MINNEAPOLIS PARK & RECREATION BOARD

2013

WATER RESOURCES REPORT

Environmental Stewardship
Water Resources Management
www.minneapolisparks.org
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Minneapolis
Park & Recreation Board

2013
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LIST OF ABBREVIATIONS

% DO	Percent Dissolved Oxygen
µg	Microgram
µm	Micrometer
µmhos	Micromhos
µS	Micro Siemens
ACSP	Audubon Cooperative Sanctuary Program
Al	Aluminum
Alk	Alkalinity
alum	Aluminum sulfate
As	Arsenic
BCWMC	Bassett's Creek Watershed Management Commission
BMP	Best Management Practices
C	Celsius
CAMP	Citizen Assisted Monitoring Program
cBOD	5 day Carbonaceous Biochemical Oxygen Demand
Cd	Cadmium
CDS	Continuous Deflective Separation
cf	Cubic foot
cfs	Cubic foot per second
cfu	Colony forming unit
chl-*a*	Chlorophyll-*a*
Cl	Chloride
cm	Centimeter
COD	Chemical Oxygen Demand
Cond	Conductivity
Cu	Copper
CV	Coefficient of Variance
CWP	Center for Watershed Protection
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
ERA	Environmental Resource Associates
EWM	Eurasian watermilfoil
F	Fahrenheit
F. coli	Fecal Coliform
Fe	Iron
FIN	Fishing in the Neighborhood Program
ft	Foot
GIS	Geographical Information System
GPS	Global Positioning System
Hard	Hardness, Total as CaCO3
HPLC	High Pressure Liquid Chromatography
IBI	Index of Biological Integrity

ID	Insufficient Data
in/hr	Inches per hour
IRI	Instrumental Research, Inc.
IWMI	Interagency Water Monitoring Initiative
kg	Kilogram
L	Liter
LAURI	Lake Aesthetic and User Recreation Index
m	Meter
MAX	Maximum
MCES	Metropolitan Council Environmental Services
MCWD	Minnehaha Creek Watershed District
MDL	Minimum Detection Limit
MDNR	Minnesota Department of Natural Resources
mg	Milligram
MIN	Minimum
mL	Milliliter
Mn	Manganese
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
Mpls	Minneapolis
MPN	Most probable number
MPRB	Minneapolis Park and Recreation Board
MPW	Minneapolis Public Works
msl	Mean sea level
MRL	Minimum Reporting Limit
N/A	Not Applicable
n/c	Not Collected
NA	No Data Available
NB	No Swimming Beach
NCHF	North Central Hardwood Forests
ND	Not Detected
NDC	National Data Center
NH3	Ammonia, Un-ionized as N
Ni	Nickel
NO3/NO2	Nitrate+Nitrite
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrite+Nitrate, Total as N
NPDES	National Pollutant Discharge Elimination Systems
NS	Not Sampled
NTU	Nephelometric Turbidity Unit
NURP	Nationwide Urban Runoff Program
NWS	National Weather Service
OHW	Ordinary High Water Level
OTP	Ortho Phosphorus
P	Phosphorus

Pb	Lead
PE	Performance Evaluation
PFC	Perflorinated Chemical
PFOA	Perflurorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RL	Reporting Limit
RPD	Relative Percent Difference
s	Second
Si	Reactive Silica
Sp. Cond.	Specific Conductivity
SRP	Soluble Reactive Phosphorus
STDEV	Standard Deviation
TCMA	Twin Cities Metropolitan Area
TDP	Total Dissolved Phosphorus
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TRPD	Three Rivers Park District
TSI	Trophic State Index
TSS	Total Suspended Solids
US EPA	US Environmental Protection Agency
USGS	US Geological Survey
VSS	Volatile Suspended Solids
WHEP	Wetland Health Evaluation Program
WOMP	Watershed Outlet Monitoring Program
WPA	Works Progress Administration
Zn	Zinc

EXECUTIVE SUMMARY

As part of its stewardship of the lakes and other water bodies within the City of Minneapolis, the Minneapolis Park and Recreation Board (MPRB) monitors lakes, streams, and stormwater flows for contaminants and other water quality indicators. This report presents the results for the 2013 monitoring season. The report is primarily based on data collected by the MPRB Environmental Stewardship Section.

The MPRB monitors the water quality of Brownie, Calhoun, Cedar, Diamond, Grass, Harriet, Hiawatha, Isles, Loring, Nokomis, Powderhorn, Spring, Webber, and Wirth Lakes. Historical data from 1991-2013 are used to calculate trophic state index (TSI) trends and estimate the trophic status for each lake. Based on the trophic state report for 2013 the following observations are made:

Lakes with increasing water quality indicators	**Lakes with stable trend**	**Lakes with decreasing water quality indicators**
➢ Lake Calhoun	➢ Brownie Lake	➢ Diamond Lake
➢ Cedar Lake	➢ Lake of the Isles	➢ Loring Pond
➢ Lake Harriet	➢ Lake Nokomis	➢ Spring Lake
➢ Powderhorn Lake	➢ Lake Hiawatha	
➢ Wirth Lake		

Water Quality Highlights

The Minneapolis lakes once again experienced a cool wet spring followed by warm drought conditions from August through October in 2013. The annual recorded rainfall total for 2013 was 32.77 inches, 2.64 inches above normal, and the average annual temperature was 45.2 ºF, 0.9 ºF below normal.

The water quality of Lakes Calhoun and Harriet continues to be strong for lakes in urban settings. Water quality indicators show increased water quality since the early 1990s; however, the last decade of monitoring data have shown a possible trend towards slight degradation in water quality. Monitoring data should be used to track this nascent trend and to develop next generation plans for these lakes.

Powderhorn Lake received its tenth barley straw treatment. Filamentous algae growth in the summer impacted the aesthetics and clarity of the lake. The decomposition of algae combined with the hot dry summer led to low oxygen levels at Powderhorn Lake.

Wirth Lake continued its increasing water quality trend. Wirth Lake currently meets the Minnesota Pollution Control Agency (MPCA) guidelines for phosphorus, chlorophyll-*a*, and Secchi depth and has for most years since 2000.

The TSI value for Cedar Lake indicated poorer water quality in 2013. However, the long term record shows a slight increase in water quality since 1991. Future monitoring will determine whether 2013 was indicative of a longer term trend or just an abnormal year.

Lake Nokomis entered the third year of a biomanipulation study in 2013, which aims to reduce sediment disturbance by burrowing fish. While the TSI has remained stable, the project may eventually have a positive effect on clarity when there is a lower level of sediment phosphorus release. Future monitoring will show the effectiveness of this approach on water quality in Lake Nokomis.

The water quality at Lake Hiawatha is controlled by the large inflow from Minnehaha Creek. Drought years strongly influence this lake. The Minnehaha Creek – Lake Hiawatha TMDL study was completed using monitoring data from Lake Hiawatha as well as flow data from the Minnehaha Creek WOMP station and the Minneapolis-MPRB Xerxes station. As a result, the EPA approved a new 50 µg/L TP standard for Lake Hiawatha.

The floating biohavens in Spring Lake entered its second full year of establishment in 2013. The biohavens appeared to be in poor condition after the winter. Qualitative monitoring during the summer showed there was now more growth of the volunteer plants than the original plantings.

In summer 2013, MPRB began a three year project to remove hybrid and narrow-leaf cattail from Loring Pond and replant the shoreline with native vegetation. The 500 square foot demonstration area on the southern perimeter of the pond will investigate new methods for cattail management. Future years will show the effectiveness of this demonstration to restore the shoreline around the pond.

The MPRB monitored 12 public beaches for *Escherichia coli* (*E. coli*, as recommended by the US Environmental Protection Agency). These bacteria are used as proxy indicators of pathogens in water. Most beaches had low season-long geometric means with the exception of Lake Hiawatha, which closed multiple times due to exceeding the geometric mean guideline of 126 organisms per 100 mL of water. The Minnesota Pollution Control Agency single sample limit of 1,260 *E. coli* per 100 mL of water was exceeded only at Calhoun 32nd Beach once during the 2013 beach season.

Eurasian water milfoil harvesting was carried out on Calhoun, Cedar, Harriet, Nokomis, Lake of the Isles, and Wirth Lakes in 2013 to allow for improved recreational access. SCUBA divers were contracted to hand-harvest aquatic plants at Lake Nokomis and Wirth Lake in the beach areas.

MPRB, the Minnehaha Creek Watershed District, and the Friends of Lake Nokomis worked in partnership on early detection monitoring for invasive zebra mussels. In August 2013, water quality staff discovered zebra mussels on a sampling plate in Lake Hiawatha. The invasive mussel had been expected to arrive in Lake Hiawatha within a few years after their discovery in Lake Minnetonka, due to its direct connection with Minnehaha Creek. No zebra mussels were found in the other Minneapolis lakes in 2013.

The MPRB monitors storm sewers within Minneapolis to comply with the federal National Pollutant Discharge Elimination System (NPDES) permit. The purpose of this monitoring is to characterize the impacts of stormwater discharges to receiving waters and review the effectiveness of treatment best management practices (BMPs). The results of the 2013 data were typical for stormwater as compared to reports from other cities. The MPRB monitored performed baseline monitoring at 56th & 21st on the East side of Lake Nokomis. The Nokomis (56th & 21st) monitoring will be used with future data to determine the effectiveness of BMP street sweeping. Monitoring was also performed at Minnehaha Creek where it enters Minneapolis at Xerxes Avenue South.

Monitoring partners for 2013 included: the Bassett Creek Watershed Management Commission, The Friends of Lake Nokomis, Minneapolis Public Works, and the Minnehaha Creek Watershed District.

1. MONITORING PROGRAM OVERVIEW: 1991-2013

LAKE MONITORING

Background

The Environmental Operations Section of the Minneapolis Park and Recreation Board (MPRB) implemented a lake water quality monitoring program in 1991 as part of a diagnostic study for the Chain of Lakes Clean Water Partnership. The Chain of Lakes includes Brownie, Cedar, Isles, Calhoun, and Harriet. The monitoring program was expanded in 1992 to include Hiawatha, Nokomis, Diamond, Powderhorn, Loring, Webber, and Wirth Lakes. Spring Lake was added on a limited basis in 1993. Grass and Ryan Lakes were added on a limited basis in 2002. **Figure 1-1** shows the location of the lakes in Minneapolis. For purposes of this overview, these fifteen lakes will be collectively referred to as the Minneapolis lakes.

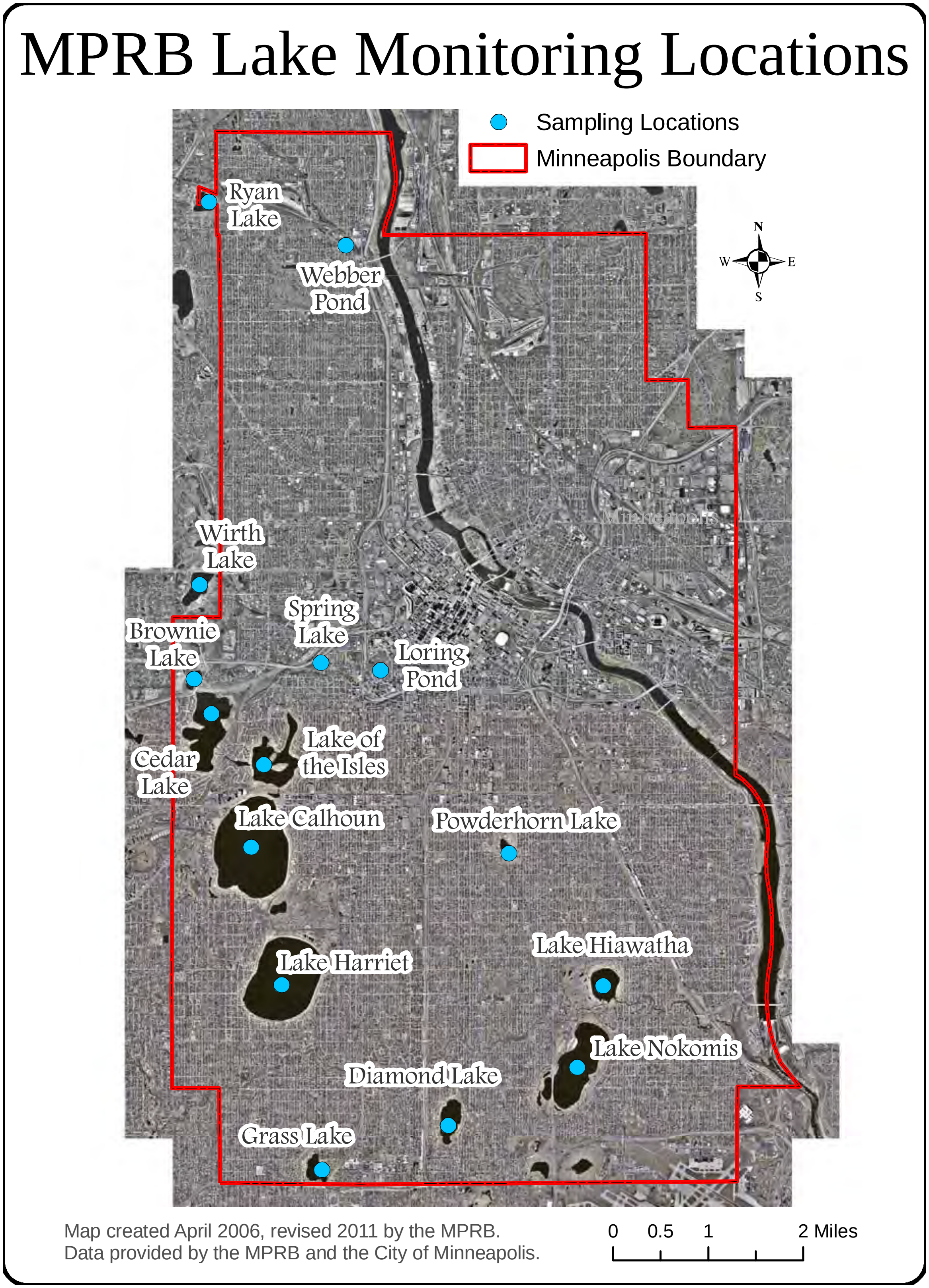
The objectives of the MPRB lake monitoring program are to:

1) Protect public health.
2) Establish a database for tracking water quality trends.
3) Quantify and interpret both immediate and long-term changes in water quality.
4) Provide water quality information to develop responsible water quality goals.
5) Provide a basis for water quality improvement projects.
6) Evaluate the effectiveness of implemented best management practices such as ponds and grit chambers.

The intent of this overview is to provide a description of the MPRB lakes monitoring program schedule and methods. Both Jensen (1997) and Shapiro (1997) offer some historical water quality analysis of the Chain of Lakes.

The fifteen Minneapolis lakes and their watersheds are located within the cities of Minneapolis, St. Louis Park, Richfield, Golden Valley, Robbinsdale, Brooklyn Center, and Edina. Residential housing is the predominant land use within all of the watersheds although industrial and commercial land uses are significant in several areas. The watersheds associated with Loring and Webber ponds are predominantly parkland. All of the Minneapolis lakes' watersheds are considered fully developed and little change in land use is projected.

The geology of the lakes and watersheds consist of Paleozoic bedrock that has been altered by fluvial processes and covered with glacial till. Area bedrock is generally concealed under 200–400 feet of unconsolidated deposits. The bedrock surface is composed of plateaus of limestone and dolomite penetrated by a system of dendritic preglacial river valleys. These river valleys were filled by a combination of fluvial sedimentation and deposition of late Wisconsin glacial drift. Each glacial advance stripped the landscape of earlier overburden and filled the preglacial and interglacial valleys with drift. The last glacial episode resulted in the formation of most of the lakes in Minneapolis.



Map created April 2006, revised 2011 by the MPRB.
Data provided by the MPRB and the City of Minneapolis.

Figure 1-1. Location of lakes monitored by MPRB.

The glacial ice sheet deposited large ice blocks at its margin as it retreated. Ice blocks that were deposited in a north-south tending pre-glacial (or interglacial) valley led to the formation of the Chain of Lakes. Lake Nokomis, Lake Hiawatha, and Powderhorn Lake formed as a result of a similar series of events in another preglacial valley (Zumberge, 1952; Balaban, 1989).

Nearly all of the Minneapolis lakes were physically altered by dredging in the early 1900s (Pulscher, 1997). The Minneapolis lakes currently represent a wide range of morphometric characteristics (see **Table 1-1**) including shallow wetland systems (Diamond and Grass Lakes), protected meromictic lakes (Brownie and Spring Lakes), and more classic, deep dimictic lakes (Lake Harriet and Lake Calhoun).

Table 1-1. Minneapolis lakes morphometric data.

Lake	Surface Area (acres)	Mean Depth (m)	Max Depth (m)	% Littoral*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
Brownie	18	6.8	15.2	67%	4.98×10^5	369	20.5	2.0
Calhoun	421	10.6	27.4	31%	1.80×10^7	2,992	7.1	4.2
Cedar	170	6.1	15.5	37%	4.26×10^6	1,956	11.5	2.7
Diamond	41	0.9[†]	2.1[†]	100%	7.15×10^4	669[‡]	16.3	NA
Grass	27	0.6	1.5	NA	NA	386	14.3	NA
Harriet	353	8.7	25.0	25%	1.25×10^7	1,139	3.2	3.4
Hiawatha	54	4.1	7.0	26%	8.95×10^5	115,840	2145	0.03
Isles	103	2.7	9.4	89%	1.11×10^6	735	7.1	0.6
Loring	8	1.5	5.3	NA	4.88×10^4	24	3.0	NA
Nokomis	204	4.3	10.1	51%	3.54×10^6	869	4.3	4.0[‡]
Powderhorn	11	1.2	6.1	99%	9.04×10^4	286	26.0	0.2[‡]
Ryan	18	NA	10.7	50%	NA	5,510	306	NA
Spring	3	3.0	8.5	NA	3.65×10^4	45	15.0	NA
Webber	3	0.9	2.0	NA	1.10×10^4	2	0.7	NA
Wirth	39	4.3	7.9	61%	6.70×10^5	348	9.4	NA

*Littoral area defined as less than 15 feet deep

[†] Based on long term average data.

[‡] Recent projects have altered these statistics.

NA= Information not available.

Methods

The 2013 schedule of physical and chemical parameters is shown in **Table 1-2**. Most lakes followed this schedule and were sampled once per month in February, April, and October and twice per month during the period of May through September. There were several exceptions to this schedule. Webber Pond and Spring Lake were each sampled once per month from April through October. Diamond Lake and Webber Pond were not sampled in winter because they were frozen to the bed.

Table 1-2. Schedule of sampled parameters for most lakes in 2013.

Parameter	Winter	March/April	May – Sept	October
Alkalinity	Once	Once	Once	Once
Chloride	Once	Once	Twice a Month	Once
Chlorophyll-*a*	Once	Once	Twice a Month	Once
Conductivity	Once	Once	Twice a Month	Once
Dissolved Oxygen	Once	Once	Twice a Month	Once
Escherichia Coli	Not sampled	Not Sampled	Once	Not Sampled
Hardness	Once	Once	Once	Once
pH	Once	Once	Twice a Month	Once
Phytoplankton	Once	Once	Twice a Month	Once
Secchi Transparency	Once	Once	Twice a Month	Once
Silica	Once	Once	Once a Month	Once
Temperature	Once	Once	Twice a Month	Once
TKN, NO_x	Once	Once	Once	Once
TP, SRP, TN	Once	Once	Twice a Month	Once
Turbidity	Once	Once	Twice a Month	Once
Zooplankton	Not sampled	Once	Once a Month	Once

All physical measurements and water samples for chemical analyses were obtained from a point directly over the deepest point in each lake (sampling station). The sampling stations were determined from bathymetric maps and located using shoreline landmarks and an electronic depth finder. Webber Pond and Grass Lake samples were taken as grab samples from the shore or by wading if water levels were too low.

A Hydrolab Minisonde 5 Multiprobe was used to record temperature, pH, conductivity, dissolved oxygen, and turbidity profiles. These parameters were measured at 1-meter intervals from the surface to the lake bottom. The multiprobe was calibrated according to the manufacturer's guidelines prior to each sampling trip. Secchi disk transparency was determined with a black and white 20-cm diameter disk on the shady side of the boat.

Two composite surface water samples were collected using a stoppered 2-m long, 2-inch diameter white PVC tube and combined in a white plastic bucket. Water from this mixed sample was decanted into appropriate bottles for analysis. Chlorophyll-*a* samples were stored in opaque bottles for analysis. Total phosphorus, soluble reactive phosphorus, total nitrogen, and chlorophyll-*a* concentrations were determined from the surface composite sample for all sampling trips. Phytoplankton samples were collected each sampling trip April through October for all lakes (**Table 1-2**). Phytoplankton were collected from the 0-2 m surface composite sample and stored in an opaque plastic container with a 25% glutaraldehyde preservative solution. Vertical zooplankton tow samples were taken at the sampling station for each lake once per month during the growing season (except at

Brownie Lake, Diamond Lake, Webber Pond, and Spring Lake). Zooplankton were collected using a 80-µm mesh Wisconsin vertical tow net retrieved at a rate of 1 m/s through the full water column. The 80-µm mesh Wisconsin bucket was rinsed with distilled water or ethanol from the outside. The sample was preserved 90% denatured histological ethanol to a mix of approximately 50% sample 50% ethanol.

Subsurface samples were collected with a 2-liter Wildco™ Kemmerer water sampler. Total phosphorus and soluble reactive phosphorus concentrations were determined every sampling trip at predetermined depths in each lake (**Table 1-3**). In spring, mid-summer, and fall deep subsurface chloride samples were also taken at most lakes. Each lake sample collection regime was determined based upon maximum depth, stratification characteristics, and the results of previous studies.

Table 1-3. Sampling depth profiles for the 2013 MPRB lakes monitoring program.

Lake	Sampling Depths in meters				
Brownie Lake	0-2 composite	6	12		
Lake Calhoun	0-2 composite	6	12	18	22
Cedar Lake	0-2 composite	5	10	14	
Diamond Lake	Grab (surface)				
Grass Lake	Grab (surface)				
Lake Harriet	0-2 composite	6	12	15	20
Lake Hiawatha	0-2 composite	4			
Lake of the Isles	0-2 composite	5	8		
Loring Pond	0-2 composite	4			
Lake Nokomis	0-2 composite	4	6		
Powderhorn Lake	0-2 composite	4	6		
Spring Lake	0-2 composite	4	6		
Webber Pond	Grab (surface)				
Wirth Lake	0-2 composite	4	7		

Immediately following collection all samples were placed on ice in a cooler and stored at approximately 4°C. Samples were transported to the contract laboratory for analysis within 8 hours of collection. Sampling procedures, sample preservation, and holding times followed procedures described in Standard Methods (2005) or US Environmental Protection Agency (US EPA, 1979 (revised 1983)). The 2013 contract laboratory for chemical analyses was Instrumental Research, Inc. (IRI). PhycoTech, Inc. analyzed all phytoplankton and zooplankton samples. The methods and reporting limits for parameters are listed in **Table 1-4**.

Table 1-4. Methods and reporting limits used for parameter analysis in the 2013 Minneapolis lakes monitoring program.

Parameter	Method	Reporting Limit
Alkalinity	STANDARD METHODS 2320 B	2.0 mg/L
Chloride	STANDARD METHODS 4500-Cl^- B	2.0 mg/L
Chlorophyll-*a*	Acetone extraction/spectrophotometric determination (pheophytin corrected) SM 10200 H	1.0 mg/m^3
Conductivity	Hydrolab Minisonde 5a Multiprobe (field)	0.1 µS/cm
Dissolved Oxygen	Hydrolab Minisonde 5a Multiprobe (field)	0.01 mg/L
Escherichia coli	Colilert Quanti-Tray, IRI	1 mpn
Hardness	STANDARD METHODS 2340 C	1.0 mg/L
Nitrate+Nitrite Nitrogen	STANDARD METHODS 4500-NO_3 E	0.03 mg/L
Silica	STANDARD METHODS 4500-Si D.	0.500 mg/L
Soluble Reactive Phosphorus	STANDARD METHODS 4500-P A. B. E.	0.005 mg/L
Sulfate	EPA 375.4	20 mg/L
Temperature	Hydrolab Minisonde 5a Multiprobe (field)	0.01 °C
Total Dissolved Phosphorus	STANDARD METHODS 4500-P A. B. E.	10 µg/L
Total Kjeldahl Nitrogen	STANDARD METHODS 4500-Norg B	0.500 mg/L
Total Nitrogen	STANDARD METHODS 4500 N C Alkaline persulfate oxidation/automated cadmium reduction method.	0.500 mg/L
Total Phosphorus	STANDARD METHODS 4500-P A. B. E.	0.010 mg/L
Turbidity	Hydrolab Minisonde 5a Multiprobe (field)	1 ntu
Transparency	Secchi disk depth measurement	0.01 m

More information and results for the physical and chemical parameters can be found in individual lake sections and the data **Appendix**.

WELLS

Background

Groundwater levels are monitored by the MPRB staff at seven piezometric wells. Piezometric wells are drilled to specific depths in order to monitor hydraulic head, the groundwater pressure above a known datum. Irrigation wells use groundwater for golf course turf and greens area maintenance. Augmentation wells are used to maintain water levels at lakes and ponds, and if permitted are occasionally used for winter ice rinks. **Figure 1-2** is a map of the piezometric, irrigation, and augmentation well locations in Minneapolis.

The Minnesota Department of Natural Resources (MDNR) issues the permits and determines pumping limits for irrigation and augmentation wells. The MPRB is not allowed to exceed these limits. Annual fees and reports are sent to the MDNR. The MPRB staff records groundwater levels from piezometric wells throughout Minneapolis.

Methods

Piezometric well readings are taken with a Herron Instrument Water Level Meter. This water tape is read at the top of the well casing to +/- 0.01 feet and its accuracy complies with US GGG-T-106E EEC Class III protocols. Piezometric wells A, B, and C are monitored once a month January, February, March, and December and twice a month April through November. Wells D, E, F, and G are monitored quarterly.

Results & Discussion

The piezometric well readings are taken throughout the year, and data is archived in a MSExcel spreadsheet.

Results from the 2013 lake augmentation well readings and annual usage can be found in each respective lake section (Powderhorn Lake, Loring Pond, and Webber Pond). All of the irrigation and augmentation wells used were below their MDNR allotted groundwater pumping volumes.

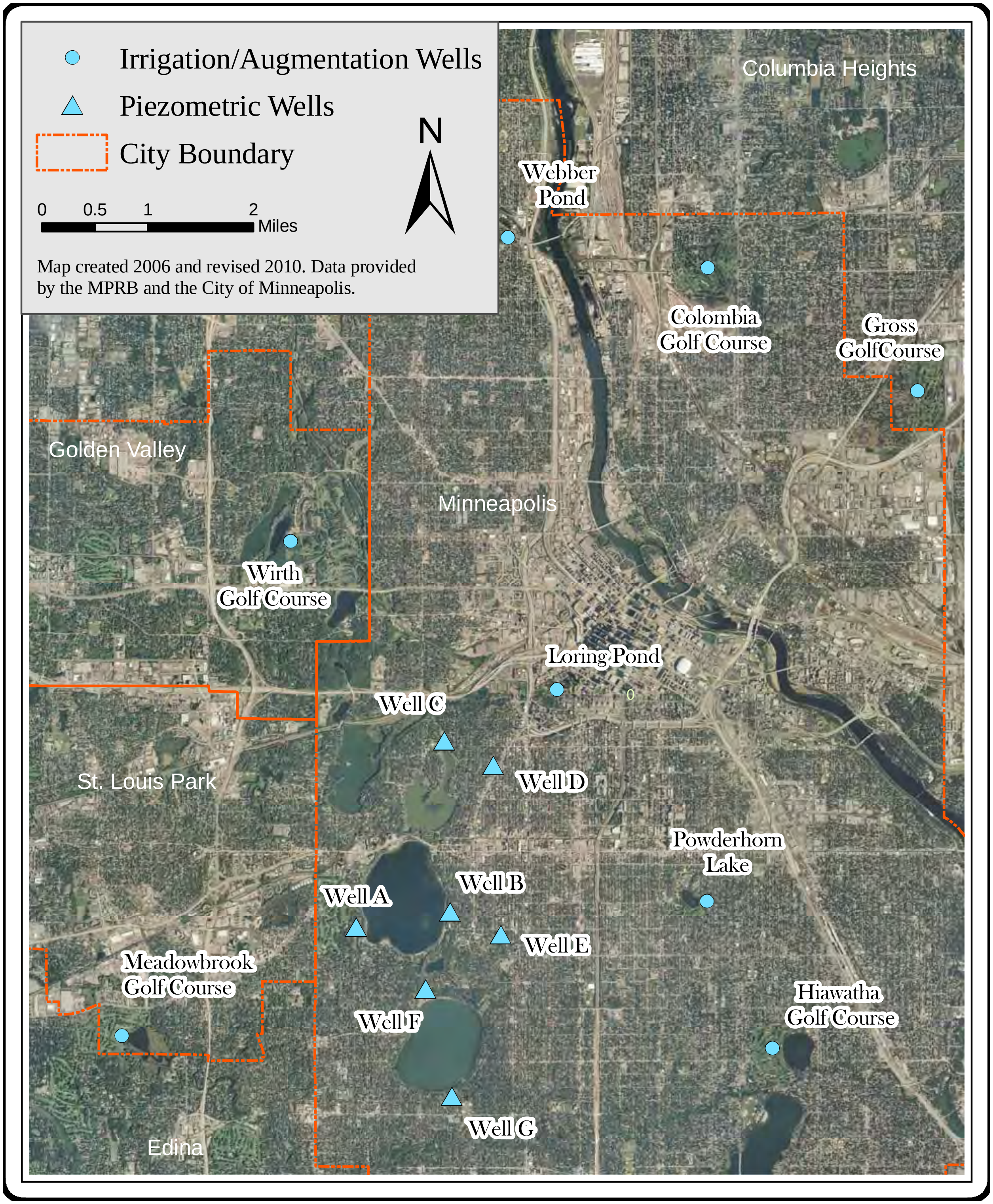


Figure 1-2. Map of piezometric and irrigation/augmentation well locations monitored by MPRB Environmental Operations.

WATER QUALITY TRENDS (TSI)

Scientists have analyzed water quality parameters in Minneapolis lakes sporadically since 1927 and consistent bi-weekly monitoring began in 1991. In 2013, the MPRB monitored 13 city lakes according to the current schedule and protocols (**Table 1-2**). The data collected was used to determine nutrient related water quality (trophic status) and general usability.

Trophic status is used to estimate water quality and is based on Carlson's Trophic State Index (TSI; Carlson, 1977). Trophic state is calculated using three nutrient related water quality parameters collected from surface water: water transparency (Secchi depth), chlorophyll-*a* (chl-*a*), and total phosphorus (TP).

> **Water transparency** is measured using a 20-cm black and white Secchi disk. The Secchi disk is lowered into the water until it cannot be seen. Then it is lowered a short distance further and raised until it is seen again. The average of these two numbers represents the Secchi depth. The Secchi depth is dependant on algal biomass or other factors that may limit light penetration (e.g. suspended solids, dissolved organic material).
>
> **Chlorophyll-*a*** is a pigment algae used to capture sunlight and is a measure of how much algal biomass is in the lake.
>
> **Phosphorus** is the limiting nutrient in most freshwater lakes and therefore controls the growth of algae. By measuring TP in lake water it is possible to estimate algal growth and the potential for algal blooms (high algal growth).

Individual Secchi, chl-*a*, and TP TSI scores are calculated for the growing season (May-September) for each lake. The yearly lake TSI score is the average of the individual (Secchi, chl-*a* and TP) TSI scores. It should be noted that some annual lake TSI scores are an average of only two parameters (chl-*a* TSI, TP TSI) if a Secchi is not or cannot be taken on a particular lake. The individual TSI formulas are below.

Secchi TSI=	(60-14.41)*ln (Average growing season Secchi in meters)
Chl-a TSI=	9.81*ln (Average growing season chl-*a* in µg/L)
TP TSI=	14.42*ln (Average growing season TP in mg/L*1000) + 4.15
Annual TSI=	(Secchi TSI + chl-*a* TSI + TP TSI)/3

TSI scoring is based on a 0-100 scale, although theoretically the scale has no upper or lower bounds, with higher numbers relating to higher trophic status and lower water quality. Three TSI scores are possible using the parameters described above and can be reported separately or as an average. The TSI score based on chl-*a* is thought to be the best measure of trophic state because it is the most accurate at predicting algal biomass (Carlson, 1977). TSI scores reported by the MPRB are an average of the three parameters.

It is important to consider soil type and land use in the surrounding watershed when using the TSI to determine lake water quality. The state of Minnesota has seven ecoregions determined by land use, soil type, and natural vegetation. Minneapolis lies within the North Central Hardwood Forests (NCHF) ecoregion, an area with fertile soils and agriculture as a dominant land use in rural areas.

Lakes in this ecoregion generally have higher concentrations of nutrients and 90% of the TSI scores are between 41 and 77. In the Twin Cities metro area it is recommended that a TSI score of 59 or lower be maintained in lakes used for swimming. This recommendation is based upon the aesthetic appeal of the water body.

One of the methods used to classify lakes involves using categories based on the TSI score. Lakes generally fall into one of three categories based on trophic status that include: eutrophic, mesotrophic, and oligotrophic (Horne and Goldman, 1994).

> **Oligotrophic** (TSI < 30) lakes are characterized by low nutrients, oxygen throughout the water column and clear water. Salmonid fisheries may dominate
>
> **Mesotrophic** (40 > TSI <50) lakes generally are moderately clear and have an increased probability of experiencing hypolimnetic anoxia during the summer months
>
> **Eutrophic** (50 > TSI < 70) lakes are considered fertile and characterized by high algal biomass and may have macrophyte problems in some systems. Hypolimnetic anoxia occurs in stratified lakes and only warm water fisheries can be sustained.

Lakes that have a TSI score greater than 70 are termed hypereutrophic and generally have very high algal biomass and low macrophyte densities due to light limitation by algae.

Lakes in the NCHF ecoregion frequently fall into the eutrophic category and the lowest trophic status lakes typically fall into the mesotrophic category. All the sampled lakes in Minneapolis are either eutrophic or mesotrophic. Detailed information on TSI scores and nutrient related water quality parameters can be found in the individual lake sections and **Appendix A**.

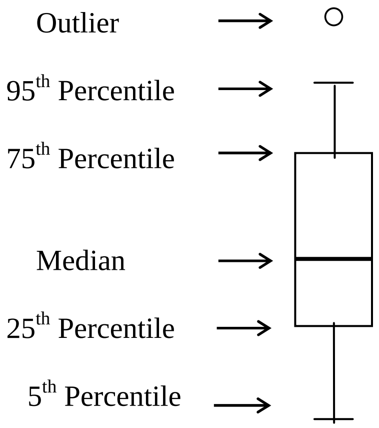
Changes in lake water quality can be tracked by analyzing long-term trends in TSI scores. The MPRB uses TSI scores to assess changes in water quality and evaluate the effectiveness of restoration and management activities on the trophic state of the lakes. Linear regression analysis is a common method used for determining trends in average TSI over time. A graph was made of average annual TSI scores for each lake (found in each individual lake's section). A trend line was fit through the data points. The linear regression line is defined as $y = mX + b$, where m is the slope of the line. The slope indicates the general trend of the data. The R^2 value indicates how well the trend fits the data with 1.00 being a perfect fit. R^2 values closer to 1.00 indicate a stronger trend over time. Low R^2 values indicate a weaker trend or that those changes in water quality are not time dependent. Both the slope and R^2 values must be looked at together when interpreting the TSI regression. Based upon these results it is possible to describe the direction of the trend (a negative or positive slope) and the degree of confidence one can place upon the trend. Better water quality and decreasing productivity in surface water is generally indicated by a decreasing TSI score and negative slope of the regression equation (as shown in the TSI figures in each individual lake's section). Conversely, a positive slope and increasing TSI scores generally indicates increasing productivity and a decrease in water clarity.

BOX AND WHISKER PLOTS

Additional analysis of the three TSI parameters can include using box and whisker plots. The box and whisker plots for each lake are another way to determine trends and are valuable for assessing variability over the years. Box and whisker plots can be used to look at short-term (seasonal) and long-term trends at the same time. Box plots for the three trophic state parameters (transparency, surface chlorophyll-*a* levels and surface total phosphorus levels) were created for each lake and presented in individual lake sections.

For each plot the box represents the middle 50 percent of the data from the 25th percentile to the 75th percentile. The "whiskers" (the vertical lines extending off of the boxes) represent the data from the 25th and 75th percentiles to the 5th and 95th percentiles, respectively. Any data falling above the 95th percentile or below the 5th percentile are marked as outliers. The horizontal line that cuts across the box represents the median value. In this report, all outliers in the box and whisker plots are represented by a circle.

Generally more compact box plots with short "whiskers" and few outliers indicate low yearly variability for the lakes. Long-term trends can be seen by the box plots trending in an up or down direction.



The box and whisker plots include all available MPRB data for each parameter.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Many lake monitoring programs use Carlson's TSI to track the environmental health of a lake. The TSI index is not intuitive or readily understandable to the general public. Additionally, TSI does not measure recreational access issues well.

In 2004, the MPRB worked with Barr Engineering Company with funding from Minneapolis Public Works to develop a new index. The original Lake Aesthetic and User Recreation Index (LAURI) was the result of this development. It was designed to give recreational users a source of information about conditions affecting their use of city lakes. The goal was to have an easily understandable recreational indicator. The two major constraints in developing the indices were that they were to be collected by existing water quality staff and within the existing budget.

In 2009, the LAURI was further refined to give a more accurate, and science based indicator for the public. The revised LAURI has five indices:

- Public Health (*E. coli* measured at public swimming beaches)
- Water Quality (water clarity/Secchi depth)
- Habitat Quality (aquatic plant and fish diversity)
- Recreational Access (availability and ease of public access)
- Aesthetic Considerations (color and odor of water, garbage and debris)

Data for the LAURI analysis is collected during the growing season from May to September and during regular lake monitoring activities.

The LAURI has proven to be useful to users of the Minneapolis park system. Someone interested in walking or biking around a lake may use only the aesthetic score. A swimmer may compare lakes based on the public health, aquatic plant, aesthetic, and water quality scores. A sailor or kayak user may be primarily concerned with the recreational access score.

Public Health Index

To determine whether a lake meets guidelines for full-body recreational contact for people the existing beach monitoring program data were used. *E. coli*, the indicator recommended by the Environmental Protection Agency (EPA) was measured at every public beach in the park system. Beaches exist on Calhoun, Cedar, Harriet, Hiawatha, Nokomis, and Wirth Lakes. The scoring used the season long geometric mean from the beach monitoring program for each lake (**Table 1-5**). Lakes with more than one beach were averaged together. EPA and Minnesota guidelines state that beaches should not exceed a geometric mean of 126 organisms per 100 mL during a 30-day time period. Lower numbers of organisms indicate less risk of illnesses for lake users.

Table 1-5. Scoring for the public health portion of LAURI.

E. coli **bacteria, (MPN/100mL) ***	**Score**
<2 (Not Detected)	10
2 - 10	9
11 - 20	8
21 - 35	7
36 - 50	6
51 - 65	5
66 - 80	4
81 - 100	3
101 - 125	2
>126	1

* The value used is the running geometric mean for the year, averaged for all the beaches on a lake.

Water Quality Index

Water clarity is easy to measure and easy to understand. This simple measure is a good integrator of various parameters affecting the eutrophication status of a lake. The average Secchi transparency reading from all the data collected during the growing season (May-September) is used. The lakes are separated into deep lakes and shallow lakes using criteria developed by the Minnesota Pollution Control Agency (MPCA). A shallow lake is defined as 80% littoral (< 15 feet deep). Calhoun, Cedar, Harriet, and Wirth were considered deep lakes. Loring, Isles, Hiawatha, Nokomis, and Powderhorn are considered shallow lakes. Higher numbers indicate clearer water. LAURI scoring is shown below in **Table 1-6.**

Table 1-6. Scoring for the water quality portion of LAURI.

Secchi Depth (m)	**Deep Lake Score**	**Shallow Lake Score**
0 - 0.5	1	2
0.6 - 1	2	4
1.1 - 1.5	3	6
1.6 - 2.0	4	8
2.1 - 2.5	5	10
2.6 - 3.0	6	
3.1 - 3.5	7	
3.6 - 4.0	8	
4.1 - 4.5	9	
> 4.6	10	

Habitat Quality Index

LAURI assessments of habitat quality are done as a visual survey from a boat and also during beach *E. coli* sampling. Scoring is based on presence of aquatic plants (macrophytes), density of plants, and amount of coverage (**Table 1-7**). The more aquatic plants are observed, the higher the habitat quality index was scored. Points are also awarded for diverse fish populations. Each lake is scored based on the most recent available fish survey done for a lake by the MDNR. The score from the aquatic plant and fish surveys are averaged for the LAURI.

Table 1-7. Scoring for the habitat portion of LAURI.

Macrophyte species	**Score**	**Density**	**Score**	**Coverage >15 ft.**	**Score**	**# Fish species**	**Score**
0	0	Low	0	0-25	2	≤6	2
1-2	3	Low-med	3	25-50	4	7-8	4
2-4	6	Medium	6	50-75	7	9-11	6
5-6	8	Med-high	8	75-100	10	12-14	8
> 6	10	High	10			≥15	10

Recreational Access Index

The lakes are also scored for the quantity and quality of recreational access to the water. The recreational score considers the number of fishing docks, beaches, boat launches, intra lake connections, canoe racks and rentals, picnic areas, and concessions at a lake, **Table 1-8**. While aquatic plants are a necessary part of a healthy lake ecosystem they can also interfere with recreational uses of the lake; therefore, lakes also receive points for invasive plant growth management.

Table 1-8. Scoring for the recreational access portion of LAURI.

Recreational Op	#	Total # Ops + Aq Plnt Mgmt	Score
Fishing Dock		0	1
Beach		1	2
Boat Landing		2	3
Boat rental		3	4
Boat storage		4	5
Picnic area		5	6
Concessions		6	7
Aquatic Mgmt = yes	+ 4	7 - 8	8
Aquatic Mgmt = no	+ 0	8 - 9	9
TOTAL		> 10	10

Aesthetic Considerations Index

The lakes are scored for water color, odor, and debris based on an assessment done from shore, dock, or boat, **Table 1-9**. Lower numbers indicate worse aesthetics. The scores are averaged over the season. Aesthetics can be difficult to evaluate as they are strongly qualitative and dependent on individual experience.

Table 1-9. Scoring for the aesthetic portion of LAURI.

Color	Score		**Odor**	Score		**Debris**	Score
Clear	10		None/Natural	10		None	10
lt. Brown or green	8		Musty - faint	8		Natural	9
Bright Green	5		Musty - strong	6		Foam	8
Milky White	4		Sewage/fishy/ garbage - faint	5		Piles of milfoil (>3)	7
Brown/Reddish/ Purple	2		Sewage/fishy/ garbage - strong	2		Trash: fixed (>3)	4
Gray/Black	0		Anaerobic/septic	0		Trash: floating (>3)	3
						Many dead fish (>5)	2
						Green scum	2
						Oil film	1
						Sewage Solids	0

WINTER ICE COVER

An interesting climatological statistic to track over time is the date that a lake freezes in the fall and the date it thaws in the spring. Ice phenology affects migration and breeding patterns of birds, food supply of fish and animals, and water chemistry. Length of ice cover in our region is affected by local weather patterns as well as changes in regional and global cycles. Magnuson, et al (2001) found that northern hemisphere temperate climate ice records reflected changes in the strength of a low pressure zone that builds over the Aleutian Islands (the Aleutian Low) and El Nino cycles (cycles of warming the surface waters of the tropical Pacific Ocean). Ice-out and on dates are given in the individual lake sections and a comparison among lakes can be found in **Section 18** in **Tables 18-6** and **18-7**.

However, some caution must be used when interpreting the historical data. Over the years many different people have been responsible for writing down the dates and ice dates can be somewhat subjective with people using different observation techniques. Since 2000, the MPRB has been using the definition of ice-on as occurring when the lake is 100% covered with ice, preferably in the afternoon (when ice may break up on a sunny day). Ice-off occurs when the lake is essentially ice free (<10% covered with ice).

AQUATIC PLANTS

Aquatic plants (macrophytes) form the foundation of a healthy lake ecosystem. Aquatic plants provide important habitat for insect larvae, snails, and other invertebrates which are food sources for fish, frogs, turtles, and birds. Aquatic plants also provide shelter for fish and food for waterfowl. Therefore, the health of a lake depends upon having a healthy plant community. MPRB assesses macrophyte communities in the Minneapolis lakes on a rotating basis. No macrophyte surveys were conducted in 2013; however, all lakes were assessed for curly-leaf pondweed prevalence during June.

Lakes with macrophytes are usually clearer than lakes without macrophytes. Plant roots stabilize sediments and shorelines and prevent the suspension of sediments (from wind or fish) that would otherwise result in turbid, murky waters. Aquatic plant growth produces oxygen and uses nutrients from the water column and from the sediments which would otherwise be used by algae. Macrophytes add an enormous amount of surface area to lakes providing habitat for microscopic plants and animals to grow and utilize nutrients otherwise available to planktonic algae. Large zooplankton use aquatic plants as a refuge against fish. Lakes with a vegetation-dominated clear state typically have more diverse fish communities and larger numbers and diversity of waterfowl.

Eurasian Watermilfoil Control Program

Overgrowth of Eurasian watermilfoil (*Myriophyllum spicatum*) is a recreational access problem in several Minneapolis lakes. From a recreational perspective, milfoil is problematic in that it forms dense floating mats that interfere with boating and swimming. From an ecological standpoint, milfoil can provide vertical structure and habitat for fish. Eurasian watermilfoil also out-competes native species and may reduce the available habitat for sensitive species.

Currently, no environmentally safe method has been proven to rid lakes of milfoil but several management methods exist to treat the symptoms of infestation. The MPRB primarily uses mechanical harvesting to control the growth of milfoil in city lakes. Harvesting milfoil is analogous to mowing a lawn. Only the top two meters of the milfoil plants are removed but this temporarily allows for problem-free boating and swimming. Harvesting was completed on Calhoun, Cedar, Harriet, Nokomis Lake of the Isles, and Wirth Lakes in 2013. For acreage see individual lake sections. In 2013, 142 flatbeds of milfoil were removed from the lakes, roughly 818 cubic yards of aquatic plant material.

PHYTOPLANKTON AND ZOOPLANKTON MONITORING

Background

Biological parameters are routinely measured as part of a lake’s assessment. Phytoplankton (algae) and zooplankton are two of the common biological parameters collected because they are essential to the aquatic food web and influence other aspects of the lake including color and clarity of the water and fish production.

Phytoplankton are microscopic plants that are an integral part of the lake community. Phytoplankton use nutrients in the water and sunlight to grow and are the base of the aquatic food web. Chlorophyll-*a* is the primary photosynthetic pigment contained in algae. Because the chlorophyll-*a* concentration can be easily measured in a water sample it is a common way to estimate the phytoplankton biomass in the water (Paerl and Sandgren, 1998).

Zooplankton are tiny animals that feed on phytoplankton and other zooplankton. They are vital to the lake community and form the second level in the food web. Rotifers and arthropods are the two most commonly found zooplankton in Minneapolis lakes. Rotifers are smaller in size but are of great importance in the aquatic food web because of their abundance, distribution, and wide range of feeding habits. Copepods and cladocerans are larger arthropods and members of the class Crustacea. Copepods are the most diverse group of crustaceans. A cladoceran genus, *Daphnia*, is known as the common "water flea" and is a very well-known zooplankton.

Methods

Phytoplankton

Phytoplankton samples were collected twice a month from most of the monitored lakes (Calhoun, Cedar, Harriet, Hiawatha, Isles, Loring, Nokomis, Powderhorn, and Wirth) except for February, April, and October which were sampled once per month. Samples were collected once a month at Webber Pond and Spring Lake. Surface water composite samples were collected for phytoplankton using a 2-m long, stoppered 2-inch diameter PVC tube. Before sampling the PVC tube was scrubbed with a brush and rinsed with lake water three times. Two such samples were mixed in a clean white plastic bucket that had also been scrubbed and rinsed with lake water. Water from this mixed sample was decanted for analysis into amber bottles, preserved with 25% glutaraldehyde (a preservative) back at the lab, and sent to PhycoTech Incorporated (St. Joseph, MI) laboratory for analysis. Analysis was completed using the phytoplankton rapid assessment count developed by Edward Swain and Carolyn Dindorf of the MPCA. This method involves a sub-sample being placed in a counting chamber and analyzed using an inverted microscope. The algal division, taxa, genus, and species are identified and the percent abundance by volume is estimated. Identification protocol is according to Weber (1971) and Prescott (1951). The results are presented by division (phylum) in the individual lake sections. Common phytoplankton divisions and a common description are given in **Table 1-10**.

Table 1-10. Phytoplankton divisions and brief descriptions.

Division	Description
Bacillariophyta	Diatoms
Chlorophyta	Green algae
Chrysophyta	Golden-brown algae
Cryptophyta	Cryptomonads
Cyanophyta	Blue-green algae
Euglenophyta	Euglenoids
Pyrrophyta	Dinoflagellates
Xanthophyta	Yellow-brown algae

Chlorophyll-*a* concentrations were used to estimate phytoplankton biomass in the lakes. Each lake section shows chlorophyll-*a* concentrations and the distribution of phytoplankton divisions throughout the sampling season.

Zooplankton

Zooplankton samples were collected monthly from most Minneapolis lakes (**Table 1-2)**. Webber Pond and Diamond Lake were not sampled because of their shallow depths. Brownie and Spring Lakes were not sampled due to lack of zooplankton in most years. Samples were collected using an 80-µm plankton net and a Wisconsin-type bucket. The net was raised from the bottom of the water column to the surface at a rate of 1 meter per second. The captured zooplankton were rinsed into a bottle using 90% denatured histological ethanol to a final concentration of 50% sample and 50% preservative. The distance the net was pulled through the water column (tow depth) was recorded on field sheets and on the bottle label. Zooplankton were identified at PhycoTech Inc. as completely as possible by: class, subclass, order, suborder, family, genus, species, and subspecies. Zooplankton were identified according to standard protocols and twelve taxonomic authorities (Edmondson, 1959). The zooplankton results were divided into groups for presentation as shown in **Table 1-11**. Results are presented in the individual lake sections.

Table 1-11. Major zooplankton groups and brief descriptions.

Major Group	Description
Calanoid	Phylum Arthropoda. Type of copepod. Generally herbivorous.
Cladoceran	Phylum Arthropoda. Eats algae. Commonly called “water flea.”
Cyclopoid	Phylum Arthropoda. Type of copepod. Many are carnivorous.
Protozoan	Single celled organisms. Many are shelled amoeba.
Rotifer	“Wheel animals.” Eat particles up to 10 µm.

FISH STOCKING

Many of the lakes in Minneapolis are stocked with fish by the MDNR. This information is on the MDNR LakeFinder website (http://www.dnr.state.mn.us/lakefind/index.html).

Stocking Fish Sizes:

- Fry - Newly hatched fish. Walleye fry are 1/3 of an inch or around 8 mm.
- Fingerling - Fingerlings are one to six months old and range in size from one to twelve inches.
- Yearling - Yearling fish are at least one year old and can range from three to twenty inches.
- Adult - Adult fish that have reached maturity age.

FISH KILLS

Many of the summer fish kills in Minneapolis lakes are attributed to *Columnaris* bacteria. The naturally occurring *Flexibacter columnaris* bacteria cause the disease. This disease is usually associated with a stress condition such as high water temperature, low dissolved oxygen concentration, crowding, or handling. Symptoms of this disease include grayish-white lesions on parts of the head, fins, gills, or body usually surrounded by an area with a reddish tinge. On crappies the lesions are generally confined to the fins and gills and rarely extend to the body.

Columnaris is known to only infect fish species and is not a health risk to humans. The bacteria are most prevalent in lakes when water temperatures approach 65-70 degrees F from late May to late June. *Columnaris* levels can increase after a major rainfall and runoff which supply additional nutrients to area lakes.

Bluegill, crappie, yellow perch, and bullhead fish species are most affected by the disease. The *Columnaris* disease causes erosion of the fishes' skin causing a leakage of the bodily fluids and an influx of lake water into the fishes' body. There is little that the MDNR or the public can do to prevent this naturally occurring phenomenon.

Winter fish kills on lakes are often due to thick ice and snow cover leading to low dissolved oxygen conditions in the water below. Usually small lakes and ponds are most affected by winter fish kills.

QUALITY ASSURANCE/QUALITY CONTROL

The contract laboratory analyzed blanks and appropriate standards with each set of field samples. Equipment blanks were analyzed to detect any equipment contamination. In addition, field duplicate samples were analyzed each lake sampling trip (weekly) and blind laboratory performance standards were analyzed every month sampling occurred. Field blanks were done every sampling trip. Ideally, laboratory split samples are analyzed twice a year between a minimum of three labs.

Calibration blanks, reagent blanks, quality control samples, laboratory duplicate samples, and matrix spike/duplicate samples were analyzed at a 10% frequency by the contract laboratory. The quality control samples analyzed by the laboratory consisted of two sets:

- samples of known concentration (control standards) that served as a independent verification of the calibration standards and as a quality control check for the analytical run and
- Blind samples (of unknown concentration) provided by the MPRB Environmental Operations staff.

For more details and QA/QC results for 2013, see the Quality Assurance Assessment Report in **Section 30**.

2. BIRCH POND

HISTORY

Birch Pond is a 6-acre water body on the east side of Theodore Wirth Parkway in Theodore Wirth Regional Park near the Eloise Butler Wildflower Garden and Bird Sanctuary, **Figure 2-1**. The pond lies within the original Glenwood Park parcel. In 1910 the pond was named for the white birch trees which grew along its shores and hillsides. It has no public boat access or fishing docks. Birch Pond is protected from winds by large hills and mature trees that surround it. Aesthetics and bird watching opportunities are Birch Pond's main recreational values.

Buckthorn was removed from the understory of the Birch Pond basin in 2006 as a part of vegetation restoration efforts in preparation for the centennial anniversary of the Eloise Butler Wildflower Garden and Bird Sanctuary. Buckthorn (*Rhamnus cathartica* and *Rhamnus frangula*) is an invasive species that threatens native woodlands.

The Minneapolis Park & Recreation Board (MPRB) currently does not include Birch Pond in its regular lake sampling program.

Figure 2-1. Birch Pond after 2006 buckthorn removal.

LAKE LEVEL

Lake level records for Birch Pond were historically kept by both the City of Minneapolis and the MPRB. More recently the MDNR has created an accurate bench mark and has set an Ordinary High Water Level (OHW) of 846.3 msl for Birch Pond. Lake levels in Birch pond have varied over time due to changes in climate and rainfall patterns as well as periodic augmentation through pumping. Birch Pond was once part of a water conveyance system which carried water from the Mississippi River to the Chain of Lakes. A remnant of the old conveyance system remains on the east side of the pond. There is currently not a surveyed lake level gauge on Birch Pond.

Figure 2-2 shows historic water level records for Birch Pond compiled by the MPRB, the City of Minneapolis and the MDNR.

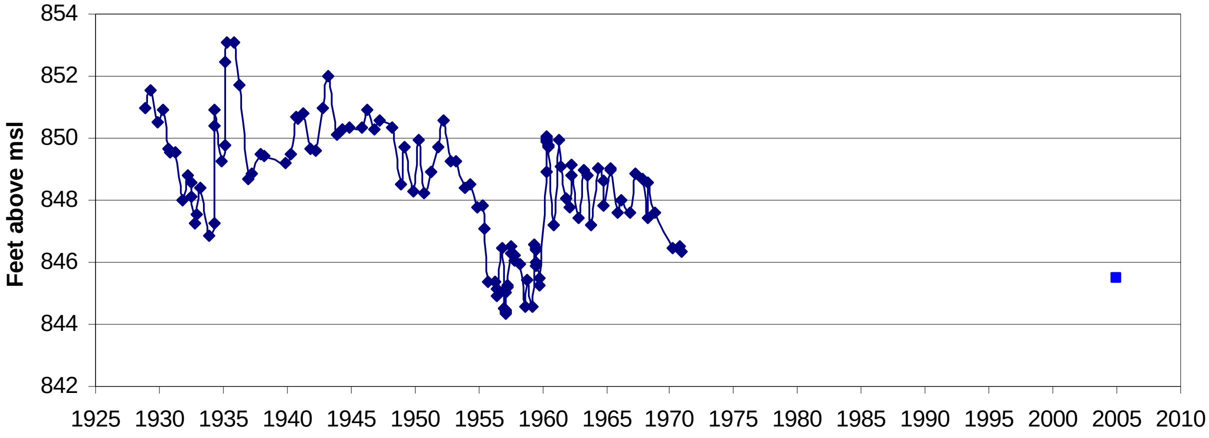


Figure 2-2. Historic level records for Birch Pond compiled by MPRB, City of Minneapolis and MDNR. Fluctuations are due to climate, season, and historic pumping.

WINTER ICE COVER

Ice came off Birch Pond on April 28, 2013 which was 24 days later than average and the latest ice-off date recorded. Ice came back to the pond November 25, 2013, the average date for ice-on. See **Section 18** for additional ice monitoring data.

3. BROWNIE LAKE

HISTORY

Human activities drastically changed the shape and size of Brownie Lake over the past 150 years. Construction of a railroad embankment in 1883 caused a decrease in lake surface area of 34%, transforming the lake formerly known as Hillside Harbor. In 1916 the connection between Cedar and Brownie Lakes was completed further decreasing the surface area of the lake by another 56% by dropping the water level 3 m (~10 ft) and creating the lake that we see today (Wirth, 1945; Trembley, 2012). **Figure 3-1** shows a picture of Brownie Lake.

Figure 3-1. Kayakers on Brownie Lake

Structural changes to the lake have had implications to its water chemistry. Brownie Lake is permanently stratified (also called meromictic) due to a strong density difference that exists between water near the surface and a deeper layer of water containing high levels of dissolved minerals. The sharp density difference between the surface waters and deeper water in meromictic lakes is called a chemocline. Meromictic lakes do not mix due to the stability of the chemocline. Swain (1984) first theorized that the structural changes made to Brownie Lake caused its state of permanent stratification. Swain's 1984 study of a 117-cm lake sediment core found changes in the ratios of iron to manganese (Fe:Mn) and iron to phosphorus (Fe:P) at a layer in the sediment corresponding to approximately 1925. The change in the chemistry of the sediments indicates the onset of permanently anoxic bottom-water signifying to Swain that Brownie Lake had become meromictic. In the past, stormwater inputs from Interstate 394 (old U.S. Highway 12) added pollutants to Brownie Lake and has contributed to the stability of the chemocline.

Swain's lake-core analysis found further evidence of the influence that human activities had on Brownie Lake. Ragweed pollen first appeared at sediment core at depths that corresponding to 1850-1860, an indication of European-American settlement (Swain, 1984). Later, changes in the watershed led to increases in primary productivity, algal biomass, and sediment accumulation indicating eutrophication. As water clarity decreased over time benthic diatoms were replaced by planktonic forms and the zooplankton community shifted from large bodied *Daphnia* to the smaller *Bosmina* species (Swain, 1984).

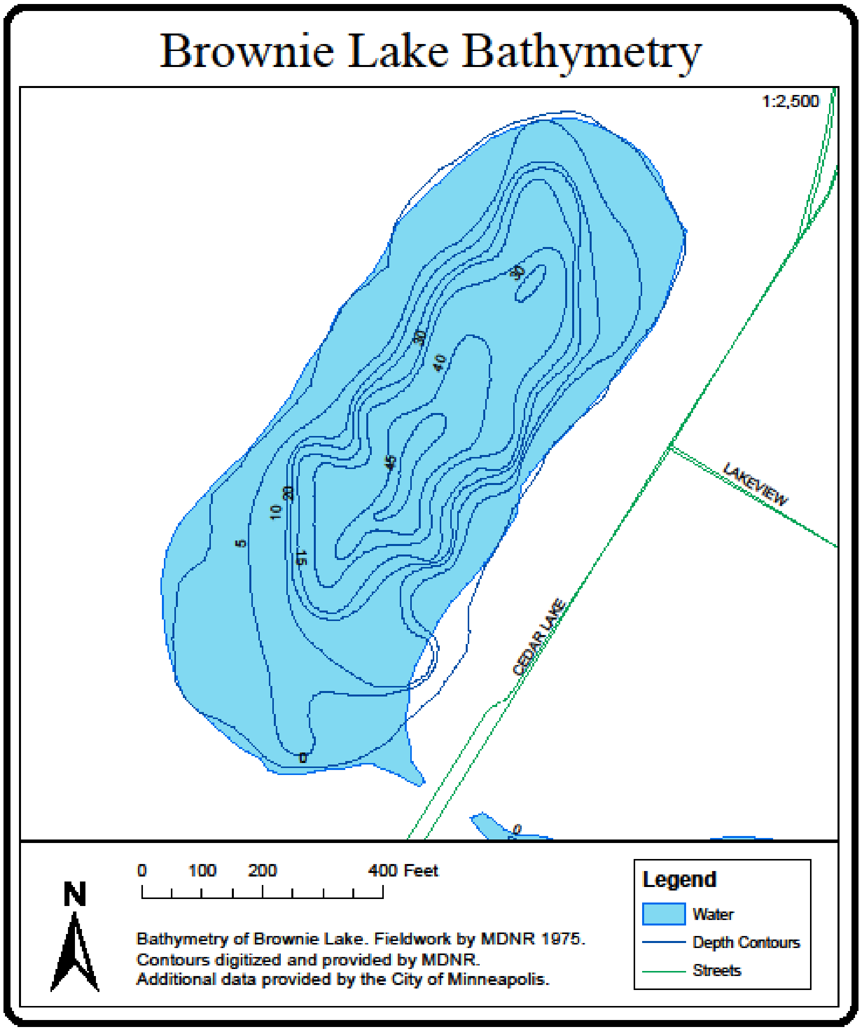
Water levels in Brownie Lake have been manipulated at various times in its history. Groundwater was first used to augment lake levels in the Chain of Lakes (Brownie, Cedar, Isles and Calhoun) in 1933 and continued through 1938. During the 1950s the Prudential Insurance Building began discharging 50 thousand gallons of cooling water per day into Brownie Lake. During this time-period, a link was created between Brownie Lake and Bassett's Creek that provided water to the Chain of Lakes during times of low water levels. In 1966, a pumping station was constructed at the Mississippi River to augment flow in Bassett's Creek. Water levels in the Chain of Lakes were regulated by pumping from the Mississippi River into Brownie Lake until 1990.

Brownie Lake is on an every other year sampling schedule, and was not sampled in 2013. All water quality data presented pertains to the 2012 sampling season. **Figure 3-2** shows the bathymetric map and **Table 3-1** shows the morphometric data for Brownie Lake.

Table 3-1. Brownie Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
18	6.8	15.2	39%	4.98×10^5	369	20.5	2.0

* Littoral area defined as less than 15 feet deep.



Bathymetry of Brownie Lake. Fieldwork by MDNR 1975.
Contours digitized and provided by MDNR.
Additional data provided by the City of Minneapolis.

Figure 3-2. Bathymetric map of Brownie Lake.

LAKE LEVEL

The Ordinary High Water Level (OHW) for Brownie Lake as determined by the MDNR, is 853 ft (msl). The OHW is defined as the elevation where high water levels can be maintained for a long enough a period of time to leave evidence of the water level on the landscape.

See **Section 4, Lake Calhoun** for more information on water levels in the Chain of Lakes.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Figure 3-3 shows the Brownie Lake TSI scores and linear regression. The 2012 TSI score for Brownie Lake was 60. The TSI score was higher than typical and caused the linear regression to trend towards higher scores and decreasing water quality. The trend could be due to seasonal variation or the every-other-year sampling schedule, and caution should be used when interpreting the R^2 value. Brownie Lake is scheduled to be sampled again in 2014. A detailed explanation of TSI can be found in **Section 1**.

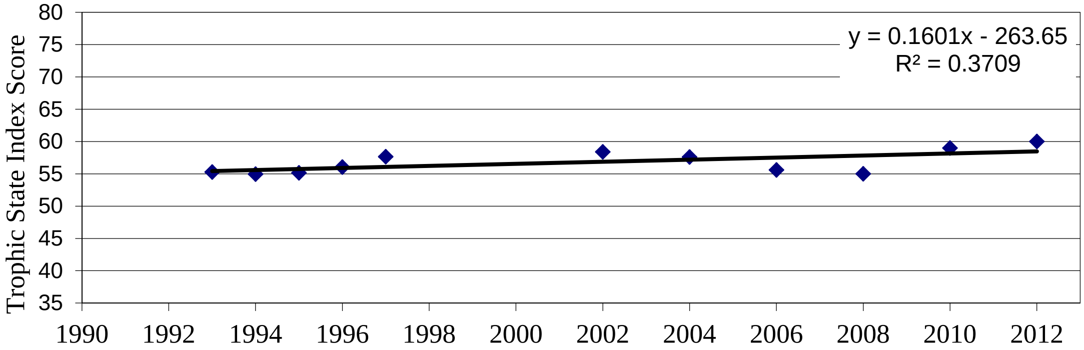


Figure 3-3. Brownie Lake TSI scores and regression analysis.

Brownie Lake falls near the 50th percentile category for lakes in this ecoregion, based on calculations from the Minnesota Lake Water Quality Assessment Data Base Summary (MPCA, 2004).

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 3-4** show the distribution of data for Secchi depth, chlorophyll-*a*, and total phosphorus sampling from 2002 to the present. The horizontal line crossing the graph represents the MPCA eutrophication standard for deep lakes. Data for the entire period of record presented in box and whisker plot format is available in **Appendix A**. Long-term lake monitoring is necessary to evaluate the seasonal and year-to-year variations seen in each lake and predict trends. A detailed explanation of box and whisker plots can be found in **Section 1**.

2012 had shallower Secchi depths, higher chlorophyll-*a* values, and higher total phosphorus concentrations than in the previous several years. Seasonal factors, like a hot and wet summer, may have contributed to the worse than typical conditions in the lake. In 2012, Brownie Lake did not meet the MPCA nutrient criteria for deep lakes. Due to Brownie Lake’s permanent stratification, it may not be reasonable to compare Brownie Lake to the deep lake standard. A better measure of the health of Brownie Lake may be to look at long term trends in the Brownie Lake data.

Brownie Lake is unusual because it is permanently stratified (meromictic). The only other meromictic lake in Minneapolis is Spring Lake. This unusual characteristic needs to be considered when comparing Brownie Lake data to other lakes.

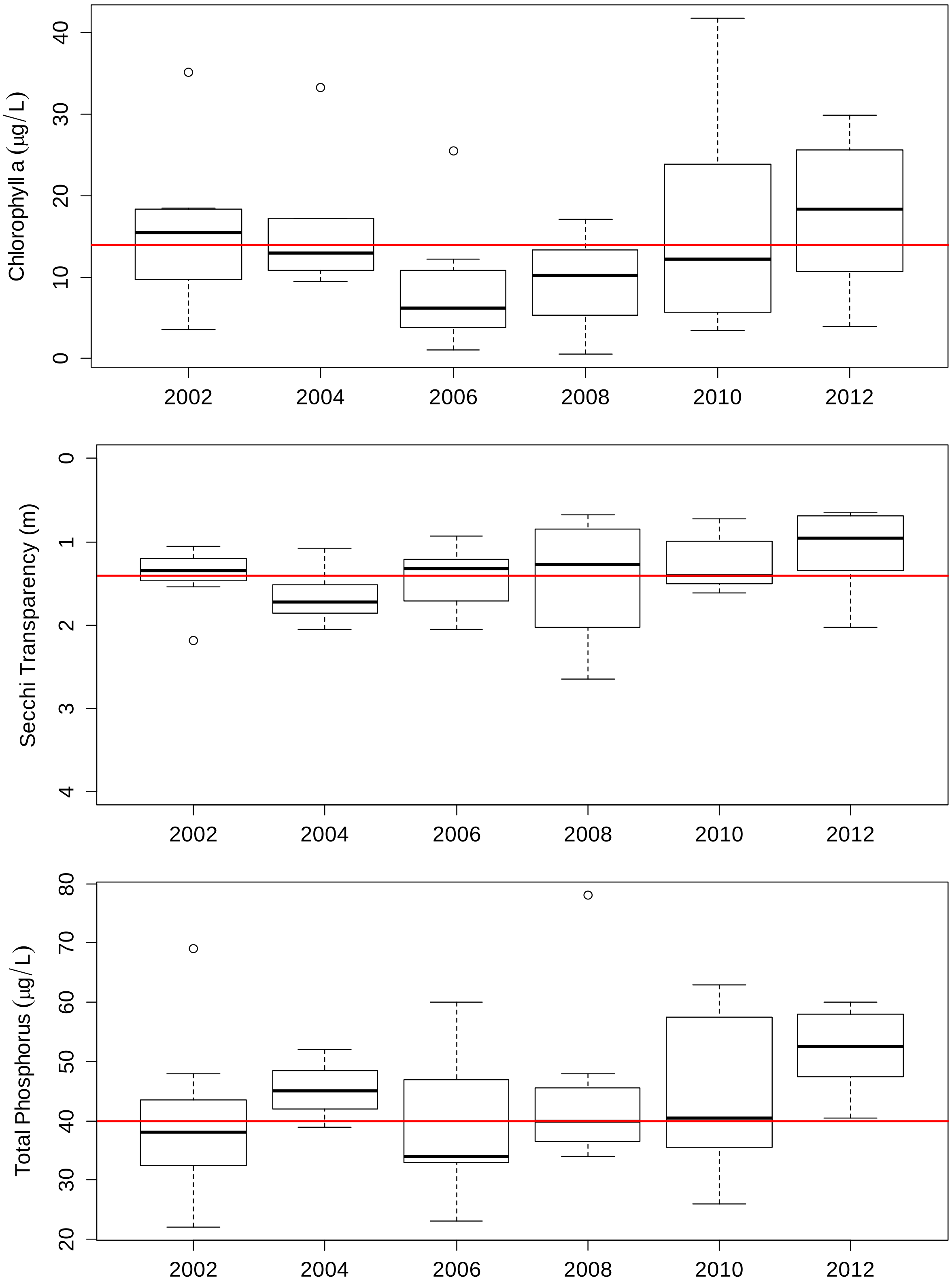


Figure 3-4. Brownie Lake box and whisker plots of TSI data for the past ten years. Horizontal lines represent MPCA eutrophication standard for deep lakes. Data for the entire period of record can be found in Appendix A.

WINTER ICE COVER

Ice came off Brownie Lake on April 28, 2013 which was twenty five days later than average and the latest ice-off date recorded for the lake since 1959. Ice came on the lake November 25, 2013 which was three days earlier than average. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other MPRB lakes.

PHYTOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 3-5** shows the relative abundance of phytoplankton species and **Figure 3-6** shows chlorophyll-*a* concentrations and Secchi transparency readings for the 2012 sampling season. No zooplankton samples were collected from Brownie in 2013. In 2008, zooplankton tows yielded low concentrations compared to other Minneapolis lakes.

Phytoplankton divisions fluctuated in Brownie Lake throughout the 2012 sampling season as shown in **Figure 3-5**. Cryptomonads (Cryptophyta) dominated the winter sample. Chyrsophytes peaked in April while Dinoflagellates (Pyrrhophyta) had a small bloom in June. There was also a green-algae (Chlorophyta) peak in June, which occurred earlier than in previous summers. The remainder of the growing season was dominated by blue-green algae (Cyanophyta) and then cryptomonads in October. The highest chlorophyll-*a* value of the season seem to correspond to the blue-green algae bloom as can be seen in **Figures 3-5** and **3-6**. Secchi transparencies were lower than average during the summer, measured at less than a meter for most of the season.

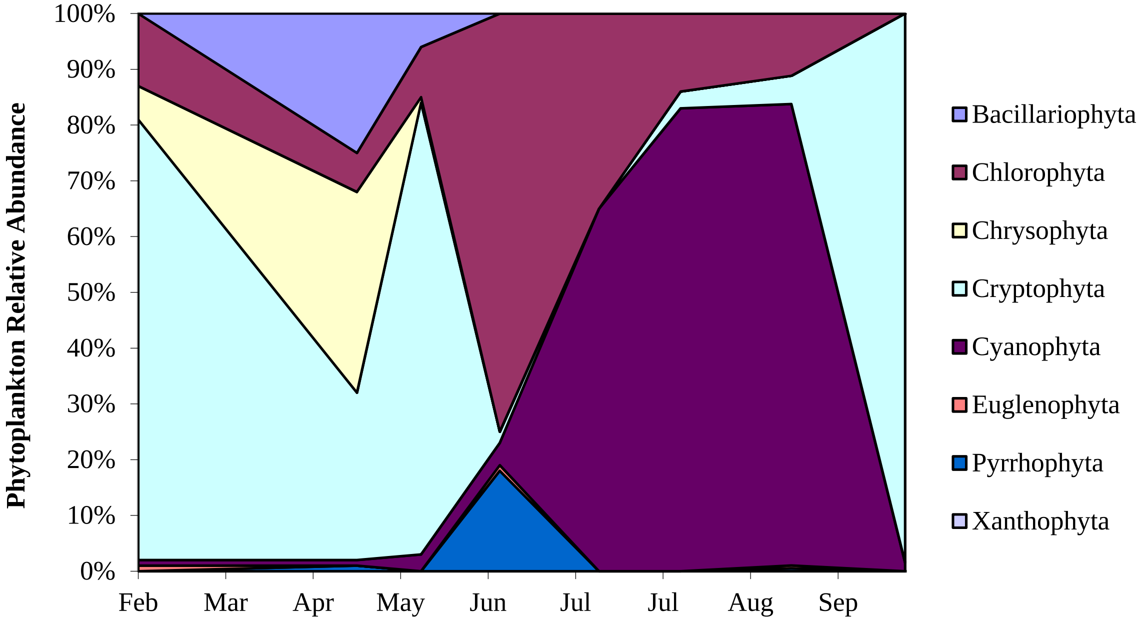


Figure 3-5. Relative abundance of phytoplankton during the 2012 Brownie Lake sampling season.

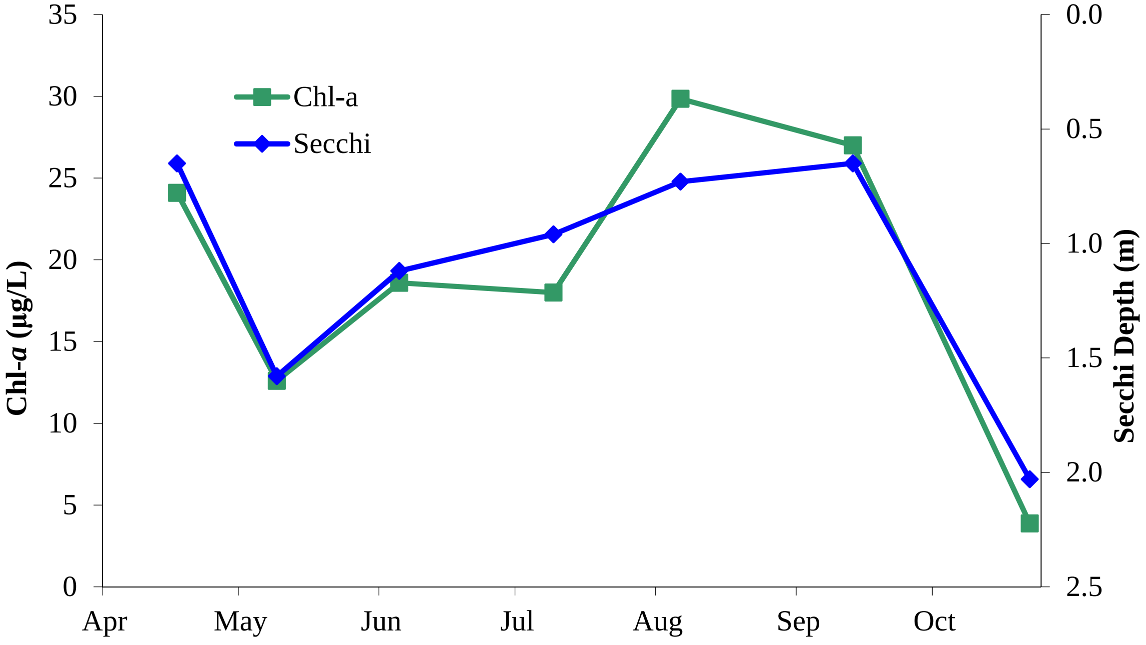


Figure 3-6. Chlorophyll-*a* concentration and Secchi transparency in Brownie Lake for the 2012 sampling season. Note that the Secchi depth axis is reversed.

WATER QUALITY IMPROVEMENT PROJECTS

The MPRB and other surrounding landowners have completed several projects improving the Brownie Lake basin. In 2007, the Target Corporation rehabilitated a stormwater pipe and restored disturbed hillside vegetation on the west side of the lake. City of Minneapolis Public Works and the MPRB worked together to solve an erosion problem on the east side of Brownie Lake in 2008. The two organizations restored an eroded area and replaced an exposed and eroding stormwater outlet with a buried drop-structure and pipe.

In March 2012, the MPRB Board of Commissioners approved an Area Plan for Brownie Lake to improve the land and park amenities surrounding the lake, including path and bike trail improvements and a new canoe launch. More information on the on-going Brownie Lake area plan can be found on the MPRB website under keywords Improvements at Brownie Lake.

4. LAKE CALHOUN

HISTORY

Lake Calhoun is the largest lake in the Minneapolis Chain of Lakes (**Figure 4-1**). It receives water from Lake of the Isles and discharges water through a weir and open channel to Lake Harriet. The lake has a multitude of recreational opportunities including personal watercraft, sail boat buoy rentals, three public beaches, fishing, and picnicking. The Minneapolis Chain of Lakes Regional Park is the most visited park in the State of Minnesota with over 5 million user visits a year (Met Council, 2014).

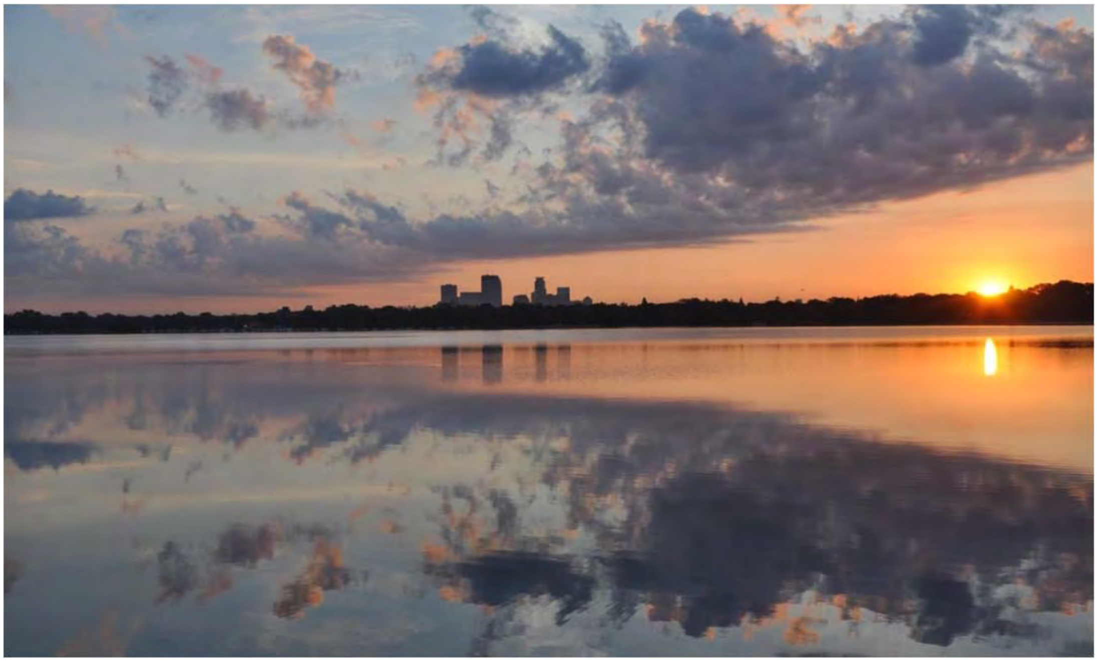


Figure 4-1. View of downtown Minneapolis from Lake Calhoun at sunrise.

Previously known as Lake of the Loons, the lake was renamed after John Caldwell Calhoun. While Calhoun was Secretary of War under President Monroe he established a military post at Fort Snelling. The lake and adjacent property were acquired by the Minneapolis Park and Recreation Board (MPRB) between 1883 and 1907 at a cost of $130,000. Similar to other lakes in the Minneapolis Chain of Lakes Lake Calhoun was dredged and surrounding wetland areas were filled (~35 acres) in the early part of the 20th century. Nearly 1.5 million cubic yards of soil were placed on the shoreline between 1911 and 1924.

An effort was made to connect Lake of the Isles and Lake Calhoun after wet years in the early 1900s increased interest in water related activities. A water connection between Isles and Calhoun was created in 1911 after the MRPB received numerous requests and petitions to join the lakes. A connection between Lake Calhoun and Lake Harriet was pondered but was never implemented due to a five foot elevation difference between the lakes. In 1967, a pipeline and pumping station were constructed between Lakes Calhoun and Harriet to help regulate water elevations in the Chain of Lakes. Between 1999 and 2001, the outlet was partially daylighted and converted to a gravity-flow connection.

Studies have shown that water quality in Lake Calhoun has degraded with human activity. In 1973, Shapiro and Pfannkuch found that phosphorus levels in the sediment were about 80% higher than they had been in the prior 80 to 90 years. Total phosphorus in the water column had also increased to 50 – 60 μg/L by the 1970s from pre-industrial levels of between 16 – 19 μg/L (Brugam and Speziale, 1983). The increases in sediment and water column phosphorus appear to be due to European settlement and land clearing for agriculture in the watershed. The construction and connection of storm sewers to Lake Calhoun (1910 to 1940) is also thought to have had a negative impact on water quality. A study by Klak (1933) showed that cyanobacteria were dominant by the early 1930s in Lake Calhoun, indicating nutrient enrichment.

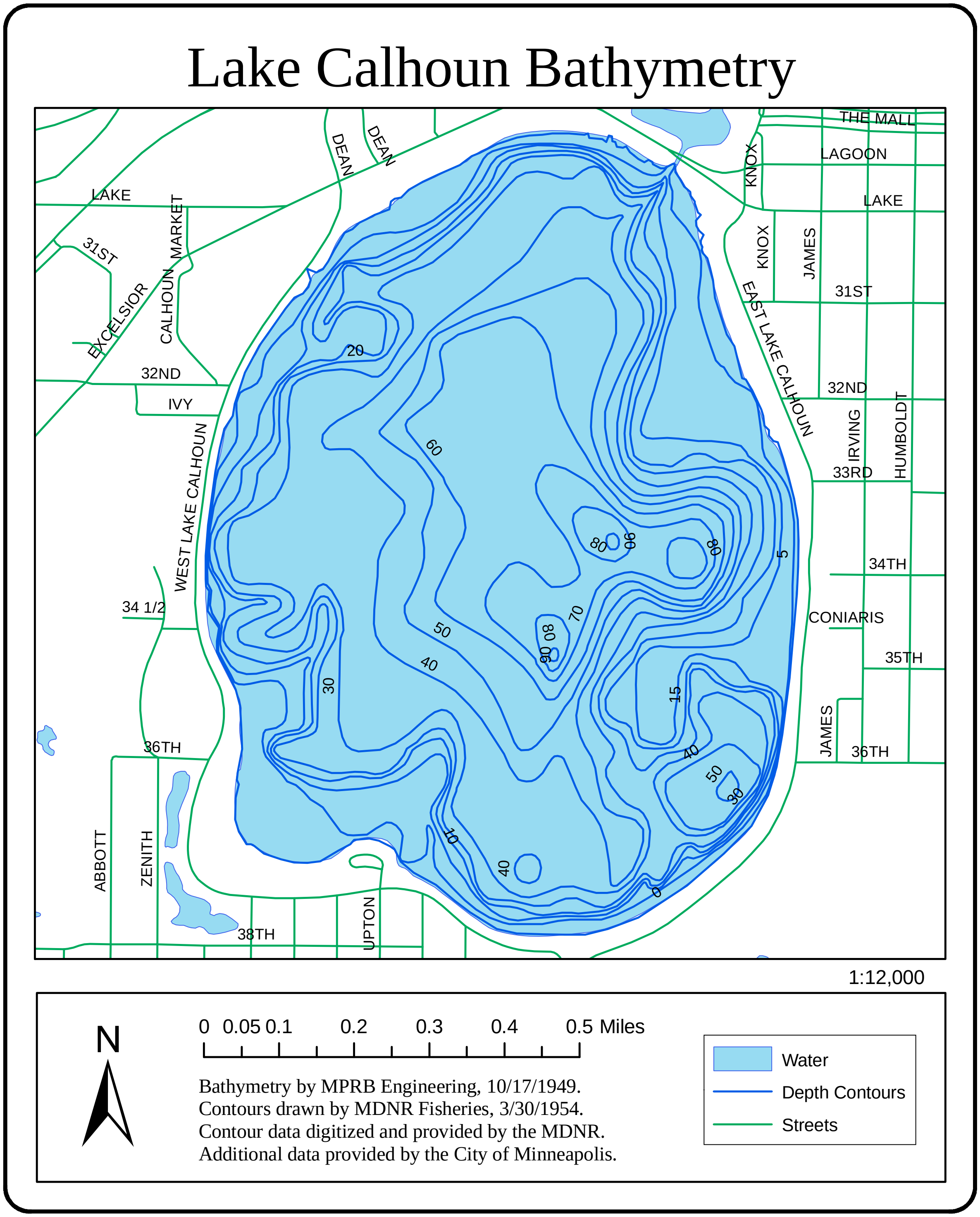
In recent years, water quality restoration projects have improved water quality in Lake Calhoun. A detailed Clean Water Partnership diagnostic study conducted in 1991 determined that phosphorus input to the Chain of Lakes should be reduced to increase water quality. Best management practices (BMP) were then implemented for Calhoun and included: public education, increased street sweeping, improved storm-water treatment including constructed wetlands (1999), grit chambers (1995, 1998, 1999), and an aluminum sulfate (alum) treatment to limit internal loading of phosphorus in 2001. Current data analysis confirms that the BMPs are having a positive effect and that water quality in Lake Calhoun is at, or even slightly better than historic conditions (Heiskary et al., 2004). For example, Lake Calhoun’s observed TP is similar to the TP level from 1750 and 1800 based on diatom reconstruction of sediment cores (Heiskary et al., 2004).

Lake Calhoun is a deep, dimictic, glacial kettle lake that generally remains stratified until late October. **Table 4-1** contains the morphometric data for Lake Calhoun. **Figure 4-2** shows the bathymetric map of Lake Calhoun.

Table 4-1. Lake Calhoun morphometric data.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
421	10.6	27.4	27%	1.80×10^7	2,992	7.1	4.2

* Littoral area was defined as less than 15 feet deep.



Lake Calhoun Bathymetry

Bathymetry by MPRB Engineering, 10/17/1949.
Contours drawn by MDNR Fisheries, 3/30/1954.
Contour data digitized and provided by the MDNR.
Additional data provided by the City of Minneapolis.

Figure 4-2. Bathymetric map of Lake Calhoun.

LAKE LEVEL

The lake level for the Upper Chain of Lakes (Brownie, Calhoun, Cedar, and Isles) is measured at Lake Calhoun. The four lakes are connected by channels and the gage at Lake Calhoun represents the level at each of the four lakes. The designated Ordinary High Water Level (OHW) for Lake Calhoun is 853 feet above mean sea level. The outlet elevation for Lake Calhoun is 851.85 ft above mean sea level. Lake levels for the Upper Chain of Lakes are shown in **Figure 4-3**. A very wet spring resulted in sustained high water levels for most of the year until drought conditions in late summer brought the lake level below the outlet elevation by fall.

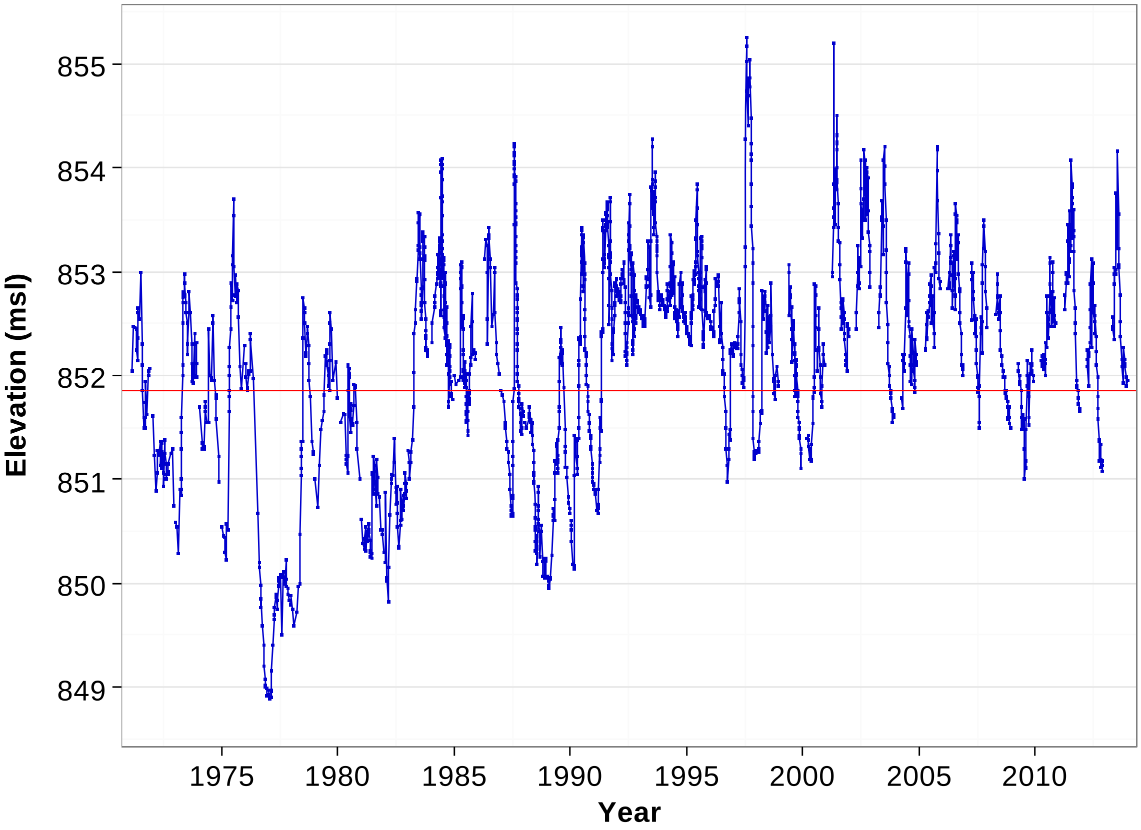


Figure 4-3. Lake levels for the Minneapolis Upper Chain of Lakes (Brownie, Cedar, Isles and Calhoun). Horizontal line represents Lake Calhoun outlet elevation (851.85 ft msl).

