoral Area: 33 acres

Surface Area: 60 acres

Subwatershed Area: 690 acres

Maximum Depth: 67 feet

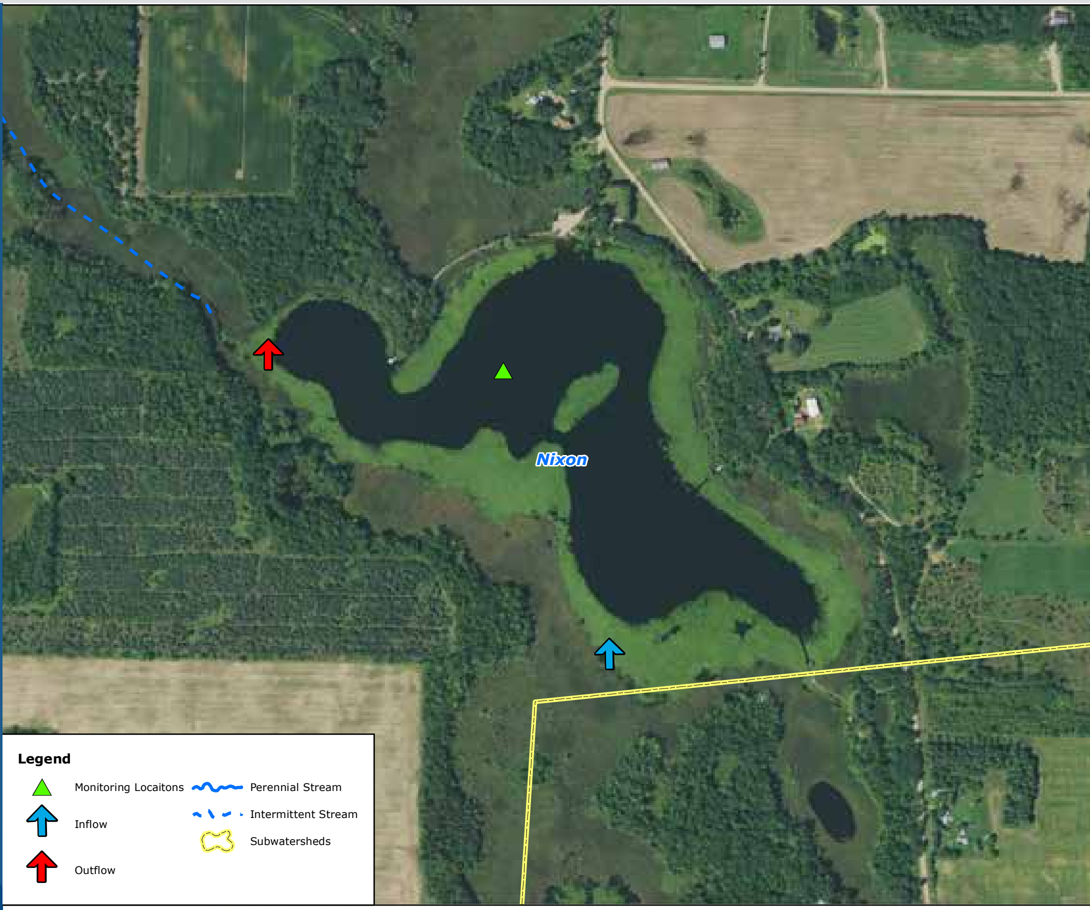
Upstream Waters: None

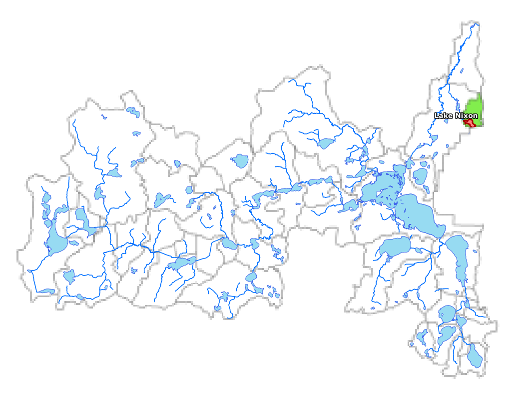
Common Fish: Bluegill, Northern Pike, Yellow Bullhead, Largemouth Bass

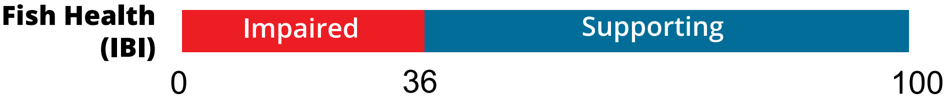
Dominant Vegetation: Currently obtaining vegetation info from DNR

Invasive Species: Currently obtaining vegetation info from DNR

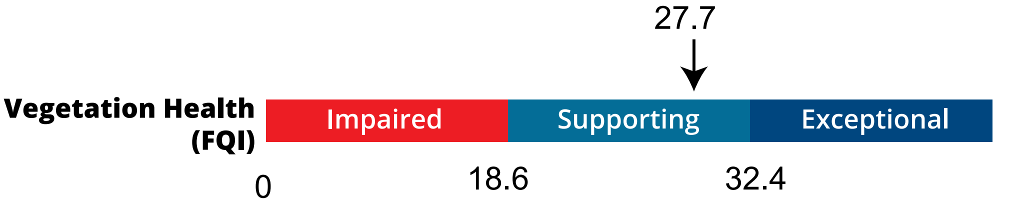
Status: Not impaired



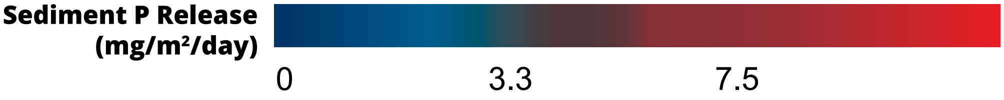




*Fish IBI has not been assessed



*Sample date: 7/29/2014



*Sediment release rate has not been assessed

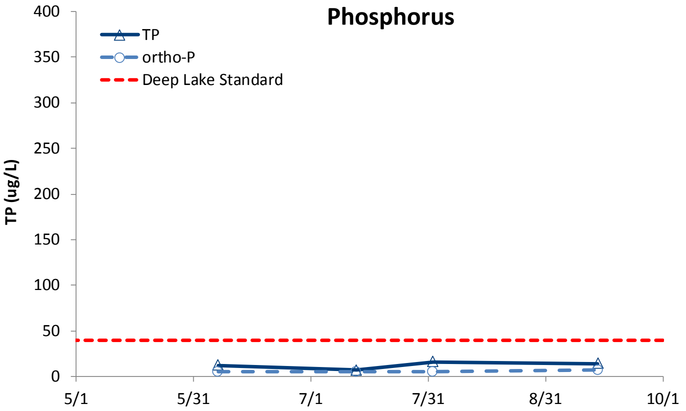
TO DO LIST

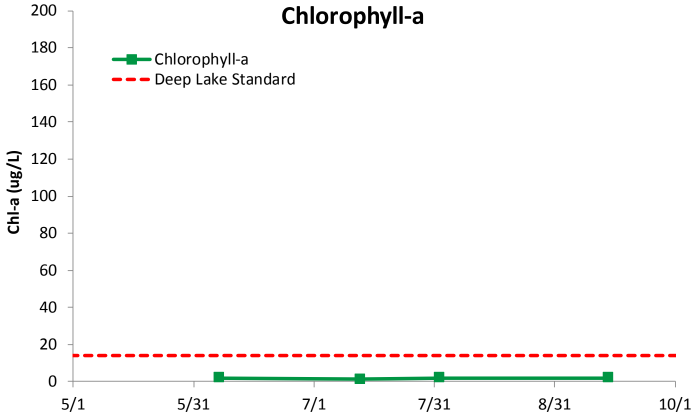
- Protect water quality
- Manage upstream loads
- AIS management and prevention

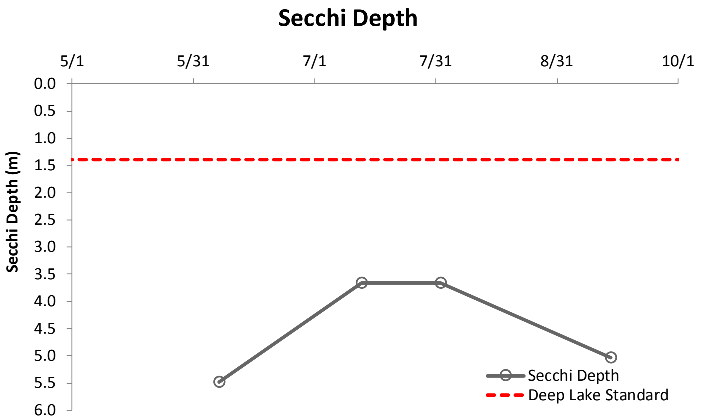
NIXON LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

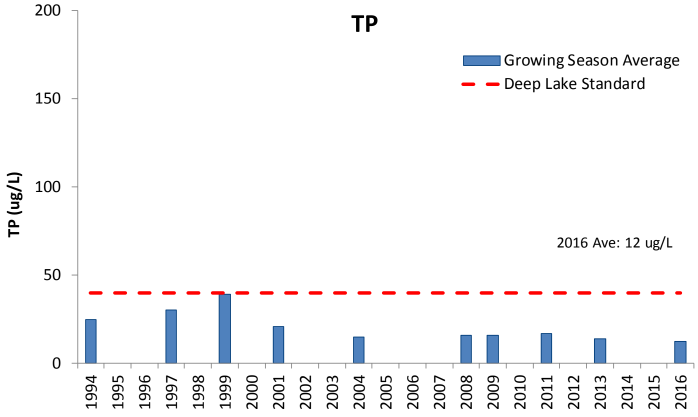
2016 Water Quality

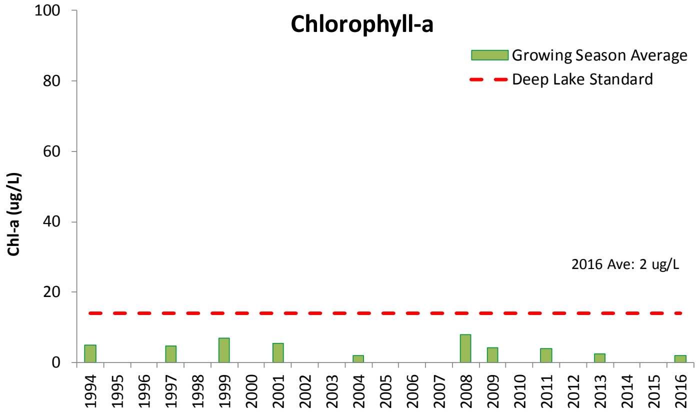


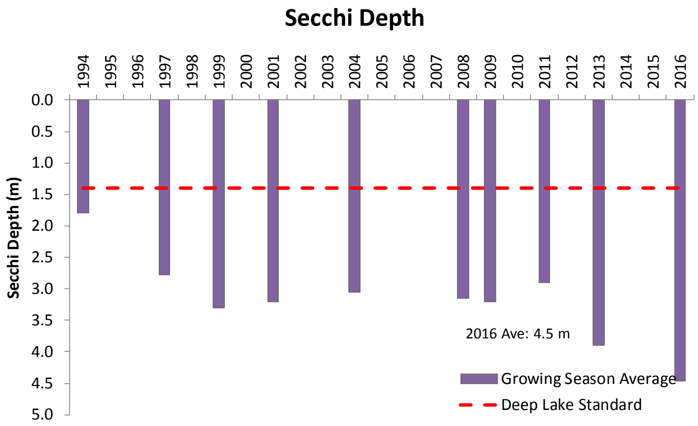




Historic Water Quality







WENCK

OTTER LAKE

QUICK FACTS

Littoral Area: 32 acres

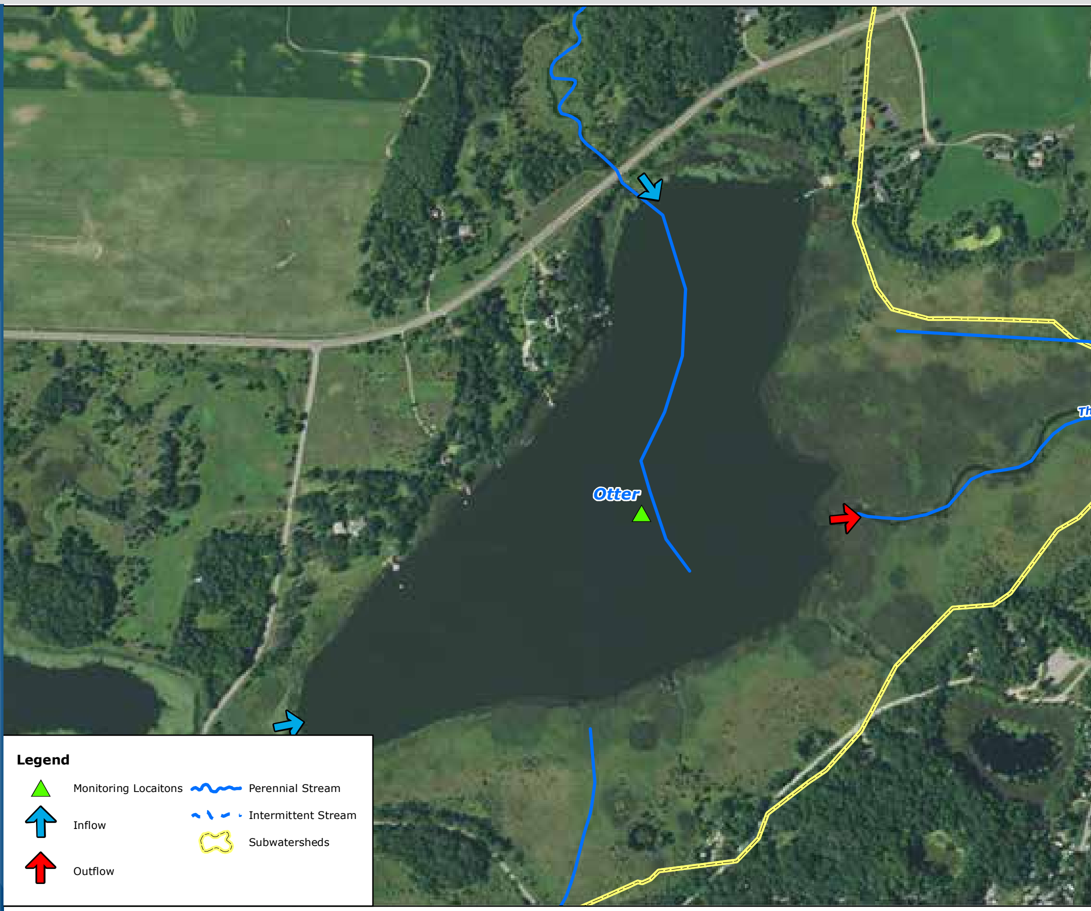
Surface Area: 92 acres

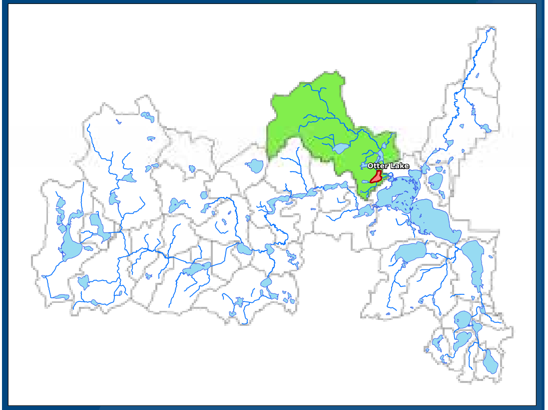
Subwatershed Area: 10,574 acres

Maximum Depth: 51 feet

Upstream Waters: Lake Laura

Common Fish	Black Crappie, Bluegill, Northern Pike, Largemouth Bass, Walleye
Dominant Vegetation	Diverse community
Invasive Species	Curly-leaf pondweed, Eurasian water milfoil
Status	Not impaired





TO DO LIST

- ▲ Protect water quailty
- ▲ Manage upstream loads

Fish Health (IBI)

Impaired	Supporting	Exceptional

0 45 64 100

**Fish IBI has not been assessed*

25.6 ↓

Vegetation Health (FQI)

Impaired	Supporting	Exceptional

0 18.6 32.4

**Sample date: 8/15/2011*

Sediment P Release (mg/m²/day)

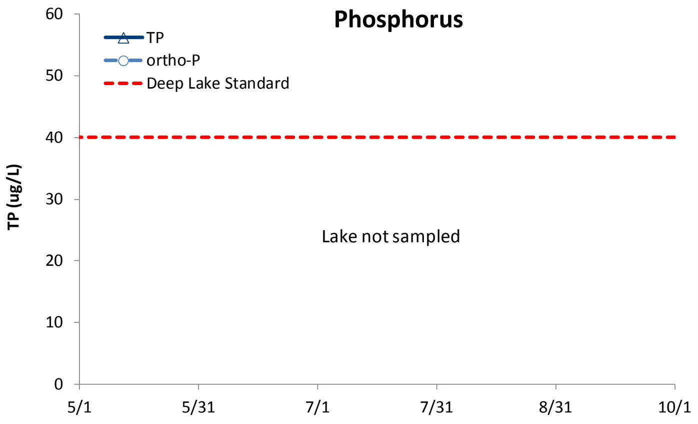
Low	Moderate	High

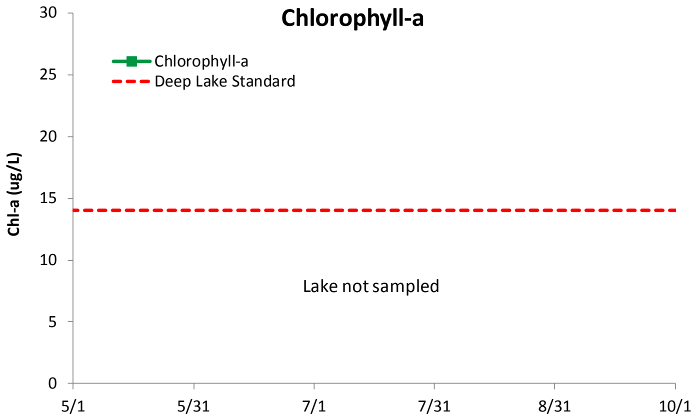
0 3.3 7.5

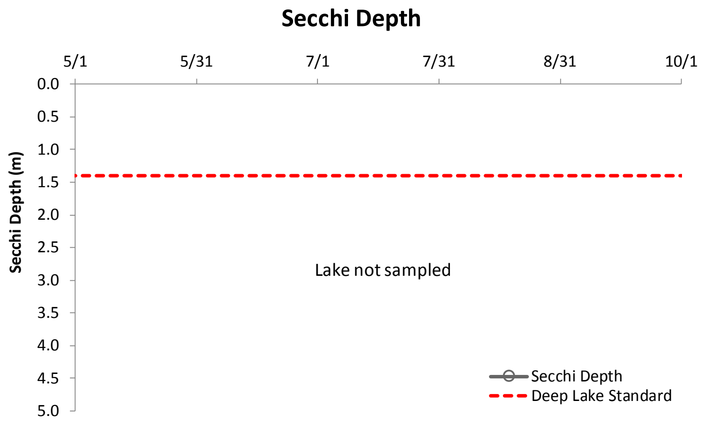
**Sediment release rate has not been assessed*

OTTER LAKE

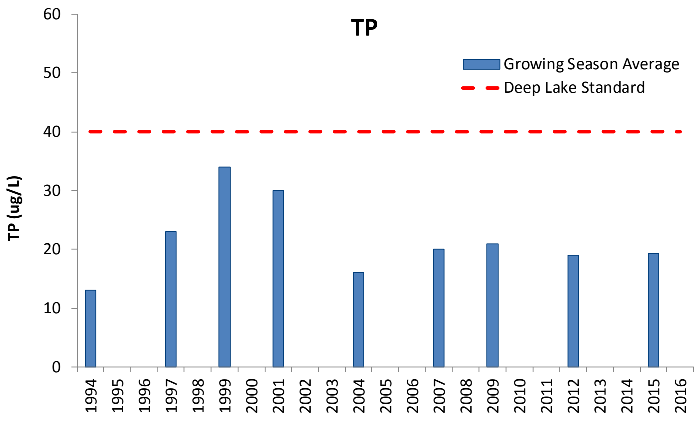
2016 Water Quality

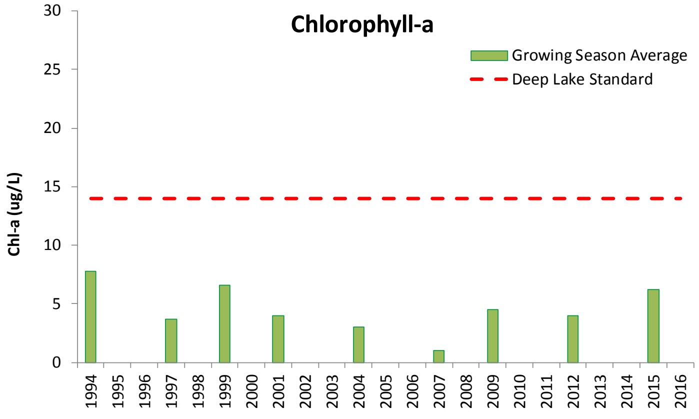


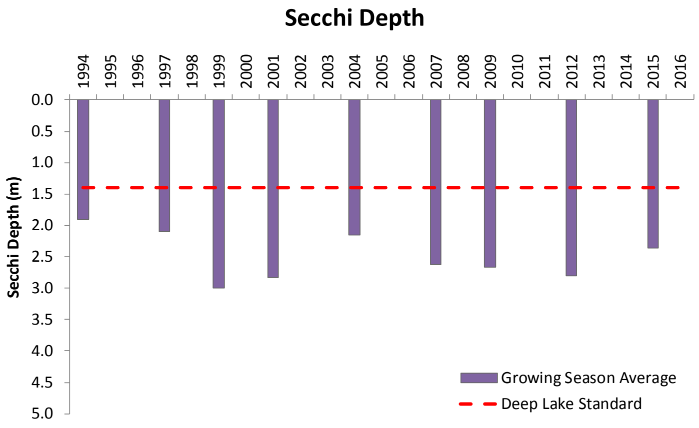




Historic Water Quality







PLEASANT LAKE

QUICK FACTS

Littoral Area: 260 acres

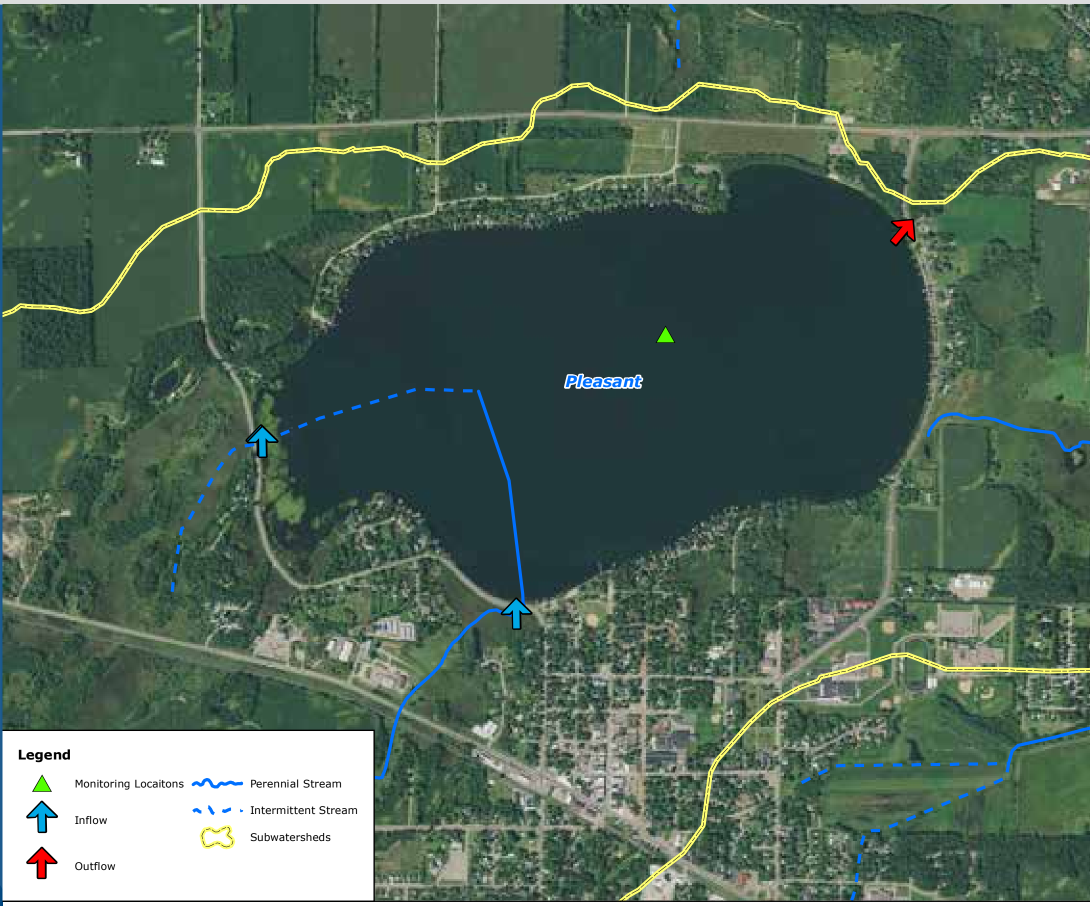
Surface Area: 597 acres

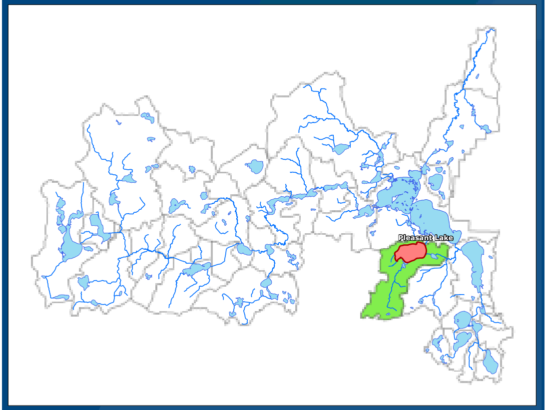
Subwatershed Area: 4,325 acres

Maximum Depth: 74 feet

Upstream Waters: None

Common Fish	Bluegill, Yellow Bullhead, Northern Pike, Pumpkinseed Sunfish
Dominant Vegetation	Currently obtaining vegetation info from DNR
Invasive Species	Currently obtaining vegetation info from DNR
Status	Not impaired

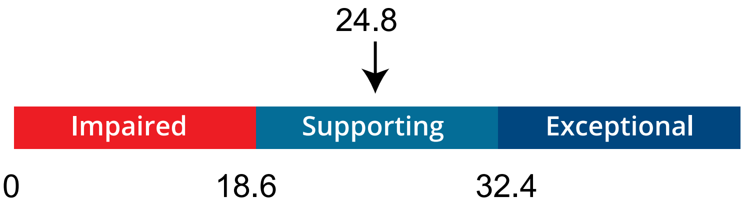




Fish Health (IBI)

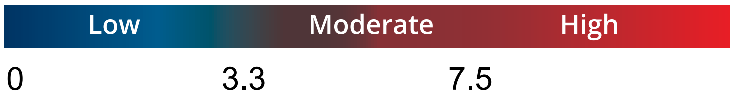
**Fish IBI has not been assessed*

Vegetation Health (FQI)



**Sample date: 7/30/2007*

Sediment P Release (mg/m²/day)



**Sediment release rate has not been assessed*

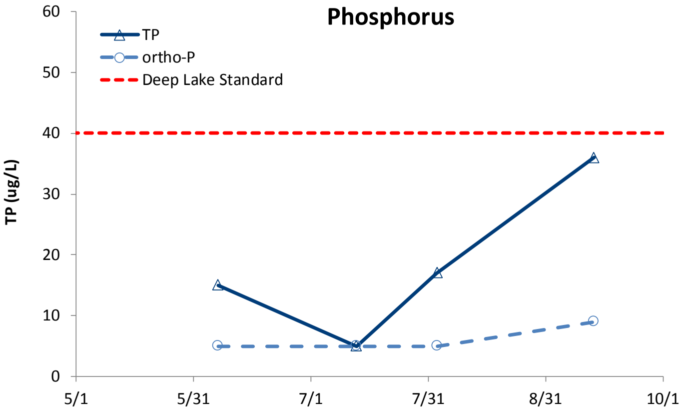
TO DO LIST

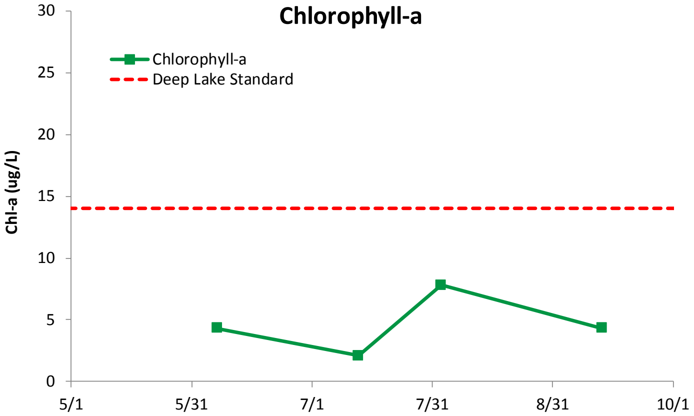
- Manage watershed loads
- Protect water quailty

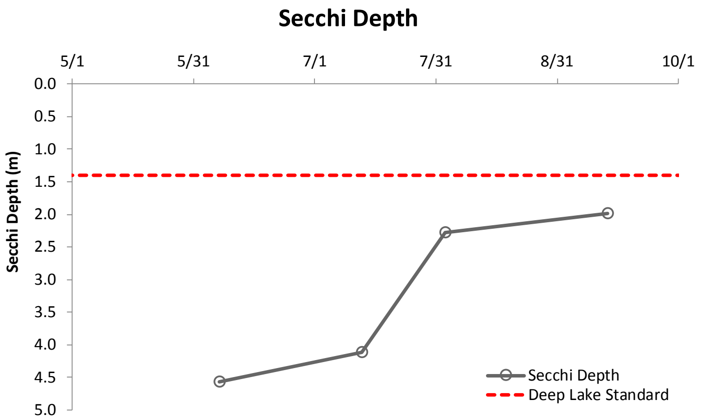
PLEASANT LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

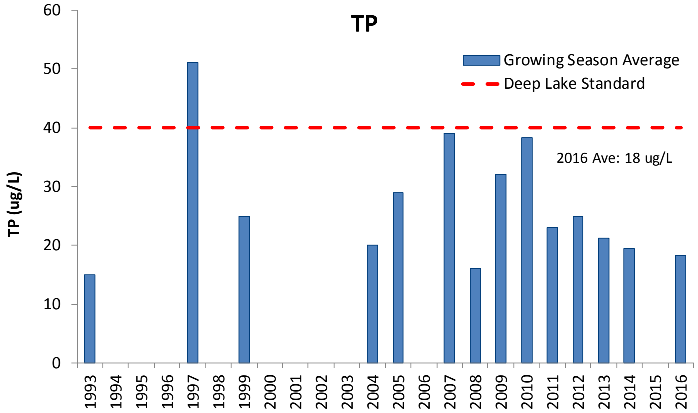
2016 Water Quality

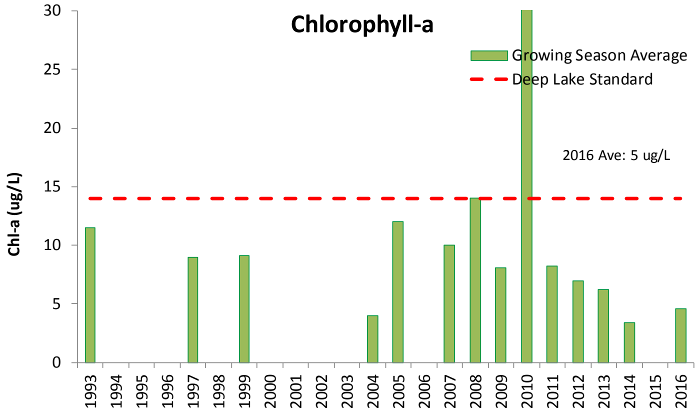


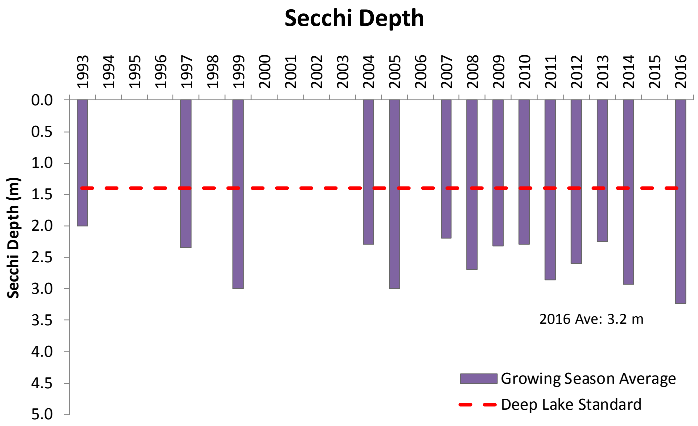




Historic Water Quality







SCHOOL SECTION LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 188 acres

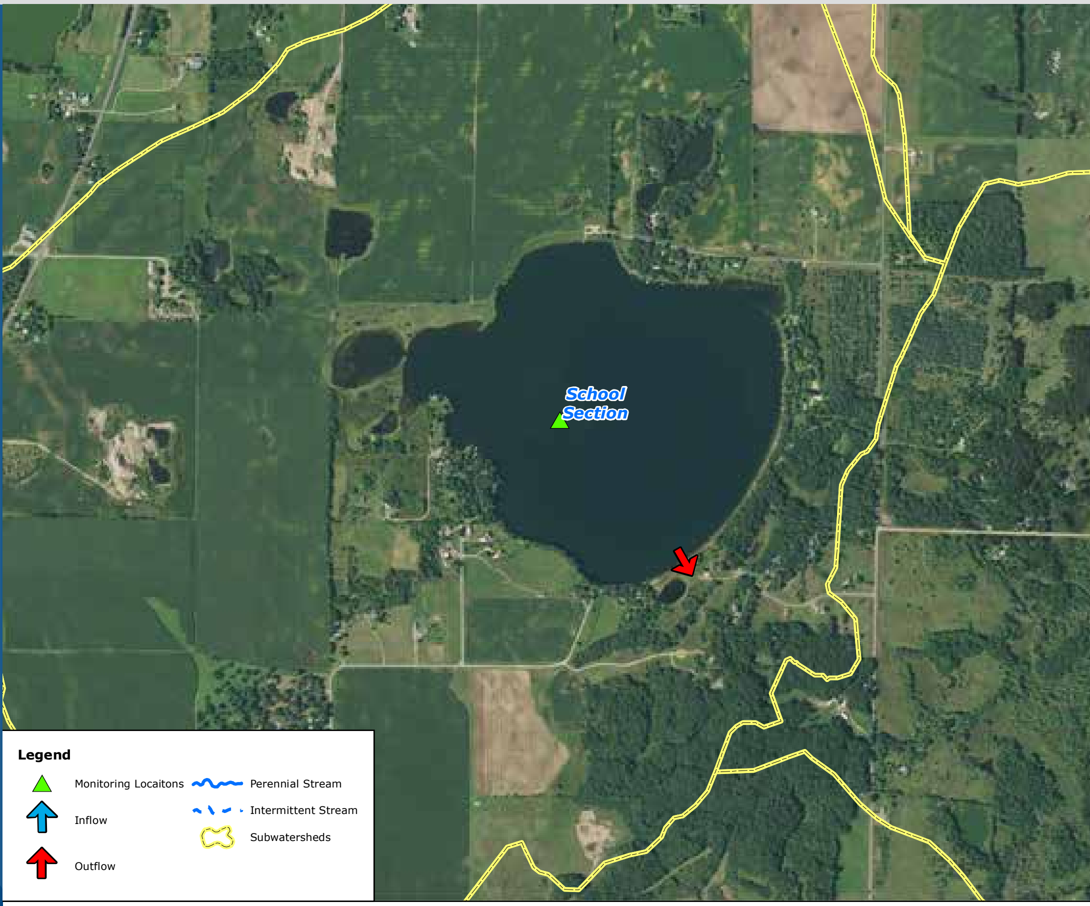
Surface Area: 193 acres

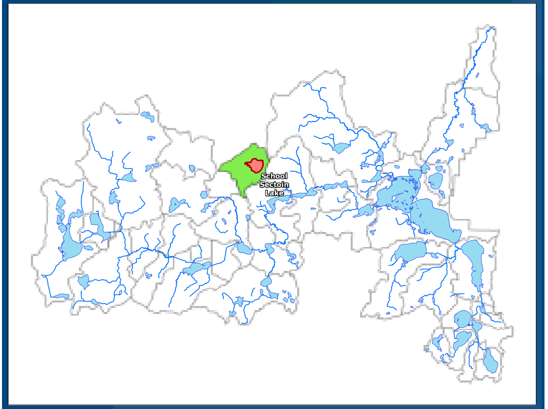
Subwatershed Area: 1,843 acres

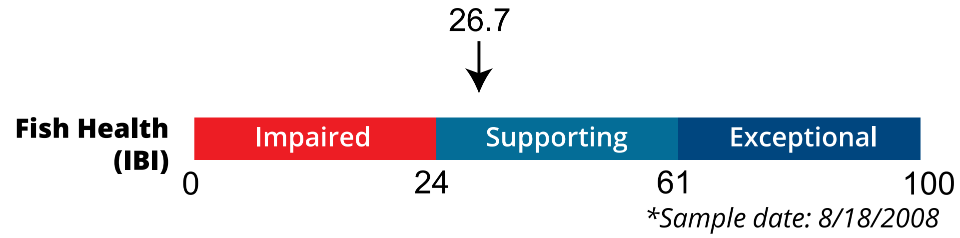
Maximum Depth: 12 feet

Upstream Waters: None

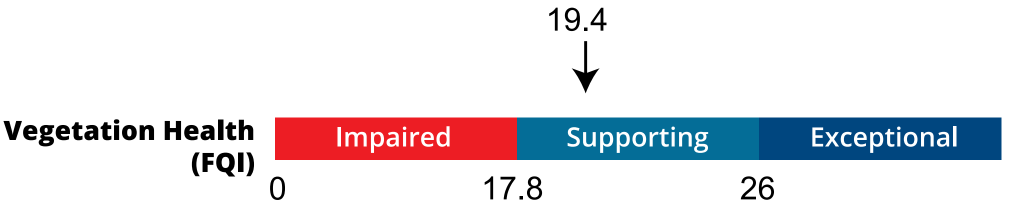
Common Fish	Black bullhead, Bluegill, Northern Pike
Dominant Vegetation	Northern water milfoil, Illinois pondweed, muskgrass
Invasive Species	Curly-leaf pondweed
Status	Not impaired



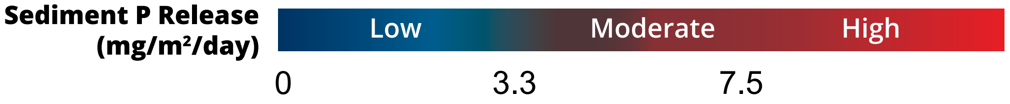




*Sample date: 8/18/2008



*Sample date: 8/11/2011



*Sediment release rate has not been assessed

TO DO LIST

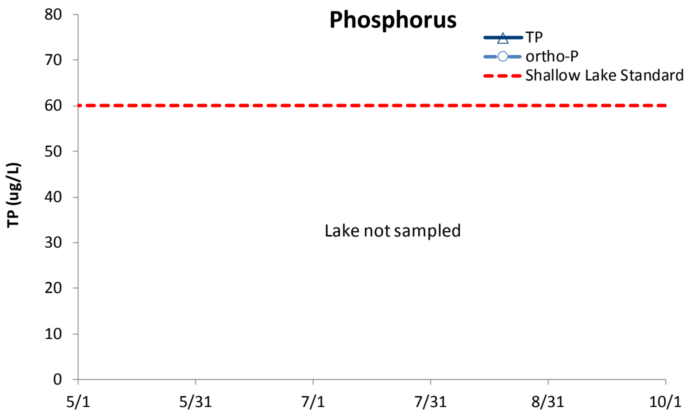
- Operate outlet to prevent flooding
- Protect water quailty

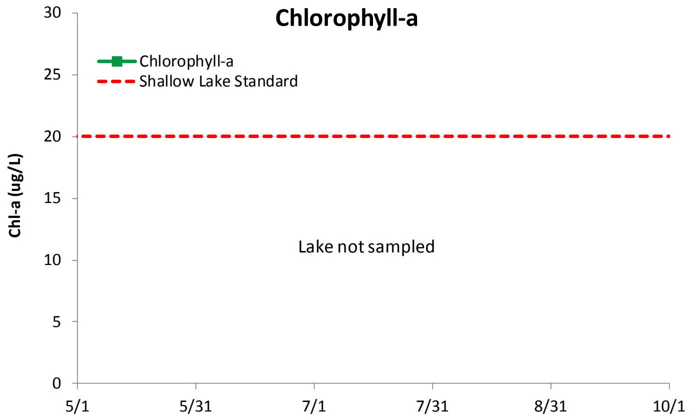
WENCK

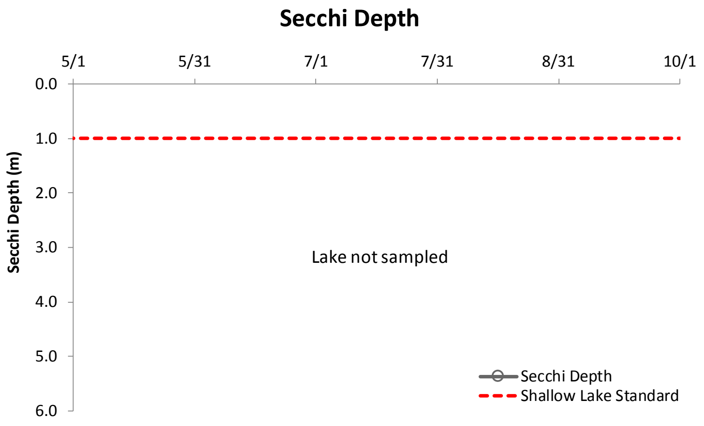
SCHOOL SECTION LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

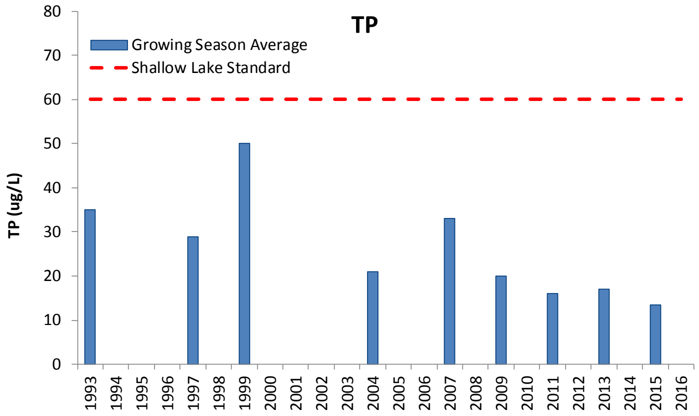
2016 Water Quality

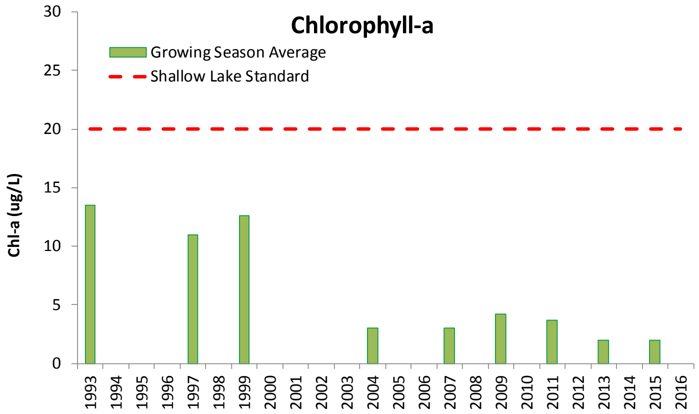


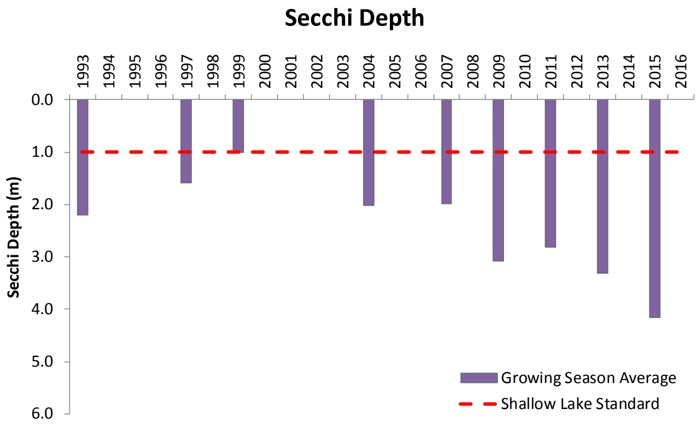




Historic Water Quality







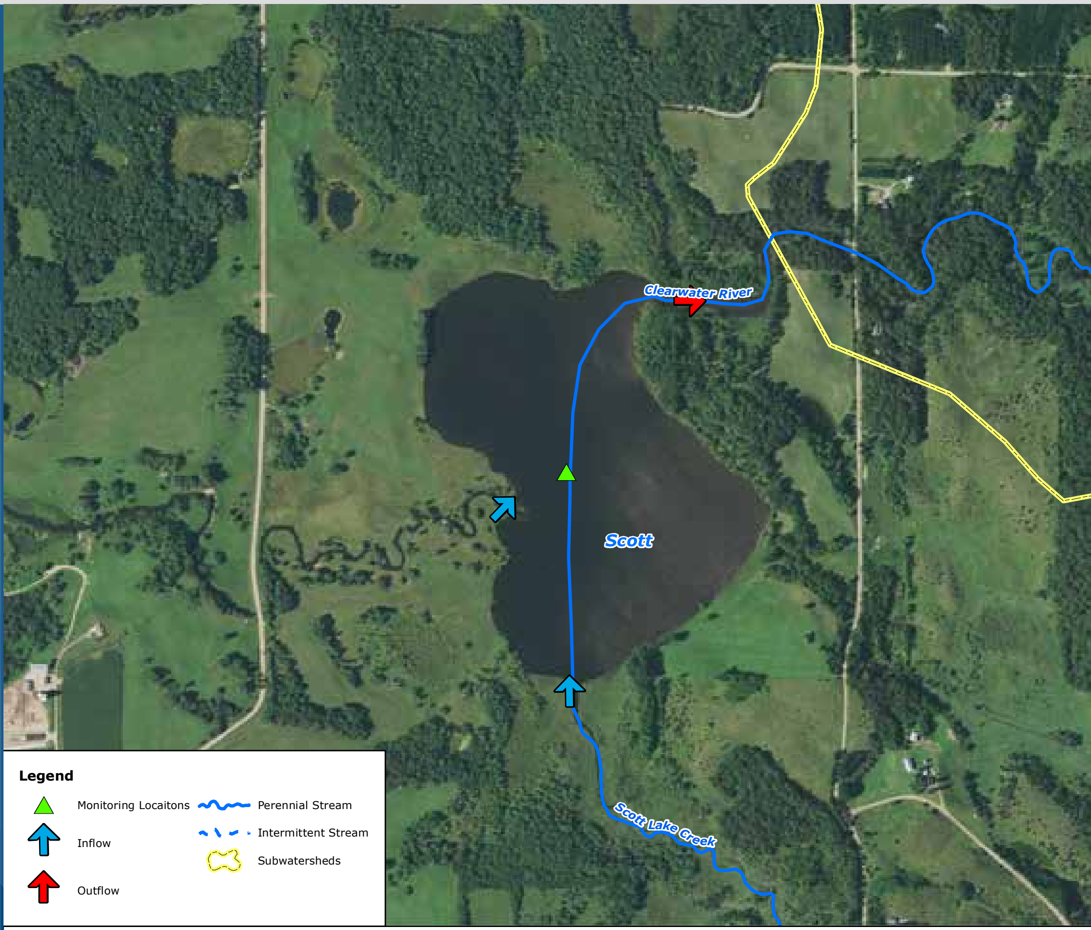
WENCK

SCOTT LAKE

QUICK FACTS

- **Littoral Area**: 52 acres
- **Resodence Time**: 12 days
- **Surface Area**: 80 acres
- **Subwatershed Area**: 51,000 acres
- **Maximum Depth**: 23 feet
- **Upstream Waters**: Clearwater River, Lake Betsy, Union Lake

Common Fish	Black Crappie, Bluegill, Channel Catfish, White Sucker
Dominant Vegetation	No Recent Survey
Invasive Species	Curly-leaf pondweed
Status	Impaired, TMDL Completed 2009



TO DO LIST

- Rough fish management
- Manage upstream loads
- Internal load management study

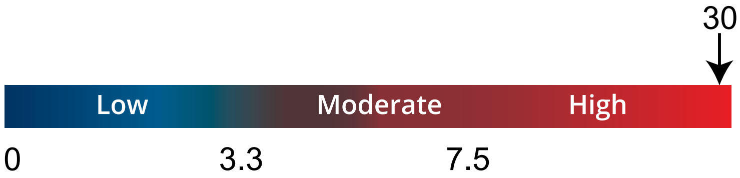
Fish Health (IBI)

**Fish IBI has not been assessed*

Vegetation Health (FQI)

**Sample date: 7/28/1997*

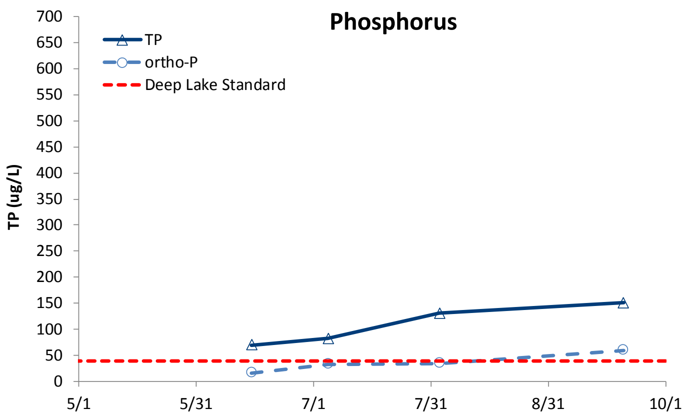
Sediment P Release (mg/m²/day)