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2013 TSI score for Lake Calhoun was 42.5. **Figure 4-4** shows historical Lake Calhoun TSI scores and trend line. The TSI data and the linear regression show that Lake Calhoun has had an improving water quality trend over the past 23 years due to rehabilitation efforts. The lake is now mesotrophic with moderately clear water and some algae.

It appears that lake conditions are relatively stable and that the post-Clean Water Partnership Project Lake Calhoun has a TSI score 10 to 15 units lower (better) than prior to the lake and watershed improvement projects. Lake Calhoun will continue to be monitored to determine whether this trend is stable or if in-lake conditions deteriorate over time. In comparison to other lakes in this ecoregion Calhoun is in the top 5% of TSI scores based on calculations using the Minnesota Lake Water Quality Data Base Summary (MPCA, 2004). A detailed explanation of TSI can be found in **Section 1**.

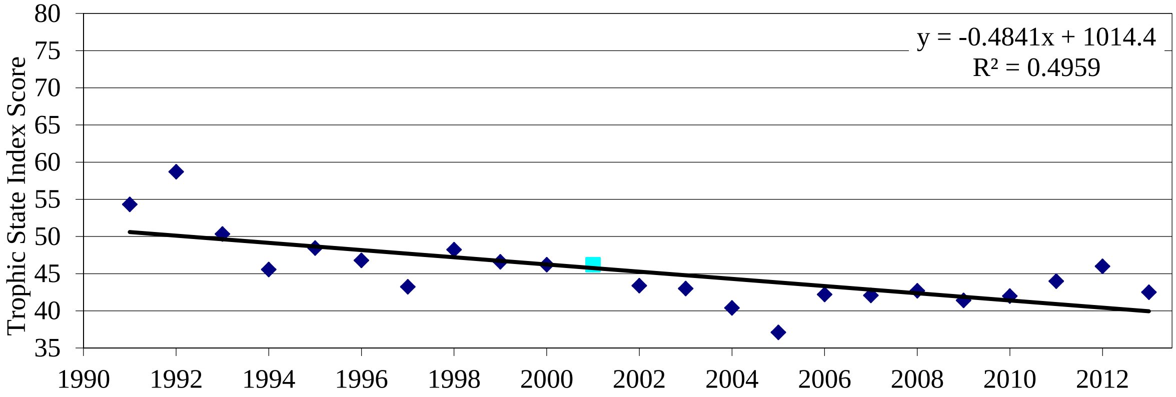


Figure 4-4. Lake Calhoun TSI scores and regression analysis. The blue square highlights the 2001 alum treatment.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 4-5** show the data distribution for Secchi transparency, chlorophyll-*a*, and total phosphorus for the past 10 years. Horizontal lines on the graphs indicate the MPCA deep lake standards. A detailed explanation of box and whisker plots can be found in **Section 1**. Data from the entire period of record in box and whisker plot format can be found **Appendix A**.

Both chlorophyll-*a* and phosphorous levels were lower in 2013 than in the past few years. Water transparency at Lake Calhoun was better than state standards for most of the year, which is typical for this lake. When comparing the boxplots in **Figure 4-5** to those in **Appendix A**, it becomes obvious that the 2001 alum treatment had a profound effect on parameters measured in Lake Calhoun, indicating an overall water quality improvement. While Secchi levels still seem to fluctuate from year to year, chlorophyll-*a* and phosphorous levels seem to be averaging towards a new normal since 2001(**Appendix A**).

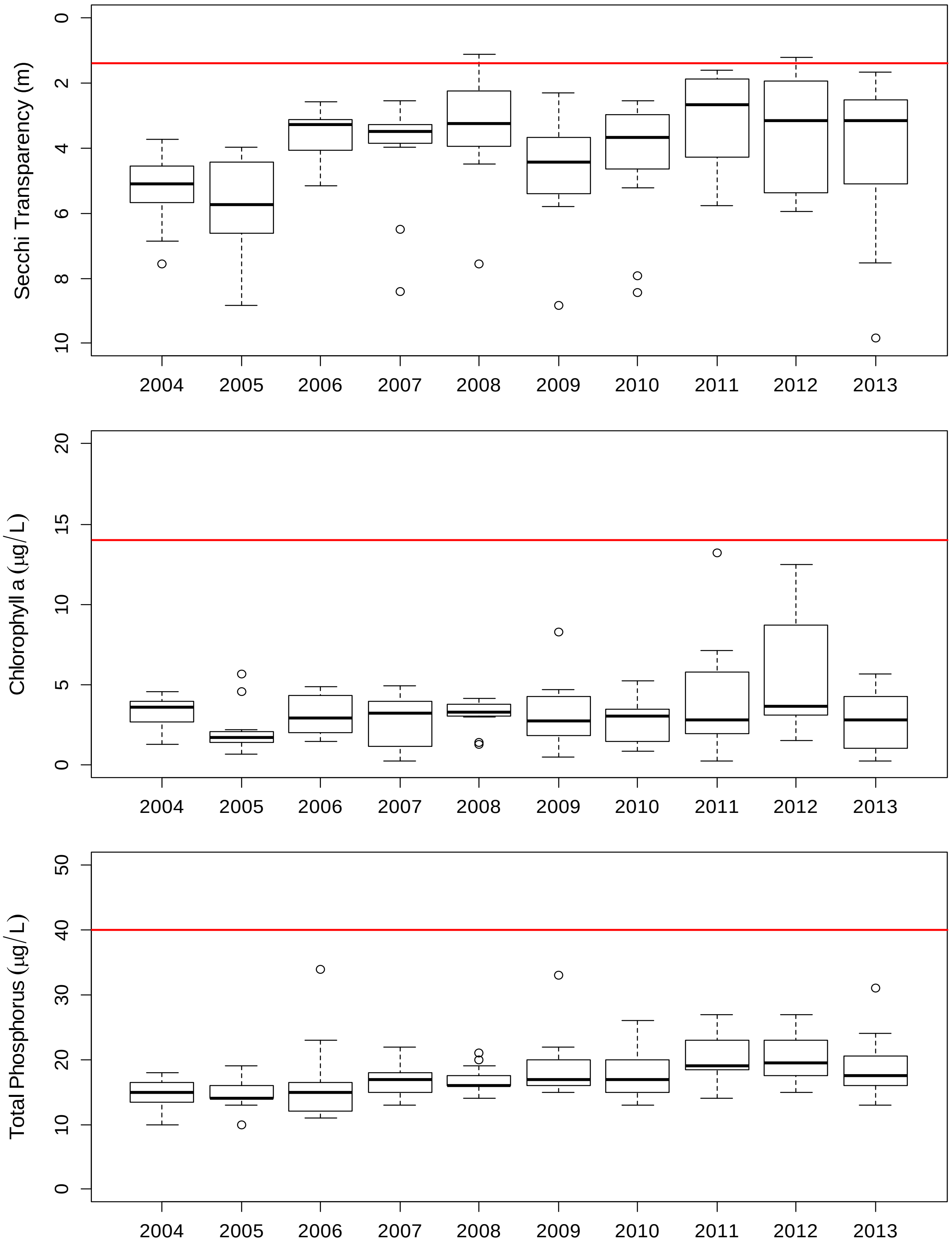


Figure 4-5. Lake Calhoun box and whisker plots of TSI data for the past 10 years. Horizontal lines represent MPCA eutrophication standard for deep lakes. See Appendix A for the entire period of record.

BEACH MONITORING

In 2013, bacteria levels were monitored at Lake Calhoun at three different locations: Calhoun 32nd Street Beach on the east side, Calhoun Main Beach on the north side, and Calhoun Thomas Beach on the south side. As shown in **Table 4-2**, the season long geometric means for *E. coli* at all three beaches were moderately low. The geometric mean of Calhoun 32nd Beach was the highest of the Lake Calhoun beaches at 28 mpn per 100mL, likely due to a July single sample exceedance. Calhoun 32nd Beach was the only Calhoun beach to close in 2013. See **Section 19** for more information on beach monitoring.

Table 4-2. Summary of *E. coli* (mpn per 100 mL) data for Lake Calhoun beaches in 2013.

Statistical Calculations	Calhoun 32nd	Calhoun Main	Calhoun Thomas
Number of Samples	14	13	13
Minimum	2	1	1
Maximum	2203	48	171
Median	17	10	12
Mean	240	13	25
Geometric Mean	28	7	11
Max 30-Day Geo Mean	28	18	19
Standard Deviation	591	15	46

Figure 4-6 illustrates the box and whisker plots of *E. coli* sampling results (per 100 mL of lake water) for Lake Calhoun beaches from 2004 to 2013. The box and whisker plots show the scatter in the dataset over several years. The light red line represents the *E. coli* standard for the 30-day geometric mean (126 mpn/100mL), while the dark red line represents the single-sample maximum standard (1260 mpn/100mL). *E. coli* results in 2013 were very similar to results in 2012.

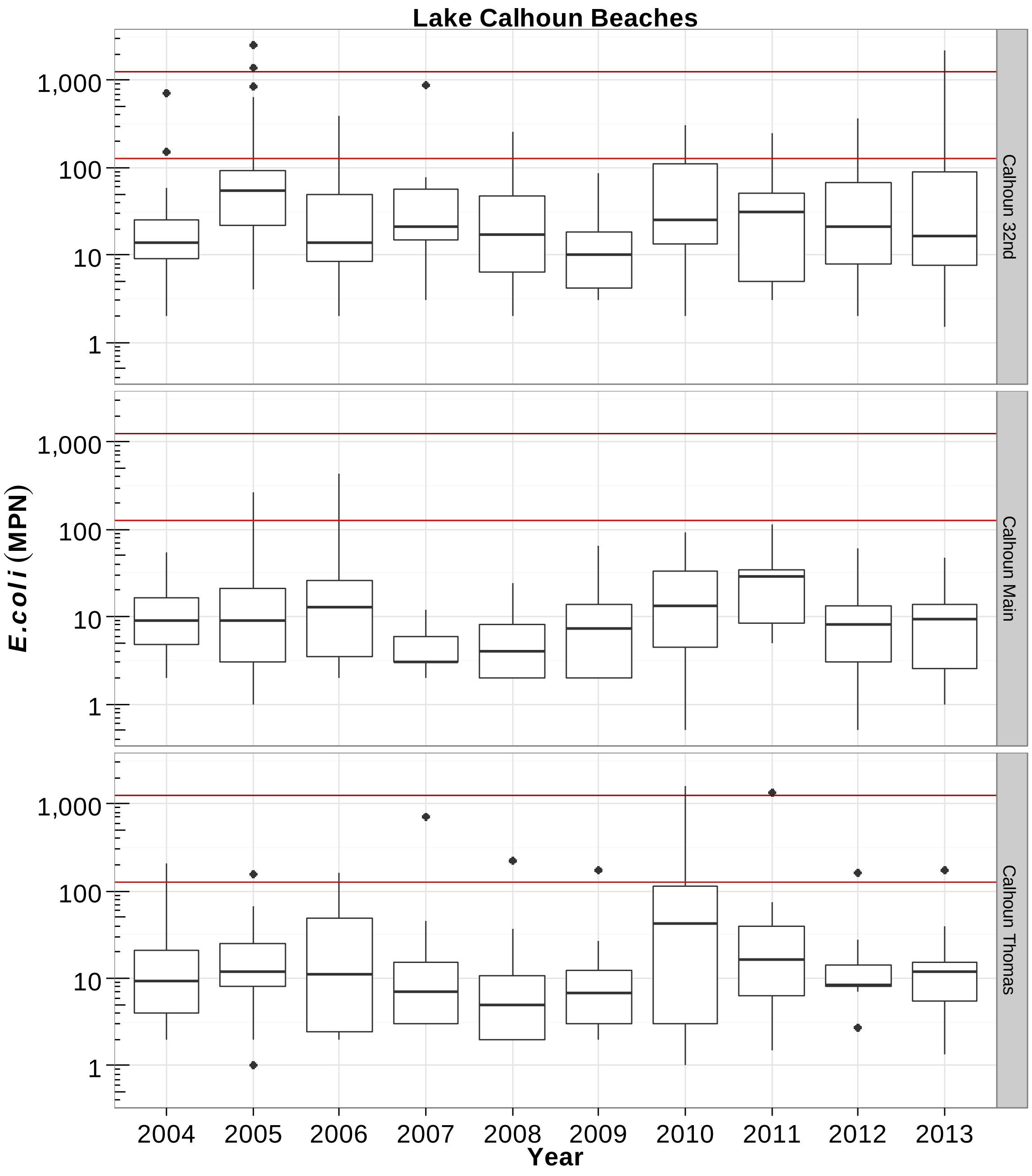


Figure 4-6. **Box and whisker plots of *E. coli* results (per 100 mL) for Lake Calhoun beaches from data collected between 2004 and 2013. The horizontal lines represent the *E. coli* standard for the 30-day geometric mean (126 mpn/100mL) and the single-sample maximum standard (1260 mpn/100mL). Note the log scale on the Y-axis.**

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Figure 4-7 shows the 2013 LAURI for Lake Calhoun. Lake Calhoun was rated excellent in aesthetics, habitat quality, clarity, public health, and recreational access. Details on LAURI can be found in **Section 1** and comparisons with other lakes can be found in **Section 18**.

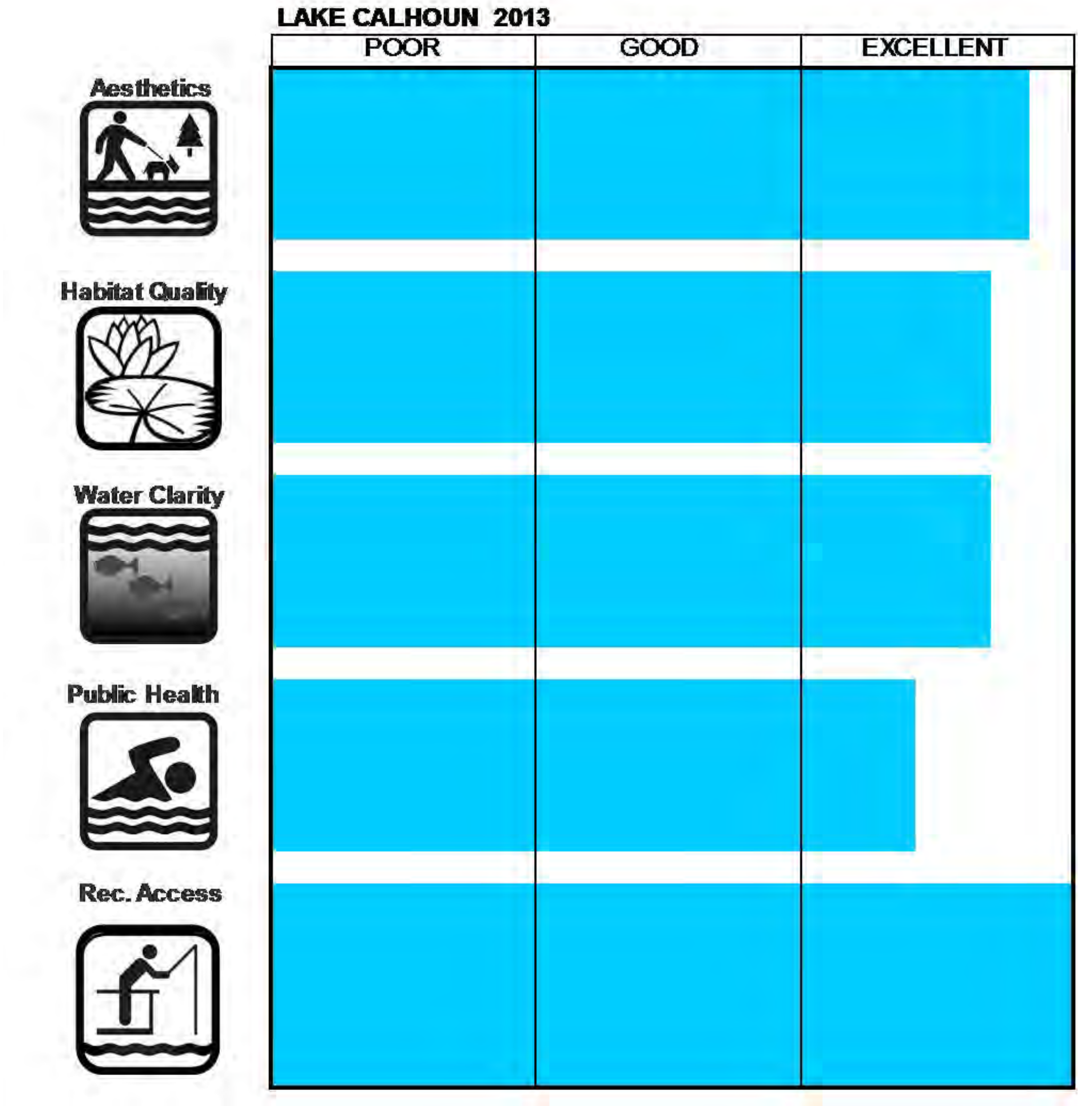


Figure 4-7. The 2013 LAURI for Lake Calhoun.

WINTER ICE COVER

Ice came off Lake Calhoun on April 28, 2013 which was eleven days later than average and the latest ice-off date recorded for the lake. Lake ice did not fully cover the lake until December 8, 2013 which was four days later than the average. (See **Figures 4-8 and 4-9** below).

Lake Calhoun has 67 years of recorded ice-off dates. While there is a lot of fluctuation in the data, the data general trend towards earlier ice-off (**Figure 4-8**). The running average ice-off date has shifted to earlier dates, floating around April 13th in the 1970s to April 9th for the past 15 years.

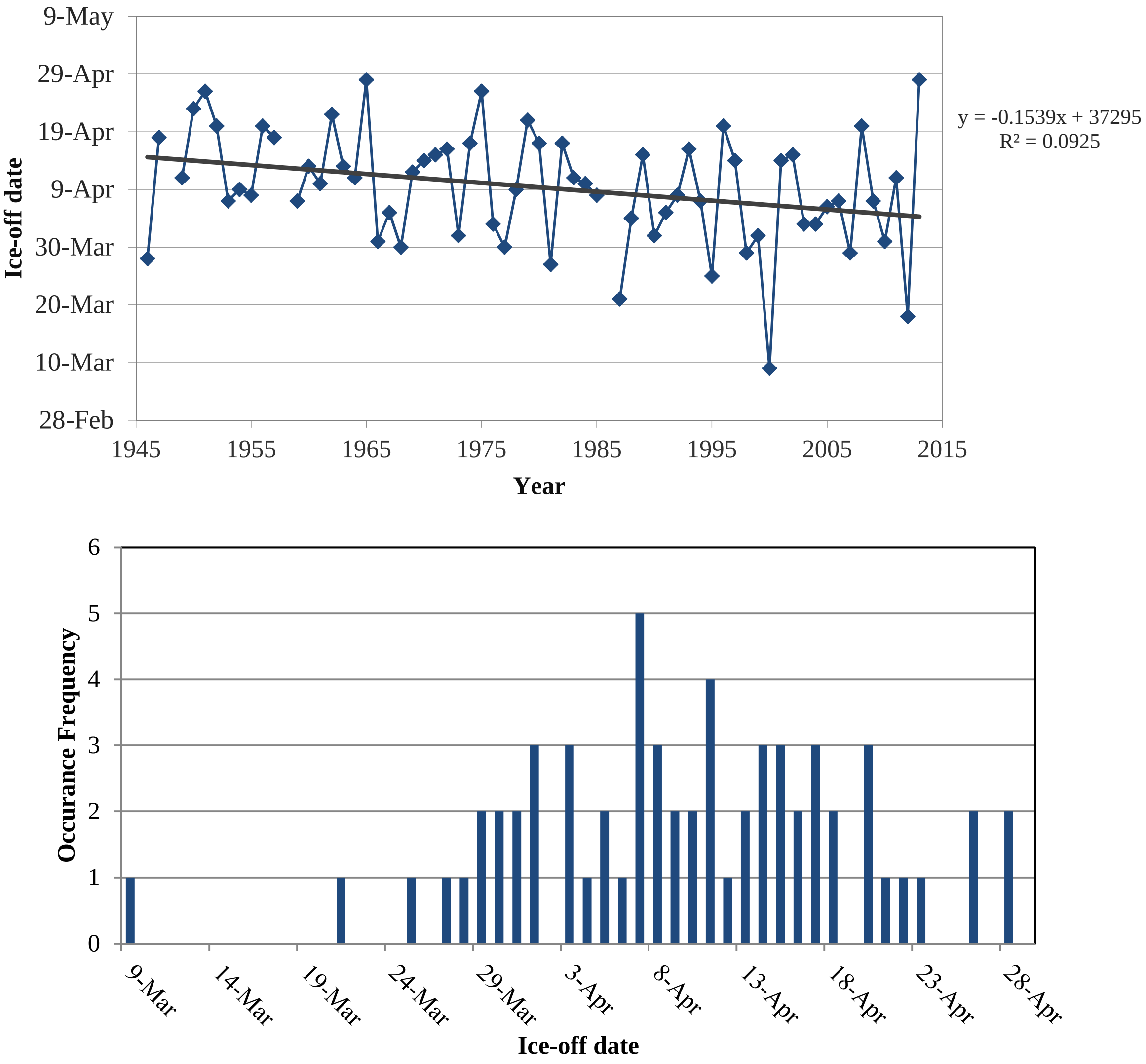


Figure 4-8. Lake Calhoun ice-off dates and frequency of the occurrence of ice-off on particular dates for all the years of record. 64 recorded ice-off dates exist over the past 67 years.

While fewer data exist for ice-on dates, there may be a very weak trend towards later ice-on at Lake Calhoun (**Figure 4-9**). The three latest ice-on dates from the past 48 years and the only outliers in the data occurred during the last eight years. The outliers may confound trend analysis until more data is collected or may be part of a trend. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

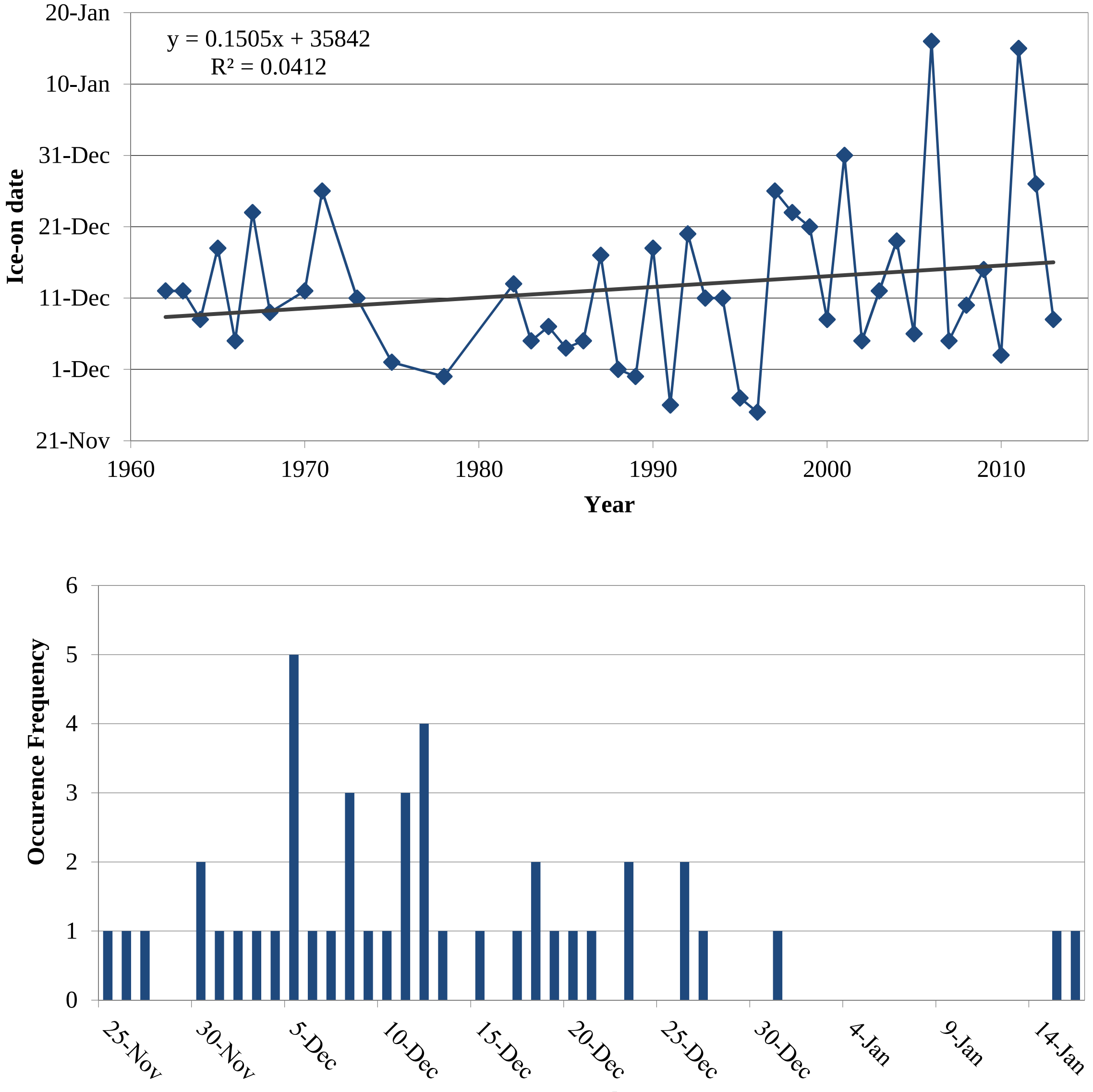


Figure 4-9. Lake Calhoun ice-on dates and frequency of the occurrence of ice-on on particular dates for all the years of record. Over 50 years, 44 ice-on records exist.

EXOTIC AQUATIC PLANT MANAGEMENT

The Minnesota Department of Natural Resources (MDNR) requires a permit to remove or control Eurasian watermilfoil. These permits limit the area from which milfoil can be harvested in order to protect fish habitat. The permits issued to the MPRB allow for harvesting primarily in swimming areas, boat launches, and in areas where public recreational access is needed. In 2013, the permitted area on Lake Calhoun was 50 acres which is about 40% of the littoral zone (area 15 feet or shallower). For more information on aquatic plants see **Section 1** and **Section 20**.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the basic food web of lake ecology. **Figures 4-10** shows the relative abundance of phytoplankton and **Figure 4-11** shows the chlorophyll-*a* concentrations with Secchi transparency during the 2013 sampling season.

The phytoplankton community of Lake Calhoun in 2013 had two very different stages as seen in **Figure 4-10**. Cryptomonads (Cryptophyta) dominated the phytoplankton community until mid-summer, despite small spikes of dinoflaggelates (Pyrrhophyta) and diatoms (Bacillariophyta) in May. Blue-green algae (Cyanophyta) dominated the phytoplankton community from mid-June through the end of the 2013 sampling season. As shown in **Figure 4-11**, water transparency and chlorophyll-*a* were closely related in 2013. The late summer emergence of cyanobacteria led to increased chlorophyll-*a* concentrations; however, algal biomass was very low throughout 2013 in Lake Calhoun.

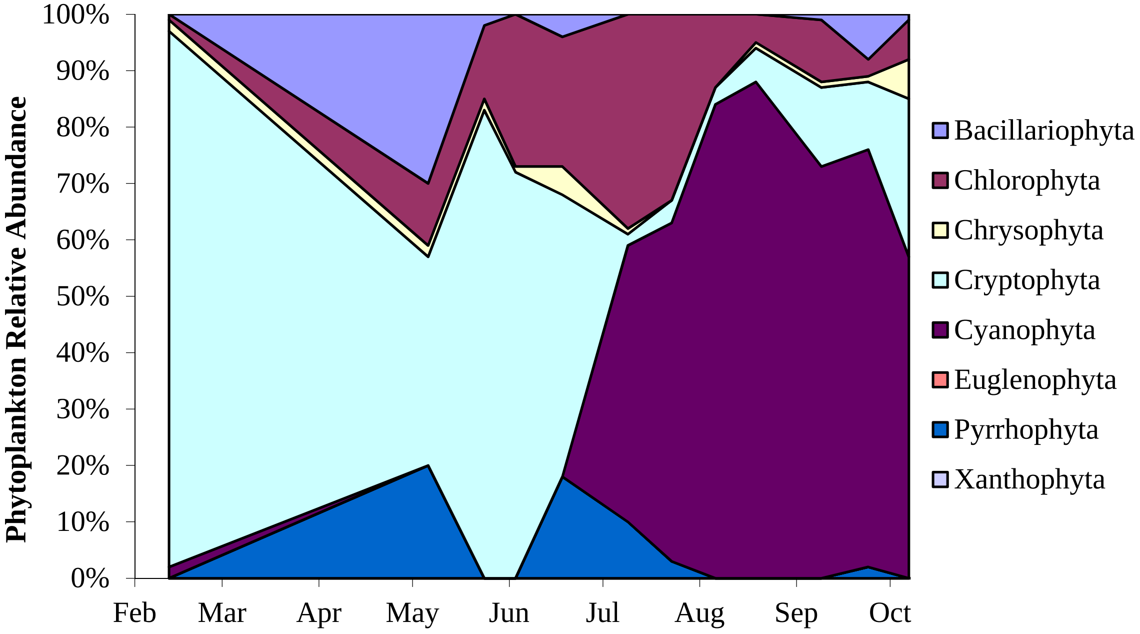


Figure 4-10. Lake Calhoun 2013 phytoplankton relative abundance.

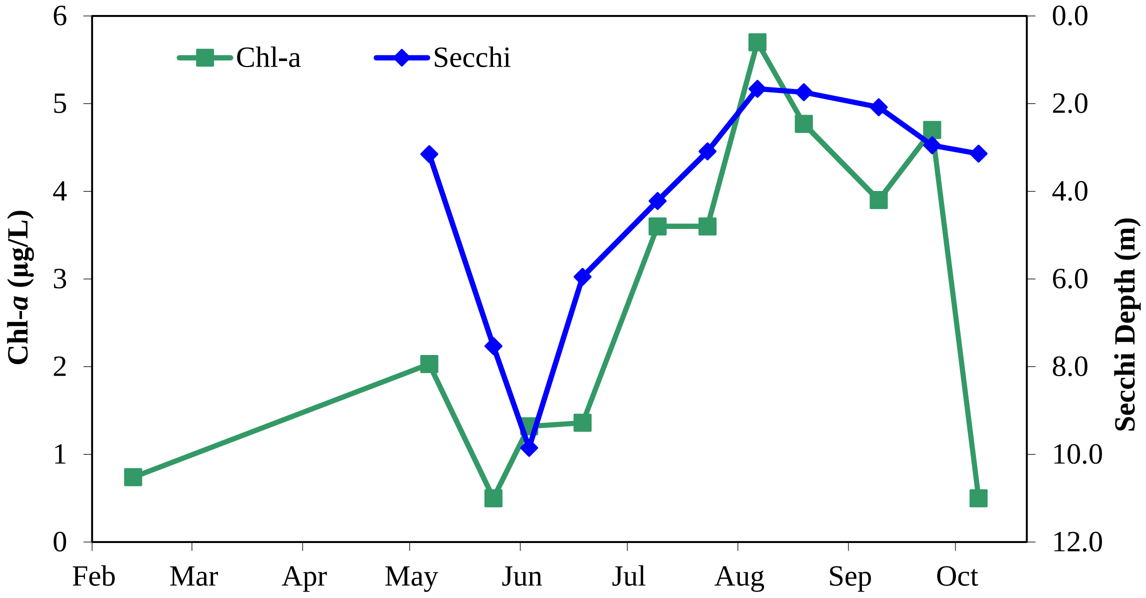


Figure 4-11. Chlorophyll-*a* concentrations and Secchi transparency in Lake Calhoun in 2013. Note that the Secchi scale is reversed.

Figure 4-12 shows the zooplankton distribution in Lake Calhoun sampled throughout 2013. Nauplii (juvenile stages of zooplankton) were found at their highest numbers in the spring sample, tapering off throughout the entire season to lower levels of reproduction. Rotifers, which are a group of small zooplankton, peaked in July. Cladocerans held greater density earlier in the season, tapering off as the weather cooled. Protozoa, cyclopoids, and calanoids were present in low concentrations throughout the entire season.

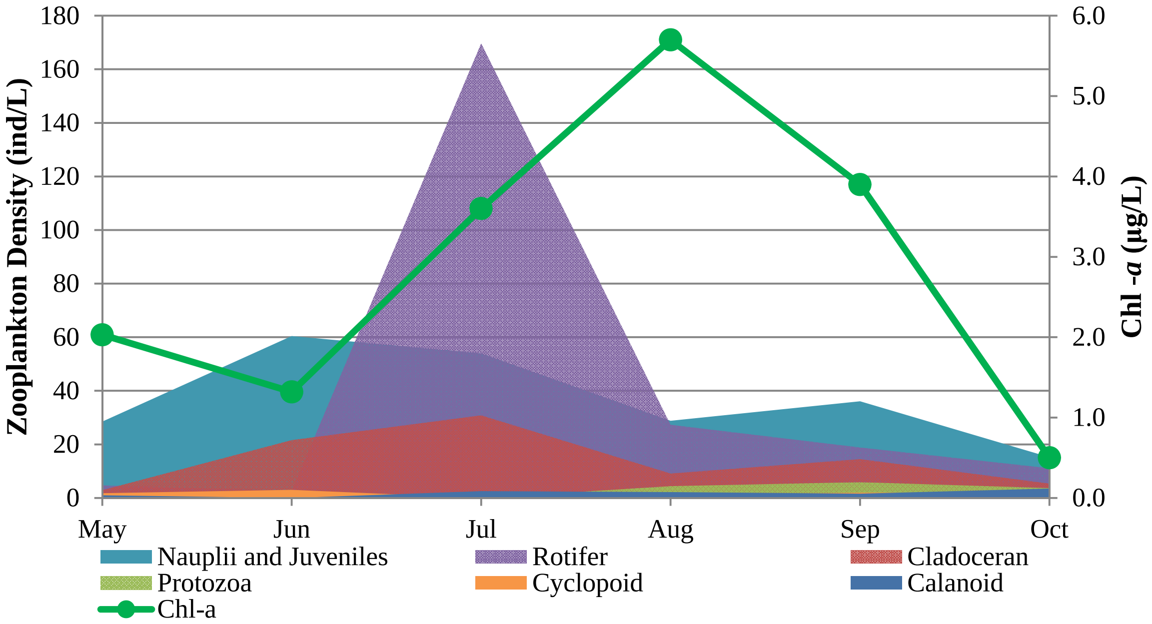


Figure 4-12. Lake Calhoun 2013 zooplankton density displayed with chlorophyll-*a*.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling and adult fish can be found in **Section 1**.

Lake Calhoun was stocked by the MDNR in:

1999 with 71 adult Muskellunge, 125 fingerling Muskellunge.
2000 with 107 adult Muskellunge, 1,590 yearling Walleye.
2001 with 12,654 fingerling Walleye.
2002 with 500 fingerling Tiger Muskellunge.
2003 with 5,545 fingerling Walleye.
2005 with 500 fingerling Tiger Muskellunge.
2006 with 2,356 fingerling Walleye.
2007 with 500 fingerling Tiger Muskellunge.
2009 with 480 fingerling Tiger Muskellunge, 9,991 fingerling Walleye, 248 yearling Walleye.
2010 with 127 fingerling Muskellunge.
2012 with 123 fingerling Muskellunge, 12,684 yearling Walleye.

EMERGING CONTAMINANTS

MPRB water quality staff have partnered with the MPCA to monitor for perflorinated chemical (PFCs) sources to lakes in Minneapolis.

Background

Perflorinated chemicals (PFCs) are a class of chemicals that were produced by the 3M and DuPont corporations since the 1950s. 3M stopped producing PFCs in 2000 and DuPont will cease production of PFCs in 2015. PFCs are used worldwide in a variety of industrial and consumer products. The chemicals have a similar structure to long-chain carbon molecules except with fluorine atoms replacing carbon atoms in the chain. Recent environmental testing has found PFCs are ubiquitous throughout the environment at low levels and that some PFCs have the ability to bioaccumulate in the tissues of plants and animals. Because PFCs can bioaccumulate and do not degrade under normal environmental conditions, they are being investigated for potential health risks.

In Minnesota, PFCs have been a large target research since 2005 when it was discovered that the chemicals were leaching into groundwater and into the Mississippi River from sources in Washington County. In 2007, PFC contamination was discovered in drinking water wells in the east Metro, sparking broad environmental testing. Environmental testing was expanded to include treatment plant influent and effluent, surface water, and fish from selected lakes and rivers. This wide-ranging round of investigation detected that PFCs are found throughout Minnesota and were not distributed uniformly.

PFCs have been found in Minneapolis lakes and in their fish populations. **Table 4-3** shows the highest average species concentrations of PFOS (one type of PFC) from fish tissue sampling from 2006-2008 in Minneapolis Lakes. PFCs do not bioaccumulate in the same pathways as other environmental contaminants do. PFC's are not fat soluble and rather tend to accumulate in proteins. PFOS has been found in highest concentrations in bluegill sunfish rather than in top predators or in larger fish. These findings prompted the Minnesota Department of Health to issue a fish advisory of one fish meal per month for bluegill sunfish, crappie, and largemouth bass in the Chain of Lakes.

Table 4-3. **Highest average species concentration of PFOS found in fish in Minneapolis Lakes from testing conducted by the MPCA from 2006-2008.**

Lake	PFOS found in fish fillets in ng/g (ppt)
Calhoun	>200
Harriet	>200
Cedar	40-200
Isles	40-200
Cedar	40-200
Hiawatha	40-200
Nokomis	<40

MPCA-MPRB Sampling

The Minneapolis lakes do not have a groundwater connection to the sources identified in Washington County. The discovery of elevated PFOS in Minneapolis lakes prompted the MPCA to undertake a study of the source of PFOS to the lakes. In 2008, MPRB staff assisted MPCA in collecting stormwater samples to determine the source of PFOS to Lake Calhoun. Stormwater samples were collected from each of five watersheds contributing to Lake Calhoun and from upstream areas with commercial and industrial land use. Results of this study found that a large watershed on the west side of Lake Calhoun contributes the highest levels of PFOS to the lake. This watershed includes large areas of commercial and industrial land use. Sampling in 2009 focused on sub-watersheds to the west of Lake Calhoun. MPRB will continue to work with the MPCA on PFCs in Minneapolis lakes.

5. CEDAR LAKE

HISTORY

Like the other lakes in the Chain of Lakes, Cedar Lake was altered from its natural state when it was dredged between 1911 and 1917. Channels connecting Cedar Lake to Lake of the Isles and to Brownie Lake were created in 1913 and 1916. The Lake of the Isles connection caused the water level in Cedar Lake to drop six feet. The new water elevation changed the shape of the lake most noticeably turning Louis Island on the west side of the lake into a peninsula. **Figure 5-1** shows a recent photograph of Cedar Lake.

Clean Water Partnership projects were implemented to improve water quality at Cedar Lake. Constructed wetlands (1995) and an aluminum sulfate (alum) treatment (1996) were best management practices (BMPs) implemented to improve water quality in the lake. The 1996 alum treatment improved phosphorus levels at the surface and the hypolimnion and was predicted to have a treatment life span of at least seven years (Huser, 2005).

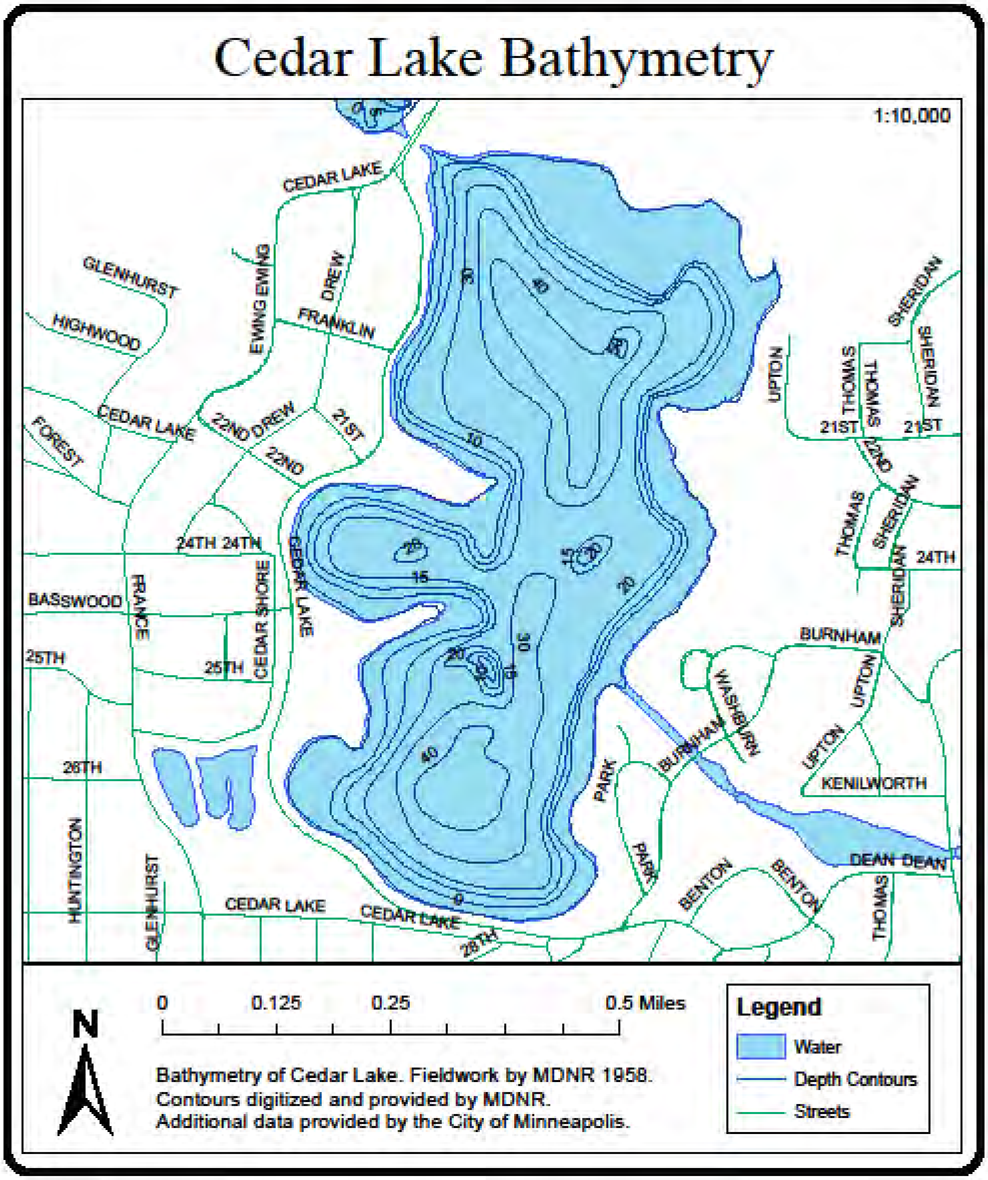
Cedar Lake is a kettle lake and is typically dimictic; however, there is evidence that in some years the lake may mix during the late summer and then re-stratify (Lee and Jontz, 1997). **Figure 5-2** shows a bathymetric map of Cedar Lake. **Table 5-1** shows the Cedar Lake morphometric data.

Figure 5-1. View of Cedar Lake from Main Beach in 2012.

Table 5-1. Cedar Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
170	6.1	15.5	37%	4.26×10^6	1,956	11.5	2.7

* Littoral area defined as less than 15 feet deep.



Bathymetry of Cedar Lake. Fieldwork by MDNR 1958.
Contours digitized and provided by MDNR.
Additional data provided by the City of Minneapolis.

Figure 5-2. Bathymetric map of Cedar Lake.

LAKE LEVEL

The designated Ordinary High Water Level (OHW) for Cedar Lake is 853 feet above msl. **Section 4, Lake Calhoun** includes more information on historic Chain of Lakes water level information.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2013 TSI score for Cedar Lake was 53, putting Cedar in the top 25% of TSI scores compared to other lakes in the ecoregion (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004). The TSI scores for all monitored years with a linear regression are shown in **Figure 5-3**. Restoration efforts begun in 1994 have helped improve water quality in the lake. Cedar Lake is currently mesotrophic with moderately clear water and some algae. A detailed explanation of TSI can be found in **Section 1**.

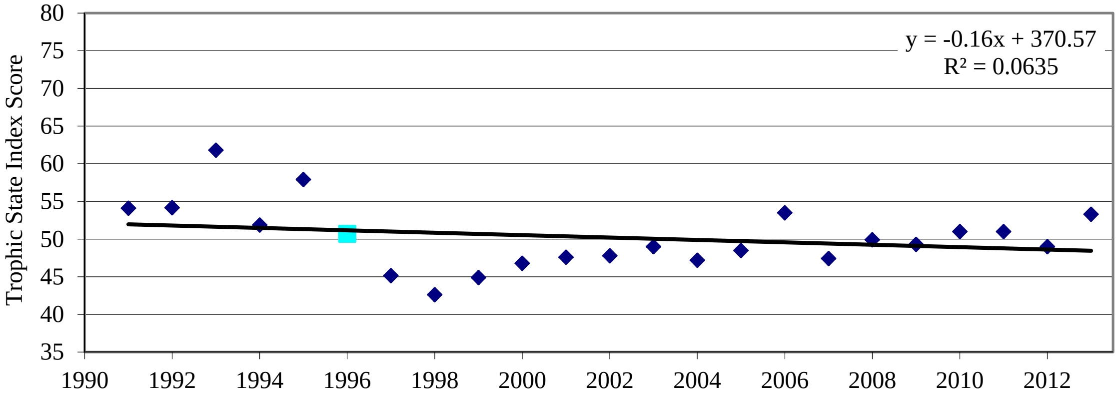


Figure 5-3. Cedar Lake TSI scores and regression analysis from 1991-2013. The alum treatment year is indicated with a blue square.

The TSI data and linear regression show Cedar Lake generally trending toward lower TSI scores and improved water quality; however, in the years since the 1996 alum treatment, TSI scores have been slowly increasing, indicating depreciating water quality. If this trend continues, then water quality will approach pre-treatment condition. Future monitoring will show the water quality trajectory in Cedar Lake.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 5-4** show the data distribution for Secchi transparency, chlorophyll-*a*, and total phosphorus for Cedar Lake for the past decade. Horizontal lines on the graphs indicate the MPCA deep lake standards. A detailed explanation of box and whisker plots can be found in **Section 1**. Data in box and whisker plot format for the entire period of record can be found in **Appendix A**.

Overall, water transparency, chlorophyll-*a*, and phosphorus levels indicated a poorer quality of water in Cedar Lake in 2013. Secchi transparency was lower than in recent years, indicating poor water clarity, perhaps due to the largest chlorophyll-*a* levels observed since 2006. Future monitoring will be needed to determine whether 2013 was indicative of a longer term trend or just an abnormal year.

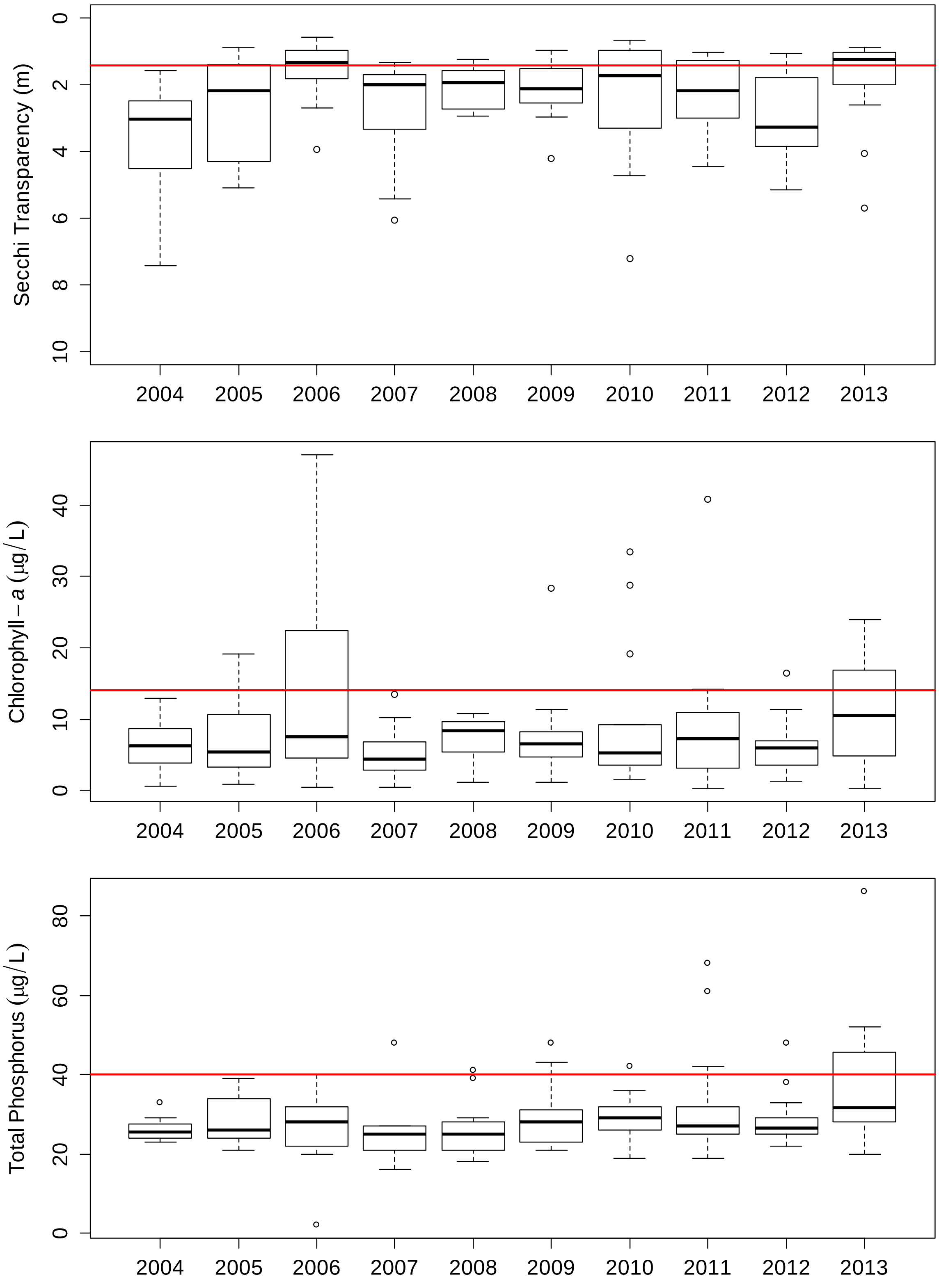


Figure 5-4. Box and whisker plot data for Cedar Lake for the past decade. Horizontal lines represent MPCA eutrophication standard for deep lakes. See Appendix A for the entire period of record.

BEACH MONITORING

Escherichia coli (*E. coli*) levels were sampled at three different locations around Cedar Lake: Cedar Main Beach, Cedar Point Beach, and East Cedar Beach (Hidden). All Cedar Lake beaches remained open for the entire season. As shown in **Table 5-2,** the season-long geometric means for *E. coli* were relatively low at all of the Cedar Lake beaches. East Cedar Beach was opened as a supervised public beach for the first time in 2007 and has had some of the lowest *E. coli* count values for all MPRB beaches. Cedar Point and Cedar Main both had one high sample over the course of the season, but it was not high enough to exceed the single-sample standard of 1260 MPN/100 mL.

Table 5-2. Summary of 2013 *E. coli* results (MPN per 100 mL) for Cedar Lake beaches.

Statistical Calculations	East Cedar (Hidden)	Cedar Main	Cedar Point
Number of Samples	13	13	13
Minimum	1	2	3
Maximum	71	433	509
Median	11	12	8
Mean	18	50	56
Geometric Mean	10	14	13
Max 30-Day Geo Mean	29	30	32
Standard Deviation	21	118	138

Figure 5-5 shows box and whisker plots of *E. coli* sampling results for 2004 - 2013. The light red line represents the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL), while the dark red line represents the single-sample maximum standard (1260 MPN/100mL). Additional information on beach monitoring can be found in **Section 19**.

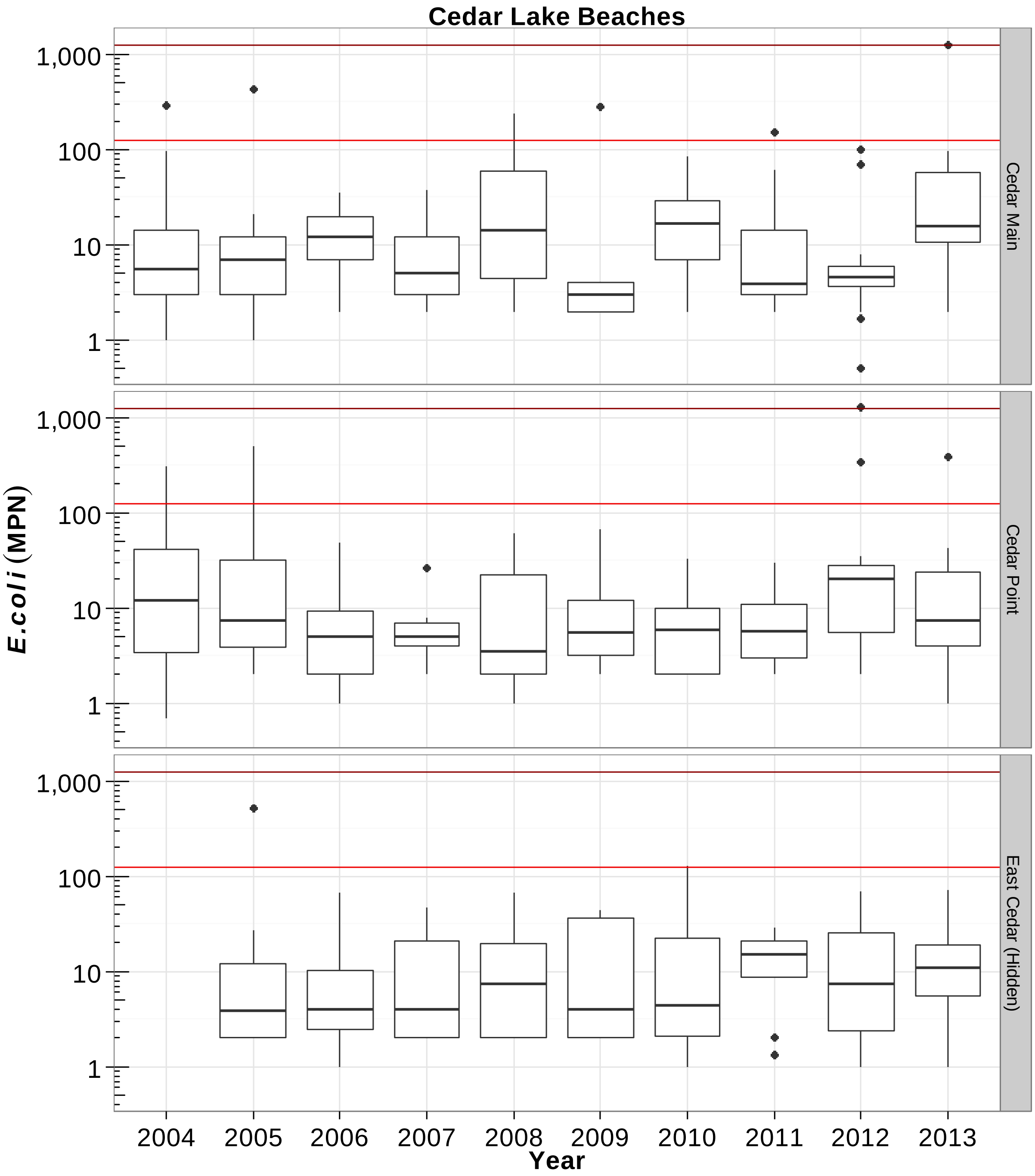


Figure 5-5. Box and whisker plots of *E. coli* results (per 100 mL) for Cedar Lake beaches for 2004 -2013. The horizontal lines represent the *E. coli* standard for the 30-day geometric mean (126 M/100mL) and the single-sample maximum standard (1260 MPN/100mL). Note the log scales on each y-axis. From 2004-2009 *E. coli* concentrations were determined as colony forming units (CFU/100ml).

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The 2013 LAURI for Cedar Lake is presented in **Figure 5-6**. Cedar Lake scored “excellent” in aesthetics, habitat quality, public health, and recreational access and “good” in water clarity. See **Section 1** for details on the LAURI index.

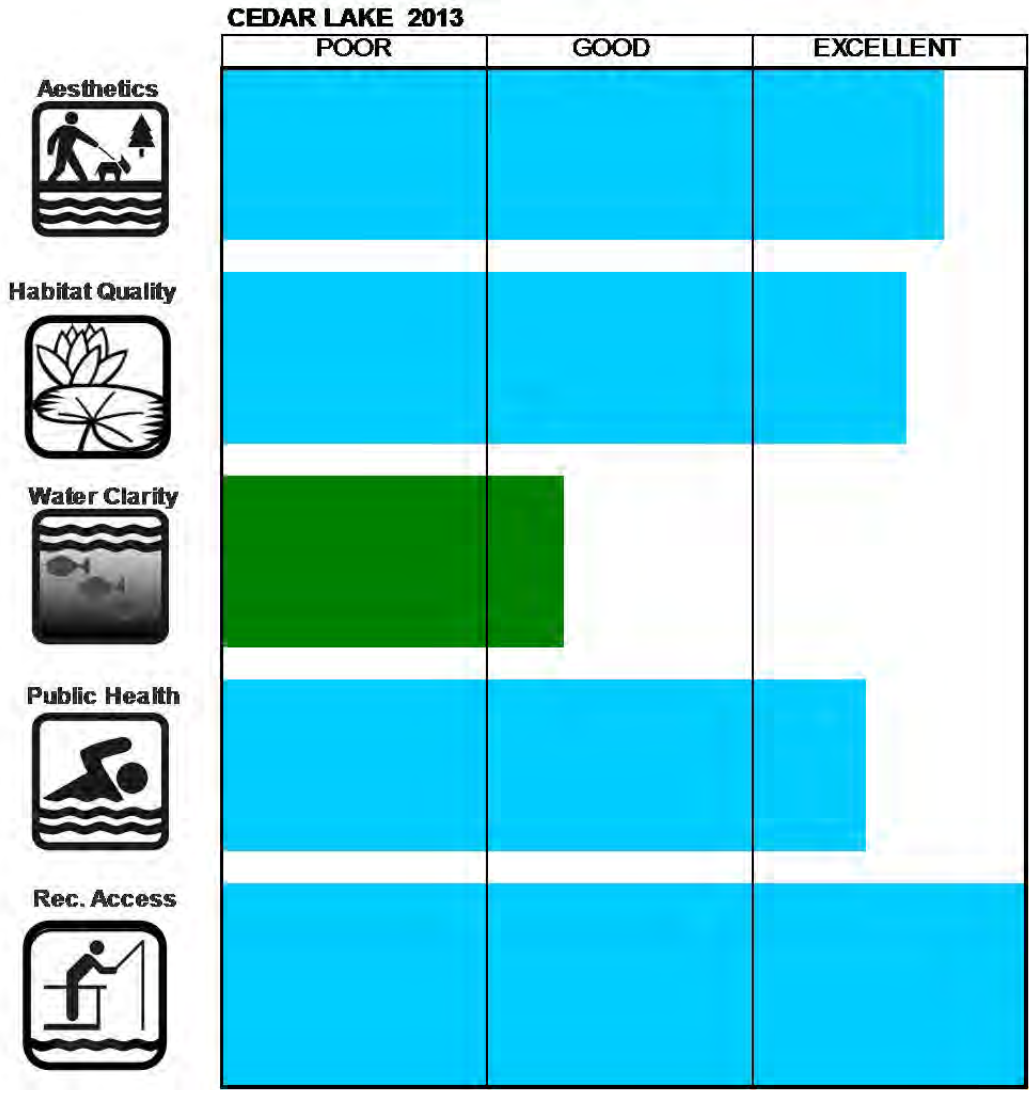


Figure 5-6. The 2013 LAURI for Cedar Lake.

WINTER ICE COVER

Ice came off Cedar Lake on April 28, 2013, which was twenty two days later than average and the latest ice-off date recorded for Cedar Lake. Ice was back on the lake by November 27, 2013, a week before the average ice-on date for the lake. See **Section 1** for details on winter ice-cover records and **Section 18** for a comparison with other lakes.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian watermilfoil. The permit limits the area from which milfoil can be harvested in order to protect fish habitat. The permits issued to the MPRB allowed for harvesting primarily in swimming areas, boat launches, and shallow areas where recreational access was necessary. In 2013, the permitted area on Cedar Lake was 19 acres which is approximately 25% of the littoral zone of the lake (area shallower than 15 feet). See **Section 1** for details on aquatic plants.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 5-7** show the distribution of phytoplankton over the 2013 sampling season and **Figure 5-8** shows chlorophyll-*a* concentrations along with Secchi disk readings. **Figure 5-9** shows the zooplankton distribution over 2013.

Several phytoplankton groups were dominant during different parts of the 2013 season, as shown below in **Figure 5-7**. The winter and spring samples were mainly dominated by high food-quality cryptomonads (Cryptophyta), chrysophytes, and diatoms (Bacillariophyta). Dinoflagellates (Pyrrhophyta) also exhibited a small peak in the spring time. Once the summer season began in June, blue-green algae (Cyanophyta) bloomed and continued to dominate for the remainder of the sampling season. Increasing chlorophyll-*a* values coincided with the mid-summer blue-green algae bloom and mirrored decreasing Secchi depths, as shown by **Figure 5-8**.

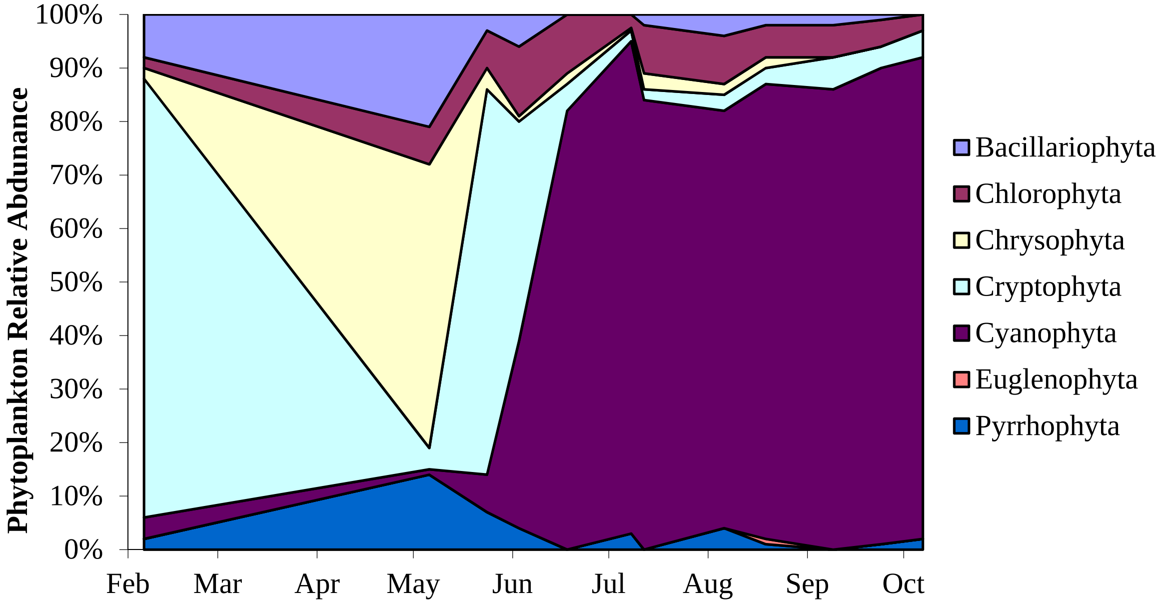


Figure 5-7. Distribution of the relative abundance of phytoplankton in Cedar Lake over the 2013 field season.

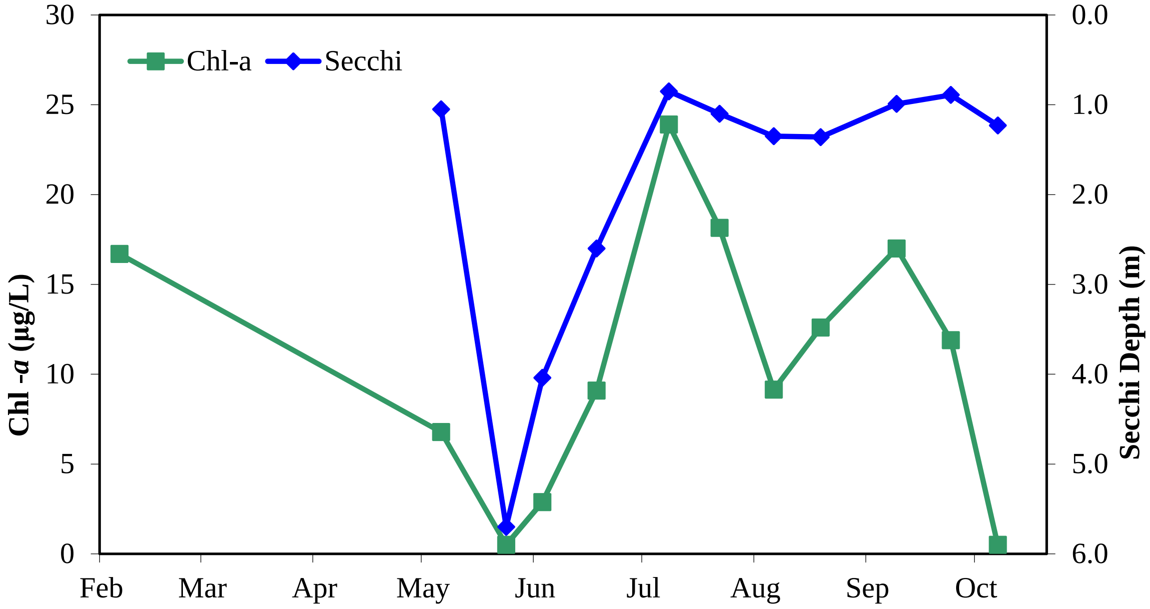


Figure 5-8. Cedar Lake 2013 Secchi disk and chlorophyll-*a* measurements.

Zooplankton were sampled once per month during the 2013 sampling season between April and October and can be seen in **Figure 5-9**. Concentrations of juvenile zooplankton, called nauplii, were abundant early in the season and slower tapered off towards lower numbers through the rest of the season. Rotifers, which are a group of small zooplankton, spiked in July and September. Calanoids were present early in the season an slowly tapered off throughout the summer. Cladocerans and cyclopoids were present at low levels throughout the sampling season. Chlorophyll-*a* trends are similar to the seasonal changes in the zooplankton community; as rotifers peaked, Chlorophyll-*a* decreased, possibly due to grazing.

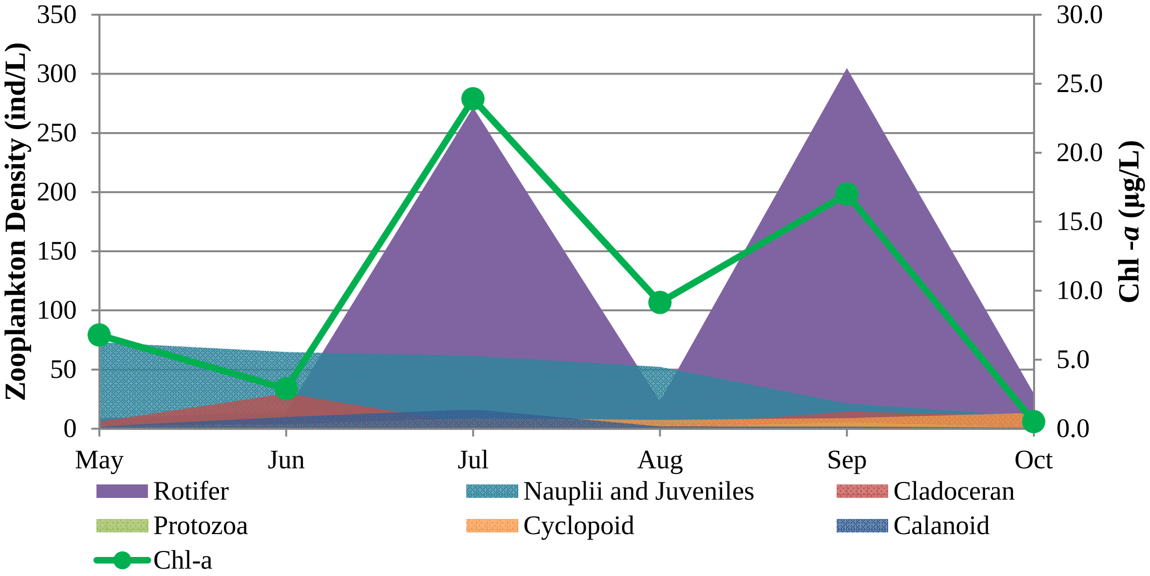


Figure 5-9. 2013 Cedar Lake zooplankton distribution shown with chlorophyll-*a* concentrations.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling, and adult fish sizes can be found in **Section 1**.

Cedar Lake was stocked by MDNR in:

1998 with 299 fingerling Muskellunge.
2001 with 200 fingerling Tiger Muskellunge.
2004 with 200 fingerling Tiger Muskellunge.
2005 with 1,168 fingerling Walleye.
2007 with 160 fingerling Tiger Muskellunge and 2,022 fingerling Walleye.
2009 with 2,835 fingerling Walleye and 115 yearling Walleye.
2010 with 67 fingerling Muskellunge.
2011 with 3,828 fingerling Walleye.
2012 with 63 fingerling Muskellunge.
2013 with 3.640 fingerling Walleye.

EMERGING CONTAMINANTS

Section 4, Lake Calhoun includes more information on the MPRB emerging contaminant partnerships.

6. DIAMOND LAKE

HISTORY

Diamond Lake is a small shallow water body predominantly surrounded by residential neighborhoods and parkland **(Figure 6-1)**. The National Wetlands Inventory classifies Diamond Lake as a lacustrine/limnetic system with an unconsolidated bed and is permanently flooded (L1UBH). The fringe of Diamond Lake is classified as palustrine semipermanently flooded wetland with emergent vegetation (PEMF; USFWS, 2012).

Diamond Lake and surrounding park areas were donated to the MPRB between 1926 and 1936. In 1937, a project was proposed to dredge Diamond Lake, generating fill to deposit in Pearl Lake to create Pearl Park. However, the Board voted against the project and decided to use fill from airport properties instead. A drain from Pearl Park was installed to divert water to Diamond Lake and prevent flooding in the park.

Water levels in Diamond Lake have fluctuated due to land use changes in the surrounding watershed. In 1940, the City of Minneapolis installed storm sewers and by 1941, 800 acres of developed land was draining into Diamond Lake causing drastic water elevation fluctuations. In 1942, the Works Progress Administration (WPA) constructed an overflow to control water elevation and an outflow pipe that carried water from the northeast shore to Minnehaha Creek. Construction of Interstate 35W during the 1960s added several miles of highway runoff to Diamond Lake. In 1991, the MPRB placed a weir at 822.0 ft msl (112.2 feet above city datum) allowing for higher water than the previous outlet which was 820.1 ft msl (110.3 feet above city datum). The increase in water elevation was made to encourage establishment of aquatic plants and to restore important wildlife habitat in Diamond Lake.

Figure 6-1. Diamond Lake in Fall 2013.

In 1953, the Minnesota Department of Natural Resources (MDNR) completed a water quality survey and determined that the lake could not be considered a fish supporting lake due to the lack of oxygen during the winter months (MDNR, 1953). MPRB sampling has confirmed that Diamond Lake freezes to the bed during some winters. In 2007, construction began on the 35W/HWY62 improvement project that changed the drainage areas in the Diamond Lake watershed. **Figure 6-2** shows a map for Diamond Lake. **Table 6-1** shows morphometric data for Diamond Lake.

Table 6-1. Diamond Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Ordinary High Water Level (msl)
41	0.9	2.1	100%	7.15×10^4	669	16.3	822.32

* Littoral area is defined as less than 15 feet deep.

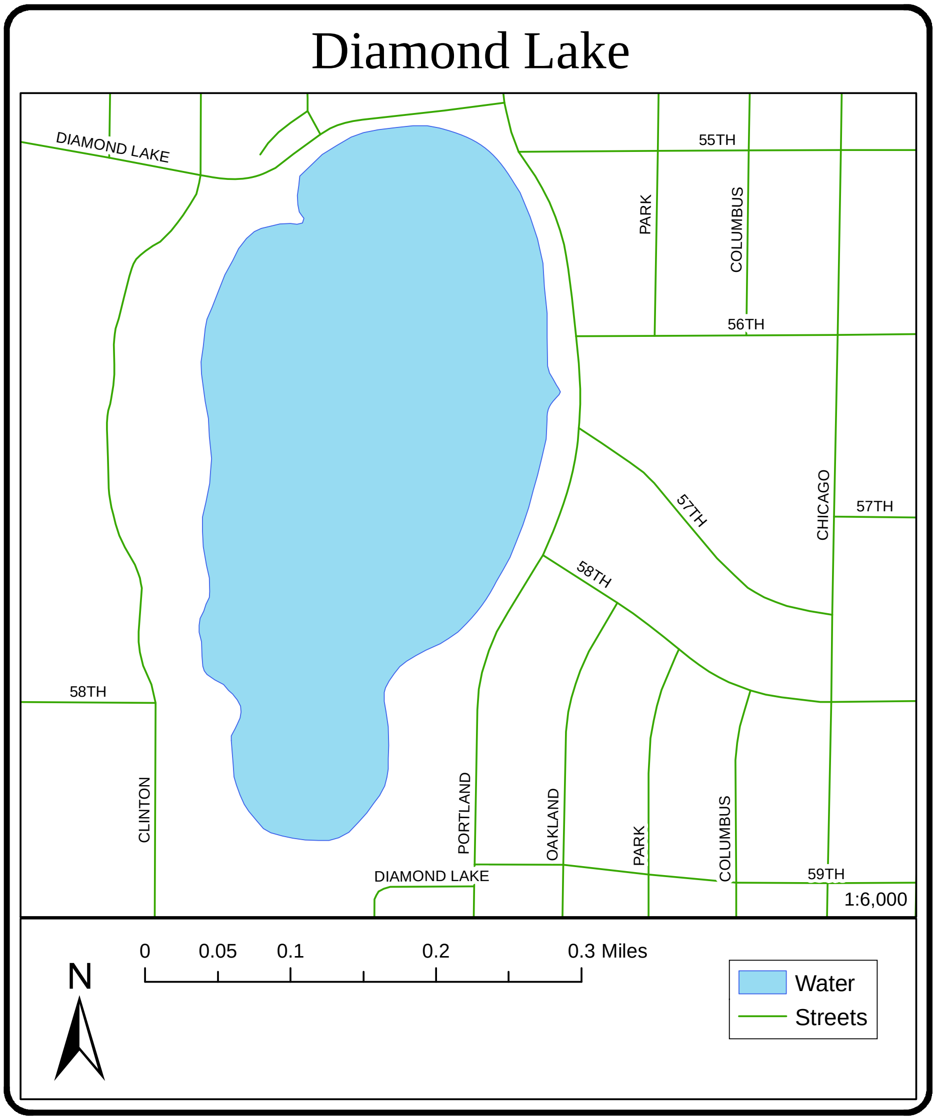


Figure 6-2. Diamond Lake map.

LAKE LEVEL

The lake level for Diamond Lake is measured at a gage near the Diamond Lake Lutheran Church and results are shown in in **Figure 6-3**. The designated Ordinary High Water Level (OHW) for Diamond Lake is 822.32 feet above mean sea level. Similar to the past two years, lake levels were high early in the season after snowmelt and large rains and dropped during the late summer drought.

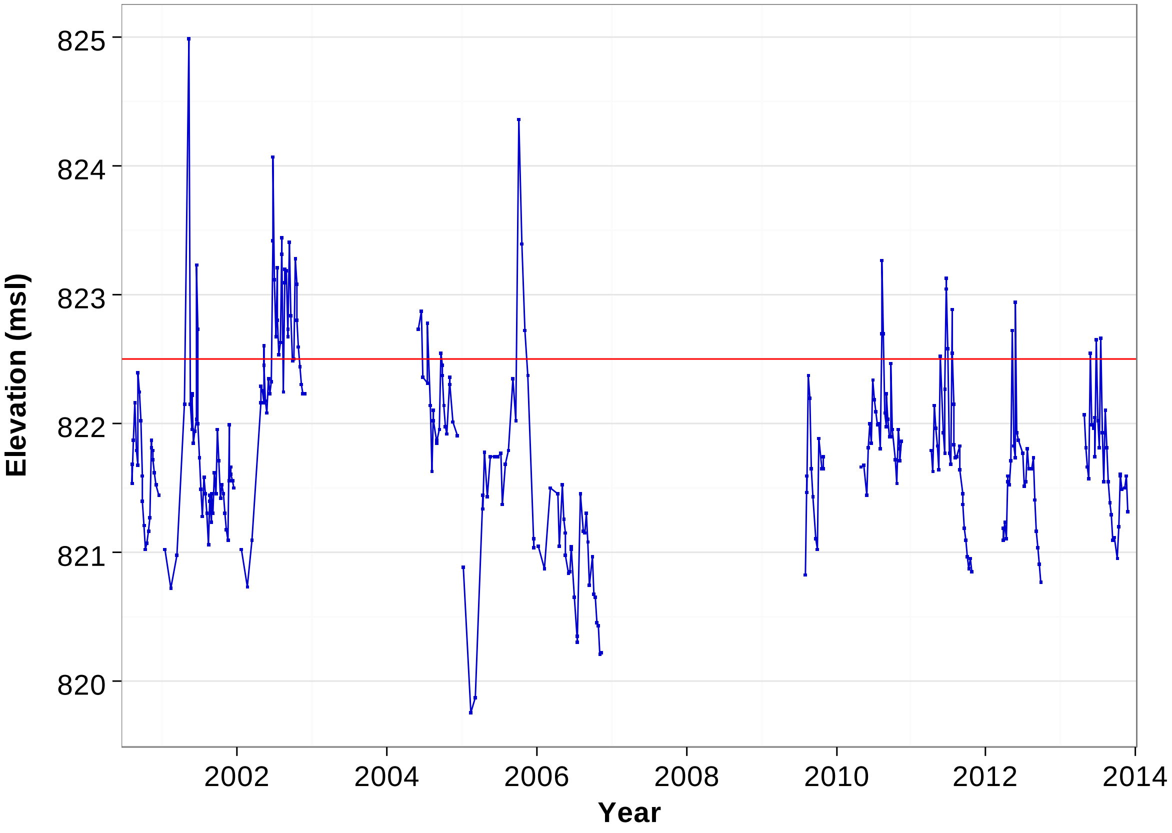


Figure 6-3. Diamond Lake levels from 2000 to the present. Horizontal line represents Diamond Lake outlet elevation (822.5 ft msl).

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2013 TSI score for Diamond Lake was 74. **Figure 6-4** shows the TSI scores and trend from 1992–2013 at Diamond Lake. A detailed explanation of TSI can be found in **Section 1**.

Carlson's TSI Index would classify Diamond Lake as eutrophic. However, Carlson's index was developed for lakes without non-algal turbidity and with low macrophyte populations. Diamond Lake does not meet these criteria. It is a fertile, very shallow water body with high non-algal turbidity and thick aquatic plant beds. Secchi depth was not used in TSI calculations of Diamond Lake, since the lake is often either clear to the bottom or the Secchi disk is obscured by dense aquatic plant growth. In 2004, the sampling location changed from a grab sample off a dock on the northeast side of the lake to a grab sample over the deep spot in the southern part of the lake from a canoe. Looking through the entire TSI record for Diamond Lake, the water quality index appears to be increasing indicating degrading water quality, as indicated by the solid black line in **Figure 6-4**. This trend may be due to the continuing impacts of stormwater and development on this shallow wetland. However over the past 9 years, the TSI scores have fallen, as denoted by the red line in **Figure 6-4**. While 2013 saw an increase in TSI scores, the recent trend indicates an improvement in water quality since 2005. This phenomenon could be due to the change in sampling location or to improvements due to water quality infrastructure constructed for the 35W/HWY62 project. More data must be collected to determine whether this trend accurately depict a new direction for water quality at Diamond Lake.

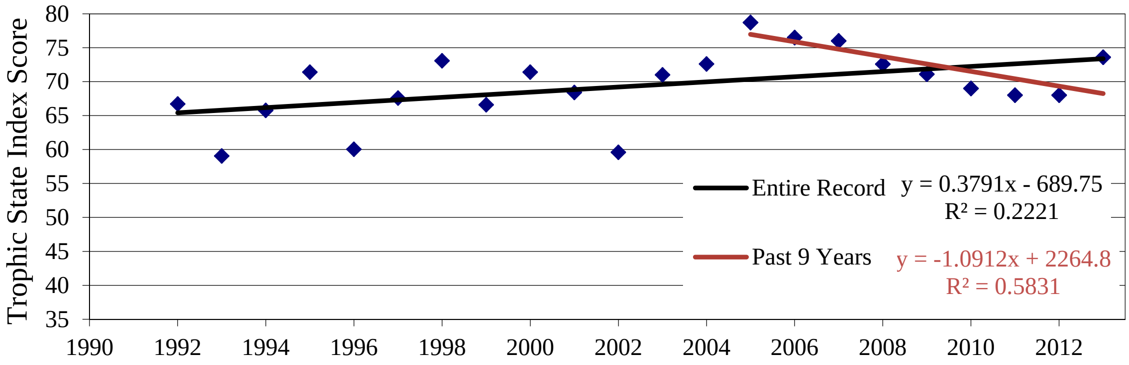


Figure 6-4. Diamond Lake TSI scores and regression analysis from 1992 to 2013.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 6-5** show the data distribution for chlorophyll-*a* and total phosphorus levels in Diamond Lake over the past ten years. Data from the entire period of record in box and whisker plot format can be found in **Appendix A**. A detailed explanation of box and whisker plots can be found in **Section 1**.

Diamond Lake has limited Secchi transparency data due to its shallowness and high macrophyte density. During 2013, only four Secchi disk readings were taken early in the season; otherwise, the lake was either clear to the bed or obscured by thick aquatic plant growth.

Chlorophyll-*a* and total phosphorus levels began to decrease in 2008. This phenomenon could be due to construction activities from the 35W/HWY 62 project and subsequent slope stabilization and constructed best management practices. Continued monitoring will help to determine if the trend will continue or whether the changes in nutrient levels are part of the natural fluctuations of the wetland.

Prior to 2004, samples were taken from the floating dock. From 2004 to the present, samples were taken from the deepest part of the lake. The change in sampling location may have added a bias to the data. Generally data from Diamond Lake is more variable and contains more scatter than deeper lakes. Increased scatter in the Diamond Lake data could be influenced by seasonal water level changes and stormwater influx.

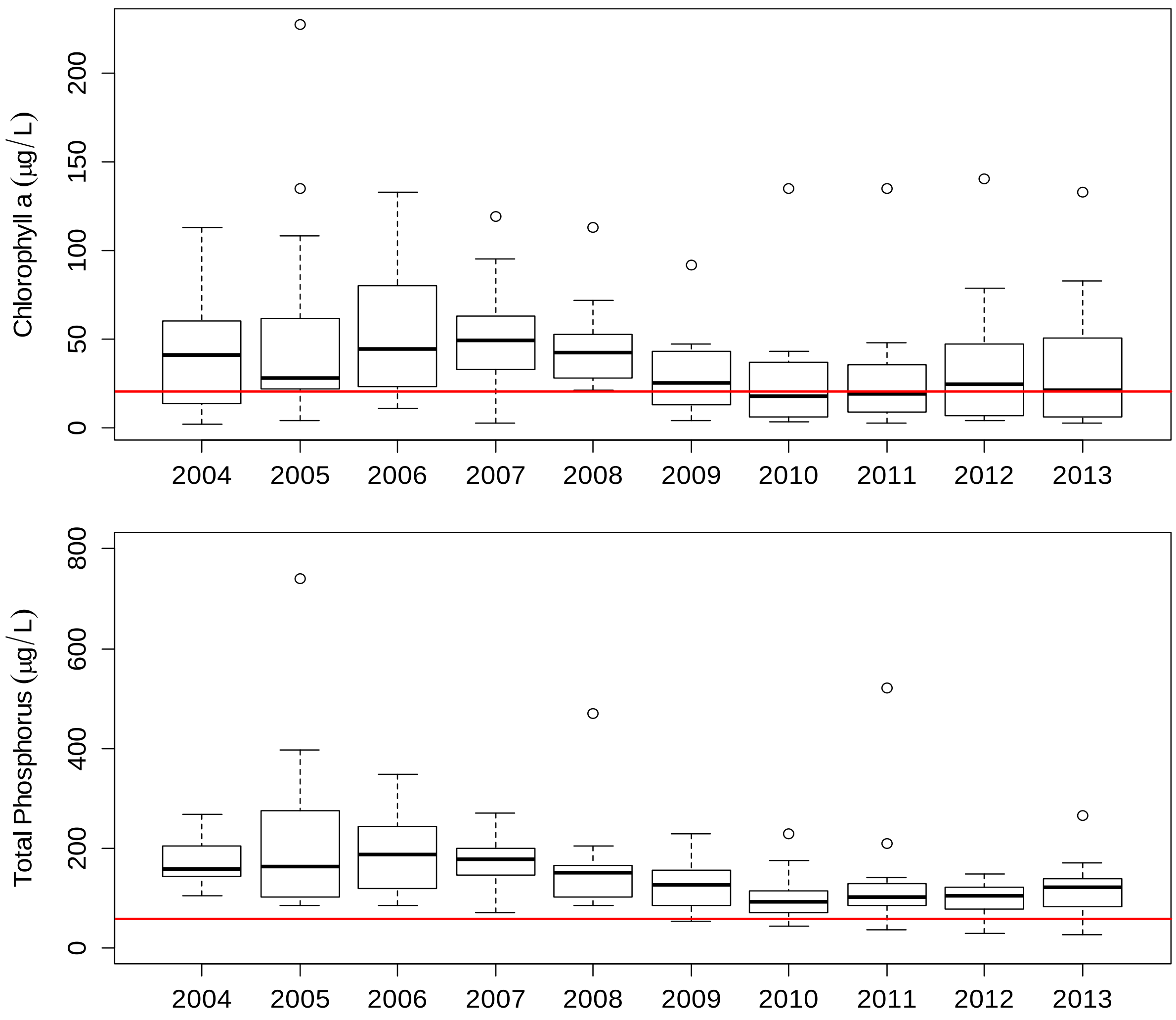


Figure 6-5. Box and whisker plots of Diamond Lake data from 2004-2013. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

WINTER ICE COVER

In the spring, ice came off of Diamond Lake on April 24, 2013, twenty two days later than average and the latest ice-off date recorded for the lake. Ice came on to Diamond Lake on November 22, 2013, eight days before the average ice-on date. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON

Phytoplankton are the microscopic plant life that form the foundation of the food web in lakes. In **Figure 6-6** shows the shifts in the phytoplankton community over the 2013 sampling season and **Figure 6-7** shows the corresponding chlorophyll-*a* levels measured in Diamond Lake.

Unlike most of the other MPRB lakes, euglenoids (Euglenophyta) were present at significant levels throughout the majority of the sampling season, more so than in recent years. In several samples, the largest component of the euglenoids was the genus *Euglena* which is commonly found in wetlands and is a potential pollution-tolerant species. Also unlike most other Minneapolis lakes, blue-green algae (Cyanophyta) were present at low levels in all samples. Golden algae (Chrysophyta) were present at levels higher than were found in most other lakes throughout the sampling season. Cryptomonads (Cryptophyta) made up the majority of community early in summer.

Chlorophyll-*a* levels did not have any obvious correlations with the phytoplankton community. There is a weak relationship between the late summer peak in Chrysophyta and chlorophyll-*a*. Diamond Lake contains high levels of dense plant growth and the phytoplankton collected may partially reflect the community of organisms living attached to plants as well as the free-floating algae community found in most of the other sampled lakes.

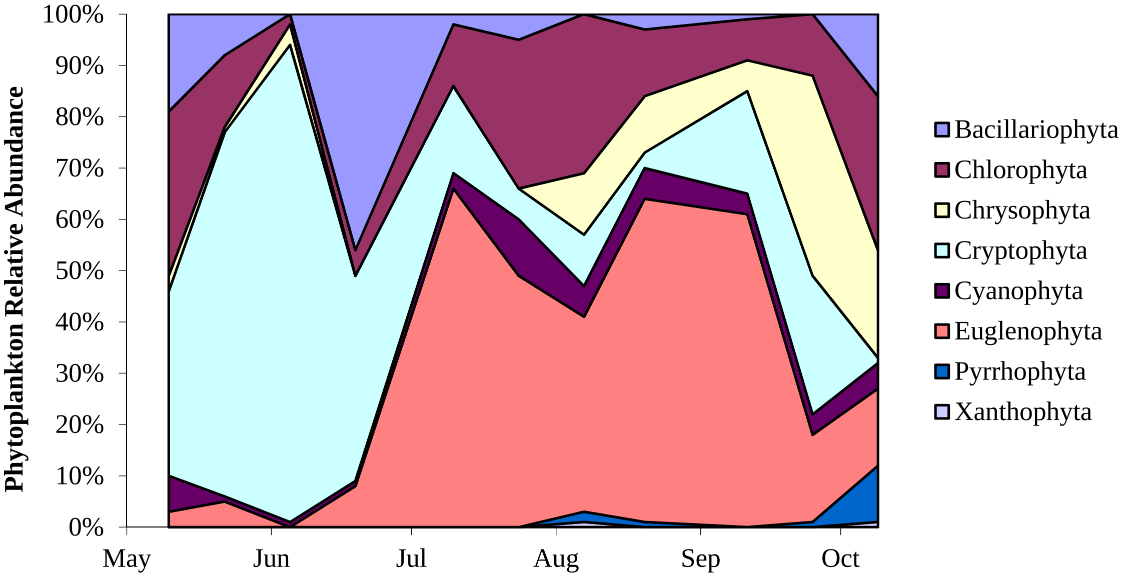


Figure 6-6. Phytoplankton relative abundance in Diamond Lake in 2013.