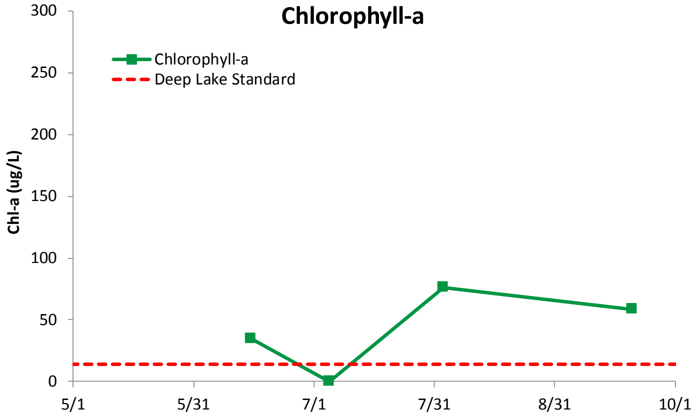


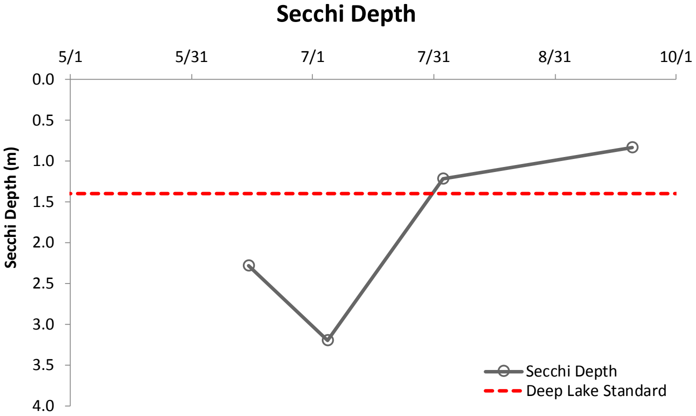
**Sample date: 2010*

SCOTT LAKE

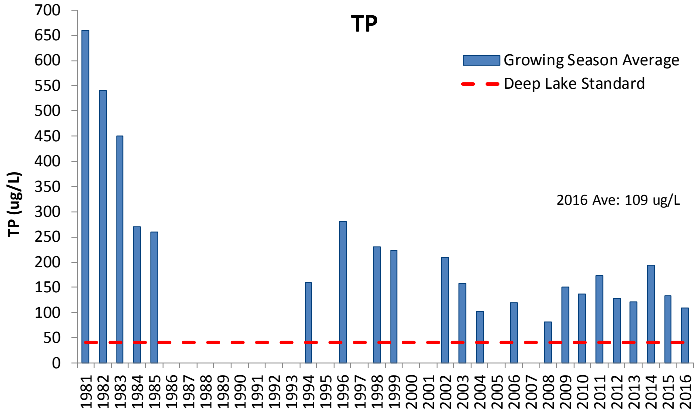
2016 Water Quality

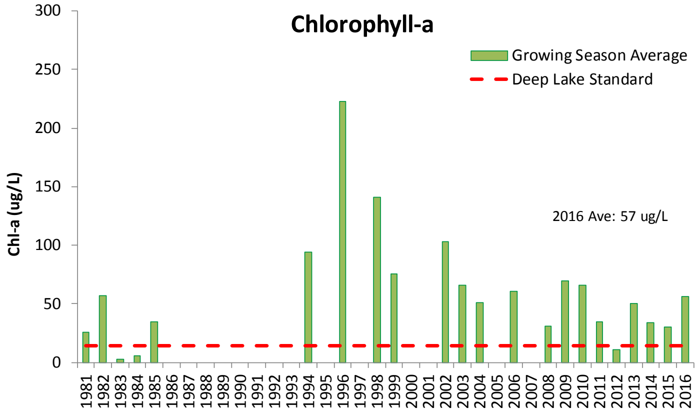


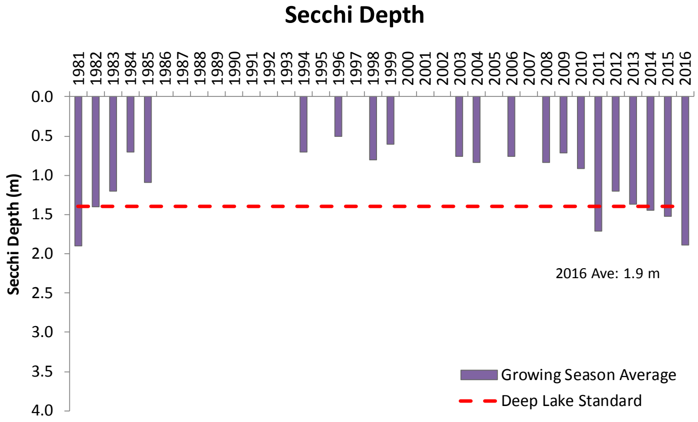




Historic Water Quality







SWARTOUT LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 171 acres

Residence Time: 460 days

Surface Area: 171 acres

Subwatershed Area: 5,551 acres

Maximum Depth: 12 feet

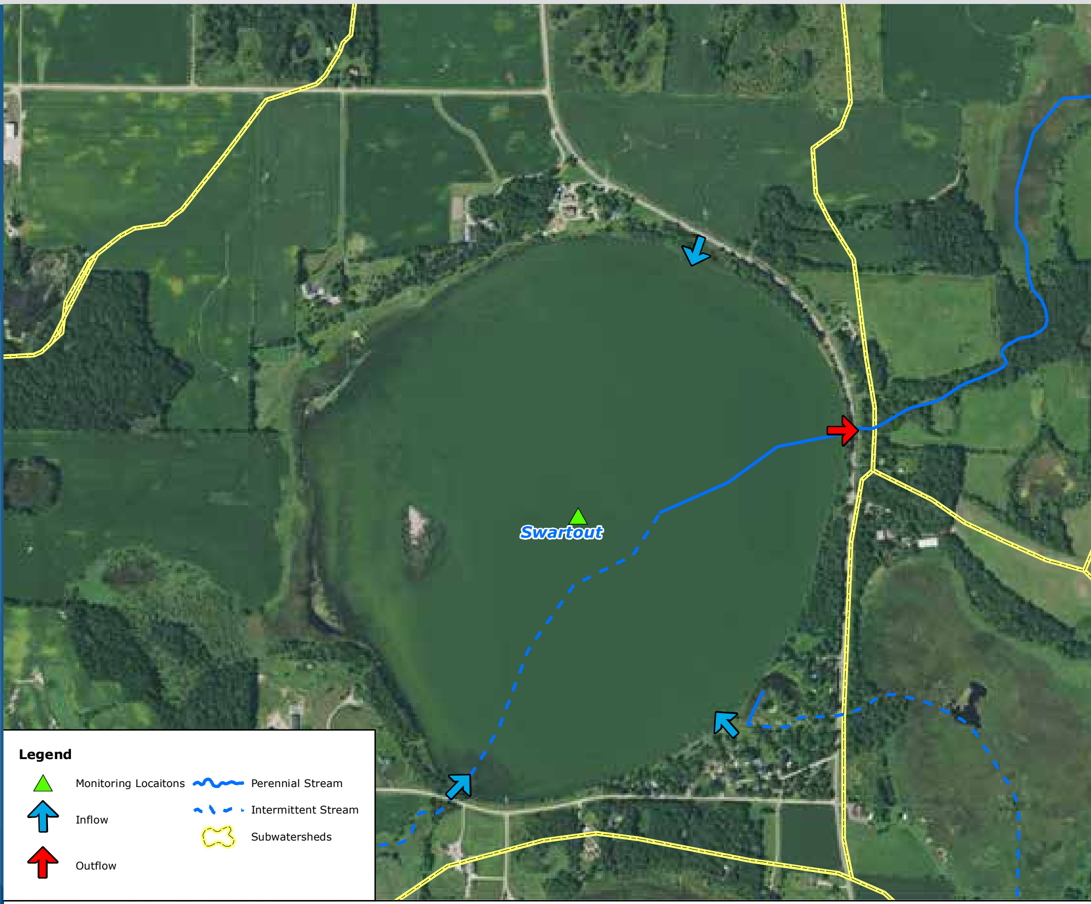
Upstream Waters: Henshaw, Albion

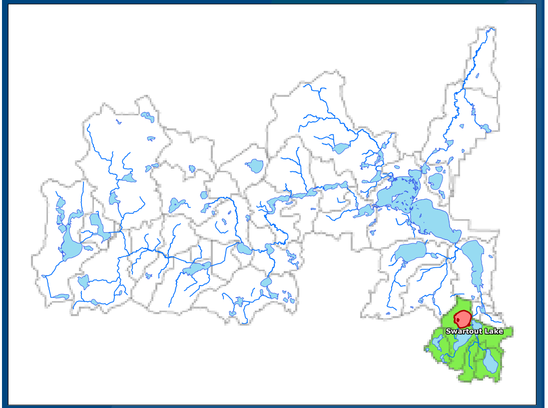
Common Fish: Black Bullhead, Black Crappie, Common Carp

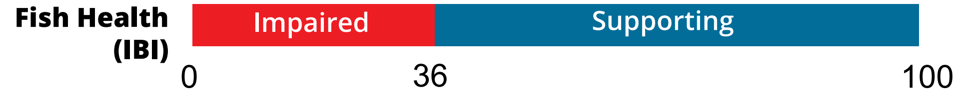
Dominant Vegetation: Coontail, sago pondweed, bushy pondweed

Invasive Species: Curly-leaf pondweed

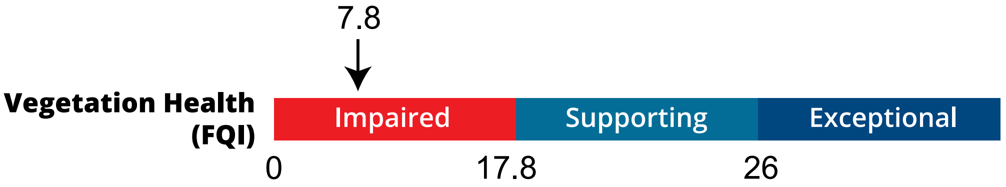
Status: Impaired, TMDL Completed 2010







*Fish IBI has not been assessed



*Sample date: 6/6/2013

*Sediment release rate has not been assessed

TO DO LIST

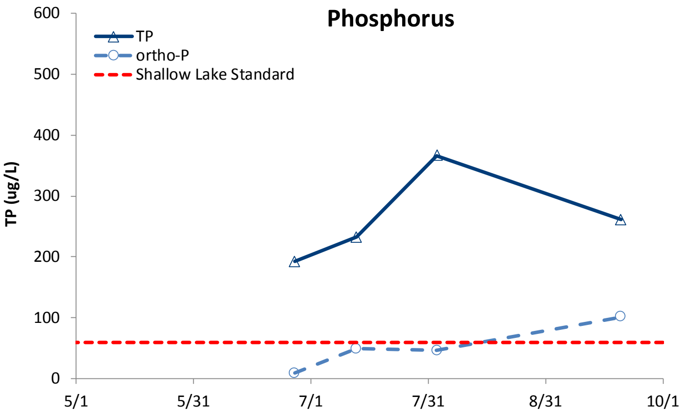
- AIS management
- Rough fish management
- Internal load management study
- Manage upstream loads

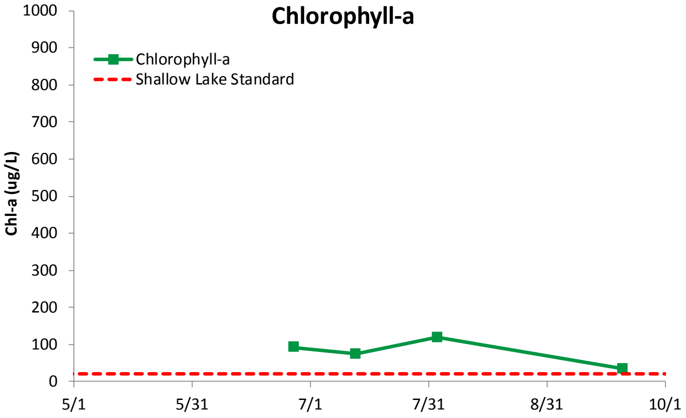
WENCK

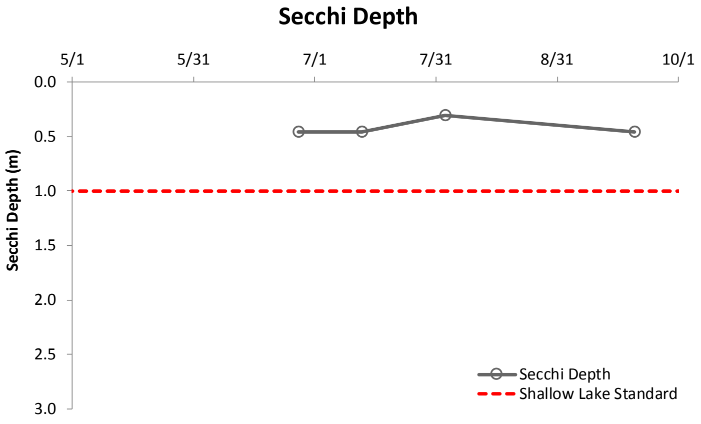
SWARTOUT LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

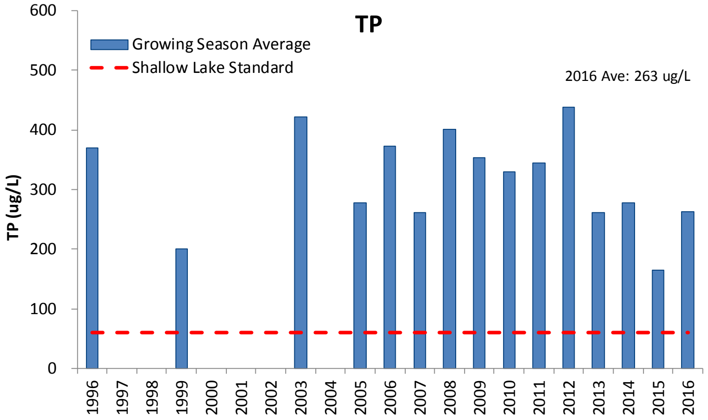
2016 Water Quality

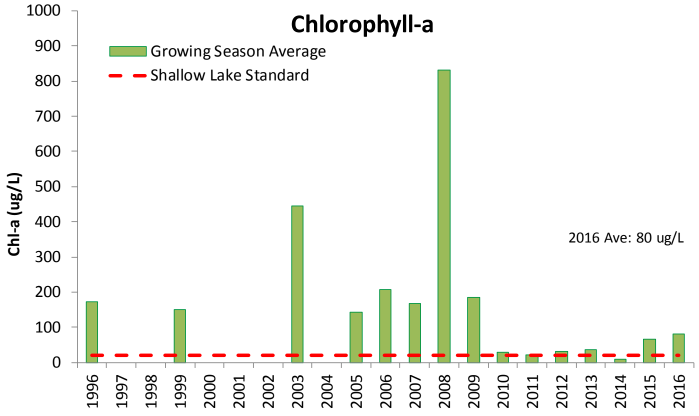


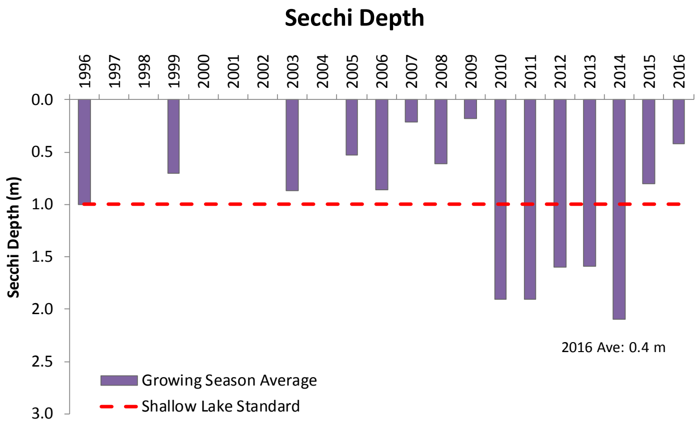




Historic Water Quality







WENCK

UNION LAKE

Clearwater River
WATERSHED DISTRICT
Promote | Protect | Preserve

QUICK FACTS

Littoral Area: 27 acres

Residence Time: 291 days

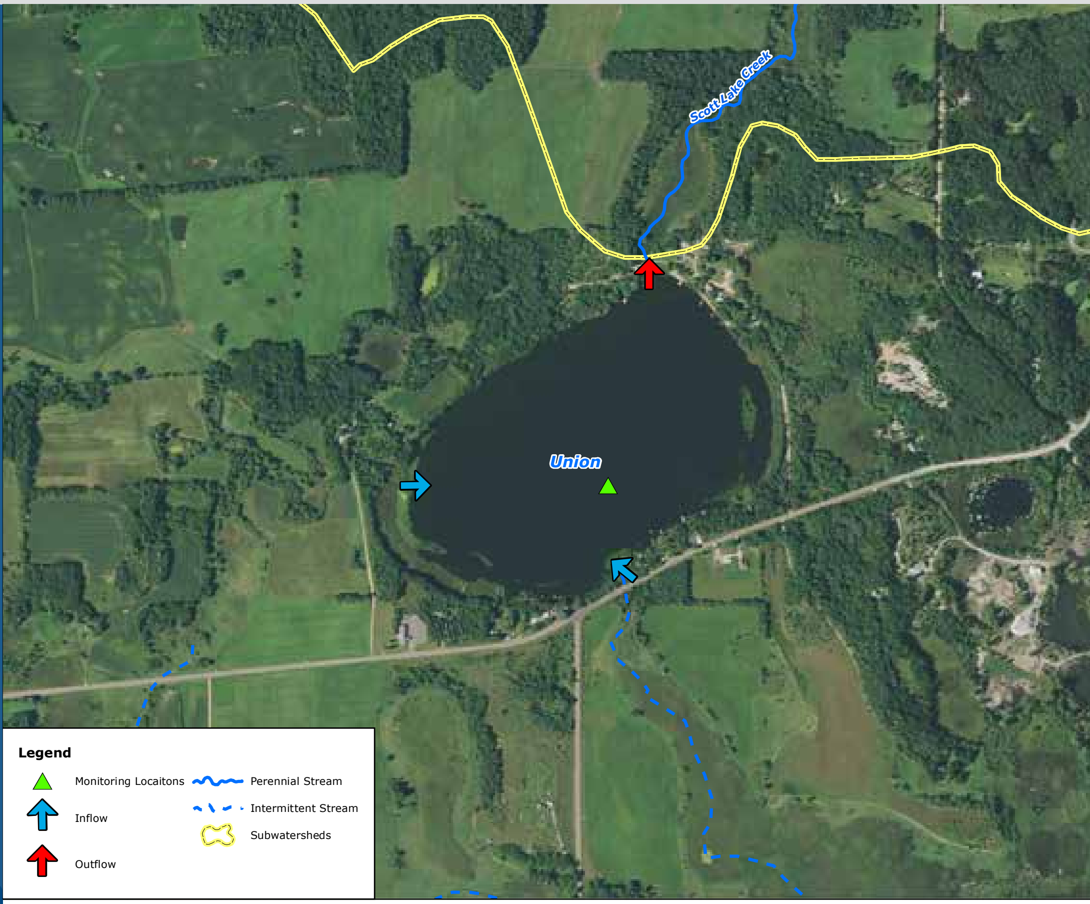
Surface Area: 93 acres

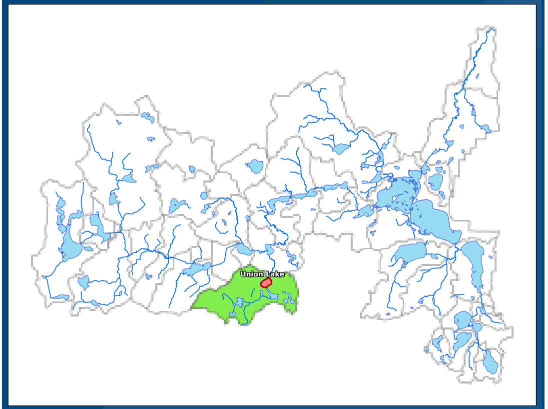
Subwatershed Area: 4,741 acres

Maximum Depth: 35 feet

Upstream Waters: None

Common Fish	Black Crappie, Bluegill, Northern Pike, Largemouth Bass
Dominant Vegetation	Coontail, curly-leaf pondweed, sago pondweed
Invasive Species	Curly-leaf pondweed
Status	Impaired, TMDL Completed 2009





TO DO LIST

- Manage upstream loads

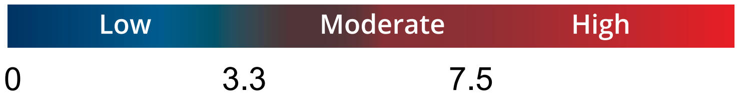
Fish Health (IBI)

*Fish IBI has not been assessed

Vegetation Health (FQI)

*Sample date: 8/25/2015

Sediment P Release (mg/m²/day)



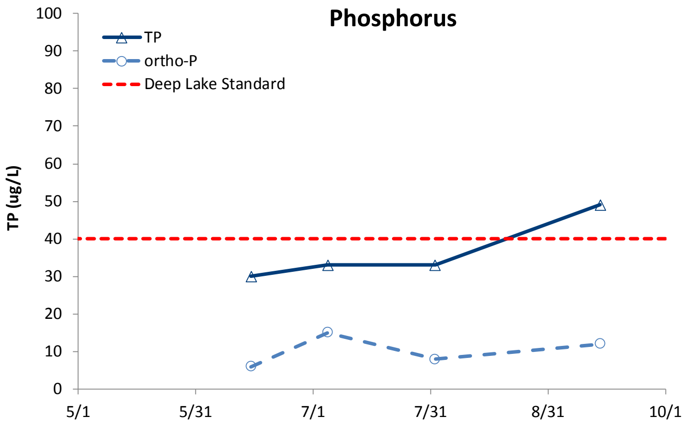
*Sediment release rate has not been assessed

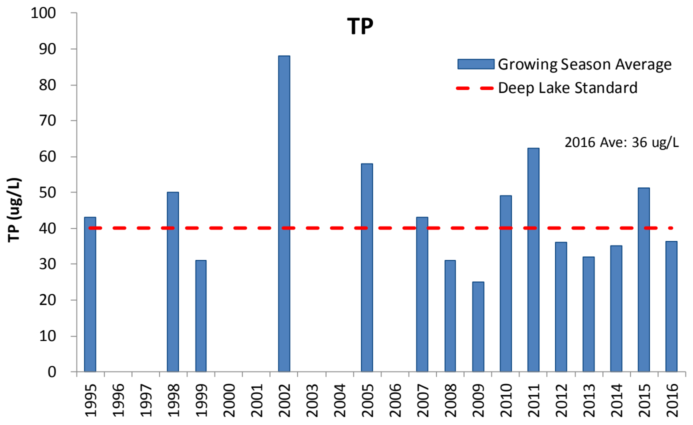
WENCK

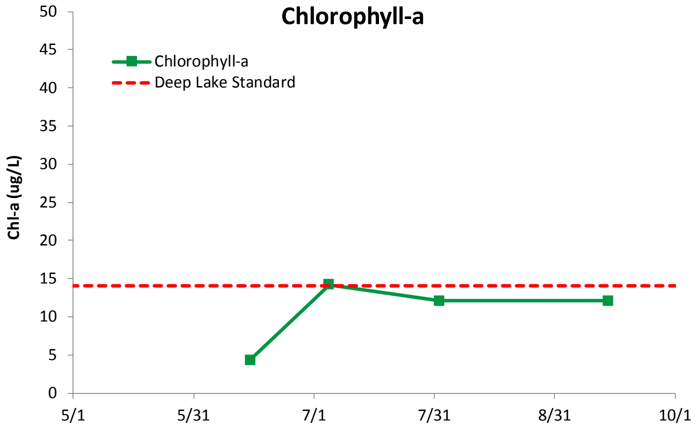
UNION LAKE

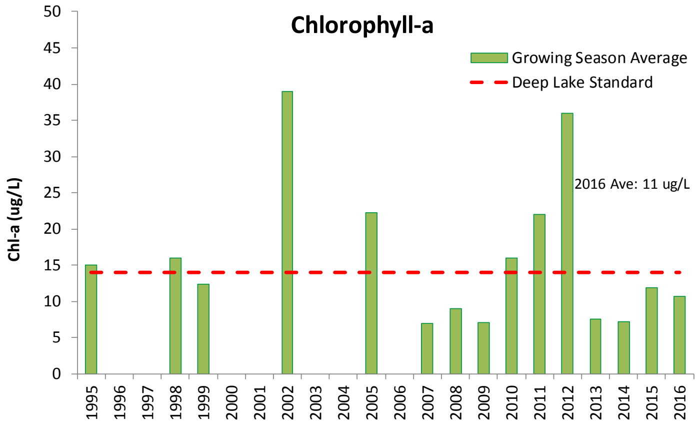
2016 Water Quality

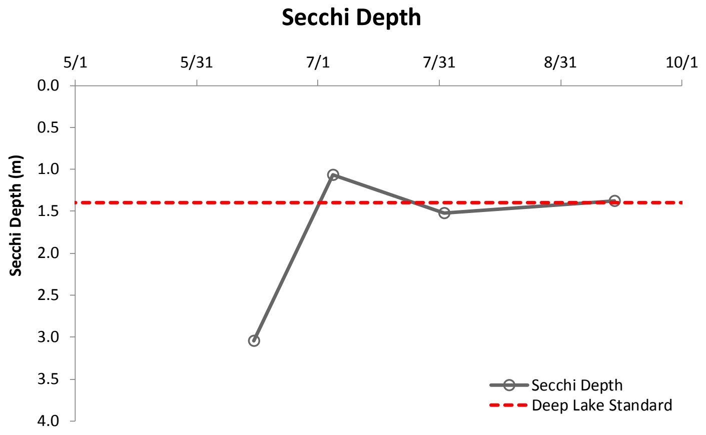
Historic Water Quality

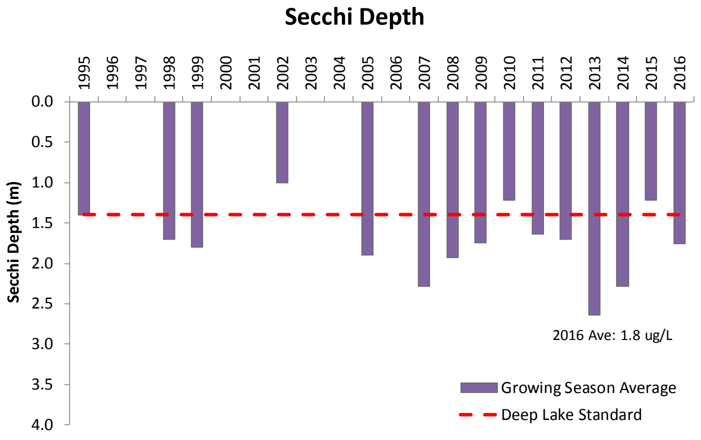




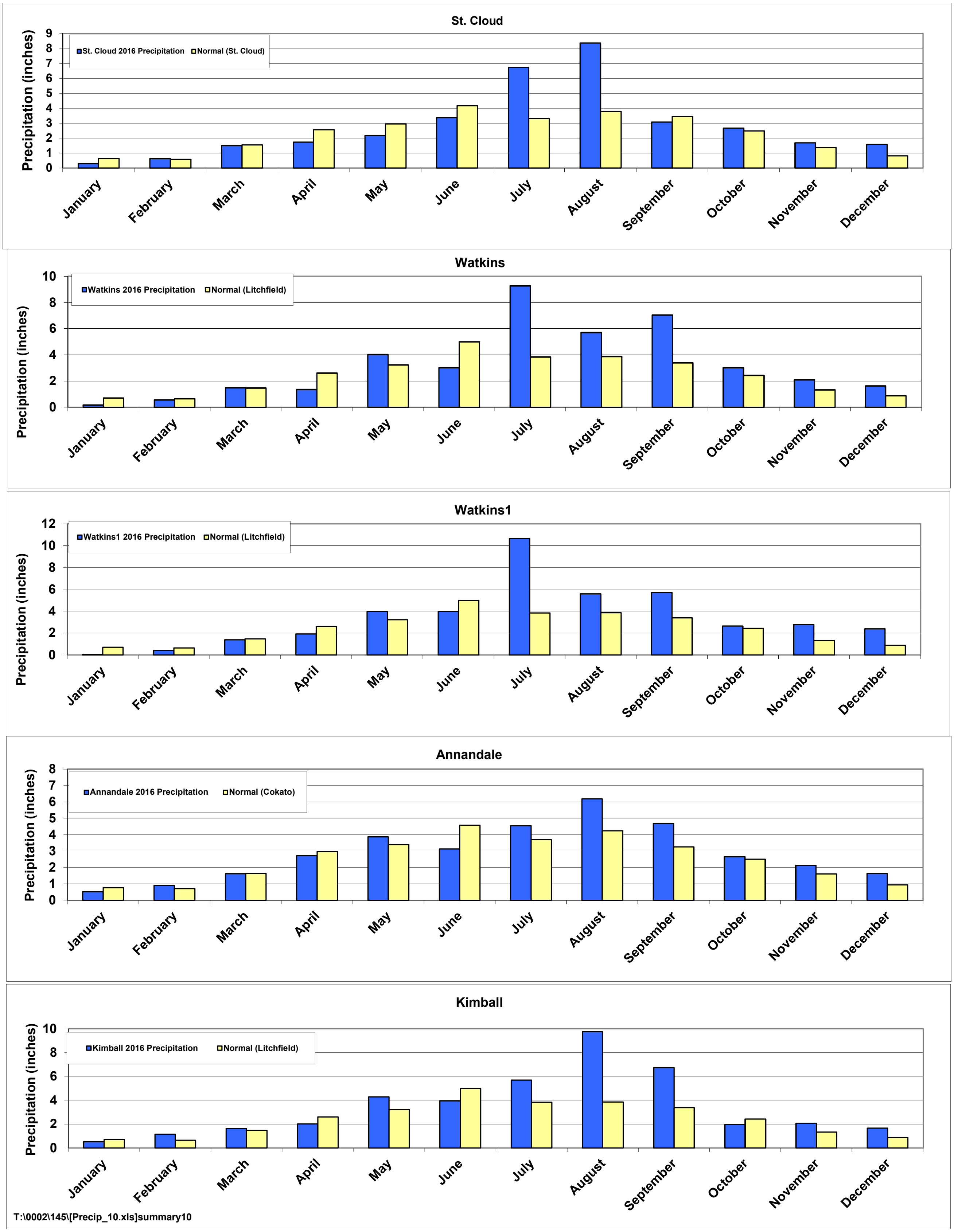








Appendix D
Figure 1
Clearwater River Watershed District Monthly Precipitation
2016 Annual Report