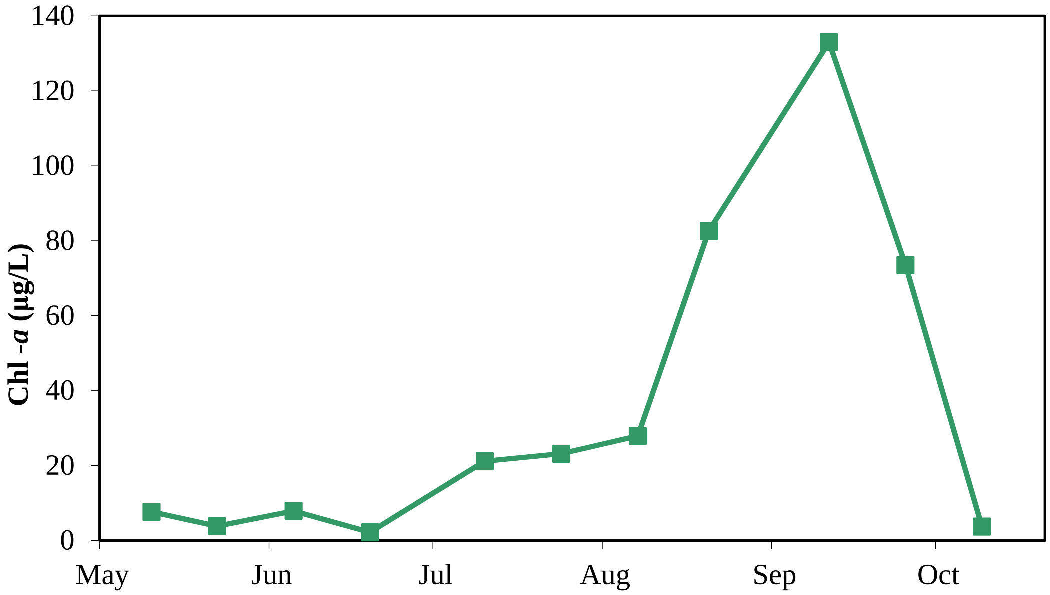


Figure 6-7. Chlorophyll-*a* concentrations at Diamond Lake during 2013.

WETLAND HEALTH EVALUATION PROJECT (WHEP)

The wetland fringe of Diamond Lake was evaluated by the Wetland Health Evaluation Project (WHEP) led by Hennepin County and a group of citizen volunteers. Results of the wetland evaluation are presented in **Section 21**. 2013 was the ninth year that Diamond Lake was evaluated in the WHEP program.

7. GRASS LAKE

HISTORY

Grass Lake was created during the construction of State Highway 62. The highway separated one waterbody into two new lakes: Grass Lake to the north and Richfield Lake to the south. The area is known for bird-watching. Land surrounding the lake is not connected to the Minneapolis Park system and is shown below in **Figure 7-1**.

Grass Lake was added to the Minneapolis Park & Recreation Board (MPRB) lake sampling program in 2002. It is typically sampled every other year and was not sampled in 2013. All water quality data presented pertains to the 2012 sampling season. Morphometric data for the lake is presented in **Table 7-1**. **Figure 7-2** shows a map of Grass Lake.

Figure 7-1. Photograph of Grass Lake.

Table 7-1. Grass Lake morphometric data. OHW= Ordinary High Water Level.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Watershed Area (acres)	Watershed: Lake Area (ratio)	OHW (msl)
27	0.6	1.5	386	14.3	830.9

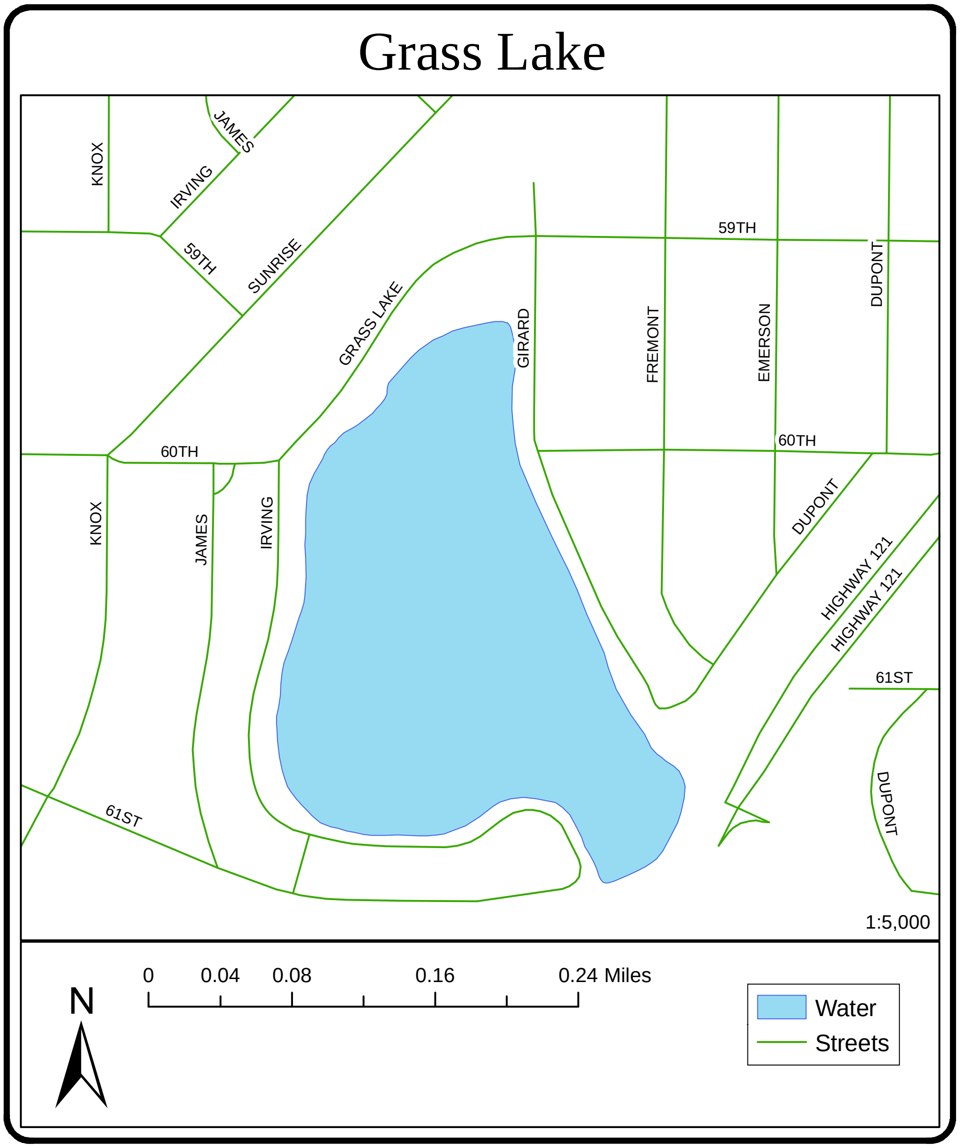


Figure 7-2. Grass Lake map.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2012 Grass Lake TSI score was 66 and **Figure 7-3** shows the Grass Lake TSI scores for 2002-2012. This data includes samples from two different locations, potentially biasing the results. The original sample location has been inaccessible since 2008 due to a construction project. A minimum of five years of data are typically collected prior to TSI analysis in order to give a benchmark, discern a possible trend, and help minimize the climactic variability within the data set. Thus, the regression line in **Figure 7-3** should be viewed with caution. Additional years of monitoring will be needed to discern a trend from natural variation seen in Grass Lake.

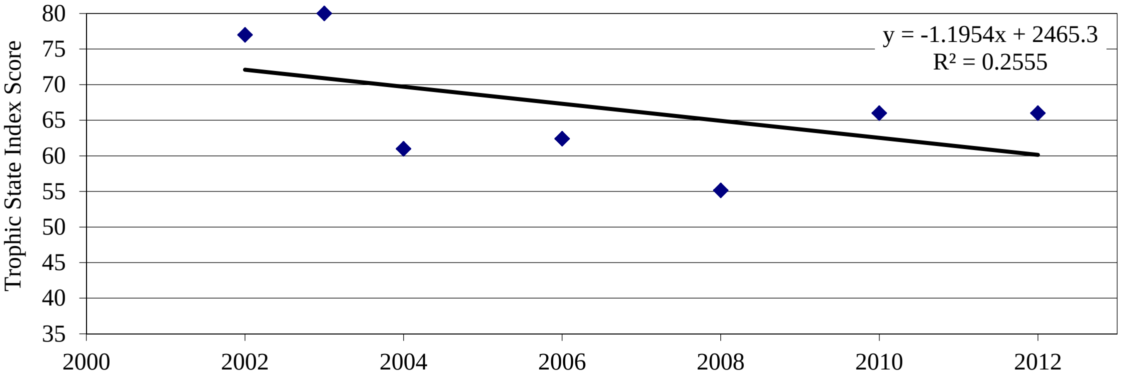


Figure 7-3. Grass Lake TSI scores for monitored years from 2002 to 2012. The trend should be viewed with caution since only 7 data points have been calculated and the sampling location changed in 2008.

Several factors play a role in TSI and could affect the TSI pattern shown in Grass Lake. Climactic variation coupled with the once a month grab sampling protocol at this lake may partially explain the TSI scatter. The TSI Index is also meant to examine lakes without non-algal turbidity and with low macrophyte populations. Grass Lake is a predominantly a Type 5 wetland containing extensive macrophytes and is too shallow to measure the Secchi depth, therefore Secchi depth was not used in TSI calculations for Grass Lake. A detailed explanation of TSI can be found in **Section 1**.

BOX AND WHISKER PLOTS

Figure 7-4 shows box and whisker plots of the Grass Lake data from 2002 to 2012. A detailed explanation of box and whisker plots can be found in **Section 1**. Data from the entire period of record in box and whisker format can be found in **Appendix A**.

Secchi readings are not taken due to the shallowness of the wetland and the sampling location. Grass Lake can freeze to the bed in some years, making it impossible to collect a winter sample. Variations in the Grass Lake data may be due to climatic differences, the monthly sampling regime, or the variability of the wetland.

WINTER ICE COVER

Ice came off Grass Lake on April 18, 2013, fifteen days later than average and the latest ice-off date recorded for the lake. Ice was back on Grass Lake on December 6, 2013, five days later than average and the latest ice-on date recorded for the lake. Ice came on the lake much later relative to the other lakes due to persistent duck activity in an area of open water. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

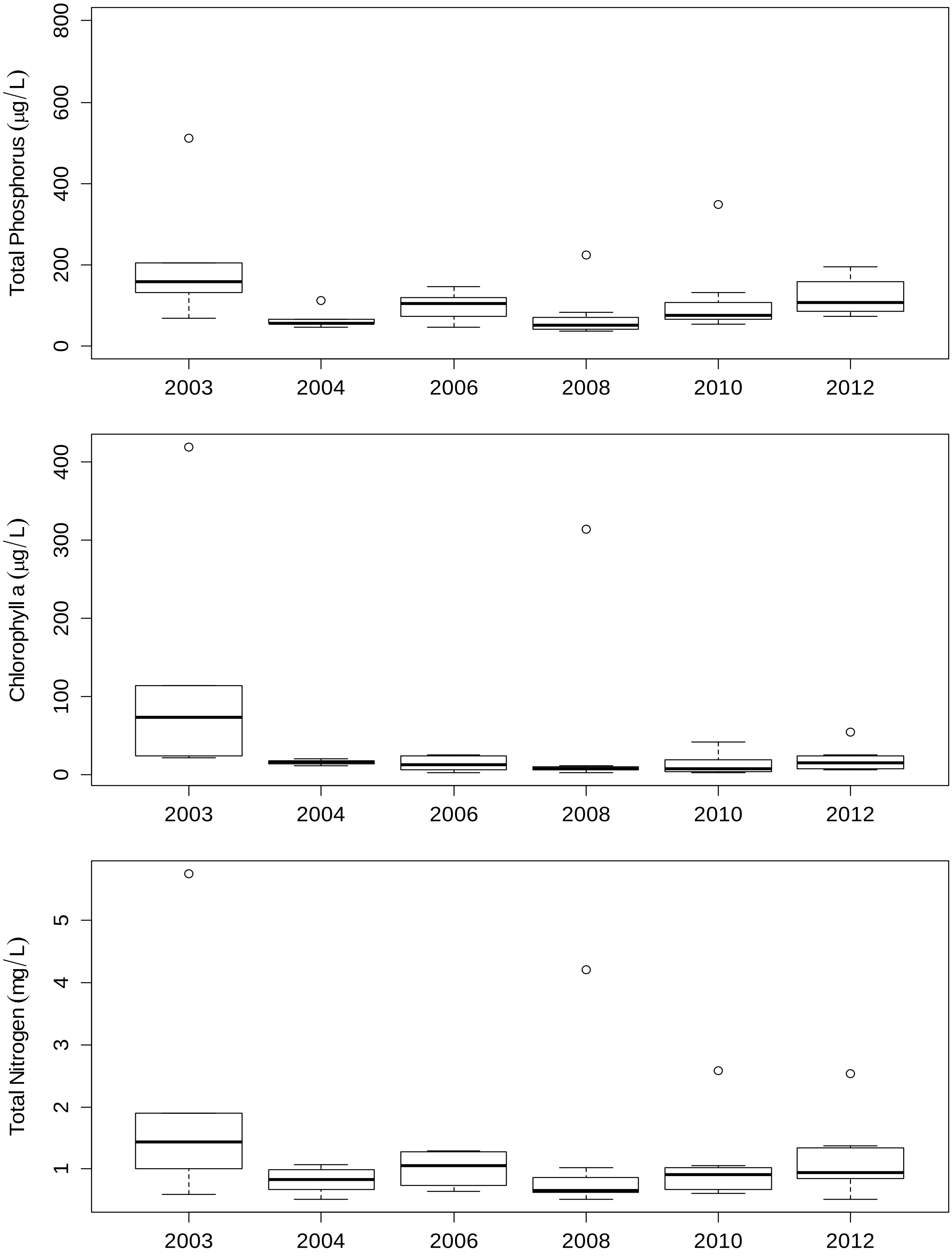


Figure 7-4. Plots of chlorophyll-*a*, total phosphorus, and total nitrogen data for Grass Lake.

PHYTOPLANKTON

Phytoplankton are the microscopic plant life that forms the foundation of the food web in lakes. **Figure 7-5** shows the relative distribution of phytoplankton divisions in Grass Lake for the 2012 sampling season. Cryptomonads (Cryptophyta) and green algae (Chlorophyta) dominated the phytoplankton assemblage throughout the season. Blue-green algae were abundant in the April and September sample, while diatoms (Bacillariophyta) peaked around June. Euglenoids (Euglenophyta) were found in the early season samples of Grass Lake similar to Diamond Lake which is the other shallow wetland sampled this year.

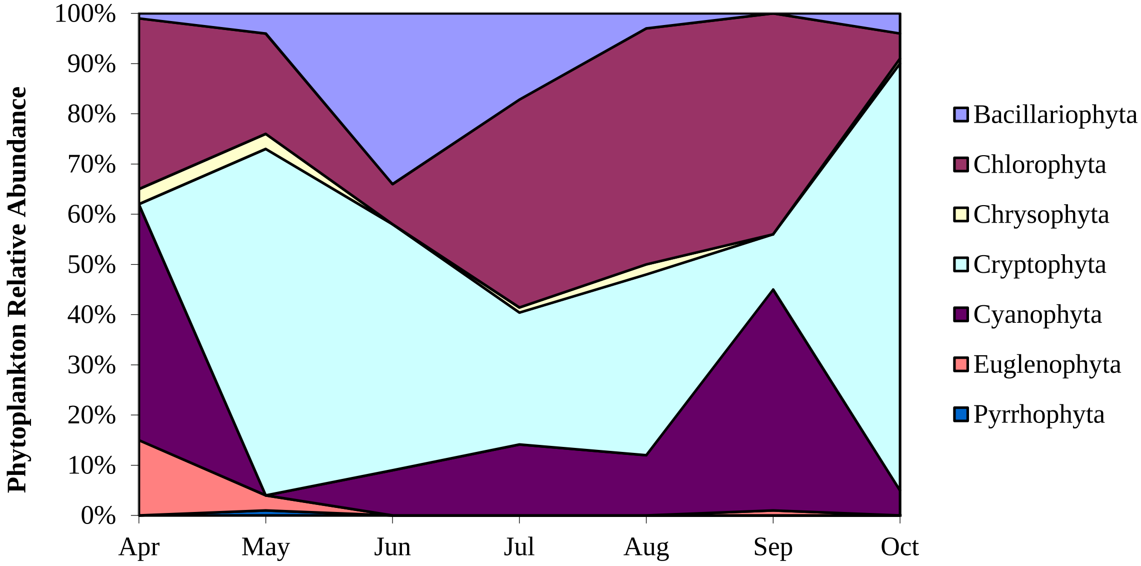


Figure 7-5. Relative abundance of phytoplankton present in Grass Lake in 2012. One sample per month was collected from April to October.

EVENTS REPORT

The location of the Grass Lake sample site was moved in 2008 due construction for the Highway 62/Crosstown reconstruction project. The new location is near the intersection of Dupont Avenue South and Girard Avenue South. This location should remain accessible in the future and allow representative samples to be collected.

Disturbance from the Highway 62/Crosstown reconstruction project ended by 2012.

8. Lake Harriet

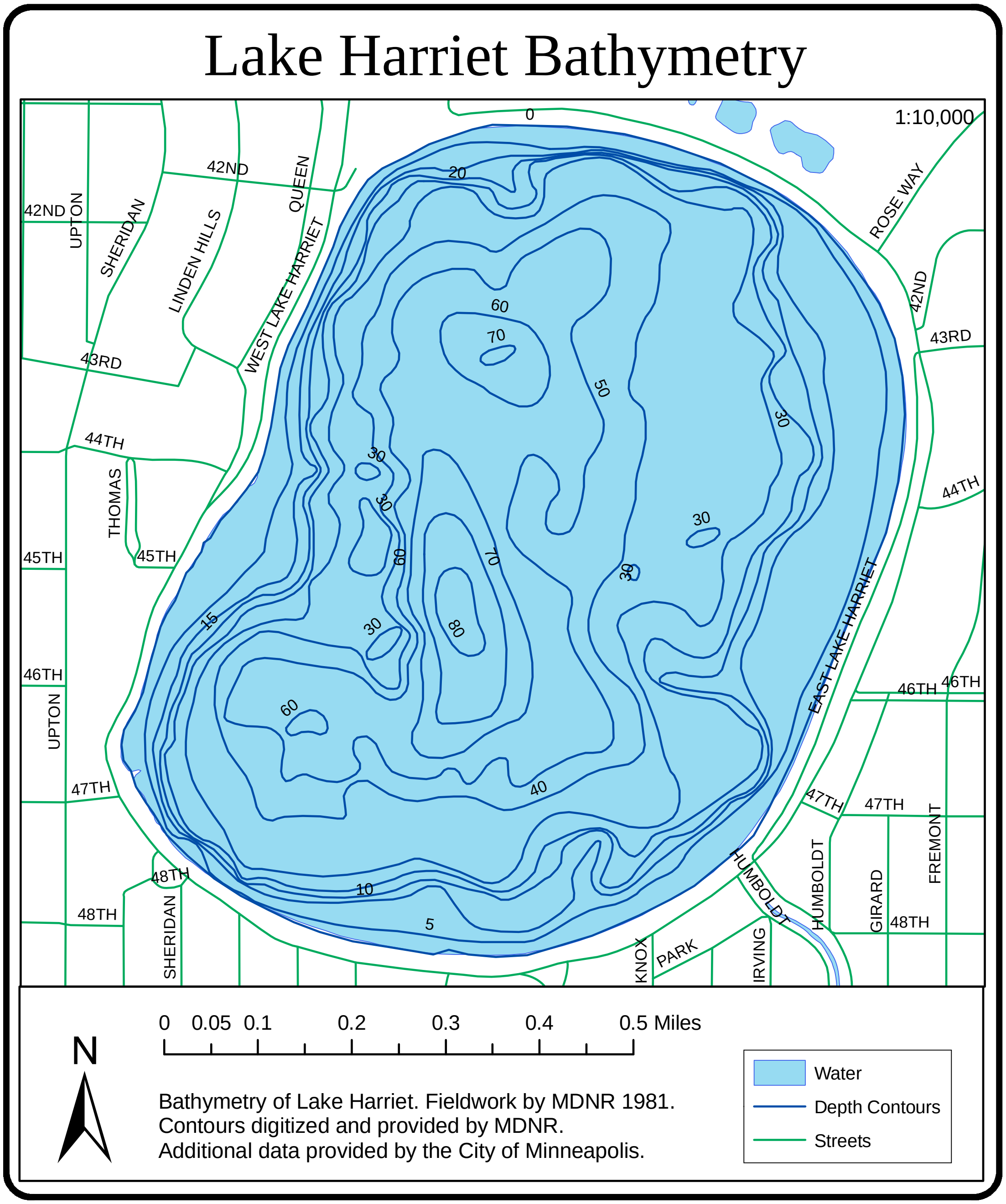
HISTORY

Lake Harriet is named after Harriet Lovejoy Leavenworth, the wife of Colonel Leavenworth. Colonel W.S. King donated a majority of the lake (360 acres) and surrounding areas (55 acres) to the Minneapolis Park & Recreation Board (MPRB) in 1885. The MPRB acquired the remainder of the surrounding land between 1883-1898 and 1921.

Lake Harriet is a deep kettle lake that generally remains strongly stratified through October. The lake offers many recreational activities including sailing, swimming, and fishing. Park patrons enjoy concerts at the bandshell and the many gardens surrounding the lake. In 2006, both of the MDNR-funded floating docks in Lake Harriet were extended. The lake is shown below in **Figure 8-1**. **Figure 8-2** shows a bathymetric map and **Table 8-1** shows the morphometric data for Lake Harriet.

Figure 8-1. Lake Harriet Bandshell at sunset

There has been less dredging and filling at Lake Harriet compared to the other MPRB lakes. A marshland on the northeast corner of the lake was filled to make room for the parkway. The wetland at the north end of the lake that is now Robert's Bird Sanctuary was deemed too expensive to fill. A proposed channel connecting Lake Harriet with Lake Calhoun was never constructed due to the 5-foot elevation difference between the upper Chain of Lakes and Harriet. Today, after several modifications to the inlet and outlet, there is a 4-foot difference between the two lakes.



Bathymetry of Lake Harriet. Fieldwork by MDNR 1981.
Contours digitized and provided by MDNR.
Additional data provided by the City of Minneapolis.

Figure 8-2. Bathymetric map of Lake Harriet.

Table 8-1. Lake Harriet morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
353	8.7	25.0	25%	1.25×10^7	1,139	3.2	3.4

* Littoral area defined as less than 15 feet deep.

In 1967, a pumping station and pipeline were constructed between Lakes Harriet and Calhoun in order to control water levels in the upper Chain. In 1999 it was replaced with a gravity outlet, open channel, and pipe connection. Lake Harriet discharges to Minnehaha Creek through a submerged pipe located at the southern edge of the lake.

Brugam and Speziale (1983) analyzed deep sediment cores and determined that European-American settlement in the 1850s led to increased sedimentation rate due to land clearing and agriculture. Diatom reconstruction of total phosphorus suggests that pre-European phosphorus levels were around 20 µg/L. However, increases in stormsewer discharge since the 1920s led to increased phosphorus levels that peaked in the 1970s. Recent observed data have shown a decline in phosphorus levels since the 1990s and suggest concentrations in Lake Harriet have returned to levels similar to pre-European settlement (Heiskary et al., 2004).

Restoration techniques and best management practices (BMPs) have improved water quality in Lake Harriet. A detailed Clean Water Partnership diagnostic study conducted in 1991 determined that phosphorus input to the Chain of Lakes should be reduced to improve water quality. BMPs implemented included: public education, increased street sweeping, constructed wetlands (1998), and grit chambers (1994-1996). In 2001, an alum treatment was also carried out on areas of the lake shallower than 25 feet to control filamentous algae growth in the littoral zone by limiting the available phosphorus. Not originally intended to do so, the alum had an unexpected benefit of limiting internal phosphorus loading in the lake (Huser, 2005). Current trophic state index (TSI) scores confirm that the BMPs have positively affected water quality in Lake Harriet.

In 2010, the MPRB and the City of Minneapolis received a Clean Water Partnership Grant to complete a diagnostic study of Lake Harriet to update and intensify existing studies at the lake and provide planning toward implementing a second-phase of improvements for water quality. The Lake Harriet Diagnostic Study and Management Plan will be used for future planning around Lake Harriet.

LAKE LEVEL

The lake level for Lake Harriet is recorded weekly and is shown in **Figure 8-3**. After high water levels in the spring, water levels fell throughout the late-summer drought.

The ordinary high water level (OHW) determined by the MDNR for Lake Harriet is 846.82 ft msl. The designated OHW is the highest regularly sustained water level that has made a physical imprint on the land, marked by either a transition in vegetation or a physical characteristic.

See **Section 18** for a comparison between other MPRB lake levels.

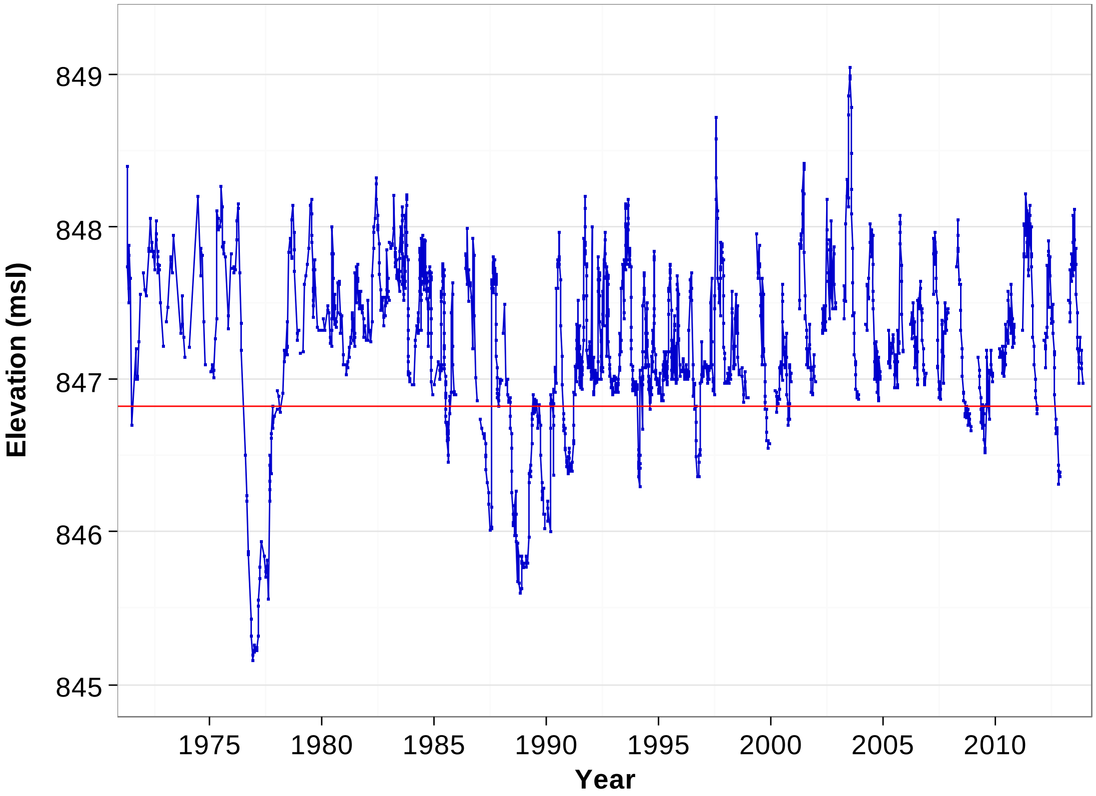


Figure 8-3. Lake levels for Lake Harriet from 1971 to the present.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The TSI scores for Lake Harriet are improving as shown by the linear regression in **Figure 8-4**. A detailed explanation of TSI can be found in **Section 1**.

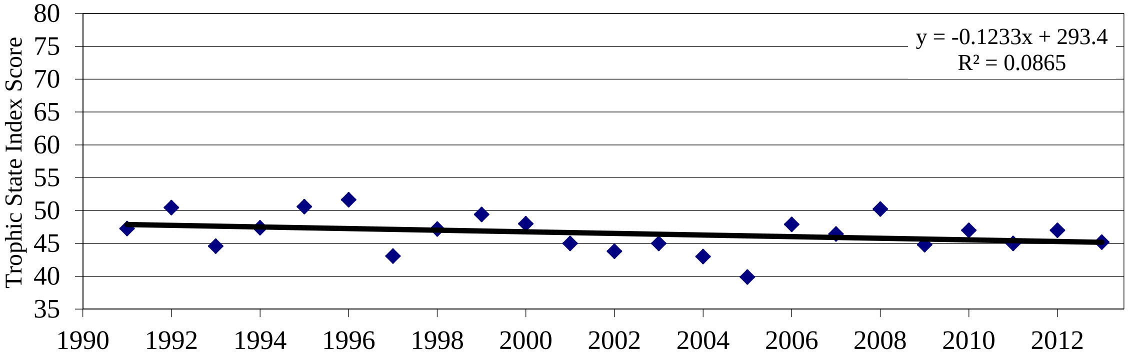


Figure 8-4. Lake Harriet TSI scores and regression analysis 1991-2013.

Lake Harriet's 2013 TSI score was 45 and classified as mesotrophic with moderately clear water and some algae. TSI scores over the past five years are similar to scores prior to the 1994-2001 restoration efforts. Lake Harriet has an overall trend towards slightly decreasing TSI score and increased clarity. The lake remains in the top 25% of TSI scores in this ecoregion (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004).

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 8-5** show the data distribution for Secchi, chlorophyll-*a,* and total phosphorus sampling for the past ten years. MPCA deep lake standards are indicated by a horizontal line across the box plot graphs. A further detailed explanation of box and whisker plots can be found in **Section 1**. **Appendix A** contains box plots of data for all of the years of record.

Water clarity in Lake Harriet in 2013 was average when compared to the past five years. Chlorophyll-*a* data were consistent and lower than in recent years. Phosphorus levels saw more variation than recent years, with the 75th percentile values higher than the MPCA nutrient standard for deep lakes.

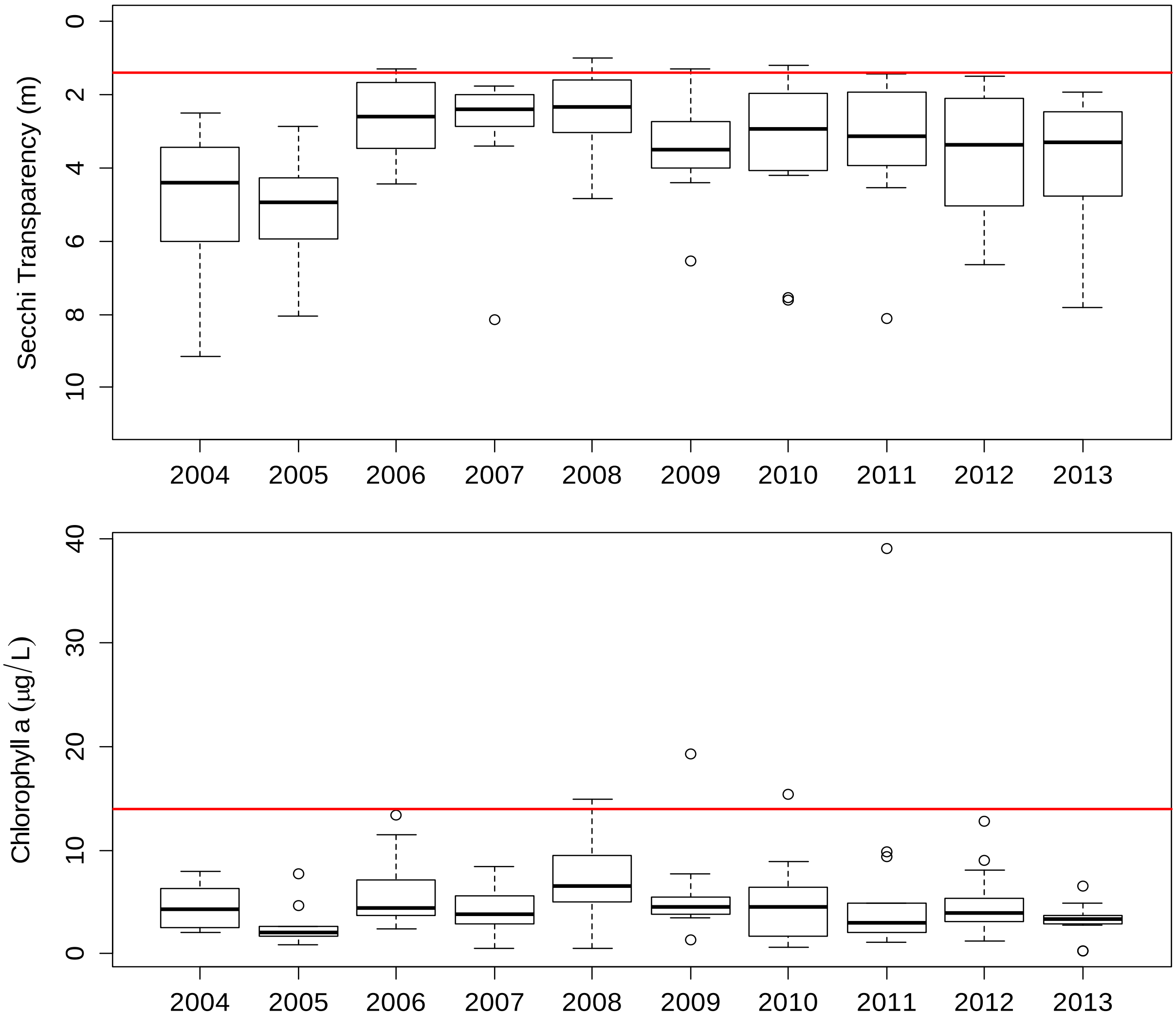


Figure 8-5. Lake Harriet box and whisker plots of TSI data for the past 10 years. Horizontal lines represent MPCA eutrophication standard for deep lakes. See Appendix A for the entire period of record.

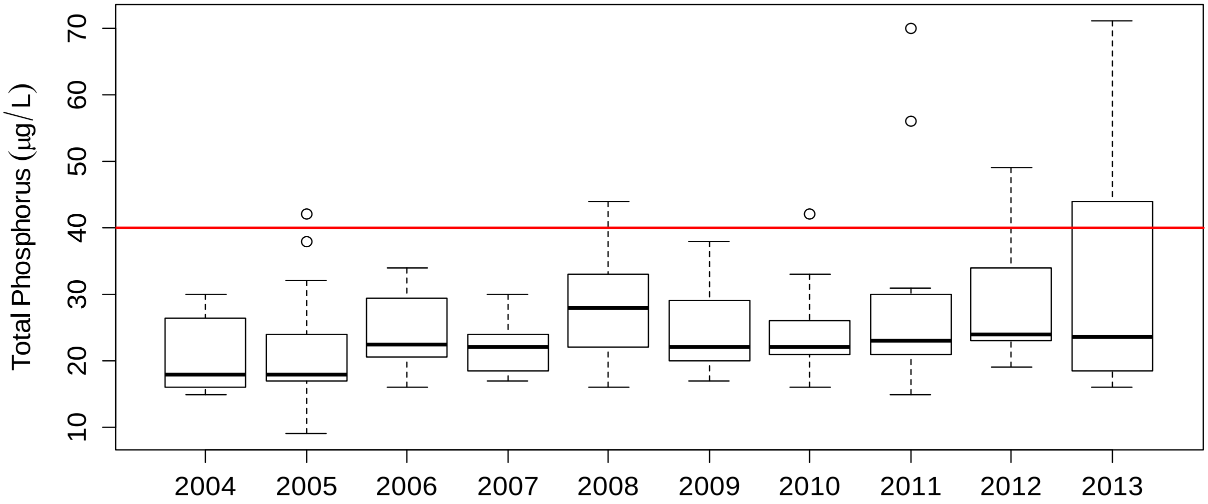


Figure 8-5. Continued. Lake Harriet box and whisker plots of TSI data for the past 10 years. Horizontal lines represent MPCA eutrophication standard for deep lakes. See Appendix A for the entire period of record.

BEACH MONITORING

Escherichia coli levels were sampled at two different locations on Lake Harriet: Harriet Main Beach and Harriet Southeast Beach. As shown in **Table 8-2** and **Figure 8-6**, *E. coli* counts were very low for the most of beach season. Neither Lake Harriet beach closed in 2013.

Table 8-2. Summary of *E. coli* results (per 100 mL) for Lake Harriet beaches in 2013.

Statistical Calculations	Harriet Main	Harriet SE
Number of Samples	13	13
Minimum	4	1
Maximum	25	44
Median	7	9
Mean	9	14
Geometric Mean	8	7
Max 30-Day Geo Mean	14	13
Standard Deviation	6	16

Figure 8-6 illustrates the box and whisker plots of *E. coli* sampling results (per 100 mL) for Lake Harriet beaches for 2004-2013. Results from 2013 were lower than in recent years. The light red line represents the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL), while the dark red line represents the single-sample maximum standard (1260 MPN/100mL). Further details on MPRB beach monitoring can be found in **Section 19**.

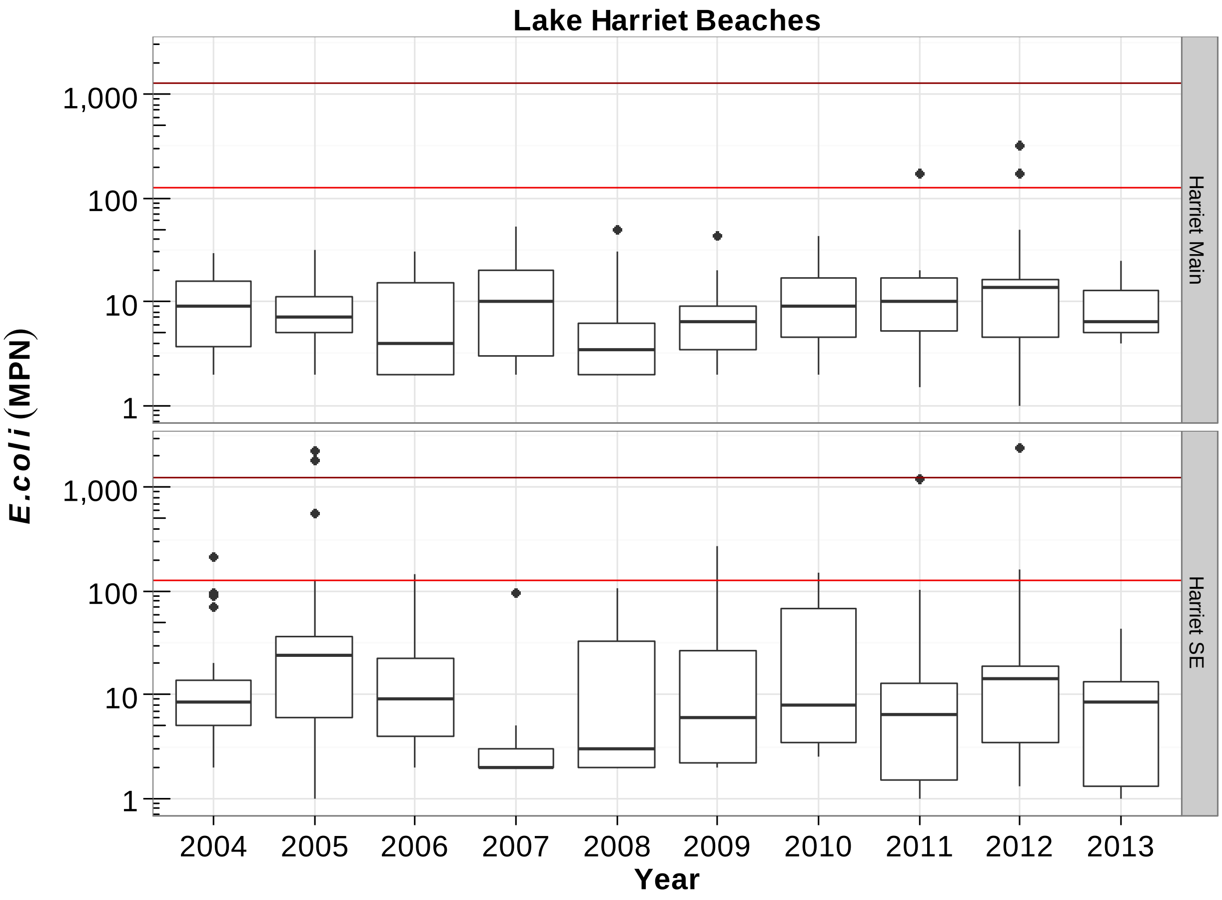


Figure 8-6. Box and whisker plots of *E. coli* results (per 100 mL) for Lake Harriet beaches, 2004-2013. The horizontal lines represent the E. coli standard for the 30-day geometric mean (126 MPN/100mL) and the single-sample maximum standard (1260 MPN/100mL). Note the log scale on the Y-axis. From 2004-2009 E. coli concentrations were determined as colony forming units (CFU/100ml).

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Figure 8-7 shows the LAURI for Lake Harriet. Lake Harriet ranked "excellent" in aesthetics, habitat quality, water clarity, public health, and recreational access. Details on the LAURI can be found in **Section 1**.

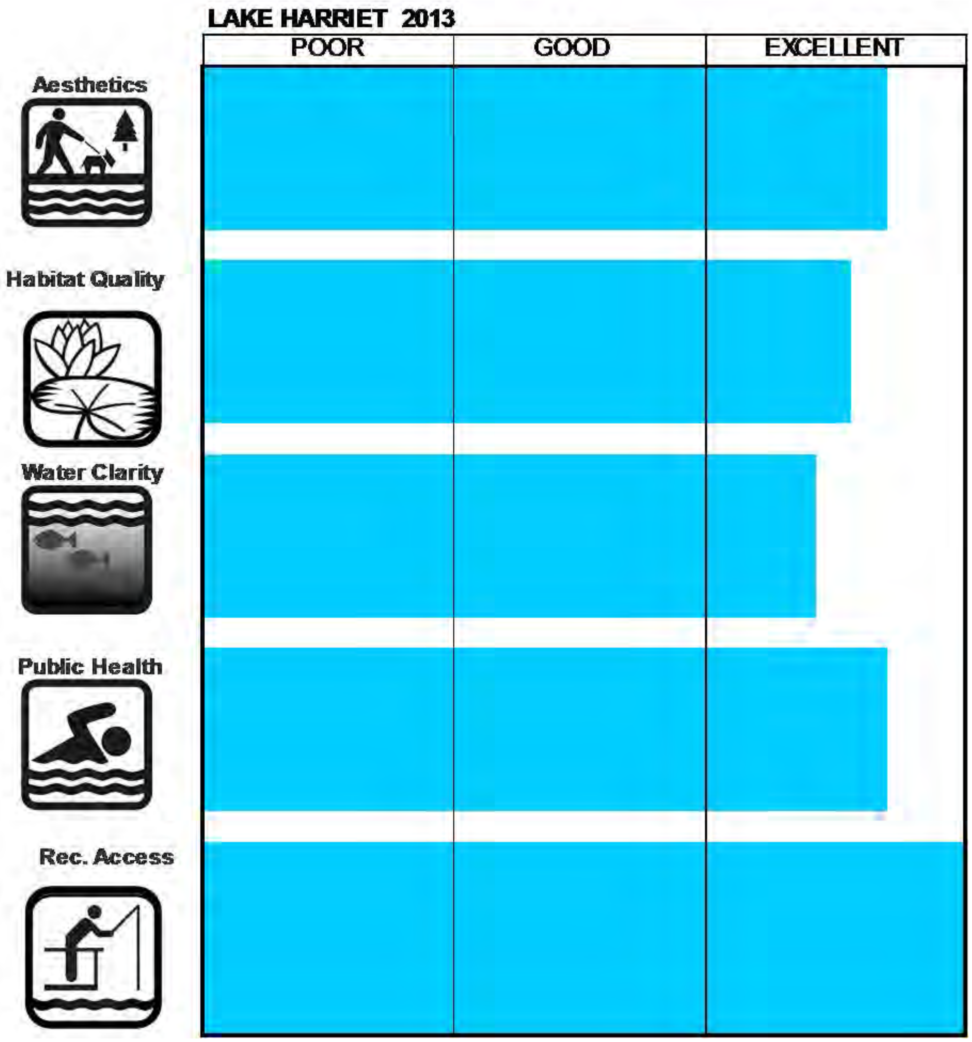


Figure 8-7. The 2013 LAURI for Lake Harriet.

WINTER ICE COVER

Ice went out on Lake Harriet on April 28, 2013 which was 21 days later than average and the latest ice-off date recorded for the lake. Ice did not completely cover Lake Harriet for the season again until December 8, 2013 which was about four days earlier than the average ice-on date. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian watermilfoil. These permits limit the area milfoil can be harvested in order to protect fish habitat. The permits issued to the MPRB allowed for harvesting primarily in swimming areas, boat launches and in shallow areas where recreational access was necessary. The permitted area for Eurasian water milfoil harvest on Lake Harriet was 40 acres, which is 45% of the littoral zone of the lake (area shallower than 15 feet). More information on aquatic plants can be found in **Section 1** and **Section 20**.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plants and animals that form the foundation of the food web in lakes. **Figure 8-8** shows the relative abundance of phytoplankton in Lake Harriet during 2013 and **Figure 8-9** displays chlorophyll-*a* concentrations with Secchi transparency during the 2013 sampling season.

The 2013 phytoplankton distribution in Lake Harriet was very similar to the 2012 data results. Cryptomonads (Cryptophyta) bloomed early and dominated the phytoplankton community until May. Cryptomonads are relatively small (3-50 µm long) members of the phytoplankton community and are common in cold waters. Dinoflaggelates (Pyrrhophyta) were abundant in one sample in early June. From June through the end of the season, cyanobacteria, or blue-green algae, formed the majority of phytoplankton relative abundance. In eutrophic lakes blue-green algae are indicators of poor water quality; however, blue-green algae often dominate even in lakes with good water quality due to their ability to scavenge nutrients and out-compete other groups.

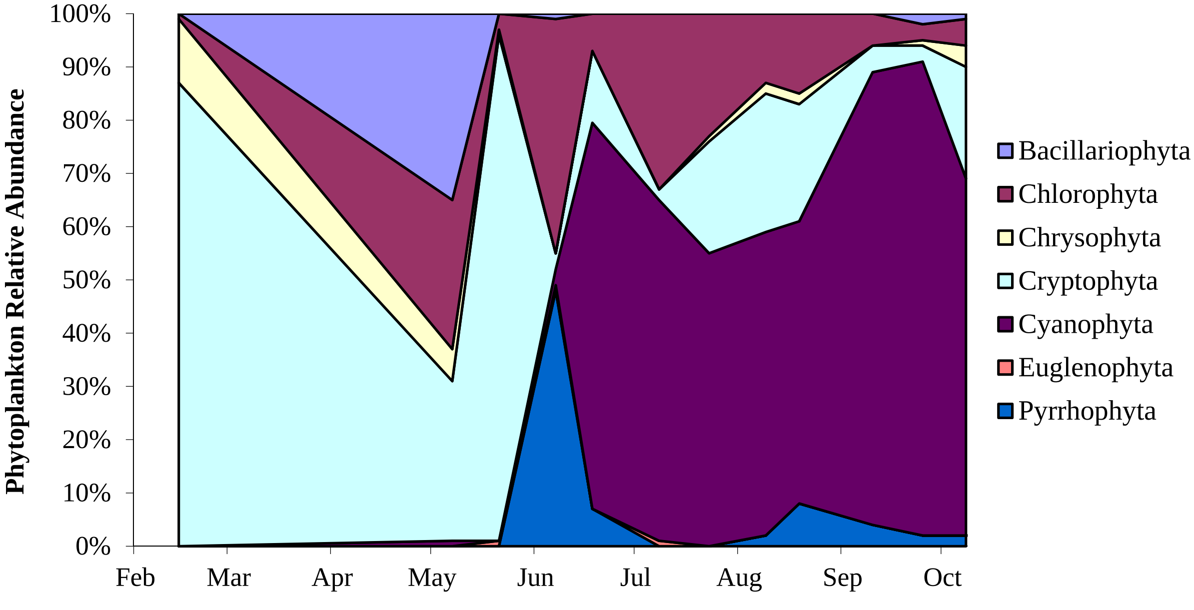


Figure 8-8. Relative abundance of phytoplankton during 2013 for Lake Harriet.

Lake Harriet chlorophyll-*a* and Secchi transparency data are shown in **Figure 8-9.** Lake Harriet has low chlorophyll-*a* values, indicating low algal biomass. In 2013, deeper water transparency measurements occurred during times of lower chlorophyll-*a* concentrations.

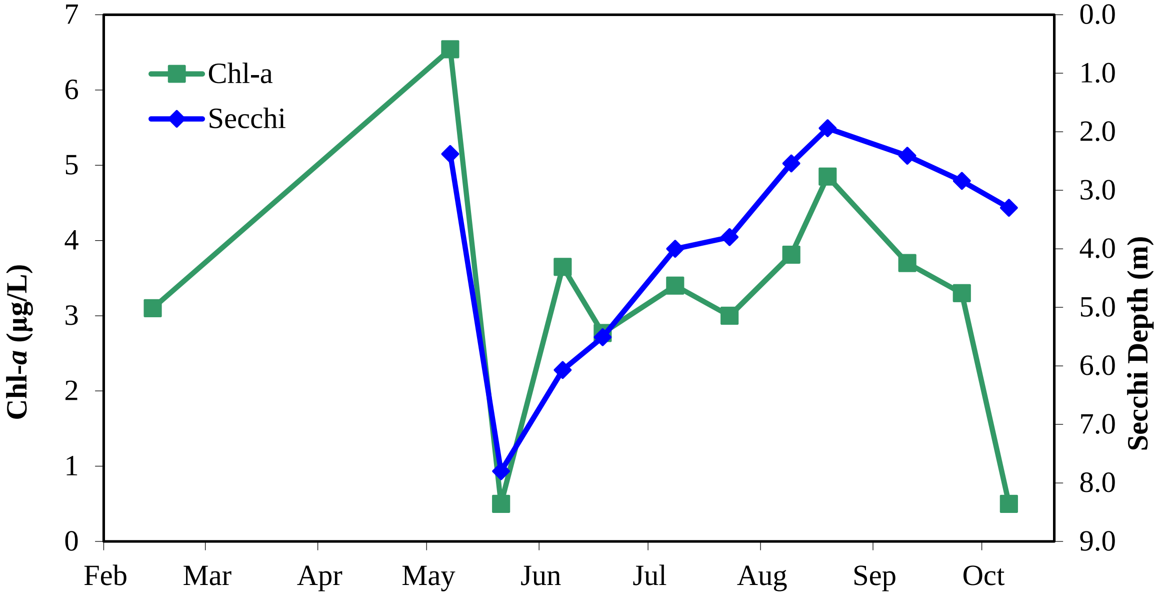


Figure 8-9. Lake Harriet 2013 chlorophyll-*a* concentrations and Secchi transparency.

Zooplankton numbers in Lake Harriet during the 2013 sampling season are shown in **Figure 8-10**. Highest nauplii density was found in the June sample, but these juvenile forms of zooplankton were present throughout the season albeit in lower concentrations. Juvenile nauplii density may have fallen due to fish predation. After peak abundance in June, cladoceran and cyclopoid counts were also relatively low. Rotifers had two strong peaks, one in July and one in September. Calanoids were present later in August, but densities remained low through the fall.

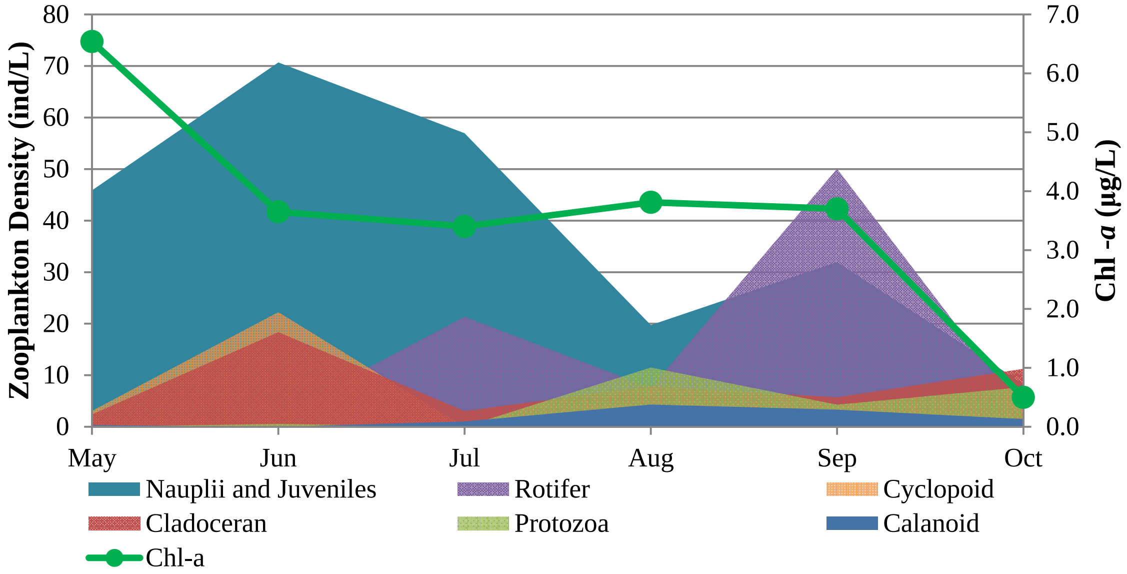


Figure 8-10. Zooplankton distribution in Lake Harriet for 2013.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling and adult size fish can be found in **Section 1**.

Lake Harriet was stocked by MDNR in:

1998 with 250 fingerling Muskellunge, 1,365 fingerling Walleye.

1999 with 824 fingerling Walleye, 50 yearling Walleye.

2000 with 175 fingerling Muskellunge, 142 adult Walleye, 499 adult Walleye.

2001 with 2,273 fingerling Walleye.

2002 with 175 fingerling Muskellunge, 312 fingerling Walleye, 698 yearling Walleye.

2003 with 554 fingerling Walleye, 33 yearling Walleye.

2004 with 175 fingerling Muskellunge, 3,447 fingerling Walleye.

2005 with 140 yearling Walleye.

2006 with 175 fingerling Muskellunge, 1,919 fingerling Walleye, 33 adult Walleye.

2007 with 136 adult Walleye, 50 fingerling Walleye, and 428 yearling Walleye.

2008 with 117 adult Walleye, 3,234 fingerling Walleye, and 175 fingerling Muskellunge.

2009 with 110 yearling Walleye, and 2,482 fingerling Walleye.

2010 with 179 fingerling Muskellunge, and 2862 fingerling Walleye.

2011 with 3,244 fingerling Walleye.

2012 with 175 fingerling Muskellunge, and 2,520 yearling Walleye.

2013 with 2,890 fingerling Walleye.

EMERGING CONTAMINANTS

Section 4, Lake Calhoun includes more information on the monitoring of emerging contaminants.

9. LAKE HIAWATHA

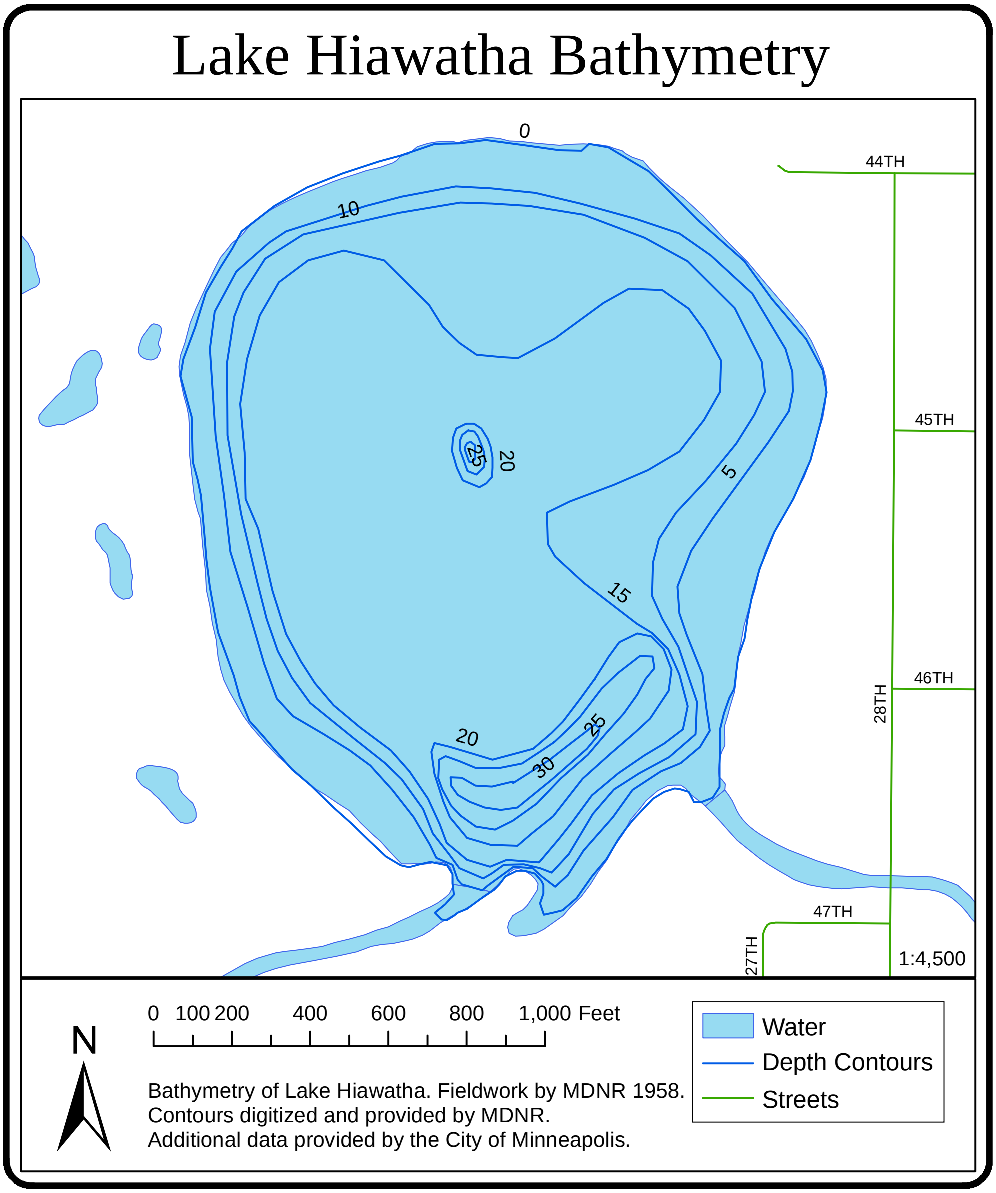
HISTORY

Lake Hiawatha was acquired by the Minneapolis Park & Recreation Board (MPRB) in 1923 at a cost of $555,000. At that time the lake was a shallow wetland named Rice Lake for the stands of wild rice that grew in its shallow waters. Lake Hiawatha was renamed after Henry Wadsworth Longfellow's poem "Song of Hiawatha" in 1925. Major changes were made to the shape and depth of Lake Hiawatha in the early part of the 20th century in an attempt to improve health and to make it more desirable to build and live near the lake. Beginning in 1929, over 1.25 million cubic yards of material were dredged and relocated to construct Hiawatha Golf Course. Today Lake Hiawatha is part of the Lake Nokomis–Lake Hiawatha Regional Park.

Figure 9-1. Lake Hiawatha in Autumn.

Lake Hiawatha has an extremely large watershed due its connection with Minnehaha Creek. **Figure 9-2** shows the bathymetric map of Lake Hiawatha. The watershed of the lake includes 115,840 acres and the large volume of runoff associated with this area (~97% of the water and ~88% of the phosphorus input to the lake) reduces the residence time of the water in the lake to an average of 11 days or less. Flushing time in Lake Hiawatha is short compared to most other lakes in Minneapolis that have residence times up to four years (**Table 18-1**). The limited amount of time the water spends in the lake affects the biology of the system. The most obvious effect is a generally less than expected level of algae in the water based on the amount of phosphorus present. The converse of this occurs during seasons with low creek flow (for example 2002, 2007, and 2009) which increased the residence time in the lake and allows excess algae to build up. **Table 9-1** shows the morphometric data for Lake Hiawatha.

Flow contributed from the creek and from storm sewer connections have other physical repercussions for Lake Hiawatha. A delta has formed at the point where Minnehaha Creek meets the lake. The water level in Lake Hiawatha varies widely due to fluctuations in the flow of Minnehaha Creek. Additionally, the creek and stormwater inflow can have a destabilizing effect on the thermal stratification of the lake during the summer months.



Bathymetry of Lake Hiawatha. Fieldwork by MDNR 1958.
Contours digitized and provided by MDNR.
Additional data provided by the City of Minneapolis.

Figure 9-2. Bathymetric map of Lake Hiawatha based on MDNR data.

Table 9-1. Lake Hiawatha morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
54	4.1	7.0	49%	$8.95x10^{5}$	115,840	2145	0.03

*Littoral area defined as less than 15 feet deep.

LAKE LEVEL

Lake levels for Lake Hiawatha are recorded weekly during the open water season. The lake levels for Lake Hiawatha from 1996 to the present are shown in **Figure 9-3**. Up to four feet of water level bounce can be seen in Lake Hiawatha due to the influence of Minnehaha Creek and the dam at Grey's Bay. After a wet spring and heavy rains in June and July, the remainder of the 2013 summer was very dry. The ordinary high water level (OHW) as determined by the MDNR is 812.8 ft msl.

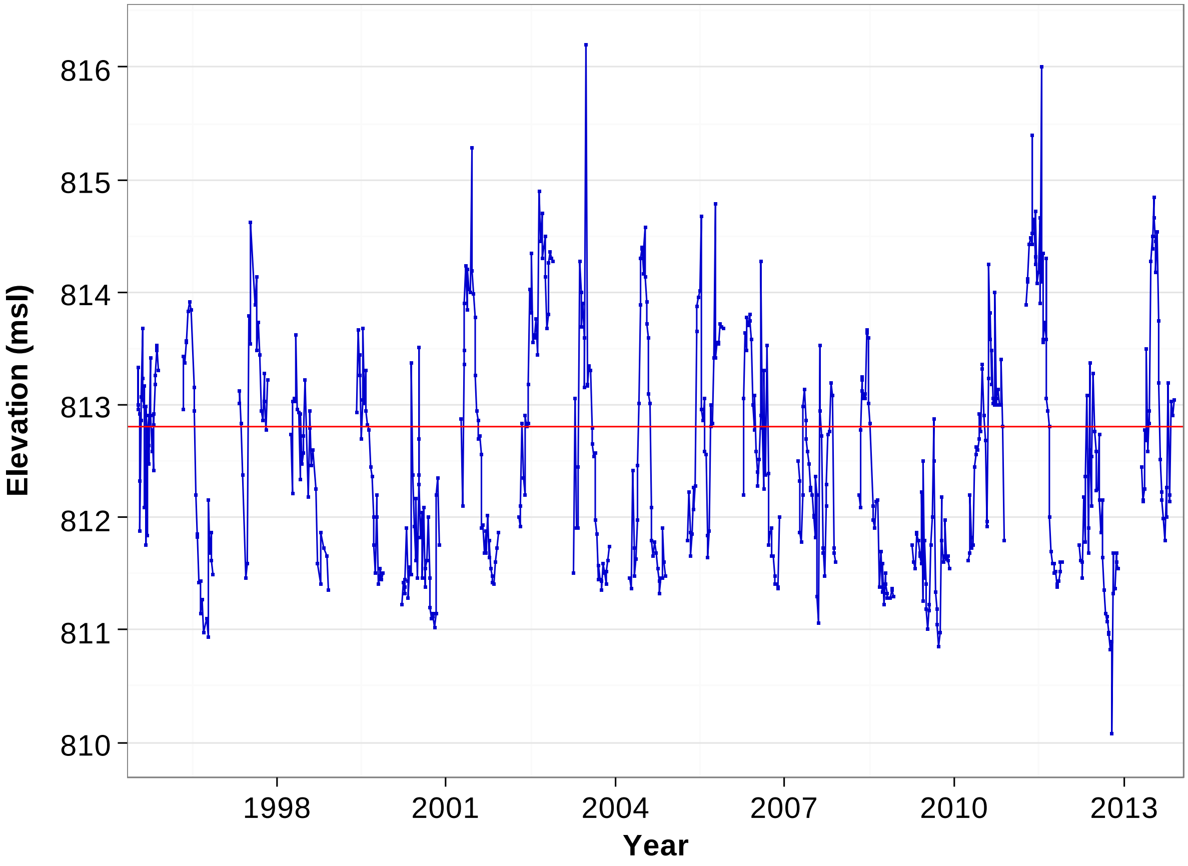


Figure 9-3. Lake levels for Lake Hiawatha 1996-2013. Horizontal line represents Lake Hiawatha outlet elevation (812.8 ft msl).

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Figure 9-4 shows the Lake Hiawatha linear regression of TSI scores over time. A detailed explanation of TSI can be found in **Section 1**. The TSI score of Lake Hiawatha mainly reflects the water it receives from Minnehaha Creek. Abnormally high TSI scores seen in the years 2000, 2007, 2009, and 2012 coincide with drought years where Minnehaha Creek was dry for at least a portion of the summer. With all years taken into consideration, Lake Hiawatha has a nearly flat but slightly increasing trend shown in **Figure 9-4.** The 2013 TSI score for Lake Hiawatha was 59. Currently Lake Hiawatha has a TSI score that is average for lakes in the Central Hardwood Forest ecoregion (MPCA, 2004).

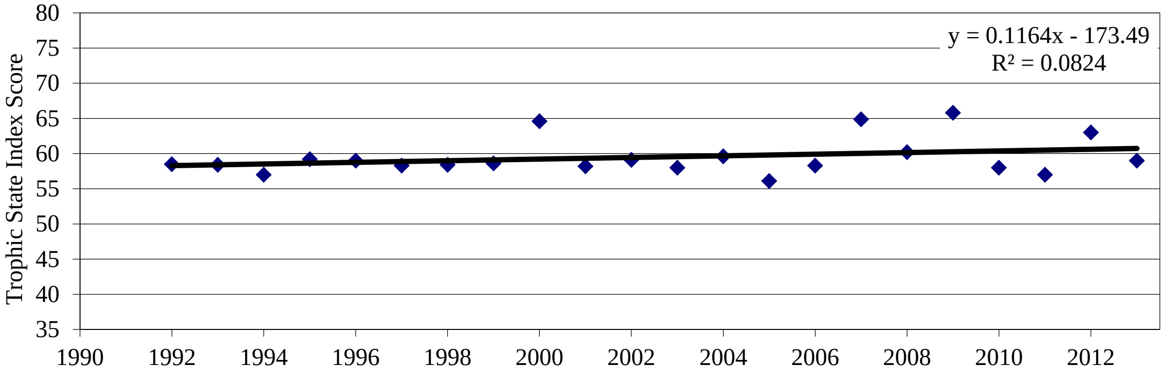


Figure 9-4. Lake Hiawatha TSI scores and regression analysis.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 9-5** show the variation between years for the Secchi, chlorophyll-*a*, and total phosphorus data for the past ten years. Lake Hiawatha site specific standards are indicated by a horizontal line on the box plot graphs. The EPA approved a new 50 µg/L TP standard for Lake Hiawatha in 2013. A detailed explanation of box and whisker plots can be found in **Section 1**. Data collected since 1992 in box and whisker format is available **Appendix A**. Long-term lake monitoring is necessary to evaluate the seasonal and year-to-year variations seen in each lake and predict trends.

In most years the Lake Hiawatha system is stable due to short residence times and the strong influence of Minnehaha Creek. The median Secchi transparency value in 2013 met MPCA deep lake standards and was the lowest recorded. Both chlorophyll-*a* and phosphorus levels were normal for non-drought years, but still exceed the eutrophication standards. Nearly 75% of the phosphorus samples in 2013 exceed the MPCA standard.

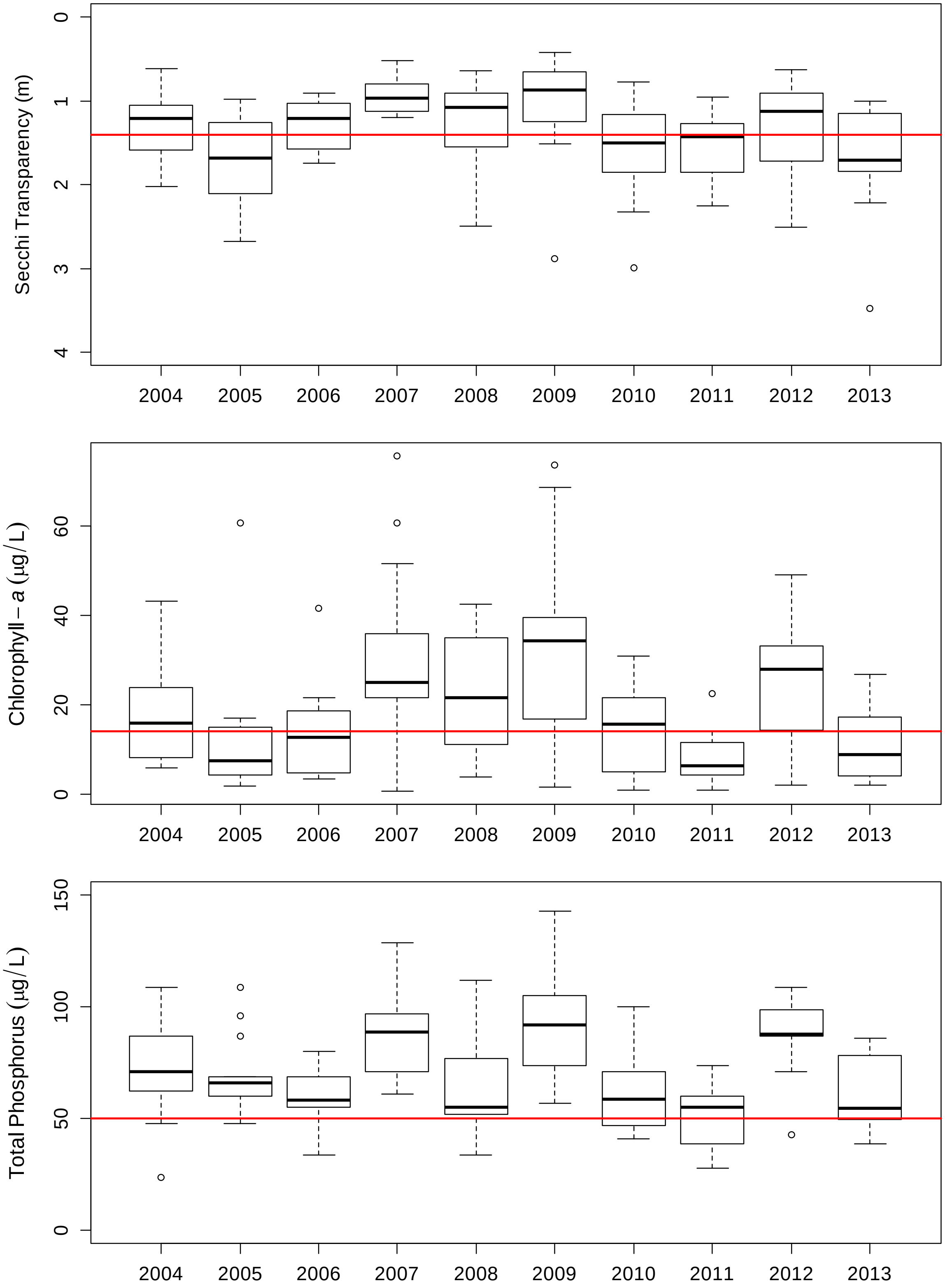


Figure 9-5. Ten years of box and whisker plots of Lake Hiawatha TSI data. Horizontal lines represent Lake Hiawatha site specific eutrophication standards. See Appendix A for the entire period of record.

BEACH MONITORING

The public beach at Lake Hiawatha was officially closed from 2004 to 2006 because of budgetary constraints and the history of *E. coli* bacteria issues at the beach. Due to concern about bacteria levels, monitoring continued while the beach was closed. Because of the beach's popularity with the public and its continued heavy use, the MPRB re-opened the beach in 2007.

The 30-day geometric mean standard of 126 MPN/100 mL was exceed twice in 2013 (**Figure 9-6**). The first occurred on July 23, but the beach re-opened one week later. The second occurred on August 5, and the beach remained closed for the remaining month of the season. **Table 9-2** shows the basic statistics on the 2013 bacteria sampling at Lake Hiawatha. Further details on MPRB beach monitoring can be found in **Section 19**.

Table 9-2. Summary of 2013 *E. coli* (MPN per 100 mL) results for Lake Hiawatha.

Statistical Calculations	Hiawatha
Number of Samples	13
Minimum	7
Maximum	994
Median	101
Mean	186
Geometric Mean	91
Max 30-Day Geo Mean	193
Standard Deviation	264

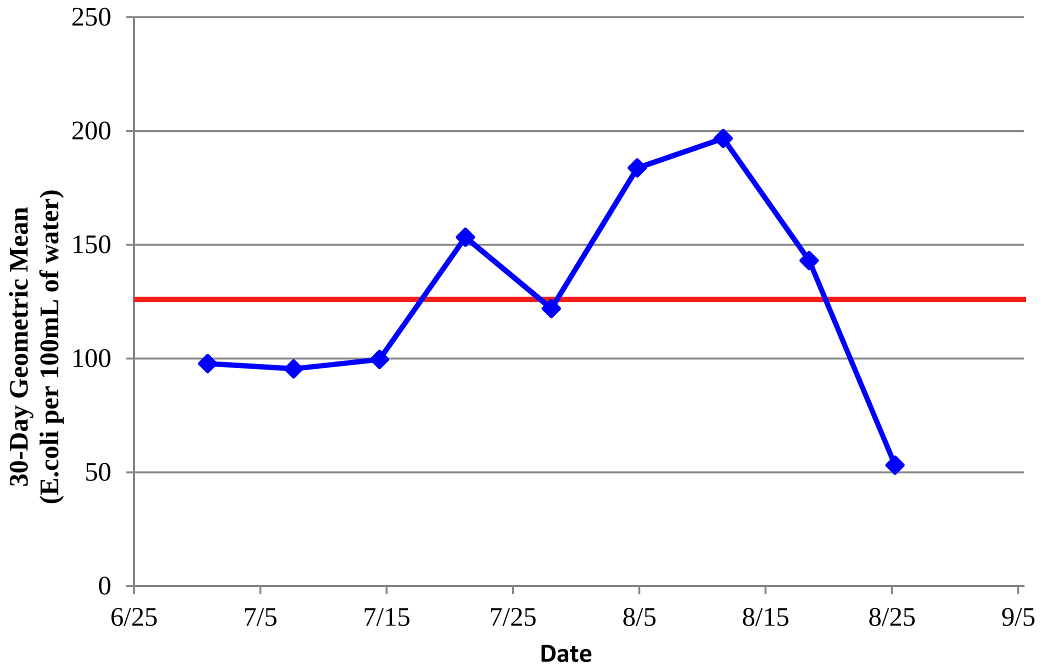


Figure 9-6. Graph of 30-day geometric means for Lake Hiawatha for 2013. The horizontal red line represents the 30-day geometric mean standard of 126 colonies per 100 mL.

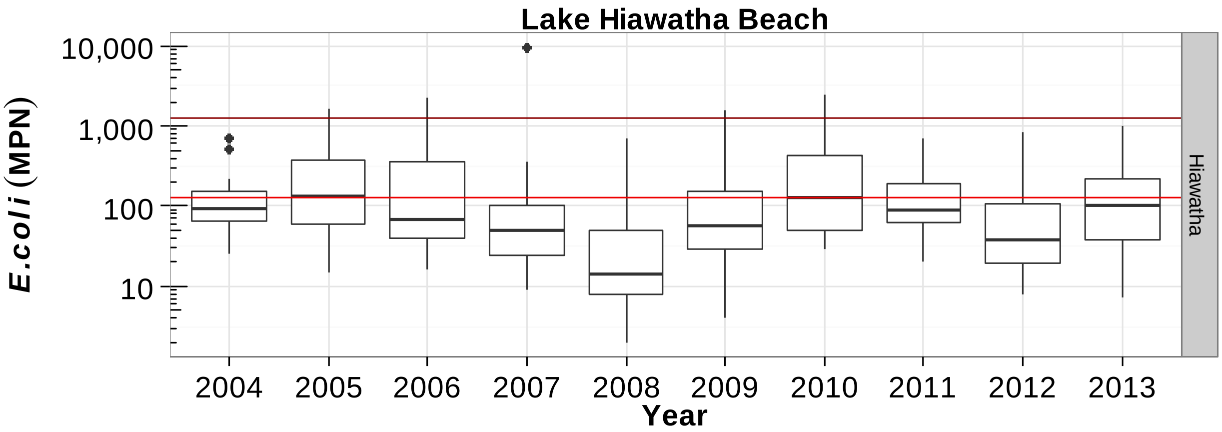


Figure 9-7. Box and whisker plot of *E. coli* results (per 100 mL) for the Lake Hiawatha site, 2004 to 2013. Note the log scale on the Y-axis. The horizontal lines represent the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL) and the single-sample maximum standard (1260 MPN/100mL). From 2004-2009 E. coli concentrations were determined as colony forming units (CFU/100ml).

Figure 9-7 shows box and whisker plots of *E. coli* sampling results (per 100 mL) for 2004 to 2013. The light red line represents the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL), while the dark redline represents the single-sample maximum standard (1260 MPN/100mL). The 2013 season had average *E. coli* counts compared to previous years. The range of results at Lake Hiawatha is larger than at the other lakes in Minneapolis due to the large influence Minnehaha Creek has on the lake’s water quality.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The LAURI for Lake Hiawatha is shown in **Figure 9-8**. Lake Hiawatha scored “excellent” in aesthetics and water clarity. The lake scored “good” in habitat quality and recreational access and “poor” on public health. Lake Hiawatha scored “excellent” in aesthetics due to low water odor and light brown/green water color; however, it collects all the trash flowing out of Lake Minnetonka down Minnehaha Creek, especially after large rainstorms. The trash gets deposited along the still shoreline of the lake where it usually remains for the rest of the summer. Details on the LAURI index can be found in **Section 1**.

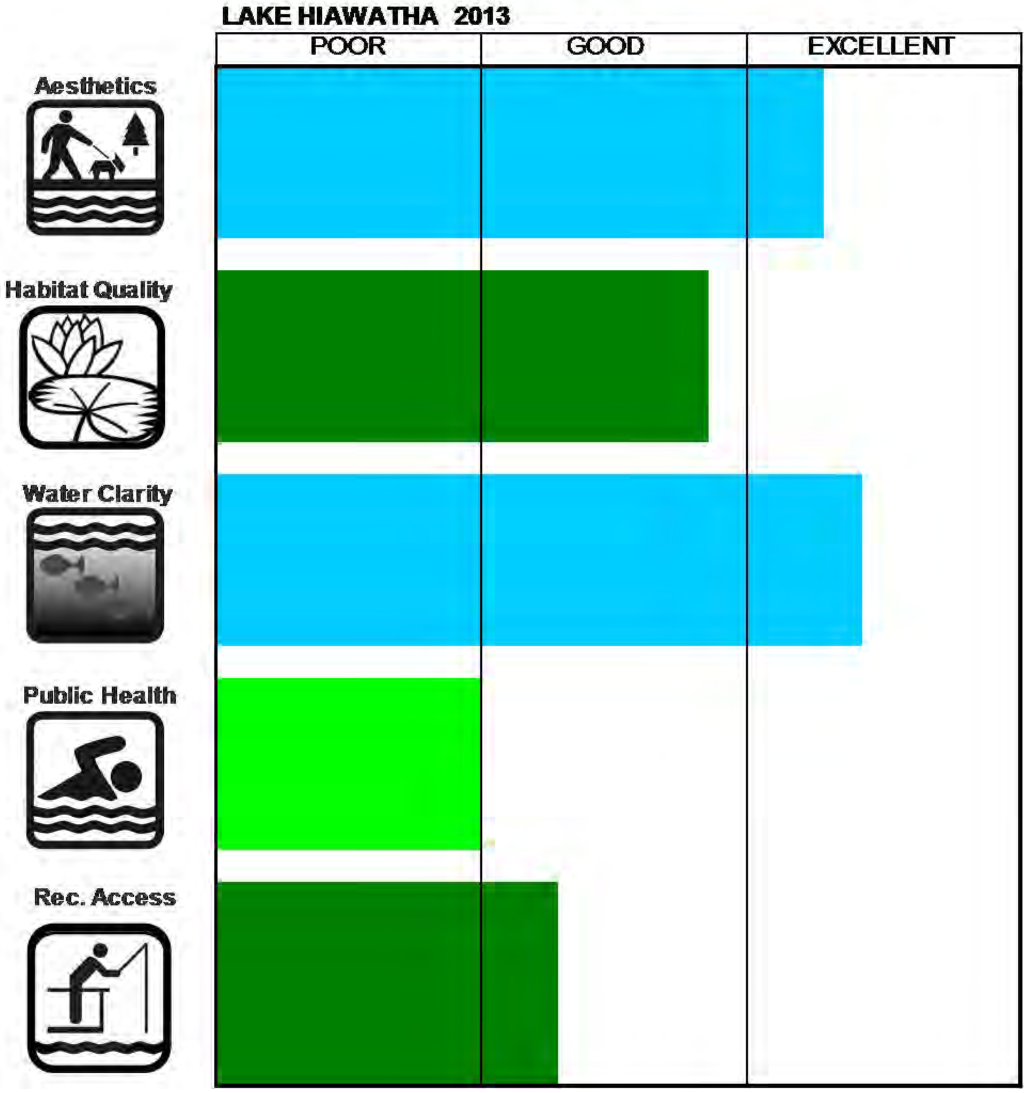


Figure 9-8. The 2013 LAURI for Lake Hiawatha.

WINTER ICE COVER

Ice came off Lake Hiawatha on April 26, 2013, twenty two days later than average and the latest ice-off date recorded for the lake. Ice returned to the lake for the winter on November 27, 2013, five days earlier than the average ice-on date. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web. The composition of the phytoplankton community shifted throughout the 2013 sampling season as can be seen in **Figure 9-9**. While typically dominate throughout the majority of the sampling season in Lake Hiawatha, blue-green algae (Cyanophyta) only dominated in October. Instead, two large spikes of diatoms (Bacillariophyta) in April and August represented most of the algal biomass. Cryptophytes (cryptomonads) were dominant in early- and mid-season. Cryptomonads are relatively small members of the phytoplankton community that contain chlorophyll-*a* for photosynthesis but some species are also able to utilize organic matter to acquire carbon. The chrysophytes (golden algae) were present in spring and early summer, and remained in low concentrations for the rest of the season.

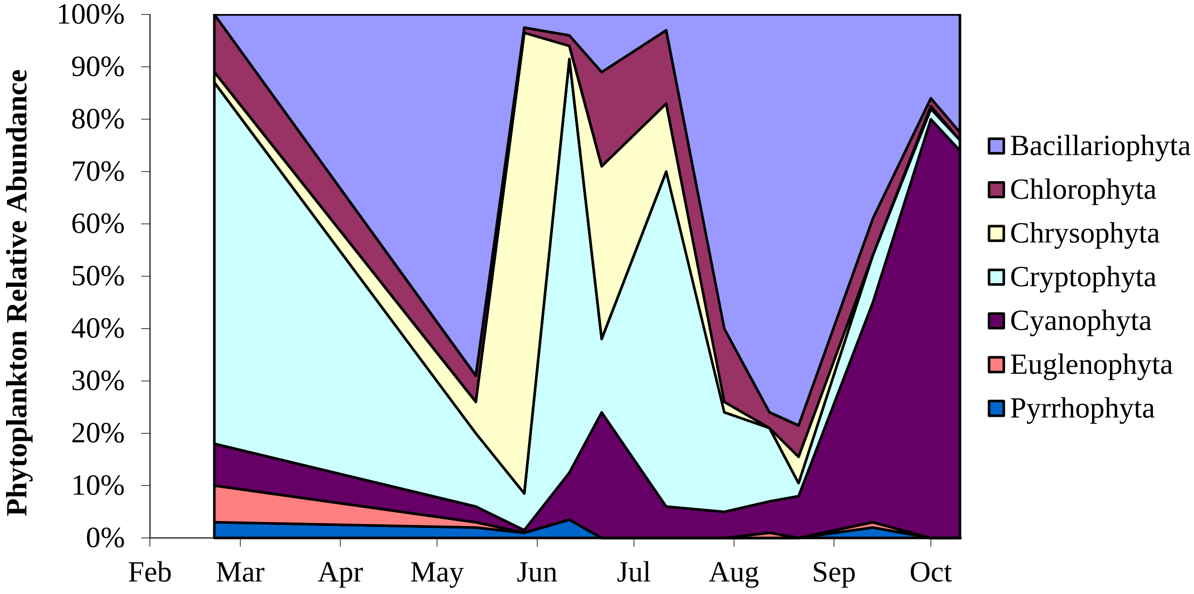


Figure 9-9. Lake Hiawatha 2013 relative abundance of phytoplankton divisions.

Chlorophyll-*a* values and Secchi depths roughly mirror each other, but do not show an obvious correlation to the phytoplankton assemblage, as can be seen in **Figure 9-10**. The peaks in chlorophyll-*a* in October may relate to the blue-green algae bloom.

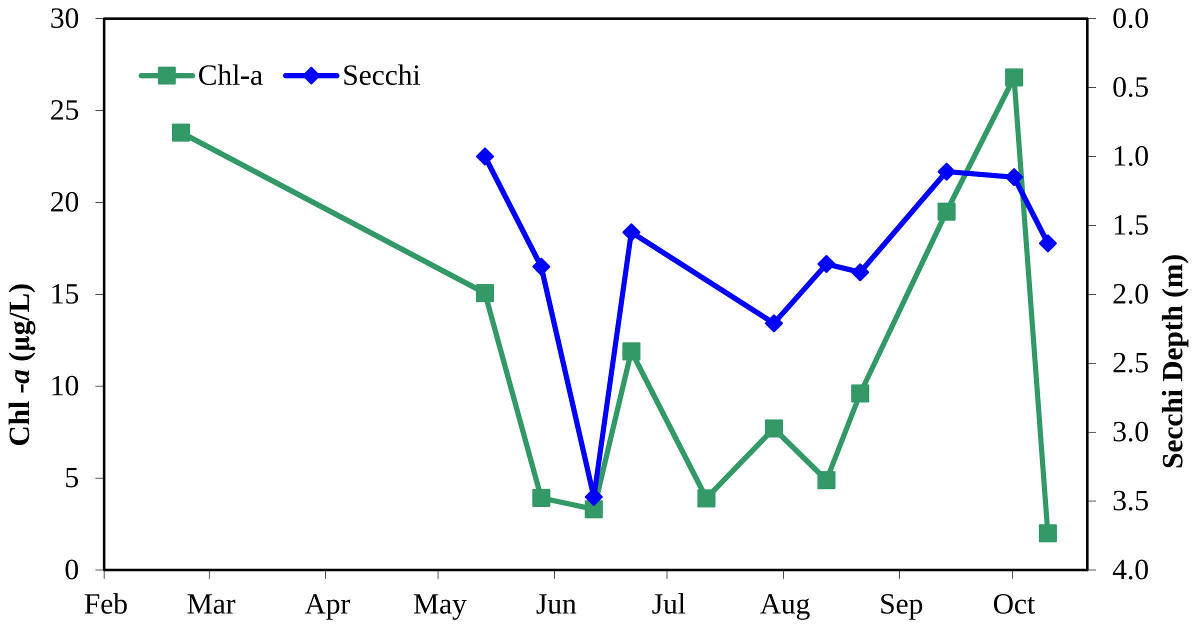


Figure 9-10. Lake Hiawatha chlorophyll-*a* and Secchi data from the 2013 sampling season.

Figure 9-11 shows the zooplankton distribution in Lake Hiawatha during the 2013 sampling season. Cladocerans, rotifers and juveniles were the dominating zooplankton groups present throughout the sampling season. Like most of the Minneapolis lakes, juvenile zooplankton was at the highest concentrations in early spring.