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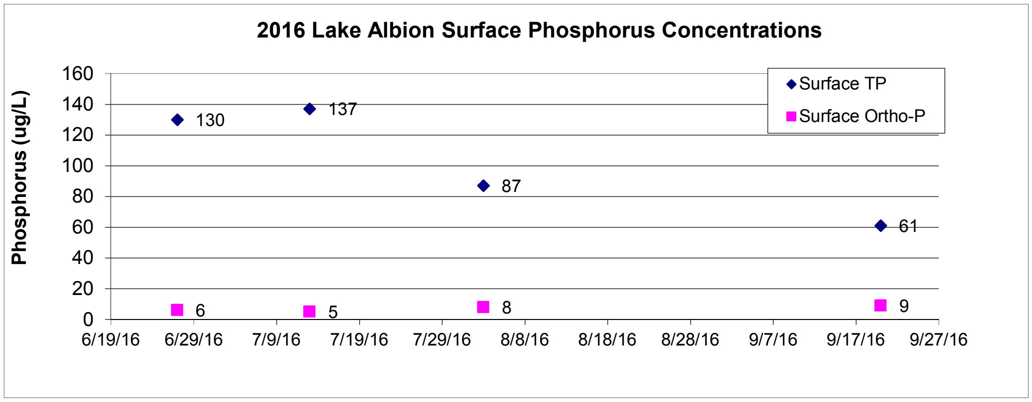
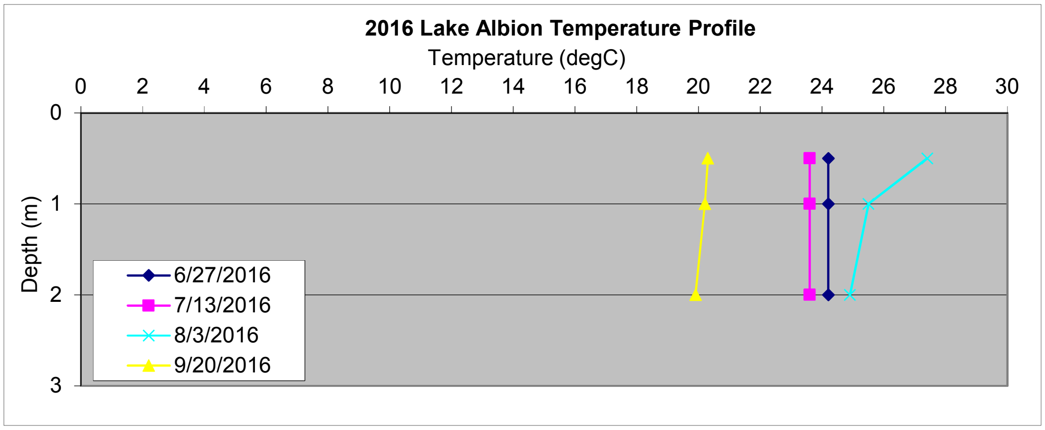
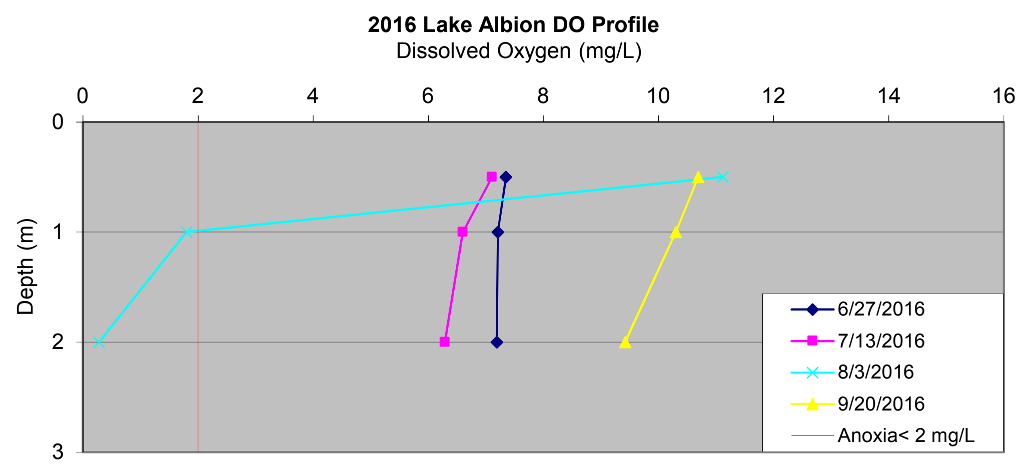
CRWD 2016 Water Quality Report
Appendix E-Lake Phosphorus and Profile Data







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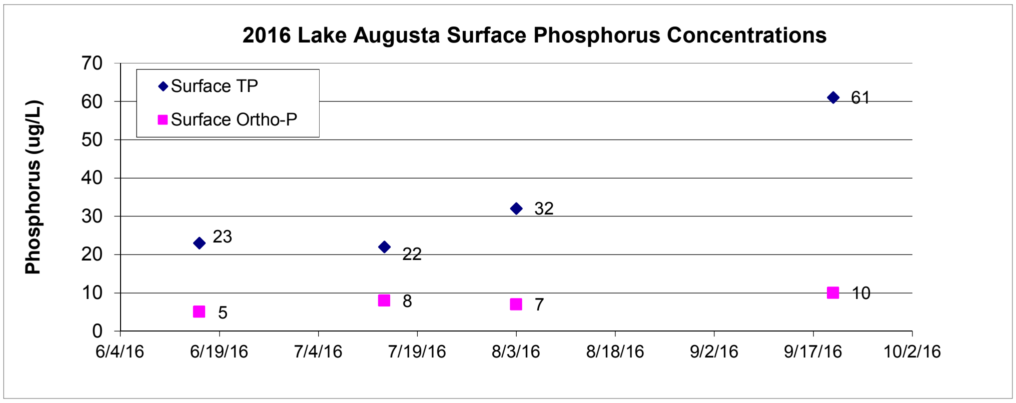

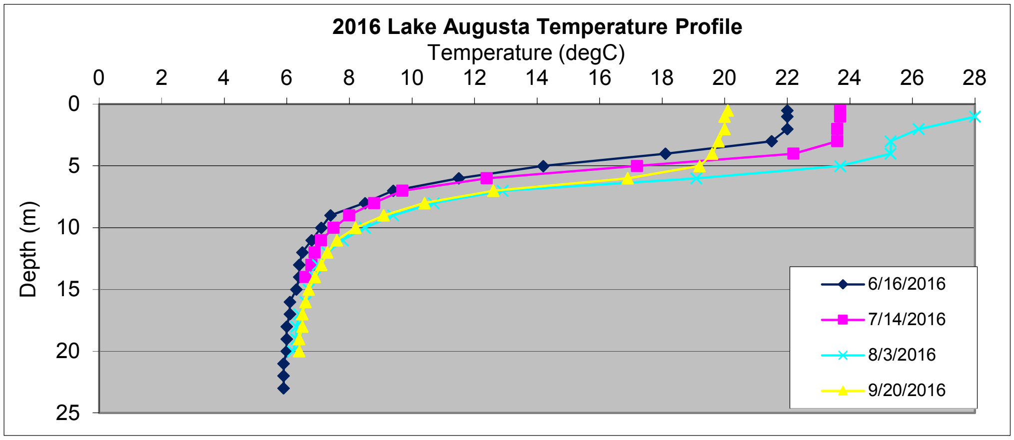

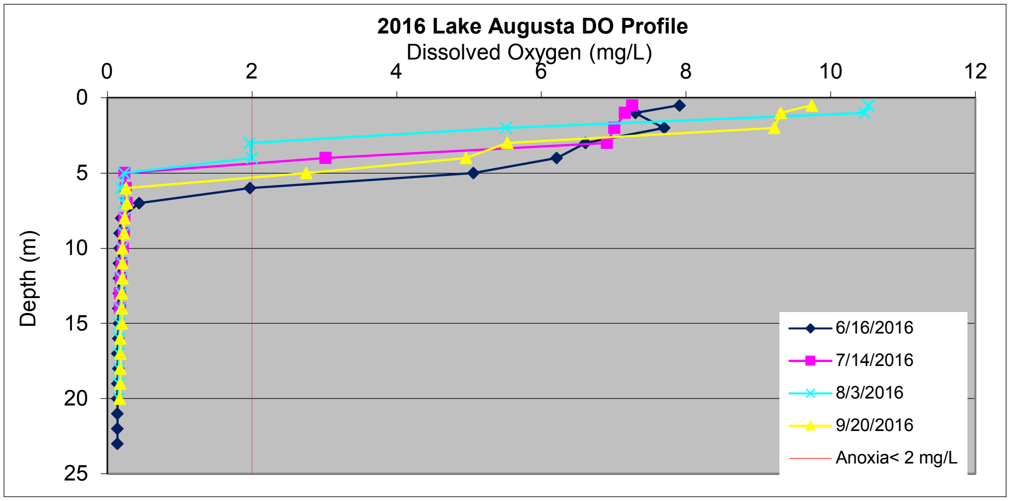

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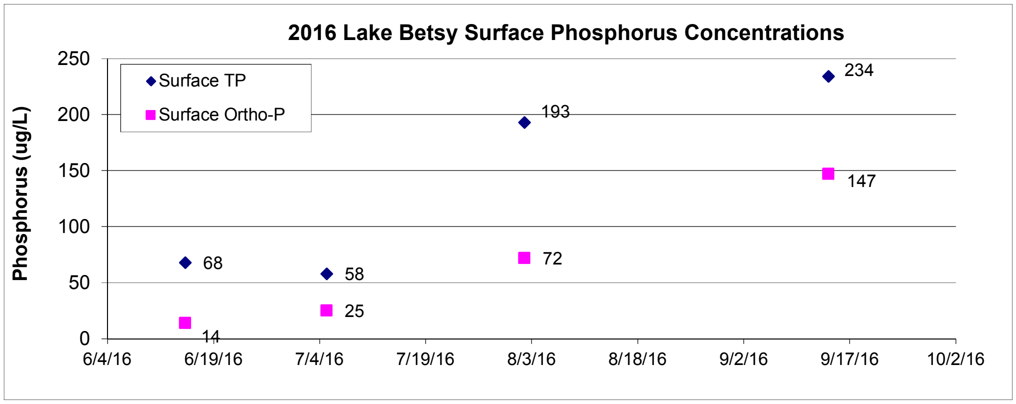

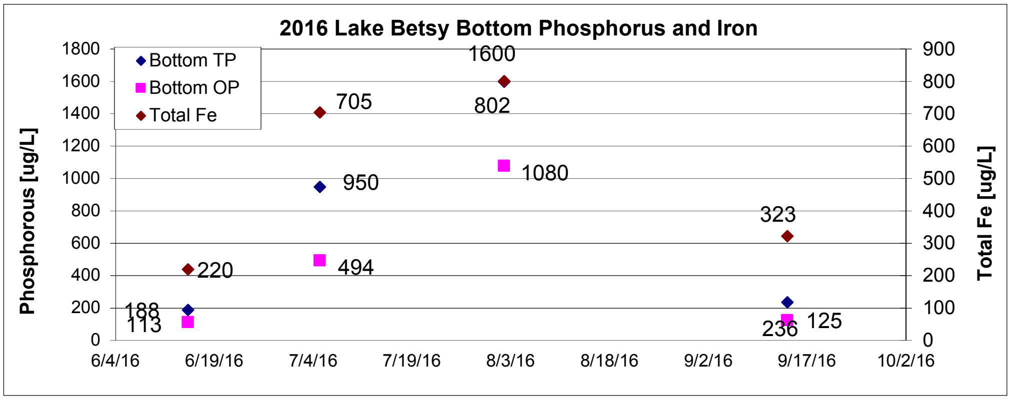

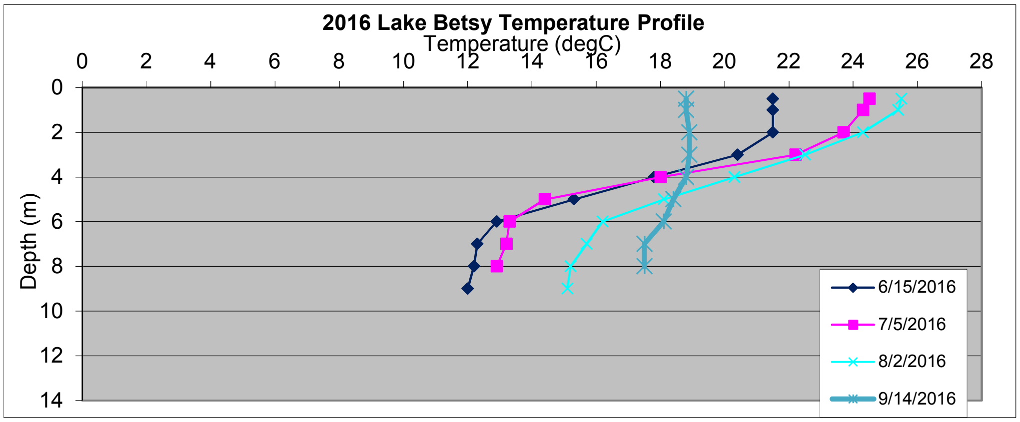

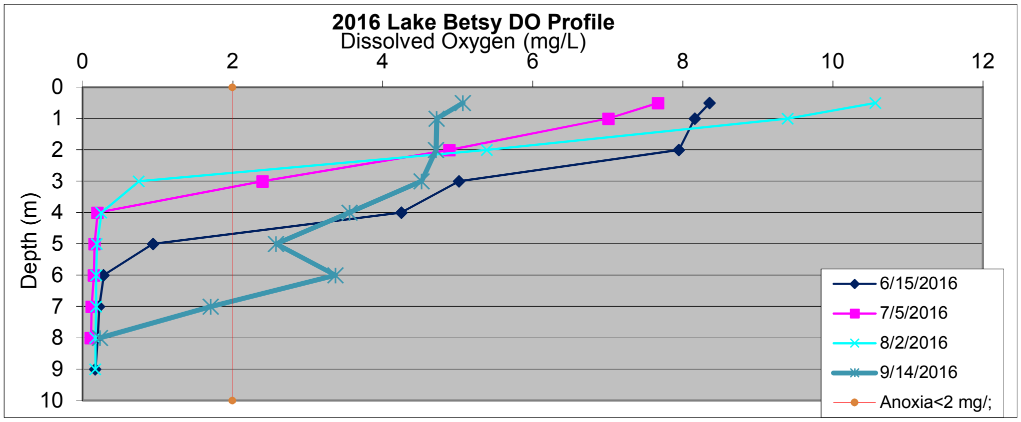

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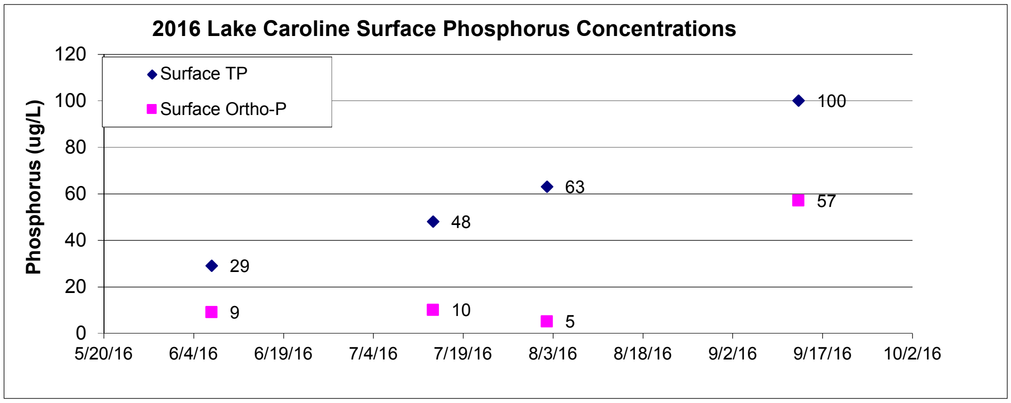

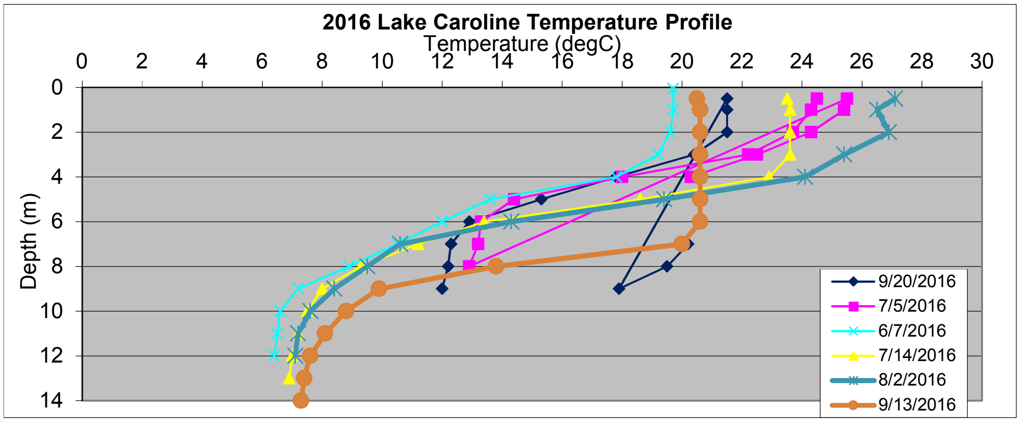

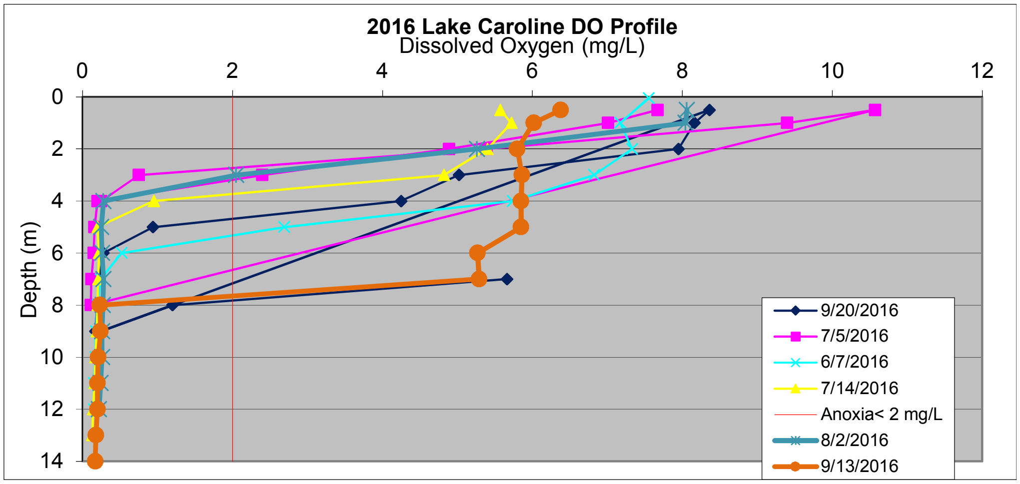

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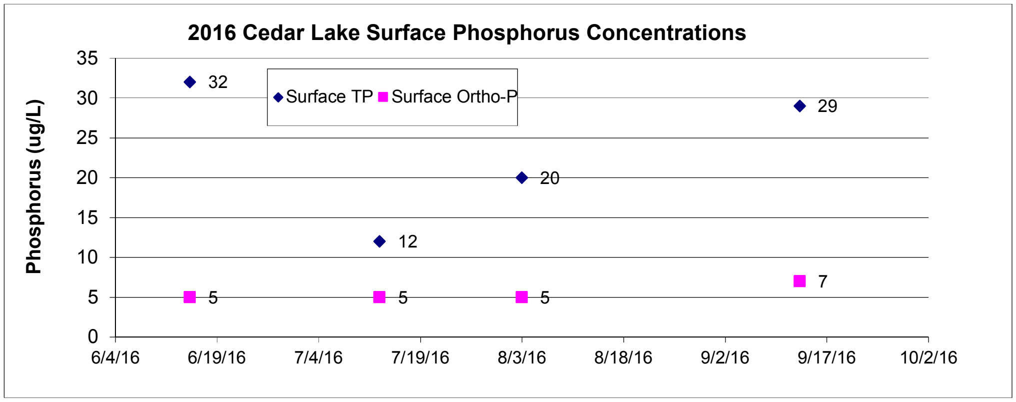

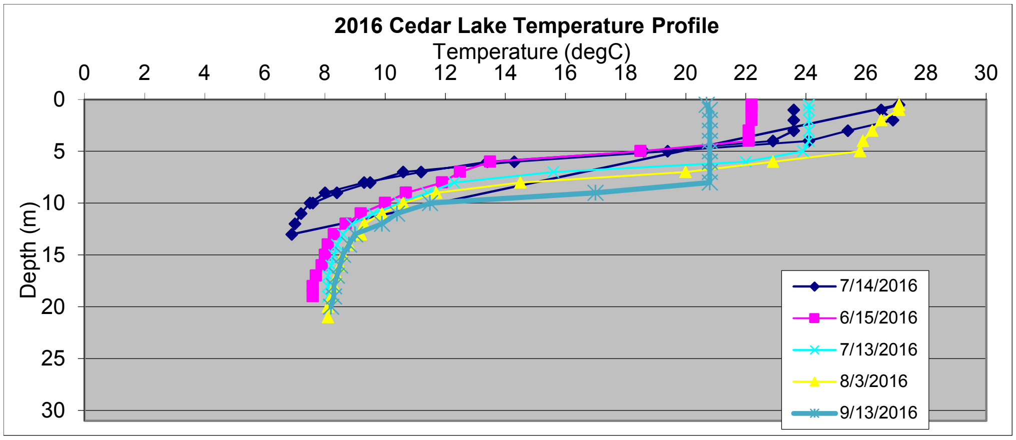

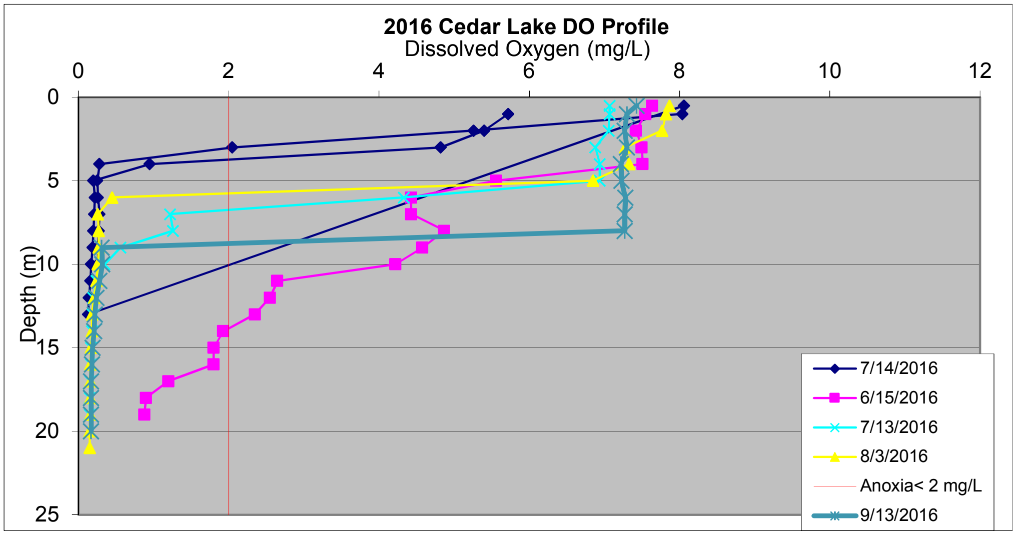

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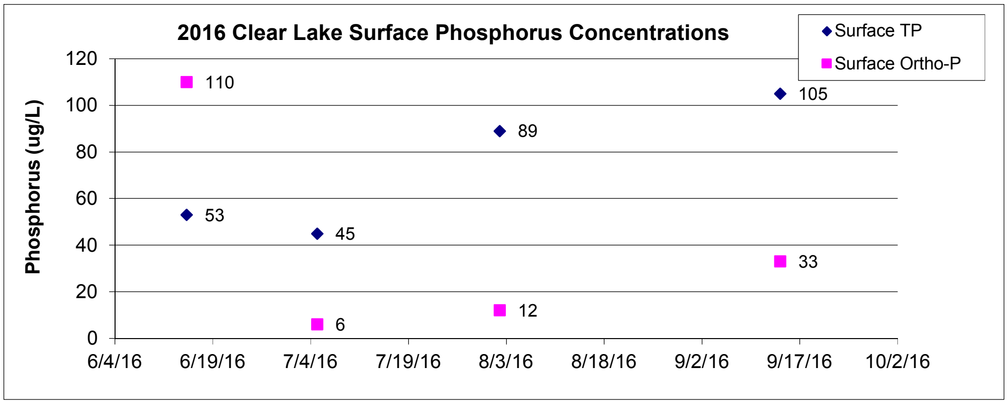

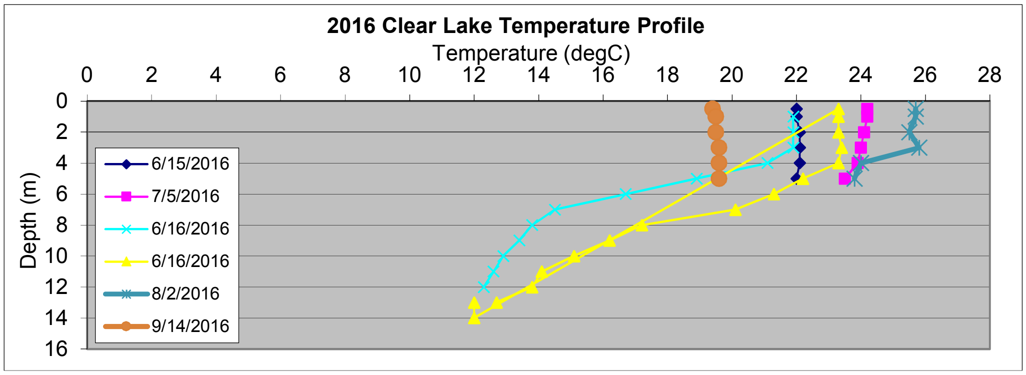

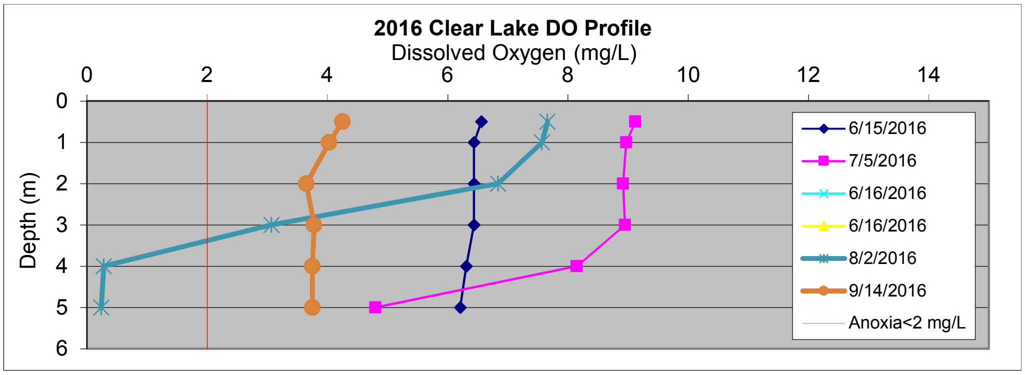

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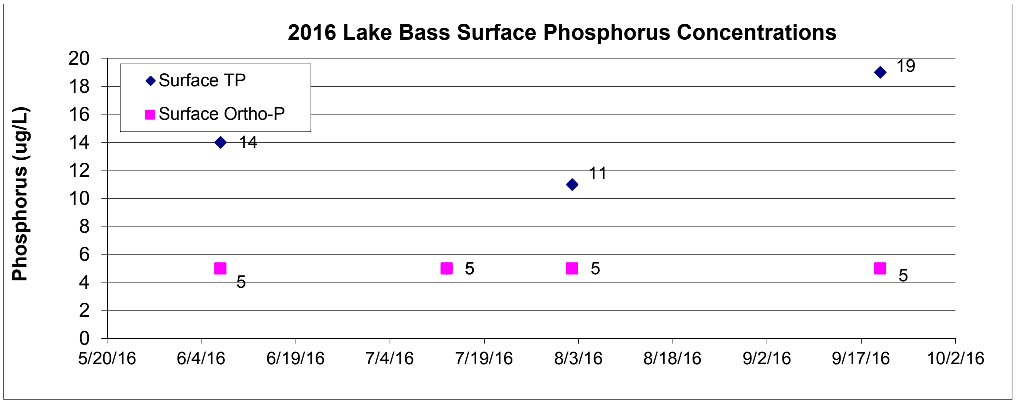

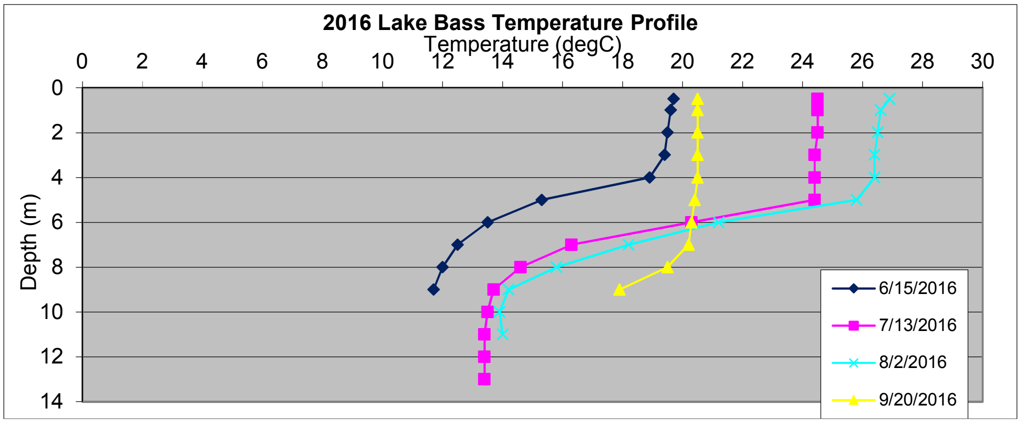

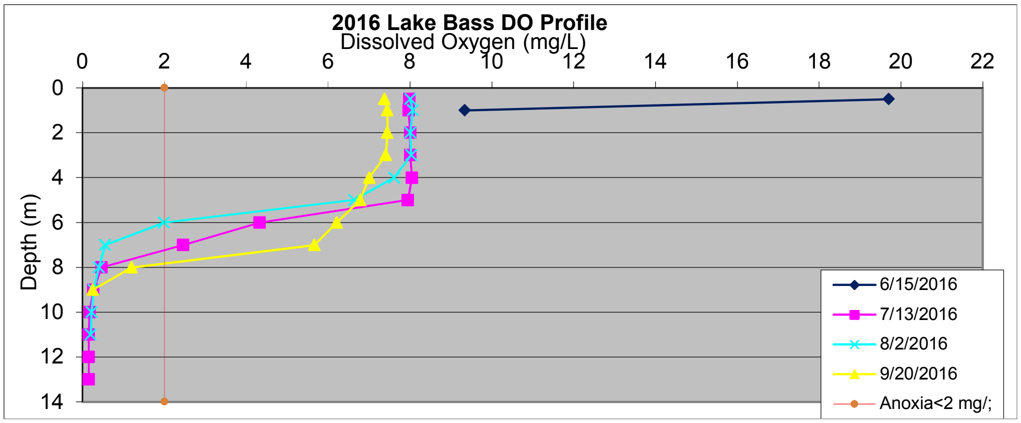

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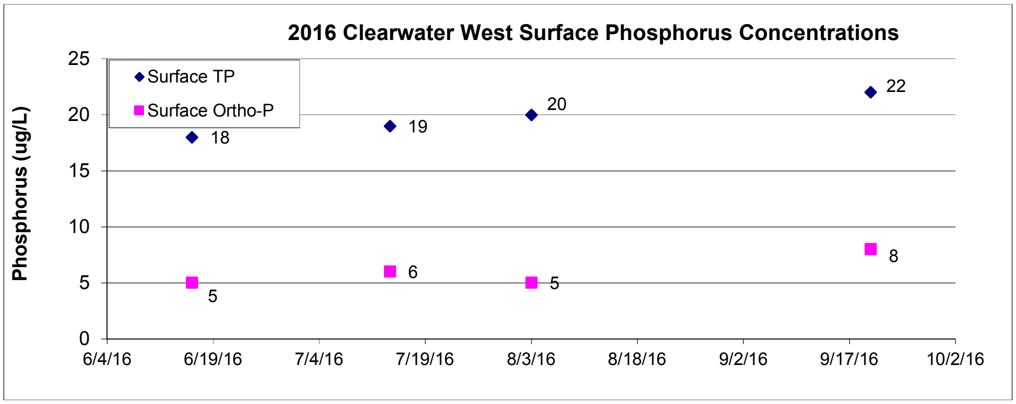

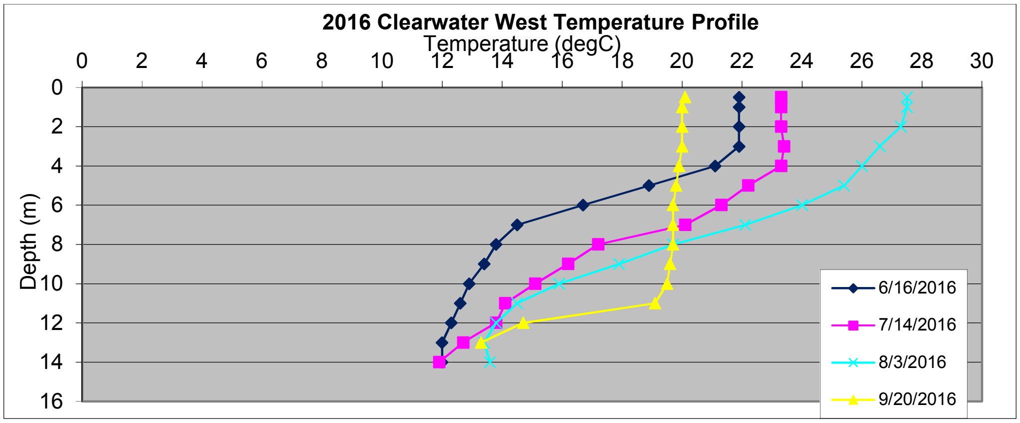

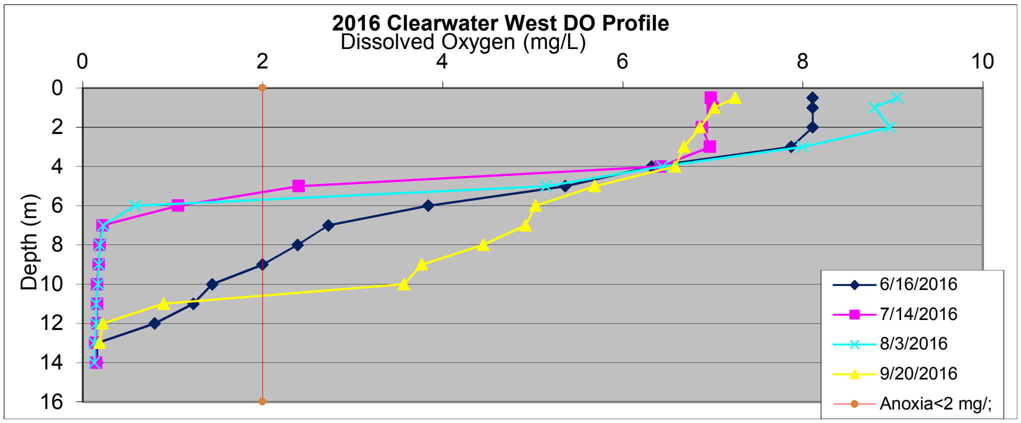

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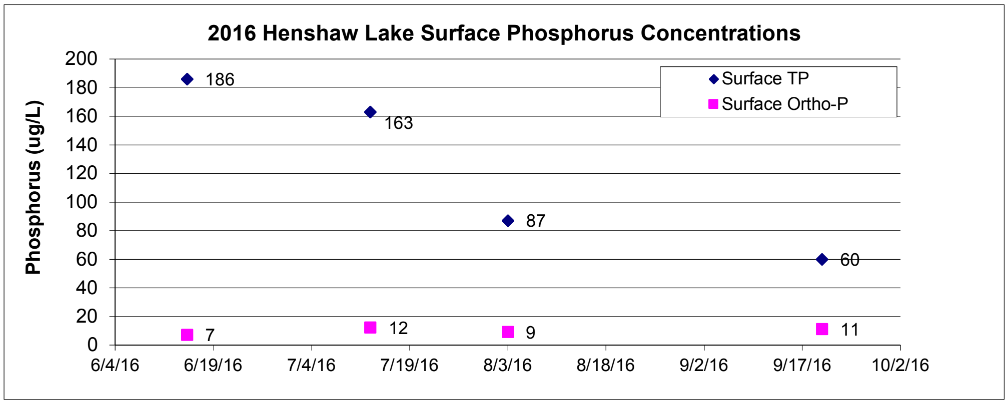

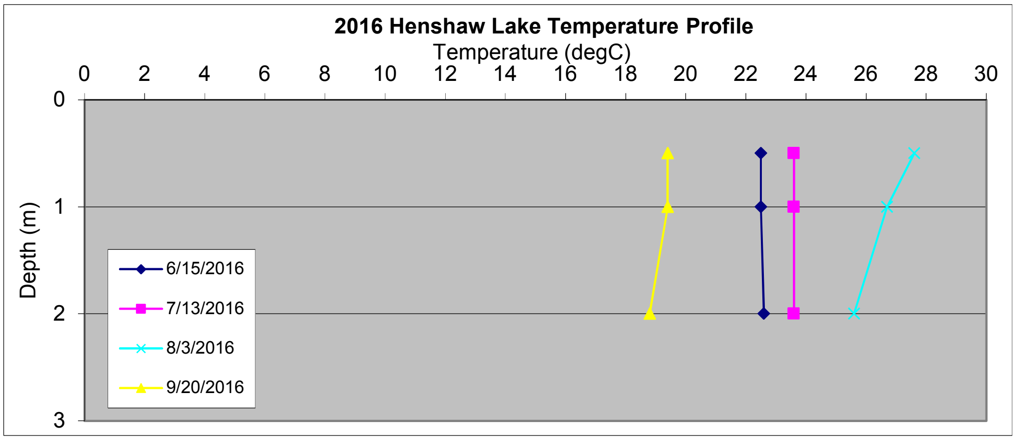

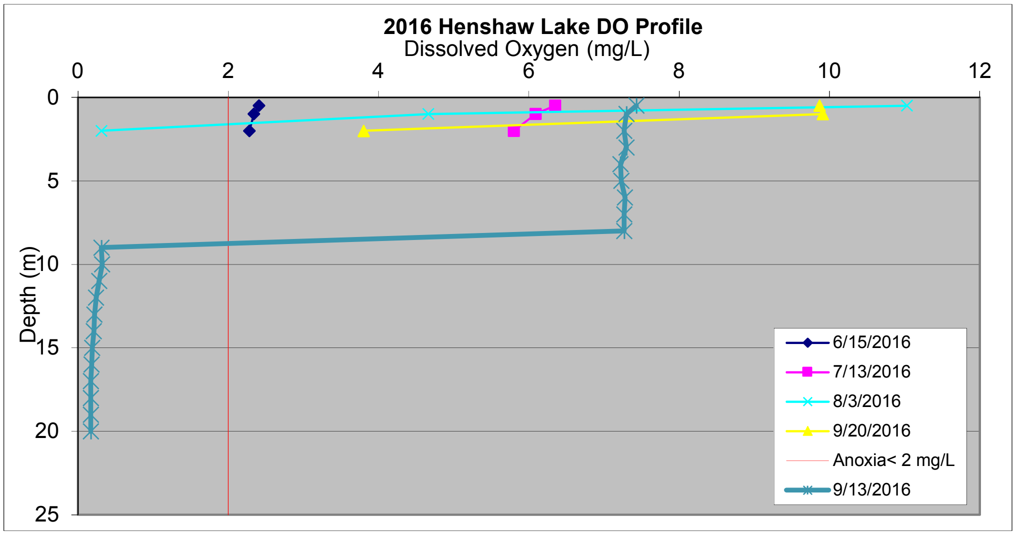

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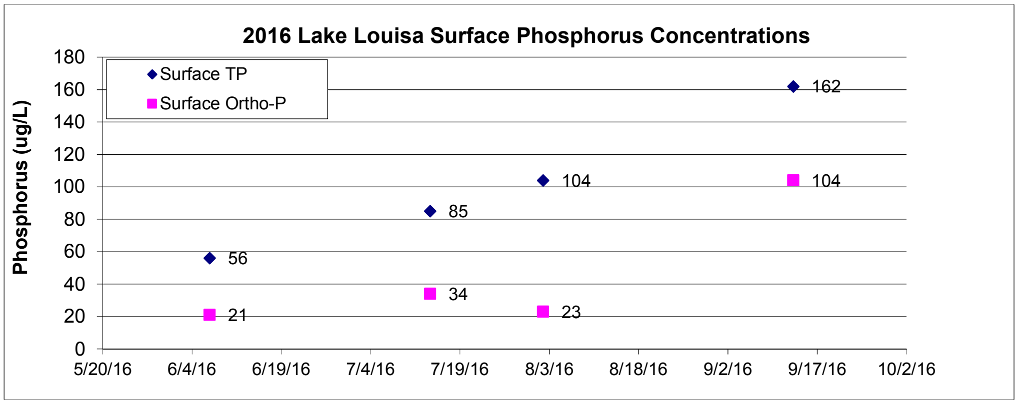

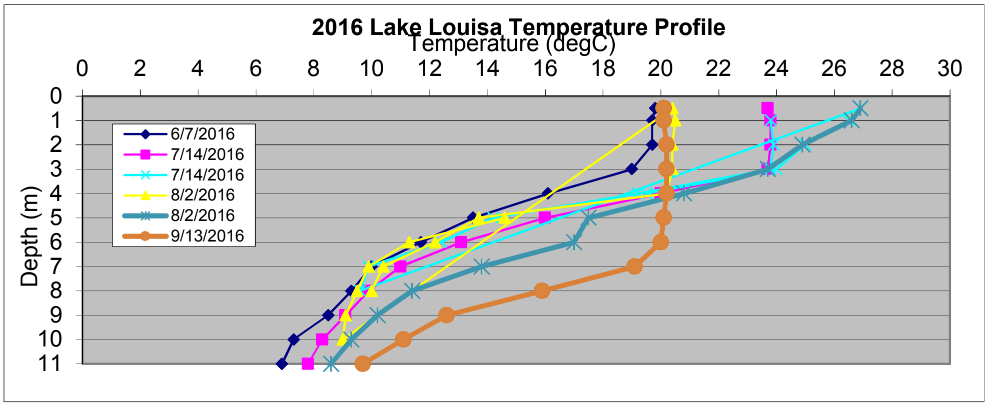

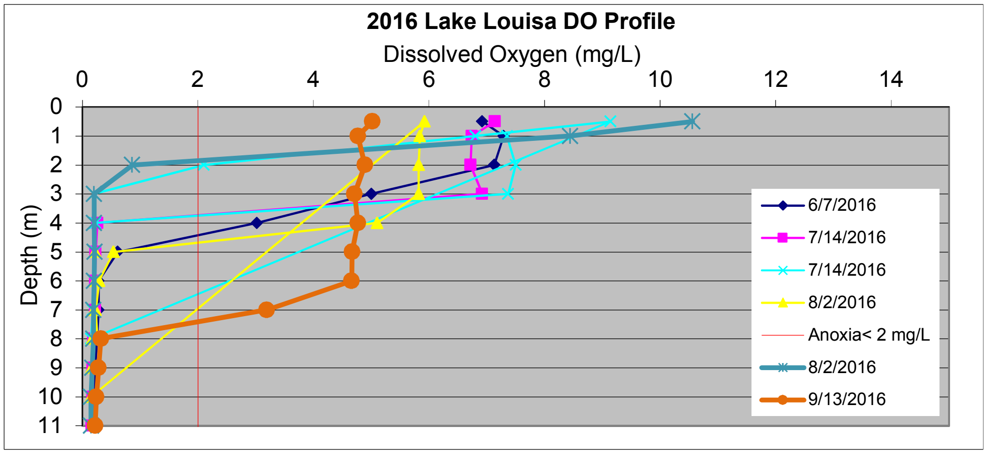

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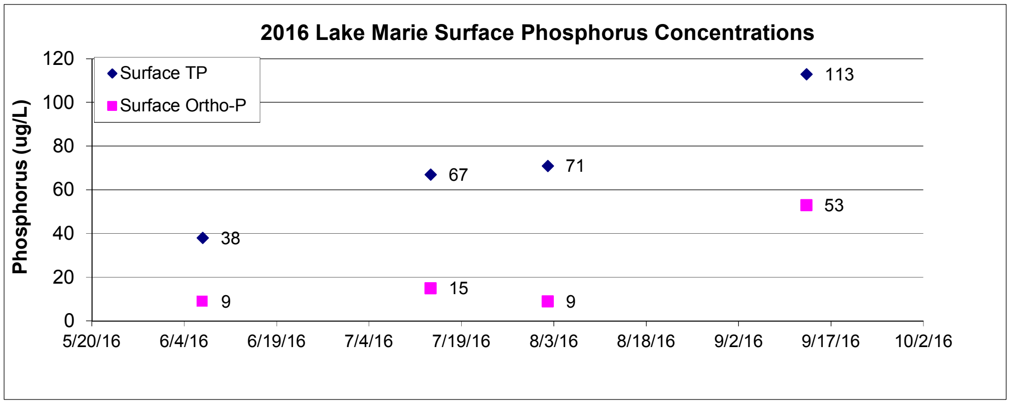

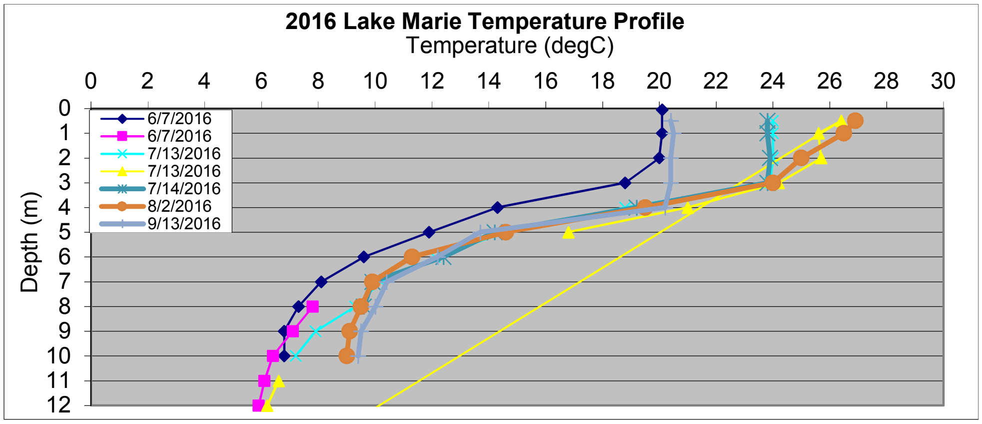

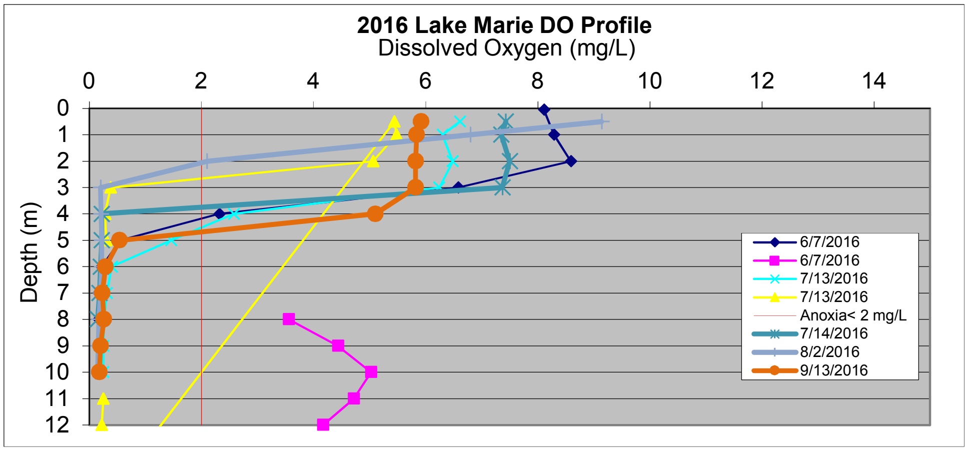

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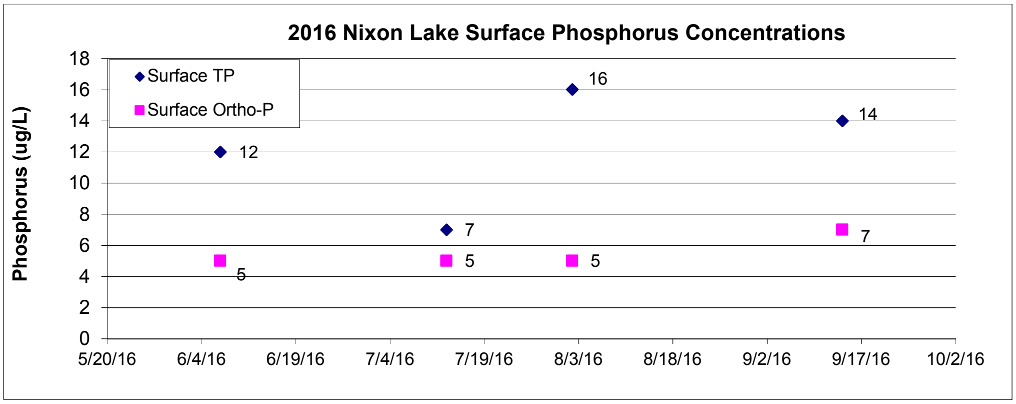

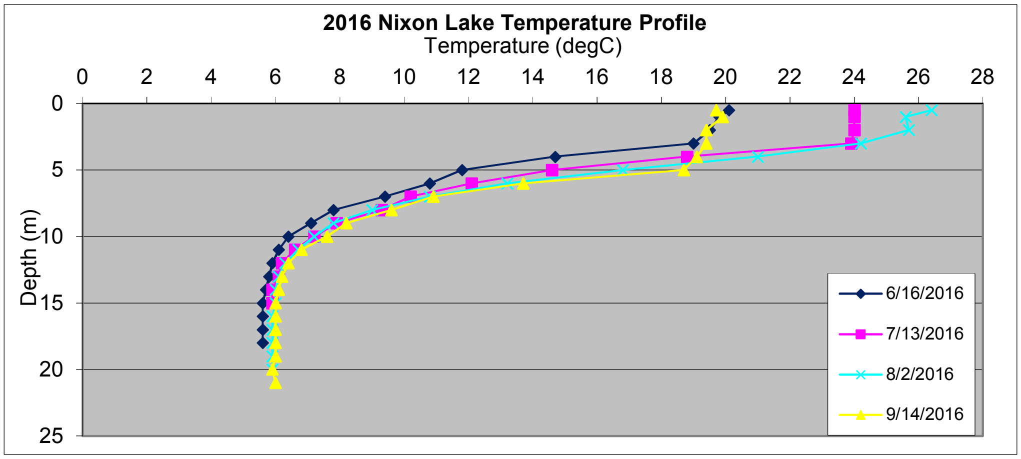

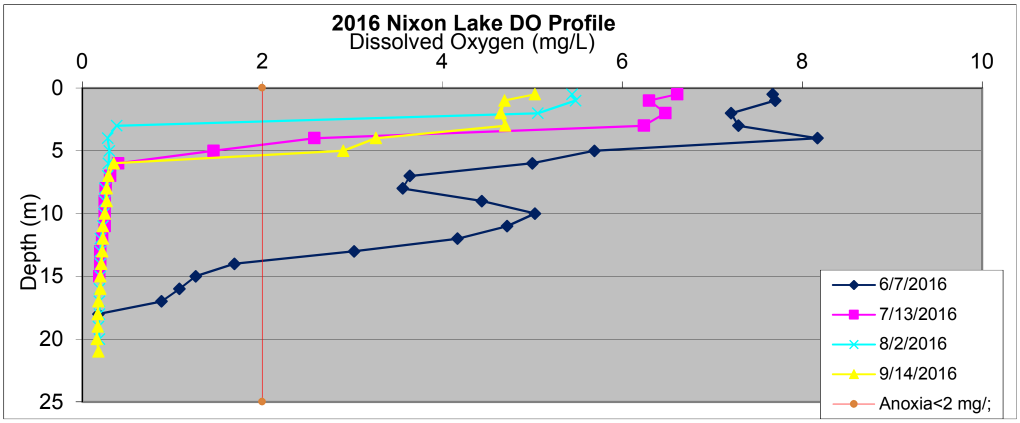

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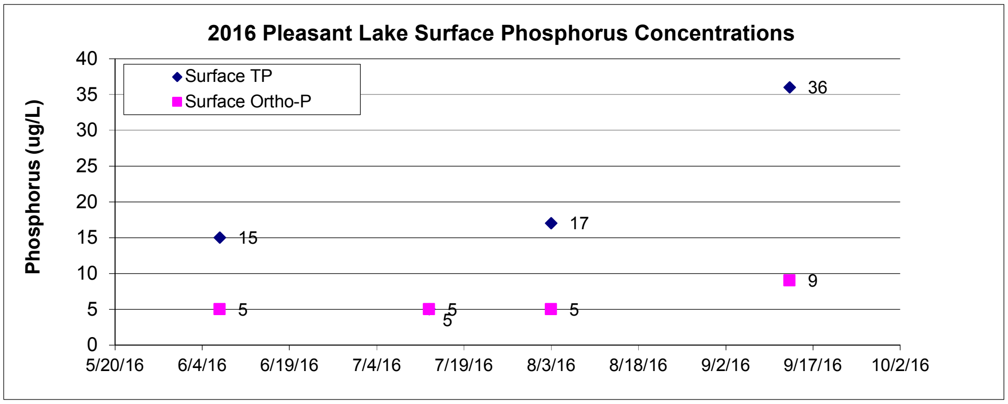