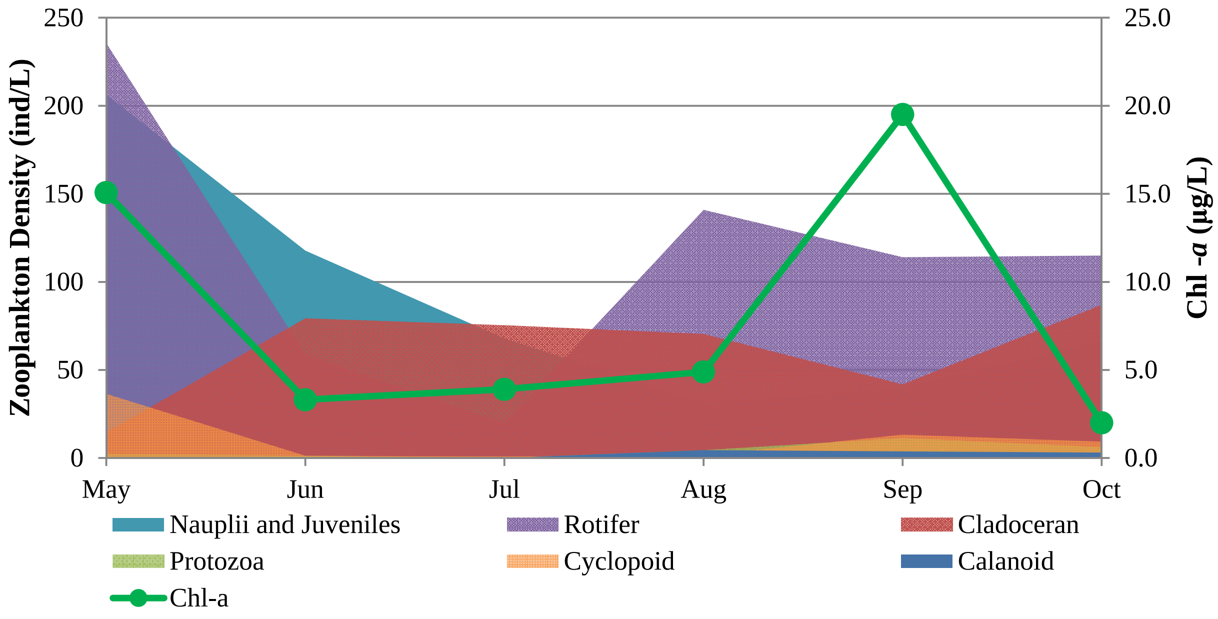


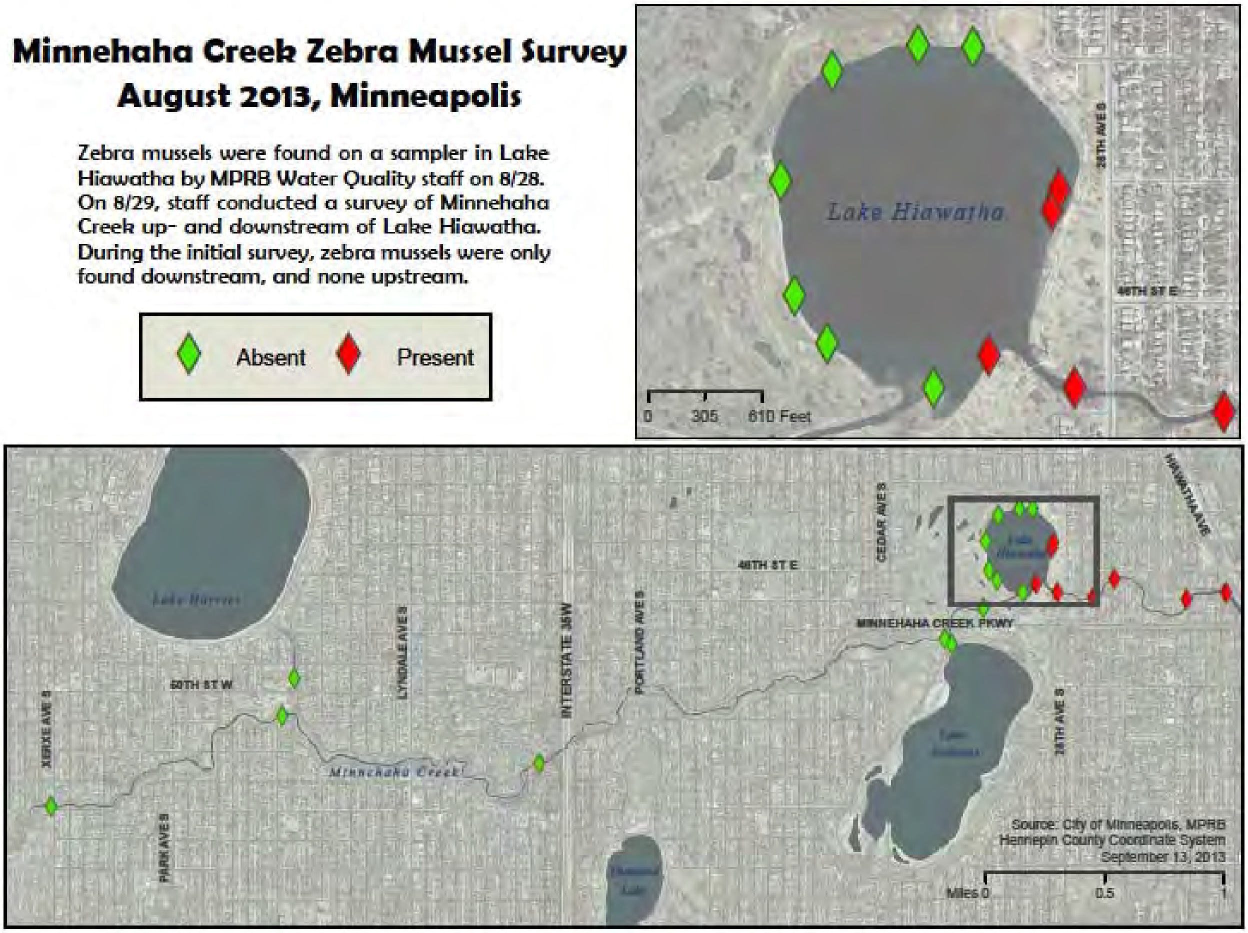
Figure 9-11. Lake Hiawatha zooplankton distribution during the 2013 sampling season.

EVENTS REPORT

On July 28 2010, zebra mussels (*Dreissena polymorpha*) were confirmed as present in Lake Minnetonka and at the headwaters of Minnehaha Creek by MDNR ecologists. The MDNR declared Lake Minnetonka, Minnehaha Creek and all public waters with creek connections to be infested with zebra mussels, including Lake Hiawatha.

In response, MPRB has been installing zebra mussel sampling plates in five lakes since 2010. In 2011, Water Quality staff began using a separate set of equipment only to be used on infested lakes as a precaution to not spread zebra mussels. Since 2012, the MPRB has operated an Aquatic Invasive Species (AIS) Inspection Program at boat launches on Lake Calhoun, Lake Harriet, and Lake Nokomis to prevent the spread of zebra mussels.

In August 2013, water quality staff discovered zebra mussels on a sampling plate in Lake Hiawatha. After the Minnesota DNR confirmed the finding, staff proceeded with a rapid survey of Lake Hiawatha and Minnehaha Creek. **Figure 9-12** shows the results of the rapid survey. Zebra mussels had been expected to arrive in Lake Hiawatha within a few years after their discovery in Lake Minnetonka, due to its direct connection with Minnehaha Creek. Future surveys will indicate whether zebra mussels will alter the ecology of the lake.



Minnehaha Creek Zebra Mussel Survey
August 2013, Minneapolis

Zebra mussels were found on a sampler in Lake Hiawatha by MPRB Water Quality staff on 8/28. On 8/29, staff conducted a survey of Minnehaha Creek up- and downstream of Lake Hiawatha. During the initial survey, zebra mussels were only found downstream, and none upstream.

Source: City of Minneapolis, MPRB
Hennepin County Coordinate System
September 13, 2013

Figure 9-12. Rapid survey map after zebra mussels discovery in Lake Hiawatha in August 2013.

10. LAKE OF THE ISLES

HISTORY

Lake of the Isles was named for the four islands that were present in the lake prior to development of the area. The original park property consisted of 100 acres of water, 67 acres of wetland, and 33 acres of land. The park was acquired by the Minneapolis Park and Recreation Board in 1886 through purchase, donation, and condemnation. One of the islands had already been eliminated in 1884 by the Chicago Milwaukee and Saint Paul Railway when tracks were laid on fill between Lake Calhoun and Isles. Half a million cubic yards of material were dredged between 1889 and 1911 eliminating a second island and increasing the lake area to 120 acres. The lake was further modified by filling 80 acres of marsh to create parkland, to deepen the North Arm to a uniform depth, and to replace the marshy east side of the lake with an upland shoreline. The connection of Isles to Calhoun was completed in 1911 and was celebrated by citywide festivities. Lake of the Isles is part of the Chain of Lakes Regional Park which received over 5 million visitors in 2013 and was the most visited park in Minnesota (Metropolitan Council, 2014).

The lake was part of the Clean Water Partnership project for the Chain of Lakes and was the focus of multiple restoration activities including grit chambers (1994, 1997, 1999) for stormwater sediment removal, constructed wetland detention ponds for further treatment of incoming stormwater, and a whole lake alum treatment (1997) to limit the internal loading of phosphorus.

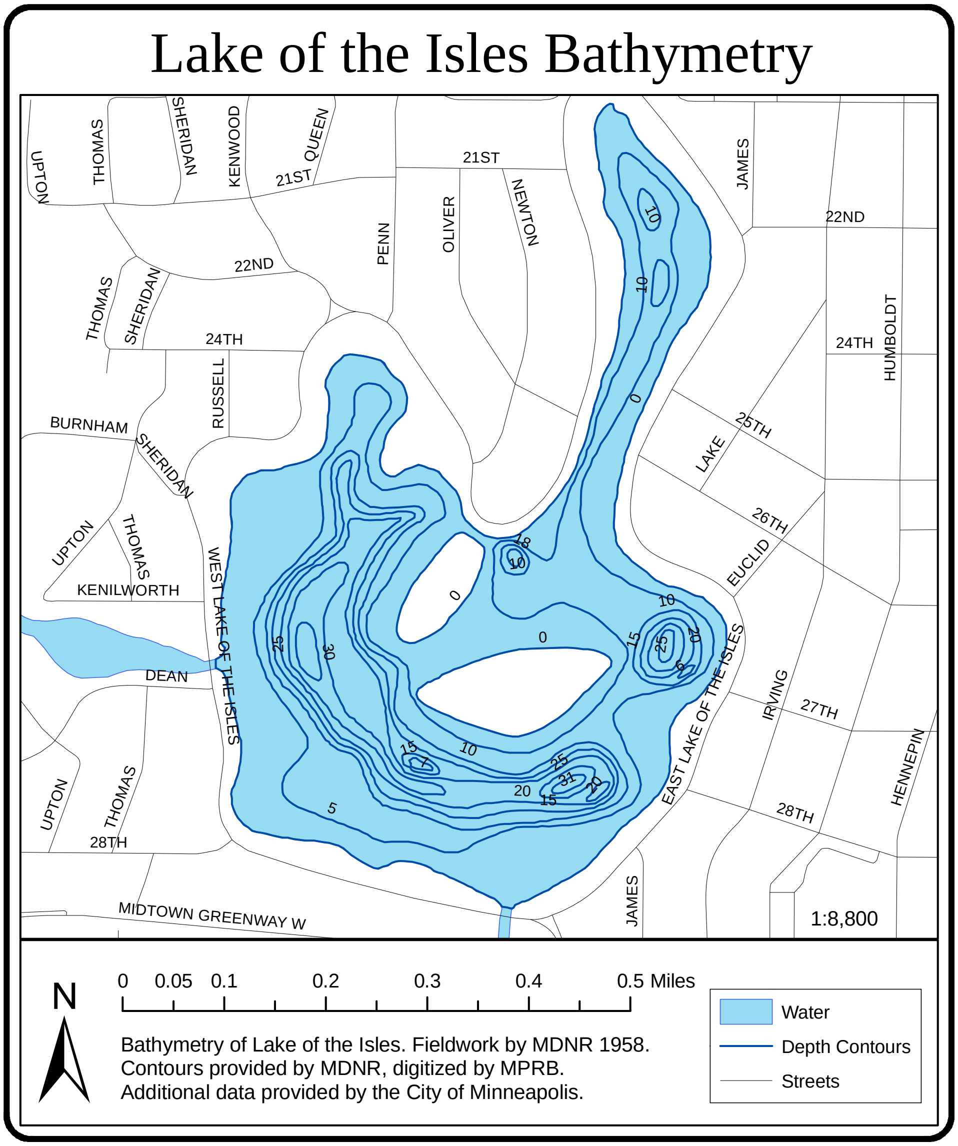
Lake of the Isles is a shallow lake with dense stands of macrophytes in some areas. The lake is polymictic as it becomes thermally stratified and periodically mixes due to wind throughout the summer. **Figure 10-1** shows Lake of the Isles in fall. **Table 10-1** shows the Lake of the Isles morphometric data. **Figure 10-2** shows the Lake of the Isles bathymetry.

Figure 10-1. Lake of the Isles.

Table 10-1. Lake of the Isles morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
103	2.7	9.4	89%	1.11×10^6	735	7.1	0.6

*Littoral area defined as less than 15 feet deep.



Lake of the Isles Bathymetry

Bathymetry of Lake of the Isles. Fieldwork by MDNR 1958.
Contours provided by MDNR, digitized by MPRB.
Additional data provided by the City of Minneapolis.

Figure 10-2. Bathymetric map of Lake of the Isles.

LAKE LEVEL

The ordinary high water level (OHW) designated by the MDNR for Lake of the Isles is 853 ft msl. The designated OHW is an estimate of the highest regularly sustained water level that has made a physical imprint on the land. This mark may be a transition in vegetation or a physical characteristic. For additional lake level information see Lake Calhoun in **Section 4**.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Figure 10-3 shows the Lake of the Isles linear regression of TSI scores from 1991 to the present. The Lake of the Isles 2013 TSI score is 58, average for this ecoregion (based on calculations from the Minnesota Pollution Control Agency using the Minnesota Lake Water Quality Data Base Summary, 2004). The water quality trend in Lake of the Isles is essentially flat with an R^2 value of only 0.007. The alum treatment in 1997 coincided with the lowest/best TSI score for Lake of the Isles, but did not result in a long term decrease in TSI scores. A detailed explanation of TSI can be found in **Section 1**.

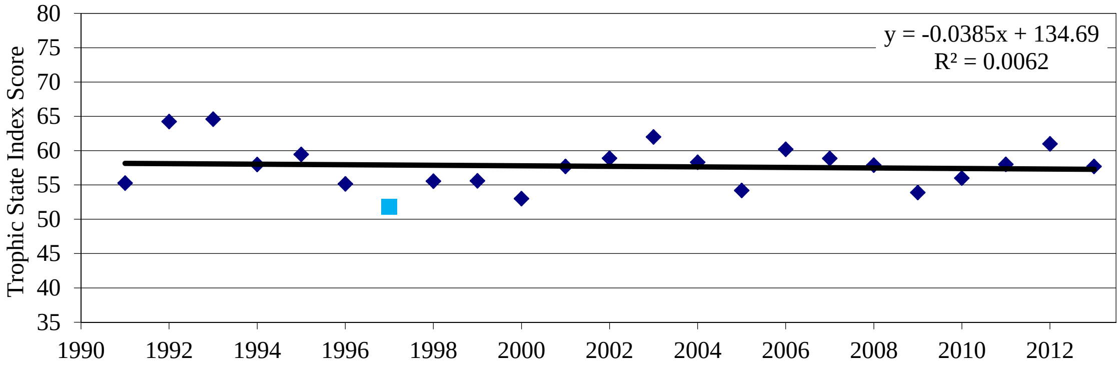


Figure 10-3. Lake of the Isles TSI scores and regression analysis. The blue square highlights the 1997 alum treatment.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 10-4** show the data distribution for the Secchi, chlorophyll-*a*, and total phosphorus for the past ten years. MPCA standards are indicated by a horizontal line on the plots. A detailed explanation of box and whisker plots can be found in **Section 1**, and all available data in box and whisker format can be found in **Appendix A.**

All data shown in **Figure 10-4** were measured after Clean Water Partnership project improvements installed between 1994 and 1997. Lake of the Isles met the shallow lake standard for phosphorus, but did not meet the standard for chlorophyll-*a* or Secchi depth. Warm water temperatures contributed to early and dense algae blooms influencing both the chlorophyll-*a* and transparency measurements.

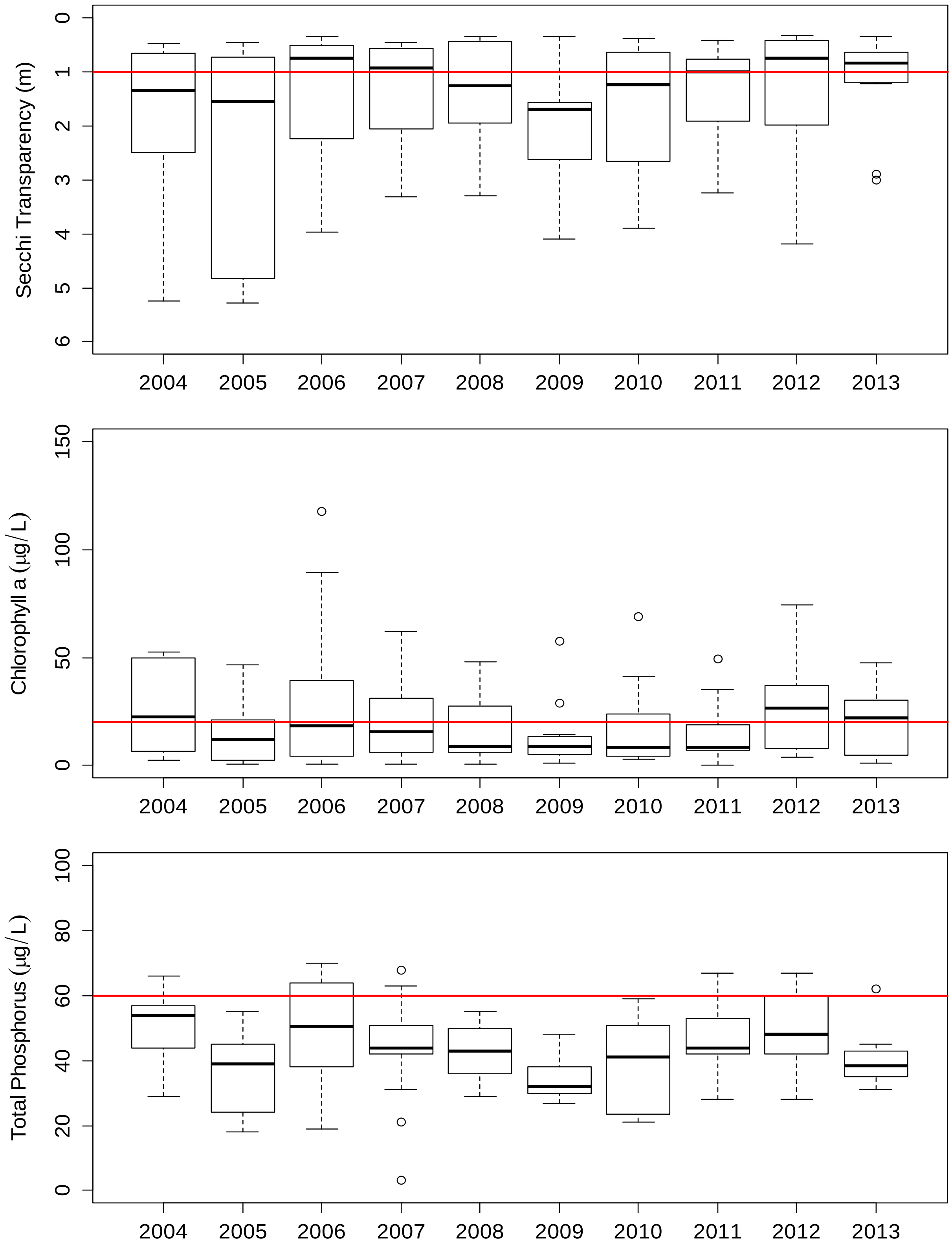


Figure 10-4. Lake of the Isles box and whisker plots of TSI data from 2004-2013. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The LAURI for Lake of the Isles is shown in **Figure 10-5**. Lake of the Isles scored "excellent" in aesthetics, habitat quality, and recreational access. The lake scored in the "good" category for water clarity. Since Lake of the Isles does not have a swimming beach a score was not calculated for public health. For more details on LAURI see **Section 1**.

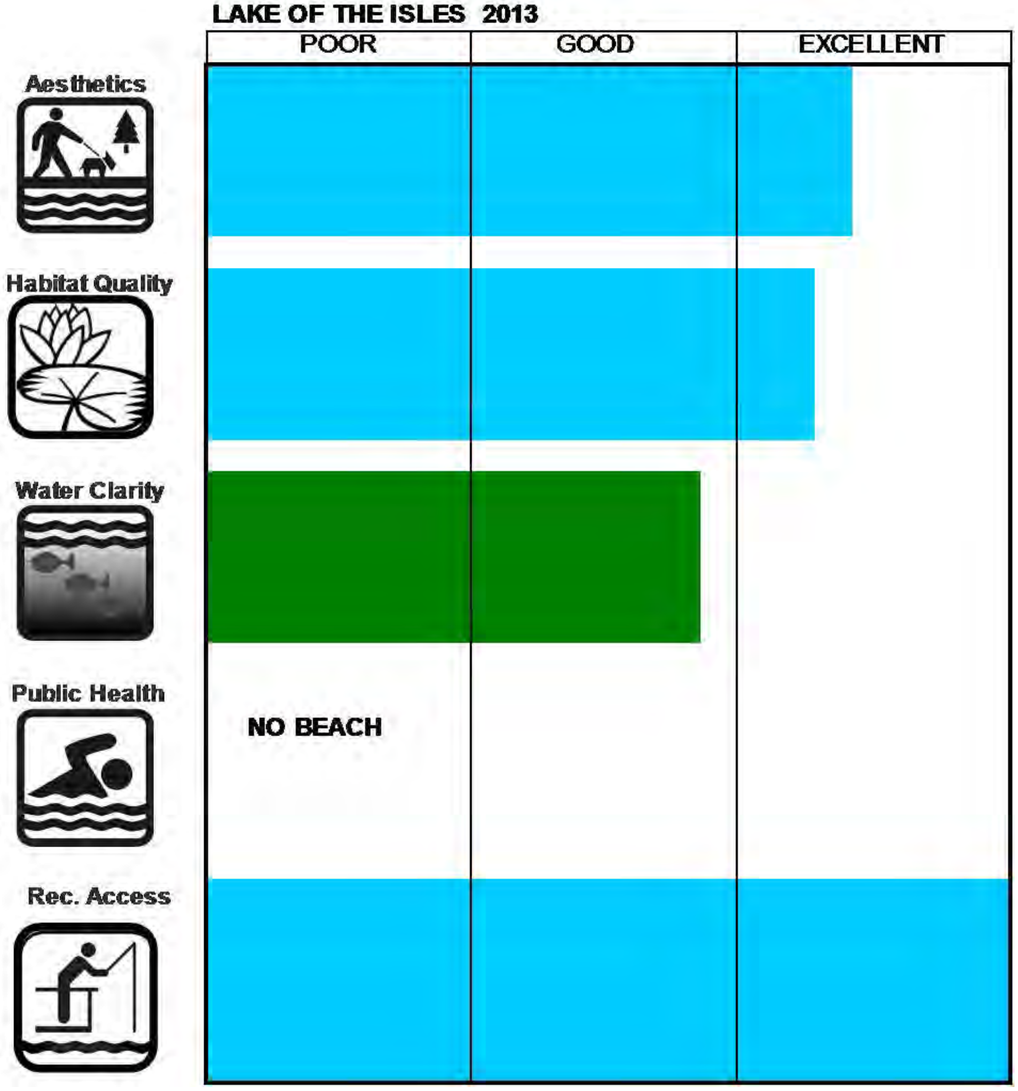


Figure 10-5. The LAURI for Lake of the Isles in 2013.

WINTER ICE COVER

Ice came off Lake of the Isles on April 28, 2013, twenty three days later than average and the latest ice-off date recorded for the lake. Ice fully covered the lake on November 25, 2013, which was six days earlier than average for Lake of the Isles. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian water milfoil. In order to protect fish habitat, the MDNR permits limit the area from which milfoil can be harvested. The permits issued to the MPRB allowed for harvesting primarily in swimming areas, boat launches, and in shallow areas where recreational access was necessary. The area permitted for milfoil harvesting in Lake of the Isles in 2013 was 38 acres which is just over 40% of the littoral zone (area shallower than 15 feet). See **Section 1** and **Section 20** for details on aquatic plants.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 10-6** shows phytoplankton relative abundance data for the 2013 sampling season. Chrysophytes (golden algae) dominated the phytoplankton community in the winter sample. Diatoms (Bacillariophyta) were abundant in May. Pyrrhophyta (dinoflagellates) peaked to 30% of the community in June. Once water temperatures warmed up in June, blue-green algae (Cyanophyta) bloomed and made up over 75% of the community in the late summer and fall. The period of strongest cyanobacteria domination corresponds to the highest levels of chlorophyll-*a* and the shallowest Secchi depths recorded for the year at Lake of the Isles as shown in **Figures 10-6** and **10-7**. Deepest Secchi depths correspond to low chlorophyll-*a* levels and the dominance of diatoms and chrysophytes (Bacillariophyta and Chrysophyta).

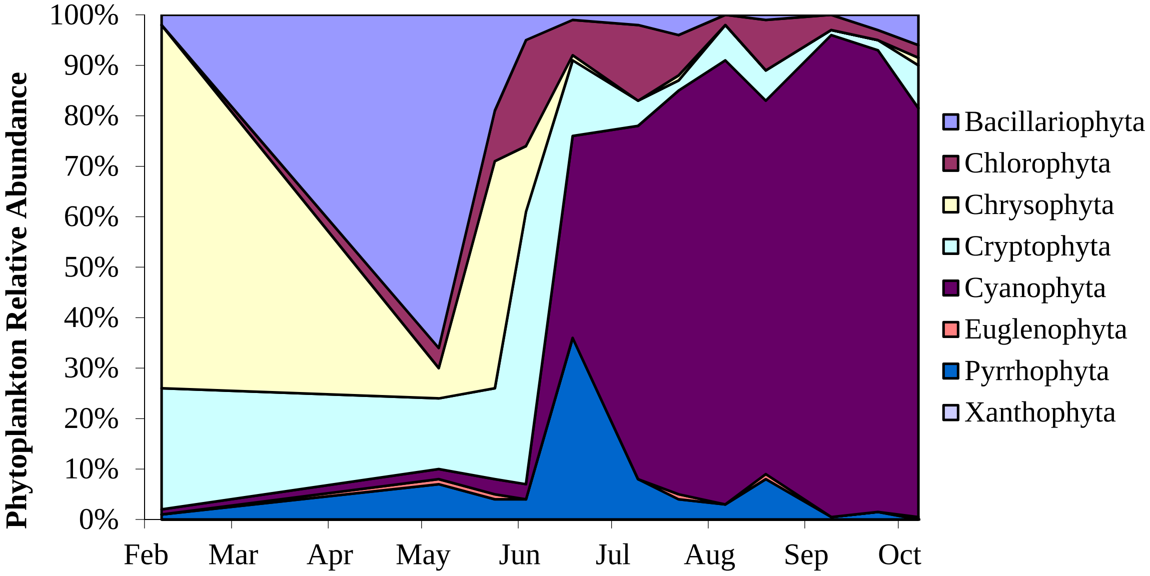


Figure 10-6. Lake of the Isles relative phytoplankton abundance during the 2013 sampling season.

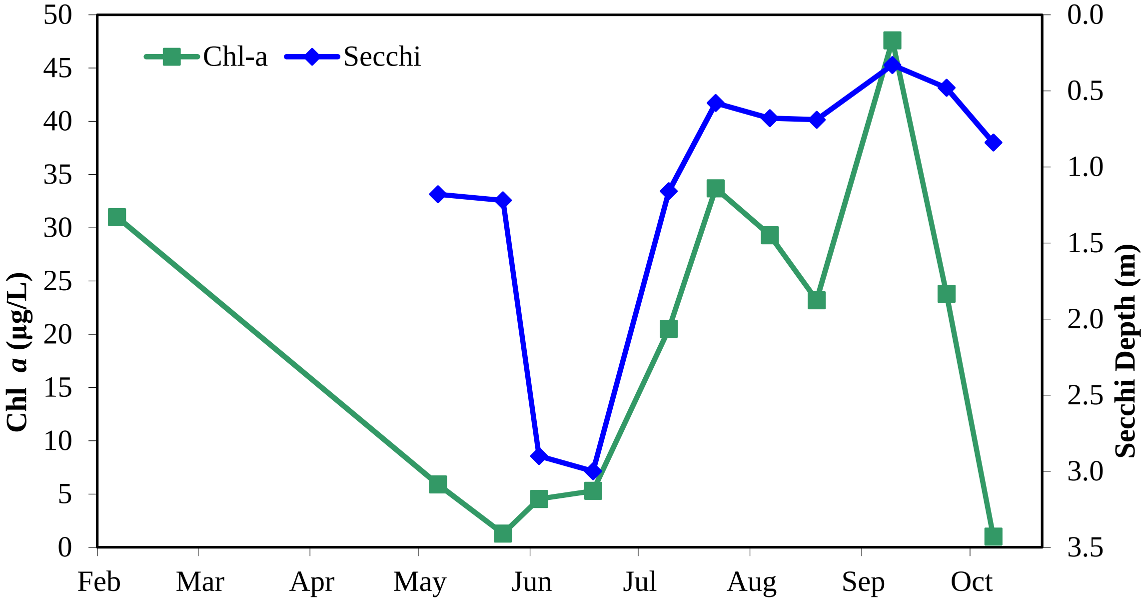


Figure 10-7. Lake of the Isles 2013 chlorophyll-*a* data and Secchi depth (note reversed axis).

The distribution of zooplankton for Lake of the Isles is shown in **Figure 10-8**. High chlorophyll-*a* levels corresponded to low zooplankton concentrations throughout the season. Nauplii and other juvenile zooplankton were present early and slowly tapered off by the end of the season. The rotifer community showed a marked spring peak, similar to the pattern in previous years. Cladocerans, large zooplankton that feed on algae peaked in spring and fall. Similar to other lakes, the carnivorous cyclpoids were present in low levels in most samples. As can be seen in **Figures 10-7** and **10-8**, chlorophyll-*a* levels rise and Secchi depths become shallow immediately after the zooplankton numbers fall in late-July. Fish predation could be one reason for this occurrence.

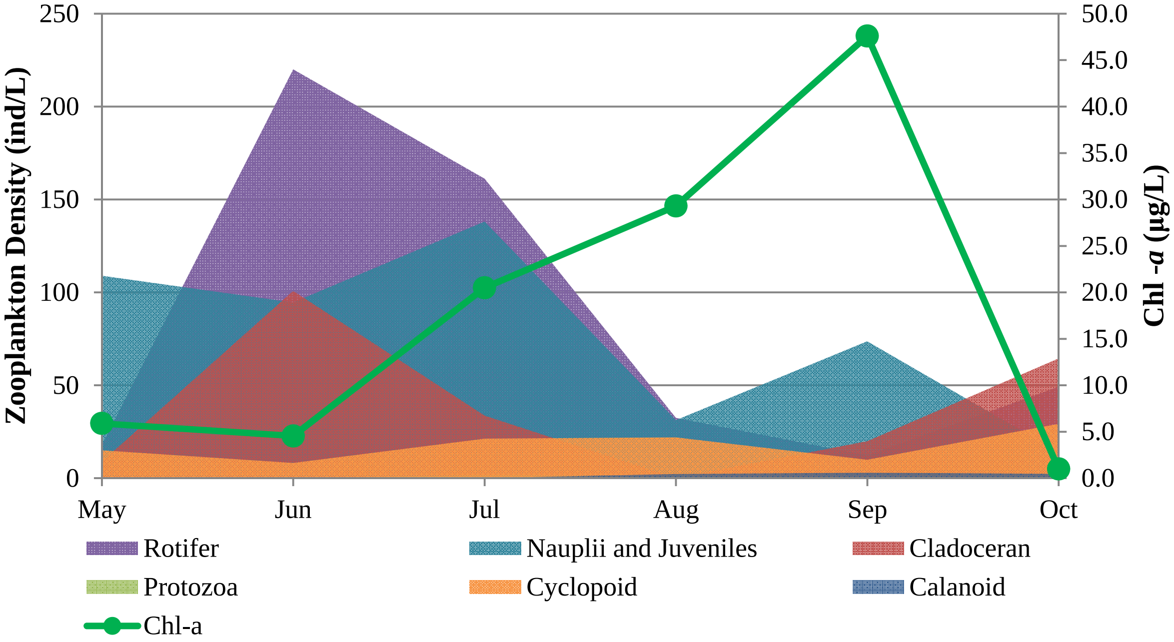


Figure 10-8. Lake of the Isles 2013 zooplankton distribution.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling, and adult fish can be found in **Section 1**.

Lake of the Isles was stocked by MDNR in:

2000 with 300 fingerling Tiger Muskellunge.

2004 with 300 fingerling Tiger Muskellunge.

2007 with 180 fingerling Tiger Muskellunge.

11. LORING POND

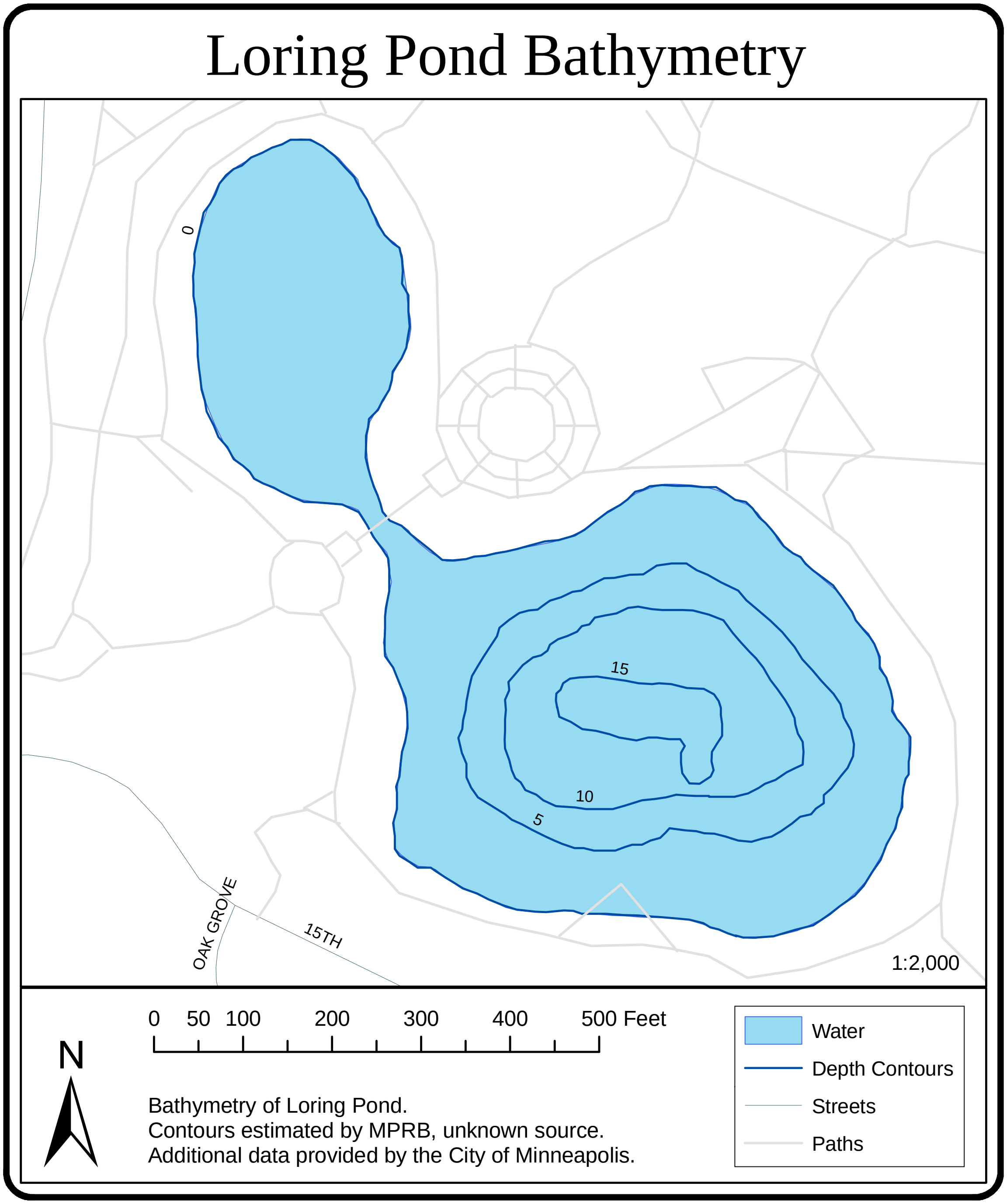
HISTORY

Loring Park was acquired in 1883 as the "Central Park" of Minneapolis. Loring Pond was named in 1890 in honor of Charles M. Loring the first president of the Board of Park Commissioners and is known as the "Father of the Minneapolis Park System."

The pond's current configuration was created by connecting two small bodies of water: Jewett Lake and Johnson's Pond. The smaller north basin of the pond was originally a wetland. In the winter of 1883-1884, peat was sawn out of the frozen ground in order to create a basin that would hold open water. Stormwater diversion has reduced the watershed of Loring Pond to the surrounding 24.1 acres of parkland and has left the lake with a negative water balance; therefore a groundwater augmentation well is used to maintain water levels.

Figure 11-1 is a photograph of Loring Pond, and **Figure 11-2** is a map of the pond showing estimated bathymetry. **Table 11-1** shows the morphometric data for Loring Pond.

Figure 11-1. Photograph of Loring Pond, Fall 2013.



Bathymetry of Loring Pond.
Contours estimated by MPRB, unknown source.
Additional data provided by the City of Minneapolis.

Figure 11-2. Map of Loring Pond showing bathymetry contours.

Table 11-1. Loring Pond morphometric data.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)
8	1.5	5.3	4.88×10^4	24.1	3.0

Several attempts were made in the 1970s to improve water quality in Loring Pond. An Olszewski tube was installed in an attempt to drain high-nutrient hypolimnetic water from the lake. The tube never functioned properly and was abandoned. Dredging of the north arm from 1976 to1977 also did not improve the water quality of the lake. Augmentation of the lake level with groundwater appears to have had a positive effect on water quality and continues today.

Further lake restoration and park improvement projects were initiated in 1997. The lake bottom was sealed, lined, and vented. An aerator was installed to help prevent oxygen depletion during the summer months. Multiple vegetation restoration projects were completed throughout the park. A fishing pier, bike and pedestrian trails, and horseshoe courts were also installed to increase park recreational opportunities. In 1999, the shoreline was planted with native vegetation in cooperation with the Minnesota Department of Natural Resources (MDNR) and the Friends of Loring Park. The native shoreline restoration provided a buffer strip for waterfowl management, protection against shoreline erosion, pollutant filtration, and improved lake aesthetics.

In 2007 the north basin was dredged to remove accumulated sediment and restore original depths in the channel between the northern and southern basins. In order to accomplish this, the northern basin was dewatered and the water level in the southern basin was lowered. The project had the unintended consequence of stimulating cattail growth that led to a multi-year cattail removal project that MPRB began in 2013.

LAKE LEVEL

Lake levels for Loring Pond are recorded weekly during ice free conditions and are shown in **Figure 11-3** for 1994-2013. Loring Pond lake levels are influenced by an augmentation well that is used to pump groundwater into the lake periodically throughout the year to maintain a consistent level.

As the water level was often below the bottom of the lake gauge on the outlet structure, a new auxiliary gauge was installed in 2013. Water levels were manipulated and drawn down throughout the summer of 2013 as part of a cattail removal demonstration project in a small path on the southern part of the lake. See Water Quality Projects for more details.

Dewatering for the north bay dredging project lowered water levels in Loring significantly in 2007. Stormsewer backflow entered Loring several times in 2010 and 2011 during high-intensity rain events, and the largest of these events can be seen as peaks in the level graph. Water pressure from stormsewer backflow caused the Loring Pond outlet to deteriorate. In 2011, MPRB staff repaired the cement at the base of the outlet and re-installed the outlet board. Staff were able to raise the level of the lake using groundwater, but pumping could not overcome the amount of water lost in the late summer drought. High water levels in 2012 were due to a malfunction in the groundwater pump.

The ordinary high water level (OHW) designated by the MDNR for Loring Pond is 818.0 ft msl. The designated OHW is an estimate of the highest regularly sustained water level that has made a physical imprint on the land. See **Section 18** for a comparison between other MPRB lake levels.

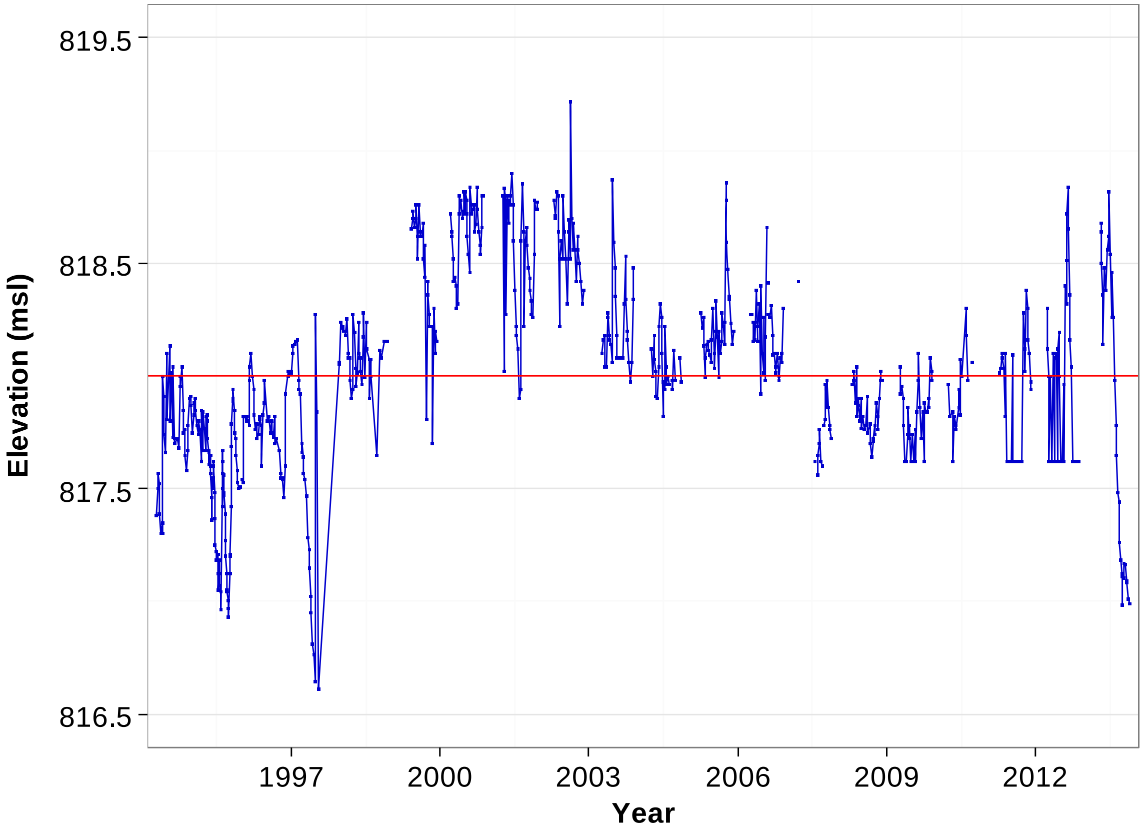


Figure 11-3. Lake levels for Loring Pond from 1994 – 2013. Water levels frequently dropped below the gage in the 2000s and water levels couldn't be accurately measured during that time. Auxiliary gage installed in 2013 is able to read lower lake levels. Horizontal line represents Loring Pond OHW (818.0 ft msl).

AUGMENTATION WELLS

An augmentation well is used to maintain the water levels at Loring Pond. The Minnesota Department of Natural Resources (MDNR) issues the permits and determines pumping limits for augmentation wells. The MPRB staff records groundwater usage monthly. **Table 11-2** shows annual usage for the past five years. No data is available for 2010 due to a broken meter. In 2013, 1.4 million gallons of groundwater was pumped into Loring Pond.

Table 11-2. Loring Pond annual pumping volume in gallons.

2009 Total (gal)	2010 Total (gal)	2011 Total (gal)	2012 Total (gal)	2013 Total (gal)
10,185,000	Meter broken	8,475,000	11,572,500	1,378,500

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2013 TSI score for Loring Pond was 67. Loring Pond has a TSI score that falls near the bottom 25th percentile category for lakes in the Northern Central Hardwood Forest ecoregion (MPCA, 2004). **Figure 11-4** shows the TSI data for Loring Pond along with a linear regression. A detailed explanation of TSI can be found in **Section 1**.

When all years are considered together Loring Pond has a trend towards increasing TSI and lower water quality. Caution should be used when viewing the Loring Pond data in total since dredging projects that disturbed all or a large portion of the lake occurred in 1997-1998 and during the summer of 2007.

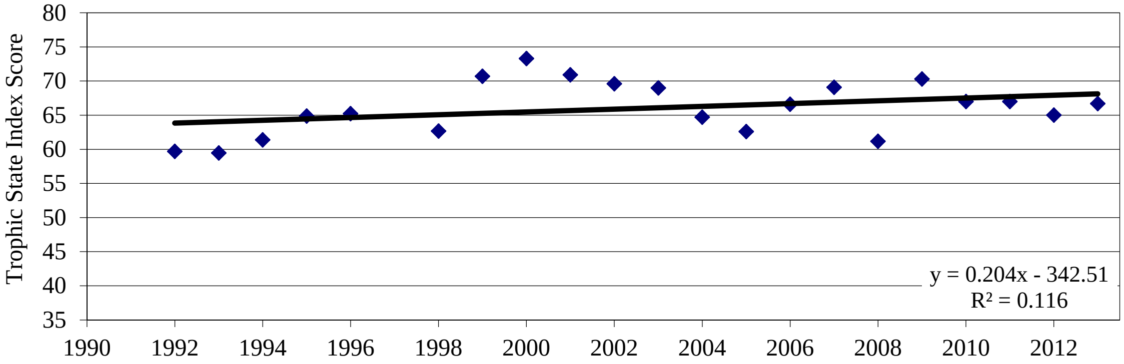


Figure 11-4. Loring Pond TSI data and regression analysis from 1990 to 2013. The lake was significantly manipulated during 1997-1998 and the summer of 2007. Due to these disturbances, linear regression should be viewed with caution.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 11-5** show the distribution of data for the Secchi, chlorophyll-*a*, and total phosphorus measurements for the past ten years. MPCA shallow lake standards are shown as a horizontal line across the box plots. A detailed explanation of box and whisker plots can be found in **Section 1**. Data presented in box and whisker plot format for the entire period of record can be found **Appendix A.**

The 303(d) assessment for impaired waters is limited to lakes of ten acres or greater (MPCA, 2014); therefore, Loring Pond is too small (8 acres) to be listed on MPCA's impaired waters list. However, it is still useful to compare Loring's data to the shallow lake standards to determine lake water quality. In 2013, Secchi transparency measurements and phosphorus levels did not meet the shallow lake standard as shown in **Figure 11-5**, while chlorophyll-*a* met the MPCA shallow lake standard. Lake sediment typically contains high levels of nutrients including phosphorus. Loring Pond has a large population of black bullhead and goldfish that stir up nutrient rich bottom sediment when they feed. Once these nutrients are re-suspended into the water column, they become available for algal growth.

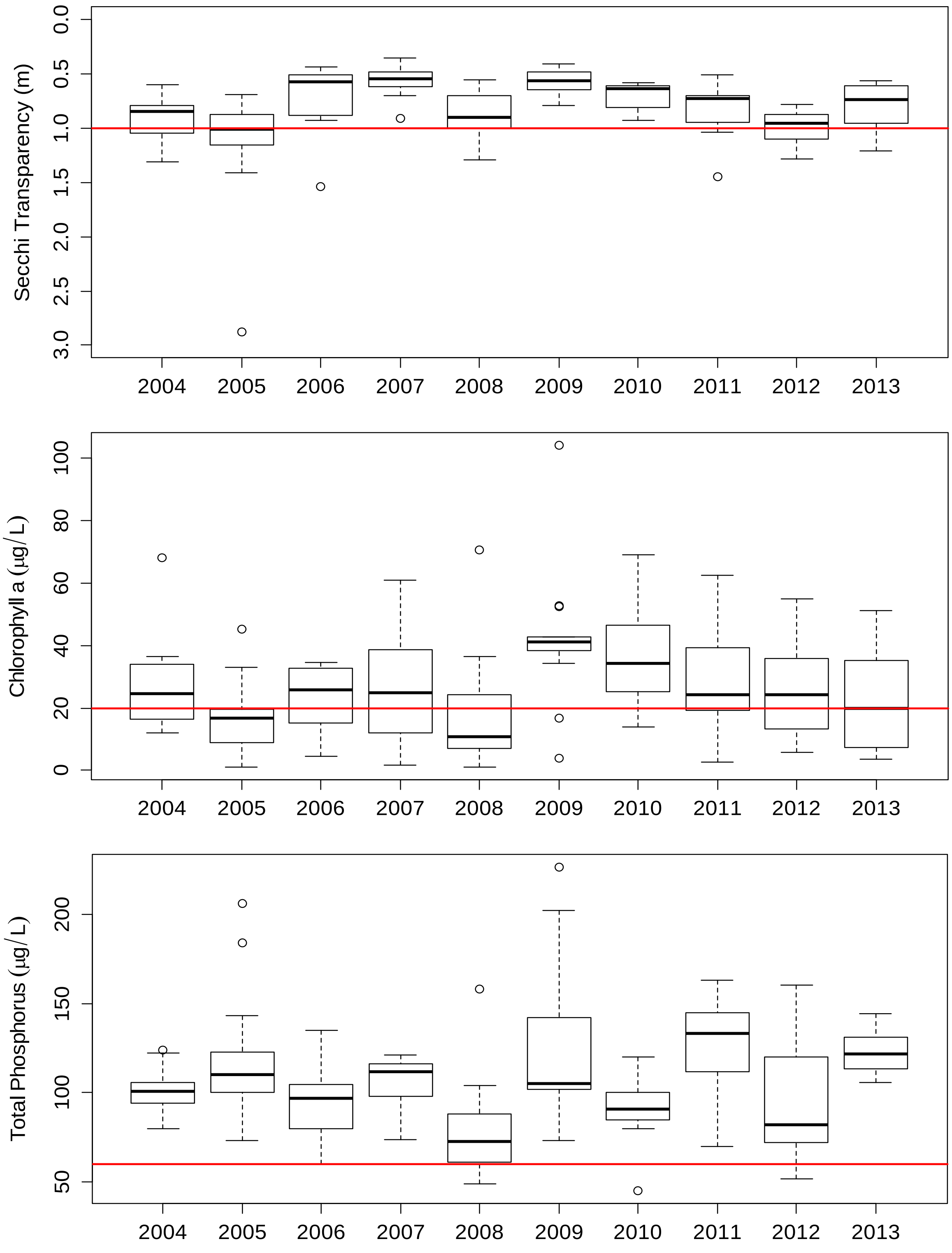


Figure 11-5. Box and whisker plots of Loring Pond TSI data for the most recent 10 years. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The LAURI for Loring Pond is shown in **Figure 11-6**. Loring Pond scored “excellent” in aesthetics and water clarity. Loring scored “good” in habitat quality. Loring Pond does not have a swimming beach and was therefore not scored for public health. Loring does not have boat or canoe access and therefore scored a “poor” in recreational access. Details on the LAURI index can be found in **Section 1**.

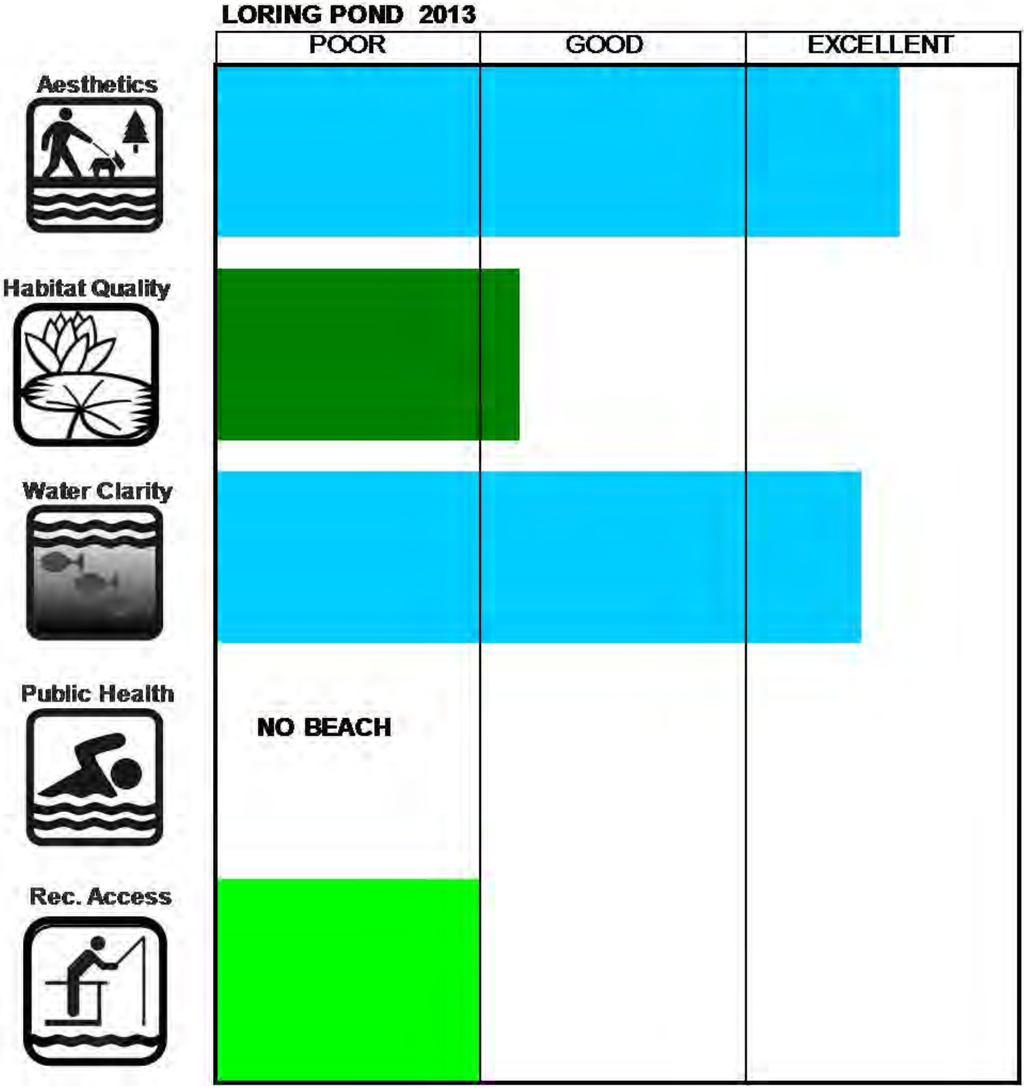


Figure 11-6. The 2013 LAURI for Loring Pond.

WINTER ICE COVER

Ice came off Loring Pond on April 25, 2013, twenty three days later than average and the latest ice-off date recorded for the lake. Ice came on to the pond on November 25, 2013, six days after the average ice-on date for Loring Pond. Loring Pond is a popular spot for geese, ducks and gulls, and some years waterfowl keep an open hole of water from freezing past normal ice-on. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. Zooplankton preferentially graze on phytoplankton and play a part in water clarity. **Figure 11-7** displays the phytoplankton community composition for Loring Pond and **Figure 11-8** shows chlorophyll-*a* and Secchi transparency for the 2013 sampling season. **Figure 11-9** shows the zooplankton density along with chlorophyll-*a* concentrations.

The phytoplankton community at Loring Pond shifted dramatically throughout the 2013 season as shown in **Figure 11-7**. In spring, Bacillariophyta (diatoms) were dominant slowly giving way to Euglenophyta (euglenoids) and Cryptophyta (cryptomonads). Once temperatures began to warm, Chlorophyta (green algae) bloomed and Cryptophyta still maintained about 20% of the total algal community. Later in the summer, Pyrrhophyta (dinoflaggelates) and Cyanophyta (blue-green algae) began to bloom. Late in the season, Bacillariophyta bloomed again, reaching almost 40% relative abundance. Typically in highly productive lakes like Loring, blue green algae dominate the algal biomass. The presence of the genus *Euglena*, made up 30% relative abundance in May was also unusual when compared to the other sampled lakes. *Euglena* spp. are typical in wetland conditions and several species are tolerant of pollution.

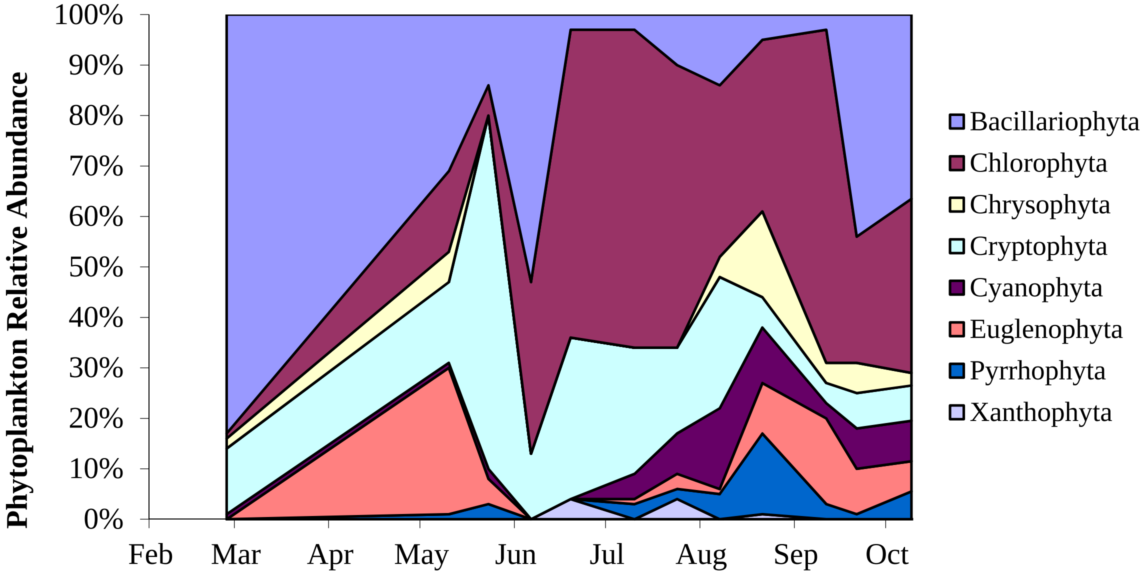


Figure 11-7. Loring Pond 2013 relative abundance of phytoplankton divisions.

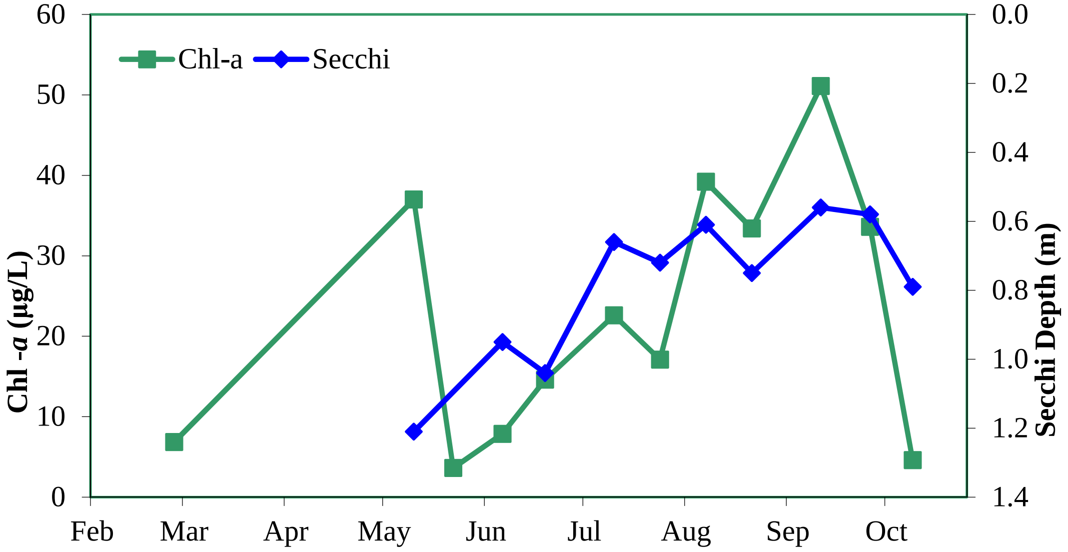


Figure 11-8. Loring Pond 2013 chlorophyll-*a* data and Secchi depths (note reversed axis).

Chlorophyll-*a* concentrations clearly trended with Secchi readings as shown in **Figure 11-8**. The increase in chlorophyll-*a* and subsequent decrease in Secchi depth occurred during times of increased chlorophyta observed in Loring Pond. Chlorophyll-*a* concentrations fluctuated from a low of around 5 ug/L to a high of over 50 ug/L.

Zooplankton density and chlorophyll-*a* concentrations at Loring Pond in 2013 are shown in **Figure 11-9**. The zooplankton populations were primarily dominated by rotifers, with two very large spikes in the early and late seasons. Cladocerans (large herbivorous plankton), and Nauplii (juvenile forms of zooplankton) were present in most samples throughout the season, albeit at lower concentrations. Cyclopoids peaked in July at a very low level.

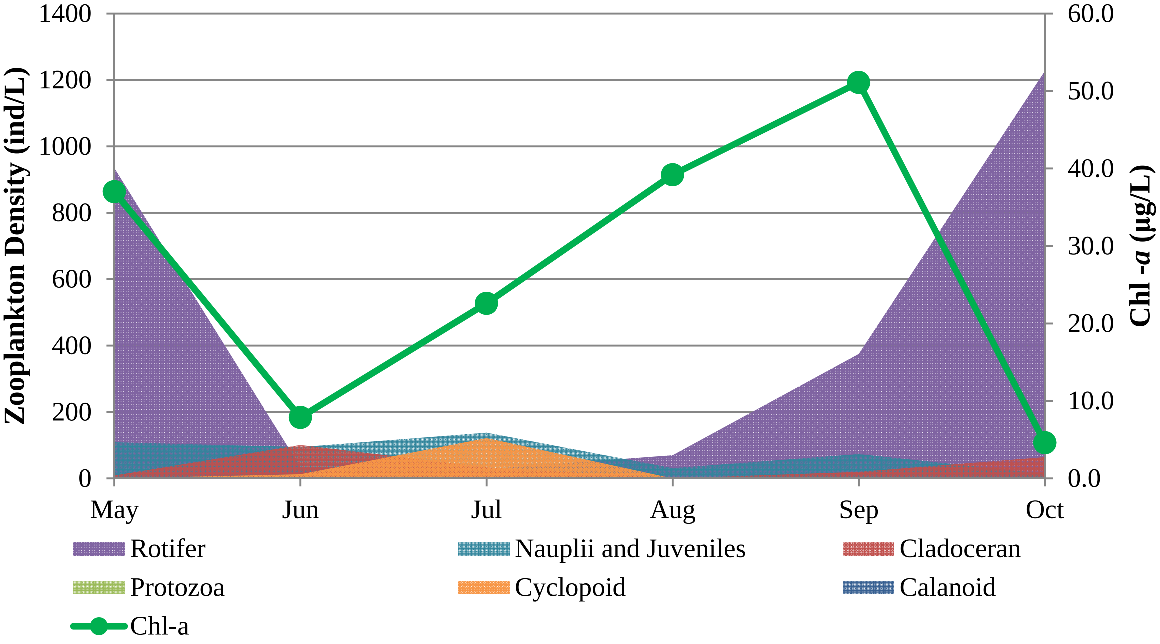


Figure 11-9. Zooplankton distribution at Loring Pond during the 2013 sampling season.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling, and adult fish sizes can be found in **Section 1**.

Loring Pond was stocked by MDNR in:

2001 with 417 adult Black Crappie, 465 adult Bluegill Sunfish.
2002 with 268 adult Black Crappie, 423 adult Bluegill Sunfish.
2003 with 107 adult Black Crappie, 417 adult Bluegill Sunfish.
2004 with 102 adult Black Crappie, 485 adult Bluegill Sunfish.
2005 with 100 adult Black Crappie, 402 adult Bluegill Sunfish, 50 adult Channel Catfish.
2006 with 102 adult Black Crappie, 400 adult Bluegill Sunfish, 50 adult Channel Catfish.
2007 with 158 adult Black Crappie, 200 adult Bluegill Sunfish.
2008 with 200 adult Black Crappie, 400 adult Bluegill Sunfish, 50 adult Channel Catfish.
2009 with 102 adult Black Crappie, 403 adult Bluegill Sunfish.
2010 with 108 adult Black Crappie, 402 adult Bluegill Sunfish, 50 adult Channel Catfish.
2011 with 79 adult Black Crappie, 329 adult Bluegill Sunfish, 28 adult Channel Catfish.

WATER QUALITY PROJECTS

Since the 1999 shoreline restoration project, a dense monoculture of cattails has enveloped the perimeter of Loring Pond, as seen in **Figure 11-1**. In summer 2013, MPRB began a three year project to remove hybrid and narrow-leaf cattail from a small demonstration area on the southern perimeter of the lake and replant the shoreline with native vegetation. The 500 square foot demonstration project at Loring Pond will investigate methods for cattail management at the lake. Water levels were drawn down in the summer of 2013 to allow the cattails to be cut at the manipulated water surface. Water levels were then raised, flooding the cut shoots and preventing oxygen from reaching the rhizomes and thus killing the plant. During the treatment, some patches within the project area were also spot treated with herbicides. Further monitoring will show the effectiveness of this demonstration project.

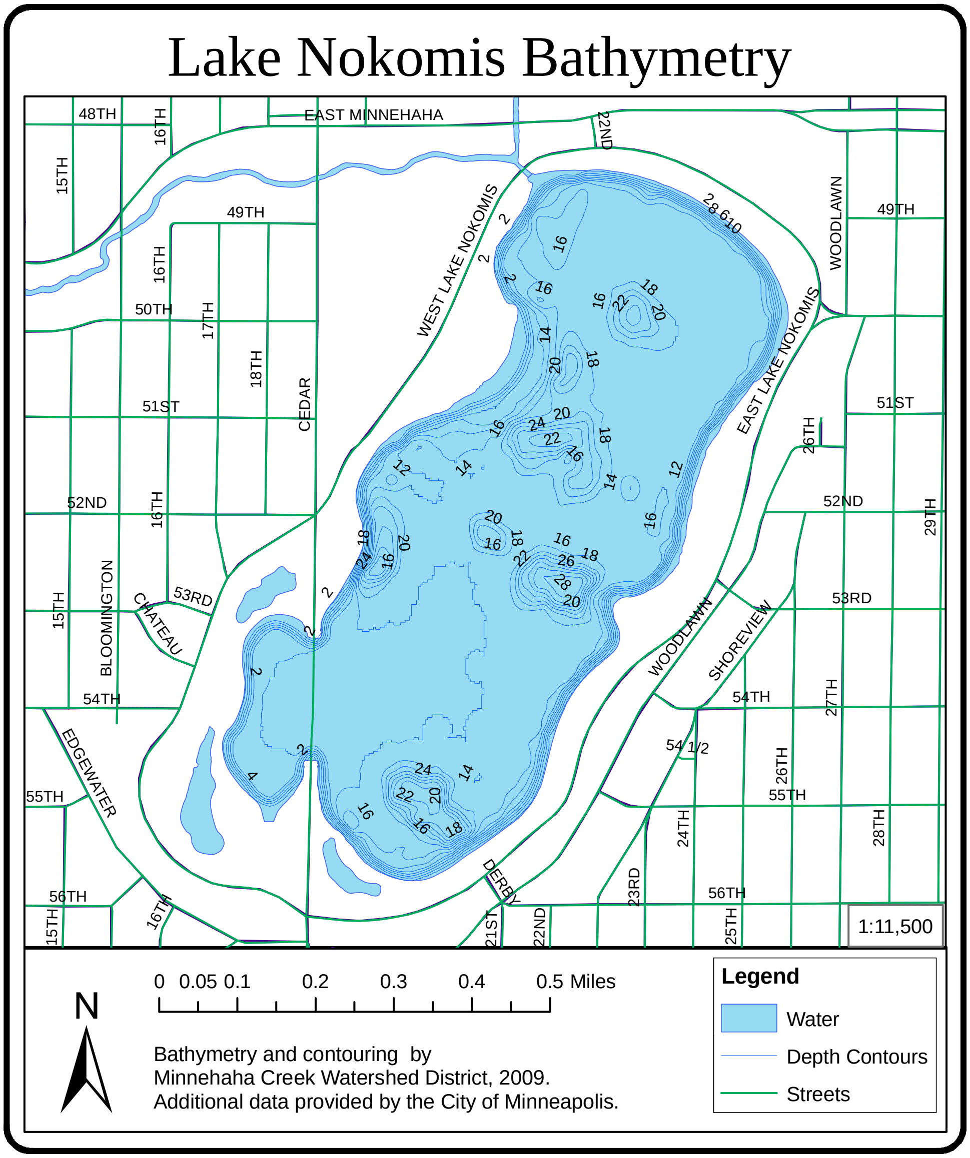
12. LAKE NOKOMIS

HISTORY

In 1907, the Minneapolis Park and Recreation Board (MRPB) purchased open water, wetland and a peat bog known as Lake Amelia, later to be Lake Nokomis. At the time wetlands were viewed as unsanitary, so Theodore Wirth developed a plan to make the area more desirable for development and to protect public health. Dredging began in 1914, moving nearly 2.5 million cubic yards of material to increase the park by 100 acres, create beaches, solid shoreline, and parkways around the lake. Wirth predicted that the new parkland would settle, which was corrected by a 1934 Works Progress Administration project.

Numerous restoration projects have been implemented to improve water quality in the lake. Carp were seined from the lake during the winter of 2001-02 in order to limit internal phosphorus loading caused by the fish foraging in the sediment. Increased street sweeping, grit chambers and wetland detention ponds were also implemented in 2001. An inflatable weir was installed in 2002 to prevent nutrients from Minnehaha Creek from entering the lake and was operational in 2003. In 2012, Minnehaha Creek Watershed District (MCWD) replaced it with a more durable fixed weir which allows the lake to overflow during periods of high water, yet still prevent the creek from flowing into the lake. A photograph of the Lake Nokomis weir is presented below in **Figure 12-1.** **Figure 12-2** is a bathymetric map of Lake Nokomis and **Table 12-1** contains morphometric data.

Figure 12-1. Newly constructed weir at Lake Nokomis outlet, taken November, 2012.



Bathymetry and contouring by
Minnehaha Creek Watershed District, 2009.
Additional data provided by the City of Minneapolis.

Figure 12-2. Bathymetric map of Lake Nokomis based on data collected by the Minnehaha Creek Watershed District.

Table 12-1. Nokomis Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
204	4.3	10.1	51%	3.54×10^6	869	4.3	4.0

* Littoral area defined as less than 15 feet deep.

Lake Nokomis is a shallow polymictic lake which mixes many times during the growing season. Mixing potential is increased when higher than normal wind speeds occur along the north-south fetch of the lake. This has the effect of destabilizing the water column and mixing hypolimnetic phosphorus into the surface water where it can be utilized by algae near the surface.

LAKE LEVEL

Weekly lake levels at Lake Nokomis for 1999 through 2013 are shown in **Figure 12-3**. In 2003, a new staff gage was surveyed in at the Lake Nokomis outlet. The ordinary high water level (OHW) designated by the MDNR for Lake Nokomis is 815.4 ft msl. The designated OHW is an estimate of the highest regularly sustained water level that has made a physical imprint on the land. See **Section 18** for a comparison between other MPRB lake levels. Nokomis lake levels were very low for several years (2003-2011) due to a combination of factors including: several consecutive drought years, less discharge from the Mother Lake watershed, and the separation from Minnehaha Creek. Higher levels were recorded in 2011-2013 after large snowmelt and spring rains. In late summer water levels typically drop naturally in Lake Nokomis due to drought conditions.

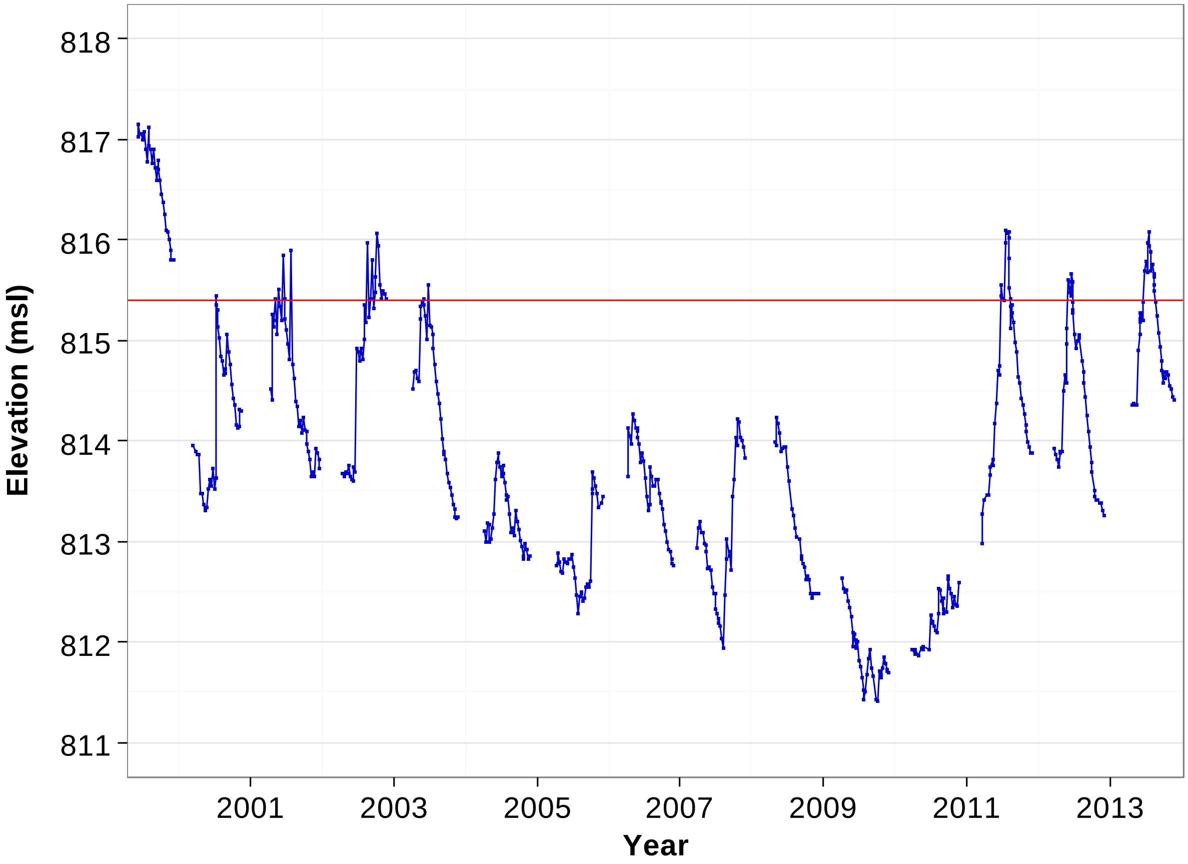


Figure 12-3. Lake levels recorded at Lake Nokomis, 1999-2013. Horizontal line represents Lake Nokomis OHW elevation (815.4 ft msl).

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Lake Nokomis's 2013 TSI score is 59. **Figure 12-4** shows the Lake Nokomis TSI scores and linear regression to be nearly flat. Nokomis has a TSI score that is below average for this ecoregion. It falls between the 50th and bottom 25th percentile compared to other lakes in our ecoregion (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004). A detailed explanation of TSI can be found in **Section 1**.

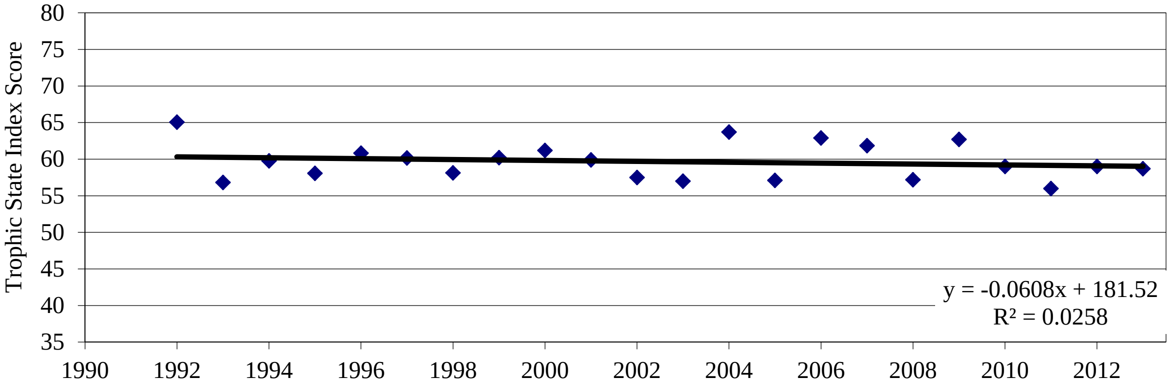


Figure 12-4. Lake Nokomis TSI scores and regression analysis.

BOX AND WHISKER PLOTS

Figure 12-5 shows box and whisker plots of Secchi transparency, chlorophyll-a, and total phosphorus data for Lake Nokomis for the most recent 10 years of data. Lake Nokomis site specific standards are indicated by a horizontal line on the box plot graphs. The EPA approved a new 50 ug/L TP standard for Lake Nokomis in 2013. A detailed explanation of box and whisker plots can be found in **Section 1**. Data in box and whisker format from the entire period of record can be found in **Appendix A**.

The relatively wide range in the Lake Nokomis data may be due to the polymictic nature of the lake. Years with more mixing events and less stable stratification may result in greater phosphorus return from the sediments and more algal productivity near the surface. The ten years since the weir separated the lake from Minnehaha Creek may represent a new normal for Lake Nokomis.

In 2013, Lake Nokomis met the MPCA shallow lakes standard for chlorophyll-*a*, while Secchi transparency and phosphorus levels did not meet the MPCA standard, as can be seen in **Figure 12-5**. A biomanipulation study began in 2010 at Lake Nokomis, which aims to reduce sediment disturbance by burrowing fish. While Secchi transparency and phosphorus are still relatively high, the project may eventually have a positive effect on clarity when there is a lower level of sediment phosphorus release. Future monitoring will show the effectiveness of this approach on water quality in Lake Nokomis.

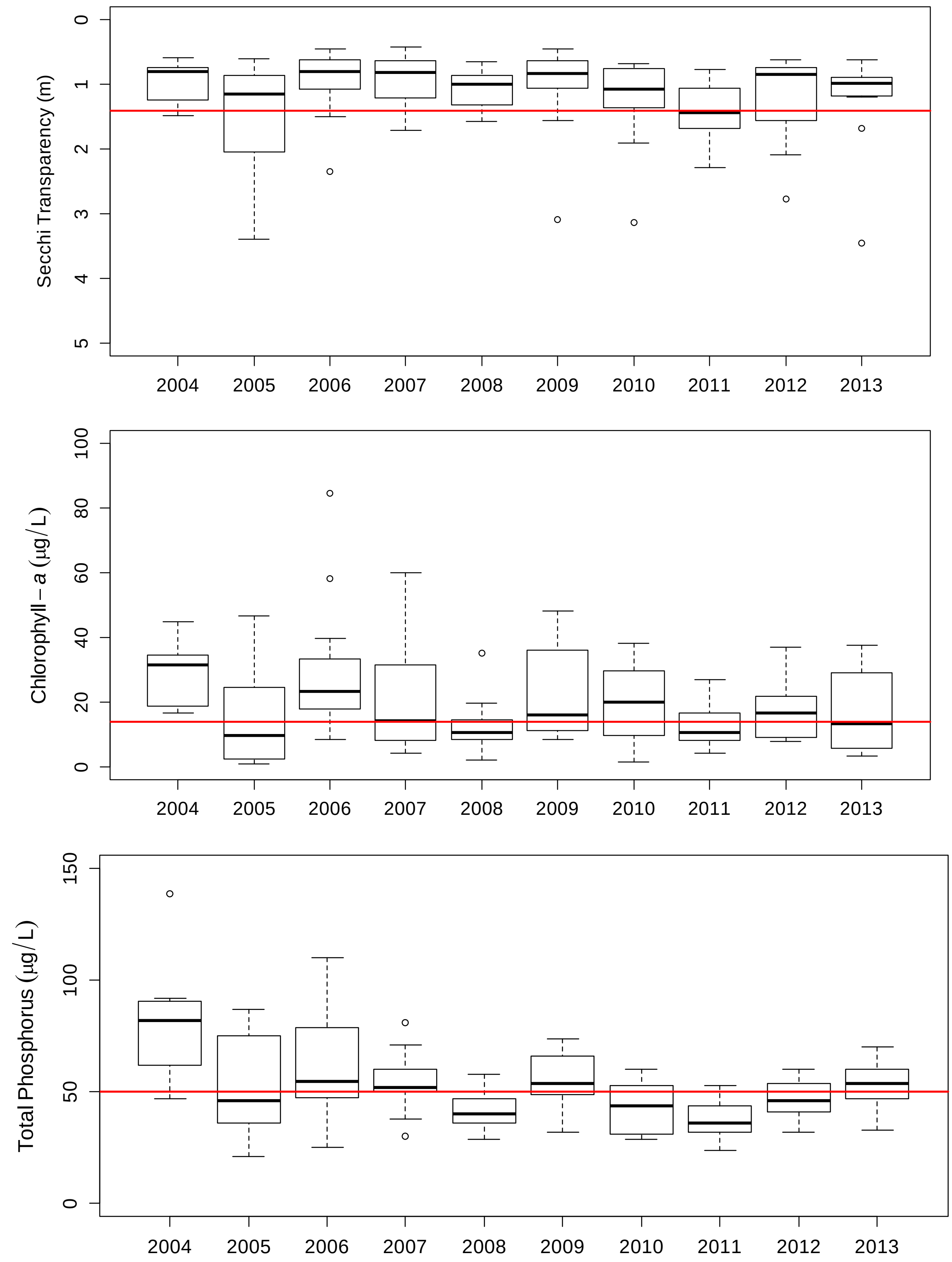


Figure 12-5. Box and whisker plots of Lake Nokomis TSI data from the last ten years. Horizontal lines represent Lake Nokomis site specific eutrophication standards. See Appendix A for the entire period of record

BEACH MONITORING

Bacteria levels were monitored at Nokomis Main Beach and Nokomis 50th Street Beach during 2013. As shown in **Table 12-2**, the season long geometric mean for *E. coli* was low for both beaches. The beaches on Lake Nokomis remained open for the entire 2013 beach season. Further details on MPRB beach monitoring can be found in **Section 19**.

Table 12-2. Summary of 2013 *E. coli* results (MPN colonies per 100 mL) on Lake Nokomis beaches.

Statistical Calculations	Nokomis 50th	Nokomis Main
Number of Samples	13	13
Minimum	2	3
Maximum	110	69
Median	9	19
Mean	20	25
Geometric Mean	10	18
Max 30-Day Geo Mean	29	29
Standard Deviation	31	21

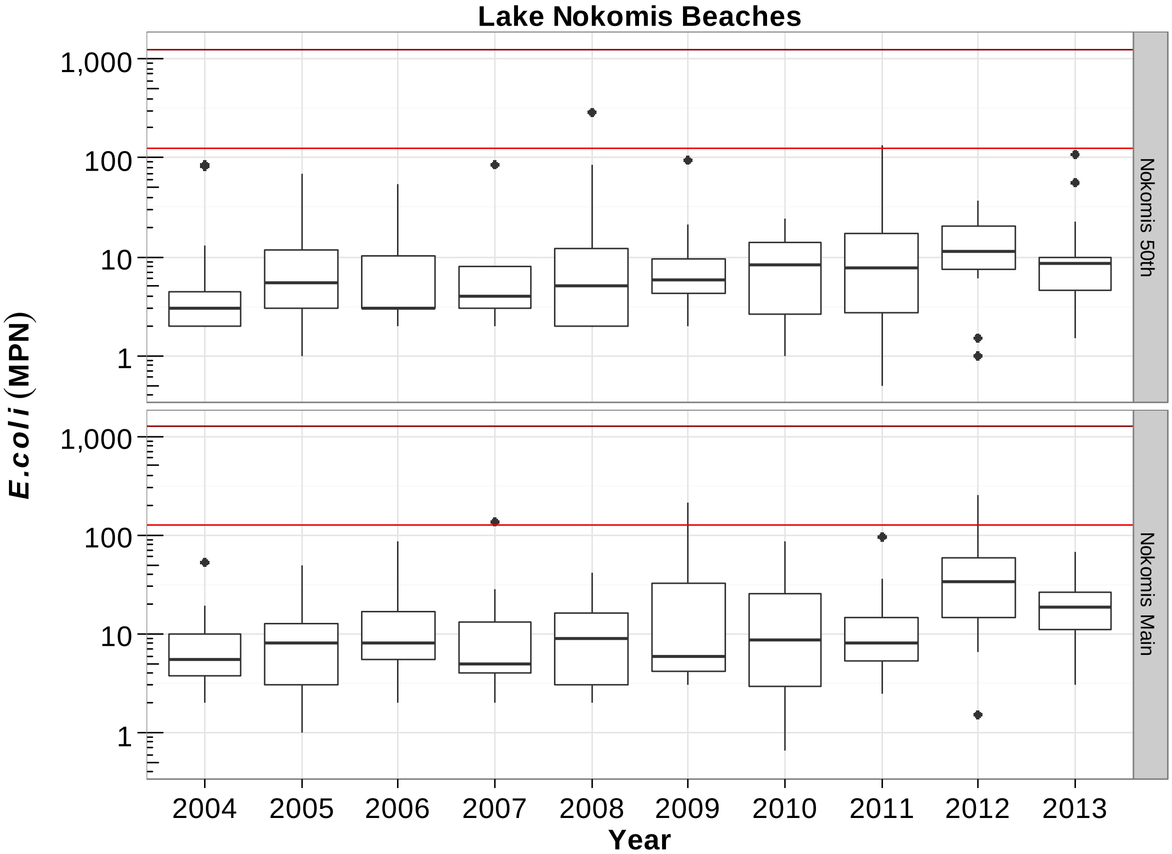


Figure 12-6. Box plots of Nokomis beach *E. coli* results (MPN per 100 mL), 2004–2013. The horizontal lines represent the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL) and the single-sample maximum standard (1260 MPN/100mL). Note the log scale on the Y-axis. From 2004-2009 E. coli concentrations were determined as colony forming units (CFU/100ml).

Figure 12-6 shows the box and whisker plots for *E. coli* sampling results (per 100 mL) for data collected from 2004 to 2013. The light red line represents the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL), while the dark red line represents the single-sample maximum standard (1260 MPN/100mL). The box and whisker plots show the data distribution for the sampling between years.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

Figure 12-7 shows the LAURI scores for Lake Nokomis. The lake scored "excellent" in aesthetics, public health, and recreation access. Habitat quality and water clarity were scored as "good." Large amounts of algae limit water clarity which prevents light from penetrating into the water column and limits the amount of plant growth in the lake. See **Section 1** for details on the LAURI index.

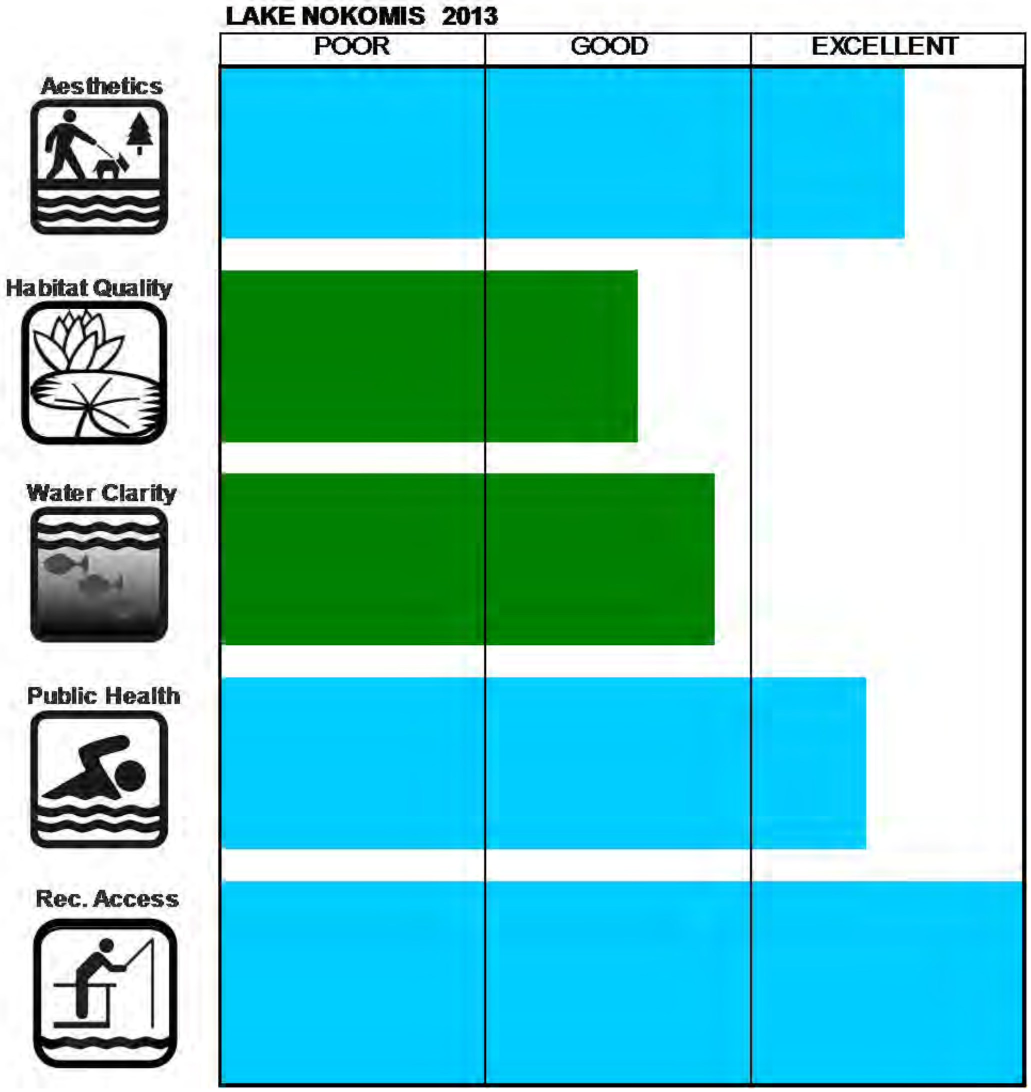


Figure 12-7. The 2013 LAURI Index scores for Lake Nokomis.