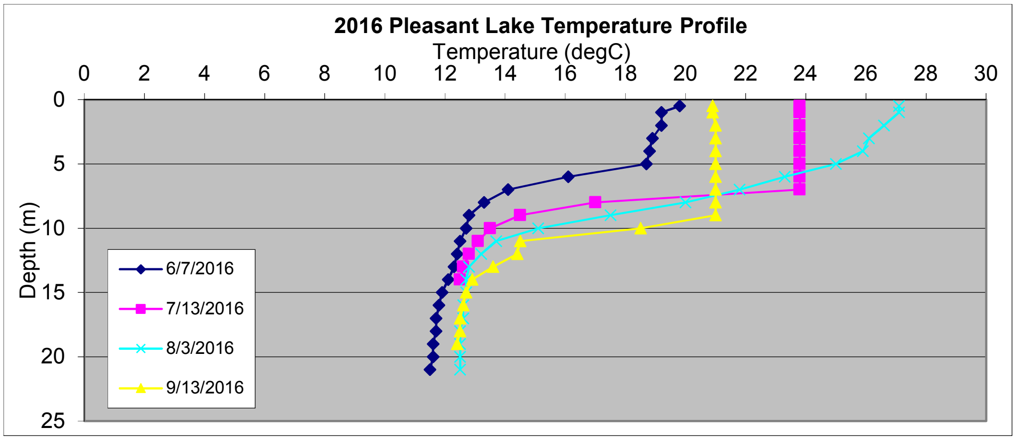

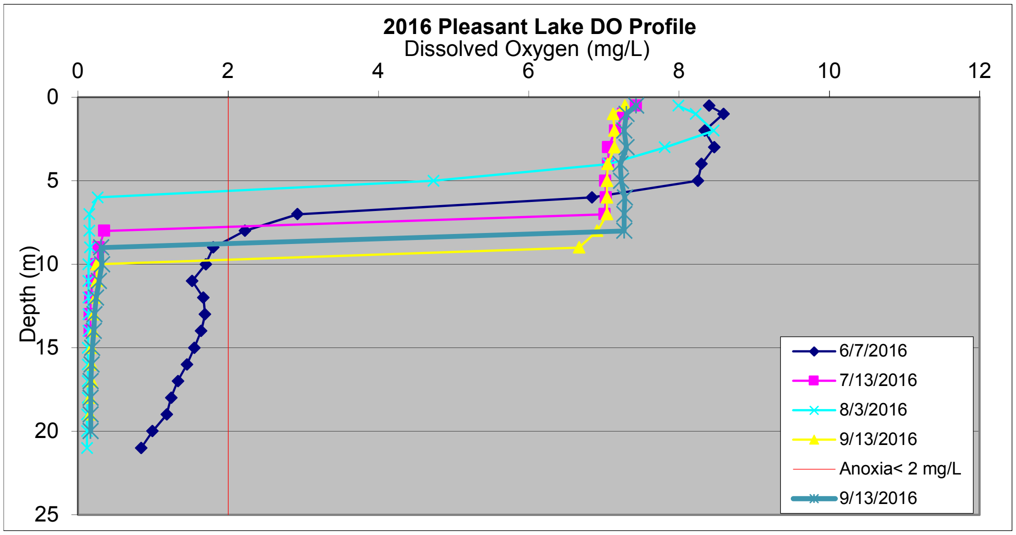

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Appendix E-Lake Phosphorus
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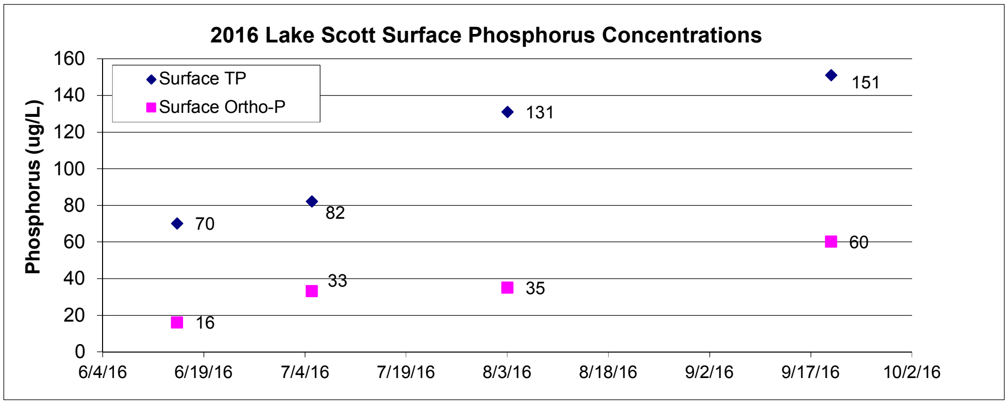

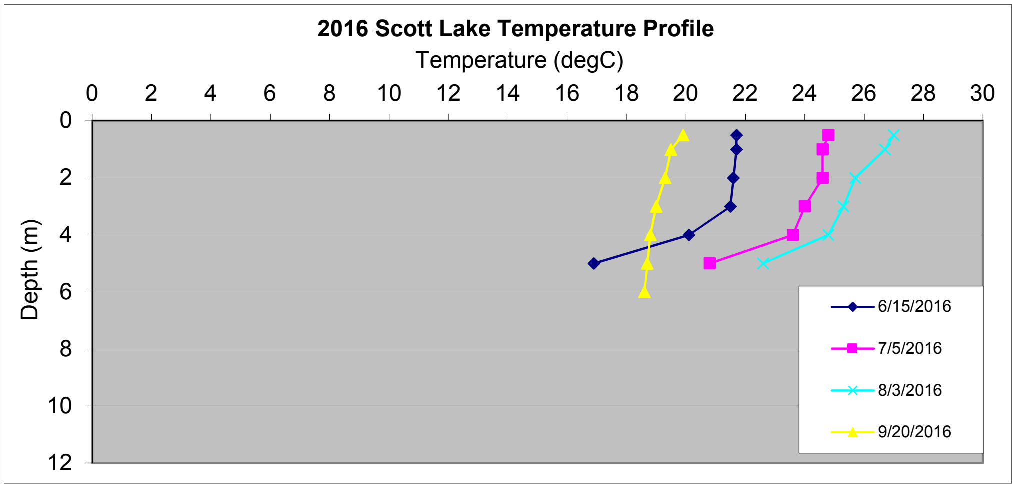

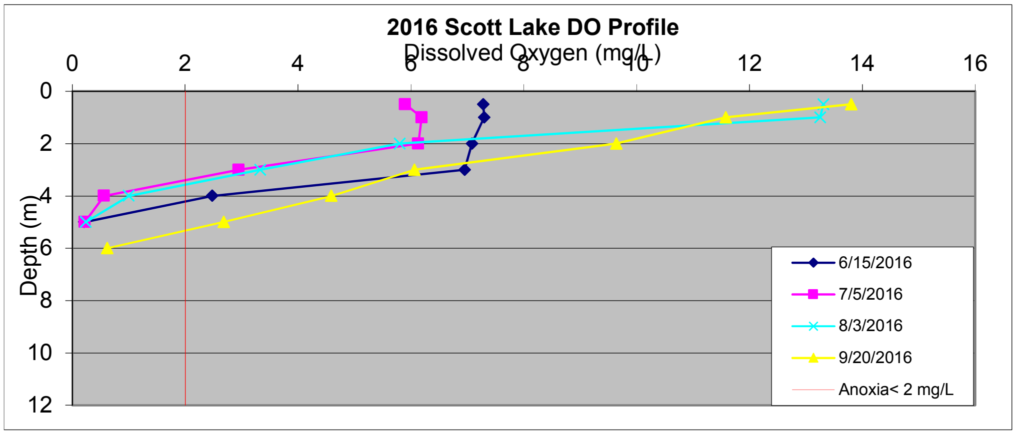

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Appendix E-Lake Phosphorus
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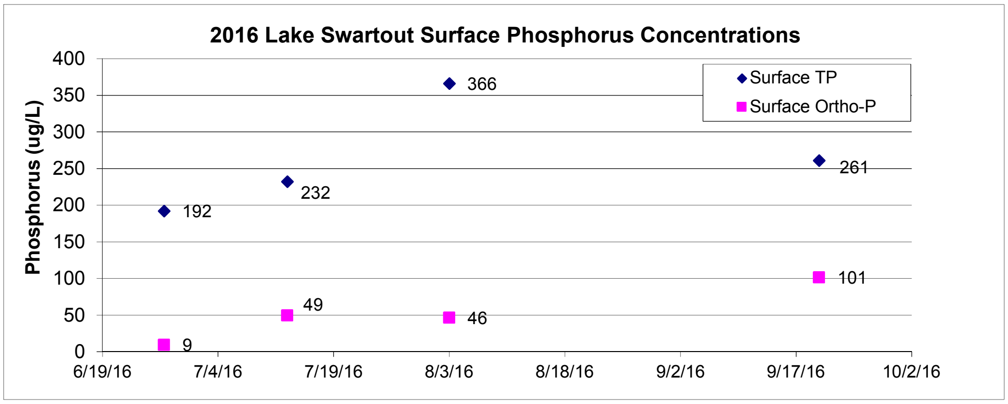

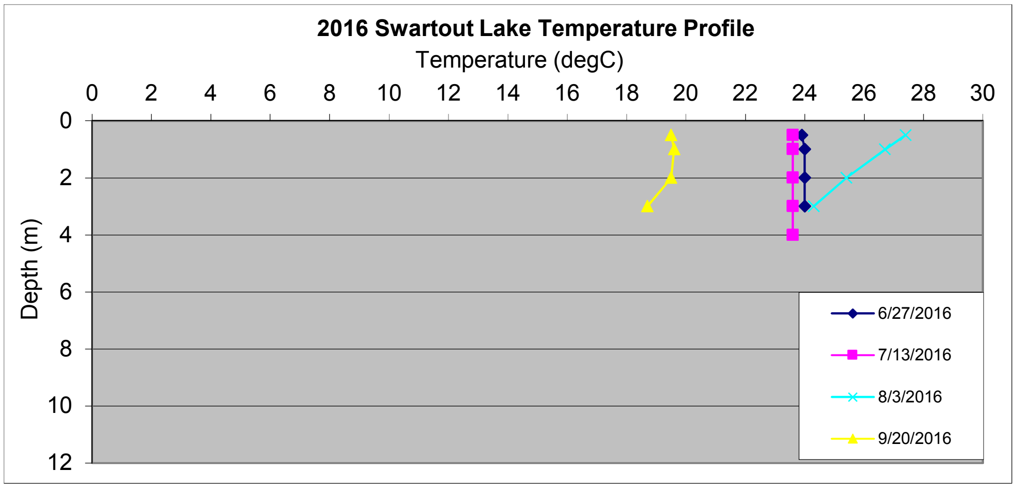

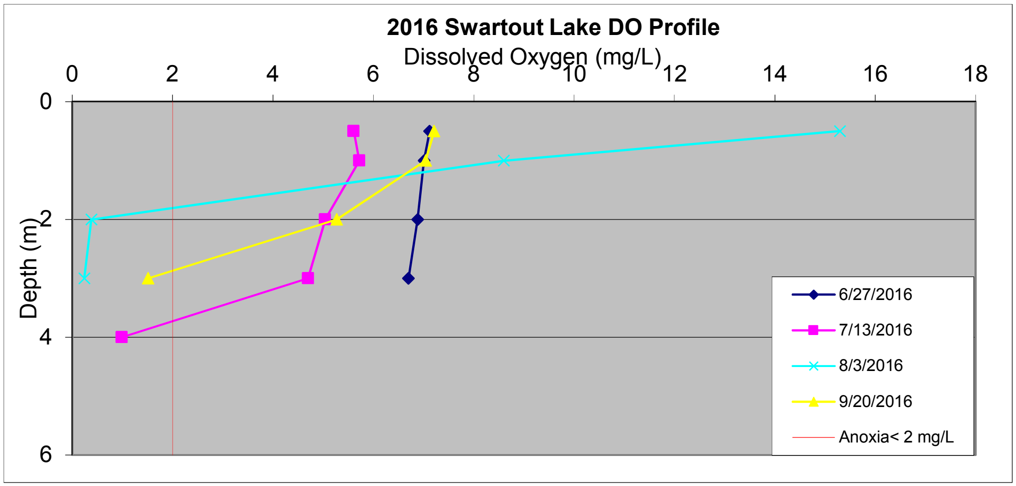

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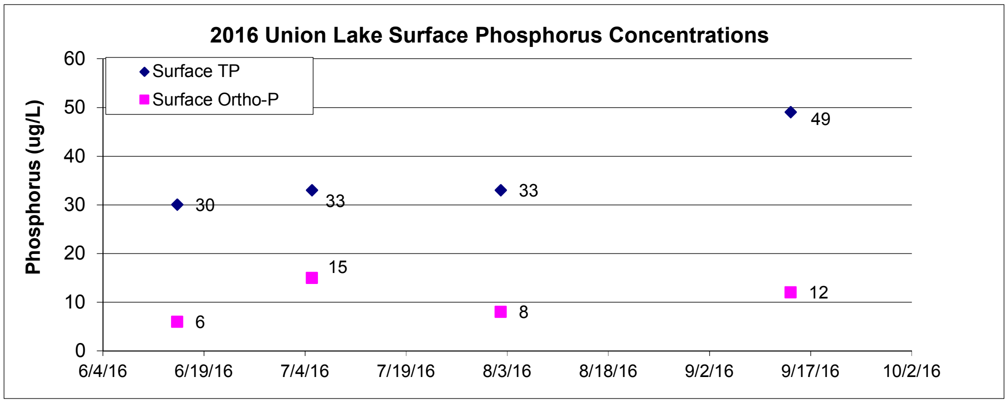
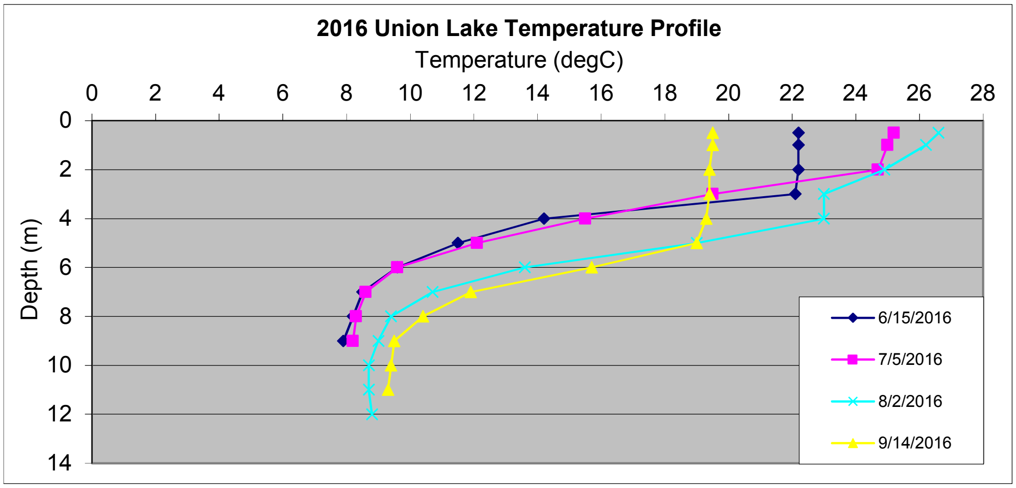
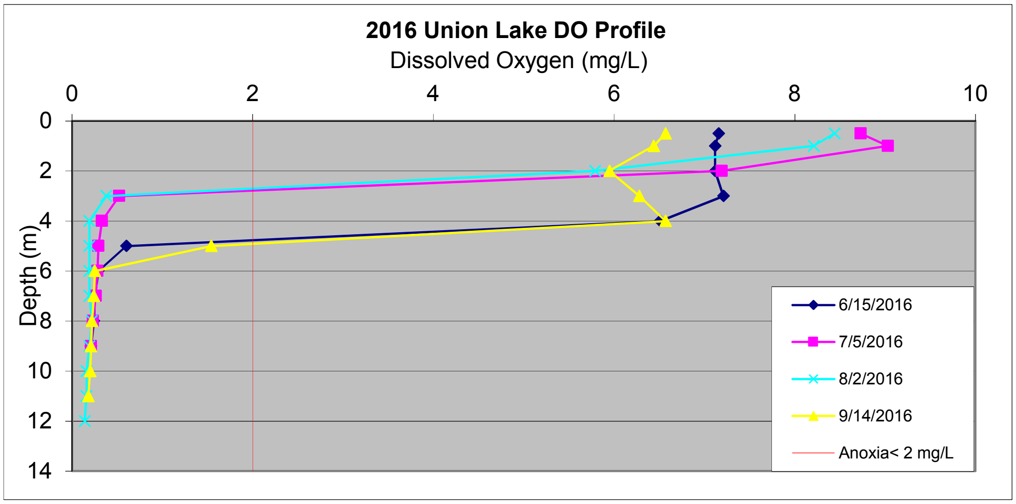
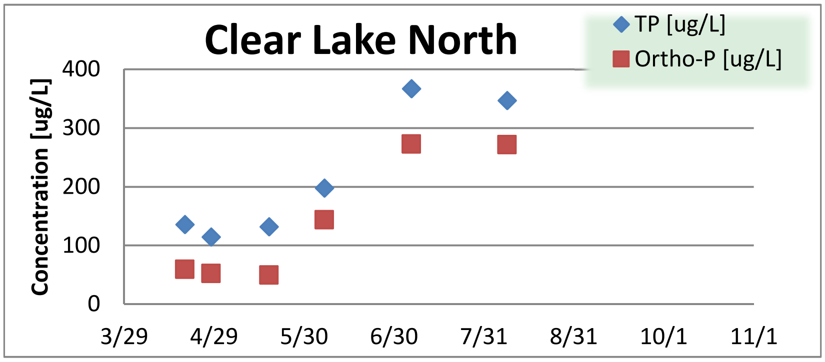
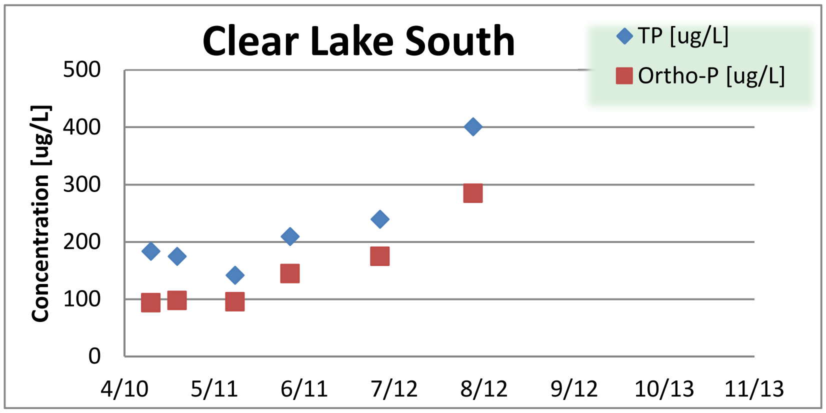


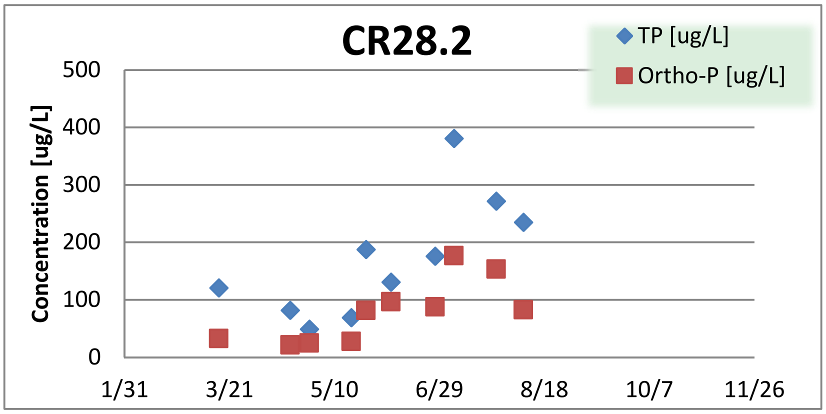


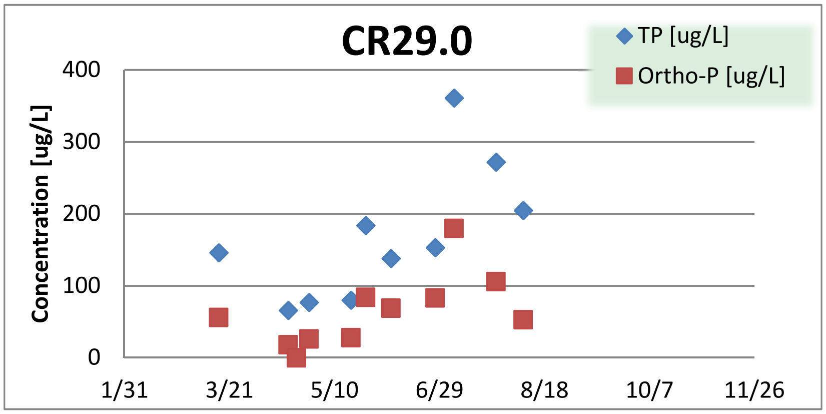


Appendix F
Clearwater River Watershed District Stream Phosphorus Concentrations
2016 Annual Report

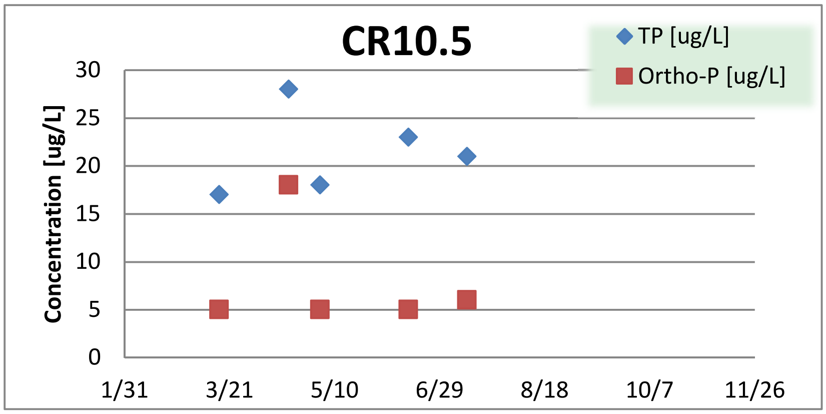


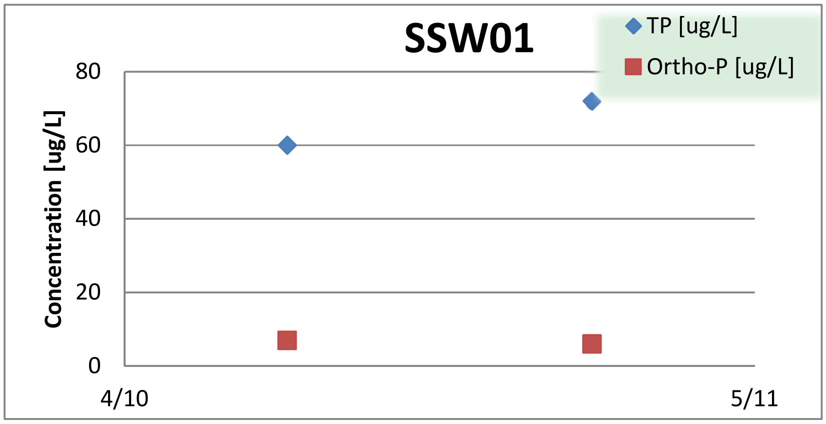


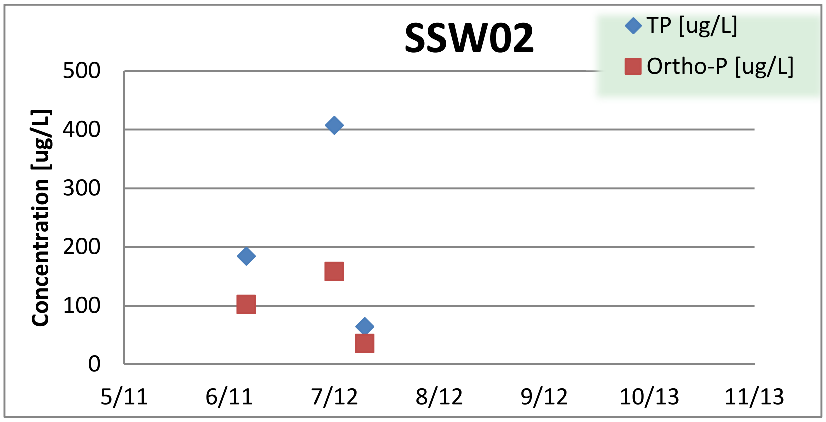




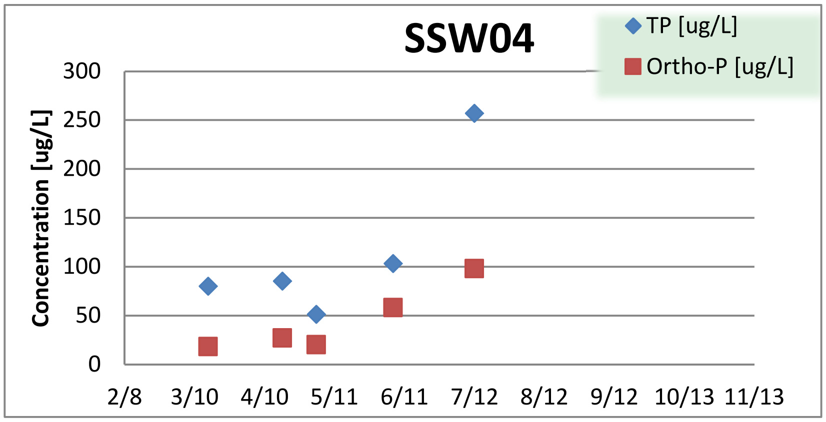
Appendix F
Clearwater River Watershed District Stream Phosphorus Concentrations
2016 Annual Report

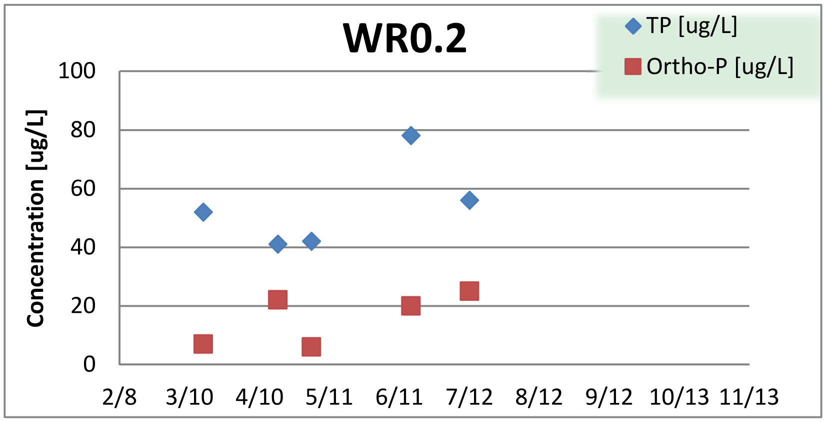


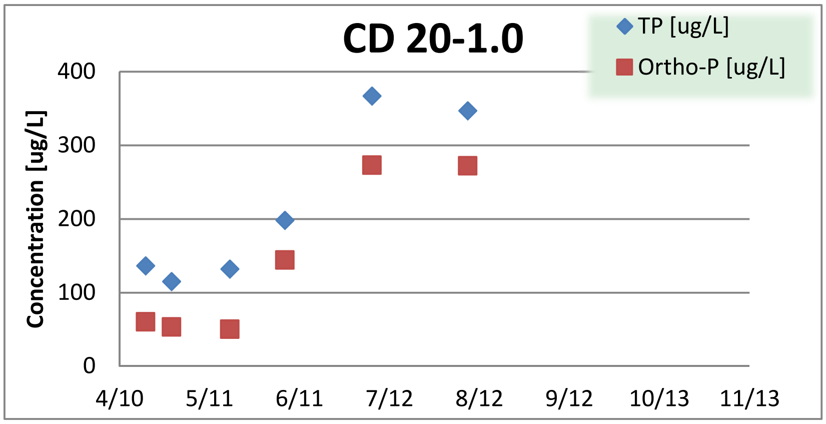


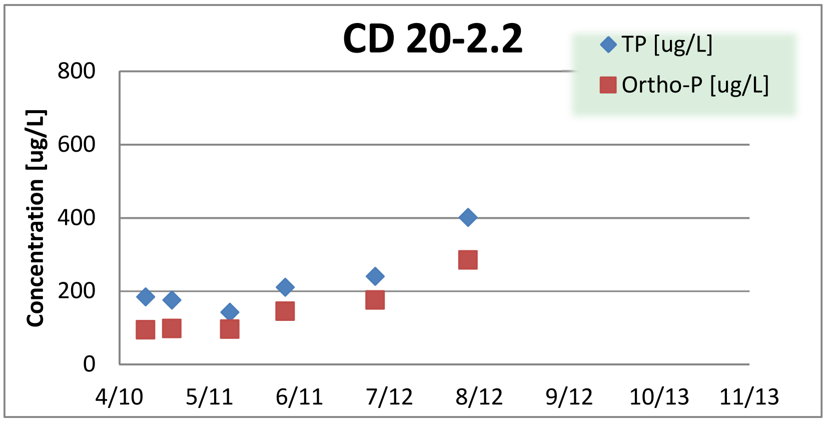


Appendix F
Clearwater River Watershed District Stream Phosphorus Concentrations
2016 Annual Report

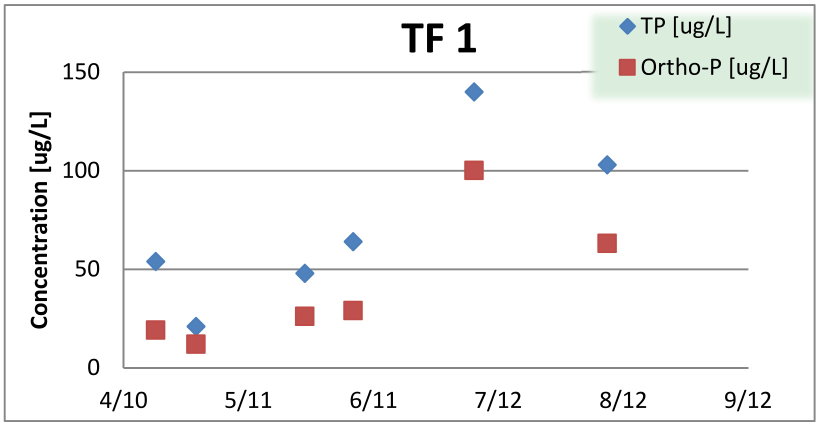


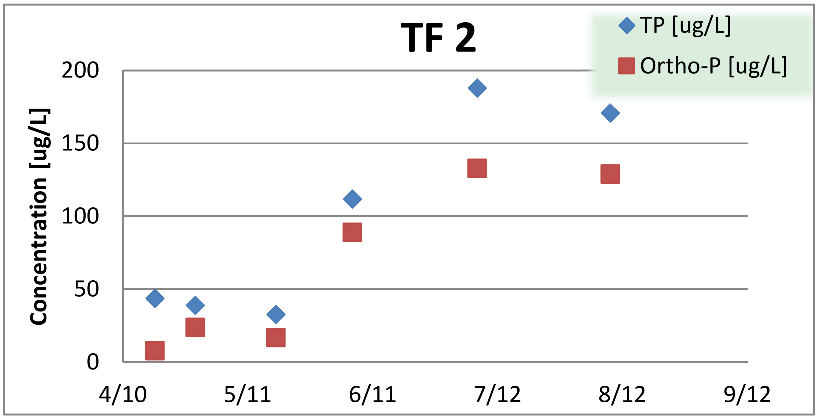


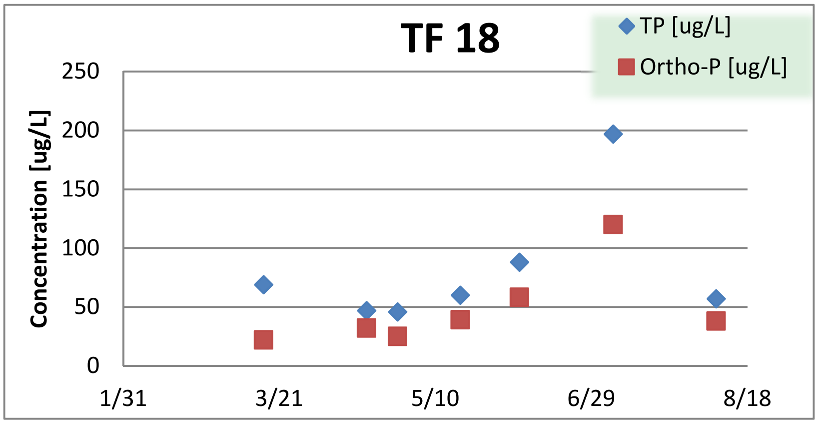


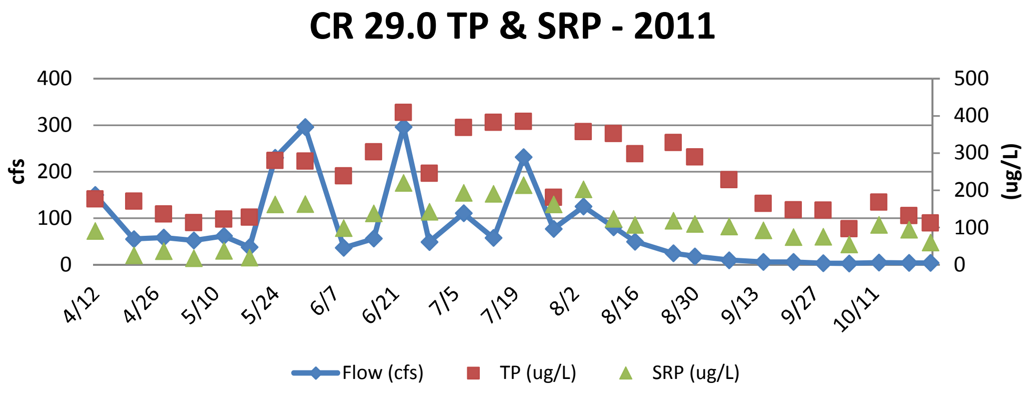


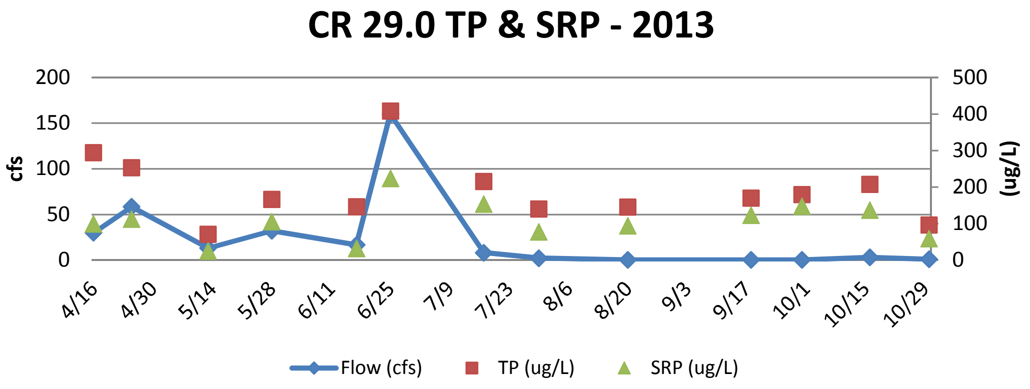
Appendix F
Clearwater River Watershed District Stream Phosphorus Concentrations
2016 Annual Report

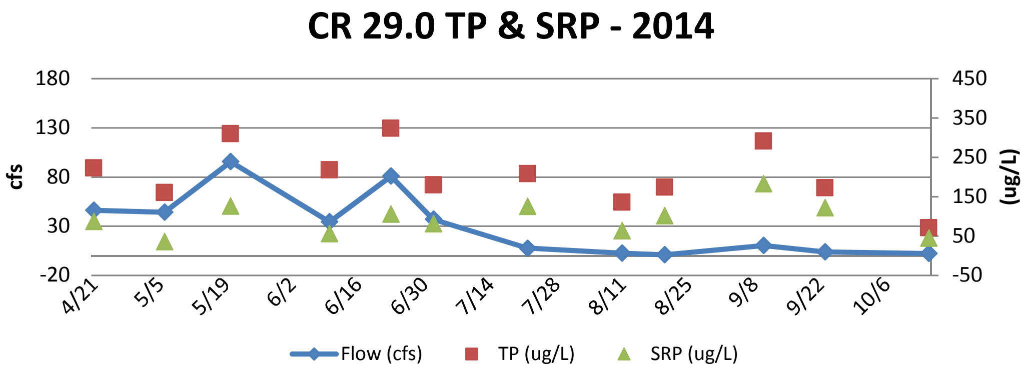


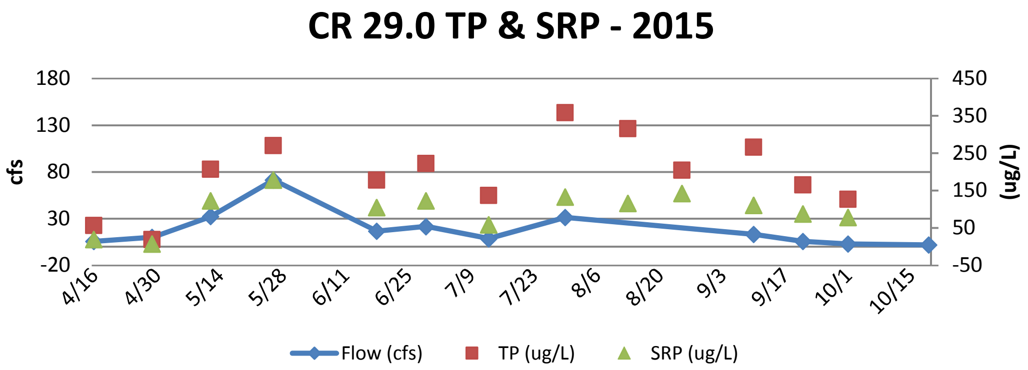


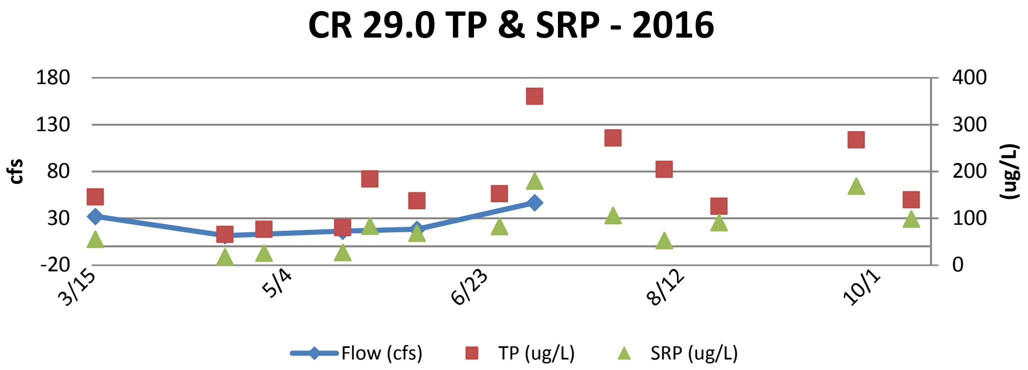


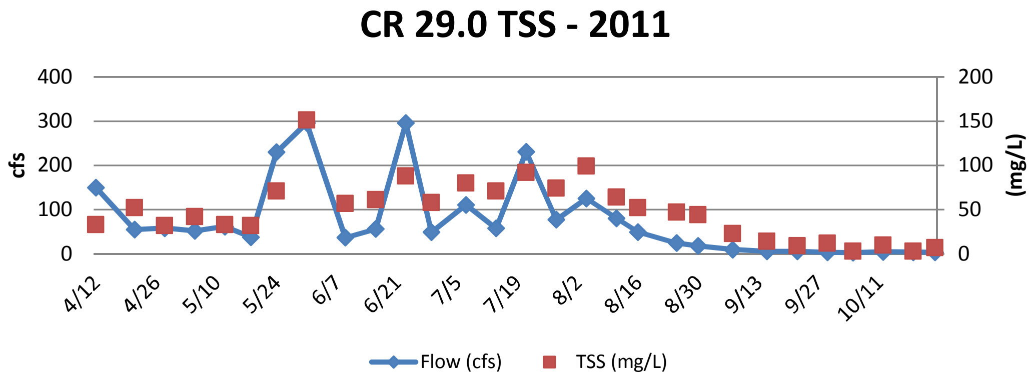

CR 29.0 TP & SRP - 2011
400
300
200
100
0
cfs
500
400
300
200
100
0
(ug/L)
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
10/11
Flow (cfs)
TP (ug/L)
SRP (ug/L)

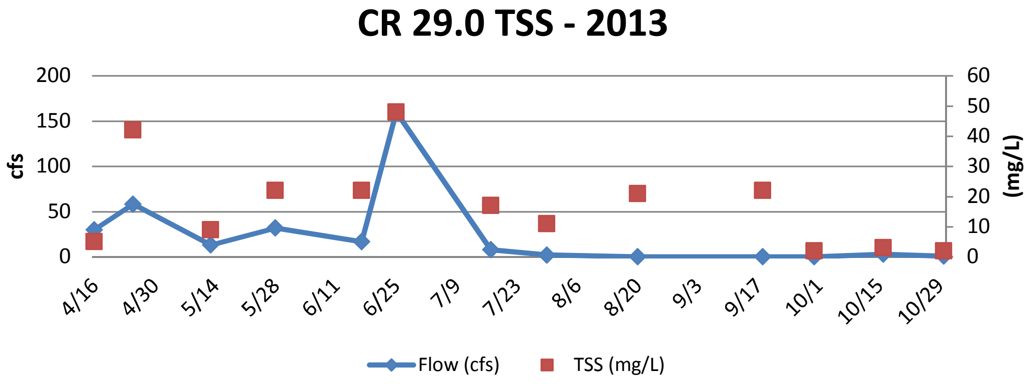

CR 29.0 TP & SRP - 2013
200
150
100
50
0
cfs
500
400
300
200
100
0
(ug/L)
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
10/29
Flow (cfs)
TP (ug/L)
SRP (ug/L)

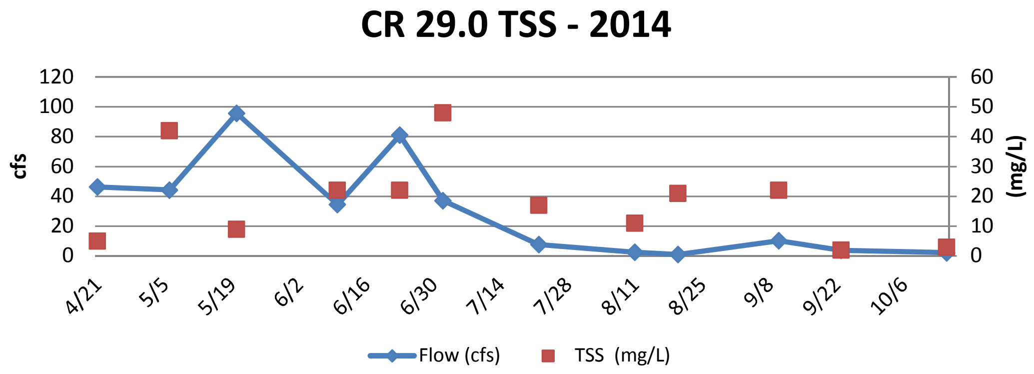

CR 29.0 TP & SRP - 2014
180
130
80
30
-20
cfs
450
350
250
150
50
-50
(ug/L)
4/21
5/5
5/19
6/2
6/16
6/30
7/14
7/28
8/11
8/25
9/8
9/22
10/6
Flow (cfs)
TP (ug/L)
SRP (ug/L)

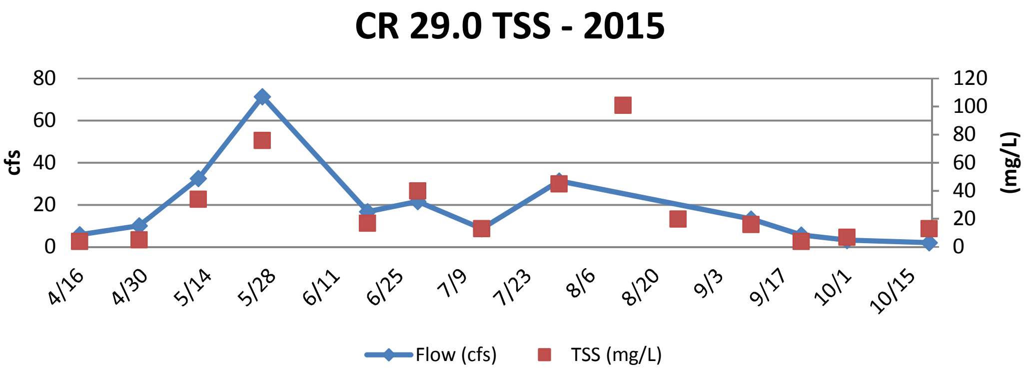

CR 29.0 TP & SRP - 2015
cfs
180
130
80
30
-20
450
350
250
150
50
-50
(ug/L)
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
Flow (cfs)
TP (ug/L)
SRP (ug/L)

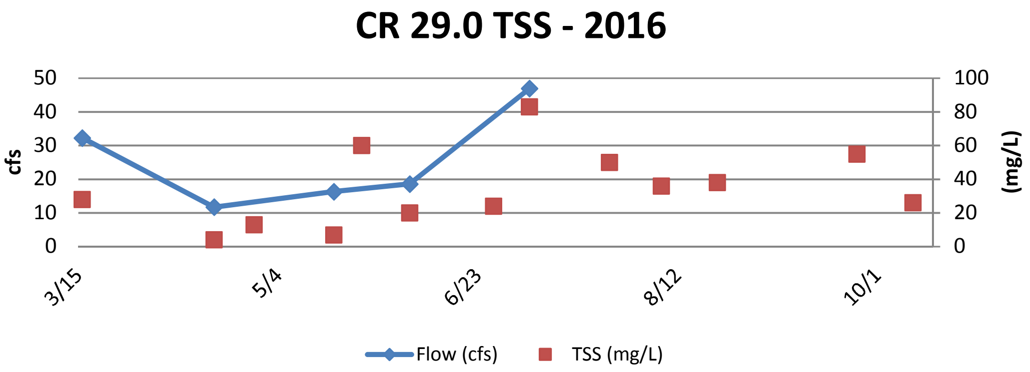

CR 29.0 TP & SRP - 2016
cfs
180
130
80
30
-20
400
300
200
100
0
(ug/L)
3/15
5/4
6/23
8/12
10/1
Flow (cfs)
TP (ug/L)
SRP (ug/L)


CR 29.0 TSS - 2011
cfs
400
300
200
100
0
200
150
100
50
0
(mg/L)
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
10/11
Flow (cfs)
TSS (mg/L)

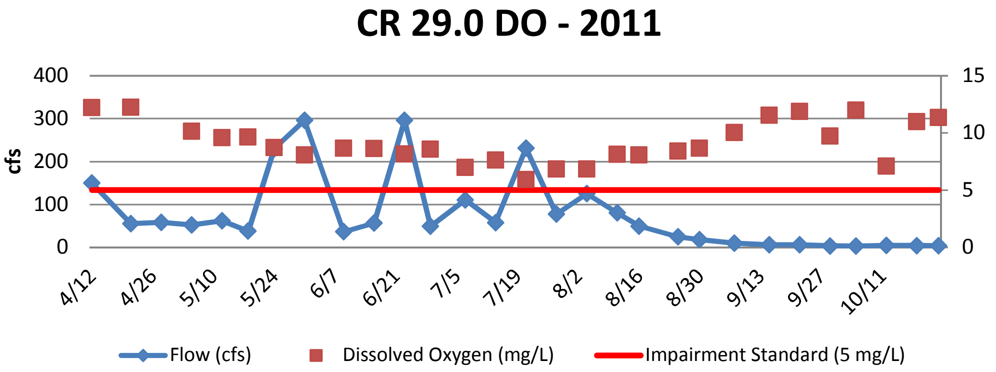

CR 29.0 TSS - 2013
cfs
200
150
100
50
0
60
50
40
30
20
10
0
(mg/L)
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
10/29
Flow (cfs)
TSS (mg/L)

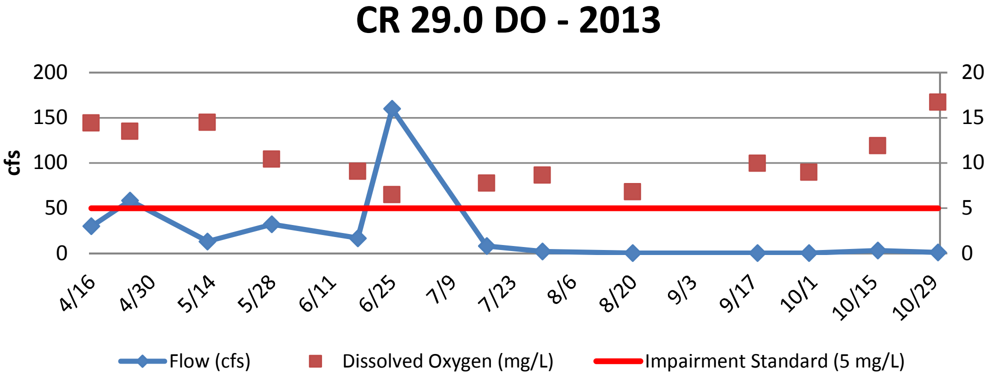

CR 29.0 TSS - 2014
cfs
120
100
80
60
40
20
0
60
50
40
30
20
10
0
(mg/L)
4/21
5/5
5/19
6/2
6/16
6/30
7/14
7/28
8/11
8/25
9/8
9/22
10/6
Flow (cfs)
TSS (mg/L)

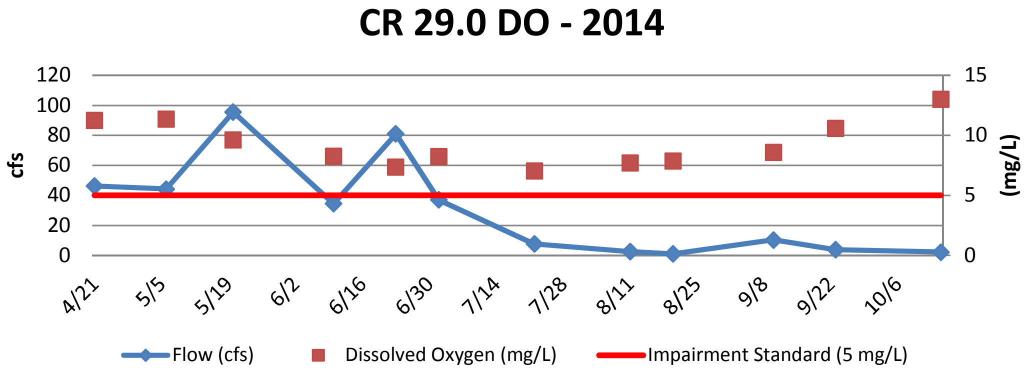

CR 29.0 TSS - 2015
cfs
(mg/L)
80
60
40
20
0
120
100
80
60
40
20
0
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
Flow (cfs)
TSS (mg/L)

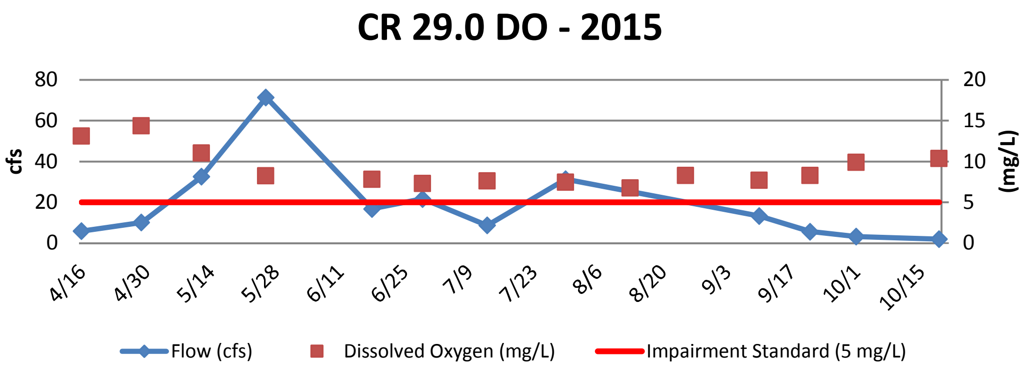

CR 29.0 TSS - 2016
cfs
(mg/L)
50
40
30
20
10
0
100
80
60
40
20
0
3/15
5/4
6/23
8/12
10/1
Flow (cfs)
TSS (mg/L)