WINTER ICE COVER

Ice came off Lake Nokomis on April 27, 2013, twenty three days later than average and the latest ice-off date recorded for the lake. Ice came back on to the lake for the winter on November 27, 2013 which was four days earlier than average for the lake. See **Section 1** for detailed winter ice records and **Section 18** for comparison with other lakes.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian watermilfoil. Permits limit the area from which milfoil can be harvested in order to protect fish habitat. The permits issued to the MPRB allow for harvesting primarily in swimming areas, boat launches and in shallow areas where recreational access is necessary. The permitted area on Lake Nokomis is typically about 25 acres, which is just under 25% of the littoral zone (area shallower than 15 feet). In 2013, 1truckload of aquatic plants was removed from the beach areas at Lake Nokomis using SCUBA divers. See **Section 1** and **Section 20** for details on aquatic plants.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 12-8** shows the phytoplankton community in Lake Nokomis and **Figure 12-9** shows the chlorophyll-*a* and Secchi data for the sampling season. 2013 was a typical year for the phytoplankton community in Lake Nokomis. Cyanophyta (blue-green algae) dominated at over 80% of total biomass in nearly all samples. Chrysophyta (golden algae) were present early in spring. Diatoms (Bacillariophyta) and green algae (Chlorophyta) were present at low concentrations throughout of the sampling season.

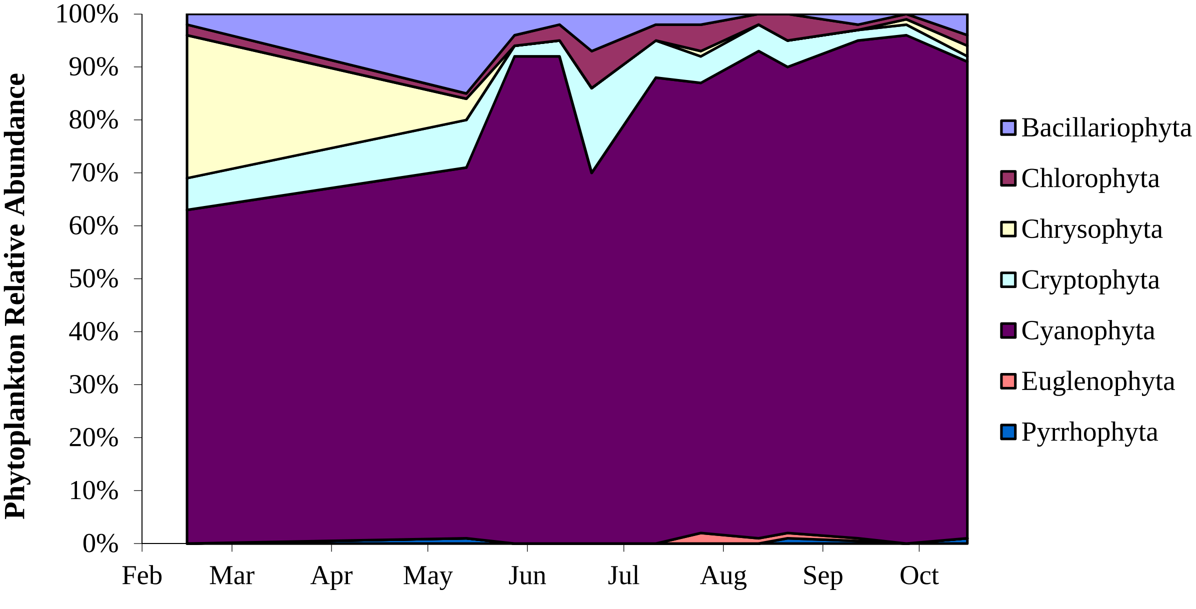


Figure 12-8. Lake Nokomis relative abundance of phytoplankton divisions for 2013.

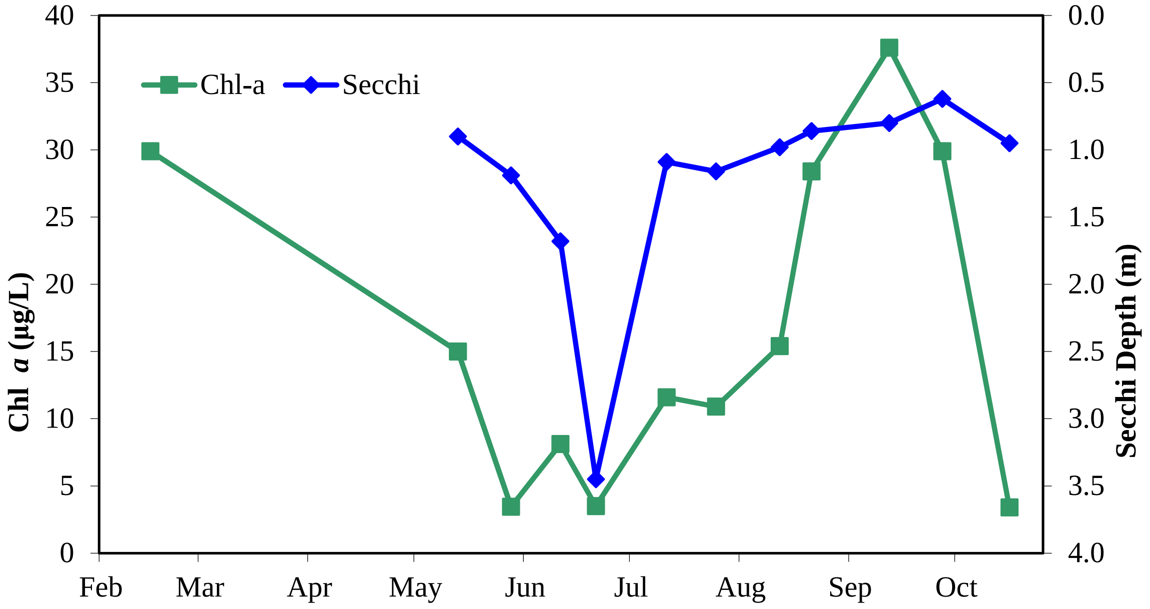


Figure 12-9. Lake Nokomis 2013 chlorophyll-*a* and Secchi data (note reversed axis).

As can be seen in **Figure 12-9,** water clarity roughly paralleled chlorophyll-*a* concentrations in 2013. The 2013 zooplankton distribution and chlorophyll-*a* in Lake Nokomis is shown in **Figure 12-10**. Rotifers exhibited two peaks, a large peak in early summer and smaller peak in September. Nauplii and juvenile zooplankton were present throughout the season, spiking in May and July. Cyclopoids and calanoids were present in most samples, but were found at low densities compared to the other groups.

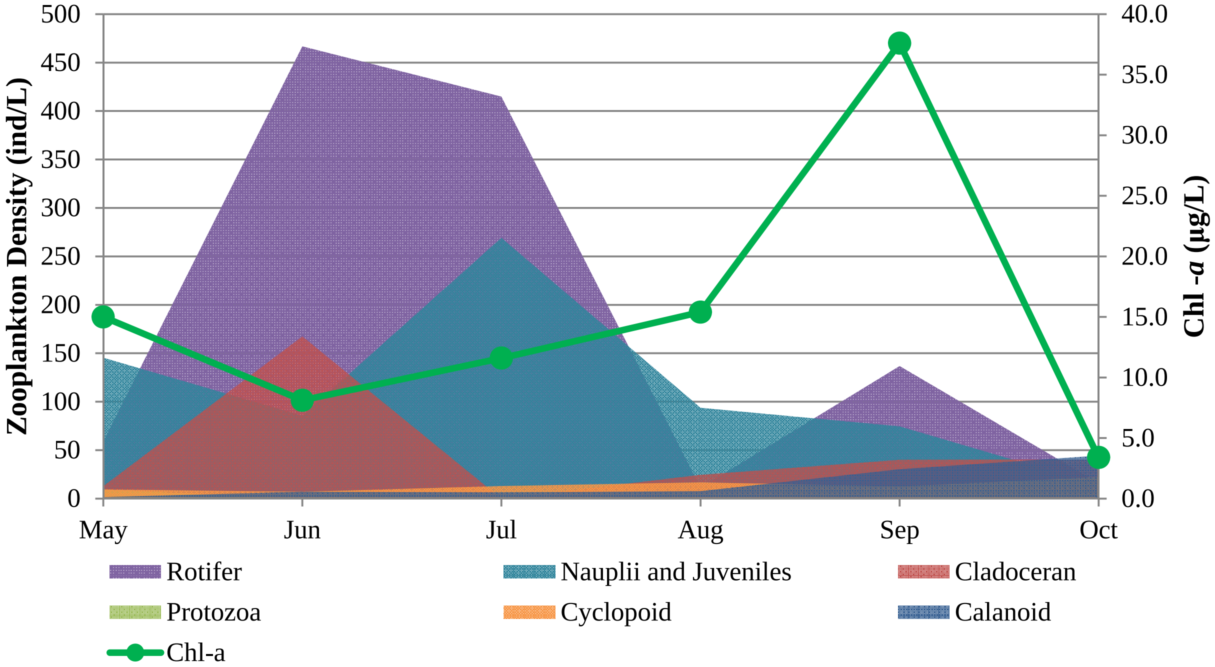


Figure 12-10. Zooplankton distribution in 2013 in Lake Nokomis.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling and adult fish can be found in **Section 1**.

Lake Nokomis was stocked by the MDNR in:

1998 with 400 fingerling Tiger Muskellunge.
1999 with 82,144 fry Tiger Muskellunge, 773 fingerling Walleye, 46 yearling Walleye.
2000 with 300 fingerling Tiger Muskellunge.
2001 with 8,065 fingerling Walleye.
2002 with 300 fingerling Tiger Muskellunge.
2003 with 7,873 fingerling Walleye.
2005 with 4,266 fingerling Walleye.
2006 with 300 fingerling Tiger Muskellunge.
2007 with 740 yearling Walleye, 63 fingerling Walleye, 156 adult Walleye.
2009 with 458 fingerling Tiger Muskellunge and 7,718 fingerling Walleye.
2010 with 200 fingerling Tiger Muskellunge.
2011 with 9,376 fingerling Walleye.
2012 with 200 Tiger Muskellunge and 2,000 yearling Walleye.
2013 with 8,476 fingerling Walleye.

EVENTS REPORT

On July 28, 2010, zebra mussels (*Dreissena polymorpha*) were confirmed to be present in Lake Minnetonka and at the headwaters of Minnehaha Creek by MDNR ecologists. The MDNR declared both Lake Minnetonka and Minnehaha Creek to be infested with zebra mussels. All public waters with Minnehaha Creek connections were also declared infested with zebra mussels including: Meadowbrook Lake, Lake Nokomis, and Lake Hiawatha. MRPB and affiliate group Friends of Lake Nokomis monitor zebra mussel sampling plates in Lake Nokomis monthly. Additionally, the fixed weir installed in 2012 will protect Lake Nokomis from zebra mussel veligers floating down Minnehaha Creek, a proactive approach to protect the lake from invading forces. As of the fall of 2013, no zebra mussels have been found in Lake Nokomis.

MPRB’s Zebra Mussel Action Plan can be found on the MPRB website keywords Zebra Mussel Action Plan.

MCWD began a three year biomanipulation study in 2010 to reduce excessive algal growth by manipulating the fish community. Black bullheads were seined from the lake and walleyes were stocked in order to reduce sediment disturbance by fish foraging. Early results show a decline in black bullhead and stunted bluegill populations. However, the macrophyte community is not responding quickly, as much of the littoral zone remains free of aquatic plants. It may take years to see potential benefits to biomanipulation and MPRB will continue to monitor any long term effects. More information can be found at http://www.minnehahacreek.org/project/lake-nokomis-biomanipulation-project.

13. POWDERHORN LAKE

HISTORY

Powderhorn Lake was acquired by the Minneapolis Park and Recreation Board (MPRB) in 1890 and was named because its original shape resembled a gun's powderhorn. Dipper dredge operations were conducted shortly thereafter from 1894 to 1904. Between 1924 and 1925 the south end of the lake was deepened by hydraulic dredging with nearly 150,000 cubic yards of spoils used to fill the north half to create parkland. Powderhorn Lake has always been a very popular neighborhood lake. It has been stocked by the MDNR as a Kid's Fishing Pond since 1980. Powderhorn Park hosts several large community events including the May Day Festival and the Powderhorn Art Festival.

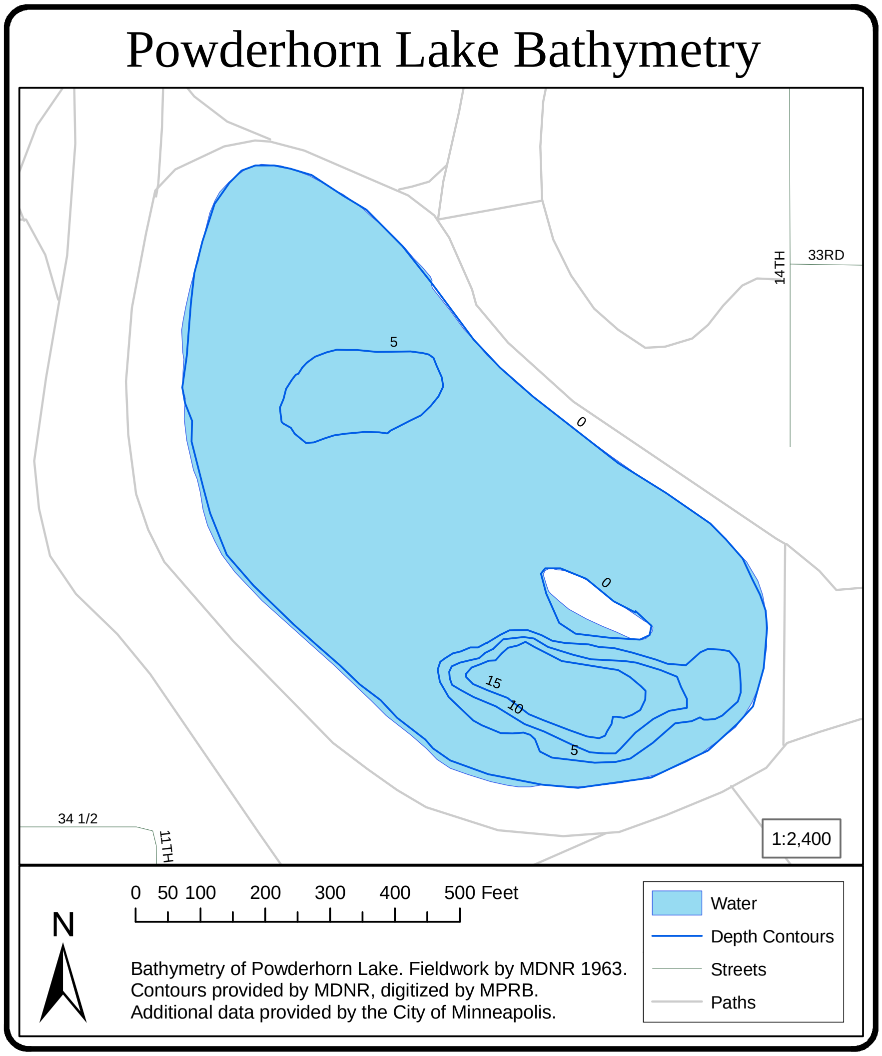
Figure 13-1. Powderhorn Lake.

Powderhorn is a shallow lake with an island and one deep hole at its southeastern end (**Figures 13-1 and 13-2, Table 13-1**). Computer modeling indicates the lake was historically eutrophic (MPRB, 1999). Restoration activities were implemented as early as 1975 when a temporary summer aerator was installed to increase oxygen content in deeper water and to prevent fish kills. In 1995, a winter aeration system was installed with the MDNR to provide a refuge for fish and prevent winter fish kills. Lake water levels are occasionally augmented with groundwater.

The MPRB and Minneapolis Public Works (MPW) developed a major restoration plan for Powderhorn Lake in 1999. In 2001, five continuous deflective separation (CDS) grit chambers were installed to remove solids from stormwater inflow. In 2002, native plants were planted to improve aesthetics and habitat, and to filter overland flow from the park. Restoration also included repairing the Works Progress Administration (WPA) stone wall, removing concrete sluiceways, and installing a permanent summer aerator. An alum treatment was conducted in May 2003 to limit phosphorus availability. The combined effects of these restoration projects have improved water quality in Powderhorn Lake; however, the large amount of stormwater entering the lake from its watershed inhibits further improvement.

The MPRB has installed barley straw treatments at Powderhorn every spring since 2004 to control algal growth. While it is difficult to ascertain which restoration activities have benefited the lake the most, the barley straw treatments seem to have been an important tipping point for improving water clarity. Macrophyte beds were first noted in 2006 and led to improved clarity and lower nutrient levels in the lake. In 2010, extensive duckweed (*Lemna spp.*) beds covered the lake and shaded out macrophyte growth. Since 2011, filamentous algae dominated large portions of the lake bed and water surface. The decomposition of thick plant and filamentous algae growth combined with a hot dry summer has led to low oxygen levels in the lake.

Restoration efforts shifted in 2007 when the invasive species *Egeria densa* (Brazilian waterweed) was discovered growing in several small but dense stands in the lake. During the fall of 2007, the MDNR treated the invasive plant with herbicide Diquat to target and eradicate the unwanted species. At the request of the MDNR, the MPRB did not use the Powderhorn Lake winter aeration system during the winter of 2007. *Egeria* has not been identified in the lake since the herbicide treatment.



Bathymetry of Powderhorn Lake. Fieldwork by MDNR 1963.
Contours provided by MDNR, digitized by MPRB.
Additional data provided by the City of Minneapolis.

Figure 13-2. Bathymetric map of Powderhorn Lake.

MPCA removed Powderhorn Lake from the EPA 303(d) list of impaired waters in 2012 due to a strong trend towards improved water quality. MPCA and MPRB will continue to evaluate the lake for potential improvement options. Improving oxygen levels, reducing trash accumulation, and reducing filamentous algae growth are all areas where improvements could continue at the lake.

Table 13-1. Powderhorn Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
11	1.2	6.1	99%	5.43×10^4	286	26.0	0.2

* Littoral area was defined as less than 15 feet deep.

LAKE LEVEL

Powderhorn Lake levels are recorded weekly during ice free season and are shown in **Figure 13-3** for 1999 through 2013. Powderhorn Lake levels are occasionally augmented with a groundwater well. There is no MDNR designated ordinary high water level (OHW) for Powderhorn Lake. See **Section 18** for comparison with other MPRB lake levels.

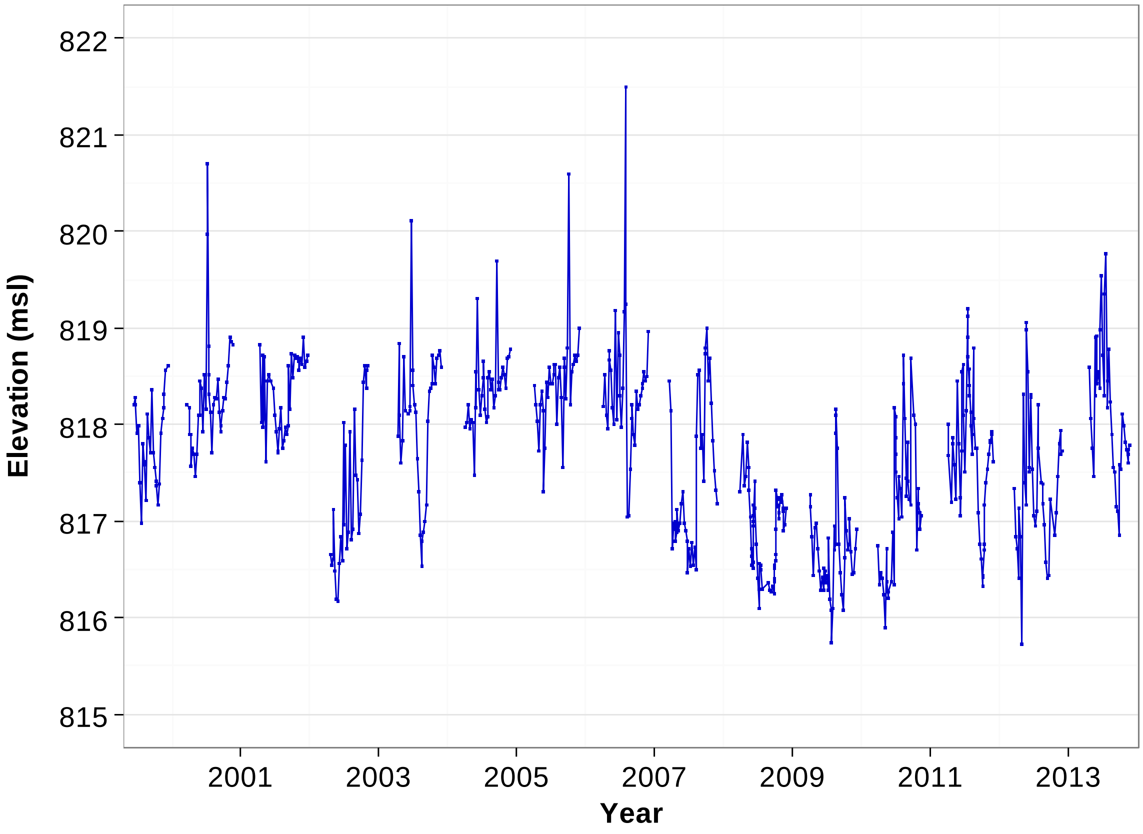


Figure 13-3. Powderhorn Lake levels from 1999 – 2013.

AUGMENTATION WELL

A groundwater well is used to maintain the water level at Powderhorn. The MDNR issues permits and determines pumping limits for augmentation wells. In 2006, the permitted pumping volume decreased from 26 million gallons per year to 10 million gallons per year. MPRB staff records groundwater usage monthly. **Table 13-2** shows the annual water usage since 2007. The groundwater well was not used in 2010. See **Section 1** for detailed information on MPRB augmentation wells.

Table 13-2. Powderhorn Lake yearly pumping volume in gallons.

2007 Total (gal)	2008 Total (gal)	2009 Total (gal)	2010 Total (gal)	2011 Total (gal)	2012 Total (gal)	2013 Total (gal)
11,184,600	8,785,200	5,824,800	No Pumping	10,371,600	8,014,500	3,261,600

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Powderhorn Lake has historically been eutrophic due to high nutrient levels. **Figure 13-4** shows TSI scores and a regression line for Powderhorn Lake. Powderhorn Lake has a TSI score of 71 in 2013 and is approximately average for the Northern Central Hardwood Forest ecoregion falling near the 50th percentile for this ecoregion (MPCA, 2004). Water quality has fluctuated over the past 20 years with improved TSI scores during restoration efforts from 2001-2009. CDS units decreased phosphorus, solids, and sediment inputs, annual barley straw treatments increased water clarity, and an alum treatment briefly decreased phosphorus and increased water clarity. However, after the majority of Restoration Plan projects had been completed in 2009, the trend is changing towards higher TSI scores and lower water quality. A detailed explanation of TSI can be found in **Section 1**.

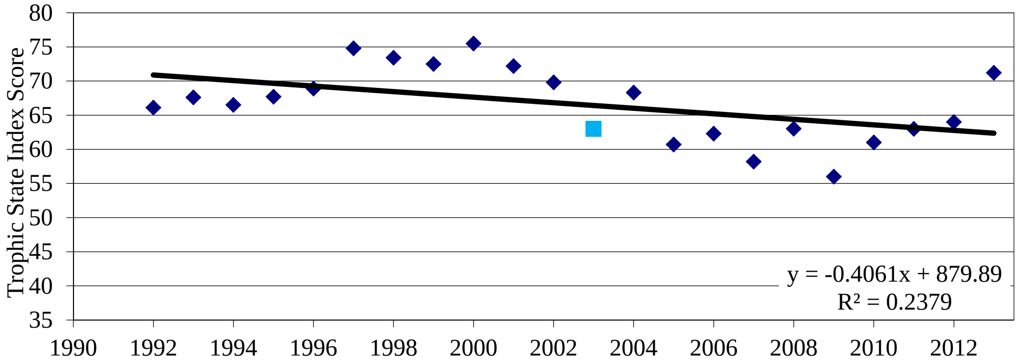


Figure 13-4. Powderhorn Lake TSI scores and regression analysis. The blue square highlights the 2003 alum treatment.

BOX AND WHISKER PLOTS

Figure 13-5 shows box and whisker plots for the Powderhorn Lake data for the past ten years. MPCA shallow lake standards are shown as a horizontal line across the graph. A further detailed explanation of box and whisker plots can be found in **Section 1**. Box and whisker plots from the entire period of record from Powderhorn Lake can be found in **Appendix A.**

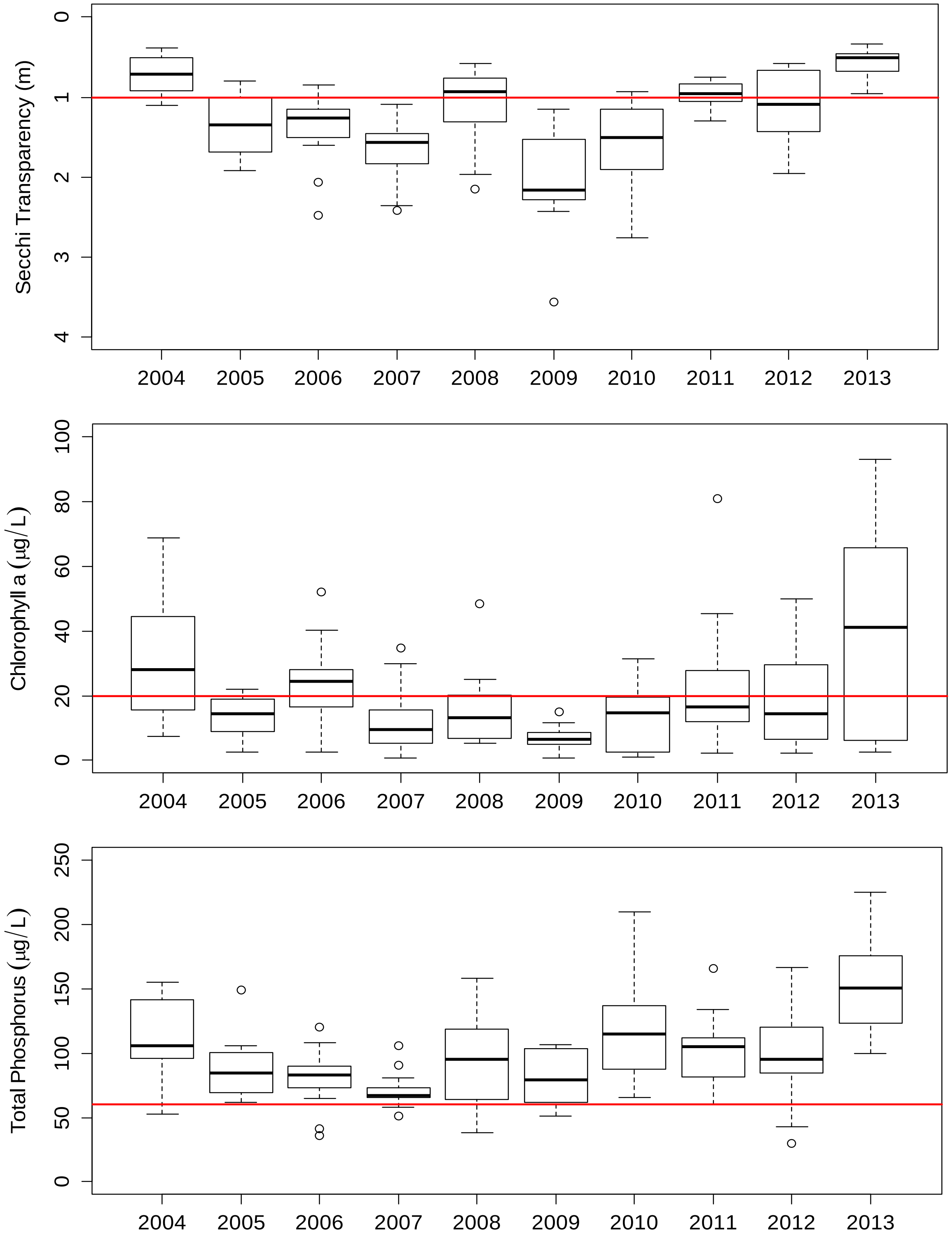


Figure 13-5. Box and whisker plots of data from Powderhorn Lake: 2004-2013. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

Marked improvements in the TSI measures have been seen in Powderhorn Lake since the restoration projects were completed, but have increased to pre-restoration levels in recent years. In 2013, all of the Secchi and phosphorus data collected did not meet MPCA standards. Average chlorophyll-*a* data did not meet standards either. As shown in **Appendix A**, 2013 data better match data from the late 1990s than the mid-2000s.

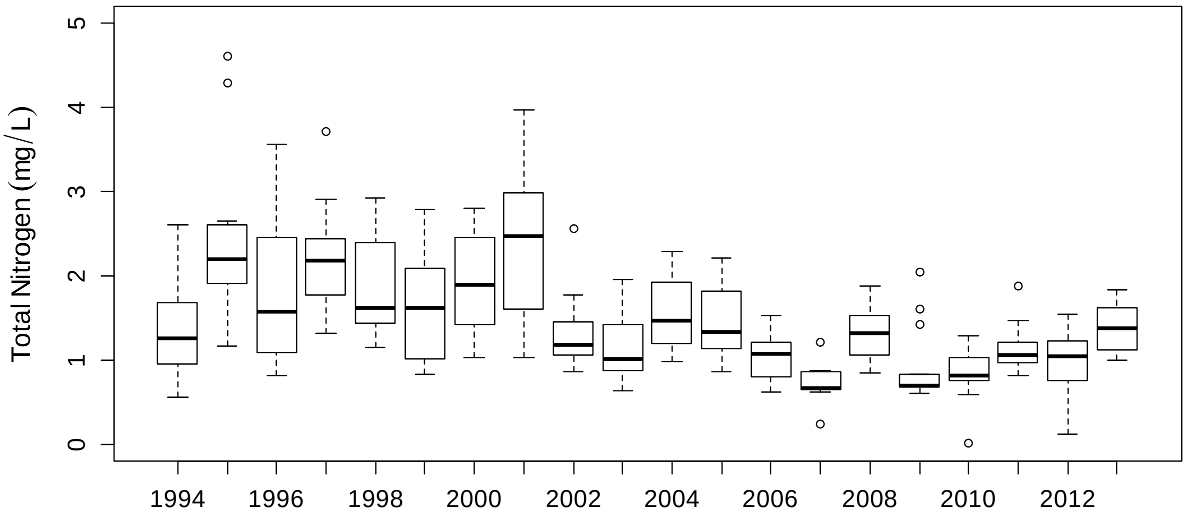


Figure 13-6. Total nitrogen data from Powderhorn Lake: 1994- 2013.

Nitrogen levels remain lower than pre-2001 levels, as shown in **Figure 13-6.** It is unknown why nitrogen levels have decreased so drastically. CDS units and grit chambers were installed in the watershed at this time, but the mechanism by which these BMPs would influence nitrogen is not known.

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The LAURI for Powderhorn Lake is shown in **Figure 13-7**. Powderhorn Lake scored "excellent" in aesthetics and "good" in habitat quality. Powderhorn received a score of "poor" in recreational access and water clarity. Powderhorn Lake does not have a swimming beach and was not scored for public health. See **Section 1** for details on the LAURI.

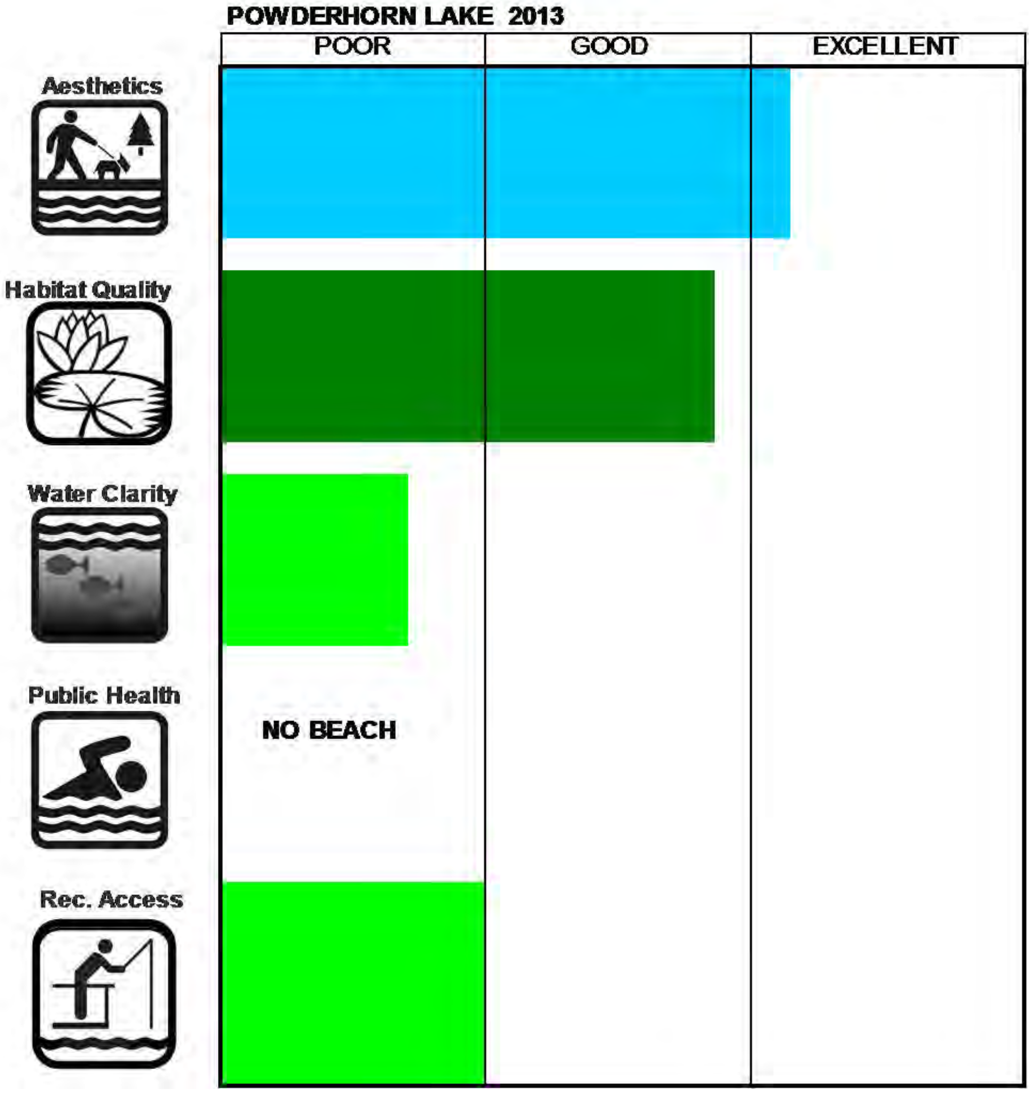


Figure 13-7. The 2013 LAURI scores for Powderhorn Lake.

WINTER ICE COVER

Ice came off of Powderhorn Lake on April 27, 2013, twenty three days later than average and the latest ice-off date recorded for the lake. Ice came back onto the lake on November 25, 2013, which was four days earlier than the average ice-on date for the lake. Waterfowl keep Powderhorn Lake open later in some years. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 13-8** shows the 2013 phytoplankton community structure and **Figure 13-9** shows the chlorophyll-*a* and Secchi transparency data for Powderhorn Lake. **Figure 13-10** shows the zooplankton densities sampled during 2013 along with chlorophyll-*a* concentrations.

The phytoplankton community in Powderhorn Lake was rather diverse in February. In May, Bacillariophyta (diatoms) were dominant, followed by a Cryptophyta (cryptomonads) peak in June. Chlorophyta (green algae) bloomed in July, lasting until a Cyanophyta (blue-green algae) bloom in August. Euglenophyta (euglenoids) and Pyrrhophyta (dinoflaggelates) were present at low concentrations in summer and spring, respectively. Chlorophyll-*a* measurements correlated well with Secchi readings indicating that the presence of algae may be a main driver of water clarity in the lake.

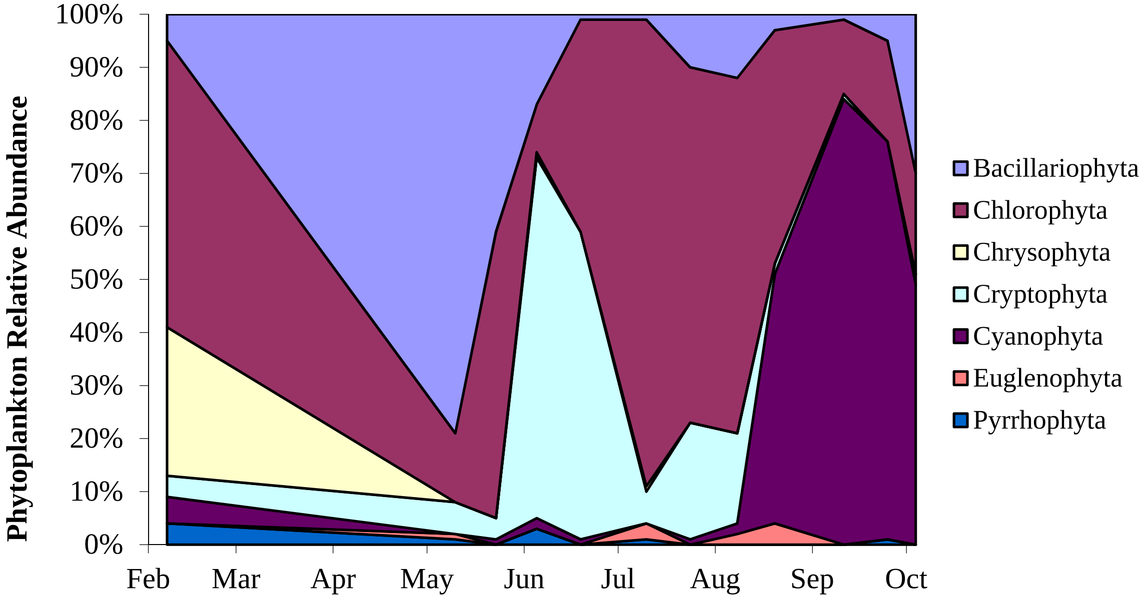


Figure 13-8. Relative abundance of phytoplankton in Powderhorn Lake during the 2013 sampling season.

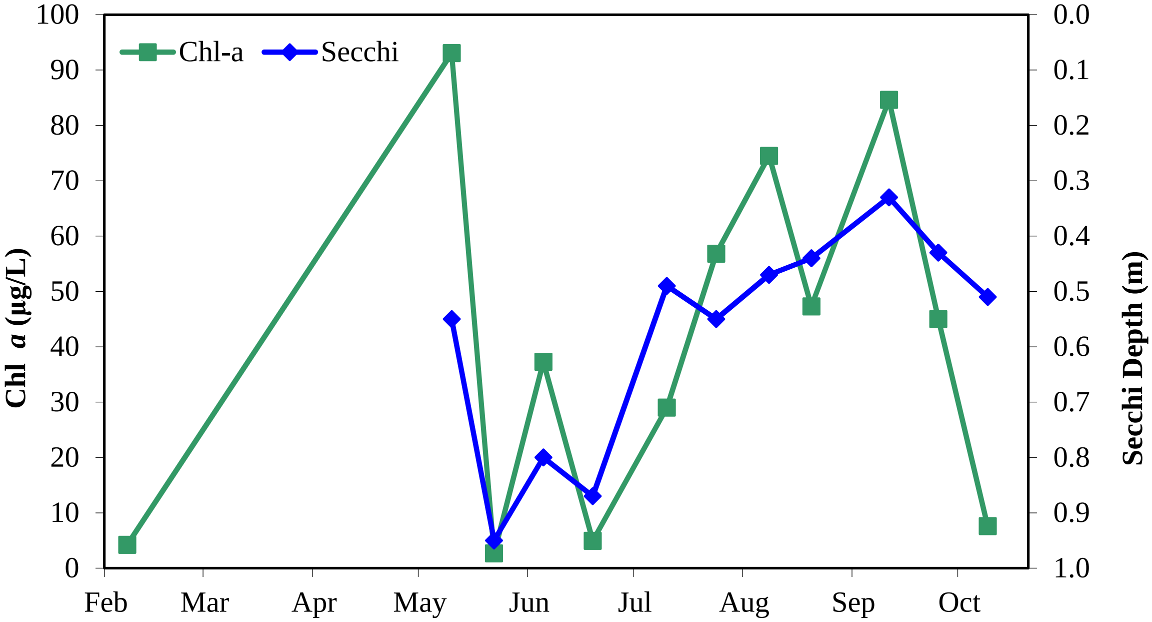


Figure 13-9. Powderhorn Lake 2013 chlorophyll-*a* and Secchi data (note reversed axis for Secchi depth).

No category of zooplankton remained at consistent levels throughout the season in Powderhorn. Rotifers spiked in May and in August. Cladocerans were present throughout the season and peaked at very high levels in July and September. Nauplii and cyclopoida also spiked in July, but tapered off to low levels throughout the remainder of the season.

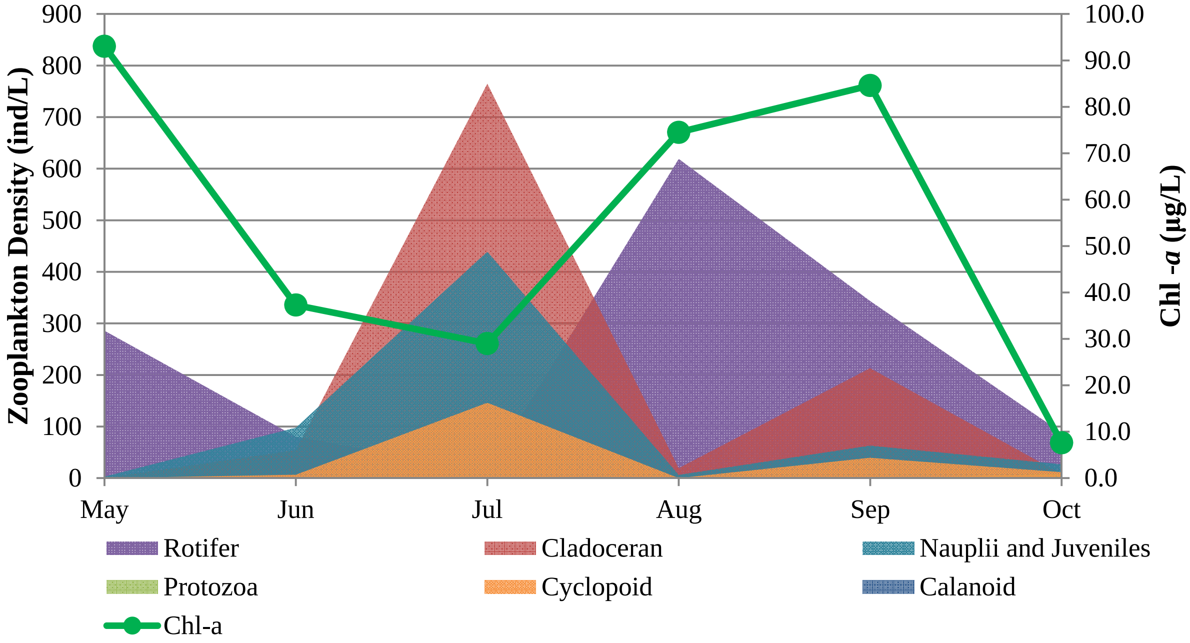


Figure 13-10. Zooplankton distribution in Powderhorn Lake during 2013.

FISH STOCKING

Additional fish stocking information can be found in **Section 1**.

Powderhorn Lake was stocked by the MDNR in:

1998 with 585 adult Bluegill Sunfish.
1999 with 501 adult Black Crappie, 1,008 adult Bluegill Sunfish, 9 adult Largemouth Bass.
2000 with 380 adult Black Crappie, 1,728 adult Bluegill Sunfish.
2001 with 510 adult Black Crappie, 1,002 adult Bluegill Sunfish.
2002 with 510 adult Bluegill Sunfish.
2003 with 422 adult Black Crappie, 1,614 adult Bluegill Sunfish.
2004 with 270 adult Black Crappie, 516 adult Bluegill Sunfish, 99 adult Channel Catfish.
2005 with 500 adult Bluegill Sunfish, 120 adult Channel Catfish.
2006 with 500 adult Bluegill Sunfish, 100 adult Channel Catfish.
2007 with 500 adult Bluegill Sunfish, 85 adult Channel Catfish.
2008 with 500 adult Bluegill Sunfish, 117 adult Channel Catfish, and 1 adult Largemouth Bass.
2009 with 499 adult Bluegill Sunfish, 75 adult Channel Catfish, 20 adult Largemouth Bass.
2010 with 623 adult Bluegill Sunfish, and 137 adult Channel Catfish.
2011 with 277 adult Bluegill Sunfish, 116 adult Channel Catfish, and 13 adult Largemouth Bass.
2012 with 711 adult Bluegill Sunfish, and 35 adult Channel Catfish.

WATER QUALITY PROJECTS

Water quality improvement projects have been implemented to improve the health of Powderhorn Lake and are detailed in the History section of this chapter. Barley straw was first used at Powderhorn Lake in 2004 when 250 pounds/acre were added. Barley straw is applied by staking loose bales below the surface of the water where it slowly decomposes. The first treatment appeared to have little effect. Application rates were increased to 364 lbs/ac or 4000 pounds for the lake, and appear to have been more successful. 2013 was the tenth application of barley straw to Powderhorn Lake.

14. RYAN LAKE

HISTORY

Ryan Lake is a small body of water that borders the cities of Robbinsdale, Brooklyn Center, and Minneapolis and is shown below in **Figure 14-1**. The Canadian Pacific Railway owns a rail line corridor in the Humboldt Industrial Park that runs along the northern shore of the lake. The City of Minneapolis owns land on the east side of the lake which is maintained by the Minneapolis Park and Recreation Board (MPRB). Private residents own the west and the south shores of Ryan Lake. The MPRB installed a new dock on the east side for use by the public in 2006. In the spring of 2006, a small rain garden was constructed. **Figure 14-2** shows a bathymetric map of Ryan Lake and **Table 14-1** shows the morphometric data on Ryan Lake.

Figure 14-1. View at Ryan Lake, 2012.

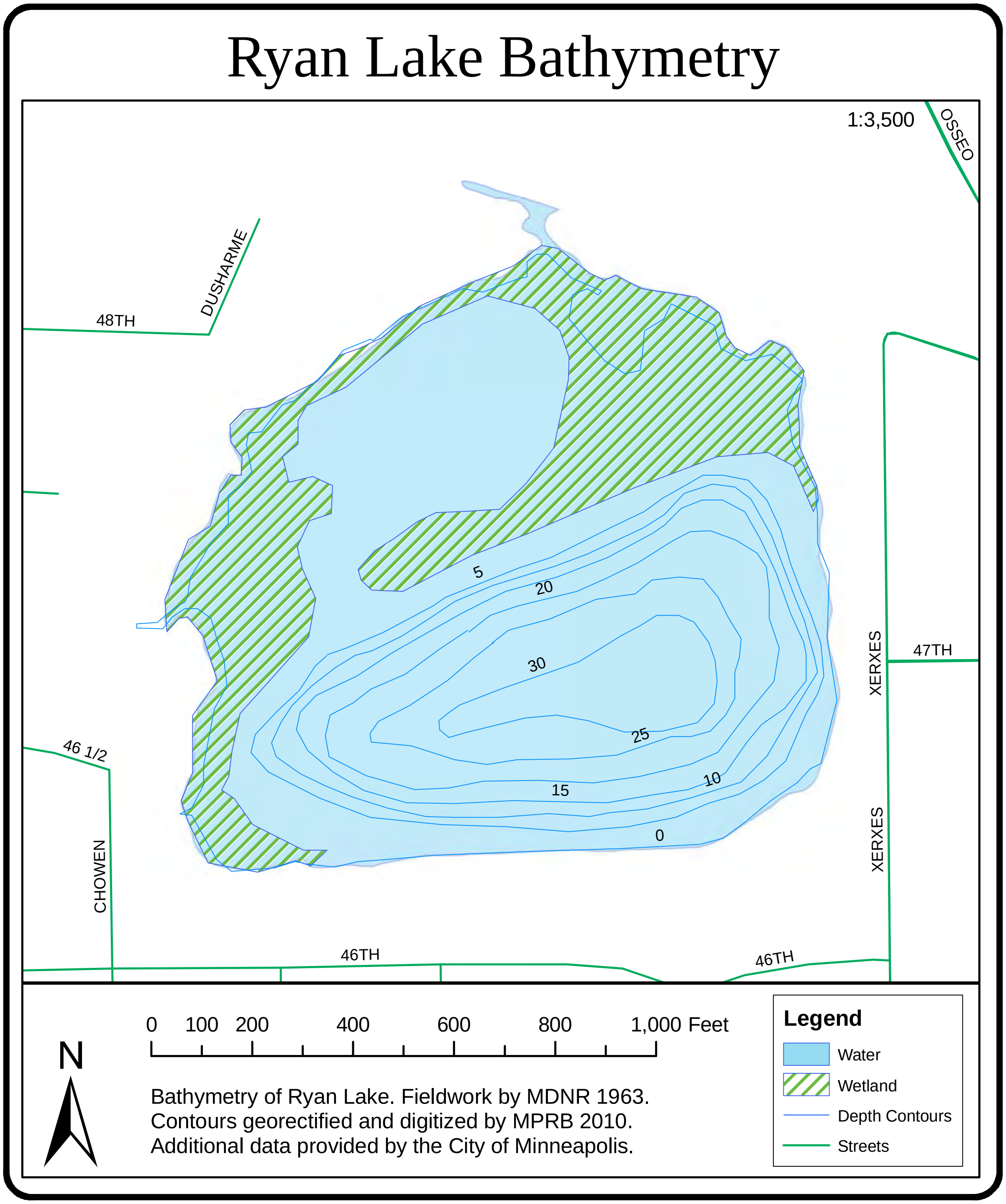


Figure 14-2. Bathymetric map of Ryan Lake.

Table 14-1. Ryan Lake morphometric data. OHW= designated ordinary high water level.

Surface Area (acres)	Max Depth (m)	Littoral Area*	Watershed Area (acres)	Watershed:Lake Area (ratio)	OHW (ft msl)
19	10.7	50%	5,510	306	849.6

*Littoral area was defined as less than 15 feet deep.

Ryan Lake has been monitored periodically through the Metropolitan Council's Citizen Assisted Monitoring Program (CAMP) since 1994. Over the years, the Ryan Lake CAMP score has fluctuated between a "B" and "D", with a most recent score of a "B". Additional information on the CAMP monitoring at Ryan Lake can be found through the Metropolitan Council on their Wastewater and Water Publications and Resources webpage.

WINTER ICE COVER

Ice was off of Ryan Lake on April 27, 2013, twenty two days later than average and the latest ice-off date recorded for the lake. Ice came back to Ryan Lake on December 2, 2013, the median ice-on date but six days earlier than the average ice-on date. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

FISH STOCKING

Additional information on fish stocking can be found in **Section 1**. Ryan Lake was stocked by MDNR in:

2004 with 20 adult Black Crappie, 30 adult Bluegill Sunfish, and 5 adult Largemouth Bass

2007 with 20 adult Black Crappie, 24 adult Bluegill Sunfish, 10 adult Largemouth Bass, and 8 adult Northern Pike.

2008 with 31 adult Bluegill Sunfish, and 100 Yellow Perch.

2009 with 20 adult Bluegill Sunfish, and 21 adult Yellow Perch.

2010 with 20 adult Black Crappie, 20 adult Bluegill Sunfish, and 20 adult Yellow Perch.

2011 with 20 adult Bluegill Sunfish, 20 Black Crappie, and 6 Largemouth Bass

2013 with 130 yearling Yellow Perch.

15. SPRING LAKE

HISTORY

Spring Lake is located to the west of Loring Pond adjacent to Kenwood Parkway and the Parade Stadium grounds in central Minneapolis. Spring Lake was acquired by the MPRB in 1893 through a special assessment requested by citizens. Today the lake appears secluded, but at the time of purchase, Spring Lake was the park's focal point. In an unusual move for the time, a 2-acre area including the lake and surrounding land was designated as a bird sanctuary and kept in a natural state. Historic photos and documents show that the north side of the lake was once a lumberyard.

Despite being surrounded by parkland on three sides, Spring Lake is a definite urban lake, **Figure 15-1**. Highway 394 borders the northwest portion of the riparian zone and contributes stormwater runoff to the lake. Spring Lake receives water from a 195-acre subwatershed of the Bassett Creek watershed. These urban stormwater inputs contribute to meromixis in Spring Lake. Meromictic lakes do not mix completely so that the deeper layers of the lake remain continually stratified. It is difficult to compare meromictic lakes with dimictic or polymictic lakes, since their chemical, physical, and trophic structures are much different.

The typical sampling schedule requires Spring Lake to be monitored every other year; however, the lake has been sampled each year since 2011 in order to assess the water quality effects of artificial islands (see Water Quality Projects section below). **Table 15-1** shows morphometric data for the lake and **Figure 15-2** shows a map of Spring Lake.

Figure 15-1. Spring Lake in October, 2011. Two of the artificial islands are visible.

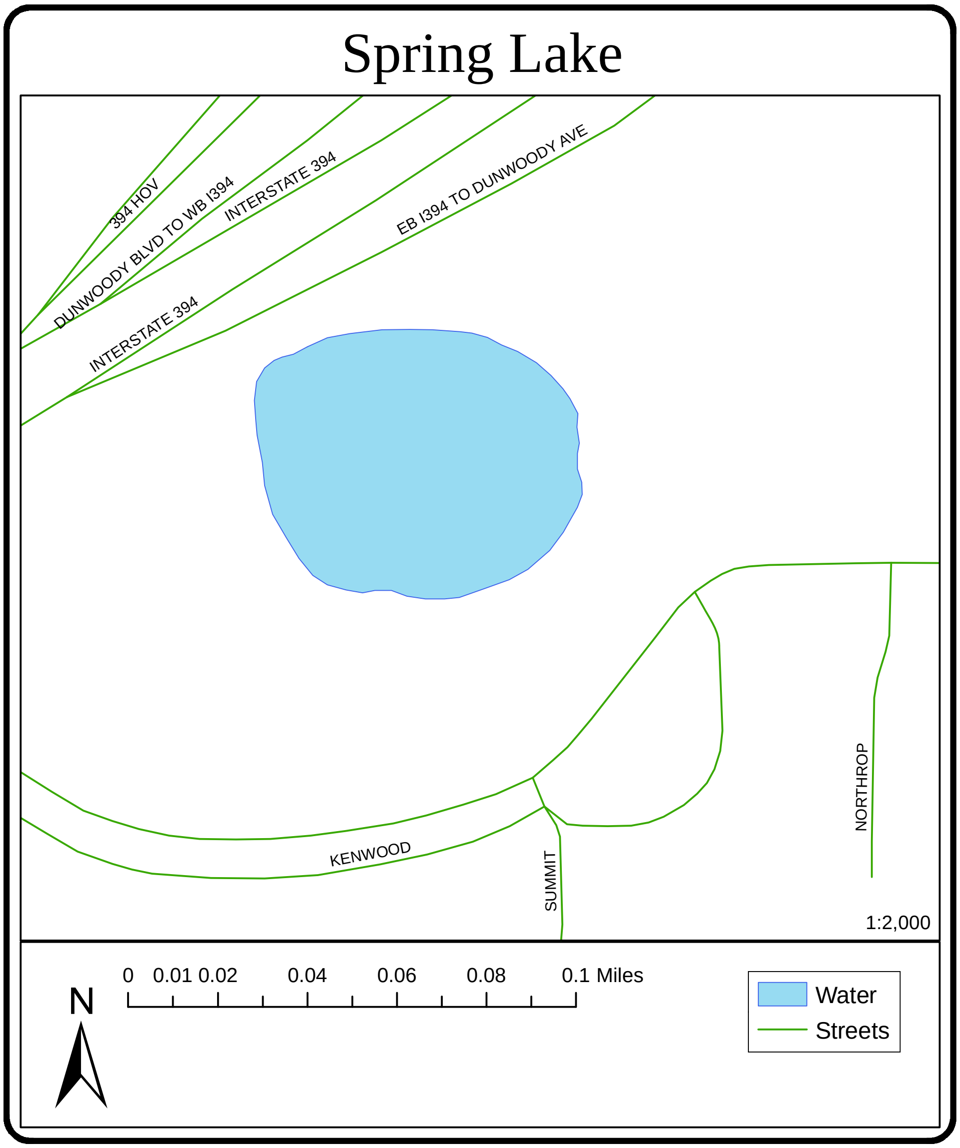


Figure 15-2. Spring Lake map.

Table 15-1. Spring Lake morphometric data. OHW=ordinary high water level.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	OHW (ft msl)
3	3.0	8.5	3.65×10^4	45	15.0	820.46

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Figure 15-3 shows the Spring Lake TSI linear regression to be roughly increasing. In 2013, Spring Lake had a TSI score of 71. A detailed explanation of TSI can be found in **Section 1**.

Spring Lake's TSI scores and trend line must be viewed with caution as both are based on a limited number of samples and the number of samples collected in a season has changed over time. From 1999–2001, samples were collected quarterly and only one sample per year was collected during the growing season; therefore, a TSI score could not be calculated. During 2002, 2003, and subsequent odd-numbered years Spring Lake was sampled monthly in order to calculate a TSI score. Although all of the data cannot be weighted equally because of sampling differences, the overall trend in Spring Lake appears to be towards increased productivity resulting in higher TSI scores and lower water quality.

The 303(d) assessment for impaired waters is limited to lakes of ten acres or greater (MPCA, 2014); therefore, Spring Lake is too small (3 acres) to be listed on MPCA's impaired waters list. However, it is still useful to compare Spring's data to the state standards to determine lake water quality.

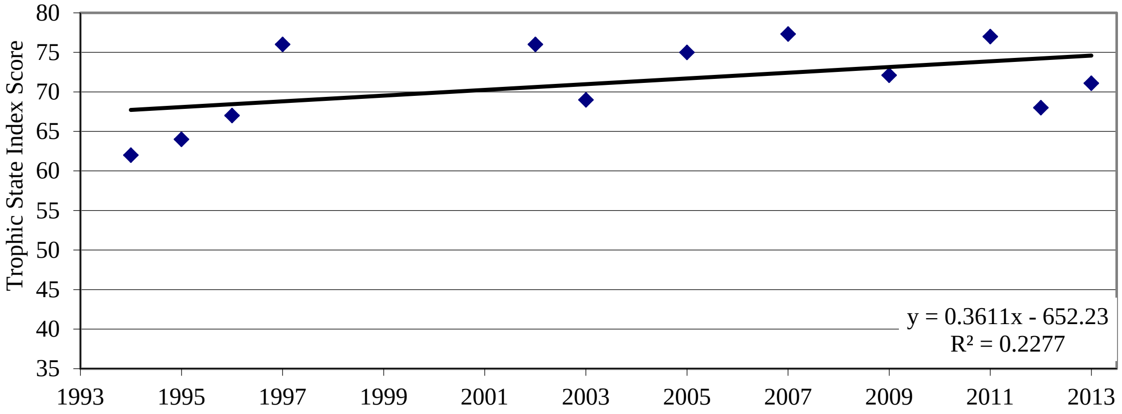


Figure 15-3. Spring Lake TSI scores and regression analysis.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 15-4** show the data distribution for the Secchi, chlorophyll-*a* and total phosphorus for Spring Lake over the last ten years. Horizontal lines indicate the MPCA nutrient criteria. A detailed explanation of box and whisker plots can be found in **Section 1**. Data in similar format for the entire period of record can be found in **Appendix A**.

Spring Lake is eutrophic with considerable amounts of algae. High nutrient concentrations in the lake generally contribute to high algal growth and shallow Secchi depths. Nutrient levels in Spring Lake are variable from year to year, but phosphorus levels remained high in 2013. Chlorophyll-*a* levels typically have had a wide annual range, perhaps due to seasonal algae blooms. However, since 2011, duckweed (*Lemna spp.*) has covered the lake for much of the summer. The thick layer of duckweed can shade photosynthetic algae, leading to lower chlorophyll-*a* concentrations, and create low dissolved oxygen levels. The fresh oxygenated layer that typically forms on the surface of Spring Lake was very thin to non-existent in 2013.

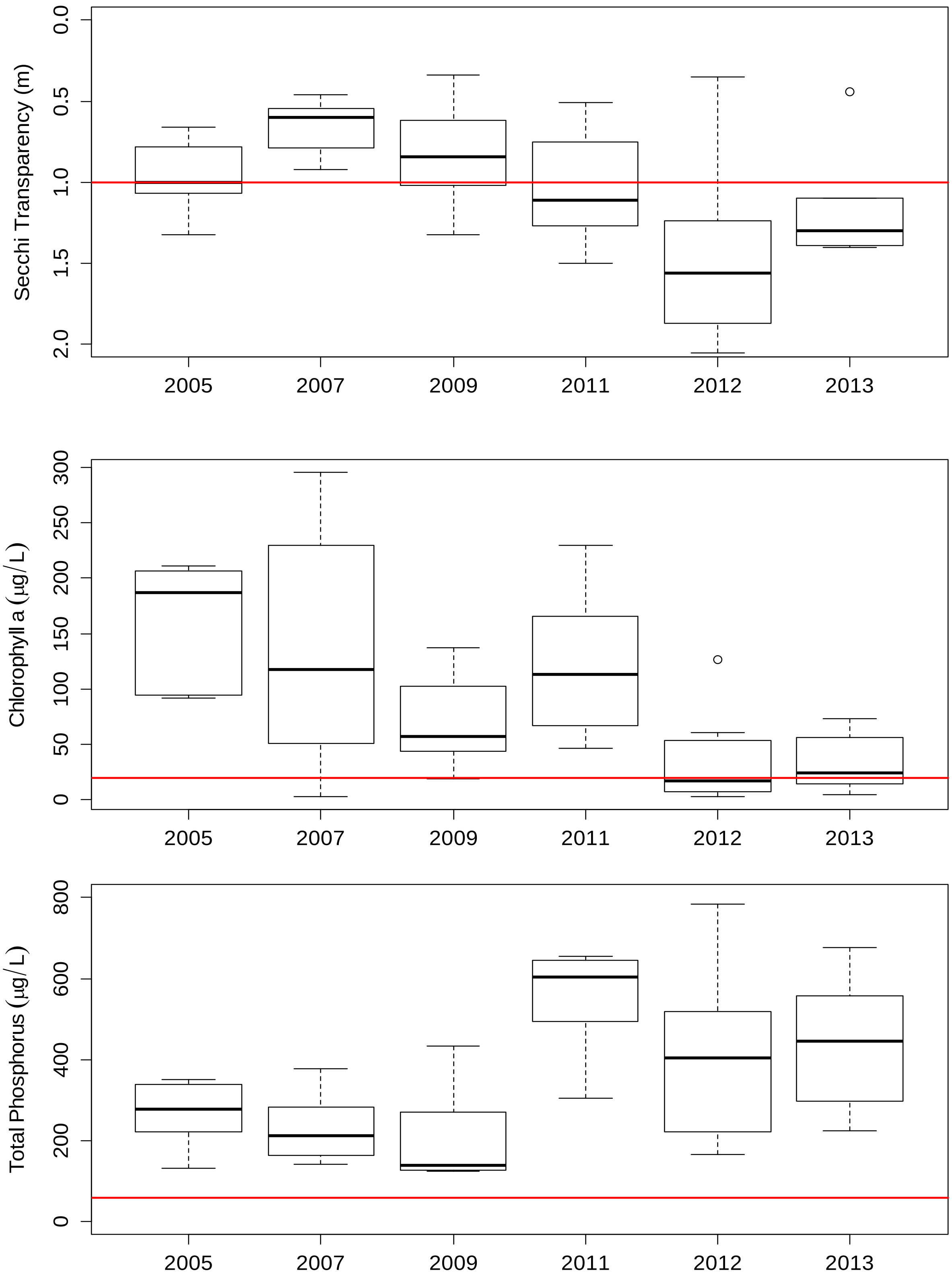


Figure 15-4. Box and whisker plots of Spring Lake TSI data: 2005-2013. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

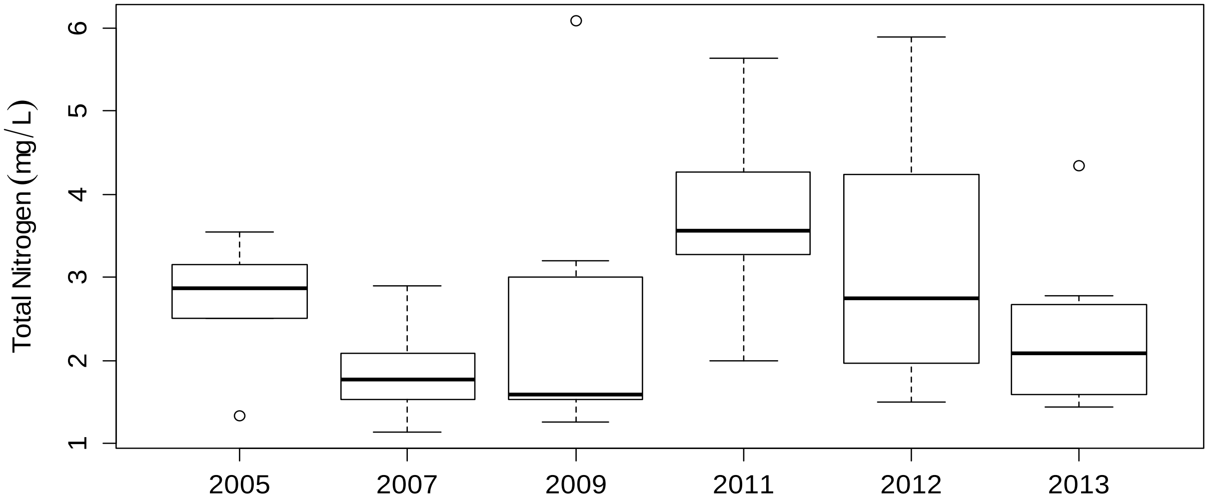


Figure 15-4 continued. Box and whisker plots of Spring Lake TSI data: 2005-2013. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

WINTER ICE COVER

The ice came off Spring Lake on April 24, 2013, twenty three days later than average and the latest ice-off date recorded for the lake. Ice covered Spring Lake on November 26, 2013, two days earlier than the average ice-on date for the lake. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton are the microscopic plant life that form the foundation of the food web in lakes. Chlorophyll-*a* is the main pigment used by phytoplankton for photosynthesis and can be used as a proxy for the density of phytoplankton growth. **Figure 15-5** shows the phytoplankton community composition and **Figure 15-6** shows the chlorophyll-*a* and Secchi data for Spring Lake in 2013.

In past sampled years, Spring Lake has had a diverse phytoplankton community; however since 2012, Spring Lake has exhibited a strongly homogenous phytoplankton population dominated by cryptomonads. It is possible that less-frequent sampling makes the community appear less complex, but *Lemna* cover in recent years may also be affecting the phytoplankton community composition. Cyrptophyta (cryptomonads) made up on average 90% of the sample in February and remained the dominant group throughout the whole season. Cryptomonads are small members of the phytoplankton community and can grow in low light conditions. Chlorophyta (green algae) had a larger presence in the system in June and September. Cyanophyta (blue green algae) also made up a small portion of the sample throughout the season but saw its largest contribution to the algal biomass in September, at 20%. Euglenophyta (euglenoids) were present through most of the season at levels of up to 10% of abundance. Chlorophyll-*a* levels and Secchi transparency did not correspond well in Spring Lake in 2013, indicating a large contribution of non-algal turbidity influencing water transparency.

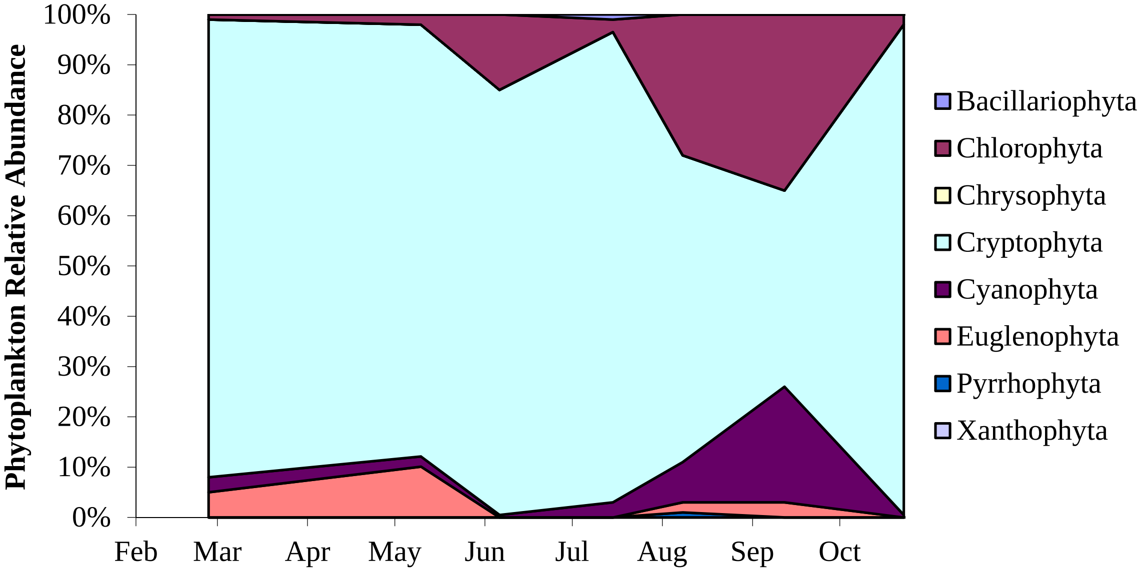


Figure 15-5. Phytoplankton community distribution in Spring Lake during 2013.

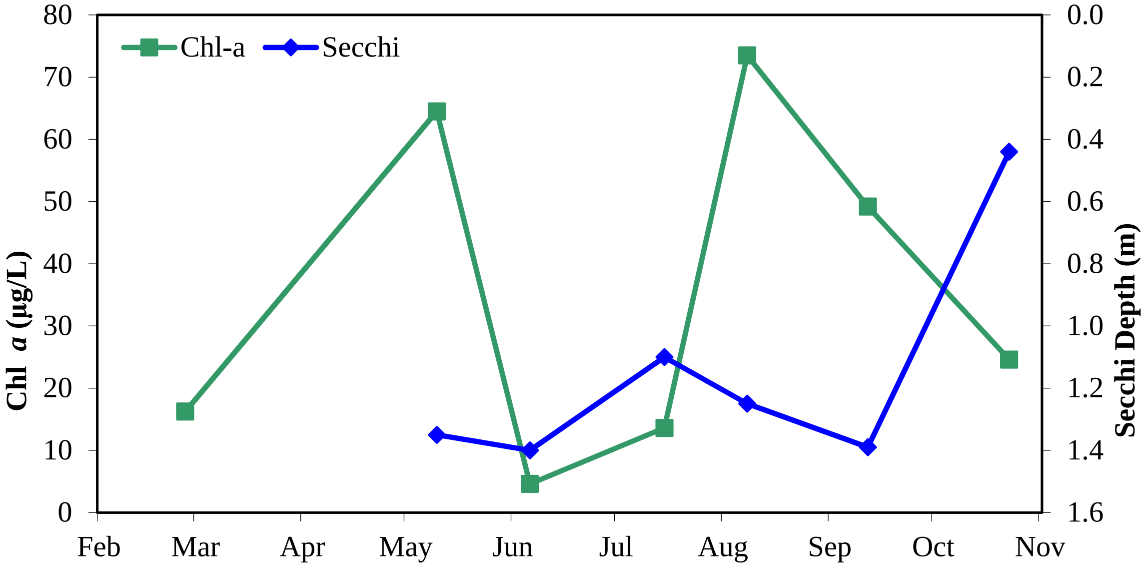


Figure 15-6. Chlorophyll-*a* concentrations and Secchi depth in Spring Lake during 2013.

Although zooplankton weren’t sampled, several surface water samples throughout the summer were dominated by bright red zooplankton. Certain zooplankton can produce a substance similar to hemoglobin that they use to store oxygen when living in low-oxygen environments.

WATER QUALITY PROJECTS

In August of 2011, the Minnesota Chapter of the American Society of Landscape Architects (ASLA), the Lowry Hill Neighborhood Association, and Blake School partnered with the MPRB to install seven floating artificial biohavens in Spring Lake (**Figure 15-7)**. Funds for the project were donated by the Lowry Hill Neighborhood and Midwest Floating Islands. Volunteers planted the biohavens with a combination of native vegetation chosen as aggressive, pioneer species, cover plants, or plants with food value for birds. Each biohaven was planted with a unique combination of plant species.

The biohavens were intended to add aesthetic value, bird habitat, and potential water quality benefits to Spring Lake. The biohavens are composed of a high surface area recycled plastic matrix, which will grow a biofilm together with root systems established by the plantings. As the biofilm and the plants on the biohaven grow, it is theorized that nutrients will be removed from the water and will be recycled back to the lake as the plants and biofilm senesce. Birds may be sources and sinks of nutrients for Spring Lake as they may eat seeds and fruits produced on the biohavens but may contribute nutrients from outside of the system as well.

Plant growth and biohaven performance were qualitatively monitored monthly during the growing season by MPRB. Regular monitoring of TSI parameters in Spring Lake will allow comparison between pre- and post-island years. Biohaven performance will be evaluated for use in other MPRB projects such as stormwater ponds and shoreline restoration.

Figure 15-7. Locations of biohavens in Spring Lake.

2011 Observations

Biohavens were planted and deployed in August, 2011. Monthly qualitative visits by MPRB staff in September and October showed the plantings were small but surviving going into the first winter.

2012 Observations

2012 was the first full growing season since the biohavens were installed. The monthly qualitative monitoring showed the success of the biohavens varied by island, with Island #2 having the thickest growth and overall best condition. Observations showed plant growth was the thickest around the edges of the islands, with three of the islands having sparse plant growth in the center. Each island tended to be dominated by one to a few plants. For example, Island #1 had lots of spike rush, Island #5 was known for its green bulrush, and Island #7 had an abundance of pointed broom sedge and boneset. Several plants observed on the islands were not originally planted, including the invasive purple loosestrife on two islands and nuisance cattails on five islands. There may have also been an attempt by the company to manually remove some of the cattails late season, as cattails near edges were found pulled out and lying flat.

Visits to the biohavens also revealed structural damage to a few of the islands. The islands' substrate was often visibly exposed, which may have been due to a physical perturbation by an animal or erosion of the soil. There was obvious evidence of geese, by note of excessive amounts of feces and feathers, associated with bent or broken fences and chewed plants. Also, many of the coir (coconut fiber) mats that were wrapped around the islands in August to protect from UV degradation were missing from the biohavens in October.

2013 Observations

2013 marked the second full year of growth for the biohavens. The first monitoring trip revealed widespread damages to the islands during the winter including: bent fences, exposed substrate, uneven edges, dug holes, and exposed roots (**Figures 15-8 and 15-9**). There was evidence of animals chewing on plants throughout the summer and by October most of the vegetation was dead. Also, Islands #6, #7, and possibly #5 appeared to have detached from their original position and floated to the perimeter of the lake.

Figure 15-8. Biohavens from April 18, 2012 (left) and May 9, 2013 (right).

Figure 15-9. Example of damage seen on biohavens in 2013 from left to right: broken fences, holes and burrows, and exposed substrate

Monitoring in 2013 showed a decrease in the observations of original planted species and an increase in the observations of volunteer plant species compared to 2012, with all islands now having more volunteer plants than original (**Table 15-2**). In 2012, the number of original and volunteer plant observations differed only by 10. However, in 2013, the gap widened and the number of volunteer species observations almost doubled the number of original species observations.

Table 15-2. Number of observations of original and volunteer species among biohavens.

Island #	**2012**		**2013**	
	Original	**Volunteers**	**Original**	**Volunteers**
1	21	14	13	17
2	27	17	9	18
3	13	11	7	18
4	21	25	14	26
5	19	23	15	35
6	22	14	17	26
7	18	27	8	31
Total	141	131	83	171

Besides a decrease in the observations of original plant species, the diversity of original plants decreased from 35 species in 2012 to 22 in 2013. At the same time, the number of volunteer plant species jumped from 35 in 2012 to 39 in 2013. Some of the original species that did flourish include: three-square rush on Island #1, blue joint grass on Island #3, and polygonum on Island #4. The invasive purple loosestrife was found on five of the biohavens and dominated the plant community on Islands #1 and #5. Despite an attempt to eradicate nuisance cattails from the biohavens in the fall of 2012, cattails were found on all islands except #1 and #2.

Any water quality benefits of the biohavens remain unclear. While Secchi depths and chlorophyll-*a* concentration may have improved since 2011, nutrient levels, both total phosphorus and total nitrogen, have increased since the islands were installed (**Figure 15-4)**. However, during the same time a thick layer of duckweed (*Lemna spp.*) covered the lake. In previous years only a small amount of duckweed was noted on the lake. This along with natural fluctuations makes it difficult to tease out any effects from the biohavens. Future monitoring will make it easier to assess the capability of the biohavens to improve water quality.

16. WEBBER POND

HISTORY

Webber Park was named in 1939 for Charles C. Webber, who donated the land in memory of his late son. Originally, a dam across Shingle Creek created a 2-acre pool known as Camden Pond. Overflow water was used to fill a swimming pool in summer and the pond was used for ice skating in winter. In the 1950s, a flood prevention project rerouted Shingle Creek to the north to increase the drop in the creek from 1.5 to 5 feet. The project removed the dam that impounded Webber Lagoon and created the configuration of Webber Pond that existed until 2013, as shown in **Figure 16-1**.

Figure 16-1. Webber Pond in 2011.

Historically, Webber Pond was a very shallow and clear water body dominated by aquatic vegetation. Occasional filamentous algae blooms caused odor issues in late summer. The water level in the pond was artificially maintained by groundwater pumping and kept at a consistent elevation. Fish kills occurred in some years when the pond froze to the bed. **Table 16-1** shows the morphometric data for Webber Pond.

Table 16-1. Webber Pond morphometric data.

Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Volume (m^3)	Perimeter (feet)	Watershed Area (acres)	Watershed:Lake Area (ratio)
3	0.9	1.5	$1.10\text{x}10^4$	1,200	2	0.7

Webber Pond was demolished on August 14, 2013 to make way for the Webber Natural Swimming Pool. In February 2012, the MPRB Board of Commissioners approved a $6.1 million Master Plan to renovate Webber Park. The plan consists of a natural swimming pool, regeneration area, stormwater pond, and pool house (**Figure 6-2**). MPRB contracted BioNova Natural Pool and Landform companies for the project scheduled for completion in summer 2014. The Webber natural swimming pool will rely on a biological filtration system rather than chemicals to maintain a safe swimming environment. Water will flow from the swimming area through filters to remove particulate matter and a regeneration pond to remove nutrients before returning to the swimming area. The regeneration basin contains plants, gravel, and other aggregates, but does not contain any soil. Therefore, the plant and microbial communities must rely on the nutrients in the water to grow, making them unavailable to nuisance algae. Webber Park will be the site of the first public natural filtration swimming pool in the United States. The natural swimming pool will be regulated similar to a public bathing beach and will be monitored for *E. coli* and standard water quality parameters.

Figure 16-2. The new Webber Natural Swimming Pool from the Webber Park Master Plan

AUGMENTATION WELL

An augmentation well was used to maintain the water level at Webber Pond and was occasionally used for winter ice rinks. The MDNR issued permits to determine the pumping limit for the augmentation well. **Table 16-2** shows the annual usage from 2006-2013.

Table 16-2. Webber Pond yearly augmentation well volumes (gallons). The permitted volume is 7 million gallons.

2006 Total	2007 Total	2008 Total	2009 Total	2010 Total	2011 Total	2012 Total	2013 Total
4,809,600	5,761,200	2,728,200	3,985,200	4,394,4000	6,082,800	3,919,200	None

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

Webber Pond was sampled four times throughout the summer until demolition in August 2013. **Figure 16-3** shows the TSI linear regression for Webber Pond. A detailed explanation of TSI can be found in **Section 1**. The 2013 TSI score for Webber Pond was 53.5. Since TSI scores fluctuate 20 units over the entire record and the linear regression exhibits an R^2 value of 0.029, no time-dependent trend can be confidently extrapolated from Webber Pond TSI data. Webber was a small waterbody with high natural variability. Since monitoring began, the pond has switched from a highly eutrophic waterbody dominated by planktonic algae with very green water, to a clear water lake dominated by attached macro-algae and aquatic plants. Since Secchi is not collected at Webber Pond, the TSI score was calculated on chlorophyll-*a* and total phosphorus only, so the TSI trend must be analyzed with caution.

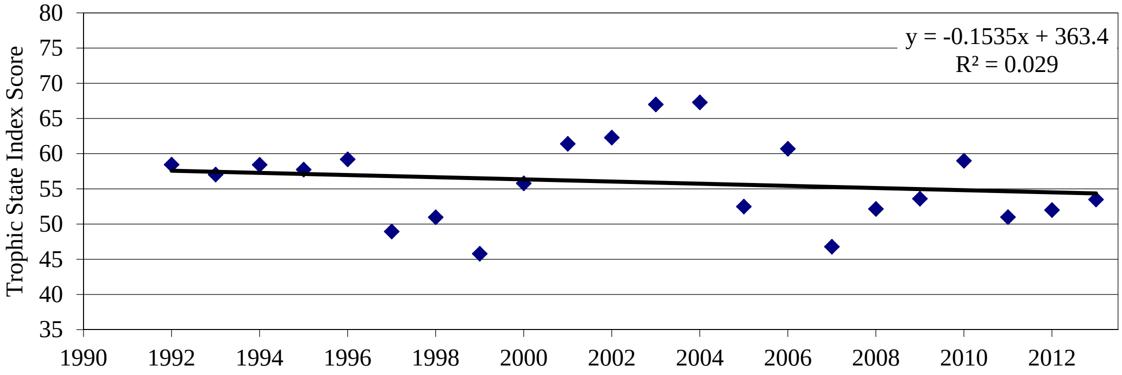


Figure 16-3. TSI scores and regression analysis at Webber Pond.

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 16-4** show the distribution of data for the chlorophyll-*a*, total phosphorus, and total nitrogen samples for Webber Pond for the past 10-years. The red horizontal line indicates MPCA shallow lake nutrient standards. A detailed explanation of box and whisker plots can be found in **Section 1**. Data from previous years can be found in box and whisker plot format in **Appendix A**. Secchi data is not presented below, as the water is clear to the bottom.

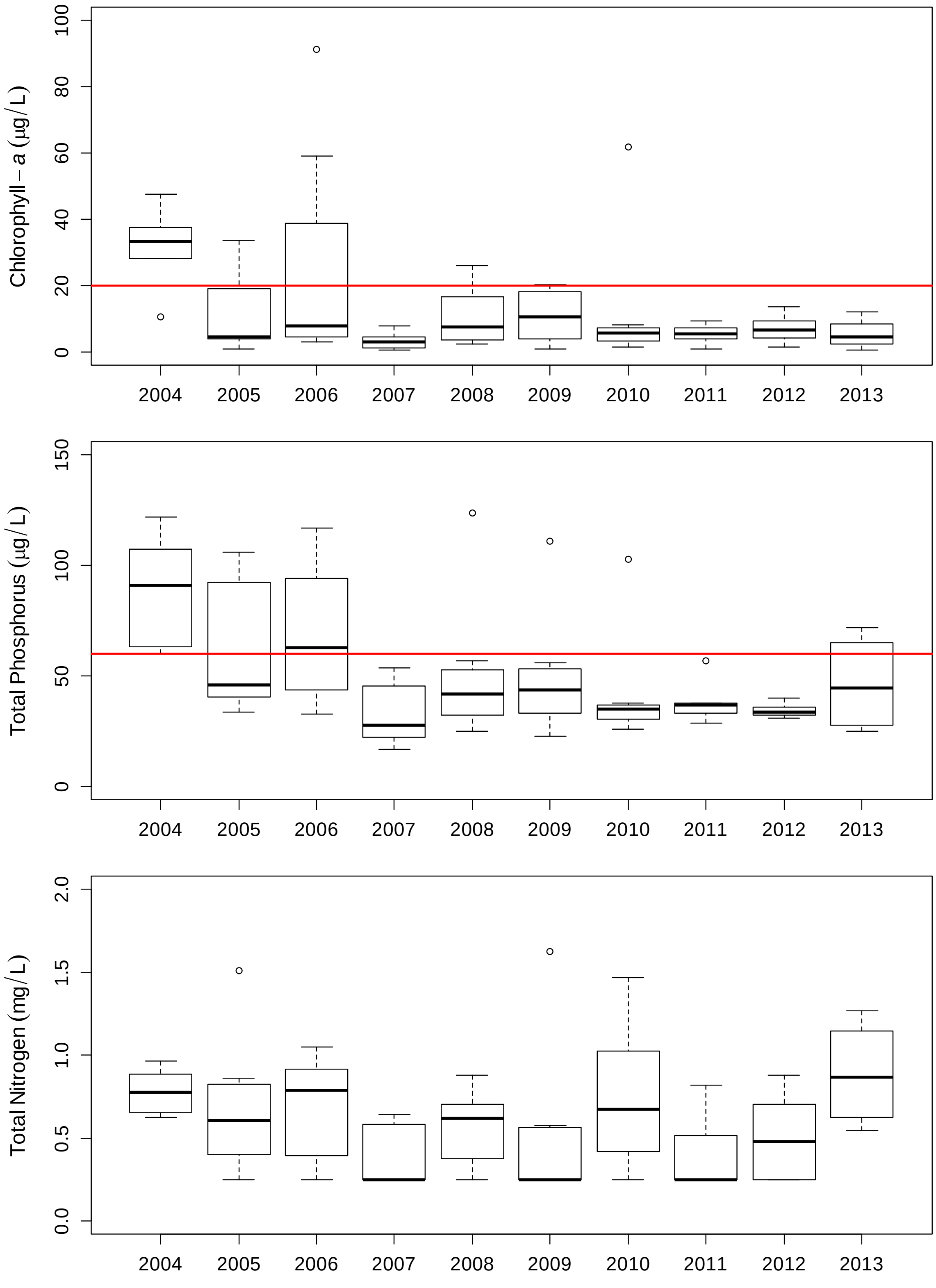


Figure 16-4. Box and whisker plots of Webber Pond TSI data from the last 10-years. Horizontal lines represent MPCA eutrophication standard for shallow lakes. Winter sample data was removed due to large outliers in 2011 and 2012. See Appendix A for the entire period of record.

Webber Pond had two stable states; one with green water that is dominated by phytoplankton or filamentous algae, and one state where the pond contains clear water and thick beds of the macro-algae chara. The boxplots in **Figure 16-4** are from the most recent ten year period where Webber has been in its clear state during most years. The 2013 box plots are typical for Webber Pond in its clear-water state; however, they are constructed from four data samples and are not fully comparable with previous year's data.

WINTER ICE COVER

Ice came off Webber Pond on April 22, 2013, twenty one days later than the average ice-off date for the pond. Webber pond was demolished months before ice began to form on other lakes. See **Section 1** for details on winter ice cover records and **Section 18** for a comparison with other lakes.

PHYTOPLANKTON

Phytoplankton are the microscopic plant life that form the foundation of the food web in lakes. **Figure 16-5** displays the 2013 phytoplankton community and **Figure 16-6** shows chlorophyll-*a* data for Webber Pond.

In 2013, four phytoplankton samples were collected, one each month from May through August, when construction for Webber Pool began. Early in the season, the phytoplankton community was diverse, with Bacillariophyta (diatoms) and Chlorophyta (green algae) having the greatest abundance. Chlorophyll-*a* values in Webber Pond correlated well with phytoplankton trends. The highest chlorophyll-*a* levels corresponded to the dominance of green algae in August.

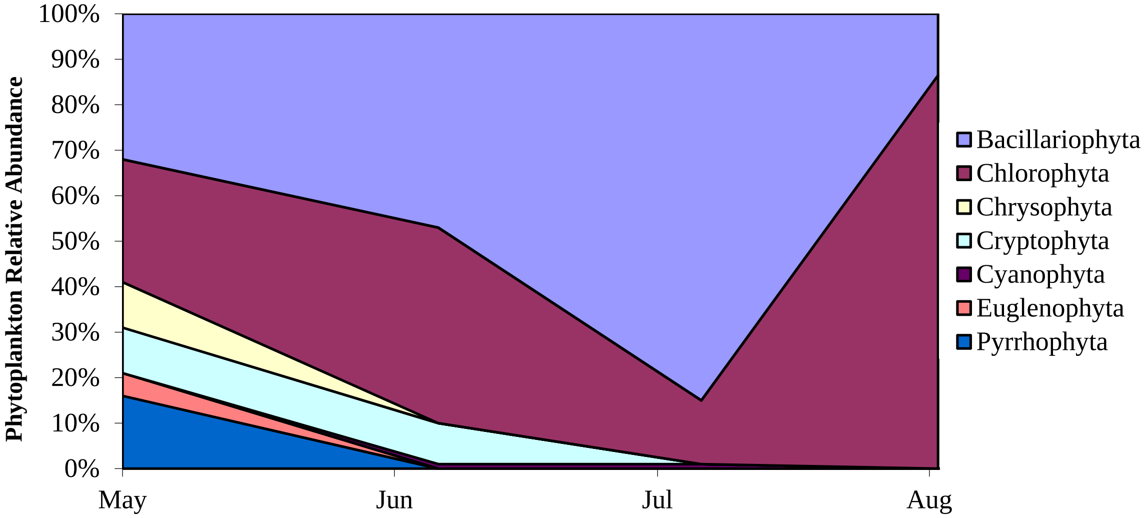


Figure 16-5. Webber Pond 2013 phytoplankton relative abundance.