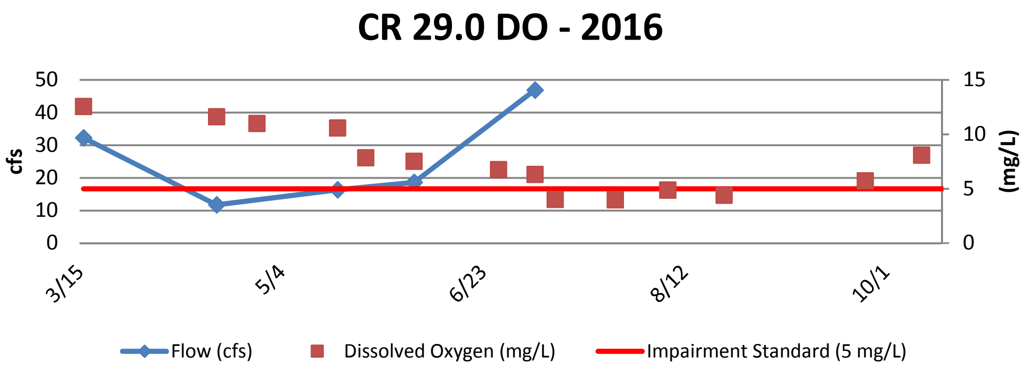
Appendix G-Kingston Wetland Monitoring Data

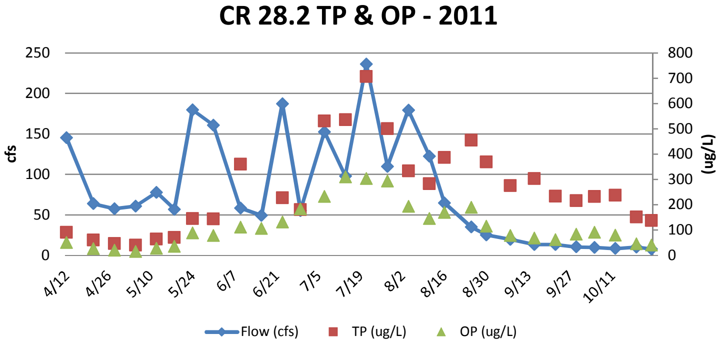


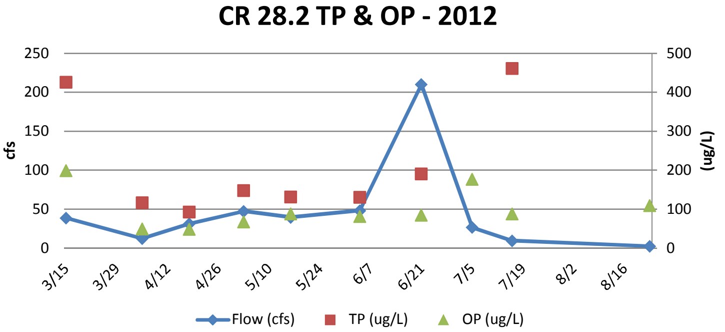


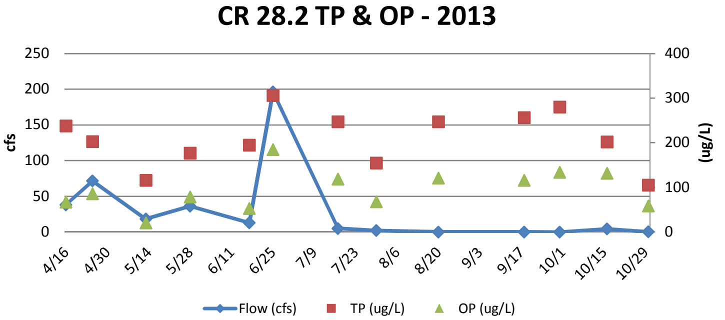


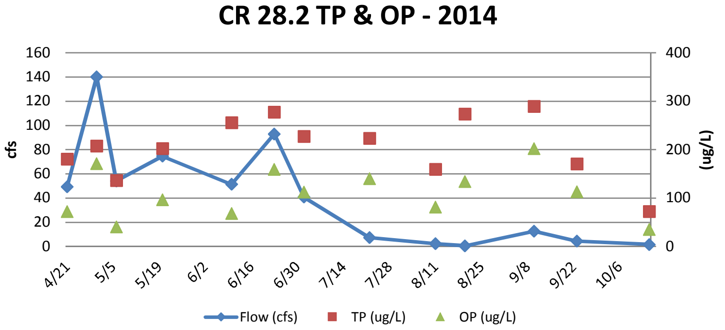

CR 29.0 DO - 2015
cfs
80
60
40
20
0
20
15
10
5
0
(mg/L)
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
Flow (cfs)
Dissolved Oxygen (mg/L)
Impairment Standard (5 mg/L)


CR 29.0 DO - 2016
cfs
50
40
30
20
10
0
15
10
5
0
(mg/L)
3/15
5/4
6/23
8/12
10/1
Flow (cfs)
Dissolved Oxygen (mg/L)
Impairment Standard (5 mg/L)

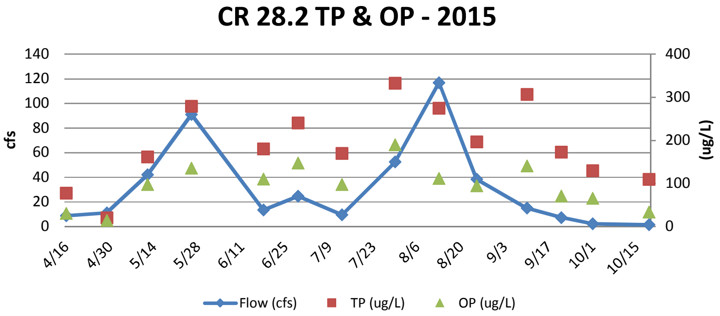

CR 28.2 TP & OP - 2011
cfs
(ug/L)
0
50
100
150
200
250
0
100
200
300
400
500
600
700
800
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
10/11
Flow (cfs)
TP (ug/L)
OP (ug/L)

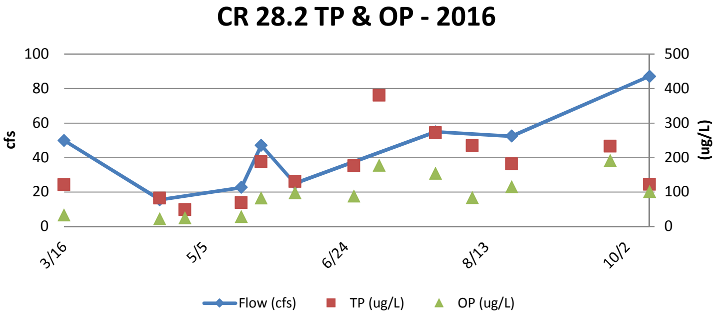

CR 28.2 TP & OP - 2012
cfs
(ug/L)
0
50
100
150
200
250
0
100
200
300
400
500
3/15
3/29
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
Flow (cfs)
TP (ug/L)
OP (ug/L)

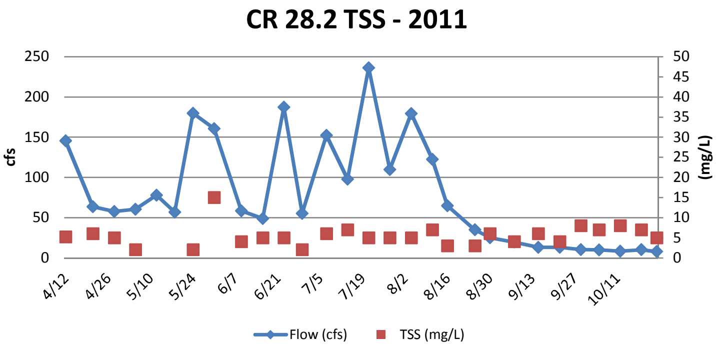

CR 28.2 TP & OP - 2013
cfs
(ug/L)
0
50
100
150
200
250
0
100
200
300
400
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
10/29
Flow (cfs)
TP (ug/L)
OP (ug/L)

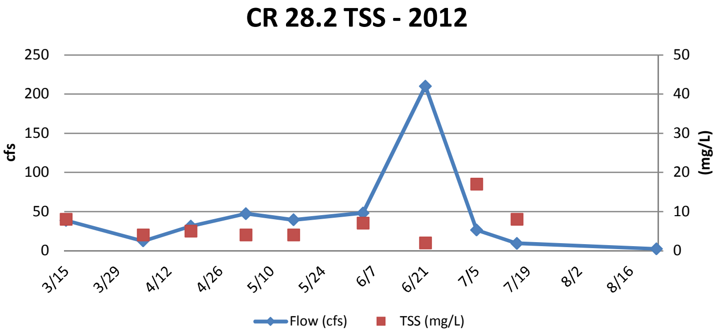

CR 28.2 TP & OP - 2014
cfs
(ug/L)
0
20
40
60
80
100
120
140
160
0
100
200
300
400
4/21
5/5
5/19
6/2
6/16
6/30
7/14
7/28
8/11
8/25
9/8
9/22
10/6
Flow (cfs)
TP (ug/L)
OP (ug/L)

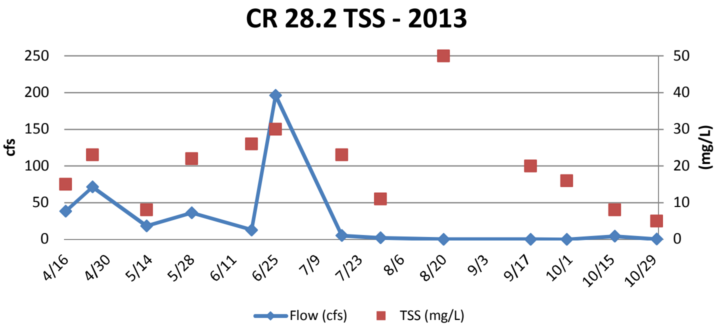
Appendix G-Kingston Wetland Monitoring Data

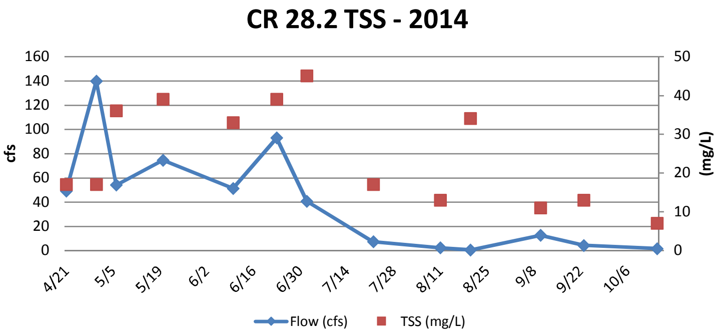




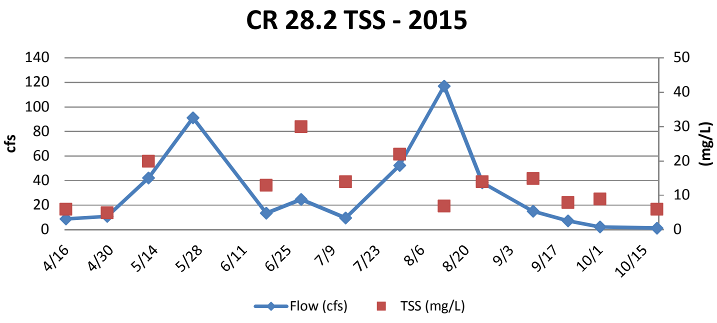

CR 28.2 TSS - 2011
cfs
(mg/L)
250
200
150
100
50
0
50
45
40
35
30
25
20
15
10
5
0
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
8/30
9/13
9/27
10/11
Flow (cfs)
TSS (mg/L)


CR 28.2 TSS - 2012
cfs
(mg/L)
250
200
150
100
50
0
50
40
30
20
10
0
3/15
3/29
4/12
4/26
5/10
5/24
6/7
6/21
7/5
7/19
8/2
8/16
Flow (cfs)
TSS (mg/L)

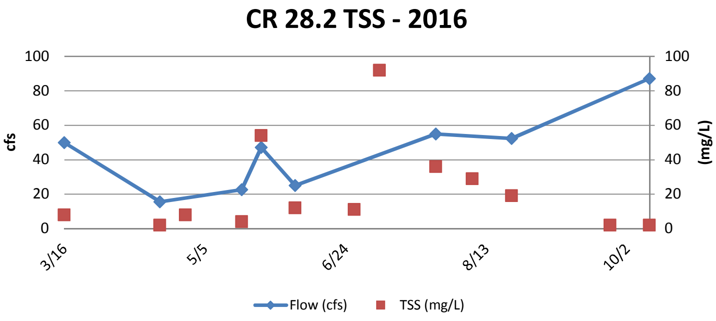

CR 28.2 TSS - 2013
cfs
(mg/L)
250
200
150
100
50
0
50
40
30
20
10
0
4/16
4/30
5/14
5/28
6/11
6/25
7/9
7/23
8/6
8/20
9/3
9/17
10/1
10/15
10/29
Flow (cfs)
TSS (mg/L)


CR 28.2 TSS - 2014
cfs
(mg/L)
160
140
120
100
80
60
40
20
0
50
40
30
20
10
0
4/21
5/5
5/19
6/2
6/16
6/30
7/14
7/28
8/11
8/25
9/8
9/22
10/6
Flow (cfs)
TSS (mg/L)

Appendix G-Kingston Wetland Monitoring Data

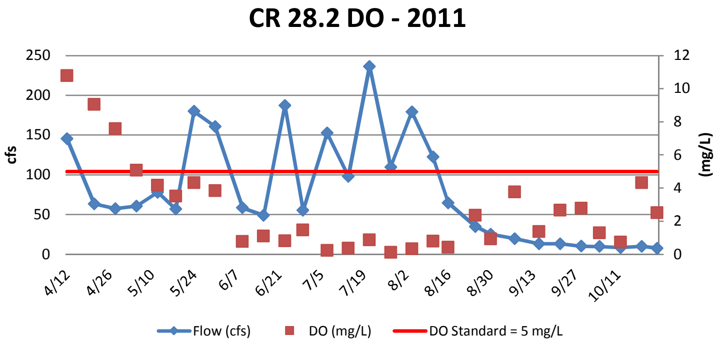


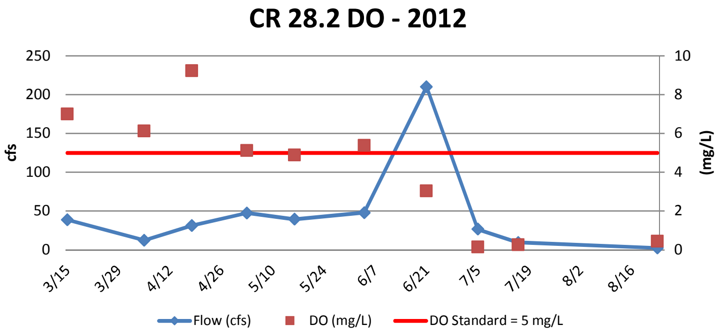
CR 28.2 TSS - 2015

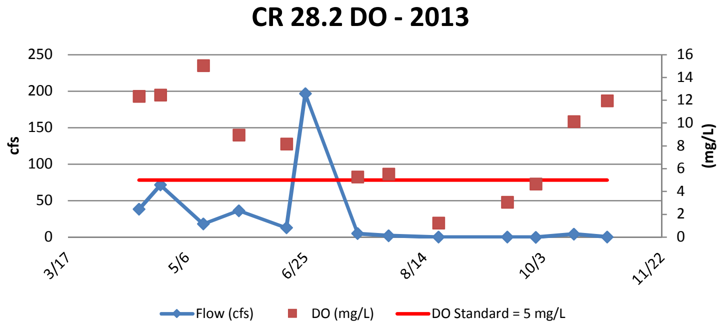


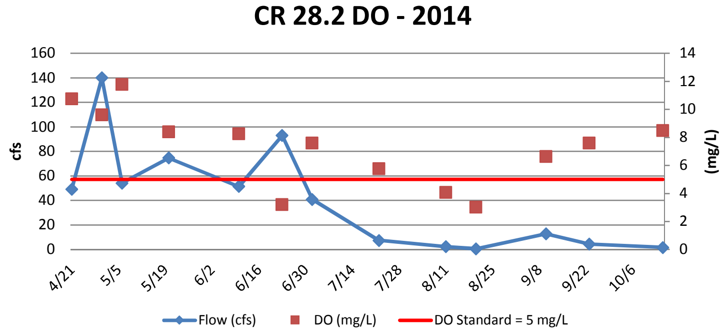
CR 28.2 TSS - 2016

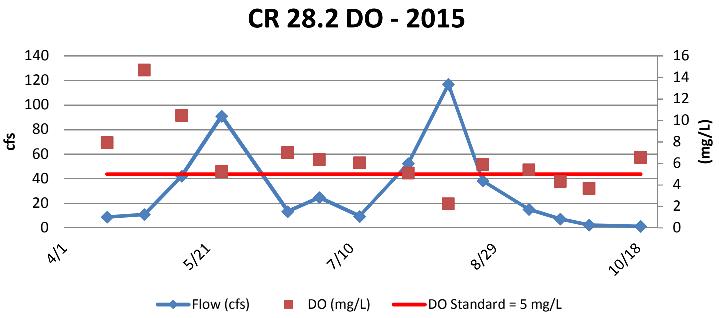
Appendix G-Kingston Wetland Monitoring Data

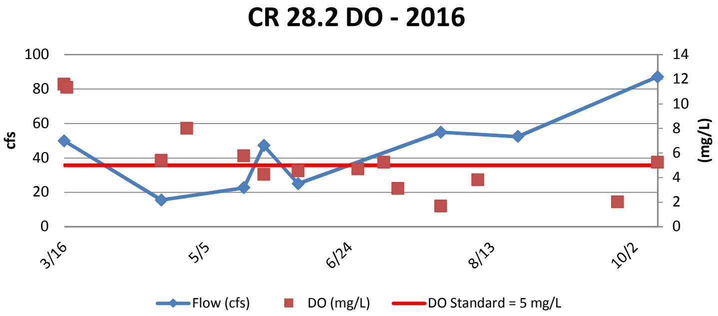




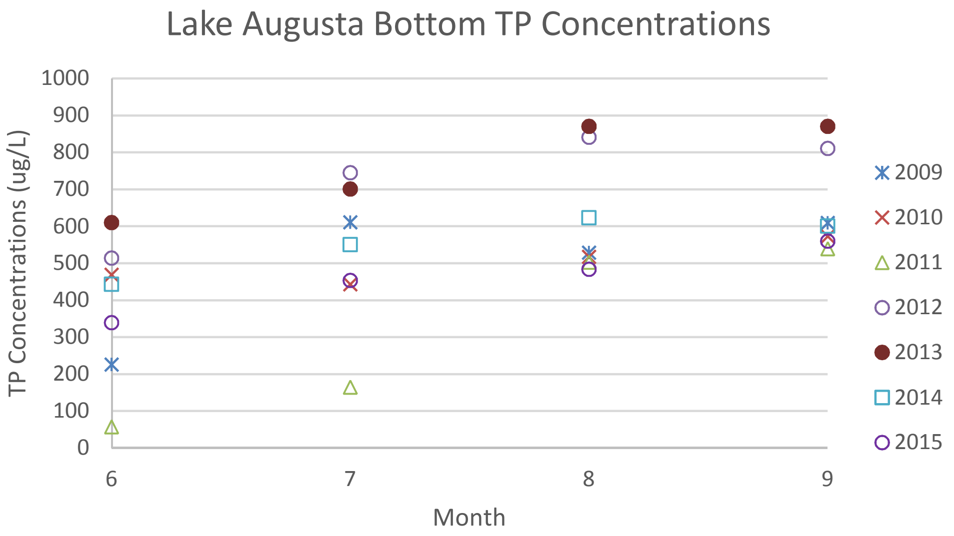


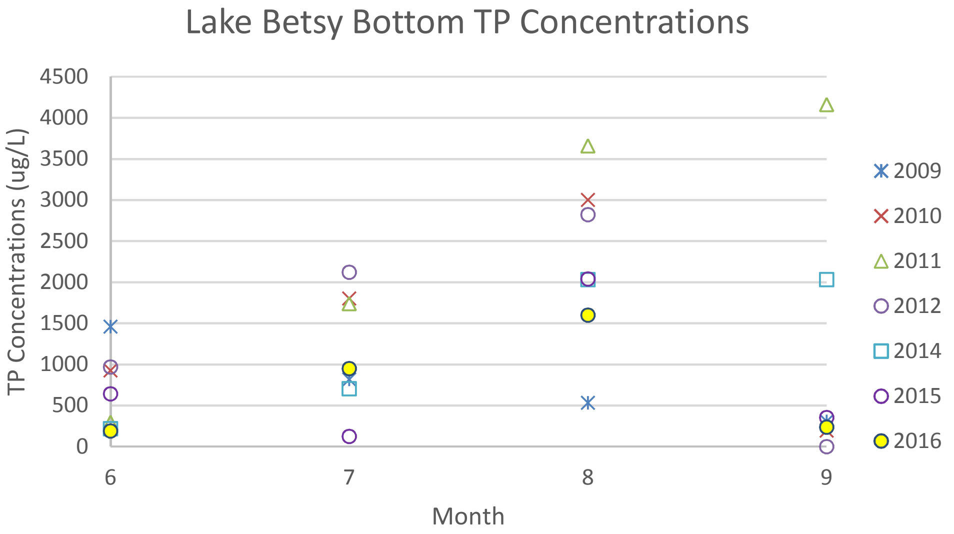


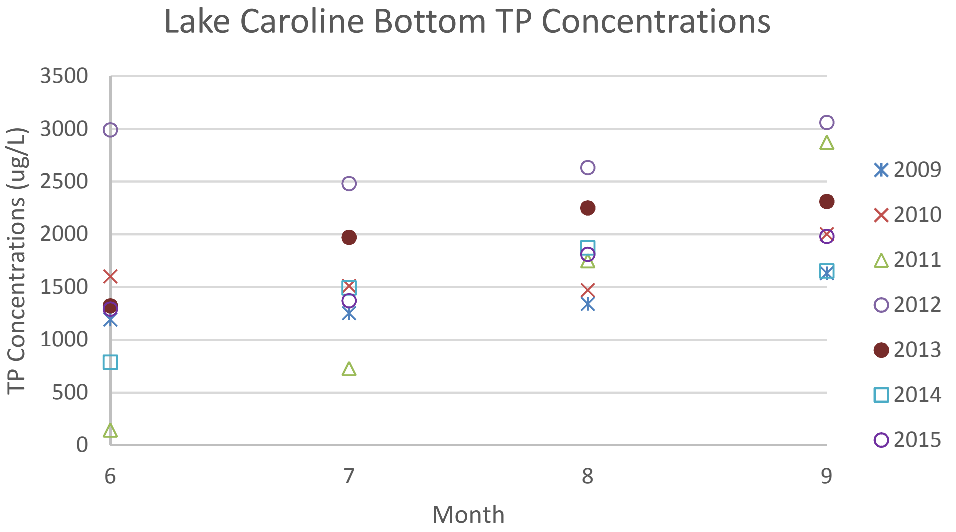

CR 28.2 DO - 2015
cfs
140
120
100
80
60
40
20
0
16
14
12
10
8
6
4
2
0
(mg/L)
4/1
5/21
7/10
8/29
10/18
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L


CR 28.2 DO - 2016
cfs
100
80
60
40
20
0
14
12
10
8
6
4
2
0
(mg/L)
3/16
5/5
6/24
8/13
10/2
Flow (cfs)
DO (mg/L)
DO Standard = 5 mg/L

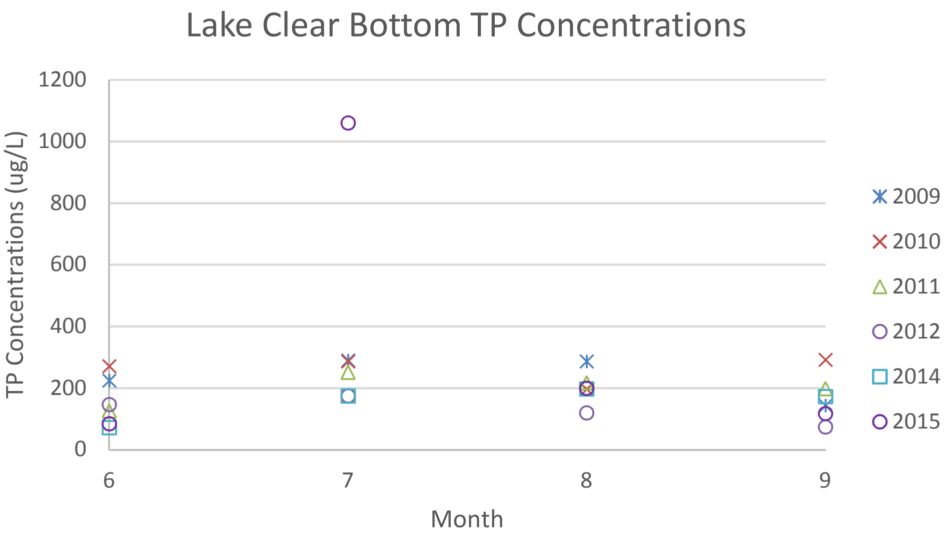
Appendix H Historical Lake Bottom Data

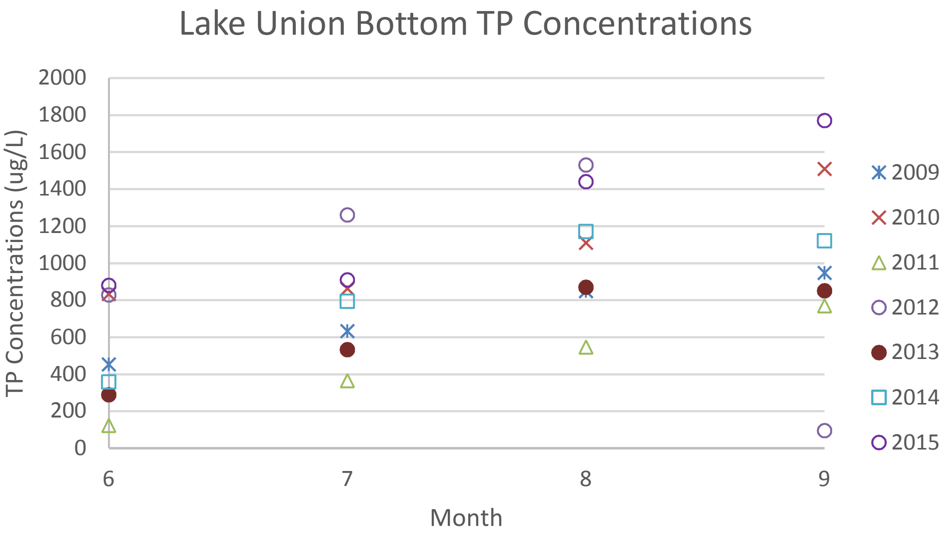






Appendix H Historical Lake Bottom Data





Appendix H Historical Lake Bottom Data