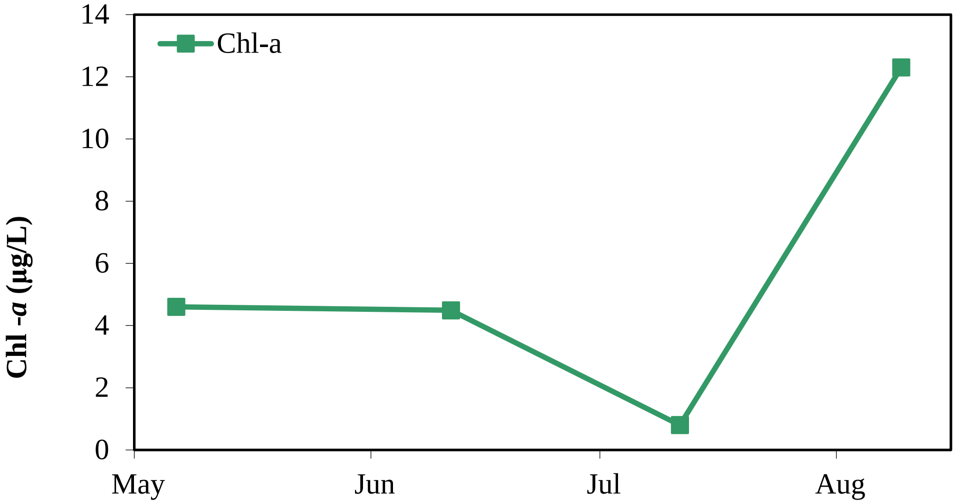


Figure 16-6. Webber Pond 2013 chlorophyll-*a* data.

FISH STOCKING

Webber Pond was stocked with fish by the MDNR as part of the Fishing in the Neighborhood program (FiN). Additional information and a definition of fry, fingerling, yearling and adult fish can be found in **Section 1**.

Webber Pond was stocked in:

1998 with 319 adult Bluegill Sunfish.
1999 with 499 adult Bluegill Sunfish.
2000 with 5 adult Black Crappie, 837 adult Bluegill Sunfish, 8 adult Largemouth Bass.
2001 with 409 adult Bluegill Sunfish.
2002 with 399 adult Bluegill Sunfish.
2003 with 420 adult Bluegill Sunfish.
2004 with 531 adult Bluegill Sunfish.
2005 with 415 adult Bluegill Sunfish, 25 adult Channel Catfish.
2006 with 400 adult Bluegill Sunfish, 25 adult Channel Catfish.
2007 with 451 adult Bluegill Sunfish, 10 adult Channel Catfish.
2008 with 400 adult Bluegill Sunfish, and 15 adult Channel Catfish.
2009 with 400 adult Bluegill Sunfish.
2010 with 402 adult Bluegill Sunfish, and 10 adult Channel Catfish.
2011 with 299 adult Bluegill Sunfish, and 10 adult Channel Catfish.
2012 with 208 adult Bluegill Sunfish.

17. WIRTH LAKE

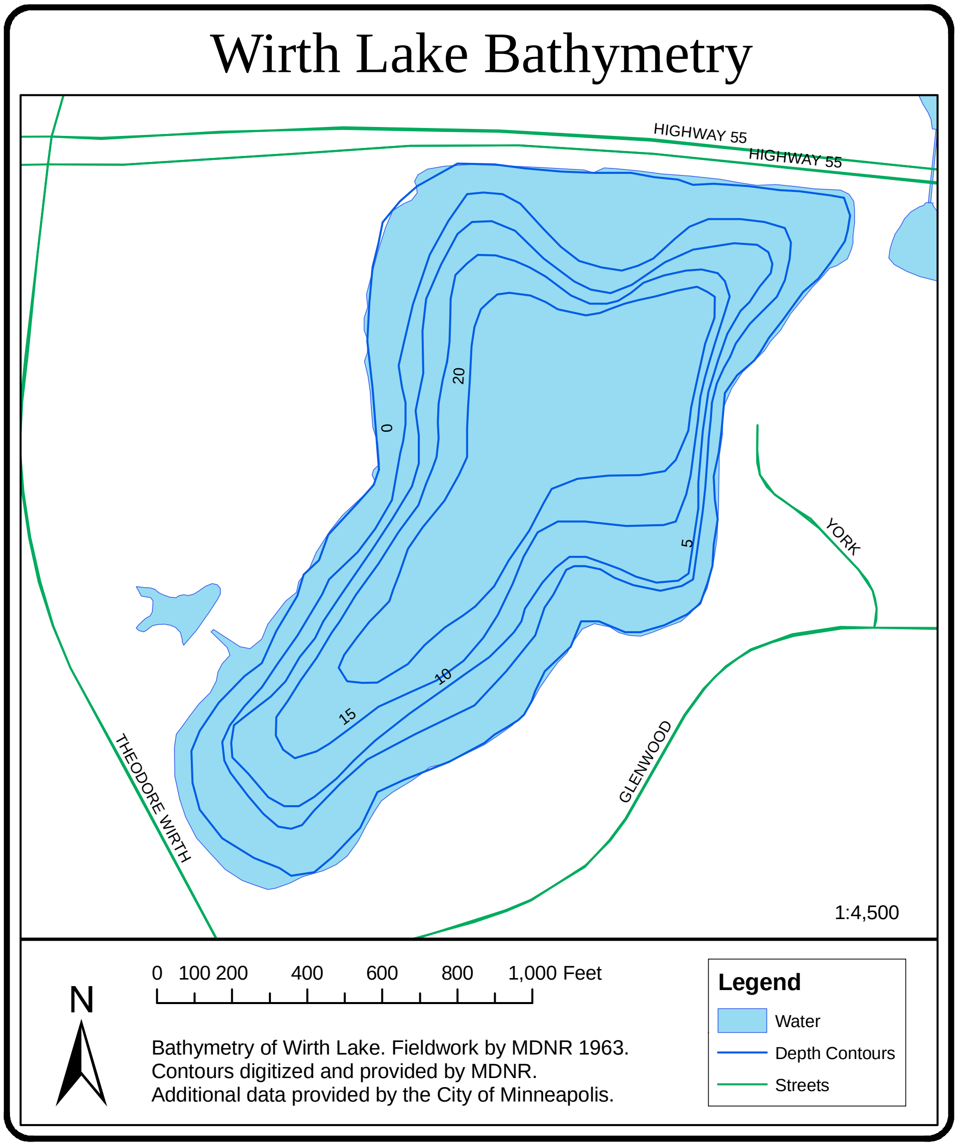
HISTORY

Wirth Lake was acquired by the Minneapolis Park and Recreation Board (MPRB) in 1909, enlarging the adjacent park from its previous size of 64 acres that was purchased in 1889. It was originally known as Keegan's Lake and renamed to Glenwood Lake in 1890. The lake was renamed yet again in 1938 after Theodore Wirth at the end of his tenure as Park Superintendent. A plant nursery was established on the west side of the lake in 1910 that provided the system with plantings through 1980.

As with most other lakes in the MPRB system thousands of cubic yards of sediment from Wirth were dredged. The spoils were used to raise the parkland near Glenwood Avenue. Wirth Lake Beach was constructed with sand purchased from sources outside of the MPRB. The lake is shown below in **Figure 17-1**.

Figure 17-1. Wirth Lake in October, 2012.

Wirth Lake is generally dimictic but can mix during extreme events when Bassett Creek backflows to the lake (Wirth Lake TMDL Report, 2010). Historically, the lake was considered oligotrophic to mesotrophic. Early restoration projects included Rotenone in 1977 to remove rough fish and subsequent stocking of channel catfish, largemouth bass, walleye, and bluegills. A summer aerator was installed and operated from the early 1980s until 1991. A portable winter aerator was used for a few years before a permanent aeration system was put in place in 2002. **Figure 17-2** shows a bathymetric map of Wirth Lake and **Table 17-1** shows the Wirth Lake morphometric data.



Bathymetry of Wirth Lake. Fieldwork by MDNR 1963.
Contours digitized and provided by MDNR.
Additional data provided by the City of Minneapolis.

Figure 17-2. Bathymetric map of Wirth Lake.

Table 17-1. Wirth Lake morphometric data.

Surface Area (acres)	Mean Depth (m)	Maximum Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)
39	4.3	7.9	59%	6.70×10^5	348	9.4

* Littoral area was defined as less than 15 feet deep.

LAKE LEVEL

Wirth Lake levels are recorded weekly during ice free conditions. The lake levels for Wirth Lake are shown in **Figure 17-3** from 1971 through 2013. The effects of new outlets installed in 1978 and in 1996 can be seen in the graph. Since the installation of the 1996 outlet fewer high flow events have backed up water from Bassett Creek into the lake. The outlet to Bassett Creek Outlet was renovated in 2013 and a new staff gauge had not been installed until August 2013. Therefore, no lake level data is available for spring or early summer at Wirth Lake. However, based on previous year trends, it is purported that Bassett Creek may have backed up into Wirth Lake twice in 2013, after two 3 to 5 inch rain events in late June and mid-July. The MDNR has not designated an ordinary high water level (OHW) for Wirth Lake. See **Section 18** for a comparison between other MPRB lake levels.

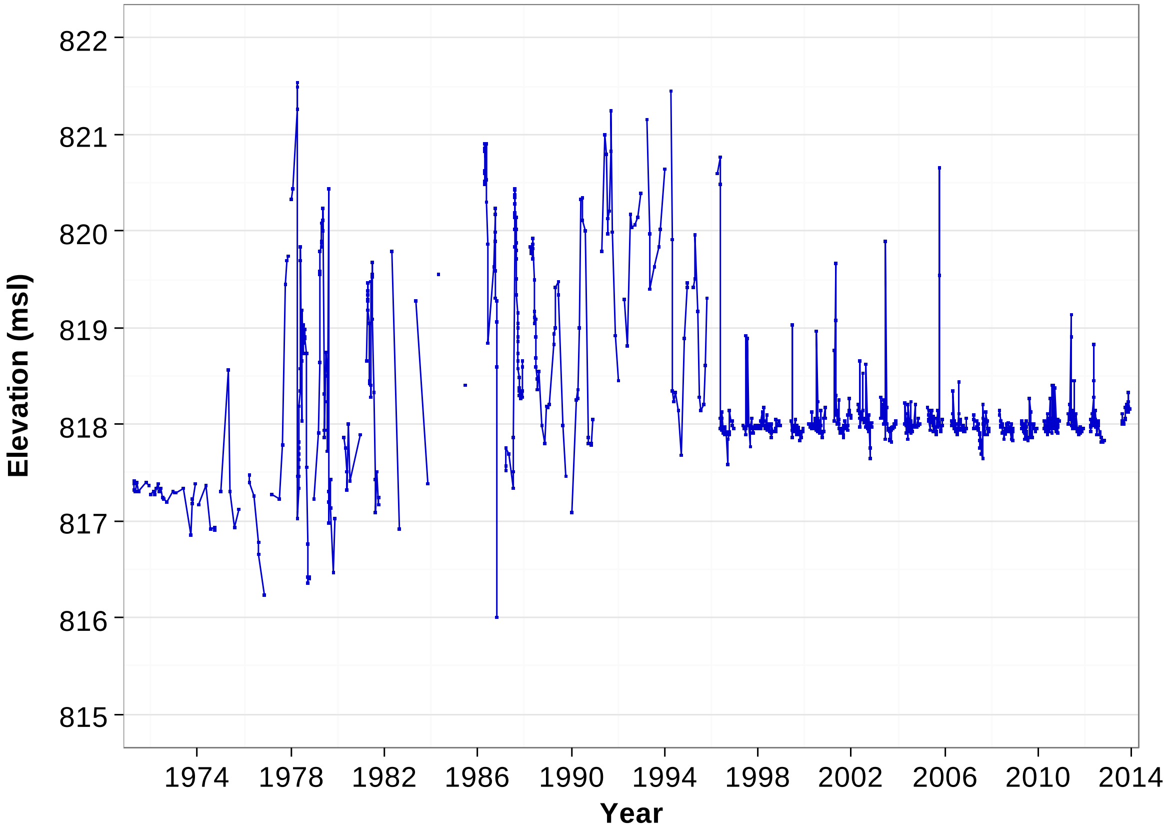


Figure 17-3. Lake levels for Wirth Lake from 1971–2013.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The 2013 TSI score for Wirth Lake was 51. **Figure 17-4** shows the Wirth Lake TSI linear regression to be decreasing as TSI scores fall over time. A detailed explanation of TSI can be found in **Section 1**.

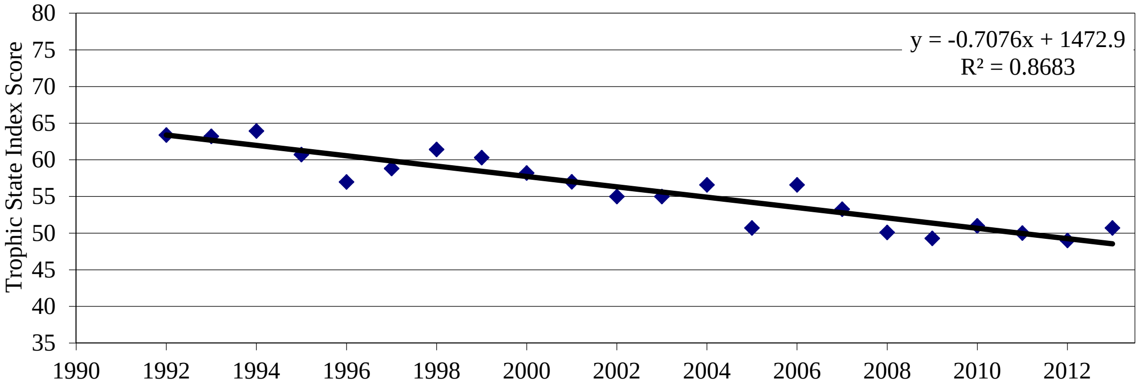


Figure 17-4. Wirth Lake TSI scores and regression line.

Water quality is improving at Wirth Lake. TSI scores in the past several years are on average 15 TSI units lower than when monitoring began. The trend has a very strong linear regression correlation with an R^2 of 0.87, the highest TSI correlation of all Minneapolis lakes. Wirth Lake has a TSI score that falls slightly above the 25th percentile category for lakes in this ecoregion (based on calculations from the Minnesota Pollution Control Agency, using the Minnesota Lake Water Quality Data Base Summary, 2004).

BOX AND WHISKER PLOTS

The box and whisker plots in **Figure 17-5** show the distribution of data for the Secchi, chlorophyll-*a*, and total phosphorus for Wirth Lake over the past ten years. The red horizontal lines indicate MPCA deep lake nutrient criteria. A detailed explanation of box and whisker plots can be found in **Section 1**. Data from the entire period of record in box and whisker format can be found in **Appendix A**.

The separation of Bassett Creek from Wirth Lake and upstream water quality improvements in the watershed may be responsible for continued improvement in Wirth Lake. Secchi transparency is increasing with deeper average readings, and the average clarity was the best recorded in Wirth Lake since monitoring began in 1992. Both phosphorus and chlorophyll-*a* levels are normal in comparison to recent years, but exhibited wider ranges in 2013. The median values for all parameters met the MPCA nutrient criteria.

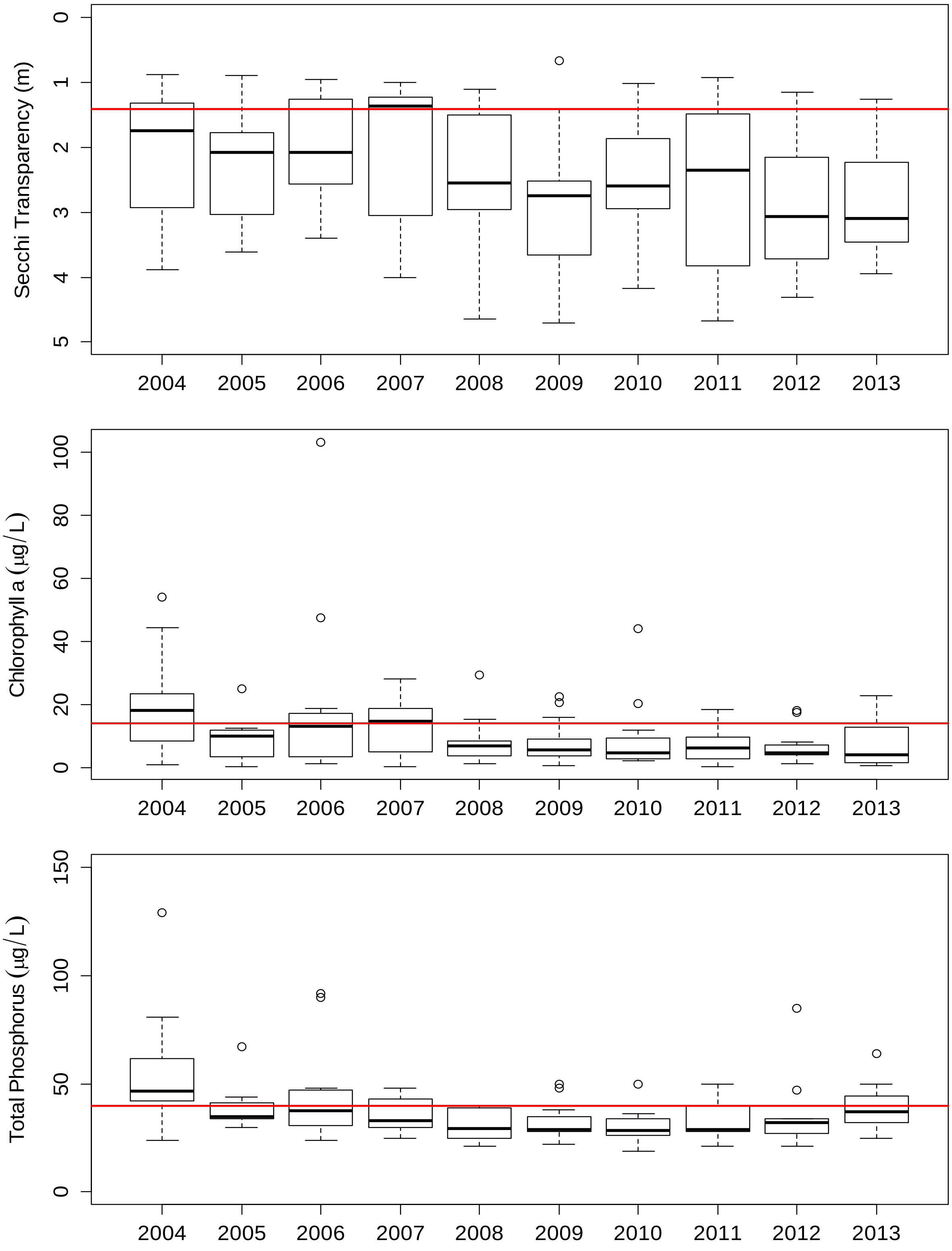


Figure 17-5. Box and whisker plots of Wirth Lake data from over the past ten years. Horizontal lines represent MPCA eutrophication standard for shallow lakes. See Appendix A for the entire period of record.

BEACH MONITORING

Bacteria levels were monitored weekly from June through August at Wirth Beach in 2013 (**Table 17-2)**. Bacteria levels at Wirth Beach in 2013 were similar to values recorded in previous years. Bacteria levels remained low throughout the entire season, unlike most years when *E. coli* increases dramatically in late summer as geese congregate in the beach area. **Figure 17-6** illustrates the box and whisker plots of *E. coli* sampling results (per 100 mL) for all data collected between 2004 and 2013. The *E. coli* 30-day geometric mean value for Wirth Lake in 2013 was 8 MPN/100mL of water and all samples were at or below 19 MPN/100mL.

Table 17-2. Summary of *E. coli* results (MPN per 100 mL) for Wirth Beach in 2013.

Statistical Calculations	Wirth
Number of Samples	13
Minimum	1
Maximum	19
Median	6
Mean	8
Geometric Mean	6
Max 30-Day Geo Mean	8
Standard Deviation	6

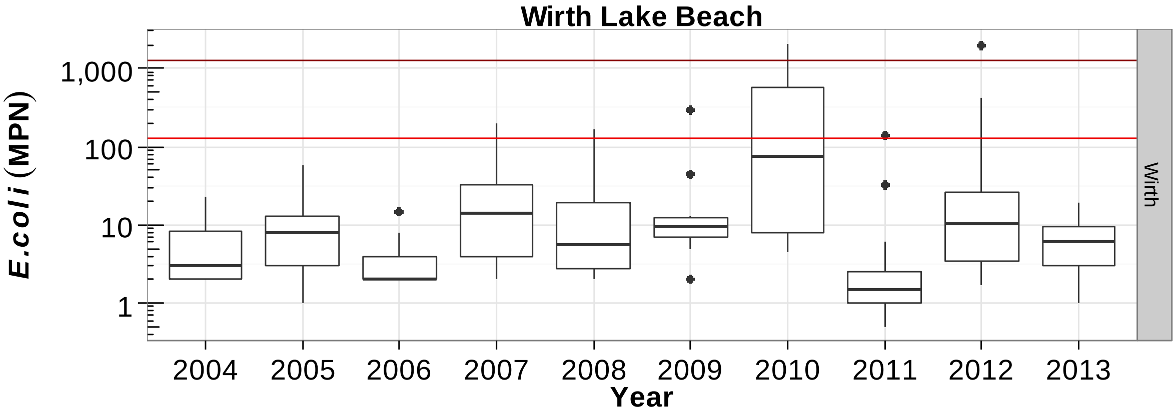


Figure 17-6. Box and whisker plot of Wirth Beach *E. coli* results (colonies per 100 mL), for 2004–2013. The horizontal lines represent the *E. coli* standard for the 30-day geometric mean (126 MPN/100mL) and the single-sample maximum standard (1260 MPN/100mL). Note the log scale on the Y-axis. From 2004-2009 E. coli concentrations were determined as colony forming units (CFU/100ml).

LAKE AESTHETIC AND USER RECREATION INDEX (LAURI)

The 2013 LAURI for Wirth Lake is shown in **Figure 17-7**. Wirth Lake scored "excellent" for aesthetics, habitat quality, public health, and recreational access opportunities and "good" for water clarity. Details on the updated LAURI can be found in **Section 1**.

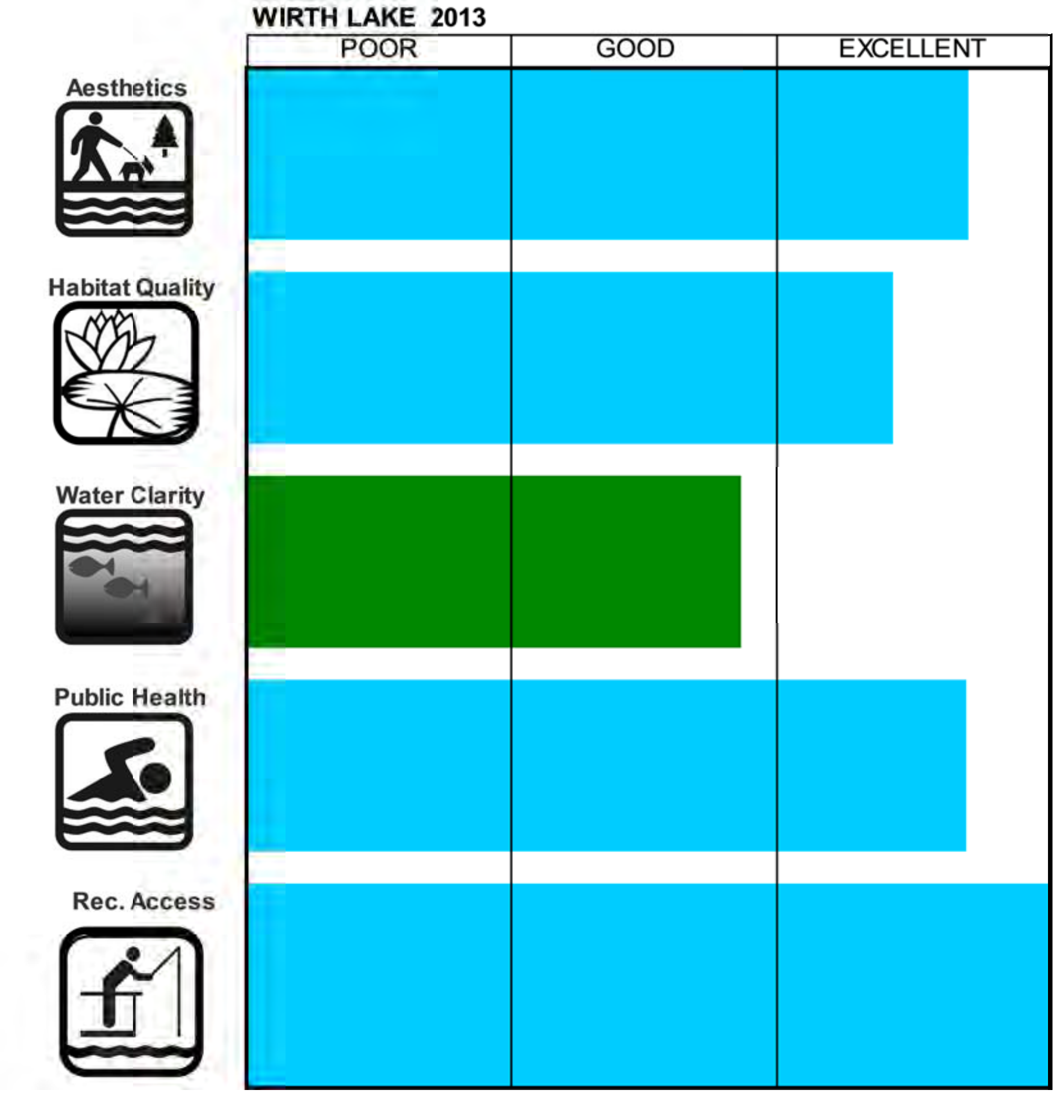


Figure 17-7. Wirth Lake LAURI for 2013.

WINTER ICE COVER

Ice came off Wirth Lake on April 27, 2013, twenty five days later than the average date and the latest ice-off date recorded for the lake. Ice came on to the lake for the winter on December 2, 2013 which was two days later than average. Details on winter ice cover records can be found in **Section 1** and a comparison with other lakes can be found in **Section 18**.

EXOTIC AQUATIC PLANT MANAGEMENT

The MDNR requires a permit to remove or control Eurasian water milfoil. Aquatic plant control permits limit the area from which milfoil can be harvested to protect fish habitat. The permits issued to the MPRB allow for harvesting at the beach and the boat launch. The permitted area on Wirth Lake was 5 acres which is 20% of the littoral zone of the lake (area shallower than 15 feet). MPRB contracted SCUBA divers to remove vegetation from areas around the swimming beach, boardwalk, and boat launch. The mechanical harvester could not be used inside of the beach boardwalk. A total of 5.25 trailer loads of aquatic plants were removed from Wirth Lake in 2013. See **Section 1** and **Section 20** for details on aquatic plants.

PHYTOPLANKTON AND ZOOPLANKTON

Phytoplankton and zooplankton are the microscopic plant and animal life that form the foundation of the food web in lakes. **Figure 17-8** displays the relative abundance of phytoplankton and **Figure 17-9** shows the chorophyll-*a* and Secchi data sampled in Wirth Lake. **Figure 17-10** shows the distribution of zooplankton sampled in 2013.

During the 2013 sampling season, Cryptophyta (cryptomonads) and Chrysophyta (golden algae) dominated the winter and spring sampling periods. In midsummer, the phytoplankton community became more diverse. Cyanobacteria (blue-green algae) bloomed in July, but Pyrrhophyta (dinoflaggelates) dominated the latter season samples. Chlorophyll-*a* levels correspond to general phytoplankton trends in 2013, and exhibited a large peak in late August corresponding to the same time that Pyrrhophyta also peaked **(Figures 17-8 & 17-9)**. Secchi depths and chlorophyll-*a* concentrations generally tracked together as shown in **Figure 17-9**, suggesting that phytoplankton biomass has a strong effect on clarity in Wirth Lake. However, it should be noted that the relationship between chlorophyll-*a* and water transparency is also influenced by other factors such as particulates and dissolved organic matter.

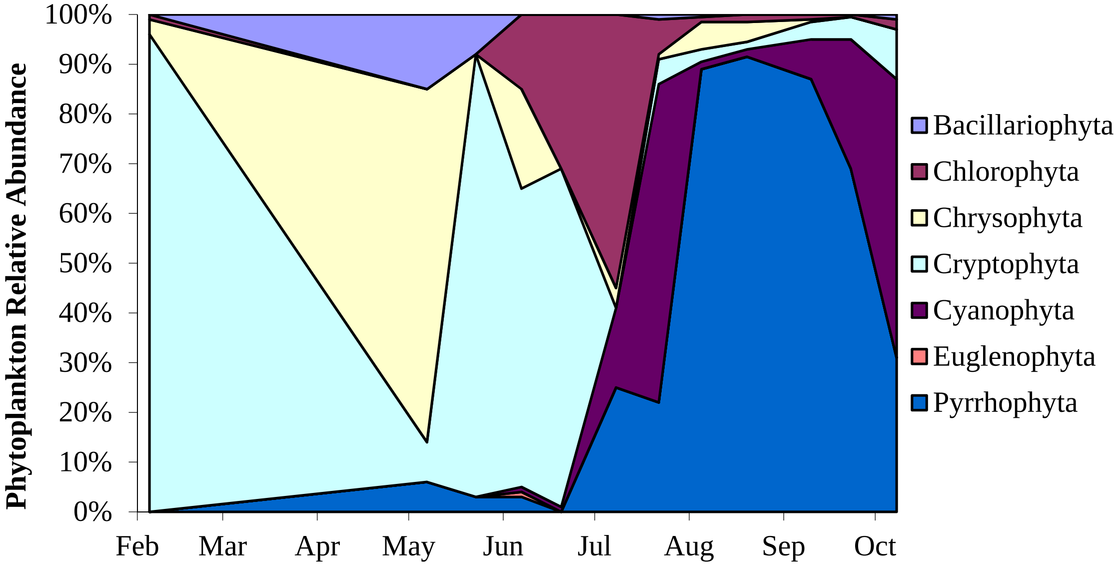


Figure 17-8. Wirth Lake phytoplankton divisions during the 2013 sampling season.

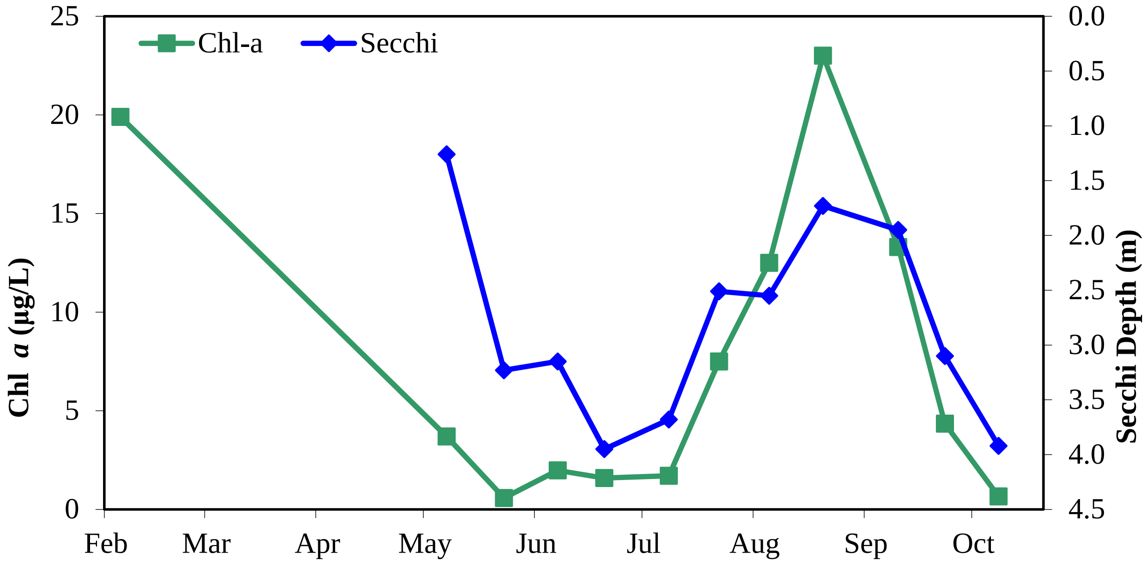


Figure 17-9. Wirth Lake 2013 chlorophyll-*a* and Secchi data. Note the reversed axis for Secchi.

Zooplankton populations varied over the 2013 sampling season, as shown in **Figure 17-10**. Juvenile zooplankton, called nauplii, were at their highest levels throughout the early season. Cladocerans, cyclopoids, and calanoids were present throughout the season. Rotifers peaked later in the summer in September.

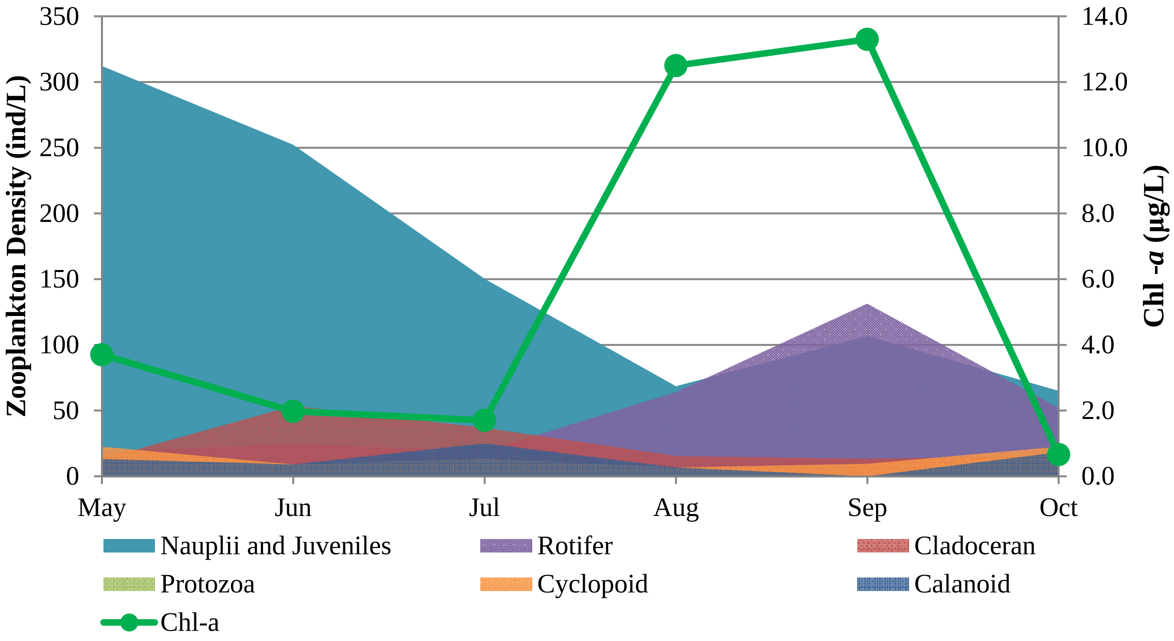


Figure 17-10. Wirth Lake 2013 zooplankton distribution shown with monthly chlorophyll-*a* levels.

FISH STOCKING

Additional information and a definition of fry, fingerling, yearling, and adult fish sizes can be found in **Section 1**.

Wirth Lake was stocked by MDNR in:

1998 with 290 adult Black Crappie 258 adult Bluegill Sunfish.
1999 with 1,900 fingerling Channel Catfish.
2000 with 1,900 fingerling Channel Catfish.
2001 with 2,304 yearling Channel Catfish.
2003 with 600 adult Walleye.
2007 with 23,000 fry Walleye.
2008 with 40 adult Walleye and 57 fingerling Walleye.
2011 with 2,772 fingerling Walleye.
2012 with 23,000 fry Walleye.

18. COMPARISON AMONG LAKES

PHYSICAL CHARACTERISTICS

Understanding the physical characteristics of a lake is important when interpreting data from an individual lake and when comparing groups of lakes. Shallow and deep lakes respond in distinct ways to environmental and watershed changes and may require entirely different approaches for rehabilitation. Lakes with large watershed to lake area ratios are typically more eutrophic and may be more complicated to manage if their watersheds cross political boundaries. A lake's residence time can also influence its overall physical condition, with long residence times causing delayed effect of rehabilitation efforts. **Table 18-1** presents the physical characteristics of the Minneapolis lakes.

Table 18-1. Minneapolis lakes physical characteristics.

Lake	Surface Area (acres)	Mean Depth (m)	Max Depth (m)	Littoral Area*	Volume (m^3)	Watershed Area (acres)	Watershed: Lake Area (ratio)	Residence Time (years)
Birch	5.8	ND	ND	ND	ND	ND	ND	ND
Brownie	18	6.8	15.2	67%	4.98×10^5	369	20.5	2.0
Calhoun	421	10.6	27.4	31%	1.80×10^7	2,992	7.1	4.2
Cedar	170	6.1	15.5	37%	4.26×10^6	1,956	11.5	2.7
Diamond	41	0.9	2.1†	100%	7.15×10^4	669‡	16.3	ND
Grass	27	0.6	1.5	NA	NA	386‡	14.3	ND
Harriet	353	8.7	25.0	25%	1.25×10^7	1,139	3.2	3.4
Hiawatha	54	4.1	7.0	26%	8.95×10^5	115,840	2,145	0.03
Isles	103	2.7	9.4	89%	1.11×10^6	735	7.1	0.6
Loring	8	1.5	5.3	NA	4.88×10^4	24	3.0	ND
Nokomis	204	4.3	10.1	51%	3.54×10^6	869	4.3	4.0‡
Powderhorn	11	1.2	6.1	99%	5.43×10^4	286	26.0	0.2‡
Ryan	18	NA	10.7	50%	ND	5,510	306	ND
Spring	3	3.0	8.5	ND	3.65×10^4	45	15.0	ND
Webber	3	0.9	2.0	ND	1.10×10^4	2	0.7	ND
Wirth	39	4.3	7.9	61%	6.70×10^5	348	9.4	ND

* Littoral area defined as less than 15 feet deep. ND= No Data Available. NA= Not Applicable
† Based on long-term data. ‡ Recent projects within the watersheds have altered these statistics.

Summary statistics of interest include:

- Largest Lake: Lake Calhoun at 421 acres.
- Smallest Lake: Webber Pond at 3 acres.
- Deepest Lake: Lake Calhoun at 89 feet 11 inches.
- Largest Watershed: Lake Hiawatha at 115,340 acres.
- Smallest Watershed: Webber Pond at 2 acres.
- Longest Residence Time: Lake Calhoun at 4.3 years.
- Shortest Residence Time: Lake Hiawatha at 11 days.

WATER QUALITY TRENDS – TROPHIC STATE INDEX (TSI)

The Minneapolis Park and Recreation Board (MPRB) calculates a trophic state index score (TSI) for each lake using chlorophyll-*a*, Secchi depth, and total phosphorus measurements. TSI scores can be used to evaluate changes in an individual lake or to compare lakes to each other. Detailed information on TSI scores can be found in **Section 1**.

In 2013, MPRB water quality scientists monitored 12 of the city's most heavily used lakes in order to calculate TSI scores. **Figure 18-1** shows the 2013 TSI data plotted on the trophic state continuum. All of the Minneapolis lakes fell into the mesotrophic or eutrophic categories, which is the typical distribution for lakes in the North Central Hardwood Forest ecoregion (MPCA, 2004). With some exceptions, the deeper lakes had lower TSI scores than the shallow lakes. Scores for Diamond Lake and Webber Pond should be viewed with caution since these lakes are too shallow to calculate the Secchi portion of the TSI index. Also, the Webber Pond TSI score was only calculated from 4 data points, since the pond was demolished in August to make way for the Webber Natural Swimming Pool.

Changes in lake water quality can be tracked by looking for trends in TSI scores over time. Historical trends in TSI scores are used by lake managers to assess the effectiveness of restoration and management activities on the trophic state of the lakes. Comparing TSI trends in single lakes to trends seen in all of the lakes can help to identify whether changes in lake water quality may be due to climate cycles or to changes specific to a watershed.

Trends were identified by using a linear regression of the TSI scores through time. **Table 18-2** shows the historical trends in TSI scores since 1991, the year sampling began for most lakes. Because the record for some lakes is so long, and because many large water quality improvement projects took place in the late 1990s and early 2000s, the long term water quality trend and 10-year trends for the Minneapolis lakes can be different. **Table 18-3** shows the TSI trends since 2003. Graphs of TSI scores over the entire period of record for each lake are shown in **Figures 18-2** and **18-3**. For more detailed information on a particular lake's trend in TSI scores and nutrient related water quality parameters, see the individual lake sections. Details on TSI scores and linear regression analysis can be found in **Section 1**.

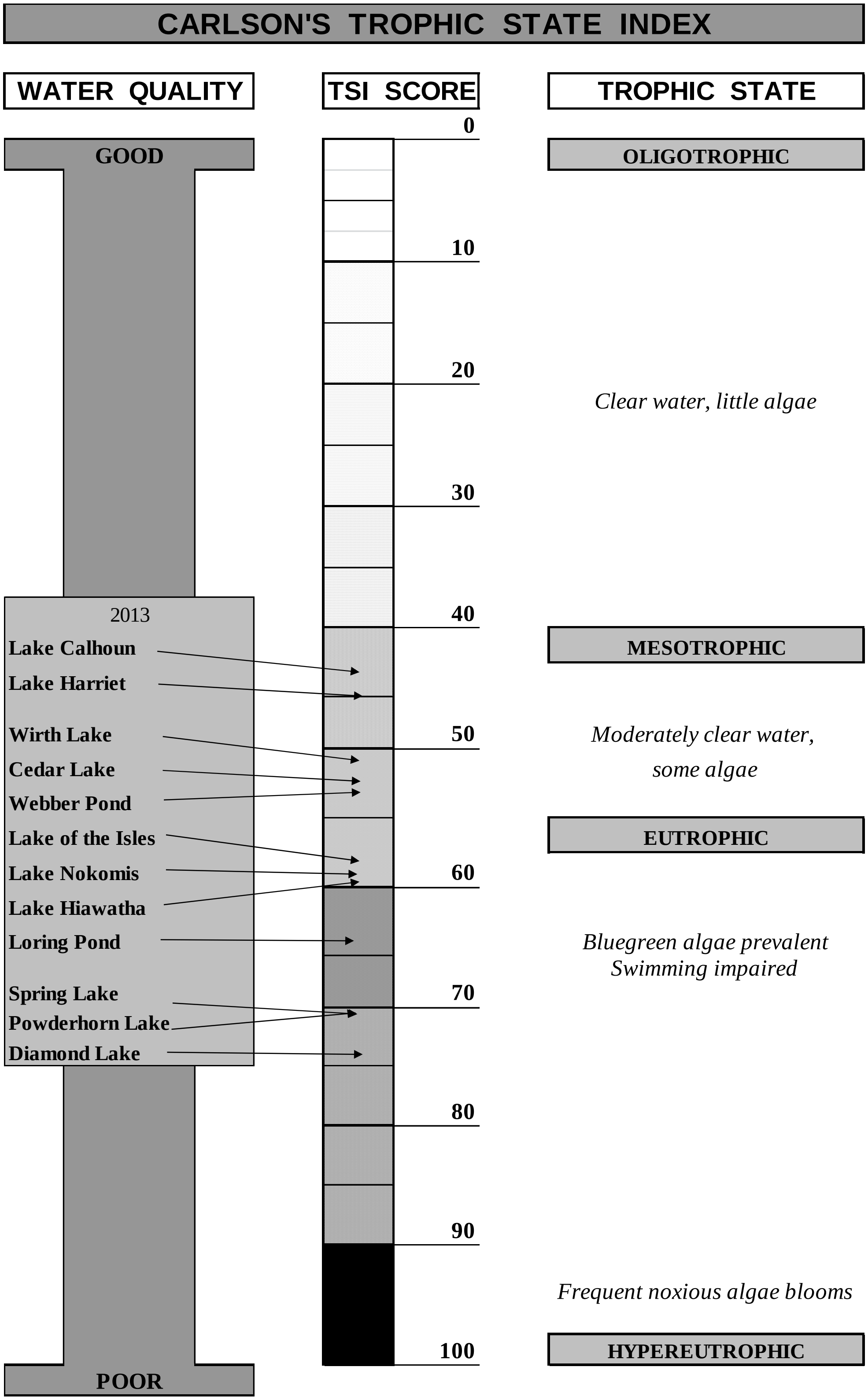


Figure 18-1. 2013 lake trophic state comparison. In general, the deeper lakes have lower TSI scores.

Table 18-2. Water quality trends in Minneapolis lakes from 1991-2013.

Lakes with increasing water quality indicators	Lakes with stable trend	Lakes with decreasing water quality indicators
➢ Lake Calhoun	➢ Brownie Lake	➢ Diamond Lake
➢ Cedar Lake	➢ Lake of the Isles	➢ Loring Pond
➢ Lake Harriet	➢ Lake Nokomis	➢ Spring Lake
➢ Powderhorn Lake	➢ Lake Hiawatha	
➢ Wirth Lake		

Table 18-3. Water quality trends in Minneapolis lakes from 2003-2013.

Lakes with increasing water quality indicators	Lakes with stable trend	Lakes with decreasing water quality indicators
➢ Diamond Lake	➢ Brownie Lake	➢ Lake Calhoun
➢ Lake Nokomis	➢ Lake Hiawatha	➢ Cedar Lake
➢ Wirth Lake	➢ Lake of the Isles	➢ Lake Harriet
	➢ Spring Lake	➢ Powderhorn Lake
	➢ Loring Pond	

Diamond Lake is a very shallow lake that can change quickly between a green colored, algae dominated state and a clear water, aquatic plant dominated state. Over the last decade, Diamond has been trending towards lower TSI scores; however, when all years of record are considered, the trend is less clear. Recent drought conditions in summer may be causing a lower nutrient load to this shallow waterbody.

Lake Nokomis might be at the beginning of a trend towards improved water quality. A biomanipulation project has been taking place in this lake for the past five years and may be starting to affect TSI scores.

Wirth Lake has had both ponding and two different lake outlet configurations implemented in its watershed, and is showing a very strong trend towards better water quality. It is expected that Wirth Lake will be taken off of the impaired waters list.

Brownie Lake, Cedar Lake, and Lake of the Isles were part of the Chain of Lakes Clean Water Partnership Project that occurred in the 1990s. Trends in Brownie Lake are difficult to evaluate because the sampling regime has changed over time. Recent improvements in this lake’s watershed outside of Minneapolis have decreased the amount of phosphorus coming to the lake, so the lake may start to respond in several years. Cedar Lake responded positively to an alum treatment in 1996, which was assumed to last until approximately 2003. Recent higher TSI scores at Cedar may be showing a new normal that does not include the residual effects from the alum treatment. Lake of the Isles also had an alum treatment in 1997, and similar to Cedar Lake, the treatment may not be currently affecting its TSI score.

Lake Hiawatha is strongly influenced by flow in Minnehaha Creek, and the lake does not seem to exhibit a temporal trend at this time.

Although the long term water quality trend for Calhoun, Harriet, and Powderhorn lakes show increased water quality since the early 1990s, the 10-year regression for these lakes show a trend towards lower water quality. This could partly be because the 10-year timeline begins with years that these lakes exhibited the best water quality in all of the years of record. This is particularly the case with Lake Calhoun, where even though the last 10 years have shown a trend towards higher TSI scores, the scores are considerably better (lower) than prior to restoration in the early 1990s (**Figure 18-2**). Both Lake Harriet and Lake Calhoun have outstanding water quality for urban lakes and have better water quality than a decade ago, when restoration efforts began.

Webber Pond was sampled four times throughout 2013 and was in a clear water state during recent years; however, the pond was demolished on August 14, 2013 to make way for the Webber Natural Swimming Pool.

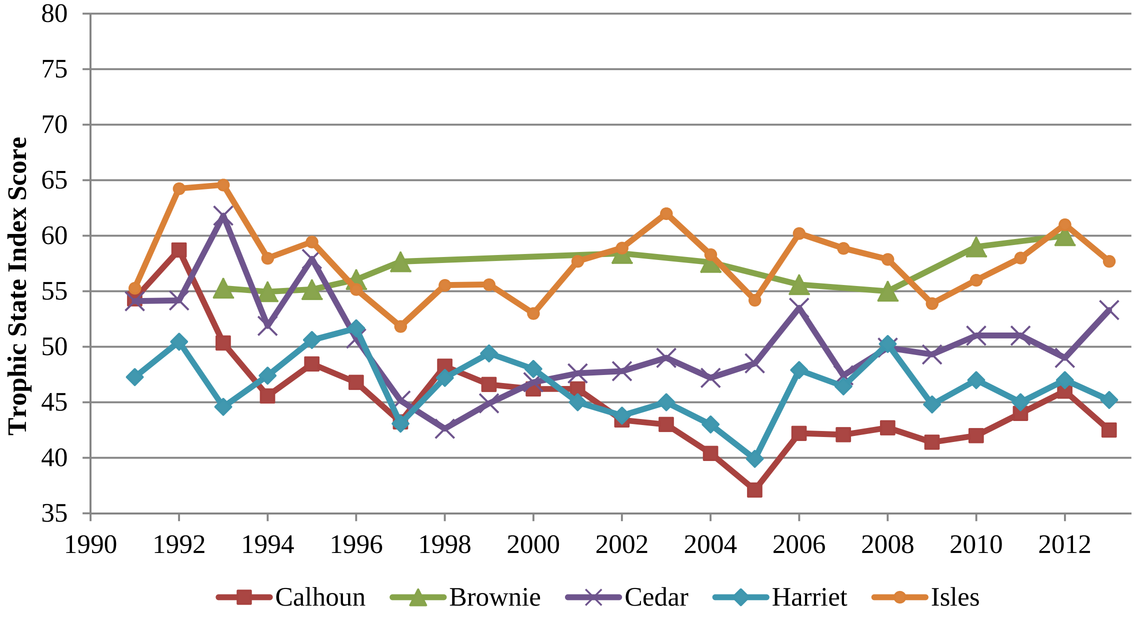


Figure 18-2. TSI scores for selected Minneapolis lakes 1991–2013. Lake Calhoun has the strongest trend towards lower TSI scores.

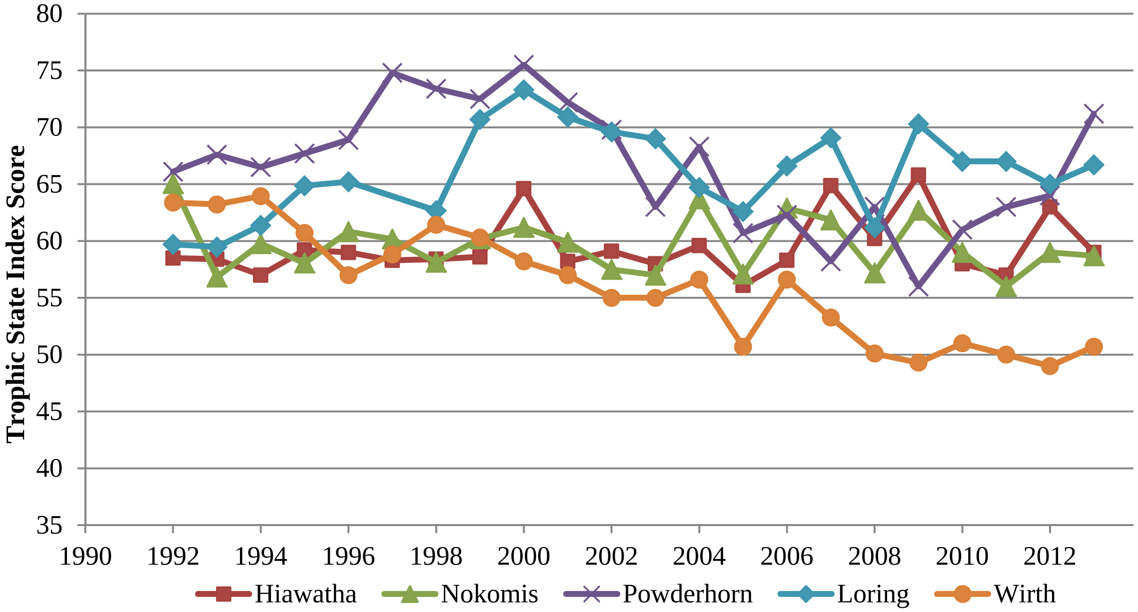


Figure 18-3. TSI scores for selected Minneapolis lakes 1992–2013. Wirth Lake has the strongest trend towards lower TSI scores and better water quality.

LAKE LEVELS

Lake levels are recorded weekly for Harriet, Hiawatha, Nokomis, Loring, Powderhorn, Wirth, and the Upper Chain of Lakes (Brownie, Calhoun, Cedar and Isles) at Lake Calhoun from ice-out to ice-on. Channels connect the Upper Chain of Lakes which makes the level at Calhoun representative of all four lakes. The new Wirth Lake gauge is shown in **Figure 18-4**. Since the Loring Pond gauge site is filled in by extensive cattail growth and in the past several years has been only occasionally functional as a level gauge, a new auxiliary gauge was installed on the south side of the pond in 2013 to measure low water levels. Fixed staff gauges are used at all locations that are shown in **Figure 18-5.** Average annual lake levels and selected statistics for each lake with a staff gauge are shown in **Tables 18-4** and **18-5**. The Chain of Lakes (Upper Chain and Lake Harriet) water levels are illustrated in **Figure 18-6**. The remaining lakes' levels are shown in **Figure 18-7**.

Lake levels vary annually based on precipitation, stream flow, and stormwater inflow. A wet May raised water levels which then fell slowly over the course of the 2013 summer. Over the 2013 season, all lakes were above their 10-year averages as can be seen in **Tables 18-4** and **18-5.** Late summer and fall returned to drought conditions, and Lakes Harriet and Calhoun levels almost dipped below their outlets. Groundwater augmentation can be seen in the level graphs for Loring and Powderhorn lakes. Historical lake levels can be found in the individual lake **Sections 2-17**.

Figure 18-4. Wirth Lake outlet and gauge, 2013.

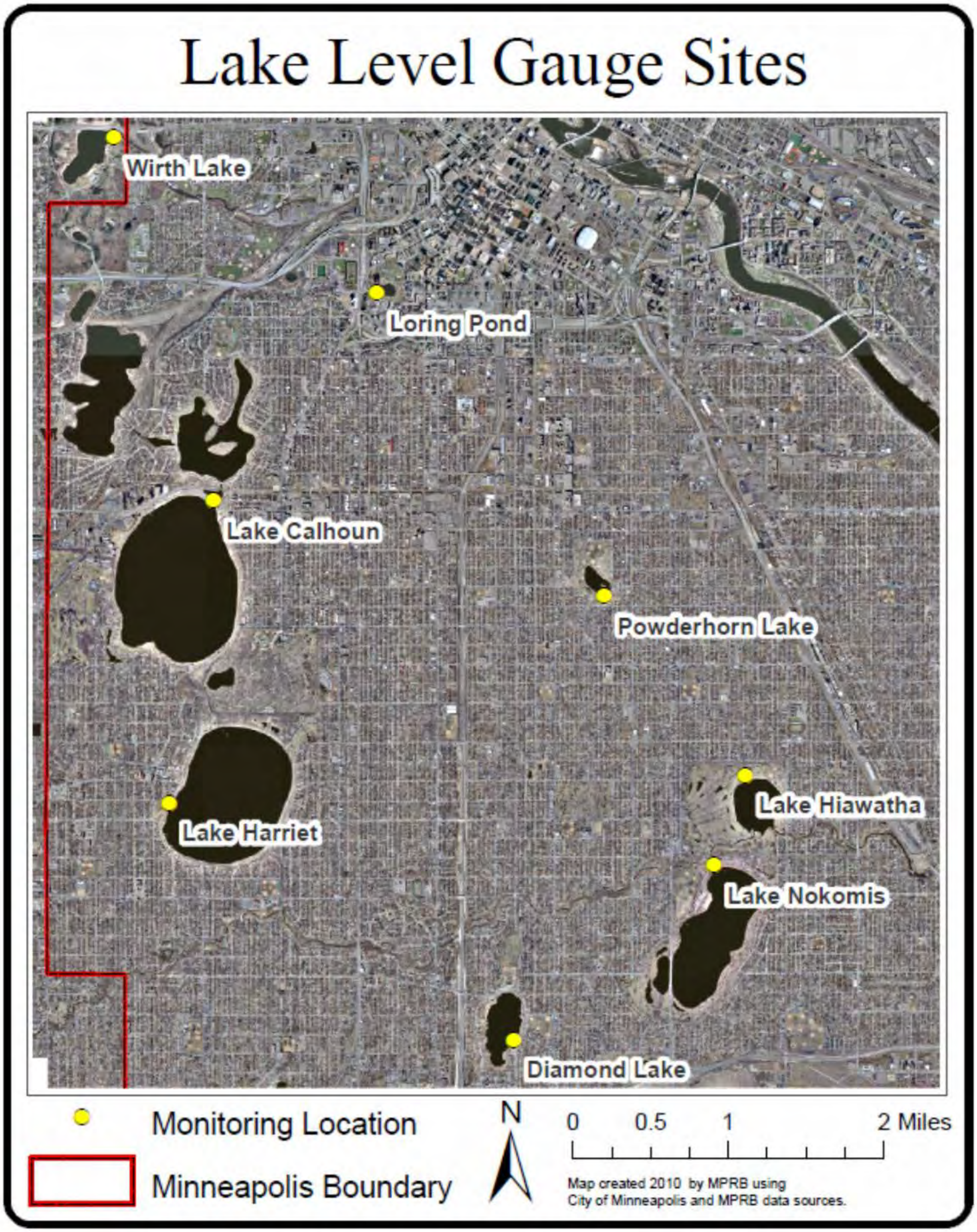


Figure 18-5. Minneapolis lake level monitoring locations.

Lake levels rose during spring storms in the Chain of Lakes and Lake Harriet and then fell through the remainder of the year, as shown in **Figure 18-6.** Lake Harriet and the Chain of Lakes were just above their 10-year averages as shown in **Table 18-6**.

Powderhorn Lake level can be augmented by a groundwater well; however, the augmentation well was only used in July and November in 2013. The lake is strongly influenced by stormwater. Peaks in Powderhorn's level in 2013 followed large storms. The lake was just over half a foot above its 10-year average in 2013.

Loring Pond is another lake that is augmented by groundwater. The average lake level was equal to its 10-year average in 2013. Towards the end of the year, Loring's water level was allowed to fall below the outlet in order to produce better conditions for a cattail control and vegetation enhancement project. Large storms have caused stormsewers to surcharge to the pond periodically in the last 10 years and can be seen in the lake level graph in Loring's individual lake chapter.

Lake Hiawatha levels are influenced by the inflow of Minnehaha Creek which changes depending on the operation of the Lake Minnetonka outlet dam. During 2013 the dam at Grey's Bay opened in early May, was open up to 300 cfs during June and July, and closed at the end of September. The 2013 average lake level was just over half an inch above the 10-year average for the lake.

Groundwater recharge to Wirth Lake is likely responsible for its stable levels. The 2013 lake level is comparable to the 10-year average.

Table 18-4. Average annual lake levels in feet above msl for the past 10 years.

Lake	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Chain[§]	852.35	852.90	852.85	852.53	852.14	851.75	852.50	852.94	852.05	852.66
Harriet	847.43	847.31	847.11	847.37	847.13	846.89	847.28	847.63	847.14	847.48
Hiawatha	812.58	812.92	812.61	812.31	812.14	811.64	812.79	813.36	811.83	813.05
Loring*	818.01	818.23	816.68	817.63	817.85	817.80	817.77	817.84	817.95	817.85
Nokomis	813.28	812.89	812.96	813.00	813.22	811.89	812.24	814.71	814.46	815.13
Powderhorn*	818.48	818.35	818.40	817.43	816.89	816.70	817.18	817.76	817.39	818.15
Wirth	818.01	818.13	817.81	817.95	817.96	817.95	818.03	818.07	818.00	818.10

[§] The Chain of lakes includes: Calhoun, Cedar, Isles, & Brownie.

* In dry years the level can be below recordable stage.

Table 18-5. Selected statistics for lakes with level data based on the past 10 years of data.

Lake	10-year avg (ft msl)	2013 avg (ft msl)	2013 comparison to 10yr average	Standard deviation around 10-year avg (ft)
Chain	852.48	852.66	0.18	0.63
Harriet	847.30	847.48	0.18	2.64
Hiawatha	812.52	813.05	0.53	1.01
Loring	817.85	817.85	0.00	0.32
Nokomis	813.53	815.13	1.60	1.16
Powderhorn	817.60	818.15	0.55	0.87
Wirth	818.02	818.10	.08	0.22

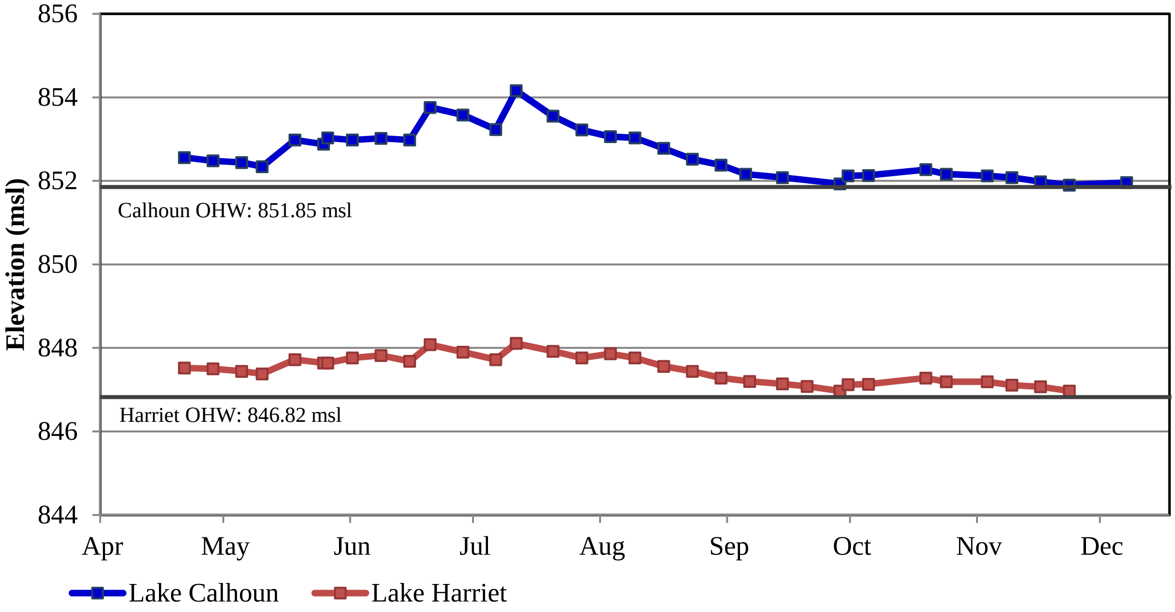


Figure 18-6. **2013 Lake levels for the Minneapolis Upper Chain of Lakes (Brownie, Cedar, Isles, and Calhoun) and for Lake Harriet.**

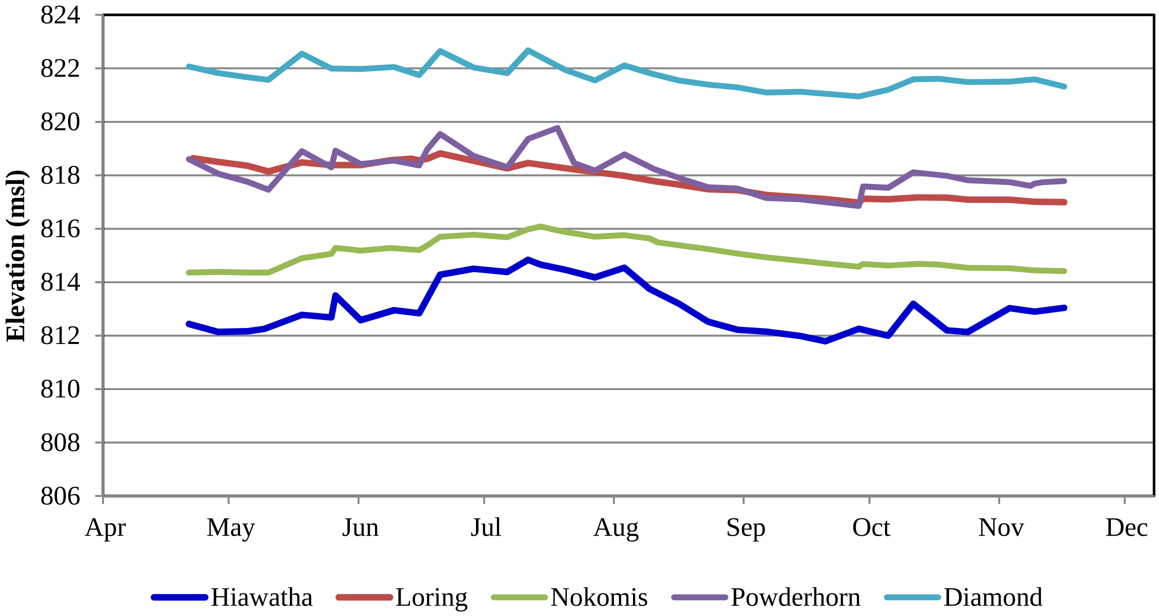


Figure 18-7. **2013 Lake levels for Lake Hiawatha, Loring Pond, Lake Nokomis, Powderhorn Lake and Diamond Lake.**

Lake Aesthetic and User Recreation Index (LAURI)

The LAURI was developed to provide recreational users with an additional source of information about the health of MPRB lakes. The LAURI provides lake users with an easily understandable recreational suitability indicator for the MPRB lakes. Background information on the LAURI can be found in **Section 1**. The LAURI index was updated in 2009 to include measures of habitat quality and recreational access, and has been used by Minneapolis and the Minneapolis Greenprint as a Citywide Metric.

All scores in the LAURI are between 1 and 10 with 10 as the best possible score. **Table 18-6** shows the LAURI scores of each lake for 2013. If the LAURI parameters were looked at for all of the lakes together, it would look like the LAURI presented in **Figure 18-8.**

Table 18-6. 2013 sub-scores and classifications for each LAURI category.

Lake	Aesthetics	Habitat Quality	Water Clarity	Public Health	Rec. Access
Calhoun	9.3	9	9	8	10
Cedar	8.9	8	4	8	10
Harriet	8.9	8.5	8	9	10
Hiawatha*	7.7	6.3	8	3	4
Isles*	8.5	7.5	6	NB	10
Loring*	8.6	3.5	8	NB	3
Nokomis*	8.7	4.8	6	8	10
Powderhorn*	7.1	6	2	NB	3
Wirth	9.2	8	6	9	10

LEGEND

Excellent **Good** **Poor**

* Denotes shallow lake.
NB = no swimming beach.

In general, lakes with the best habitat quality also had the best clarity and aesthetics. Lakes with poor clarity, odor, or trash problems scored lower in aesthetics. Larger lakes had better recreational access scores due to more opportunities to access the water through boating.

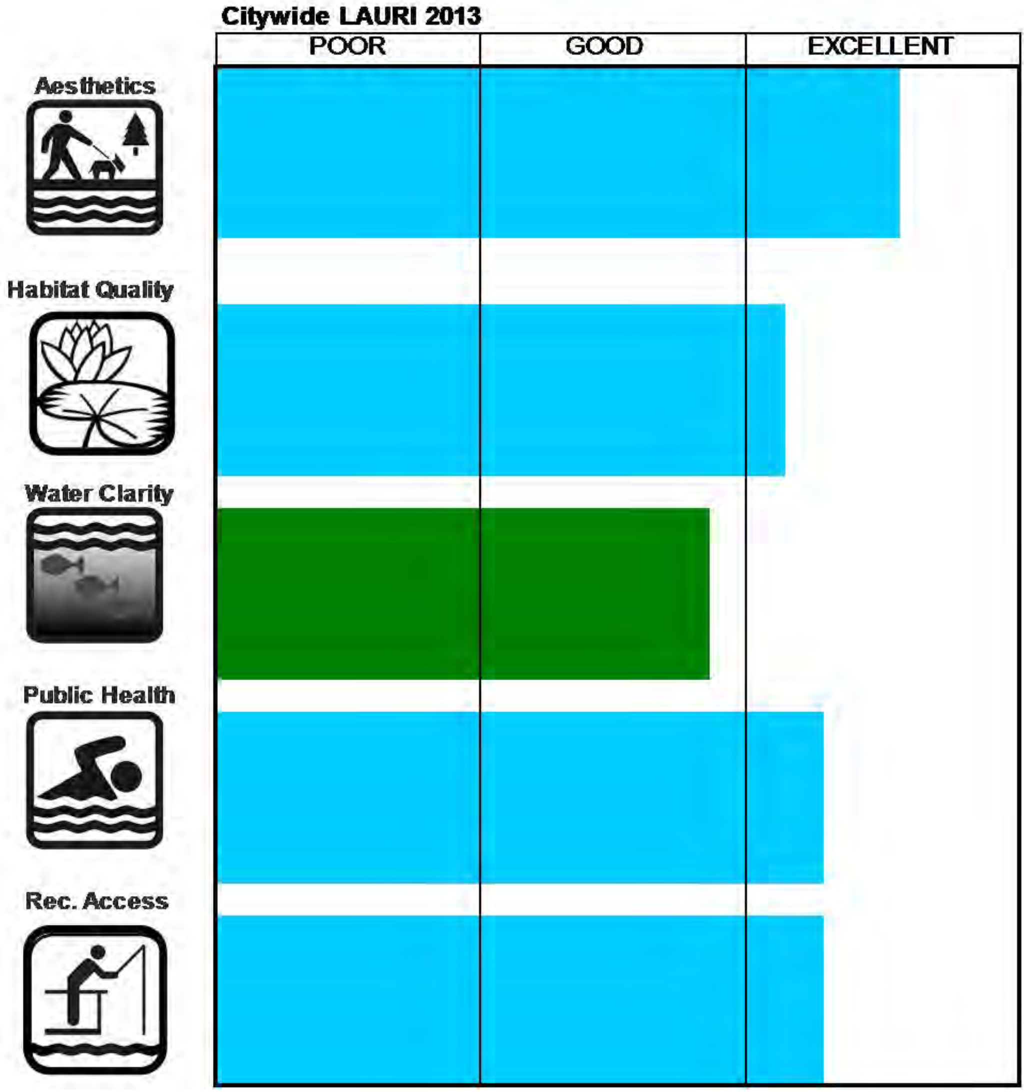


Figure 18-8. 2013 Average LAURI for Minneapolis. Includes: Calhoun, Cedar, Harriet, Hiawatha, Isles, Loring, Nokomis, Powderhorn, and Wirth Lakes.

WINTER ICE COVER

The Minneapolis lakes had a shorter than average ice-free period in 2013. With unusually cold spring temperatures, all lakes either set or matched the latest recorded ice-off date, as shown in **Table 18-7.** Ice-on dates varied based on lake size. Most lakes were completely frozen around a week before the average recorded ice-on date, as can be seen from **Table 18-8.** A few warmer than average days in early December caused the small lakes to open up again after freezing completely, however, shortly after they became ice covered for the remainder of the season. For further information on winter ice cover records see **Section 1** and individual lake sections.

Table 18-7. Statistics related to ice-off dates.

Lake	2013	Earliest Ice Off	Year Occurred	Latest Ice Off	Year Occurred	Mean	Median	Years of Record
Birch	4/28	3/8	2000	4/28	2013	4/4	4/4	28
Brownie	4/28	3/9	2000	4/28	2013	4/3	4/3	32
Calhoun	4/28	3/9	2000	4/28	1965, 2013	4/9	4/10	64
Cedar	4/28	3/9	2000	4/28	2013	4/6	4/6	40
Diamond	4/24	3/6	2000	4/24	2013	4/2	4/4	21
Harriet	4/28	3/9	2000	4/28	1965, 2013	4/7	4/7	46
Hiawatha	4/26	3/8	2000	4/26	2013	4/4	4/4	39
Isles	4/28	3/8	2000	4/28	2013	4/5	4/5	44
Loring	4/25	3/6	2000	4/25	2013	4/2	4/3	33
Nokomis	4/27	3/8	2000	4/27	2013	4/4	4/4	42
Powderhorn	4/27	3/8	2000	4/27	1965, 2013	4/4	4/3	34
Spring	4/24	3/6	2000	4/24	2013	4/1	4/2	23
Wirth	4/27	3/7	2000	4/27	2013	4/2	4/3	37

Table 18-8. Statistics related to ice-on dates.

Lake	2013	Earliest Ice On	Year Occurred	Latest Ice On	Year Occurred	Mean	Median	Years of Record
Birch	11/25	11/1	1991	12/16	1998	11/25	11/27	28
Brownie	11/25	11/5	1991	12/20	2001	11/28	12/1	32
Calhoun	12/8	11/25	1996	1/16	2006-7	12/12	12/11	44
Cedar	11/27	11/18	1989	12/21	1998, 1999, 2001	12/4	12/4	32
Diamond	11/22	11/18	2000, 2008	12/20	2001	12/1	12/1	19
Harriet	12/8	11/25	1996	1/16	2006-7	12/12	12/11	41
Hiawatha	11/27	11/1	1991	1/31	2006-7	12/2	12/3	33
Isles	11/25	11/5	1991	1/2	2006-7	12/1	12/2	39
Loring	11/25	11/1	1991	12/21	1999, 2001	12/1	12/3	29
Nokomis	11/27	11/1	1991	1/17	2011-12	12/1	12/1	34
Powderhorn	11/25	11/1	1991	12/20	2001	11/28	11/30	29
Spring	11/26	11/10	1995	12/20	2001	11/28	11/27	23
Wirth	12/2	11/5	1991	12/21	2001	11/30	12/2	33

INVASIVE SPECIES MONITORING

MPRB has been actively monitoring invasive species since the late-1980s to early 1990s when Eurasian watermilfoil (*Myriophyllum spicatum*) was first discovered in the Chain of Lakes. By 1992, MPRB and the Hennepin County Conservation District began managing milfoil in the Chain of Lakes with financial support from the MDNR. In the early 1990s MPRB staff tracked areas of invasive Eurasian watermilfoil (EWM) versus native northern watermilfoil (*Myriophyllum exalbescens*). Later, MPRB partnered with Dr. Ray Newman of the University of Minnesota. Dr. Newman conducted some early studies in the Minneapolis lakes and the potential use of a native beetle, *Euhrychiopsis lecontei*, that prefers to feed on EWM and can be grow to high enough densities to diminish the growth of EWM in lakes in certain situations.

MPRB first began managing aquatic invasive species when Eurasian water milfoil was discovered; however, the EWM was not the first invasive aquatic species to be introduced to the MPRB lakes. In 1910, curly-leaf pondweed (*Potamogeton crispus*) was first documented in the state of Minnesota. Curly-leaf pondweed has an unusual life cycle in that it is an annual that begins growing under the ice and dies off in June. During spring, after mild winters, curly leaf pondweed often produces thick mats of vegetation that are a nuisance for boating; however, this plant can be held to low levels of growth by harsh Minnesota winters. Macrophyte surveys by Shapiro (1974) documented curly-leaf pondweed in Lakes Calhoun, Harriet, Isles, and Nokomis; however, surveys carried out by Shapiro were in late-July which was likely too late in the season to capture the full extent of curly leaf pondweed in the Minneapolis Lakes.

The 1974 Shapiro surveys found that aquatic plants grew to only about 15 feet of depth in Lakes Calhoun and Harriet. Lake of the Isles and Lake Nokomis only had plants growing out to about 5 to 6 feet of water. Wirth Lake only had a shallow ring of aquatic plants growing out to a depth of 3 feet. Intact and robust native plant communities are better able to withstand invasion by exotics. Therefore, the lack of plant growth throughout the littoral zones of the Minneapolis Lakes may have left them vulnerable to invasion by EWM two decades later.

Most other exotic aquatic species only occur in a few lakes in the MPRB system as can be seen from **Figure 18-9** and **Table 18-9**. Brazilian water weed (*Egeria densa*) was found in Powderhorn Lake in 2007 during a routine MPRB plant survey. The MDNR mapped areas where the invasive plant was growing and chemically treated those areas with diquat, an herbicide approved for aquatic use. Brazilian water weed has not been identified in the lake since treatment. This plant can grow to extremely high densities limiting growth for native plants. It is a common aquarium plant and likely found its way to Powderhorn Lake via an aquarium release.

Chinese Mystery Snails (*Bellamya chinensis*) have been identified by MDNR and MPRB in Webber Pond, Loring Pond, Powderhorn Lake, and Grass Lake as shown in **Figure 18-9** and **Table 18-9.** The Chinese mystery snail, which is native to Asia, was introduced to California in 1892, and was found on the East Coast by 1915(MDNR, AIS website). The species is a popular aquarium snail, and new populations are often a result of an aquarium release. This species has the capability of growing to high densities and tends to have boom and bust cycles. When the population reaches the “bust” portion of the cycle, large concentrations of dead snails can ring the shoreline and create odor and aesthetic issues as they decompose.

Lakes Nokomis and Hiawatha have been declared infested with zebra mussels (*Dreissena polymorpha*) because of their connection with Minnehaha Creek and Lake Minnetonka. However, as of fall 2013, zebra mussels have not been confirmed to be present in Lake Nokomis. The Minnehaha Creek Watershed District (MCWD) and MPRB have performed rapid assessments on MPRB lakes each fall since zebra mussels were confirmed in Lake Minnetonka in 2010. MPRB also deploys monthly samplers in Calhoun, Harriet, and Hiawatha as an early detection method. Additionally, Friends of Lake Nokomis monitors a monthly sampler in Lake Nokomis. In August 2013, Zebra mussels were confirmed as present in Lake Hiawatha. No zebra mussels were found in the other Minneapolis lakes via MPRB and MCWD's rapid assessments or zebra mussel sampling program in 2013.

Lakes containing European carp (*Cyprinus carpio*) and goldfish (*Carassius auratus*) are identified in **Figure 18-9.** The data shown were taken from MDNR Lake Finder and is based on MDNR fish surveys. Other Minneapolis lakes may have carp or goldfish but these species have not been identified specifically in fish surveys. Each of these species can reproduce to very high densities. At high densities, these bottom-feeding fish are capable of disturbing lake beds to the extent that water quality can be diminished. Lakes with an overgrowth of European carp typically have high phosphorus concentrations, low water clarity, and little to no aquatic plant growth. Carp eat vegetation and can alter or destroy the aquatic plant community in a lake. In 1977, MDNR chemically treated Wirth Lake with Rotenone to remove rough fish and stocked the lake with largemouth bass, walleye, and channel catfish. In 2002, the MCWD sponsored a carp removal at Lake Nokomis.

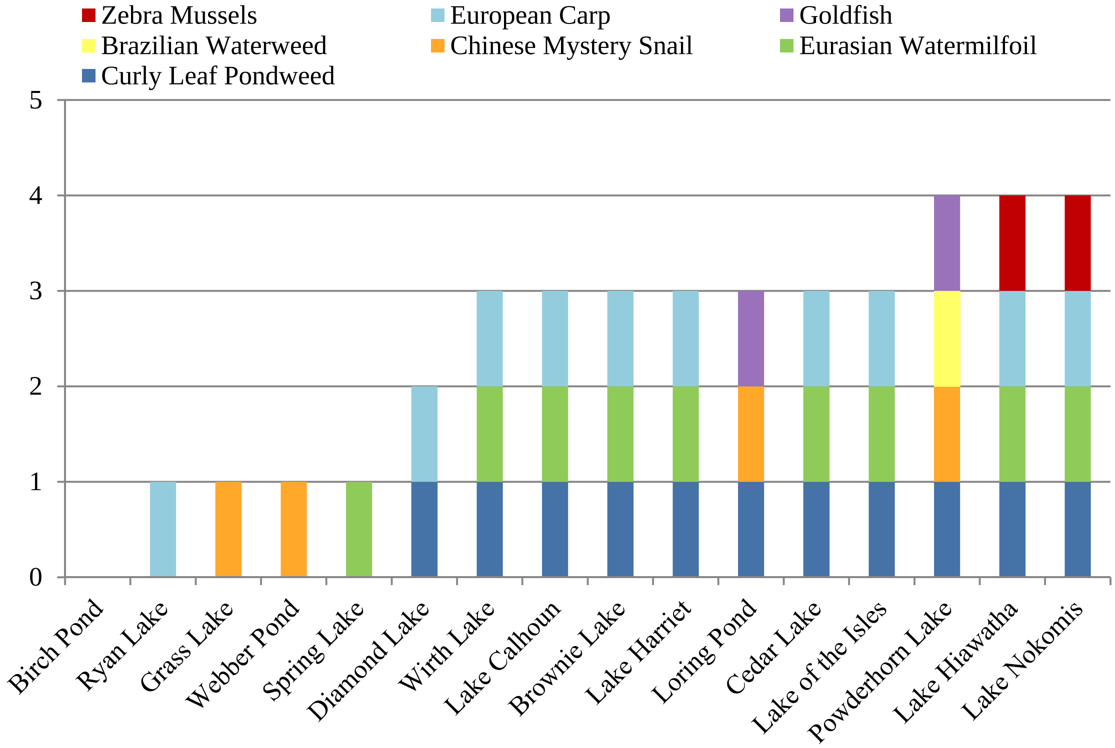


Figure 18-9. Invasive and exotic aquatic species found in MPRB Lakes. Birch Pond, Ryan, and Grass Lakes have not been fully surveyed for invasive species. Zebra mussels have not been confirmed present in Lake Nokomis. Brazilian water weed in Powderhorn was successfully treated with chemicals in 2007.

Table 18-9. Exotic species established in MPRB lakes, the number of lakes where the species are found and the data source used.

Common Name	Scientific Name	# of Lakes	Data Source
Curly leaf pondweed	*Potamogeton crispus*	11	MPRB
Eurasian watermilfoil	*Myriophyllum spicatum*	10	MDNR infested waters list
European carp	*Cyprinus carpio*	8	MDNR fish survey
Chinese mystery snail	*Bellamya chinensis*	4	MDNR
Zebra mussel**§**	*Dreissena polymorpha*	2	MDNR infested waters list
Goldfish	*Carassius auratus*	2	MDNR fish survey
Brazilian water weed*	*Egeria densa*	1	MDNR infested waters list

§Lakes Nokomis is considered infested with zebra mussels due to its connection with Minnehaha Creek and Lake Minnetonka. The species has not been confirmed present in Lake Nokomis as of fall 2013.
* Treated successfully in 2007 by MDNR.

19. PUBLIC BEACH MONITORING

BACKGROUND

The Minneapolis Park and Recreation Board (MPRB) has twelve official beaches located on six lakes (**Figure 19-1**). Prior to 2003 the City of Minneapolis Environmental Health Department monitored the beaches for fecal coliform bacteria. The MPRB began beach monitoring in 2003 and tested the beaches for *Escherichia coli* (*E. coli*) as well as fecal coliform bacteria. From 2004 to the present MPRB Environmental Operations staff monitored the beaches for *E. coli* alone as recommended by the US Environmental Protection Agency (USEPA). USEPA guidelines for *E. coli* require that a single sample should not exceed 235 organisms per 100 mL of water and that the geometric mean of not less than 5 samples equally spaced over a 30-day period should not exceed 126 organisms per 100 mL of water (USEPA, 1986). MPRB followed this set of guidelines for the 2004 and 2005 beach seasons. Epidemiological testing allowed the Minnesota Pollution Control Agency (MPCA) to develop an inland lakes standard which MPRB has followed since 2006. The inland lakes standard has a single-sample limit of 1,260 organisms per 100 mL and was accepted into rule by MPCA in 2008 and has been used by MPRB since that time.

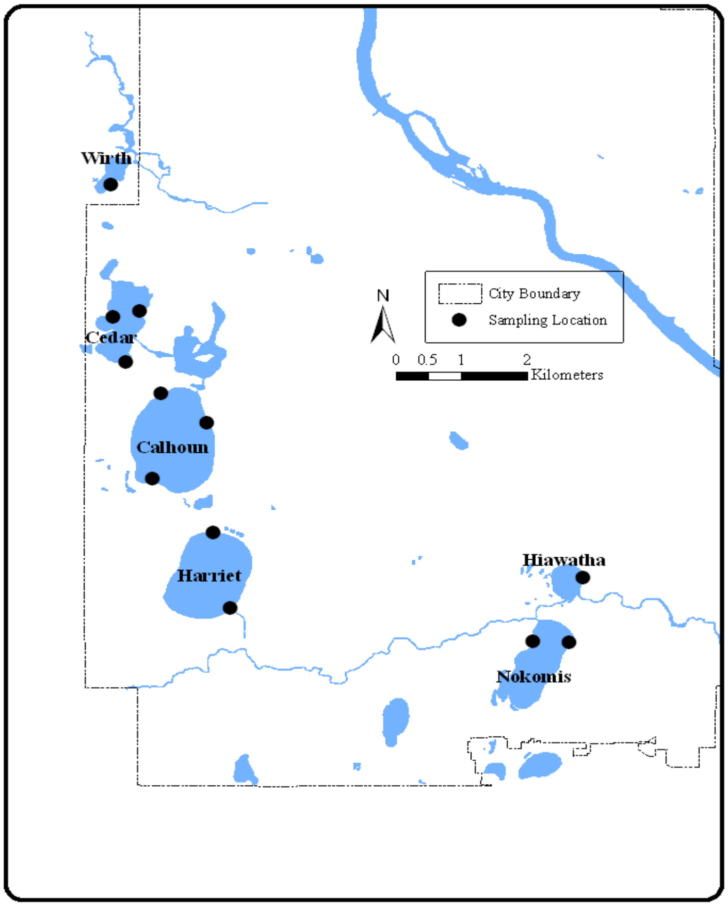


Figure 19-1. Map MPRB public beaches monitored in 2013.

A great diversity of pathogenic microorganisms exist, and testing for a large array of microbes would be time consuming and expensive. Due to this difficulty, *E. coli* is used as an indicator organism for monitoring and regulation. *E. coli* is a proxy for the measure of fecal contamination in recreational waters (USEPA, 2005). Indicator organisms do not cause illness under normal conditions which makes them useful when determining if a potential health risk is present in the lake water. Bacteria can enter the aquatic environment from agricultural and stormwater runoff, direct discharge of waste from mammals and birds, and from untreated human sewage. Elevated bacteria levels generally occur in aquatic environments after rain events when bacteria from various sources are washed into the lakes. Elevated bacteria levels in MPRB lakes usually return to normal levels within 24 to 48 hours of a rain event.

Potential sources of *E. coli* in lake water include:

- foreshore beach sand
- organic debris
- leaking diapers, bather defecation
- polluted stormwater runoff
- sewage spills near the beach
- sewer line break discharges
- stream inflows
- wild and domestic animal waste (such as geese, gulls, raccoons, dogs, etc.).

Research originally used to develop *E. coli* as an indicator organism held that it does not survive well outside of the digestive systems of warm-blooded animals. Half-lives of approximately 1 day in water, 1.5 days in sediment, and 3 days in soil were once thought to be typical survival rates of *E. coli* outside of its host environment (Winfield and Groisman, 2003).

More recent findings indicate that *E. coli* is able to survive and grow outside of its host environment and mats of algae can be a potential source of *E. coli*. Whitman et al. (2003) found that *Cladophora* (green algae) mats in Lake Michigan are capable of supporting *E. coli* in significant numbers. Bacteria from the dried mats grew upon re-hydration even after 6 months. *Shigella*, *Salmonella*, *Campylobacter*, and a shiga toxin-producing strain of *E. coli* (STEC) have also been found to be associated with a common filamentous algae species, *Cladophora* (Byappanahalli et al, 2009).

Beach sand has also been identified as another potential growth medium for *E. coli*. Whitman and Nevers (2003) have shown that *E. coli* can sustain itself in wet beach sand that can serve as a non-point source of bacterial contamination. Another study by Byappanahalli et al. (2003) found *E. coli* to be ubiquitous and persistent in a Midwestern stream. *E. coli* was common in stream banks and wetted sediments acting as a source of contamination to the stream. Genthner et al. (2005) found that after tidal events, the swash zone (area of beach where waves continuously wash up on the sand) harbored higher densities of microorganisms and indicator bacteria, which is partially attributable to entrapment. It has also been found that biological (e.g. nutrients and protection from predation) and physical (e.g. particulate matter, periodic wetting and drying, and protection from solar irradiation) factors enhance bacteria survival while providing a growth-promoting environmental niche. In studies in the Upper Midwest, Ishii et al. (2005) found significant populations of viable, naturalized *E. coli* in northern temperate soils in three Lake Superior watersheds. Ishii et al. (2007) found that the distribution of human and naturalized sources of *E. coli* at beaches can change over the course of a summer.

METHODS

Samples were collected from twelve MPRB beaches every Monday during the beach season (6/10/13 through 8/26/13). Beaches monitored in the 2013 MPRB program were:

- Calhoun 32nd Street
- Calhoun Main (North)
- Calhoun Thomas (South)
- Cedar Main (South)
- Cedar Point
- East Cedar (Hidden)
- Harriet Main
- Harriet Southeast
- Hiawatha
- Nokomis 50th Street (East)
- Nokomis Main
- Wirth

Two samples were taken from each beach in knee deep water (1.8 feet) roughly six to twelve inches below the surface. The samples were then transported in an ice water bath to Instrumental Research Incorporated's lab (IRI). IRI used a Colilert-Quanti Tray to determine the most probable number (MPN) of *E. coli* colonies in the samples. Field duplicates were also collected every sampling day on a rotating schedule. Water and air temperature were measured using a digital thermometer. Rain data was collected at the MPRB South Side Service Center using a tipping bucket rain gage.

Other parameters collected in the field when samples were taken included:

- air temperature
- current weather
- LAURI parameters of beach (For additional information on the LAURI see **Section 1**)
- number of adults, children, and children in diapers not in the water broken
- number of geese, ducks, and gulls on the beach
- number of swimmers in the water broken down by adults, children, and children in diapers
- water quality parameters (when permitted)
- water temperature
- comments (anything unusual, visible fecal material).

Additional data compiled in the office were:

- amount of previous day's rainfall
- wind speed and direction
- duration of rain event
- hours since last rain event
- intensity of rain event
- lake level
- beach attendance.

RESULTS & DISCUSSION

Specific lake and beach results are discussed in each of the lake sections.

Table 19-1 shows the basic descriptive statistics of *E. coli* (MPN organisms per 100 mL of water) in the beach water sampled during the 2013 beach season. Most beaches had low season-long geometric means with the exception of Lake Hiawatha, which closed multiple times due to exceeding the geometric mean guideline of 126 organisms per 100 mL of water. Four beaches had extremely low season long geometric means where the geometric mean was below 10 MPN/100mL. The single sample limit of 1,260 *E. coli* per 100 mL of water was exceeded only at Calhoun 32nd Beach during the 2013 beach season. The high bacteria event at 32nd was purported to be caused by a weekend rainstorm. The elevated levels lasted for a short period of time and the beach was back to its typically low bacteria levels two days later.

Table 19-1. Minimum, maximum, median, mean, geometric mean (entire season), and maximum 30-day geometric mean for *E. coli* values (MPN/100mL) from the twelve beaches monitored by the MPRB in 2013.

Statistical Calculations	Calhoun 32nd	Calhoun Main	Calhoun Thomas	Cedar Hidden	Cedar Main	Cedar Point	Harriet Main	Harriet SE	Hiawatha	Nokomis 50th	Nokomis Main	Wirth
Number of Samples	14	13	13	13	13	13	13	13	13	13	13	13
Minimum	2	1	1	1	2	3	4	1	7	2	3	1
Maximum	2203	48	171	71	433	509	25	44	994	110	69	19
Median	17	10	12	11	12	8	7	9	101	9	19	6
Mean	240	13	25	18	50	56	9	14	186	20	25	8
Geometric Mean	28	7	11	10	14	13	8	7	91	10	18	6
Max 30-Day Geo Mean	28	18	19	29	30	32	14	13	193	29	29	8
Standard Deviation	591	15	46	21	118	138	6	16	264	31	21	6

In general, rain is likely the single most influential cause of elevated *E. coli* levels in Minneapolis lakes. Rain washes the bacteria off of hard surfaces and sends it through the storm sewer system to the lakes. 2010 had the most storms, but 2011 had the most rain in a beach season. 2011 also had the largest single rain event. Very little rain fell during the 2008 and 2012 beach seasons. 2013 saw 9.66 inches of rain, however, nearly a third of that fell in one 3.00 inch storm on 7/13/2013. **Table 19-2** shows the number of storms during the beach season, the amount of rain received in the largest single rain event, the average amount of precipitation per rain event, and the total amount of rain received during the beach season.

The relationship between rain and *E. coli* at the beaches is likely complex. Differences in the timing and pattern of rainfall may be more influential on *E. coli* levels than rainfall amounts. The combination of rain intensity and duration may also influence bacteria at some of the beaches.

Table 19-2. Number of storms, largest storm (inches), average storm (inches), and total rain (inches) at MPRB South Side Service Center for the 2008–2013 beach seasons.

	2008	2009	2010	2011	2012	2013
Number of storms	11	11	20	15	16	12
Max rain single event	0.85	2.27	2.52	3.71	0.85	3.00
Avg. rain per event	0.38	0.64	0.62	0.91	0.42	0.80
Total Rain	4.21	7.02	12.49	13.81	6.70	9.66

It is difficult to assess the quality of water the same day of sample collection since testing requires 24 hours. The lag time between sample collection and receipt of test results can result in unnecessary beach closures and/or exposure to poor water quality. A study by Ha Kim and Grant (2004) found that the public is mis-notified about current water quality status and beaches are mis-posted up to 40% of the time. An example of this at MPRB occurred in 2013 when a sample was taken at Calhoun 32nd Beach on July 22nd. The beach was closed around noon on the 23rd when the results were found to exceed the single sample limit and the beach was re-sampled. The results from that sample came back on July 24th and were below the limit. The beach was open on July 22nd when it should have been closed and closed unnecessarily on July 23rd when it should have been open. The 24-hour delay caused posting errors on 2 days.

MPRB Environmental Operations staff seeks out the latest *E. coli* and beach pathogen research as well as technology for a rapid *E. coli* test to eliminate unnecessary closures. In the past, staff members have also participated in a Metro-Wide Beach Regulators group to enhance consistency among the different organizations operating beaches in the Metro.

In the USEPA Environmental Health Perspective (2005), the number of illnesses attributable to recreational water exposures was reported to be increasing. In Minnesota, there have been 12 outbreaks which were traced to water contact at lakes or swimming ponds since the year 2004. The majority (48%) of outbreaks were caused by *Cryptosporidium*. Other pathogens associated with outbreaks were: *E. coli* O157, *Legionella*, norovirus, *Pseudomonas* and *Shigella* (Minnesota Department of Health, 2014). It should be noted that none of the waterborne illness outbreaks were at Minneapolis beaches.

Communicating the results of beach monitoring with the public is a very important aspect of the process and also offers an opportunity for water and public health education. A phone and email tree is utilized to quickly notify staff and elected officials of beach closures and re-openings. A Beach Information Telephone Line (612.313.7713) is updated daily on beach closures due to bacteria testing. Results from testing are also put on the MPRB website the day results are received. The communication efforts were very successful in 2013 and offered the public many opportunities to obtain information regarding beach water quality and closures.

20. AQUATIC PLANT MANAGEMENT

EURASIAN WATER MILFOIL (*MYRIOPHYLLUM SPICATUM*)

Eurasian watermilfoil (*Myriophyllum spicatum*) has been an ongoing concern in several Minneapolis lakes. From an ecological standpoint it out-competes native species and changes the habitat for fish and other organisms. Milfoil often forms dense floating mats that interfere with boating and swimming.

The Minneapolis Park and Recreation Board (MPRB) primarily uses harvesting to maintain recreational access to city lakes. Only the top two meters of the milfoil plants are removed and this temporarily allows for problem-free boating and swimming. The MDNR permits limit the area of milfoil harvest. Harvesting was completed on Calhoun, Cedar, Harriet, Isles, Wirth, and Nokomis in 2013. MPRB Staff removed 143 flatbed truck loads of milfoil in 2013 which is comparable to 818 cubic yards of aquatic plant material. For harvested acreage see each individual lake section. MPRB contracted out harvesting work on Wirth and Nokomis to Waterfront Restoration, LLC, who removed milfoil from high traffic recreational areas by hand via SCUBA.

In previous years the MPRB and the University of Minnesota released aquatic weevils that eat Eurasian water milfoil into Cedar Lake, Lake of the Isles, Lake Harriet, and Lake Hiawatha. The weevils were not successful controlling milfoil. The most likely explanation is that the high density of sunfish in the lakes fed on the weevils and limited their population.

BRAZILIAN WATERWEED *(EGERIA DENSA)*

In August of 2007, a new aquatic invasive species, *Egeria densa*, was identified in Powderhorn Lake. The new invasive is native to South America and used extensively in aquariums and water gardens. It is likely that *Egeria* was introduced to Powderhorn Lake though an aquarium release. In September of 2007, the MDNR spot-treated stands of *Egeria* with diquat, an herbicide approved for aquatic use. MDNR and MPRB staff have not found any *Egeria* in Powderhorn since the herbicide treatment.

PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA*)

Since 1999, the MPRB has collaborated with the MDNR to introduce leaf-feeding beetles (*Galerucella spp*.) as a biocontrol for purple loosestrife (*Lythrum salicaria*). Both biocontrol methods and chemical herbicides are used to manage purple loosestrife throughout the park system. Beetles were found feeding at major purple loosestrife sites on MPRB properties in 2013. The MPRB and MDNR staff continues to monitor beetle release sites. Additionally, MPRB led a volunteer effort to cut purple loosestrife inflorescence around Lake of the Isles in order to limit seed dispersal. 2013 was the second year of volunteer management efforts around Lake of the Isles. MPRB has tracked the spread of purple loosestrife around Lake of the Isles to monitor its spread and efforts to limit seed dispersal.

21. Wetland Health Evaluation Project (WHEP)

BACKGROUND

The Wetland Health Evaluation Project (WHEP) began in 1997 in Dakota County with Environmental Protection Agency (USEPA) funding. In 2001, Hennepin County began its own WHEP program as a pilot project. The pilot program was successful at both the county and local levels and has continued as a partnership between the two counties, cities, and other water management organizations. WHEP utilizes teams of trained volunteers to collect and analyze wetland data to characterize wetland health. Hennepin County Environmental Services staff then cross-check, synthesize, and report the collected data back to the partner organizations and to the public.

MPRB has sponsored citizen volunteer teams who monitor wetlands within the park system each year since 2002. Every summer between two and four wetlands are monitored within Minneapolis depending on the needs of the MPRB. During 2013 the wetlands monitored were: a portion of the wetland edge of Diamond Lake, Cedar Meadows, Amelia Pond, Heritage Park North Wetland, and Wirth Golf Course wetland. The Roberts Bird Sanctuary wetland is also monitored annually as a reference wetland site for the City of Minneapolis.

For more information see the Minnesota WHEP website at www.mnwhep.org.

METHODS

Volunteers for the project are trained in three sessions by MPCA staff. Training sessions cover monitoring methods, macroinvertebrate identification, and vegetation identification. Spot checks and quality control checks are conducted by other citizen teams and by a technical expert for quality assurance purposes.

Sampling from the wetlands includes both vegetation and invertebrate data. All wetland evaluation and sampling protocols followed the *Vegetation Method for Wetland Evaluation* (Gernes, 2002). A vegetation survey was performed in a 100 square meter plot considered representative of the entire wetland for each site. Additionally, an invertebrate survey was completed with two samples from a dip-net within the emergent vegetation zone, near the shoreline, and in six overnight bottle trap samples.

The information is then used to evaluate the wetland’s biological health based on metrics developed by the Minnesota Pollution Control Agency. An index of biotic integrity (IBI) has been developed by the MPCA to include both vegetation and invertebrate metrics. The IBI metrics are listed below.

Vegetation IBI metrics (identification to genus level)

- Total number of forbs, woody species, and grass-like plants
- Total number of mosses, lichens, liverworts, and macro-algae (*Chara* and *Nitella*)
- Cover of sedge (*Carex*)
- Presence of Bladderwort (*Ultricularia*)
- Total number of "Aquatic Guild" plants
- Cover of plants with persistent standing litter

Invertebrate IBI Metrics (identification to family level)

- Number and type of leeches in net and bottle trap samples
- Proportion of Water Boatmen (*Corixidae*) in a bottle trap in relation to the total number of aquatic beetles and all bugs in the sample
- Number of types of dragonflies and damselfly nymphs in dip-net samples
- Total number of mayflies, plus the number and type of caddis flies, plus presence of fingernail clams and dragonflies
- Number of types of snails
- Number of taxa above, plus the number of crustaceans, plus the presence of *Chaoborus*

Ratings developed for the invertebrate and vegetation IBI are shown below in **Table 21-1**. The IBI assessment is useful to give a wetland a qualitative description that makes it easier to communicate results. Wetlands with poor ratings would have minimal species richness and diversity indicating disturbance and poor wetland health. A wetland with a rating of excellent would have high diversity and species richness indicating a healthy wetland and relatively minimal ecological disturbance.

Table 21-1. Ratings for the invertebrate and vegetation IBIs.

Invertebrate Index of Biotic Integrity		**Vegetation Index of Biotic Integrity**	
Sum of invertebrate metric scores	**Interpretation**	**Sum of vegetation metric scores**	**Interpretation**
6-14	Poor	7-15	Poor
15-22	Moderate	16-25	Moderate
23-30	Excellent	26-35	Excellent

RESULTS AND DISCUSSION

During the summer of 2013, WHEP-trained volunteers monitored five wetlands within the MPRB system. Roberts Bird Sanctuary was monitored for its eleventh time serving as a reference wetland for the Minneapolis WHEP program. IBI scores for other monitored wetlands can be compared to scores for the reference wetland to determine the effects of inter-annual variation or regional changes (drought, wet periods, plant diseases, etc.) on wetland heath. Results and discussion for each wetland are presented individually within this section.

Roberts Bird Sanctuary (Reference Site)

The Roberts Bird Sanctuary is located north of Lake Harriet. The Sanctuary is a natural area that has been preserved, and thus has been used as a reference wetland for the Minneapolis WHEP program. The wetland is estimated to be ten acres in size, within a 1000+ acres watershed. The WHEP team accesses the monitoring location near a tamarack stand from the boardwalk. 2013 was the eleventh year that WHEP monitored the site. **Table 21-2** shows the results for Roberts Bird Sanctuary. In 2013, the wetland scored 24/excellent for invertebrates and 15/poor for vegetation.

Table 21-2. WHEP scores at the Roberts Bird Sanctuary Site.

Year	Invertebrate Score	Invertebrate Quality Rating	Vegetation Score	Vegetation Quality Rating
2003	20	Moderate	17	Moderate
2004	20	Moderate	17	Moderate
2005	22	Moderate	15	Poor
2006	22	Moderate	17	Moderate
2007	28	Excellent	13	Poor
2008	20/22	Moderate/Moderate	21/17	Moderate/Moderate
2009	26	Excellent	19	Moderate
2010	20/22	Moderate/Moderate	21/19	Moderate/Moderate
2011	22/23	Moderate/Moderate	21/23	Moderate/Moderate
2012	26	Excellent	11	Poor
2013	24	Excellent	15	Poor

Diamond Lake Wetland Fringe

Diamond Lake has been monitored nine times in the WHEP Program. The wetland fringe at Diamond Lake has typically scored poor in both the invertebrate and vegetation IBI (**Table 21-3**). In 2013, the Diamond Lake Wetland Fringe scored 15/poor for vegetation quality and 26/excellent for invertebrates, the highest recorded score. This site is located in an urban setting with a large urban watershed and provides valuable bird habitat. The high invertebrate score may reflect a change in WHEP sampling technique. Even though vegetation scored a “poor” rating it was the second highest score recorded at this site.

Table 21-3. WHEP scores at Diamond Lake.

Year	Invertebrate Score	Invertebrate Quality Rating	Vegetation Score	Vegetation Quality Rating
2002	8	Poor	13	Poor
2005	14	Poor	7	Poor
2006	16	Moderate	13	Poor
2008	10	Poor	15	Poor
2009	18	Moderate	11	Poor
2010	24	Excellent	20	Moderate
2011	8	Poor	11	Poor
2012	24	Excellent	15	Poor
2013	26	Excellent	15	Poor

Amelia Pond

Amelia Pond is located at the S.W. corner of Lake Nokomis. It was once part of a large wetland called “Lake” Amelia. Around 1917 the Minneapolis Park and Recreation Board began dredging Lake Amelia to create what is now called Lake Nokomis. In the 1980’s native wetland and wet prairie vegetation was planted in the area, since the location was prone to flooding. In 2001 the Minnehaha Creek Watershed District dredged and created Amelia pond as a stormwater pond to “treat” stormwater runoff entering Lake Nokomis. Plantings of native vegetation were completed the summer of 2001. The site was dredged again in 2010. The summer of 2013 was the fourth time Amelia Pond was monitored through the WHEP Program.

Results have shown improvement in wetland quality since the reconstruction in 2001 (**Table 21-4**). This wetland was newly reconstructed prior to its first summer in the WHEP program and the wetland has now had several growing seasons to establish and develop increasing diversity and richness. In 2013, the wetland received a 21/moderate score for invertebrates and a 29/excellent for vegetation.

Table 21-4. WHEP scores at Amelia Pond

Year	Invertebrate Score	Invertebrate Quality Rating	Vegetation Score	Vegetation Quality Rating
2003	12	Poor	19	Moderate
2004	16	Moderate	23	Moderate
2007	36	Excellent	23	Moderate
2013	21	Moderate	29	Excellent

Heritage Park North Wetland

Heritage Park North Wetland is located in Sumner Field Park. The wetland was developed in 2006-2007. It catches stormwater runoff from multiple inlets and outlets at corner of 8th and Aldrich N where water then flows to Bassett Creek Tunnel, under downtown and to Mississippi River. The site was planted with wetland vegetation and infiltration trenches have been re-worked several times which has disturbed vegetation in the immediate area. The site has many BMPs in design, such as grit chambers and level spreaders, with additional rain gardens upstream.

2013 was the second year Heritage Park was included in WHEP monitoring, as presented below in **Table 21-5**. In 2013, Heritage Park received an invertebrate score of 20/moderate and a vegetation quality score of 23/moderate.

Table 21-5. WHEP scores at Heritage Park North Wetland

Year	Invertebrate Score	Invertebrate Quality Rating	Vegetation Score	Vegetation Quality Rating
2012	12	Poor	23	Moderate
2013	20	Moderate	23	Moderate

Wirth Golf Course Wetland

Wirth Golf Course Wetland is located on the par 3 golf course at Theodore Wirth Park. This site is fed by groundwater springs year-round, receives runoff from the adjoining development, and it outlets under Glenwood Avenue to Wirth Lake.

2013 was the sixth year of monitoring at the Wirth Golf Course Wetland and the first time since 2009, as presented below in **Table 21-6**. Wirth Golf Course Wetland received a score of 19/moderate for the vegetative IBI metric and a score of 18/moderate for invertebrates. The site is difficult to monitor due to the steep drop-off on the wetland's sides.

Table 21-6. WHEP scores at Wirth Golf Course Wetland

Year	Invertebrate Score	Invertebrate Quality Rating	Vegetation Score	Vegetation Quality Rating
2002	10	Poor	15	Poor
2003	18	Moderate	13	Poor
2004	22	Moderate	19	Moderate
2008	30	Excellent	19	Moderate
2009	24	Excellent	19	Moderate
2013	18	Moderate	19	Moderate

22. BASSETT CREEK WATERSHED OUTLET MONITORING PROGRAM (WOMP) STATION

BACKGROUND

Stormwater runoff carries non-point source pollutants from diverse and widely scattered sources to Twin Cities area streams and rivers. Monitoring is necessary to determine the extent of non-point source pollutant loading from tributaries to the Mississippi River. It also provides information for the development of target pollutant loads for the watershed and helps evaluate the effectiveness of best management practices all in an effort to improve water quality in streams and rivers.

In 1997 the Minnesota Legislature provided $575,000 to the Metropolitan Council Environmental Services (MCES) via the *Interagency Water Monitoring Initiative* (IWMI) for expansion of MCES water quality monitoring efforts. With this funding the Metropolitan Area Watershed Outlet Monitoring Program (WOMP) 2 was implemented in early 1998. The new WOMP2 program expanded the existing MCES WOMP stream-monitoring network in the metro area. Long-term stream monitoring data are critical for understanding non-point source pollutant impacts on water quality and for documenting water quality improvements as non-point source best management practices are implemented. The Minneapolis Park and Recreation Board (MPRB) operates the Bassett Creek WOMP station in cooperation with the Metropolitan Council and the Bassett Creek Watershed Management Commission (BCWMC). The Bassett Creek station is located at 100 Irving Avenue North near the Minneapolis Impound Lot (**Figure 22-1**).

The Bassett Creek watershed is slightly larger than 40 square miles and is divided into four major subwatersheds:

Main Stem: The Main Stem of Bassett Creek originates in Medicine Lake and generally flows east through parts of Plymouth, Golden Valley, and Minneapolis to the Mississippi River.

Medicine Lake Branch: The Medicine Lake Branch drains portions of Plymouth that discharge to Plymouth Creek. Plymouth Creek originates in western Plymouth and generally flows southeast through Plymouth to Medicine Lake.

North Branch: The North Branch of Bassett Creek drains portions of northern Plymouth, southern New Hope, and Crystal. It joins the Main Stem immediately upstream of Highway 100.

Sweeney Lake Branch: The Sweeney Lake Branch drains portions of northern St. Louis Park and southern Golden Valley and joins the Main Stem in Theodore Wirth Park near Golden Valley Road.

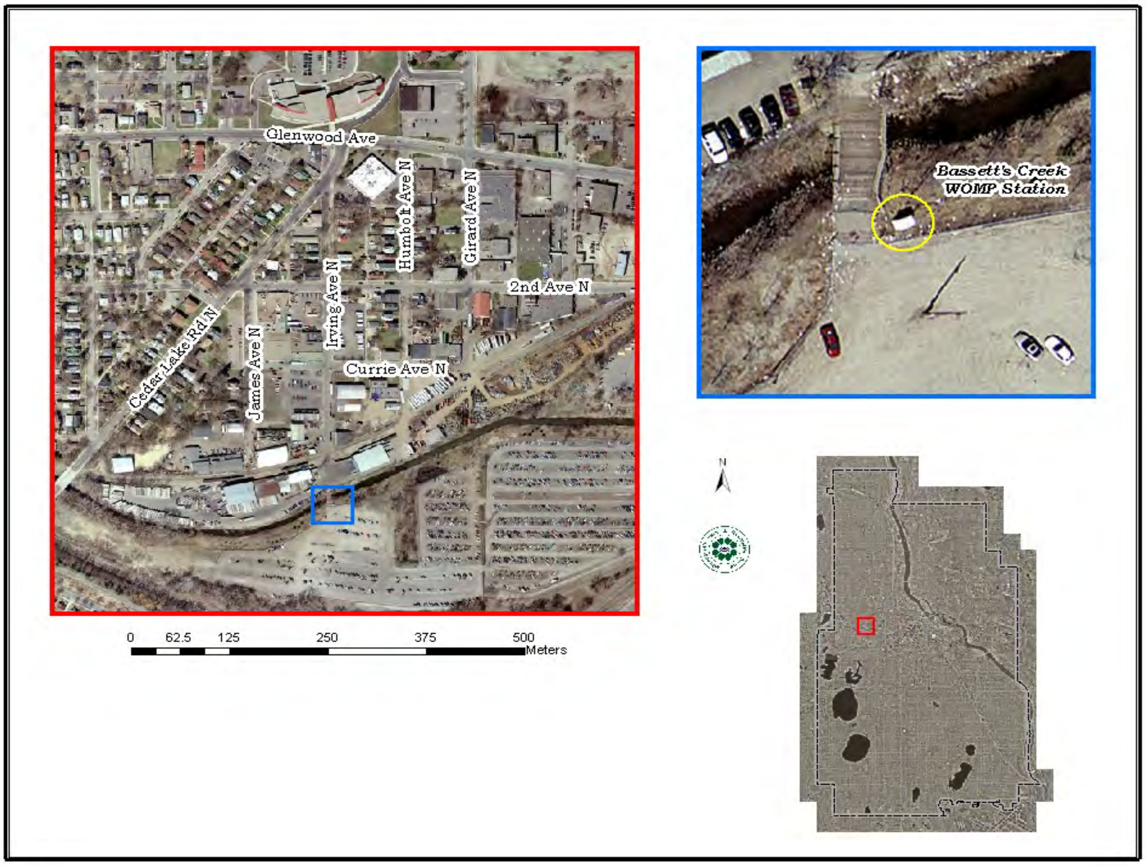


Figure 22-1. Map of the Bassett Creek WOMP2 station, Minneapolis, MN.

METHODS

The Bassett Creek WOMP2 station is located approximately ¼ mile upstream of where the creek enters a City of Minneapolis storm sewer tunnel. The creek eventually empties into the Mississippi River.

In July 2001 the MPRB began monitoring the WOMP2 station at Bassett Creek. The MPRB cooperator role is to gather monthly base flow and storm event samples. The WOMP2 station previously began operation under the MCES in early 2000. The BCWMC gathers data to build the rating curve for the station and participates with the MPRB for support and operation of the Bassett Creek station. The MCES laboratory analyzes all collected samples and maintains, repairs, and coordinates larger aspects of the station.

The Bassett Creek station shelter is equipped with electricity, heat, and telephone modem. The station measures stage using a bubbler and pressure transducer which is connected to a Campbell datalogger. The datalogger records and calculates the conversion of stage (ft) readings into discharge (cfs) using a rating curve polynomial. The data are averaged over 15-minute intervals and are downloaded via modem. The Bassett Creek station also uses an ultrasonic transducer, mounted under a bridge to measure stage. The station is equipped with a non-heated tipping bucket rain gauge. An automatic Sigma™ sampler equipped with one, 24 -liter sample bottle is also housed at the station. When stream stage increases to a chosen trigger depth, the datalogger controls and activates flow pacing to the sampler. The sampler multiplexes (200 mL samples) to collect up to 96 flow-weighted samples per storm. A Campbell Scientific 247 conductivity/temperature probe was installed in the stream and continually records data. The Campbell conductivity probes are cleaned monthly and calibrated at each visit or when a new program is downloaded. A handheld Oakton Con 100 series conductivity probe and Oakton TDS 1413 single calibration standards are used to check the in stream calibration.

During runoff events the individual flow paced samples are collected and combined into one large sample. Grab samples were taken monthly all year during baseflow conditions. To comply with holding times water quality parameters were selected for analysis based on the elapsed time since the end of sample collection.

Remote access to the site via modem allows the MPRB Environmental Operations staff to manage and check many aspects of the site without having to travel there. Staff used a desktop computer and modem to download data, troubleshoot, and reprogram the datalogger "triggers" in anticipation of storm events. Data were downloaded and imported into spreadsheets for analysis and reporting. The MCES also download the data each evening from each of its stations.

Since the sampler creates flow paced composites it is important to have accurate rating curves at Bassett Creek. Stream gauging is conducted by Barr Engineering. The stream gauge information is used to develop a scatter plot and multiple regression equation or power curve fit to the points. The resulting polynomial equation is programmed into the station datalogger. This allows for accurate flow pacing of the sampler and for total discharge volumes to be summed which result in accurate load calculations.

When samples were collected from the station, a tape-down measurement was made from a fixed point on the top downstream edge of the bridge railing (surveyed at 814.86 feet on 7-29-02) to the water surface. The stage reading plus this measurement must equal the distance from the creek bed to the bridge railing of 12.03 feet. The tape-down provides a quick check as to the bubbler stage accuracy at the station.

RESULTS

Due to MPRB staffing levels the WOMP contracts were ended June 25th 2012. Inquiries for WOMP data should be directed to the Metropolitan Council Environmental Services. See the MCES Stream Monitoring Report for further information:

http://es.metc.state.mn.us/eims/support_information/data_catalog_detail.asp?optn=42&catID=5

23. MINNEHAHA CREEK WATERSHED OUTLET MONITORING PROGRAM (WOMP) STATION

BACKGROUND

Stormwater runoff carries non-point source pollutants from diverse and widely scattered sources to Twin Cities area streams and rivers. Monitoring is necessary to determine the extent of non-point source pollutant loading from tributaries to the Mississippi River. It also provides information for the development of target pollutant loads for the watershed and helps evaluate the effectiveness of best management practices in an effort to improve water quality in streams and rivers.

In 1997 the Minnesota Legislature provided $575,000 to the Metropolitan Council Environmental Services (MCES) via the *Interagency Water Monitoring Initiative* (IWMI) for expansion of MCES water quality monitoring efforts. With this funding the Metropolitan Area Watershed Outlet Monitoring Program (WOMP) 2 was implemented in early 1998. The new WOMP2 program expanded the existing MCES WOMP stream-monitoring network in the metro area. A long-term stream monitoring data set is critical for understanding non-point source pollutant impacts on water quality and for documenting water quality improvements as non-point source best management practices are implemented. The Minneapolis Park and Recreation Board (MPRB) operates the WOMP2 station in partnership with the MCES and Minneapolis Public Works.

Minnehaha Creek begins at the east end of Lake Minnetonka at the Gray’s Bay outlet (**Section 26, Figure 26-1**) where an adjustable weir controls flow out of the lake. The current concrete outlet structure was built in 1979. When adjustments are made at the weir, it can have a dramatic effect on the levels and discharge of Minnehaha Creek. The creek is roughly 22 miles long from Gray’s Bay to Minnehaha Falls and enters the Mississippi River ¾ mile downstream from Minnehaha Falls. Approximately 181 total square miles drain to Minnehaha Creek. The upper watershed drainage area, including Lake Minnetonka, is 123 square miles (Lake Minnetonka surface area is 23 square miles). The size of the lower watershed below Lake Minnetonka is 59 square miles. The Minnehaha Creek station is located at 4712 32nd Avenue South and Minnehaha Parkway (**Figure 23-1**).

There are heavily used MPRB walking and biking paths along side Minnehaha Creek as it flows through Minneapolis. The Minnehaha Regional Park received roughly 1,276,200 visitors and Minnehaha Parkway Regional Trails received 1,602,800 visitors in 2010 (Metropolitan Council, 2010). The creek is a popular recreational canoeing thoroughfare enjoyed by many residents and visitors.

Figure 23-1. Map of the Minnehaha Creek WOMP2 station in Minneapolis.

In 2006 a USGS station was installed downstream of the Minnehaha Creek WOMP station east of Hiawatha Avenue. It can be viewed in real time at:

http://waterdata.usgs.gov/mn/nwis/uv?dd_cd=01,02,03,04,06,12&format=gif&period=7&site_no=05289800

Due to MPRB staffing levels the WOMP contracts were ended June 25th 2012. Inquiries for WOMP data should be directed to the Metropolitan Council Environmental Services. See the MCES Stream Monitoring Report for further information:

http://es.metc.state.mn.us/eims/support_information/data_catalog_detail.asp?optn=42&catID=5

The winter of 2013-2014 the Minnehaha Creek WOMP station was vandalized inside and out with graffiti and the Metropolitan Council decided to pull the equipment and decommission the station.

24. NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) MONITORING

BACKGROUND

The Minneapolis Park and Recreation Board (MPRB) and Minneapolis Public Works (MPW) Department are co-signatories on the National Pollutant Discharge Elimination System (NPDES) stormwater permit. The MPRB has performed the NPDES stormwater monitoring since 2000. The purpose of the stormwater monitoring is to characterize the impacts of stormwater discharges to receiving waters. In 2013 four different Minneapolis land use sites (residential, commercial/industrial, mixed use, and parkland) were monitored for stormwater runoff quantity and quality. The watersheds represent the major land uses in Minneapolis. Representative sampling is mathematically extrapolated to calculate contaminant loading on a citywide scale.

At the beginning of the NPDES permit (2001-2004), the MPRB and MPW partnered with the City of St. Paul to fulfill the NPDES monitoring requirements. Five sites in both Minneapolis and St. Paul were jointly monitored between 2001–2004. In 2005, MPRB stopped monitoring stormwater in St. Paul and four new sites in Minneapolis were selected for monitoring. In 2006, new sites were chosen in Minneapolis to comply with the NPDES permit and to assist MPW with their modeling and load allocation efforts.

METHODS

The summary below includes descriptions of equipment installation at each site, parameters monitored, field quality assurance sampling, data handling, validation, and reporting.

Site Installation

The equipment installed at each site included an ISCO 3700 sampler, a low profile area/velocity pressure transducer, and an ISCO 2150 datalogger. The dataloggers were flow-paced and adjusted throughout the year to collect samples over the entire hydrograph of a storm event. Each site was equipped with a 2103ci or 2105ci interface module that contained a cell phone modem. Each site automatically uploaded data to the network server database daily. Each site could also be communicated with remotely by Flowlink Pro software in order to adjust pacing, on/off conditions, etc.

Equipment installation began when freezing spring temperatures were no longer a concern in order to prevent area velocity transducer damage. See **Figure 24-1** for a map of site locations. 8a (Pershing Park) was installed on 5/14/13. Site 6 (22nd/Aldrich), Site 7 (14th/Park), and Site 9 (61st/Lyndale) were installed on 5/15/13. See **Table 24-1** for site characteristics.

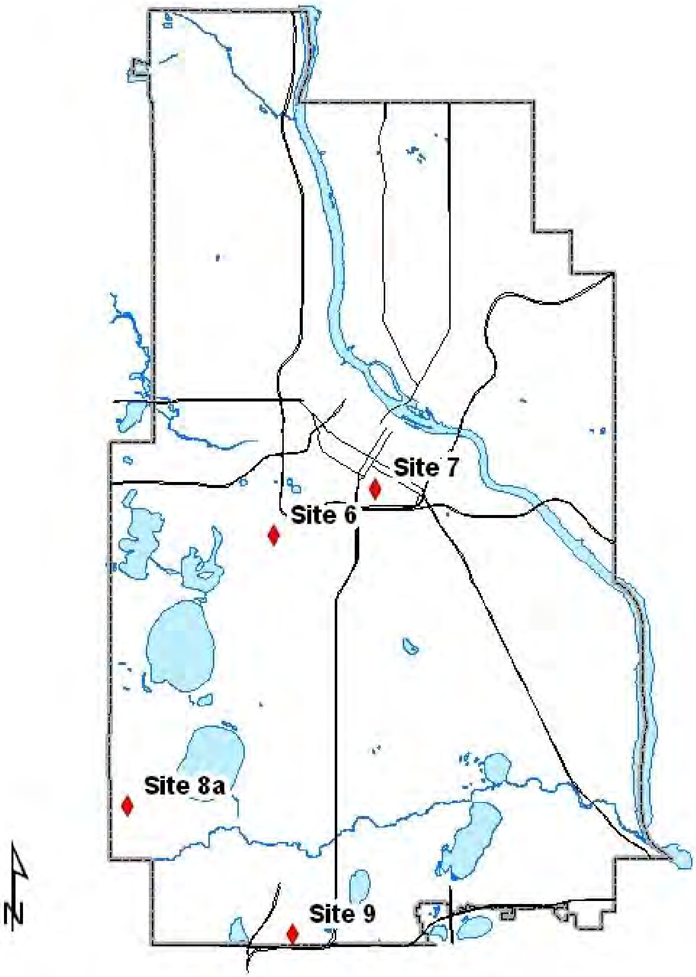


Figure 24-1. Map of the 2013 NPDES sites located in Minneapolis.

Table 24-1. 2013 NPDES stormwater monitoring sites for Minneapolis.

Site ID	**Site 6**	**Site 7**	**Site 8a**	**Site 9**
Location	22nd St & Aldrich Ave S	E 14th St & Park Ave S	Pershing Field east of 49th St & Chowen Ave	335 ft. east of 61st St & Harriet Ave S
Land Use	Multi–Family Residential	Commercial/Industrial/ High Rise Residential	Recreational/Parkland	Commercial/Industrial
Area (acres)	8.9	13.1	2.5	34.9
Pipe Diameter (inches)	18	42	12	36
Outfall ID#	10 – 430J	10 – 430D	57 – 100A/B	71 – 070

Sample Collection and Monitored Parameters

The new NPDES permit target frequency for storm event sample collection annually is 15 samples per site per year. If a sample was missed during one month due to lack of precipitation events, then two or more were taken the next month. In 2013, flow-paced storm event samples were collected from May through early November. Two snowmelt grab samples were collected in 2013 from each site. Snowmelt samples were collected at Sites 6, 7, and 9 on 1/10/13, 1/11/13, and 2/27/13 and at site 8a on 4/3/13 and 4/23/13. Most snowmelt samples were brown to dark brown and very turbid except Site 8a which was relatively clear.

The total volume sampled for each site and total recorded volumes in 2013 are given in **Table 24-2** along with the seasonal aggregate percentage sampled. Detailed information on sampling events is shown in **Table 24-3**.

Table 24-2. NPDES site volume totals for the sampling period 5/15/13 – 11/14/13.

	Site 6	Site 7	Site 8a	Site 9
Total volume of sampled events (cf)	91,825	378,173	38,084	912,745
Total volume recorded (with Flowlink) for 2013 (cf)	195,381	724,710	71,371	1,306,830
% sampled ANNUAL	47%	52%	53%	70%
% sampled SPRING (May- June)	26%	26%	13%	30%
% sampled SUMMER (July- September)	12%	21%	37%	34%
% sampled FALL (October- November)	10%	5%	3%	5.2%

Table 24-4 shows the parameters tested as part of the NPDES permit for each sample collected. **Table 24-5** gives the approved methods used for analysis, reporting limit, and holding time for each parameter as reported by the contract laboratory Instrumental Research, Inc. (IRI). Legend Technical Services Laboratory analyzed all metals samples.

Limited parameter sample designation is when the sample is collected after some of the parameters (e.g. BOD, TDP) holding times have expired and those parameters are not analyzed. In 2013, limited parameters were collected nineteen times. These samples were recovered after more than 24 hours and parameters with short holding times were not analyzed (e.g. cBOD, TDP) or there was limited composite volume.

As required by the NPDES permit, *E. coli* grab and pH samples were collected by quarterly sampling. *E.coli* was collected at all sites except at Site 8a, which is inaccessible for grab sampling after installation of equipment. When flow and time were sufficient, *E. coli* grab samples were collected four times per year. Two sites (14th/Park, and 61st/Lyndale) were collected four times, one site (22nd/Aldrich) was collected five times, and one site (Pershing) was collected twice for a total of fifteen *E. coli* grabs in 2013. The pH was measured in the field using an Oakton Waterproof pHTestr 2™ or at the laboratory IRI. If the Oakton field meter was used the pH meter was calibrated with 2-point calibration prior to each sampling trip.

With the exception of the drought when fall quarter of *E. coli* grab and pH samples were not collected, all required sampling was successfully accomplished in 2013.

Table 24-3. 2013 precipitation event data and samples collected for NDPES sites. A precipitation event is defined as being greater than 0.10 inches and separated by 8 hours. The rain gage is located at 3800 Bryant Ave. S., Minneapolis, MN.

										2013 NPDES Events Collected			
Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	Site 6 22nd/Aldrich	Site 7 14th/Park	Site 8a Pershing	Site 9 61st/Lyndale
+1	1/10/2013	14:45	n/a		n/a	n/a	n/a		grab	X(w/Ecoli)			X(w/Ecoli)
+2	1/11/2013	14:00	n/a		n/a	n/a	n/a		grab	X(w/Ecoli)	X(w/Ecoli)		X(w/Ecoli)
+3	2/26/2013	14:00	n/a		n/a	n/a	n/a		grab				X(w/Ecoli)
+4	2/27/2013	14:15	n/a		n/a	n/a	n/a		grab	X(w/Ecoli)	X(w/Ecoli)		
+5	4/13/2012	14:20	n/a		n/a	n/a	n/a		grab			X(w/Ecoli)	
+6	4/23/2013	13:00	n/a		n/a	n/a	n/a		grab			X(w/Ecoli)	
7	5/17/2013	1:30	5/17/2013	17:30	0.27	16.0	0.02	194.0	composite		X(lmtd)		
8	5/18/2013	6:30	5/18/2013	11:00	0.93	4.5	0.21	13.0	composite		X(lmtd)	X(lmtd)	X(lmtd)
9	5/19/2013	6:30	5/22/2013	21:00	2.09	86.5	0.02	19.5	composite	X	X		X
10	5/29/2013	16:30	5/30/2013	1:30	1.04	9.0	0.12	111.0	composite	X	X		X
11	5/31/2013	1:30	5/31/2013	15:30	0.42	14.0	0.03	24.0	composite	X	X		X
12	6/5/2013	4:00	6/5/2013	18:30	0.20	14.5	0.01	108.5	composite	X			X
13	6/9/2013	2:00	6/9/2013	14:30	0.46	12.5	0.04	79.5	composite	X	X		X
14	6/12/2013	1:30	6/12/2013	18:30	0.59	17.0	0.03	59.0	comp/grab	X	X(w/Ecoli)	X	X(w/Ecoli)
15	7/9/2013	8:15	7/9/2013	9:15	0.51	1.0	0.51	236.0	comp/grab	X(Ecoli only)	X(Ecoli only)	X	X(w/Ecoli)
16	7/13/2013	3:30	7/13/2013	7:30	3.00	4.0	0.75	90.3	composite	X(lmtd)	X(lmtd)	X(lmtd)	X(lmtd)
17	7/21/2013	6:15	7/21/2013	9:45	0.18	3.5	0.05	190.7	composite	X(lmtd)	X(lmtd)		X(lmtd)
18	8/5/2013	2:00	8/5/2013	8:00	0.52	6.0	0.09	227.8	composite	X	X	X	X
19	8/6/2013	19:30	8/6/2013	21:00	0.86	1.5	0.57	35.5	composite	X	X	X	X
20	9/14/2013	16:30	9/15/2013	12:00	0.54	19.5	0.03	931.5	composite	X(lmtd)	X	X(lmtd)	X(lmtd)
21	9/17/2013	19:00	9/18/2013	8:30	0.11	13.5	0.01	55.0	composite				X(lmtd)
22	9/19/2013	11:30	9/19/2013	12:30	0.19	1.0	0.19	27.0	composite	X	X		X
23	9/28/2013	10:30	9/28/2013	13:30	0.15	3.0	0.05	214.0	composite	X(lmtd)	X		X(lmtd)
24	10/2/2013	19:00	10/3/2013	23:00	1.12	28.0	0.04	101.5	composite	X	X	X	X
25	10/4/2013	21:30	10/5/2013	16:00	0.31	18.5	0.02	22.5	composite	X(lmtd)			X(lmtd)
26	10/17/2013	19:00	10/18/2013	5:30	0.33	10.5	0.03	39.5	composite	X			X
27	10/29/2013	22:00	10/31/2013	5:30	0.17	31.5	0.01	280.5	composite				X
28	11/4/2013	12:00	11/4/2013	13:30	0.16	1.5	0.11	102.5	composite	X	X		
			Totals		**14.15**					**21**	**19**	**10**	**23**

$^{+}$snowmelt event

n/a = not applicable

X = event sampled with full parameters

X(lmtd) = event sampled with limited parameters generally due to holding times e.g.BOD, TDP, etc.

X(w/Ecoli) = event sampled with fecal coliform

X(Ecoli only) = only fecal coliform sampled

Table 24-4. The list of monitored chemical parameters for the NPDES permit. BOD is biochemical oxygen demand.

Parameter	Abbreviation	Units	Sample Type
BOD –carbonaceous, 5 Day	cBOD	mg/L	Composite
Chloride, Total	Cl	mg/L	Composite
Specific Conductivity	Sp. Cond	µmhos/cm	Composite
E. coli (*Escherichia Coliform*)	E. coli	MPN/100mL	Grab (4X year)
Hardness	Hard	mg/L	Composite
Copper, Total	Cu	µg/L	Composite
Lead, Total	Pb	µg/L	Composite
Zinc, Total	Zn	µg/L	Composite
Nitrite+Nitrate, Total as N	NO_2NO_3	mg/L	Composite
Ammonia, Un-ionized as N	NH_3	mg/L	Composite
Kjeldahl Nitrogen, Total	TKN	mg/L	Composite
pH	pH	standard unit	Grab (4X year)
Phosphorus, Ortho-P	Ortho-P	mg/L	Composite
Phosphorus, Total Dissolved	TDP	mg/L	Composite
Phosphorus, Total	TP	mg/L	Composite
Solids, Total Dissolved	TDS	mg/L	Composite
Solids, Total Suspended	TSS	mg/L	Composite
Solids, Volatile Suspended	VSS	mg/L	Composite
Sulfate	SO_4	mg/L	Composite

Table 24-5. Analysis method, reporting limit, and holding times for parameters used by Instrumental Research, Inc.

Parameter	Method	Reporting Limit	Holding Times
cBOD, carbonaceous, 5 Day (20°C)	SM 5210 B	1.0 mg/L	24 hours
Chloride, Total	SM 4500-Cl^- B	2.0 mg/L	28 days
Specific Conductivity	SM 2510 B	10 µmhos/cm	28 days
E. coli (*Escherichia Coliform*)	SM 9223B	1 MPN per 100mL	< 24hrs
Hardness	SM 2340 C	2.0 mg/L	6 months
Copper, Total	EPA 200.9	1.4 µg/L	6 months
Lead, Total	SM 3500-Pb B	3 µg/L	6 months
Zinc, Total	SM 3500-Zn B	2 µg/L	6 months
Nitrite+Nitrate, Total as N	SM 4500-NO_3 E	0.030 mg/L	28 days
Ammonia, Un-ionized as N	SM 4500-NH_3 F	0.500 mg/L	7 days
Kjeldahl Nitrogen, Total	SM 4500-Norg B	0.500 mg/L	7 days
Phosphorus, Ortho-P	SM 4500-P A, B, G	0.010 mg/L	48 hours
Phosphorus, Total Dissolved	SM 4500-P A, B, G	0.010 mg/L	48 hours
Phosphorus, Total	SM 4500-P A, B, E	0.010 mg/L	48 hours
Solids, Total Dissolved	SM 2540 C	10.0 mg/L	7 days
Solids, Total Suspended	SM 2540 D	1.0 mg/L	7 days
Solids, Volatile Suspended	SM 2540 E	2.0 mg/L	7 days
Sulfate*	ASTM D516-90	15 mg/L	28 days

Sulfate* samples were spiked (10 mg/L) and then spike later subtracted to lower the 2013 detection limit.

FIELD QUALITY ASSURANCE SAMPLES

Ten percent of samples were laboratory quality assurance samples (e.g. duplicates, spikes). Field blanks consisted of deionized water which accompanied samples from the field sites to the analytical laboratory. As part of the overall QA/QC program, blind monthly performance samples were made for all monitored parameters and delivered to IRI. A field blank was generated for each sampling trip and was analyzed for all NPDES parameters. All field blank parameters were below the minimum detection limits.

If the Oakton field meter was used, the pH meter was calibrated with 2-point calibration prior to each sampling trip.

An equipment blank (~ 2 L sample) was collected at 8a (Pershing) 11/19/13. This has a standard NPDES stormwater monitoring set up. To collect the equipment blank, a large bottle of deionized water was placed at the strainer end of the sampler tubing. The intake line was filled and flushed with deionized water simulating the pre-sample flush. After the flush was pumped to waste and a sample of deionized water was collected. The sample taken was of sufficient volume to allow analysis of all parameters. All analytes came back from the laboratory below the minimum detection limits.

Manual transcription of data was minimized to reduce error introduction. A minimum of 10% of the final data were checked by hand against the raw data sent by the laboratory to ensure there were no errors entering, manipulating, or transferring the data. See **Section 30**, Quality Assurance Assessment Report for details.

Field measurements were recorded on a Field Measurement Form in the 2013 Field Log Book and then entered into a computer database. Electronic data from the laboratory were forwarded to the MPRB in pre-formatted spreadsheets via email. Electronic data from the laboratory were checked and passed laboratory quality assurance procedures. Protocols for data validity followed those defined in the Storm Water Monitoring Program Manual (MPRB, 2001). For data reported below the reporting limit, the reporting limit value was divided in half, for use in statistical calculations.

A Chain of Custody form accompanied each set of sample bottles delivered to the lab. Each sampler tray or container was iced and labeled indicating the date and time of collection, the site location, and the field personnel initials. The ultimate collection date and time assigned to the sample was when the last sample of the composite was collected. The time that each composite sample was collected was recorded from the ISCO sampler onto field sheets. A complete description of methods can be found in the Storm Water Monitoring Program Manual (MPRB, 2001).

Statistics for event mean concentrations were calculated using Microsoft Excel. The computer model P8 v2.41 was calibrated and verified and used to estimate snowmelt runoff. The P8 snowmelt estimated runoff, ISCO Flowlink measured runoff, and chemistry data were put into FLUX32 v3.10 and used to calculate flow-weighted mean concentrations. In Flux32, all the data were run unstratified, and also if possible stratified by flow and month. A minimum of three data points are required in any stratification cut in the data. FLUX32 methods 2 and 6 were recorded for each parameter run. The mean concentration value with the lowest coefficient of variation was chosen and used for load calculations.

A description of P8 as described in the software's introduction:

> P8 is a model for predicting the generation and transport of stormwater runoff pollutants in small urban catchments. Simulations are driven by hourly rainfall and daily air-temperature time series.

A description of FLUX32 as described in the help menu (US Army Corps, 2009):

> The theory and the file formats described in this original manual, as well as much of the software's operation and menu structure is still applicable to Flux.
>
> This version of FLUX for the Win32 environment is a major revision to the original DOS/FORTRAN program authored by William W. Walker Ph.D.
>
> Flux32 is interactive software designed for use in estimating the transport (load) of nutrients or other water quality constituents past a tributary sampling station over a given period of time.
>
> The basic approach of Flux32 is to use several calculation techniques to map the flow/concentration relationship developed (modeled) from the sample record onto the entire flow record. This provides an estimate of total mass transport for the whole period of study with associated error statistics. Note that this approach does NOT focus on estimating changes in loads over time (i.e. time series).
>
> An important option within Flux32 is the ability to stratify the data into groups based upon flow, date, and/or season. This is a key feature of the FLUX approach and one of its greatest strengths. In many (most) cases, stratifying the data increases the accuracy and precision of loading estimates.

The P8 model was used to estimate daily flows for snowmelt events and grab samples from January through early May. Average daily flows (using both P8 and Flowlink measurements) and collected chemical data were used as input for the interactive program FLUX32. Daily temperature and hourly precipitation files obtained from the National Oceanic and Atmospheric Administration (NOAA) National Data Center (NDC) were used as input for P8. Data from a heated rain gauge (for snowmelt water equivalent) was used and is located at the Minneapolis/St. Paul International Airport.

RESULTS & DISCUSSION

Snowmelt

2013 event data concentrations are listed in **Table 24-6**. These data generally show peaks during snowmelt and early spring for many parameters, but at some sites there are additional peaks that occurred in late fall.

Most snowmelt samples were brown to dark brown and very turbid except for the parkland site, Site 8a which was relatively clear. The snowmelt clarity of site 8a is most likely due to the filtering effect of the parkland turf as this site receives mostly park overland flow runoff and little or no street runoff.

TSS and TDS

TDS and TSS generally tend to be high during the snowmelt/spring months and late fall with the exception of Site 8a which is parkland. High TSS values in the snowmelt/spring might be attributed to the wash-off of accumulated sand applied to icy winter roads. A small amount of sand can lead to very high TSS values. The high late fall values of TSS are likely the product of a very dry fall and subsequent accumulation and wash-off.

Chloride

High Cl^- concentrations are typical seen during winter snowmelt and early spring stormwater. The majority of the Cl^- is from road salt which is used throughout the winter and subsequently washed off the streets and gutters during snowmelt and early spring rains. Site 9 (61st & Lyndale) and Site 6 (22nd and Aldrich) showed small amounts of chloride continuously washing off throughout the summer months. Site 9 has many commercial industries surrounding it which may be contributing to increased chloride levels during the summer months.

E. Coli monitoring

E. coli values were generally lowest for the snowmelt event and peaked mid-summer to fall. This result is expected, since temperature plays a significant role in bacterial growth and survival. There was a significant drought during August and September that may have played a role in build-up and wash-off of animal excrement. There currently is no standard for *E. coli* in stormwater.

Metals

It is interesting again to note that Site 6 (22nd & Aldrich) had a marked increase in Pb (lead) annually, when compared to the other sites. This is an older residential watershed and it is unknown where the Pb is originating. It is possible that it is a remnant from old lead house paint loading the surrounding soils and then continually washing off. It is interesting to note Pb was below the detection limit for two thirds of Site 8a (Pershing) events and it continues to generally decrease in the environment. The Pb levels in stormwater have historically been decreasing since it was removed from gasoline in the 1990's.

It was observed that maximum metal (Pb, Cu, and Zn) values generally followed the same trend as TSS throughout the year, this is as expected since metals generally tend to stick to organic solids.

TSS and VSS

The annual VSS data show that a much less than expected portion of the TSS number is organic (~20-40%). Many of the VSS peaks were observed in the spring and fall, and were likely organic material (e.g. bud drop, grass clippings, leaf fall) washing off the watershed. The remaining (60- 80%) of VSS were likely inorganic sand (see **Table 24-6)**.

Table 24-6. 2013 NDPES sampled event data by site.

Date Sampled	Time	Sample Type	Site Location	TP mg/L	TDP mg/L	OrthoP mg/L	TKN mg/L	NH3 mg/L	NO3NO2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate* mg/L	Sp.Cond. uhmos	pH std units	Cu ug/L	Pb ug/L	Zn ug/L	E. Coli MPN
1/10/2013	14:45	Grab	Site 6, 22nd & Aldrich -SM	0.940	0.156		10.7	6.31	0.435	4883	276	106	51	7261	37	46.0	7230	7.8	48	140	210	173
1/11/2013	14:00	Grab	Site 6, 22nd & Aldrich -SM	0.888	0.492		6.26	2.40	0.668	460	64	75	38	828	18	7.5	1183	6.8	25	69	150	1043
2/27/2013	14:15	Grab	Site 6, 22nd & Aldrich -SM	2.33	0.036		13.3	4.12	3.10	2223	176	1333	426	3538	34	11.0	>20,000	6.4	180	510	1100	<10
5/20/2013	23:39	Composite	Site 6, 22nd & Aldrich	0.239	0.025		2.16	1.14	0.251	4	18	88	30	19	4	4.4	32	6.8	17	53	59	
5/29/2013	23:32	Composite	Site 6, 22nd & Aldrich	0.282	0.021		2.29	0.705	0.109	<2.0	18	103	39	44	8	<15.0	48	7.2	18	90	73	
5/31/2013	2:14	Composite	Site 6, 22nd & Aldrich	0.554	0.070		2.30	0.782	0.271	<2.0	18	78	32	56	13	4.9	48	7.0	18	34	48	
6/5/2013	19:05	Composite	Site 6, 22nd & Aldrich	0.599	0.091		3.91	0.959	0.334	<2.0	30	69	42	81	35	9.8	100	6.6	21	50	87	
6/9/2013	13:20	Composite	Site 6, 22nd & Aldrich	0.328	0.079		1.78	0.683	0.025	<2.0	22	39	24	61	16	7.0	66	7.0	16	34	68	
6/12/2013	10:42	Composite	Site 6, 22nd & Aldrich	0.321	0.070		2.13	0.672	<0.030	151	16	56	26	78	10	5.9	49	7.1	14	68	70	>24196
7/9/2013	8:55	Grab	Site 6, 22nd & Aldrich																			9208
7/13/2013	5:20	Composite	Site 6, 22nd & Aldrich	0.240			1.73		0.035	<2.0	16	57	25						13	27	44	
7/21/2013	9:37	Composite	Site 6, 22nd & Aldrich	0.588			4.00		0.045	6	44	37	27				120		30	71	140	
8/5/2013	4:24	Composite	Site 6, 22nd & Aldrich	0.378	0.112	0.142	3.02	<0.500	<0.030	<2.0	24	54	29	99	33	8.3	58	6.8	20	29	75	
8/6/2013	20:51	Composite	Site 6, 22nd & Aldrich	0.195	0.074	0.027	1.44	0.898	0.187	<2.0	16	73	28	30	6	5.4	38	7.1				
9/15/2013	5:13	Composite	Site 6, 22nd & Aldrich	0.318			2.17		0.378	<2.0	26	49	33				70		22	33	89	
9/19/2013	9:02	Composite	Site 6, 22nd & Aldrich	0.398	0.107	0.167	2.60	0.735	0.470	<2.0	24	149	66	40	7	7.1	64	7.1	20	55	90	
9/28/2013	14:15	Composite	Site 6, 22nd & Aldrich	0.510			5.05		0.114	8	46	58	33				136		24	40	90	
10/3/2013	0:26	Composite	Site 6, 22nd & Aldrich	0.275	0.078	0.108	2.32	0.862	0.746	<2.0	26	86	42	28	14	5.9	67	7.1	16	66	76	
10/6/2013	19:15	Composite	Site 6, 22nd & Aldrich	0.193			1.25		0.219	2	24	34	18				57		12	23	43	
10/18/2013	2:21	Composite	Site 6, 22nd & Aldrich	0.282	0.136	0.185	1.16	<0.500	<0.030	<2.00	20	23	16	44	23	7.6	59	6.9	<5.00	37	41	
10/19/2013	15:05	Composite	Site 6, 22nd & Aldrich	0.449			3.19		<0.030	4	38	95	52				83		28	78	110	
10/20/2013	12:23	Composite	Site 6, 22nd & Aldrich	0.336			1.26		<0.030	<2.0	30	18	13				82		<5.00	9	36	
11/4/2013	13:58	Composite	Site 6, 22nd & Aldrich	0.599	0.201	0.176	3.93	<0.500	<0.030	7	38	115	73	101	76	10.0	113	7.2	27	63	120	
1/11/2013	13:45	Grab	Site 7, 14th & Park -SM	0.424	0.214		2.42	1.17	0.689	460	60	26	11	813	11	3.3	1241	6.7	16	8	98	1700
2/27/2013	14:30	Grab	Site 7, 14th & Park -SM	0.690	0.034		4.06	1.48	1.57	2624	128	169	73	3928	32	5.7	>20,000	6.5	40	35	210	187
5/17/2013	15:12	Composite	Site 7, 14th & Park	0.583			4.61		0.106	<2.0	30	178	63				97		52	23	230	
5/18/2013	9:38	Composite	Site 7, 14th & Park	0.287			2.47		0.423	<2.0	20	120	37				47		26	18	99	
5/21/2013	0:23	Composite	Site 7, 14th & Park	0.128	0.025		1.38	0.920	0.298	4	16	52	18	20	3	4.3	37	6.8	16	12	50	
5/29/2013	23:27	Composite	Site 7, 14th & Park	0.125	<0.010		1.45	<0.500	0.246	<2.0	14	69	23	51	6	<15.0	48	7.6	19	18	63	
5/31/2013	2:30	Composite	Site 7, 14th & Park	0.190	0.019		1.37	0.594	0.316	<2.0	14	56	20	45	6	4.6	48	7.1	13	11	45	
6/9/2013	15:03	Composite	Site 7, 14th & Park	0.117	0.034		0.530	<0.500	0.462	<2.0	16	20	11	57	5	6.0	54	6.9	10	3	34	
6/12/2013	11:07	Composite	Site 7, 14th & Park	0.157	0.048		1.32	0.572	0.285	<2.0	12	44	18	82	5	4.1	40	7.5	12	10	58	12997
7/9/2013	9:15	Grab	Site 7, 14th & Park																			1467
7/13/2013	8:18	Composite	Site 7, 14th & Park	0.126			0.875		0.272	<2.0	16	53	10						15	7	45	
7/21/2013	10:00	Composite	Site 7, 14th & Park	0.234			1.83		0.938	5	34	43	15						27	7	78	
8/5/2013	4:44	Composite	Site 7, 14th & Park	0.116	0.073	0.095	1.09	<0.500	0.337	<2.0	14	38	16	70	8	8.1	44	7.4	16	6	62	
8/6/2013	21:13	Composite	Site 7, 14th & Park	0.113	0.034	0.032	1.07	<0.500	0.301	<2.0	14	49	16	29	4	4.9	39	7.4	15	10	57	
9/15/2013	2:46	Composite	Site 7, 14th & Park	0.345			3.35		0.523	6	48	55	29				148		32	8	120	
9/19/2013	13:00	Composite	Site 7, 14th & Park	0.137	0.031	0.068	1.40	0.517	0.995	<2.0	22	66	24	39	5	7.8	75	7.5	13	9	81	
9/20/2013	18:08	Composite	Site 7, 14th & Park	0.511					<0.030	23	74						268					
9/28/2013	12:43	Composite	Site 7, 14th & Park	0.255			2.48		0.610	6	36	42	18				124		26	6	60	
10/2/2013	21:45	Composite	Site 7, 14th & Park	0.221			2.34		0.672	4	28	123	74				93		19	10	110	
11/4/2013	13:28	Composite	Site 7, 14th & Park	0.323	0.041	0.063	2.79	0.625	0.445	5	26	77	36	47	21	9.1		7.2	29	9	110	

Table 24-6. 2013 NDPES sampled event data by site. (Continued)

Date Sampled	Time	Sample Type	Site Location	TP mg/L	TDP mg/L	OrthoP mg/L	TKN mg/L	NH3 mg/L	NO3NO2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate* mg/L	Sp.Cond. uhmos	pH std units	Cu ug/L	Pb ug/L	Zn ug/L	E. Coli MPN
4/3/2013	14:20	Grab	Site 8a, Pershing -SM	1.49	1.31		4.86	2.88	0.047	2	20	25	15	69	20	7.8	82	6.6	<5.00	<3.00	<20.0	146
4/23/2013	13:00	Grab	Site 8a, Pershing -SM	0.038	0.024		<0.500	<0.500	0.222	<2.0	22	3	2	55	<1.00	<15.0	63	6.2	<5.00	<3.00	<20.0	1
5/18/2013	8:32	Composite	Site 8a, Pershing	1.31			6.43		0.033	<2.0	26	80	49				64		17	3	81	
6/12/2013	12:18	Composite	Site 8a, Pershing	0.309	0.169		1.31	0.506	0.199	67	34	39	12	92	3	6.4	93	7.4	9	3	16	
7/9/2013	8:55	Composite	Site 8a, Pershing	0.378	0.288		1.81	0.813	0.725	<2.0	20	46	10	53	9	5.0	70	7.0	11	<3.00	<20.0	
7/13/2013	5:22	Composite	Site 8a, Pershing	0.162			0.829		0.183	<2.0	12	18	5						<5.00	<3.00	<20.0	
8/5/2013	4:28	Composite	Site 8a, Pershing	0.386	0.232	0.256	1.55	<0.500	<0.030	3	26	16	9	60	14	11.3	72	6.7	7	<3.00	<20	
8/6/2013	21:35	Composite	Site 8a, Pershing	0.421	0.301	0.266	1.53	<0.500	0.206	<2.0	30	62	16	42	5	11.1	64	7.2	11	4	<20.0	
9/15/2013	4:50	Composite	Site 8a, Pershing	0.344			<0.500		0.499	2	30	48	30				80		14	<3.00	59	
10/3/2013	0:29	Composite	Site 8a, Pershing	0.628	0.542	0.536	1.535	0.698	0.546	<2.0	32	29	13	43	6	6.2	73	7.1	7	<3.00	<20.0	
1/10/2013	13:30	Grab	Site 9, 61st & Lyndale -SM	1.58	0.403		4.60	1.13	3.43	3073	700	645	143	5788	114	71.7	>20000	9.7	59	18	240	
1/11/2013	13:05	Grab	Site 9, 61st & Lyndale -SM	0.547	0.091		2.29	0.808	0.927	1113	96	108	36	1853	12	11.8	3340	6.4	30	13	190	20
2/26/2013	14:00	Grab	Site 9, 61st & Lyndale -SM	0.412	0.051		3.02	0.782	3.93	1973	212	197	39	3189	301	23.7	3830	9.2	29	7	110	23
5/18/2013	9:00	Composite	Site 9, 61st & Lyndale	0.591			3.68		0.601	32	70	340	71				212		43	26	240	
5/21/2013	0:29	Composite	Site 9, 61st & Lyndale	0.634	0.296		2.39	1.13	0.493	24	42	139	34	117	3	12.3	170	6.7	24	17	91	
5/29/2013	23:41	Composite	Site 9, 61st & Lyndale	0.757	0.334		2.09	0.882	0.252	107	44	214	42	249	5	11.5	467	7.8	33	19	210	
5/31/2013	2:28	Composite	Site 9, 61st & Lyndale	0.440	0.056		2.68	0.838	1.93	432	54	165	42	776	7	11.6	1501	7.2	23	20	100	
6/5/2013	18:59	Composite	Site 9, 61st & Lyndale	0.389	0.055		1.93	0.838	0.678	71	44	148	20	193	6	10.2	377	7.7	24	20	120	
6/9/2013	13:51	Composite	Site 9, 61st & Lyndale	0.220	0.104		0.84	<0.500	0.490	42	48	61	12	148	5	13.0	273	9.2	13	5	50	
6/12/2013	14:52	Composite	Site 9, 61st & Lyndale	0.381	0.082		1.33	<0.500	0.249	<2.0	46	247	38	127	3	7.6	183	9.3	24	16	130	1529
7/5/2013	7:47	Composite	61st & Lyndale -Illicit Disch	0.617			10.9		0.538	67	300	753	80				710		48	28	410	
7/9/2013	9:58	Composite	Site 9, 61st & Lyndale	0.378	0.103		2.34	0.835	0.388	15	44	288	35	107	14	9.0	176	9.6	26	10	110	4106
7/13/2013	5:36	Composite	Site 9, 61st & Lyndale	0.186			2.08		0.251	7	54	114	17						17	8	73	
7/21/2013	10:29	Composite	Site 9, 61st & Lyndale	0.225			5.40		0.525	35	58	139	20				275		21	5	90	
8/5/2013	8:09	Composite	Site 9, 61st & Lyndale	0.391	0.170	0.287	3.78	2.52	0.363	22	56	109	21	125	9	18.4	198	8.6	21	9	120	
8/6/2013	20:58	Composite	Site 9, 61st & Lyndale	0.261	0.073	0.132	1.72	0.599	0.235	8	52	229	32	55	4	7.1	108	8.8	20	13	100	
9/6/2013	0:44	Composite	61st & Lyndale -Illicit Disch	0.230					26.1	194	292								19	<3.00	68	
9/10/2013	12:12	Composite	61st & Lyndale -Illicit Disch	0.206					2.25		272						1288					
9/15/2013	8:23	Composite	Site 9, 61st & Lyndale	0.345			<0.500		0.476	16	56	72	22				187		15	4	160	
9/18/2013	8:06	Composite	Site 9, 61st & Lyndale	0.226			9.60		1.41	50	96	39	15				372		18	4	140	
9/19/2013	13:46	Composite	Site 9, 61st & Lyndale	0.666	0.070	0.362	7.82	2.12	0.755	36	84	511	85	158	11	22.1	279	8.3	48	27	340	
9/25/2013	20:00	Composite	61st & Lyndale -Illicit Disch	0.282					4.14	68	200						661					
9/28/2013	13:57	Composite	Site 9, 61st & Lyndale	0.402			7.71		0.307	37	98	177	48				323		37	10	170	
10/3/2013	0:58	Composite	Site 9, 61st & Lyndale	0.281	0.064	0.226	2.15	1.03	0.674	9	58	179	39	75	7	7.2	174	9.2	17	9	100	
10/4/2013	23:23	Composite	Site 9, 61st & Lyndale	0.648								436	16									
10/5/2013	16:45	Composite	Site 9, 61st & Lyndale	0.263								142										
10/6/2013	14:24	Composite	61st & Lyndale -Illicit Disch	1.41								57										
10/7/2013	13:45	Composite	61st & Lyndale -Illicit Disch	1.41								70										
10/18/2013	3:16	Composite	Site 9, 61st & Lyndale	0.228	0.044	0.228	2.24	<0.500	0.394	21	60	88	27	106	13	13.0	208	8.3	<5.00	5	64	
10/21/2013	9:51	Composite	61st & Lyndale -Illicit Disch	0.267			1.09					29	5	159			268					
10/22/2013	15:58	Composite	61st & Lyndale -Illicit Disch	0.284													555					
10/22/2013	17:13	Composite	61st & Lyndale -Illicit Disch	0.943													538					
10/25/2013	15:58	Composite	61st & Lyndale -Illicit Disch	0.108													790					
10/30/2013	5:34	Composite	Site 9, 61st & Lyndale	1.28	1.20	0.305	15.0	6.62	0.954	58	156	101	38	377								
11/2/2013	13:50	Composite	61st & Lyndale -Illicit Disch	0.302	0.227	0.247			0.777	72	139	24	4	322		26.4						
11/4/2013	17:11	Composite	Site 9, 61st & Lyndale	1.44	0.131	0.705	5.94	1.45	0.681	29	106	368	70	158	15	16.7	349	9.3	66	38	350	

Table 24-7 lists the statistical calculations for all measured parameters for each site. Most of the geometric mean maximums occurred at site 9 (61st and Lyndale) the industrial site. The lowest geometric mean values generally occur at Site 8 (Pershing) and Site 7 (14th & Park). This is as expected since Site 8 (Pershing) is parkland and Site 7 (14th & Park) is a mixed use watershed with little vegetation.

Geometric Mean Comparison
Site 6 (22nd & Aldrich), a residential watershed, had a maximum geometric mean for VSS, BOD, and Pb. The cause of VSS and BOD may be the dense leaf canopy in the watersheds organic load. The geometric mean concentration of Pb has been persistently high at this site and is likely a remnant of lead based paints shedding from the older houses and soils.

Site 7 (14th & Park) had the highest *E. coli* geometric mean concentration. High bacteria levels may be shed from urban wildlife or pets owned by a dense concentration of apartment/condo dwellers. Site 7 also had the lowest geometric mean for all phosphorus, NO_2NO_3, and sulfate values. This is likely the result of the hard surface landscape in this mixed use watershed.

Site 8 (Pershing) had the highest geometric mean TDP and Ortho-P values likely due to decaying organic material in the park . Site 8 also had the lowest geometric mean TKN, Cl, Hardness, TSS, VSS, BOD, *E. coli*, Pb, and Zn.

Site 9 (61st and Lyndale) had the highest geometric mean TP, TKN, NH3, NO2NO3, CL, Hardness, TSS, TDS, Sulfate, Cu, and ZN. This watershed is a light industrial site (cement factory, natural gas facility, etc.) and it is expected that many of the parameters would be higher than other watersheds due to industrial activities.

Table 24-7. 2013 event concentration statistics.

Site ID	Statistical Function	TP mg/L	TDP mg/L	Ortho-P mg/L	TKN mg/L	NH_3 mg/L	NO_3NO_2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate mg/L	pH std units	E. coli MPN/100mL	Cu ug/L	Pb ug/L	Zn ug/L
6, 22nd Aldrich	MEAN (geometric)	0.416	0.086	0.114	2.80	0.109	0.883	5	31	71	36	112	16	8	7.0	726	18.5	51.6	87.7
6, 22nd Aldrich	MEAN (arithmetic)	0.511	0.117	0.134	3.54	0.340	1.40	353	46	127	53	820	22	10	7.0	6925	27.3	75.2	134
6, 22nd Aldrich	MAX	2.33	0.49	0.185	13.3	3.10	6.31	4883	276	1333	426	7261	76	46	7.8	24196	180.0	510	1100
6, 22nd Aldrich	MIN	0.193	0.021	0.027	1.16	0.015	0.250	1	16	18	13	19	4	4	6.4	5	2.50	9.00	36.0
6, 22nd Aldrich	MEDIAN	0.357	0.079	0.155	2.31	0.151	0.78	1	25	71	32	61	16	8	7.0	1043	20.0	53.0	76.0
6, 22nd Aldrich	STDEV	0.46	0.11	0.059	3.05	0.653	1.68	1119	61	271	85	1998	19	10	0.3	10387	36.3	103.6	225
6, 22nd Aldrich	NUMBER	22	15	6	22	22	15	22	22	22	22	15	15	15	15	5	21.0	21.0	21.0
6, 22nd Aldrich	COV	0.890	0.983	0.443	0.861	1.92	1.20	3.17	1.34	2.14	1.60	2.43	0.844	1.03	0.045	1.50	1.33	1.38	1.68
7, 14th Park	MEAN (geometric)	0.224	0.035	0.060	1.77	0.367	0.516	4	26	60	23	88	7	6	7.1	1569	19.9	9.93	78.0
7, 14th Park	MEAN (arithmetic)	0.267	0.051	0.065	2.05	0.500	0.625	166	33	71	28	471	10	6	7.1	4088	22.0	11.6	89.4
7, 14th Park	MAX	0.690	0.214	0.095	4.61	1.57	1.48	2624	128	178	74	3928	32	9	7.6	12997	52.0	35.0	230
7, 14th Park	MIN	0.113	0.005	0.032	0.530	0.015	0.250	1	12	20	10	20	3	3	6.5	187	9.80	3.30	34.0
7, 14th Park	MEDIAN	0.221	0.034	0.066	1.64	0.423	0.572	1	22	54	19	51	6	6	7.2	1584	17.5	9.55	70.5
7, 14th Park	STDEV	0.173	0.057	0.026	1.12	0.363	0.411	604	29	46	21	1169	9	2	0.4	5977	11.02	7.64	53.9
7, 14th Park	NUMBER	19	11	4	18	19	11	19	19	18	18	11	11	11	11.0	4	18.0	18.0	18.0
7, 14th Park	COV	0.647	1.119	0.400	0.547	0.72	0.658	3.65	0.88	0.646	0.727	2.48	0.928	0.321	0.052	1.46	0.501	0.657	0.603
8, Pershing	MEAN (geometric)	0.371	0.248	0.332	1.30	0.154	0.537	2	24	28	11	57	5	8	6.9	12	6.82	2.48	15.4
8, Pershing	MEAN (arithmetic)	0.547	0.409	0.353	2.04	0.268	0.807	8	25	37	16	59	8	8	6.9	74	8.41	2.58	22.6
8, Pershing	MAX	1.49	1.31	0.536	6.43	0.725	2.88	67	34	80	49	92	20	11	7.4	146	17.0	3.7	81.0
8, Pershing	MIN	0.203	0.114	0.315	0.78	0.070	0.412	1	23	16	7	55	2	7	6.8	2	5.27	2.38	12.6
8, Pershing	MEDIAN	0.382	0.288	0.266	1.53	0.203	0.506	1	26	34	12	55	6	8	7.0	74	8.10	2.50	10.0
8, Pershing	STDEV	0.477	0.427	0.159	2.01	0.242	0.943	21	7	23	14	17	7	2	0.4	103	5.00	0.72	25.6
8, Pershing	NUMBER	10	7	3	10	10	7	10	10	10	10	7	7	7	7.0	2	10.0	10.0	10.0
8, Pershing	COV	0.874	1.04	0.450	0.989	0.903	1.17	2.58	0.268	0.637	0.862	0.294	0.818	0.308	0.062	1.39	0.595	0.279	1.13
9, 61st Lyndale	MEAN (geometric)	0.436	0.119	0.285	2.88	0.621	0.911	46	74	169	34	265	11	14	8.4	232	23.6	11.3	132
9, 61st Lyndale	MEAN (arithmetic)	0.526	0.196	0.321	3.95	0.886	1.31	313	101	210	40	800	33	17	8.4	1420	27.8	13.8	150
9, 61st Lyndale	MAX	1.58	1.20	0.705	15.0	3.93	6.62	3073	700	645	143	5788	301	72	9.7	4106	66.0	38.0	350
9, 61st Lyndale	MIN	0.186	0.044	0.132	0.250	0.235	0.250	1	42	39	12	55	3	7	6.4	20	2.50	3.60	50.0
9, 61st Lyndale	MEDIAN	0.391	0.091	0.287	2.39	0.525	0.838	35	58	165	36	158	8	12	8.7	776	24.0	11.5	120
9, 61st Lyndale	STDEV	0.378	0.280	0.184	3.39	0.969	1.49	755	137	149	29	1525	76	15	1.0	1927	15.1	8.8	82
9, 61st Lyndale	NUMBER	25	17	7	23	23	17	23	23	25	24	17	16	16	16.0	4	22.0	22.0	22.0
9, 61st Lyndale	COV	0.717	1.43	0.575	0.857	1.093	1.14	2.41	1.35	0.707	0.713	1.91	2.30	0.928	0.122	1.36	0.543	0.638	0.547
All	MEAN (geometric)	0.357	0.091	0.162	2.27	0.268	0.739	8	38	80	27	130	10	9	7.4	381	17.7	13.9	75.7
All	MEAN (arithmetic)	0.460	0.170	0.218	3.10	0.541	1.117	246	57	129	38	630	21	11	7.5	3787	23.4	29.8	112
All	MAX	2.33	1.31	0.705	15.0	3.93	6.62	4883	700	1333	426	7261	301	72	9.7	24196	180	510	1100
All	MIN	0.038	0.005	0.027	0.250	0.015	0.250	1	12	3	2	19	1	3	6.2	1	2.50	1.50	10.0
All	MEDIAN	0.345	0.079	0.181	2.29	0.350	0.782	5	33	75	28	79	9	8	7.2	1043	19.0	12.0	87.0
All	STDEV	0.388	0.255	0.168	2.78	0.711	1.34	798	89	181	51	1501	45	11	0.9	6811	22.8	63.2	138
All	NUMBER	76	50	20	73	74	50	74	74	75	74	50	49	49	49.0	15	71.0	71.0	71.0
All	COV	0.844	1.50	0.771	0.899	1.31	1.20	3.24	1.56	1.40	1.35	2.38	2.16	1.02	0.125	1.80	0.973	2.12	1.24
🟦	-Highest value																		
🟧	-Lowest value																		

All = all 4 sites, STDEV = standard deviation, COV = coefficient of variation.

Median Comparison

Table 24-8 shows median residential, mixed use, and composite values for the 2013 sites. Most results were similar or less than Nationwide Urban Runoff Program (NURP) values with the notable exception of TKN and residential Pb values. It is unknown why MRPB TKN median values are higher than NURP values. A possible explanation is there is more vegetative material in Minneapolis watershed decaying than in the NURP watersheds studied. The NURP studies were done in the 1980’s when lead was widely used in gasoline (from the 1920’s to 1990’s) and banned after 1996. The lead (Pb) reduction in the environment is clearly seen in the MPRB data sets. Most 2013 parameters were comparable or lower than the data from 2001-2012 with the notable exception of residential Pb. It is unknown why residential 2013 Pb data are higher than previous year’s medians, but may possibly be due to soil disturbance or home exterior maintenance disturbing lead paint in the watershed. In 2013, all three land use categories saw a decrease in all the median value concentrations of many parameters from the previous comparative years. It is important to note that the sites monitored in 2005-2013 are located in different watersheds and have similar but not identical land uses to those monitored in 2001-2004.

Table 24-8. Typical Median stormwater sampled concentrations.

Land Use	Residential			Mixed			Composite of all categories		
Location	MPRB[1]	MPRB[2]	NURP	MPRB[3]	MPRB[4]	NURP	MPRB[5]	MPRB[6]	NURP
Year(s)	2013	2001–2012		2013	2001–2012		2013	2001–2012	
TP (mg/L)	0.357	0.441	0.383	0.221	0.255	0.263	0.345	0.364	0.33
TKN (mg/L)	2.31	2.41	1.9	1.64	1.59	1.29	2.29	2.02	1.5
NO_3NO_2 (mg/L)	0.151	0.352	0.736	0.423	0.415	0.558	0.35	0.407	0.68
cBOD (mg/L)	16	11	10	6	9	8	9	10	9
TSS (mg/L)	71	87	101	54	64	67	75	85	100
Cu (µg/L)	20.0	17.9	33	17.5	19	27	19.0	18.2	30
Pb (µg/L)	53.0	26.8	144	9.6	14	114	12.0	14.1	140
Zn (µg/L)	76.0	79.0	135	70.5	86	154	87.0	83.0	160

[1] Site 6 data.
[2] Sites 1 and 2 data, (Site 6, 2005-2012).
[3] Site 7 data.
[4] Sites 5 and 5a data, (Site 7, 2005-2012).
[5] Sites 6 – 9 data.
[6] Sites 1 – 5a data, (Site 6 – 9, 2005-2012).
NURP = median event mean concentrations as reported by the Nationwide Urban Runoff Program (USEPA, 1996).
MPRB = median values calculated by the MPRB for the identified year(s).

Mean Comparison

Mean data were comparable to typical urban stormwater data from the Nationwide Urban Runoff Program (NURP), Center for Watershed Protection (CWP), and Bannerman (**Table 24-9)**. Most MPRB mean concentrations were comparable to other studies as listed in **Table 24-9** below. Data from MPRB Sites 1–5a (2001–2004) and 6–9 (2005–2012) were generally similar to Sites 6–9 in 2013. All measured compared parameters were roughly equal to or lower in 2013, with the exception of TDP, TDS, and TKN. The 2013 increase in TDP, TDS, and TKN are likely the result of organic material in the watersheds interacting with the wet spring and dry summer/fall.

Table 24-9. Typical Mean urban stormwater concentrations. " -- " = not reported.

Parameter	NURP[1]	CWP[2]	Bannerman *et al.*[3]	Mpls PW[4]	St. Paul[5]	MWMO 2013[6]	MPRB[7] 2001–2012	MPRB[8] 2013
TP (mg/L)	0.5	0.3	0.66	0.417	0.484	0.395	0.478	0.460
TDP (mg/L)	--	--	0.27	0.251	--	0.107	0.145	0.170
TKN (mg/L)	2.3	--	--	--	2.46	2.69	2.76	3.10
NO_3NO_2 (mg/L)	0.86	--	--	--	0.362	0.695	0.512	0.541
NH_3 (mg/L)	--	--	--	0.234	--	0.331	1.02	1.12
Cl (mg/L)	--	230 (winter)	--	--	--	459	290	246
BOD (mg/L)	12	--	--	14.9	25	16	16	21
TDS (mg/L)	--	--	--	73.3	78	911	549	630
TSS (mg/L)	239	80	262	77.6	129	116	122	129
Cu (µg/L)	50	10	16	26.7	30	24.7	26.3	23.4
Pb (µg/L)	240	18	32	75.5	233	14.6	24.7	29.8
Zn (µg/L)	350	140	204	148	194	125	125	112

[1] USEPA (1996)
[2] Center for Watershed Protection (2000)
[3] Monroe study area of Bannerman *et al.* (1993)
[4] City of Minneapolis Public Works Department (1992) – average from a combination of land uses
[5] City of St. Paul 1994 stormwater data – average from a combination of land uses
[6] Mississippi Watershed Management Organization 2013 data, average of snowmelt and storms from all sites
[7] MPRB arithmetic mean data calculated from NPDES Sites 1 – 5a (2001 – 2004), 6 – 9 (2005 – 2012)
[8] MPRB arithmetic mean data calculated from NPDES Sites 6 – 9 (2013)

Flow-weighted Mean Comparison

The flow-weighted mean concentrations presented in **Table 24-10** were calculated using FLUX32. Sample concentrations and associated daily average flows were used as input for these calculations. The data were often stratified by flow or season to achieve the most accurate and precise results. The method and event mean concentration with the lowest coefficient of variation (CV) was chosen as the final value.

Table 24-10. Flow-weighted mean concentrations and statistics for NPDES parameters in 2013.

Site	TP (mg/L)	TDP (mg/L)	Ortho-P (mg/L)	TKN (mg/L)	NO_3NO_2 (mg/L)	NH_3 (mg/L)	Cl* (mg/L)	Hardness (mg/L)	TSS (mg/L)	VSS (mg/L)	TDS* (mg/L)	cBOD (mg/L)	Sulfate (mg/L)	Cu (µg/L)	Pb (µg/L)	Zn (µg/L)
6	0.311	0.081	0.106	2.89	0.299	0.832	37	47.8	77	33	60	13	6.6	17	60	76
7	0.204	0.047	0.064	1.69	0.388	0.653	43	23.5	65	24	164	7	5.6	19	11	77
8a	0.504	0.331	0.363	2.24	0.226	0.508	5	28.7	54	21	68	7	8.1	14	2	23
9	0.455	0.171	0.244	2.52	0.696	0.996	205	63.9	184	37	913	24	12.3	24	16	139
MEAN	**0.369**	**0.157**	**0.194**	**2.34**	**0.402**	**0.747**	**72**	**41.0**	**95**	**29**	**301**	**13**	**8.1**	**19**	**22**	**79**
MEDIAN	**0.383**	**0.126**	**0.175**	**2.38**	**0.344**	**0.743**	**40**	**38.3**	**71**	**29**	**116**	**10**	**7.3**	**18**	**14**	**77**
STANDEV	**0.137**	**0.127**	**0.136**	**0.506**	**0.207**	**0.212**	**90**	**18.5**	**60**	**8**	**411**	**8**	**2.9**	**4**	**26**	**47**

🟦 -Highest value
🟧 -Lowest value

* Flow–weighted mean concentrations for Cl and TDS were difficult to estimate using FLUX32 due to large outliers from the two snowmelt samples; these estimates should be used with caution.
STANDEV= standard deviation.

Site 6 (22nd & Aldrich) is a multi-family residential watershed. Site 6 had the highest modeled concentrations of TKN and Pb. Site 6 had the lowest TDS. It is believed this may be due to its location between two heavily traveled thoroughfares (Hennepin and Lyndale) where a mature leaf canopy may collect airborne material and deposit it following precipitation.

Site 7 (14th & Park) is a densely developed mixed-use watershed. Site 7 did not have any of the highest modeled parameters. Site 7 had the lowest modeled TP, TDP, Ortho-P, TKN, hardness, and sulfate.

Site 8a (Pershing) is an open parkland watershed. Site 8a had the highest modeled event mean concentrations of TDP and Ortho-P. This is unknown why, but it may be due to turf maintenance. Site 8a had the lowest modeled NO_3NO_2, NH_3, Cl, TSS, VSS, cBOD, Cu, Pb, and Zn.

Site 9 (61st and Lyndale) is a commercial/industrial watershed. Site 9 had the highest modeled concentration of TP, NO_3NO_2, NH_3, Cl, hardness, TSS, VSS, TDS, Sulfate, Cu, and Zn. Site 9 did not have any of the lowest modeled chemical parameters. Industrial activities in this watershed likely explain the higher pollutant loads. Site 9 is located adjacent to a large cement aggregate mixing facility which may explain the higher TSS values. This site sometimes had a small baseflow which could be sampled during future monitoring to distinguish high concentrations from storm events or baseflow. Site 9 also had eleven events in 2013 that could not be traced to precipitation. Further investigation should locate the source of these illicit discharges of water.

Table 24-11 includes flow-weighted mean pollutant concentrations of data collected in the 1980's and reported by the U.S. Geological Survey (USGS) for various sites within the Twin Cities (as cited in MPCA, 2000). The Yates watershed was a stabilized residential area. The Iverson site was a residential watershed under development and the Sandberg watershed was predominantly light industrial land-use area, as reported by the USGS. Site 6 is more closely related to the Yates watershed land-use characteristics. Sites 7 and 9 are more comparable to the Sandberg watershed land-use characteristics.

When comparing the USGS flow-weighted mean concentrations to the MPRB sites in **Table 24-11** Site 6 had lower or similar concentrations with Yates for all parameters. Compared to Sandberg, Sites 7 and 9 have lower flow-weighted mean concentrations for all parameters and are well within the ranges shown in **Table 24-11**. Site 7 had significantly lower values than Sandberg, where Minneapolis data had roughly one quarter to half of the Sandburg values.

The overall mean comparison of **Table 24-11** to MPRB water quality values at sites 6, 7, 8a, and 9 shows Minneapolis sites were the same or roughly half of the values for the compared parameters. The Minneapolis mean lead values are similar to the Yates and Sandburg studies.

Table 24-11. Flow-weighted mean stormwater pollutant concentrations (mg/L) and ranges as reported by the USGS (as cited in MPCA, 2000).

Pollutant		Monitoring Site		
		Yates area (stabilized residential)	Iverson area (developing residential)	Sandburg area (light industrial)
TSS	Mean Range	133 (2 – 758)	740 (17 – 26,610)	337 (7 – 4,388)
Pb	Mean Range	0.23 (0.015 – 1.8)	0.02 (0.008 – 0.31)	0.19 (0.003 – 1.5)
Zn	Mean Range	0.198 (0.02 – 2.2)	0.235 (0.028 – 0.53)	0.185 (0.02 – 0.81)
TKN	Mean Range	3.6 (0.6 – 28.6)	1.2 (1.0 – 29.2)	2.5 (0.4 – 16.0)
TP	Mean Range	0.63 (0.10 – 3.85)	0.62 (0.2 – 13.1)	0.63 (0.07 – 4.3)

Table 24-12 shows the flow-weighted mean concentrations in 2013 compared to previous years. Flow-weighted mean concentrations for Cl and TDS were difficult to estimate using FLUX32 due to large outliers from the snowmelt samples. These estimates should be used with caution. When samples were below the MDL (minimum detection limit), half of the MDL was used for calculations.

Table 24-12. MPRB Flow–weighted mean concentration compared to previous years. Each year is the average flow–weighted mean concentration of all sites monitored that year.

	Flow-weighted mean concentrations												
	Sites 1-5a				**Site 6-9**								
Parameter	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
TP (mg/L)	0.470	0.337	0.474	0.332	0.354	0.548	0.472	0.486	0.583	0.341	0.355	0.368	0.369
TDP (mg/L)	0.112	0.095	0.114	0.121	0.123	0.135	0.108	0.139	0.249	0.063	0.126	0.123	0.157
Ortho-P (mg/L)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	0.179	0.097	0.194
TKN (mg/L)	2.21	1.60	2.10	1.94	3.48	3.54	4.43	3.22	3.61	1.53	1.74	2.00	2.34
NO_3NO_2 (mg/L)	0.398	0.423	0.496	0.382	0.448	0.638	0.496	0.582	0.755	0.414	0.498	0.397	0.402
NH_3(mg/L)	0.494	0.722	0.346	0.918	1.74	1.64	0.970	0.966	1.64	0.666	0.922	0.719	0.747
Cl (mg/L)	37	11	587	40	18	91	412	139	803	60	213	14	72
Hardness (mg/L)	nc	na	nc	nc	na	nc	nc	nc	nc	na	48.0	37	41
TSS (mg/L)	116	83	116	70	108	156	180	148	121	107	104	101	95
VSS (mg/L)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	30.2	31	29
TDS (mg/L)	306	85	725	130	252	183	737	507	3323	124	693	97	301
cBOD (mg/L)	12	8	16	20	9	9	17	25	53	7	11	13	13
Sulfate (mg/L)	nc	nc	nc	nc	nc	nc	nc	nc	nc	nc	15.4	18.4	8.1
Cd (µg/L)	0.532	0.518	2.11	2.80	2.50	nc	nc	nc	nc	nc	nc	nc	nc
Cu (µg/L)	15	31	23	15	19	29	36	16	40	23	25	16	19
Pb (µg/L)	23	17	22	14	41	31	34	28	23	24	18	15	22
Zn (µg/L)	180	76	107	76	86	94	133	132	204	100	103	90	79

nc = data not collected.
na= data not analyzed for.
Note: Cadmium (Cd) was discontinued from monitoring in 2006 because Cd concentrations had typically been below detection for the Minneapolis/St. Paul area and it was not useful information. It should also be noted the detection limit for Cd has changed over time. In 2002 it was <0.500 µg/L; in 2003 it was <2.00 µg/L and in 2004 it was <5.00 µg/L. Also in 2011 the parameters ortho-P (or TDP), hardness (for metals toxicity calculations), and sulfate were added for a more complete analysis of the stormwater and watersheds.

Chemical concentrations in stormwater are highly variable. Climatological factors such as precipitation amount and intensity, street sweeping type and frequency, BMP maintenance schedule frequency, etc. can cause fluctuations in chemical concentrations. **Table 24-12** illustrates the variability of stormwater from year to year.

The variability from year to year is due to three likely causes. First, the watersheds monitored have occasionally changed. Second, the timing between street sweeping frequency, BMP maintenance frequency, and sampling probably affect variability within the monitoring year and between years. Third, precipitation frequency, intensity, and duration affect results.

Seasonal statistics (snowmelt, spring, summer, and fall) of the data for the combination of all sites were calculated and are listed in **Table 24-13**. Seasonal patterns are evident. Snowmelt had the highest geometric mean concentrations for most of the parameters: TP, TDP, TKN, NH_3, NO_2NO_3, Cl, hardness, VSS, TDS, cBOD, sulfate, Cu, and Zn. Snowmelt is very dirty, but it had the lowest geometric mean concentration for E *coli*., which is temperature dependent. Spring stormwater had the highest TSS and Pb geometric mean concentration and it had the lowest geometric mean concentrations for TDP, hardness, TDS, cBOD, sulfate, and pH. Summer had the highest concentrations of *E coli*, but had the lowest geometric mean concentrations for the majority of parameters: TP, Ortho-P, TKN, NH_3, $NO_2NO_{3,}$ Cl, hardness, TSS, VSS, Cu, Pb, and Zn. Fall had the highest geometric mean concentrations of Ortho-P and pH. Fall had none of the lowest geometric mean concentration.

Surcharge Events

Large rain events can lead to pipe surcharges. If surcharge water inundates the auto-sampler tray the samples are considered contaminated and dumped. Surcharges occur when water backs up in pipes and creates hydrostatic pressure head, beyond the diameter of the pipe, which can result in inaccurate daily flow calculations and must be considered when evaluating flow-weighted mean concentrations. Surcharge events happen during high precipitation totals or high intensity storm events that exceed the drainage capacity of the pipes. With the exception of Site 8a, most of the surcharging events were storms greater than 1 inch. The following surcharges occurred at the NPDES sites in 2013:

- Site 6 (22nd and Aldrich): 5/30, 6/22, 7/13, 8/29.
- Site 7 (Park and 14th): 6/21.
- Site 8a (Pershing): 5/18-20, 5/29, 5/31, 6/12, 6/21, 6/23, 6/28-29, 7/13, 8/6, 9/3, 10/15.
- Site 9 (61st and Lyndale): 6/21, 8/6.

Site 8a (Pershing) is of special concern as it had fourteen surcharges in 2013, storms as small as 0.42 inches or as large as 3.00 inches caused surcharging. At the site, two pipes and overland flow enter the manhole basin and the outlet is a 12 inch PVC pipe. This entire watershed/area of Minneapolis is lower in elevation than the surrounding areas causing a regular back up of many storm sewers in the system. Minneapolis Public Works is aware of this problem. The surcharges at this site do not appear to have caused any flooding problems. Site 8a samples appear to not be significantly affected by surcharging since the sampler is in a dog-house enclosure.

Table 24-13. 2013 statistical summary of concentrations by season from all sites (6 –9).

2013 Season	Statistical Function	TP mg/L	TDP mg/L	Ortho-P mg/L	TKN mg/L	NH_3 mg/L	NO_3NO_2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate mg/L	pH std units	*E. coli* MPN/100mL	Cu ug/L	Pb ug/L	Zn ug/L
SNOWMELT (February-March)	**MEAN (geometric)**	0.640	0.128	NA	3.57	1.49	0.813	392	104	93	36	1243	22	12	7.1	64	23.2	18.6	114
	MEAN (arithmetic)	0.934	0.281		5.18	2.13	1.50	1681	175	269	83	2732	58	20	7.2	366	43.2	80.3	233
	MAX	2.33	1.31		13.3	6.31	3.93	4883	700	1333	426	7261	301	72	9.7	1700	180	510	1100
	MIN	0.038	0.024		0.25	0.250	0.047	1	20	3	2	55	1	3	6.2	1	2.50	1.50	10.0
	MEDIAN	0.789	0.124		4.33	1.33	0.808	1543	112	107	38	2521	26	9	6.6	146	29.5	15.5	170
	STDEV	0.685	0.396		4.00	1.87	1.44	1578	202	417	127	2460	91	22	1.26	598	51.4	157	315
	NUMBER	10	10		10	10	10	10	10	10	10	10	10	10	10	9	10	10	10
	COV	0.734	1.41		0.773	0.877	0.961	0.94	1.15	1.55	1.52	0.90	1.57	1.13	0.175	1.63	1.19	1.96	1.35
SPRING (April-May)	**MEAN (geometric)**	0.377	0.043	NA	2.45	0.746	0.268	5	26	111	36	71	6	7	7.1	NA	22.6	20.1	89.8
	MEAN (arithmetic)	0.471	0.095		2.72	0.805	0.410	47	30	129	38	153	6	8	7.1		24.5	26.5	107
	MAX	1.31	0.334		6.43	1.14	1.93	432	70	340	71	776	13	12	7.8		52.0	90.0	240
	MIN	0.125	0.005		1.37	0.250	0.033	1	14	52	18	19	3	4	6.7		13.0	3.30	45.0
	MEDIAN	0.440	0.025		2.30	0.838	0.271	1	20	103	37	51	6	7	7.1		19.0	19.0	81.0
	STDEV	0.327	0.127		1.44	0.274	0.481	119	18	81	16	244	3	3	0.358		11.6	22.6	71.0
	NUMBER	13	9		13	9	13	13	13	13	13	9	9	9	9		13	13	13
	COV	0.696	1.34		0.529	0.341	1.18	2.55	0.600	0.623	0.405	1.60	0.516	0.438	0.050		0.472	0.853	0.664
SUMMER (June-August)	**MEAN (geometric)**	0.262	0.095	0.115	1.70	0.494	0.182	4	27	62	18	74	8	8	7.6	5466	15.0	9.34	51.1
	MEAN (arithmetic)	0.292	0.115	0.155	1.97	0.626	0.298	17	31	83	21	84	10	8	7.6	8917	16.6	16.8	66.7
	MAX	0.599	0.301	0.287	5.40	2.52	1	151	58	288	42	193	35	18	9.6	24196	30.0	71.0	140
	MIN	0.113	0.034	0.027	0.530	0.250	0.015	1	12	16	5	29	3	4	6.6	1467	2.50	1.50	10.0
	MEDIAN	0.285	0.082	0.137	1.73	0.572	0.261	1	28	55	19	78	6	8	7.4	6657	16.0	9.30	68.0
	STDEV	0.135	0.080	0.104	1.16	0.530	0.234	34	16	72	10	42	9	3	0.95	8757	6.71	19.7	39.4
	NUMBER	26	19	8	26	19	26	26	26	26	26	19	19	19	19	6	25	25	25
	COV	0.460	0.70	0.673	0.590	0.846	0.784	1.98	0.507	0.873	0.466	0.504	0.893	0.413	0.124	0.982	0.404	1.18	0.590
FALL (Sept-Nov)	**MEAN (geometric)**	0.376	0.114	0.205	2.47	0.775	0.257	6	43	84	32	74	13	9	7.7	NA	16.3	13.6	88.2
	MEAN (arithmetic)	0.441	0.220	0.261	3.66	1.28	0.478	13	51	122	37	101	18	10	7.7		21.6	23.7	112
	MAX	1.44	1.20	0.705	15.0	6.62	1.41	58	156	511	85	377	76	22	9.3		66.0	78.0	350
	MIN	0.137	0.031	0.063	0.250	0.250	0.015	1	20	18	13	28	5	6	6.9		2.50	1.50	10.0
	MEDIAN	0.344	0.093	0.206	2.41	0.717	0.476	6	38	82	33	61	13	8	7.2		19.0	10.0	90.0
	STDEV	0.301	0.338	0.193	3.42	1.77	0.351	16	34	126	22	98	20	5	0.869		14.8	23.3	83.4
	NUMBER	27	12	12	24	12	25	25	25	26	25	12	11	11	11		23	23	23
	COV	0.684	1.53	0.739	0.935	1.38	0.736	1.24	0.661	1.03	0.579	0.969	1.12	0.496	0.112		0.682	0.980	0.746

🟦 -highest concentration
🟧 -lowest concentration

STDEV= standard deviation, COV= coefficient of variation, “Blue” highlighted cells have the highest seasonal geometric mean, “Orange” has the lowest seasonal geometric mean.

25. NOKOMIS 56TH & 21ST BMP MONITORING

BACKGROUND

Best management practices (BMPs) include procedures and structures designed to help reduce water pollution as well as good housekeeping practices like street sweeping. Monitoring of BMPs in Minneapolis is done as a part of the Federal NPDES stormwater permit activities (permit #MN0061018).

As part of the NPDES permits BMP requirement Minneapolis Public Works is attempting to quantify the measurable stormwater effects of street sweeping. The project will use both automated flow and flow paced sampling to collect runoff measuring stormwater solids (TSS, TVS) and phosphorus (TP, TDP).

Target watersheds chosen for study were on the southeast side of Lake Nokomis. A paired watershed design was initially attempted. After initial reconnaissance the paired watershed design was deemed unworkable due to site conditions. Three sites were investigated. 1) Woodlawn & 50th was too shallow to hang a sampler and had four 10 inch leaders making laminar flow and accurate measurement impossible. 2) Woodlawn & 53rd had 12+ inches of standing water in the pipe which would negatively affect results due to with settling and re-suspension. 3) The watershed outlet of 56th & 21st was acceptable, did not have major issues with standing water and had room for equipment. It was chosen and monitored in 2012 - 2013 for pre-activity and baseline conditions (see **Figure 25-1)** prior to commencement of sweeping.

The drainage area to the 56th and 21st site is approximately 50 acres, as measured from the Minneapolis pipeshed GIS layer, and the majority land use is single family homes. The outfall ID associated with the site is 72-060.

Figure 25-1. Aerial photograph of 56th and 21st located on the S.E. side of Lake Nokomis in Minneapolis.

METHODS

The summary below includes descriptions of equipment installation at each site, parameters monitored, field quality assurance sampling, data handling, validation, and reporting.

Site Installation
The 56th & 21st outlet is a 30" reinforced concrete pipe, as shown in **Figure 25-2**. Auto-monitoring equipment installed at the site consisted of a low profile area/velocity pressure transducer with an ISCO 2150 datalogger, 2105 interface module, and 2103ci cell phone modem interface coupled with an ISCO 3700 sampler. The AV probe and intake strainer were placed at the invert as shown in **Figure 25-3**. Cell phone modems were used to allow remote communication and adjustment.

Equipment installation began when freezing temperatures were no longer a concern in order to prevent area velocity transducer damage. Installation occurred on 5/23/13.

Monitoring
Snowmelt grab samples were collected on 1/11/13 and 2/26/13 in 2013. The auto monitoring sampling period was from 5/23/13 – 11/14/13. With the exception of snowmelt grabs, all stormwater samples in 2013 were collected by flow weighted auto monitoring.

Figure 25-2. The manhole street view of the 56th and 21st 30" pipe.

Figure 25-3. The AV probe and intake strainer being anchored to the invert.

The 56th & 21st site had approximately 3” of standing water that was present for most of the season, except during an August – September drought. At times, the site appears to have had a baseflow condition as well as water coming from a non-event illicit discharge source e.g. lawn sprinklers.

Monitored Parameters

The parameters chosen for this site were solids (TSS, VSS) and phosphorus (TP, TDP), listed below in **Table 25-1**. When a sample event was collected and no precipitation was measured at the MPRB Southside Service Center weather station, it was determined to be a non-event sample or potential illicit discharge.

Table 25-1. Parameters monitored at 56th and 21st.

Parameter	Abbreviation	Units	Sample Type
Phosphorus, Total Dissolved	TDP	mg/L	Composite
Phosphorus, Total	TP	mg/L	Composite
Solids, Total Suspended	TSS	mg/L	Composite
Solids, Volatile Suspended	VSS	mg/L	Composite
Fluoride	Fl	mg/L	Composite

Holding times and detection limits for all parameters are listed in **Section 24, Table 24-5**.

The dates, times, and sample information on storms and illicit discharges collected are shown below in **Table 25-2.** Fluoride was added for a few illicit discharge samples to help determine origin.

Table 25-2. The 56th and 21st 2013 events and illicit discharge events. A precipitation event was defined as greater than 0.10 inches separated by 8 hours.

Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	2013, 56th & 21st Events Collected
+1	1/11/2013	14:00	n/a		n/a	n/a	n/a	n/a	grab	X(w/Ecoli)
+2	2/26/2013	14:00	n/a		n/a	n/a	n/a	n/a	grab	X(w/Ecoli)
3	6/5/2013	4:00	6/5/2013	18:30	0.20	14.5	0.01	108.5	composite	X
4	6/9/2013	2:00	6/9/2013	14:30	0.46	12.5	0.04	79.5	composite	X
5	6/12/2013	1:30	6/12/2013	18:30	0.59	17.0	0.03	59.0	composite	X
6	7/9/2013	8:15	7/9/2013	9:15	0.51	1.0	0.51	236.0	composite	X
7	7/13/2013	3:30	7/13/2013	7:30	3.00	4.0	0.75	90.3	composite	X
8	8/5/2013	2:00	8/5/2013	8:00	0.52	6.0	0.09	227.8	composite	X
9	9/14/2013	16:30	9/15/2013	12:00	0.54	19.5	0.03	931.5	composite	X
10	9/19/2013	11:30	9/19/2013	12:30	0.19	1.0	0.19	27.0	composite	X
11	9/28/2013	10:30	9/28/2013	13:30	0.15	3.0	0.05	214.0	composite	X
12	10/2/2013	19:00	10/3/2013	23:00	1.12	28.0	0.04	101.5	composite	X
13	10/4/2013	21:30	10/5/2013	16:00	0.31	18.5	0.02	22.5	composite	X
14	10/14/2013	19:00	10/16/2013	3:30	1.31	32.5	0.04	32.5	composite	X
15	11/4/2013	12:00	11/4/2013	13:30	0.16	1.5	0.11	102.5	composite	X
			Totals		**9.06**					**15**

+snowmelt event

n/a = not applicable

X = event sampled with full parameters

X(w/Ecoli) = event sampled with fecal coliform

Illicit Discharges

Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	2013, 56th & 21st Events Collected
1	n/a	n/a	7/5/2013	8:17	n/a	n/a	n/a	n/a	composite	X
2	n/a	n/a	8/3/2013	2:42	n/a	n/a	n/a	n/a	composite	X
3	n/a	n/a	8/10/2013	2:32	n/a	n/a	n/a	n/a	composite	X(lmtd)
4	n/a	n/a	8/17/2013	2:35	n/a	n/a	n/a	n/a	composite	X
5	n/a	n/a	8/20/2013	2:26	n/a	n/a	n/a	n/a	composite	X(lmtd)
6	n/a	n/a	9/20/2013	11:42	n/a	n/a	n/a	n/a	composite	X
7	n/a	n/a	10/22/2013	2:44	n/a	n/a	n/a	n/a	composite	X
8	n/a	n/a	10/26/2013	2:54	n/a	n/a	n/a	n/a	composite	X
9	n/a	n/a	10/29/2013	2:35	n/a	n/a	n/a	n/a	composite	X
10	n/a	n/a	11/2/2013	3:01	n/a	n/a	n/a	n/a	composite	X
			Totals							**10**

n/a = not applicable

X = event sampled with full parameters

X(lmtd) = event with low volume so limited parameters

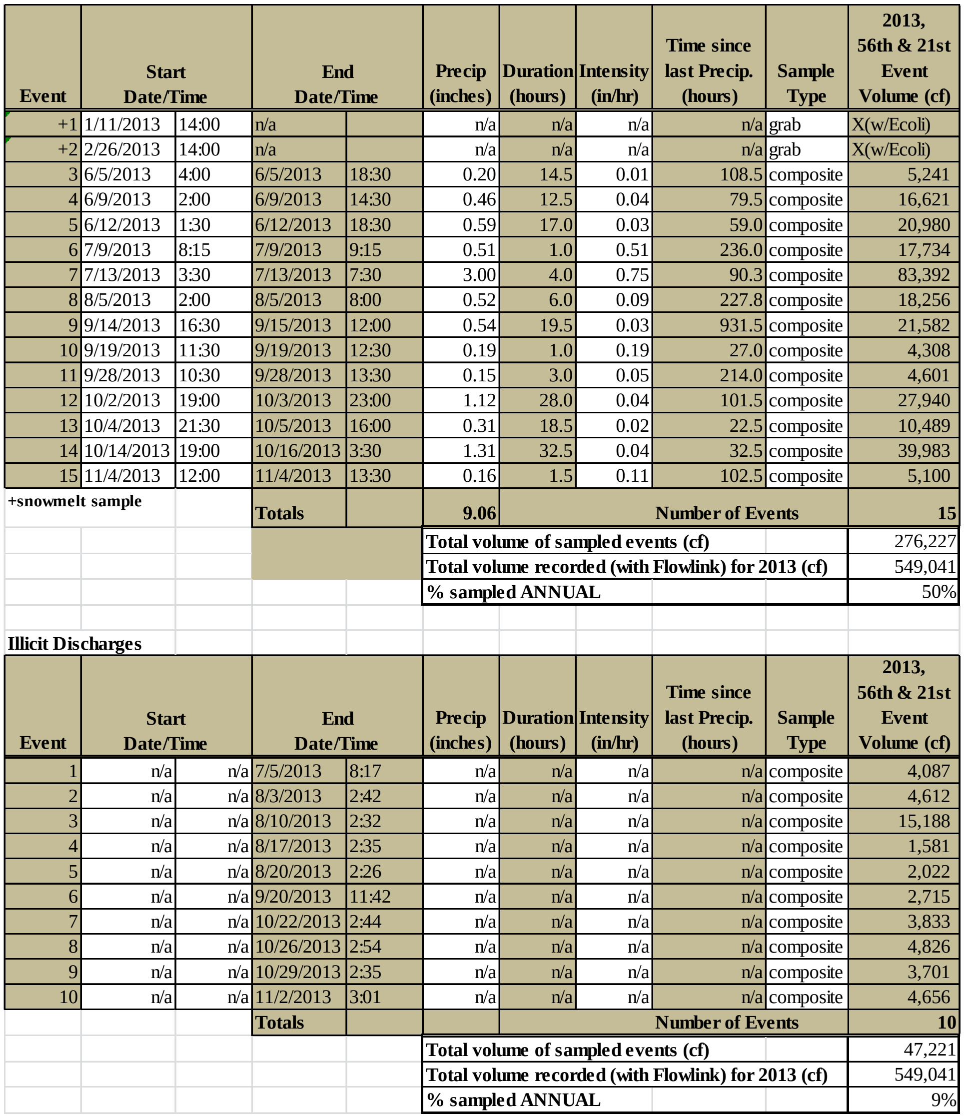
RESULTS & DISCUSSION

In 2013, at the 56th & 21st site a total of 15 storms and 10 non-precipitation illicit discharge sample events were collected. Most of the illicit discharge occurred from late summer to fall (July – November) and between 2:30 am and 3:00 am. At this time it is unknown where these non-precipitation events are emanating from, but it could be from automated lawn sprinklers in the watershed. An extensive physical watershed investigation was done with the City of Minneapolis staff Steve Kennedy and John Thomas, and no source was found to date.

Surcharge events are very infrequent at this site. Only one surcharge event occurred on 8/6/13.

Table 25-3 Shows the volumes collected for each event, the total annual volume, and the annual percentage of runoff collected. Using flow paced samplers, approximately 50% of the annual storm runoff was measured and collected. Additionally 9% of the annual runoff collected was determined to be due to illicit discharges. Baseflow presence and stagnant water are issues at this site.

Table 25-3. The 56th and 21st, 2013 sampled events and illicit discharges with associated flow data.



Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	2013, 56th & 21st Event Volume (cf)
+1	1/11/2013	14:00	n/a		n/a	n/a	n/a	n/a	grab	X(w/Ecoli)
+2	2/26/2013	14:00	n/a		n/a	n/a	n/a	n/a	grab	X(w/Ecoli)
3	6/5/2013	4:00	6/5/2013	18:30	0.20	14.5	0.01	108.5	composite	5,241
4	6/9/2013	2:00	6/9/2013	14:30	0.46	12.5	0.04	79.5	composite	16,621
5	6/12/2013	1:30	6/12/2013	18:30	0.59	17.0	0.03	59.0	composite	20,980
6	7/9/2013	8:15	7/9/2013	9:15	0.51	1.0	0.51	236.0	composite	17,734
7	7/13/2013	3:30	7/13/2013	7:30	3.00	4.0	0.75	90.3	composite	83,392
8	8/5/2013	2:00	8/5/2013	8:00	0.52	6.0	0.09	227.8	composite	18,256
9	9/14/2013	16:30	9/15/2013	12:00	0.54	19.5	0.03	931.5	composite	21,582
10	9/19/2013	11:30	9/19/2013	12:30	0.19	1.0	0.19	27.0	composite	4,308
11	9/28/2013	10:30	9/28/2013	13:30	0.15	3.0	0.05	214.0	composite	4,601
12	10/2/2013	19:00	10/3/2013	23:00	1.12	28.0	0.04	101.5	composite	27,940
13	10/4/2013	21:30	10/5/2013	16:00	0.31	18.5	0.02	22.5	composite	10,489
14	10/14/2013	19:00	10/16/2013	3:30	1.31	32.5	0.04	32.5	composite	39,983
15	11/4/2013	12:00	11/4/2013	13:30	0.16	1.5	0.11	102.5	composite	5,100
+snowmelt sample			Totals		9.06	Number of Events				15
					Total volume of sampled events (cf)					276,227
					Total volume recorded (with Flowlink) for 2013 (cf)					549,041
					% sampled ANNUAL					50%

Illicit Discharges

Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	2013, 56th & 21st Event Volume (cf)
1	n/a	n/a	7/5/2013	8:17	n/a	n/a	n/a	n/a	composite	4,087
2	n/a	n/a	8/3/2013	2:42	n/a	n/a	n/a	n/a	composite	4,612
3	n/a	n/a	8/10/2013	2:32	n/a	n/a	n/a	n/a	composite	15,188
4	n/a	n/a	8/17/2013	2:35	n/a	n/a	n/a	n/a	composite	1,581
5	n/a	n/a	8/20/2013	2:26	n/a	n/a	n/a	n/a	composite	2,022
6	n/a	n/a	9/20/2013	11:42	n/a	n/a	n/a	n/a	composite	2,715
7	n/a	n/a	10/22/2013	2:44	n/a	n/a	n/a	n/a	composite	3,833
8	n/a	n/a	10/26/2013	2:54	n/a	n/a	n/a	n/a	composite	4,826
9	n/a	n/a	10/29/2013	2:35	n/a	n/a	n/a	n/a	composite	3,701
10	n/a	n/a	11/2/2013	3:01	n/a	n/a	n/a	n/a	composite	4,656
			Totals			Number of Events				10
					Total volume of sampled events (cf)					47,221
					Total volume recorded (with Flowlink) for 2013 (cf)					549,041
					% sampled ANNUAL					9%

Flow-weighted composite data and associated statistics are shown in **Table 25-4**. It is interesting to note that the geometric mean percentage of both TDP and VSS are roughly 50% or greater. This means over half of the phosphorus (TP) are dissolved (TDP) and the solids (TSS) are organic solids (VSS). It would be expected that street sweeping would address the TP, TSS, and VSS but have a very small effect on TDP, which makes up approximately half of the load. This watershed may be a candidate for an enhanced iron sand filter, which targets dissolved phosphorus.

Table 25-4. The 56th & 21st 2013 Sampled event data and illicit discharge data with associated statistics. NA = data not available due to expired holding times or limited volume.

Date Sampled	Time	Site Location	Type	TP mg/L	TDP mg/L	% TDP	TSS mg/L	VSS mg/L	% VSS
1/11/2013	13:25	56th & 21st -SM	Grab	0.845	0.640	76%	23	12	51%
2/26/2013	14:30	56th & 21st -SM	Grab	0.279	0.089	32%	67	30	45%
6/5/2013	19:29	56th & 21st	Composite	0.449	0.244	54%	26	14	56%
6/9/2013	15:36	56th & 21st	Composite	0.302	0.146	48%	18	12	70%
6/12/2013	13:07	56th & 21st	Composite	0.278	0.120	43%	35	20	56%
7/9/2013	10:00	56th & 21st	Composite	0.564	0.373	66%	42	18	42%
7/13/2013	6:06	56th & 21st	Composite	0.211	0.101	48%	53	19	36%
8/5/2013	8:28	56th & 21st	Composite	0.512	0.295	58%	33	20	59%
9/15/2013	5:54	56th & 21st	Composite	0.420	0.210	50%	57	24	42%
9/19/2013	12:08	56th & 21st	Composite	0.278	0.136	49%	112	50	45%
9/28/2013	14:37	56th & 21st	Composite	0.503	0.356	71%	16	10	65%
10/3/2013	1:16	56th & 21st	Composite	0.262	0.146	56%	36	19	54%
10/5/2013	1:26	56th & 21st	Composite	0.206	0.142	69%	10	6	58%
10/17/2013	23:47	56th & 21st	Composite	0.485	0.358	74%	46	35	76%
11/4/2013	14:22	56th & 21st	Composite	0.990	0.552	56%	25	19	78%
SM=snowmelt			**Mean**	0.439	0.261	59%	40	21	52%
			Geo Mean	0.393	0.217	**55%**	34	18	**54%**
			Median	0.420	0.210	50%	35	19	55%
			Std Dev	0.228	0.168		26	11	
			Max	0.990	0.640		112	50	
			Min	0.206	0.089		10	6	
			Number	15	15		15	15	

Illicit Discharge

Date Sampled	Time	Site Location	Type	TP mg/L	TDP mg/L	% TDP	TSS mg/L	VSS mg/L	% VSS	Fluoride mg/L
7/5/2013	8:17	56th & 21st-Illicit Disch	Composite	1.30	0.628	48%	118	64	55%	NA
8/3/2013	2:42	56th & 21st-Illicit Disch	Composite	0.413	0.285	69%	31	23	74%	NA
8/10/2013	2:32	56th & 21st-Illicit Disch	Composite	1.29	0.097	8%		NA		0.496
8/17/2013	2:35	56th & 21st-Illicit Disch	Composite	0.519	0.133	26%	42	19	45%	0.921
8/20/2013	2:26	56th & 21st-Illicit Disch	Composite	0.695	0.146	21%		NA		0.684
9/20/2013	11:42	56th & 21st-Illicit Disch	Composite	0.297	0.198	67%		NA		NA
10/22/2013	2:44	56th & 21st-Illicit Disch	Composite	0.386	0.276	71%	13	11	86%	NA
10/26/2013	2:54	56th & 21st-Illicit Disch	Composite	0.372	0.301	81%	10	5	53%	NA
10/29/2013	2:35	56th & 21st-Illicit Disch	Composite	0.398	0.335	84%	8	4	44%	NA
11/2/2013	3:01	56th & 21st-Illicit Disch	Composite	0.373	0.304	82%	7	4	57%	NA
11/3/2013	2:41	56th & 21st-Illicit Disch	Composite	0.405	0.383	95%	4	3	86%	NA
Illicit Discharge=non precip event			**Mean**	0.586	0.281	48%	29	17	57%	
			Geo Mean	0.513	0.248	**48%**	16	10	**60%**	
			Median	0.405	0.285	70%	11	8	71%	
			Std Dev	0.366	0.147		38	21		
			Max	1.30	0.628		118	64		
			Min	0.297	0.097		4	3		
			Number	11	11		8	8		

Illicit Discharges

Illicit discharges are non-stormwater discharges. The geometric mean of the illicit discharges had both higher TP values (0.513) and TDP values (0.248) when compared to both the storm event TP values (0.393) and TDP values (0.217).

Fluoride levels measured in the illicit discharges indicate that City water is the source. Most of the illicit discharges occurred in the early morning between 2:30 and 3:00 am, possibly indicating a timer. The Minneapolis water treatment plant adjusts both the fluoride and ortho-P to 1 mg/L. Fluoride levels detected in the illicit discharges were between approximately 0.5 and 0.9 mg/L, indicating City water as a source.

In 2014, the source of the illicit discharges will need to be further investigated. The illicit discharges make up approximately 10% of the flow at this site. Without stopping the illicit discharges attempts to determine the effects of street sweeping will be complicated.

26. MINNEHAHA CREEK AT XERXES AVENUE MONITORING STATION

BACKGROUND

Minnehaha Creek originates at Gray's Bay on Lake Minnetonka and discharges into the Mississippi River below Minnehaha Falls, as seen in **Figure 26-1**. The creek carries significant amounts of stormwater from seven upstream suburban communities between Lake Minnetonka and Minneapolis. Approximately one third of the length of Minnehaha Creek is located within Minneapolis.

Between 1999 and 2012 the MPRB, City of Minneapolis, and Metropolitan Council Environmental Services (MCES) partnered to monitor the creek using a WOMP (Watershed Outlet Monitoring Program) station near the end of the creek (see Chapter 23 for more information on the Minnehaha Creek WOMP station). The WOMP station provided information for the development of target pollutant loads for the watershed and helped to evaluate the effectiveness of best management practices in an effort to improve water quality in streams and rivers. In June of 2012 the MPRB ended its partnership with MCES, and in January 2014 the station was decommissioned. In 2009, the City of Minneapolis and MPRB added a monitoring station where Xerxes Avenue South crosses Minnehaha Creek at the Minneapolis border (see **Figure 26-2)**.

The water in Minnehaha Creek at Xerxes has four main sources. First is runoff from the immediate watershed. Second is watershed runoff between Lake Minnetonka and Xerxes. Third is discharge from Lake Minnetonka at Gray's Bay dam, which is intermittent because the outlet from Lake Minnetonka (into Minnehaha creek) is adjustable so discharge rates vary and the dam closes when Lake Minnetonka reaches 928.6 msl. The fourth source of water is groundwater. Groundwater can flow into (discharge to) and out of (recharge from) Minnehaha Creek.

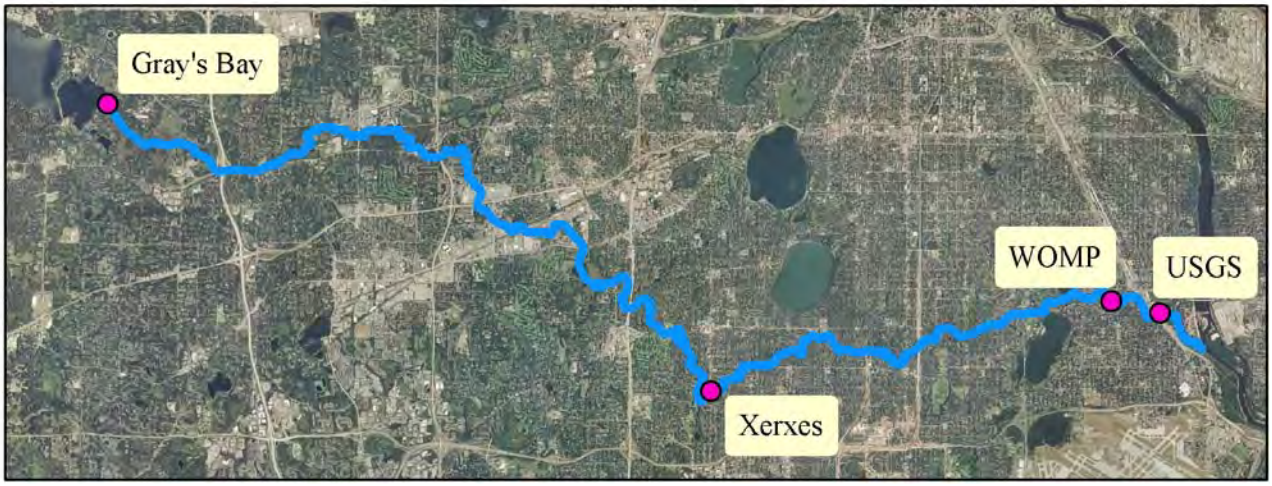


Figure 26-1. Map of Minnehaha Creek showing Gray's Bay Dam, the outlet from Lake Minnetonka, the Xerxes station, the WOMP station (decommissioned 2012), and the USGS station.

METHODS

To monitor the creek in 2013, an ISCO 2150 datalogger, 2105 interface module, and 2013ci cell phone modem was installed with a low-profile A/V (area velocity) level probe. The datalogger software used Flowlink Pro and using the cell phone modem had the ability to remotely push up data to the server and be remotely called up and programmed to change the pacing or triggers.

The sampler was a flow-paced ISCO 3700 equipped with 24 one liter bottles, 3/8” ID (inner diameter) vinyl tubing, and an intake strainer. The sampler was programmed to multiplex and take four flow-paced samples per bottle allowing 96 flow-paced samples per storm. Both the level probe cable and intake strainer tubing were armored in flexible metal conduit and anchored to the northwest upstream Xerxes bridge abutment (**Figure 26-2)**. In 2013, a plywood box housing the sampling station was upgraded to a larger metal Knaack box.

Figure 26-2. Top: Xerxes monitoring station location at Minnehaha Creek. The staff gauge is a vertical white line in the middle right. Left: Knaack installation with sampler and datalogger. Right: Close up of intake strainer and level probe anchored to the northwest bridge abutment.

Stage readings are checked against tape downs. Tape downs are a measured distance from a fixed point located at the middle of the upstream side of the Xerxes bridges to the top of the water. From the tape down point on the bridge to the stream bed is 18.00 ft. (Eighteen feet minus the distance from the bridge to the water surface is the water depth or stage). The bridge tape down point elevation is 863.01 msl. There is also a staff gauge affixed to the south bridge abutment. The staff gauge reading minus 4.00 equals the stream depth (stage) in feet.

The level feature of the A/V probe was used to obtain stage. In 2009, discharge was calculated with a weir discharge equation approximating the relatively flat stream bottom and the Xerxes bridge vertical cement wall restrictions as a broad crested weir with end contractions. After 2010, enough stage/discharge readings were taken by stream gauging to develop a look-up table with a rating curve, (see **Figure 26-3)**. The MPRB has been building a rating curve using standard protocols and methodology, USGS wading rod (or 15 pound lead fish), and a Marsh McBirney Flowmate™ velocity meter. The MPRB continues to refine and check the stage/discharge rating curve.

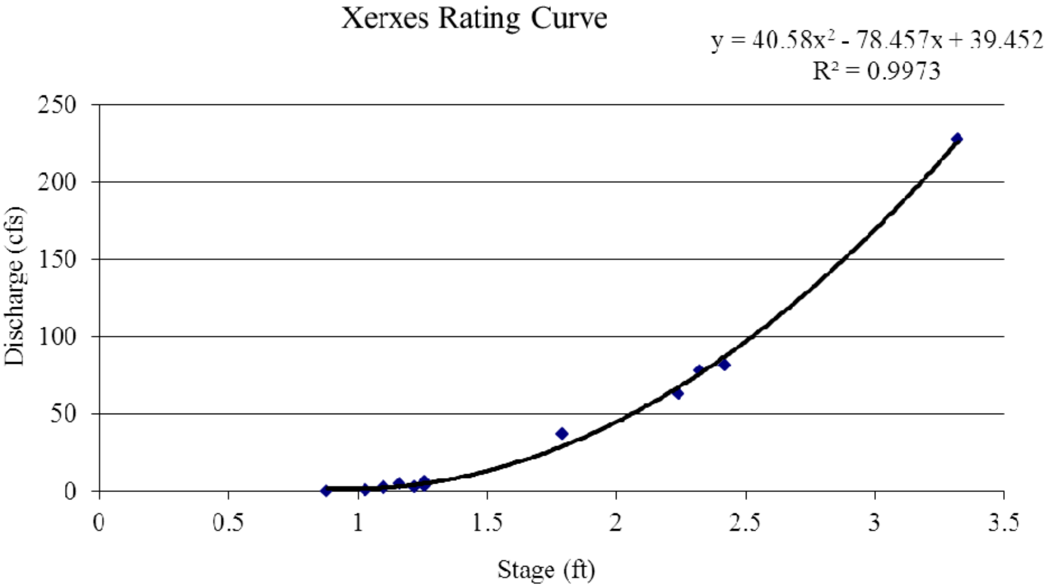


Figure 26-3. Xerxes rating curve at Minnehaha Creek.

RESULTS & DISCUSSION

2013 was the fifth year of monitoring at the Xerxes-Minnehaha Creek station. In 2013, installation was on 5/10/13 when freezing conditions had subsided.

Stream stage (level) and discharge (cubic feet per second -cfs) fluctuated widely over the sampling season, (see **Figure 26-4)**. The average 2013 stage was approximately 25.9 inches. In 2013, peak stage was 61 inches on July 13th, and the lowest stage was ~15 inches November 12th.

In reviewing **Figure 26-4** most of the storms collected were characterized by a sharp peak from the immediate watershed, followed by a sustained pulse of water from the larger watershed which can last two to four days. The spring of 2013 was very wet and by mid-summer followed by a significant drought. In **Figure 26-4** both the large rainfall volumes and sustained rainstorms of April through

June and the August through September drought can be seen. In 2013, the Gray's Bay Dam opened and closed intermittently in October and this variable discharge can be seen in **Figure 26-4**. The dam was opened May 6th and closed October 2nd, opened October 4th and closed October 11th, opened October 16th and closed October 28th for the remainder of the year. Closing the dam cut off discharge from the headwaters at Lake Minnetonka and the drop in the creek level can be seen in **Figure 26-4**.

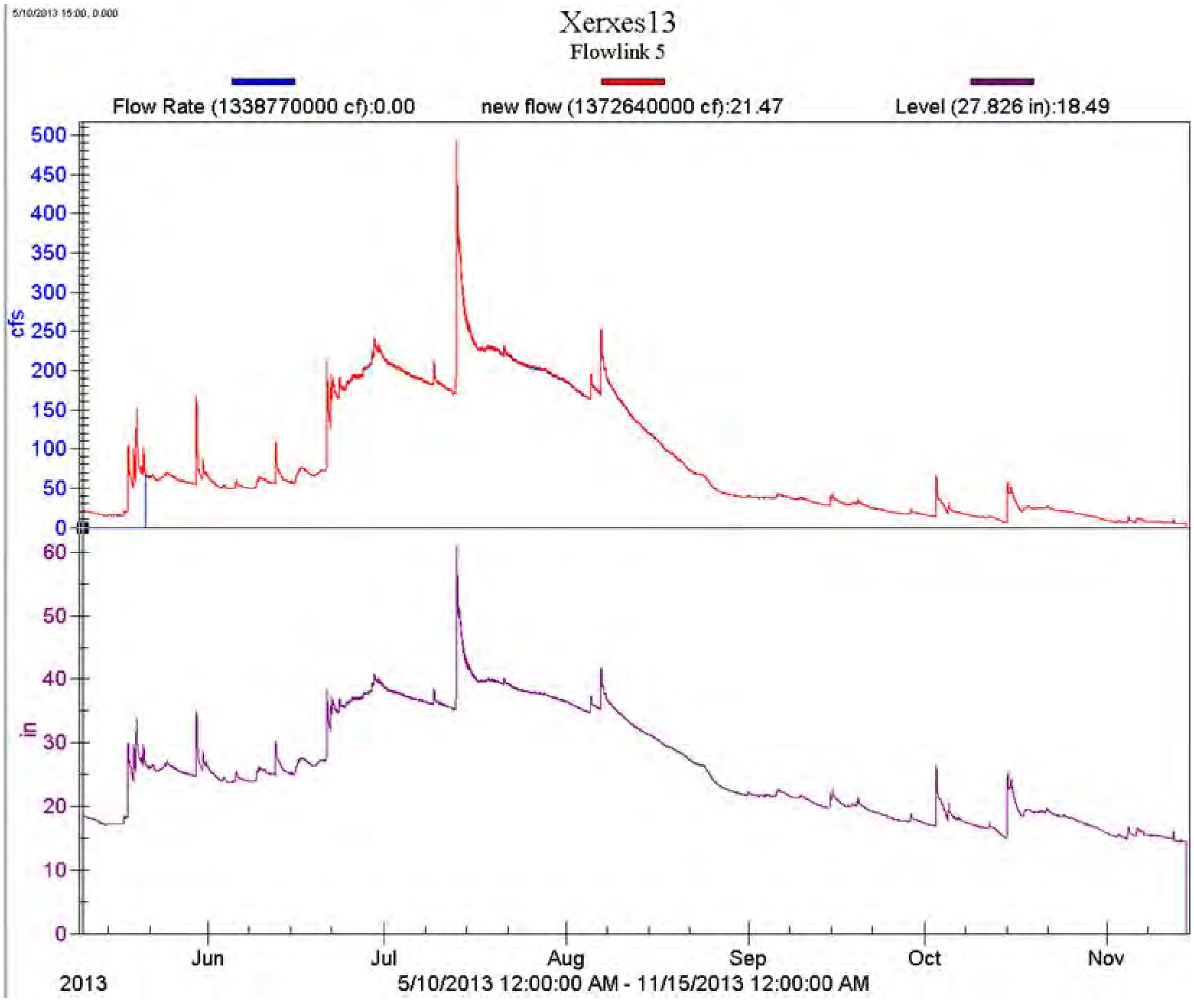


Figure 26-4. 2013 stage discharge graph of the Minnehaha Creek Xerxes monitoring station from late April to November. The (top) line represents, discharge (cubic feet per second) and the (bottom) line depicts stage data (inches).

In 2013, nine baseflow samples and seven storms of varying intensity (minimum 0.19 in, maximum 3.00 in storms) were captured throughout the sampling season, and are shown in **Table 26-1**. The event-pacing and stage trigger was adjusted for each storm to attempt collection of the entire hydrograph.

Table 26-1. Snowmelt, precipitation, and baseflow events captured at Minnehaha Creek at the Xerxes station in 2013 are shown below. A precipitation event was defined as a storm greater than 0.10 inches, separated by eight hours or more from other precipitation. If the sample exceeded holding time, some parameters (e.g. TDP, cBOD) were dropped from analysis.

Event	Start Date/Time		End Date/Time		Precip (inches)	Duration (hours)	Intensity (in/hr)	Time since last Precip. (hours)	Sample Type	2013 Xerxes Events Collected
+1	3/28/2013	13:30	n/a		n/a	n/a	n/a	n/a	Grab	X(w/Ecoli)
+2	3/29/2013	13:30	n/a		n/a	n/a	n/a	n/a	Grab	X(w/Ecoli)
+3	4/3/2013	14:30	n/a		n/a	n/a	n/a	n/a	Grab	X(w/Ecoli)
4	5/29/2013	16:30	5/30/2013	1:30	1.04	9.0	0.12	111.0	Composite	X
5	6/12/2013	1:30	6/12/2013	18:30	0.59	17.0	0.03	59.0	Composite	X
6	7/13/2013	3:30	7/13/2013	7:30	3.00	4.0	0.75	90.3	Composite	X(lmtd)
7	8/6/2013	19:30	8/6/2013	21:00	0.86	1.5	0.57	35.5	Composite	X
8	9/19/2013	11:30	9/19/2013	12:30	0.19	1.0	0.19	27.0	Composite	X
9	10/4/2013	21:30	10/5/2013	16:00	0.31	18.5	0.02	22.5	Composite	X
10	10/17/2013	19:00	10/18/2013	5:30	0.33	10.5	0.03	39.5	Composite	X
			Totals		**6.32**					**10**

Baseflow Event	Date	Time	Sample Type	Collected
1	4/22/2013	13:50	Grab	X(w/Ecoli)
2	5/8/2013	9:00	Grab	X(w/Ecoli)
3	6/20/2013	8:45	Grab	X(w/Ecoli)
4	7/12/2013	9:15	Grab	X(w/Ecoli)
5	8/2/2013	10:00	Grab	X(w/Ecoli)
6	9/5/2013	11:10	Grab	X(w/Ecoli)
7	10/1/2013	11:10	Grab	X(w/Ecoli)
8	11/7/2013	13:05	Grab	X(w/Ecoli)
9	12/17/2013	1200	Grab	X(w/Ecoli)

$^{+}$snowmelt event
n/a = not applicable
X = event sampled with full parameters
X(lmtd) = event sampled with limited parameters generally due to holding times e.g.BOD, TDP, etc.
X(w/Ecoli) = event sampled with fecal coliform

Tables 26-2, 26-3, and 26-4 show the Xerxes station data and associated statistics, the baseflow data, and the storm event data. **Table 26-2** shows the raw data with duplicates averaged. . Throughout the 2013 sampling season, a total of nine baseflow samples were taken to determine background conditions in the stream. In January through March no baseflow samples were collected due to fully frozen conditions. Nine *E. coli* grab samples were collected during baseflow. **Table 26-3** includes baseflow water chemistry statistics. In 2013, seven storm runoff events were collected. **Table 26-4** shows the storm event water chemistry statistics.

For **Tables 26-3, 26-4, and 26-5** statistics were only calculated for a chemical parameter if there were two or more measured values (not less than values). When statistical analysis is performed on the data sets, half of the less-than values are used in the calculations. In 2013, to lower the reporting limit, sulfate samples were spiked with 10 mg/L and the spike was later subtracted out.

2013 baseflow conditions in the stream were markedly different from storm events; see **Tables 26-3, 26-4**. Baseflow samples generally had lower concentrations of nutrients and metals than storm events. Baseflow also had the highest geometric mean value concentrations for Cl, Hardness, TDS, and Sp. Conductivity. The levels of these dissolved parameters indicate that baseflow is likely dominated by groundwater discharge comingled with Lake Minnetonka surface water.

The 2013, **Table 26-4** shows snowmelt as having the highest TP value and a storm event showing the highest TSS value. Storm event data consistently show higher TP and TSS values than baseflow sampling.

Non snowmelt chloride values were roughly between 17 mg/L and 93 mg/L. Chloride was generally below any MPCA standards but higher than expected during the sampling season for both baseflow and storms, as seen in **Table 26-2**. The source of low level chronic Cl^- in Minnehaha Creek is likely caused by winter road salt (NaCl) continuously leaching from the upstream soils. The MPCA chronic stream chloride standard is 230 mg/L for four days and an acute standard of 860 mg/L for one hour. The May 8th baseflow sample had a chloride level measured at 255 mg/L above the 230 mg/L chronic standard. Other than December 17th sample (220 mg/L) the other baseflow samples collected were well below the chronic stream standard. No sample approached the acute 860 mg/L one hour standard.

Baseflow grab and composite storm sampling will continue in 2014.

Due to the annual variability long term water quality is important to understand both background and year to year variations in stream chemistry.

Table 26-2. Minnehaha Creek at Xerxes Ave. water chemistry data for baseflow and precipitation events in 2013. Cells with "less than" values indicate that the concentration of that parameter was below detection limit. NA = data not available due to expired holding time or low volume, SM = snowmelt, and BF = baseflow.

Date Sampled	Time	Sample Type	Site Location	TP mg/L	TDP mg/L	OrthoP mg/L	TKN mg/L	NH3 mg/L	NO3NO2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate* mg/L	Sp.Cond. uhmos	pH std units	Cu ug/L	Pb ug/L	Zn ug/L	E. Coli MPN
3/28/2013	13:30	Grab	Xerxes SM	0.325	0.216	NA	2.57	1.63	0.357	261	156	11	6	575	5	29.6	818	7.6	12	<3.00	24	2420
3/29/2013	13:30	Grab	Xerxes SM	0.205	0.204	NA	2.77	1.64	0.373	312	140	8	4	709	5	11.5	952	7.3	7	<3.00	<20.0	NA
4/3/2013	14:30	Grab	Xerxes SM	0.247	0.168	NA	2.35	1.41	1.62	211	124	12	5	502	5	13.8	751	7.0	<5.00	<3.00	<20.0	160
4/22/2013	13:50	Grab	Xerxes BF	0.097	0.049	NA	1.05	<0.500	0.522	28	180	8	4	668	3	17.6	953	6.8	5	<3.00	<20.0	32
5/8/2013	9:00	Grab	Xerxes BF	0.062	0.042	NA	0.900	0.779	<0.030	255	272	2	<2.0	707	<1.00	22.4	745	6.9	7	<3.00	<20.0	147
5/30/2013	10:25	Composite	Xerxes	0.152	0.027	NA	1.19	<0.500	0.182	82	148	50	15	314	3	8.1	520	7.6	13	4	<20.0	NA
6/13/2013	0:16	Composite	Xerxes	0.118	0.063	NA	0.76	<0.500	0.132	17	148	19	7	319	<1.00	8.6	492	7.9	7	<3.00	<20.0	NA
6/20/2013	8:45	Grab	Xerxes BF	0.107	0.087	NA	<0.500	<0.500	0.118	93	156	4	2	369	<1.00	8.8	581	7.9	<5.00	<3.00	<20.0	115
7/12/2013	9:15	Grab	Xerxes BF	0.065	0.048	NA	0.829	<0.500	<0.030	59	164	6	3	259	<1.00	6.8	NA	7.7		<5.00	<3.00	<20.0
7/13/2013	11:01	Composite	Xerxes	0.152	NA	NA	0.920	NA	0.175	30	84	57	12	NA	NA	NA	NA	NA	12	6	<20.0	NA
8/2/2013	10:00	Grab	Xerxes BF	0.056	0.040	0.020	1.06	<0.500	<0.030	53	172	7	3	247	<1.0	8.3	441	7.9	5	<3.00	<20.0	78
8/7/2013	9:24	Composite	Xerxes	0.098	0.051	0.041	0.988	<0.500	0.064	46	120	34	10	210	2	7.8	360	7.8	9	5	<20.0	NA
9/5/2013	11:10	Grab	Xerxes BF	0.030	0.021	0.021	1.05	<0.500	0.082	70	164	4	<2.0	295	<1.00	9.8	506	8.0	148	<5.00	<3.00	<20.0
9/19/2013	20:48	Composite	Xerxes	0.050	0.014	0.026	0.593	<0.500	0.192	68	156	11	<2.0	272	3	35.1	465	8.0	9	<3.00	<20.0	NA
10/1/2013	11:10	Grab	Xerxes BF	0.033	0.021	0.010	0.712	<0.500	0.134	83	192	4	3	333	<1.00	14.3	582	8.0	<5.00	<3.00	<20.0	135
10/4/2013	8:54	Composite	Xerxes	0.064	0.030	0.027	0.964	<0.500	0.243	57	156	19	6	256	3	8.4	456	7.9	6	<3.00	<20.0	NA
10/6/2013	22:07	Composite	Xerxes	0.042	NA	NA	0.660	NA	0.266	67	168	3	2	NA	NA	NA	517	NA	11	<3.00	<20.0	NA
10/18/2013	9:05	Composite	Xerxes	0.062	0.035	0.026	0.578	<0.500	0.197	70	168	6	2	285	3	9.9	521	8.0	<5.00	<3.00	<20.0	NA
11/7/2013	13:05	Grab	Xerxes BF	0.042	0.022	0.013	0.668	<0.500	<0.030	124	236	3	2	446	<1.00	14.3	767	8.0	<5.00	<3.00	<20.0	152
12/17/2013	1200	Grab	Xerxes BF	0.032	0.019	0.014	1.30	0.314	<0.030	220	404	1	<2.0	734	<1.00	21	NA	7.7	<5.00	<3.00	<20.0	25

Table 26-3. Minnehaha Creek at Xerxes 2013 baseflow data showing water chemistry data collected during normal stream flow. All "less than data" were transformed into half the reporting limit for statistical calculations (e.g. Pb <3 becomes 1.5). NA = data not available due to expired holding time or low volume, BF = baseflow.

Date Sampled	Time	Sample Type	Site Location	TP mg/L	TDP mg/L	OrthoP mg/L	TKN mg/L	NH3 mg/L	NO3NO2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate* mg/L	Sp.Cond. uhmos	pH std units	Cu ug/L	Pb ug/L	Zn ug/L	E. Coli MPN
4/22/2013	13:50	Grab	Xerxes BF	0.097	0.049	NA	1.05	0.250	0.522	28	180	8	4	668	3	18	953	6.8	5	2	10	32
5/8/2013	9:00	Grab	Xerxes BF	0.062	0.042	NA	0.900	0.779	0.015	255	272	2	1	707	1	22	745	6.9	7	2	10	147
6/20/2013	8:45	Grab	Xerxes BF	0.107	0.087	NA	0.250	0.250	0.118	93	156	4	2	369	1	8.8	581	7.9	3	2	10	115
7/12/2013	9:15	Grab	Xerxes BF	0.065	0.048	NA	0.829	0.250	0.015	59	164	6	3	259	1	6.8	NA	7.7	3	2	10	NA
8/2/2013	10:00	Grab	Xerxes BF	0.056	0.040	0.020	1.06	0.250	0.015	53	172	7	3	247	1	8.3	441	7.9	5	2	10	78
9/5/2013	11:10	Grab	Xerxes BF	0.030	0.021	0.021	1.05	0.250	0.082	70	164	4	1	295	1	9.8	506	8.0	3	2	10	148
10/1/2013	11:10	Grab	Xerxes BF	0.033	0.021	0.010	0.712	0.250	0.134	83	192	4	3	333	1	14	582	8.0	3	2	10	135
11/7/2013	13:05	Grab	Xerxes BF	0.042	0.022	0.013	0.668	0.250	0.015	124	236	3	2	446	1	14	767	8.0	3	2	10	152
12/17/2013	1200	Grab	Xerxes BF	0.032	0.019	0.014	1.30	0.314	0.015	220	404	1	1	734	1	21	NA	7.7	3	2	10	25
		Mean (Geometric)		0.053	0.034	0.015	0.801	0.291	0.043	88	205	4	2	414	1	13	634	7.6	3	2	10	87
		Mean (Arithmetric)		0.058	0.039	0.016	0.869	0.316	0.103	109	216	4	2	451	1	14	654	7.6	4	2	10	104
		Max		0.107	0.087	0.021	1.304	0.779	0.522	255	404	8	4	734	3	22	953	8.0	7	2	10	152
		Min		0.030	0.019	0.010	0.250	0.250	0.015	28	156	1	1	247	1	7	441	6.8	3	2	10	25
		Median		0.056	0.040	0.014	0.900	0.250	0.015	83	180	4	2	369	1	14	582	7.9	3	2	10	125
		Standard Dev.		0.028	0.022	0.005	0.305	0.175	0.164	78	80	2	1	199	1	6	177	0.5	2	0	0	52
		Number		9	9	5	9	9	9	9	9	9	9	9	9	9	7	9	9	9	9	8
		COV		0.483	0.564	0.303	0.350	0.554	1.59	0.712	0.373	0.556	0.503	0.441	0.923	0.417	0.271	0.064	0.495	0	0	0.505

Table 26-4. Minnehaha Creek at Xerxes 2013 precipitation event water chemistry data showing concentrations during or after a precipitation event (defined as more than 0.10 inches) or snowmelt. All “less than data” were transformed into half the reporting limit for statistical calculations (e.g. Pb <3 becomes 1.5). SM = snowmelt, NA = data not available.

Date Sampled	Time	Sample Type	Site Location	TP mg/L	TDP mg/L	OrthoP mg/L	TKN mg/L	NH3 mg/L	NO3NO2 mg/L	Cl mg/L	Hardness mg/L	TSS mg/L	VSS mg/L	TDS mg/L	cBOD mg/L	Sulfate* mg/L	Sp.Cond. uhmos	pH std units	Cu ug/L	Pb ug/L	Zn ug/L	E. Coli MPN
3/28/2013	13:30	Grab	Xerxes SM	0.325	0.216	NA	2.57	1.63	0.357	261	156	11	6	575	5	30	818	7.6	12	2	24	2420
3/29/2013	13:30	Grab	Xerxes SM	0.205	0.204	NA	2.77	1.64	0.373	312	140	8	4	709	5	12	952	7.3	7	2	10	NA
4/3/2013	14:30	Grab	Xerxes SM	0.247	0.168	NA	2.35	1.41	1.62	211	124	12	5	502	5	14	751	7.0	3	2	10	160
5/30/2013	10:25	Composite	Xerxes	0.152	0.027	NA	1.19	0.250	0.182	82	148	50	15	314	3	8.1	520	7.6	13	4	10	NA
6/13/2013	0:16	Composite	Xerxes	0.118	0.063	NA	0.760	0.250	0.132	17	148	19	7	319	1	8.6	492	7.9	7	2	10	NA
7/13/2013	11:01	Composite	Xerxes	0.152	NA	NA	0.920	NA	0.175	30	84	57	12	NA	NA	NA	NA	NA	12	6	10	NA
8/7/2013	9:24	Composite	Xerxes	0.098	0.051	0.041	0.988	0.250	0.064	46	120	34	10	210	2	7.8	360	7.8	9	5	10	NA
9/19/2013	20:48	Composite	Xerxes	0.050	0.014	0.026	0.593	0.250	0.192	68	156	11	1	272	3	35	465	8.0	9	2	10	NA
10/4/2013	8:54	Composite	Xerxes	0.064	0.030	0.027	0.964	0.250	0.243	57	156	19	6	256	3	8.4	456	7.9	6	2	10	NA
10/6/2013	22:07	Composite	Xerxes	0.042	NA	NA	0.660	NA	0.266	67	168	3	2	NA	NA	NA	517	NA	11	2	10	NA
10/18/2013	9:05	Composite	Xerxes	0.062	0.035	0.026	0.578	0.250	0.197	70	168	6	2	285	3	9.9	521	8.0	3	2	10	NA
		Mean (Geometric)		0.113	0.060	0.029	1.11	0.460	0.238	77	140	15	5	353	3	12	561	7.7	7	2	11	622
		Mean (Arithmetric)		0.138	0.090	0.030	1.30	0.687	0.346	111	143	21	6	382	3	15	585	7.7	8	2	11	1290
		Max		0.325	0.216	0.041	2.77	1.64	1.62	312	168	57	15	709	5	35	952	8.0	13	6	24	2420
		Min		0.042	0.014	0.026	0.578	0.250	0.064	17	84	3	1	210	1	7.8	360	7.0	3	2	10	160
		Median		0.118	0.051	0.027	0.964	0.250	0.197	68	148	12	6	314	3	10	519	7.8	9	2	10	1290
		Standard Dev.		0.091	0.082	0.007	0.835	0.658	0.432	101	25	18	4	171	2	10	189	0.351	4	2	4	1598
		Number		11	9	4	11	9	11	11	11	11	11	9	9	9	10	9	11	11	11	2
		COV		0.657	0.912	0.245	0.640	0.959	1.25	0.909	0.174	0.867	0.684	0.447	0.498	0.695	0.322	0.046	0.441	0.666	0.374	1.24

27. GOLF COURSE WETLAND MONITORING

BACKGROUND

Environmental Operations assists the MPRB golf courses in water and vegetation monitoring. The Theodore Wirth and Meadowbrook Golf Courses have requested annual monitoring since 2001. In 2009 Columbia, Hiawatha, and Gross Golf Courses added environmental monitoring to their programs.

Golf Course Foremen assisted Water Quality Staff in choosing representative water bodies on each course. Physical parameters (temperature, conductivity, pH, DO and % DO) were measured at each study site with a Hydrolab Minisonde 5 Multiprobe. Chemical parameters: total phosphorus, nitrate/nitrite, and ammonia (TP, NO_3NO_2 and NH_3) were collected and taken to Instrumental Research, Inc. (IRI) laboratory for analysis. Standard MPRB sampling and QA/QC procedures were followed. A visual survey of aquatic and wetland vegetation was conducted at each sample site and at sites of interest.

COLUMBIA GOLF CLUB

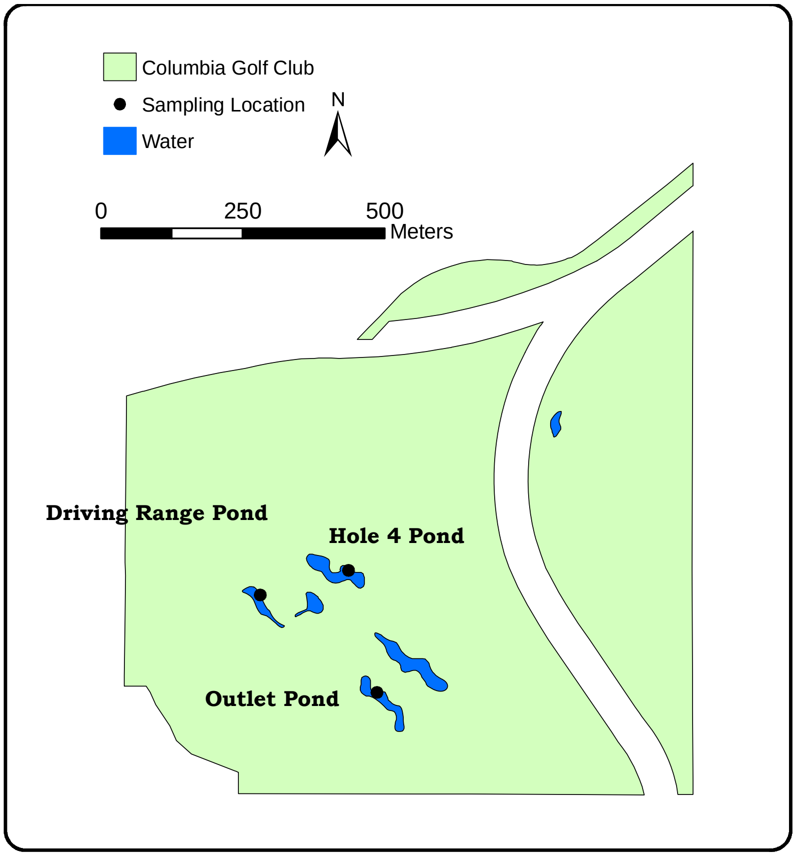


Figure 27-1. Sample sites on the Columbia Golf Club course.

Three ponds on the Columbia Golf Course were chosen for monitoring and are shown above in **Figure 27-1**. The headwaters pond is just off of Hole 4 (Pond 1). Pond 1 receives water from a groundwater well used to irrigate the golf course and has clear water all year. Pond 2 (the Driving Range Pond) receives surface drainage from the driving range and drains to an unsampled pond downstream of Pond 1. Pond 3 is the last pond in the series and outlets to a low area before entering a storm sewer that drains to the Mississippi River.

2013 was the fifth year of sampling at Columbia Golf Course. Aquatic, terrestrial, and wetland plants in the ponds and surrounding buffers were surveyed in mid-August. A few new plant species were discovered around each pond, especially Pond 3. No aquatic plants were observed in Pond 1 in 2013. Dominant species identified from the Columbia Golf Course ponds and buffer zones are presented in **Table 27-1**.

Table 27-1. Dominant plants within and surrounding the Columbia Golf Course Ponds.

Columbia Golf Course		**Pond 1, Hole 4**					**Pond 2, Driving Range Pond**					**Pond 3, Outlet Pond**				
Scientific Name	**Common Name**	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13
Terrestrial and Wetland Species																
Agrostis gigantea	Redtop														X	
Alisma subcordatum	Water Plantain															X
Ambrosia artemisiifolia	Ragweed											X	X			
Aster spp	Aster 1					X						X				
Aster spp	Aster 2											X				
Bidens cernua	Beggarstick		X											X		
Brassica spp	Mustard				X										X	
Bromus inermis	Smooth Brome							X							X	
Carex spp	Sedge	X											X	X		X
Cirsium spp	Thistle	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Cyperus esculentus	Yellow Nut Sedge															X
Eliocharis obtusa	Spike Rush			X					X						X	X
Helenium autumnale	Common Sneezeweed														X	
Helianthus spp	Sunflower														X	
Nepta cataria	Catnip			X											X	
Parthenocissus quinquefolia	Virginia Creeper					X										
Polygonum pensylvanicum	Smartweed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pontedaria cordata	Pickerelweed			X						X						
Poa pratensis	Kentucky Bluegrass			X		X			X					X	X	X
Potentilla norvegica	Rough Cinquefoil			X				X	X	X				X	X	X
Rumex crispus	Curled Dock	X	X	X	X	X	X	X			X	X	X	X	X	X
Salix spp	Sandbar Willow			X		X										
Schoenoplectus acutus	Hardstem Bulrush															X
Scirpus fluviatilis	River Bulrush											X	X	X	X	
Scirpus validus	Soft stem Bulrush														X	
Setaria veridis	Foxtail		X							X						
Sinapis spp	Mustard					X										
Solanum dulcamara	Bittersweet Nightshade					X		X	X		X		X			
Solidago spp	Goldenrod	X	X	X	X	X	X	X	X							
Typha spp	Cattail		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ulmaceaespp	Elm					X										
Urtica dioica	Stinging Nettle	X	X	X	X	X	X	X	X	X	X		X	X	X	
Verbena hastata	Blue Vervain					X		X					X	X	X	X
Vitus riparia	Riverbank Grape		X	X	X	X							X	X		
Aquatic Species																
Filamentous algae	Filamentous algae				X					X						
Ceratophyllum demersum	Coontail		X													
Chara spp	Muskgrass	X	X													
Lemna minor	Lesser Duckweed						X	X	X	X	X	X	X	X	X	
Potamogeton spp	Narrow Leaf Pondweed	X	X	X	X									X	X	
Potamogeton zosteriformis	Flat Stem Pondweed															X
Vallisneria americana	Water Celery		X													X
Wolfia colombiana	Wolfia		X					X						X	X	
Zosterella dubia	Water Stargrass	X	X													

Water quality monitoring results for Columbia Golf Course are shown in **Table 27-2**. Dissolved oxygen, dissolved oxygen percent, pH, and specific conductivity measurements were made in each pond with a Hydrolab 5a sonde. In 2013, nitrate/nitrite was below detection limits at Ponds 1 and 2. Chemical parameters, total phosphorus, ammonia, and nitrate/nitrite were analyzed by IRI, Inc.

Table 27-2. Water quality monitoring results for Columbia Golf Course. NS = not sampled.

Colombia Site	Date	Time	Temp øC	DO mg/l	DO% Sat	pH Units	SpCond µS/cm	TP mg/L	NH3 mg/L	NO3/NO2 mg/L
Pond 1 - Hole 4	11/5/2009	13:11	7.24	11.1	93.4	6.94	1386	0.028	<0.500	0.112
Pond 1 - Hole 4	9/3/2010	10:30	14.0	8.93	89.4	8.01	112	0.019	<0.500	0.304
Pond 1 - Hole 4	6/29/2011	10:20	21.3	9.48	110	7.28	1300	0.018	<0.500	0.042
Pond 1 - Hole 4	7/17/2012	10:35	16.7	7.90	84.2	7.59	1482	0.029	0.416	0.090
Pond 1 - Hole 4	8/15/2013	10:00	14.9	8.23	83.3	8.08	1615	0.058	0.871	<0.030
Pond 2 - Driving Range	11/5/2009	13:21	5.24	9.80	78.4	7.02	1360	0.230	3.77	4.08
Pond 2 - Driving Range	9/3/2010	10:30	23.2	3.12	37.3	7.14	834	0.983	2.40	0.090
Pond 2 - Driving Range	6/29/2011	10:35	15.7	0.730	7.60	7.63	754	1.27	3.36	<0.030
Pond 2 - Driving Range	7/17/2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 2 - Driving Range	8/15/2013	10:15	19.6	0.78	8.70	7.72	1357	2.24	6.23	<0.030
Pond 3 - Outlet	11/5/2009	13:29	8.78	14.0	122	7.42	971	0.316	1.12	0.605
Pond 3 - Outlet	9/3/2010	10:46	16.6	1.44	15.2	8.01	ND	0.460	1.15	0.093
Pond 3 - Outlet	6/29/2011	10:45	23.5	6.73	80.9	7.42	837	0.389	2.61	0.033
Pond 3 - Outlet	7/17/2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 3 - Outlet	8/15/2013	10:25	19.2	10.0	111	7.23	1591	0.058	3.37	0.063

The amount of NH_3 in all ponds has risen considerably over the past few years with Ponds 2 and 3 surpassing suitable levels for surface water and groundwater. The increase in NH_3 may be indicative of increased fertilizer inputs or increased organic decay. Groundwater may also be responsible for a lower than expected water temperature in Pond 1.

GROSS NATIONAL GOLF COURSE

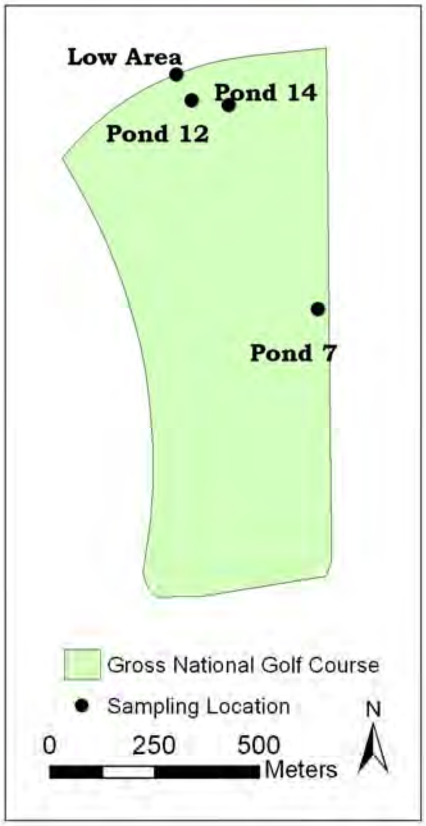


Figure 27-2. Sample sites on the Gross National Golf Course.

Three ponds and one additional vegetation monitoring site were chosen on Gross National Golf Course presented above in **Figure 27-2**. Pond 7 is one of the oldest water bodies on the golf course and may be a remnant of a natural wetland. The pond is hydrologically isolated: with no drain tile outlets and no connection to the golf course irrigation system. Ponds 14 and 12 were constructed in the mid-1990s to help improve drainage on the golf course. Drain tile from the surrounding fairways leads to each of these ponds. Groundwater for irrigation of the golf course is pumped to Pond 14. Pond 14 drains to Pond 12 and Pond 12 can be pumped to the site marked Low Area in **Figure 27-2**. A “low area” was chosen as an additional vegetation survey site since water is pumped to it and it had different vegetation than most of the golf course.

2013 was the fifth year of sampling at Gross National Golf Course. Aquatic, terrestrial, and wetland plants in the ponds and surrounding buffers were surveyed in mid-August. MPRB staff observed 8 new species in Pond 7 with a few more at the other sampling sites. Common Buckthorn was first observed in the Low Area in 2013, and the invasive plant had already become dominant at that sampling site. Dominant plants identified at the Gross National Golf Course ponds and buffer zones are presented in **Table 27-3**.

Table 27-3. Dominant plants at the Gross National Golf Course sample sites.

Gross Golf Course		Pond 7					Pond 12					Pond 14					Low Area				
Scientific Name	**Common Name**	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13
Terrestrial and Wetland Species																					
Acer saccharinum	Silver Maple		X	X		X															
Achillea millefolium	Yarrow					X															
Alnus incana	Speckled Alder																	X	X	X	X
Ambrosia spp	Ragweed					X															
Asclepcias incarnata	Marsh Milkweed				X	X															
Aster lanceolatus	Marsh Aster														X						
Aster spp	Aster	X				X	X						X	X		X	X				
Bromus inermis	Smooth Brome	X					X										X	X			
Carex spp	Sedge	X	X		X	X		X	X			X	X	X	X						
Carex spp	Sedge 2						X	X				X		X							
Carex spp	Upland sedge																X				
Circaea spp	Enchanter's Nightshade														X	X					
Cirsium spp	Thistle					X				X	X		X	X	X	X		X			
Cirsium avense	Canadian Thistle									X											
Cyperus esculentus	Yellow Nutsedge					X															
Cyperus odoratus	Flat sedge									X											
Daucus carota	Queen Anne's Lace				X																
Echinochloa crusgalli	Barnyard Grass					X		X			X		X								
Eloecharis obtusa	Blunt Spikerush						X		X	X	X		X	X	X	X					
Eupatorium perfoliatum	Boneset				X	X															
Helenium autumnale	Sneezeweed												X	X							
Juncus tenuis	Slender Rush														X						
Leonurus cariaca	Motherwort				X																
Lycopus americanus	American bugleweed				X																
Lythrum salicaria	Purple Loosestrife				X	X															
Phalaris arundinacea	Reed Canary Grass			X	X	X		X	X						X				X	X	X
Poa pratensis	Kentucky Bluegrass	X	X	X		X	X	X	X		X		X	X			X	X	X		X
Polygonum pensylvanicum	Smartweed		X			X		X					X	X		X		X		X	
Populus deltoides	Eastern Cottonwood							X													
Populus tremuloides	Aspen	X	X	X		X	X						X				X	X	X	X	X
Potentilla norvegica	Rough Cinquefoil													X							
Rhamnus cathartica	Common Buckthorn																				X
Rudbeckia hirta	Black eyed susan					X										X					
Rumex crispus	Curled Dock			X	X	X		X	X	X	X		X	X	X	X					X
Sagittaria latifolia	Broad-leaved Arrowhead				X	X		X	X	X	X		X	X	X	X					
Salix spp	Weeping Willow	X	X	X	X	X															
Salix spp	Sandbar Willow (?)						X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Schoenoplectus acutus	Hardstem Bulrush					X										X					
Scripus atrovirens	Green Bulrush															X					
Scirpus cyperinus	Woolgrass				X					X											
Scirpus fluviatilis	River Bulrush	X					X	X	X	X	X	X	X	X	X	X					
Scirpus validus	Soft stem Bulrush									X											
Scutellaria galericulata	Marsh Skullcap														X	X					
Setaria veridis	Foxtail			X		X							X			X					
Sinapis spp	Mustard					X															
Solidago canadensis	Canada goldenrod														X	X			X		X
Sonchus oleraceus	Common Sow-thistle									X						X					
Typha spp	Cattail	X	X				X	X	X	X	X	X	X	X	X	X					
Urtica dioica	Stinging Nettle				X	X															
Verbena hastata	Blue Vervain				X	X							X		X	X					
Vitus riparia	Riverbank Grape															X					X
Aquatic Species		**Pond 7**					**Pond 12**					**Pond 14**					**Low Area**				
Filamentous algae	Filamentous algae									X											
Lemna minor	Lesser Duckweed		X	X		X				X	X	X	X	X							
Potamogeton spp	Pondweed 1		X	X			X														
Potamogeton spp	Pondweed 2						X														
Potamogeton pectinatus	Sago Pondweed													X							
Riccia fluitans	Slender Riccia													X							
Spirodela polyrhiza	Big Duckweed										X		X	X							
Wolfia colombiana	Wolfia							X	X				X								

Water quality monitoring results for Gross National Golf Course are shown in **Table 27-4**. Dissolved oxygen, dissolved oxygen percent, pH, and specific conductivity measurements were made in each pond with a Hydrolab 5a sonde. Chemical parameters such as total phosphorus, ammonia, and nitrate/nitrite were analyzed by IRI, Inc.

Table 27-4. Water quality monitoring results for Gross National Golf Course.

Gross Site	Date	Time	Temp	DO	DO%	pH	SpCond	TP	NH3	NO3/NO2
			øC	mg/l	Sat	Units	µS/cm	mg/L	mg/L	mg/L
Pond 7	11/6/2009	9:16	4.6	6.53	52.1	7.20	511	0.586	<0.500	<0.030
Pond 7	9/3/2010	9:10	17.0	7.99	85.0	8.33	416	0.727	<0.500	<0.030
Pond 7	6/29/2011	9:15	20.8	9.16	104	8.46	352	0.583	<0.500	0.036
Pond 7	7/17/2012	9:25	26.6	5.42	69.8	7.53	441	1.08	0.982	<0.030
Pond 7	8/15/2013	8:50	18.9	0.470	5.10	6.81	412	1.60	1.02	<0.030
Pond 12	11/6/2009	9:32	5.1	10.9	87.8	7.68	425	0.037	<0.500	<0.030
Pond 12	9/3/2010	9:29	18.9	5.87	64.9	8.25	296	0.051	<0.500	<0.030
Pond 12	6/29/2011	9:40	21.1	5.81	66.6	7.20	367	0.071	<0.500	0.033
Pond 12	7/17/2012	9:45	26.1	6.06	77.3	7.79	427	0.138	0.081	<0.030
Pond 12	8/15/2013	9:15	19.1	1.15	12.7	6.65	346	0.320	1.01	<0.030
Pond 14	11/6/2009	9:26	5.1	14.2	115	7.70	442	0.035	0.597	<0.030
Pond 14	9/3/2010	9:20	18.9	5.46	60.4	8.33	344	0.053	<0.500	<0.030
Pond 14	6/29/2011	9:30	21.3	7.97	91.7	7.72	454	0.083	<0.500	<0.030
Pond 14	7/17/2012	9:35	25.8	4.21	53.5	7.62	443	0.198	0.107	<0.030
Pond 14	8/15/2013	9:10	18.1	8.90	95.9	7.56	385	0.075	0.637	<0.030

Dissolved oxygen levels continue to fluctuate from year to year. Duckweed covering Ponds 7 and 12 may have caused the low dissolved oxygen levels, while a fountain operating in Pond 14 may have caused high dissolved oxygen levels. Ponds 7 and 12 showed an increasing trend of TP and NH_3, while Pond 14 showed a decreasing trend. None of the ponds demonstrated detectable levels of NO_3/NO_2.

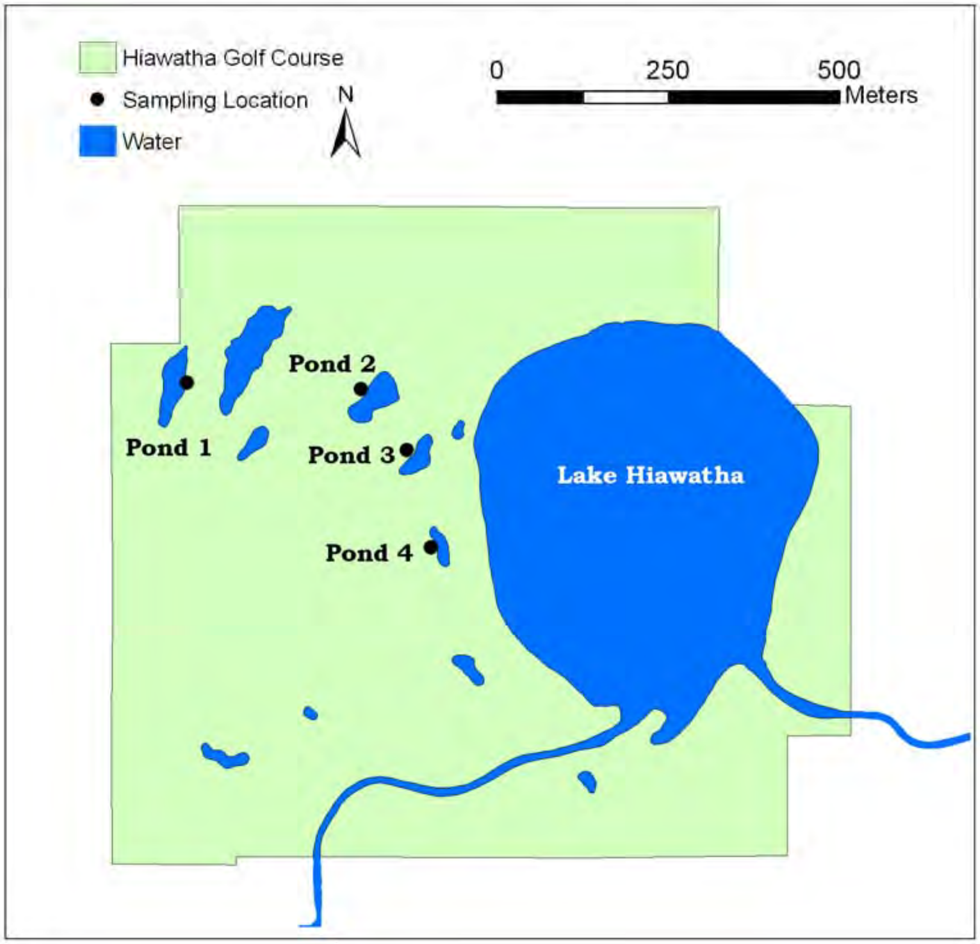


Figure 27-3. Sample sites on the Hiawatha Golf Course.

Four sample sites were chosen at the Hiawatha Golf Course. Ponds 1, 2, and 3 are part of an interconnected chain of ponds that pump to Lake Hiawatha. The chain of ponds is pumped down every day throughout the year. Several sources contribute water to the pond chain. Groundwater and drain tile are the two local sources of water to these ponds. Additionally, during storm events water from neighborhood streets overflows to the Hiawatha pond chain. To alleviate flooding, the area covering the course's parking lot is now pumped to Pond 1. Over the next several years, an additional upstream neighborhood may be piped to Pond 1 as well. Pond 4 is not connected to the chain of ponds and is isolated. The golf course occasionally pumps water from Lake Hiawatha to Pond 4.

2013 was the fourth year of sampling at Hiawatha Golf Course. Aquatic, terrestrial, and wetland plants in the ponds and surrounding buffers were surveyed in mid-August. These sites had not been sampled since 2011, and very few new species were observed in 2013. Dominant plants from the Hiawatha Golf Course ponds and buffer zones are presented in **Table 27-5.**

Table 27-5. Dominant plants within and surrounding the Hiawatha Golf Course sample sites.

Hiawatha Golf Course		**Pond 1**				**Pond 2**				**Pond 3**				**Pond 4**			
Scientific Name	**Common Name**	Nov-09	Sep-10	Jul-11	Aug-13	Nov-09	Sep-10	Jul-11	Aug-13	Nov-09	Sep-10	Jul-11	Aug-13	Nov-09	Sep-10	Jul-11	Aug-13
Terrestrial and Wetland Species																	
Acer spp	Maple (saplings)			X			X	X	X							X	X
Alnus incana	Speckled Alder													X	X	X	
Ambrosia artemisiifolia	Ragweed		X		X						X		X				X
Asclepias spp.	Milkweed	X	X	X										X	X	X	X
Asclepias incarnata	Marsh Milkweed			X													
Aster spp	Aster	X			X	X			X								
Bromus spp	Smooth Brome	X	X														
Carex comosa	Bottlebrush Sedge			X													
Carex spp	Sedge	X	X	X	X	X	X							X	X	X	
Cirsium spp	Thistle	X				X	X	X	X	X	X	X	X	X	X		
Cirsium spp 2	Thistle 2					X								X			
Cornus stolonifera	Red Osier Dogwood	X															
Eloecharis obtusa	Blunt Spikerush		X	X													
Eupatorium perfoliatum	Common Boneset			X													
Impatiens pallida	Pale Jewel Weed										X				X	X	X
Larix laricina	Tamarack									X	X	X	X	X	X		
Lythrum salicaria	Purple Loosestrife																X
Phalaris arundinacea	Reed Canary Grass	X				X	X	X	X	X	X	X	X	X	X	X	X
Poa pratensis	Kentucky Bluegrass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Polyganum perfoliatum	Tearthumb				X	X							X	X	X		
Rubus spp	Raspberry (?)															X	
Rumex crispus	Curled Dock								X	X	X	X	X	X	X	X	X
Sagiteria latifolia	Broad-leaf Arrowhead		X	X	X												
Salix spp	Sandbar Willow (?)				X						X				X		X
Scirpus atrovirens	Green Bulrush			X												X	
Scirpus fluviatiis	River Bulrush	X	X		X												
Scirpus validus	Softstem Bulrush	X	X	X		X	X	X			X						
Solidago spp	Goldenrod		X	X	X		X	X									
Sonchus oleraceous	Common Sow Thistle								X				X				
Sparganium eucarpum	Giant Burr Reed						X							X	X		
Typha spp	Cattail	X	X	X	X	X	X	X	X					X	X	X	X
Unknown	Annual Weeds		X			X	X					X	X		X		
Urtica diotica	Stinging Nettle						X					X		X	X	X	X
Aquatic Species		**Pond 1**				**Pond 2**				**Pond 3**				**Pond 4**			
Ceratophyllum demersum	Coontail			X	X	X				X		X	X		X		
Chara spp	Muskgrass	X	X	X			X										
Elodea canadensis	Canadian Waterweed	X	X	X	X		X					X			X		
Lemna minor	Lesser Duckweed											X			X	X	X
Najas flexalis	Bushy Pondweed			X													
Nymphaea odorata	White Water Lily									X			X		X		
Potamogeton foliosus	Narrow Leaf Pondweed		X	X	X				X			X	X				
Potamogeton natans	Floating Leaf Pondweed		X	X													
Potamogeton pectinatus	Sago Pondweed	X										X				X	
Potamogeton zosterformis	Flatstem Pondweed									X					X		

Water quality monitoring results for Hiawatha Golf Course are shown in **Table 27-6**. Dissolved oxygen, dissolved oxygen percent, pH, and specific conductivity measurements were made in each pond with a Hydrolab 5a sonde. Chemical parameters, total phosphorus, ammonia, and nitrate/nitrite were analyzed by IRI, Inc.

Table 27-6. Water quality monitoring results for Hiawatha Golf Course. NS = no sample.

Hiawatha Site	Date	Time	Temp	DO	DO%	pH	SpCond	TP	NH3	NO3/NO2
			øC	mg/l	Sat	Units	µS/cm	mg/L	mg/L	mg/L
Pond 1	11/9/2009	11:44	9.23	11.7	103	9.81	899	0.053	<0.500	0.270
Pond 1	8/31/2010	13:48	29.5	11.4	154	7.96	580	0.033	<0.500	<0.030
Pond 1	7/1/2011	9:06	27.1	9.09	118	7.42	636	0.036	<0.500	0.034
Pond 1	2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 1	8/16/2013	9:30	21.4	11.2	129	7.88	598	0.046	<0.500	<0.030
Pond 2	11/9/2009	11:55	9.27	4.54	40.1	8.30	982	0.064	0.969	0.222
Pond 2	8/31/2010	13:58	24.0	12.3	151	7.36	900	0.028	<0.500	0.097
Pond 2	7/1/2011	9:20	22.6	6.21	74	7.12	975	0.032	0.743	2.02
Pond 2	2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 2	8/16/2013	9:20	16.9	6.18	65.1	7.15	986	0.039	0.660	0.622
Pond 3	11/9/2009	12:06	8.47	2.40	20.7	7.90	1000	0.089	2.80	0.112
Pond 3	8/31/2010	14:08	28.1	12.6	167	7.43	853	0.090	0.897	0.065
Pond 3	7/1/2011	9:30	26.4	10.9	140	7.54	862	0.045	1.33	0.616
Pond 3	2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 3	8/16/2013	9:10	18.9	6.45	70.9	7.41	936	0.073	0.590	0.54
Pond 4	11/9/2009	12:13	9.84	1.45	13.0	7.59	1017	0.218	5.64	0.149
Pond 4	8/31/2010	14:17	28.5	9.65	128	7.20	842	0.265	1.62	<0.030
Pond 4	7/1/2011	9:35	24.5	1.99	24.6	6.82	987	0.055	3.44	0.532
Pond 4	2012	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pond 4	8/16/2013	8:55	18.3	1.93	20.9	7.09	937	0.118	1.27	0.771

In 2013, Ponds 3 and 4 showed a decrease in the amount of NH_3 from previous years. Pond 1 was super-saturated with oxygen, likely due to large amounts of algae in the pond. In the interconnected ponds, NH_3 and NO_3/NO_2 both decreased from previous years.

Although the chain of ponds is interconnected and pumped daily, each pond retains its own character. Their differences can be seen both visually and chemically. Pond 4 is isolated and has continually exhibited distinctly higher phosphorus and ammonia levels than other ponds. Pond 4's high nutrient condition could be due to a lack of flushing.

MEADOWBROOK GOLF CLUB

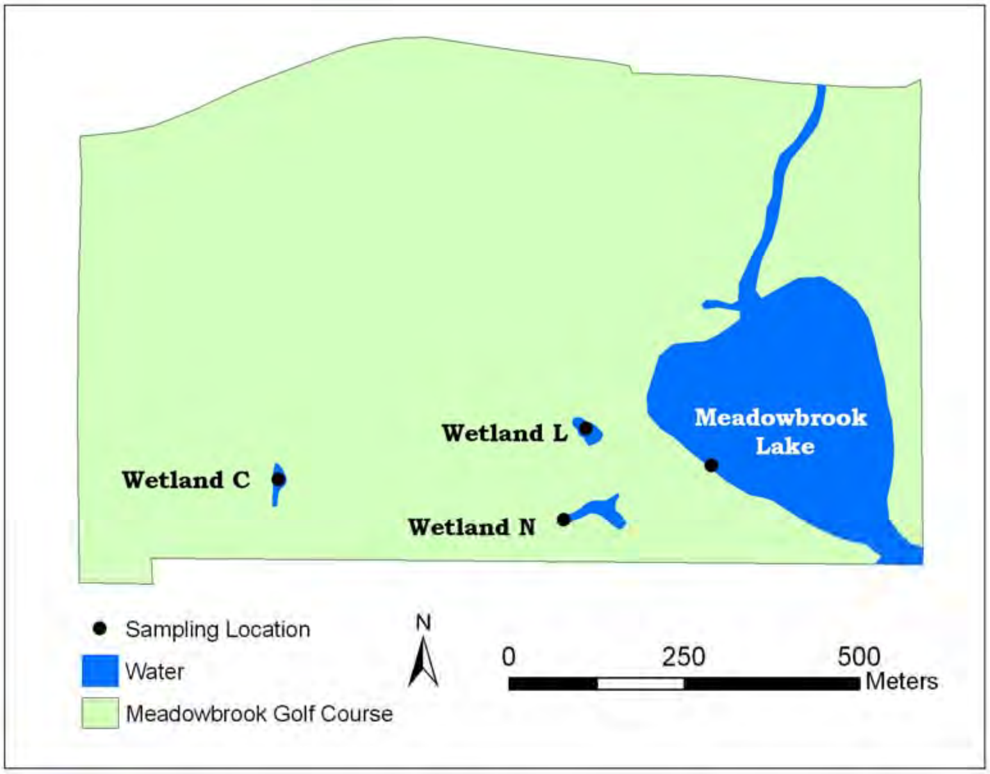


Figure 27-4. Meadowbrook Golf Course water quality and vegetation monitoring locations.

Four water bodies were monitored at Meadowbrook Golf Course: Meadowbrook Lake, Wetland C, Wetland L, and Wetland N (**Figure 27-4)**. The wetland's alphabetic labels are derived from nomenclature used by Meadowbrook Golf Course.

Each of the sampled water bodies on the Meadowbrook Golf Course has unique hydrologic characteristics. Wetland C is the furthest upstream sample site and only receives runoff from the surrounding course. Wetland N is near the course edge and receives stormwater from the neighborhood in order to reduce the risk of flooding in homes. Wetland L is a deep pond and receives water that is pumped from all the other wetlands prior to discharge into Meadowbrook Lake. Minnehaha Creek flows through Meadowbrook Lake.

2013 was the fourteenth year of water monitoring on the Meadowbrook Golf Course. Aquatic, terrestrial, and wetland plants within the ponds and in surrounding buffers were surveyed in mid-August. Many new terrestrial plants were discovered around the sampling sites. No aquatic plants were observed in Wetland L in 2013. Dominant buffer zone plants found in the Meadowbrook ponds are presented in **Table 27-7A** and dominant aquatic plants are presented in **27-7B.** Data presented are from the last five years of sampling only. Older data can be found in previous reports.

Table 27-7A. Dominant buffer zone plants surrounding the Meadowbrook Golf Course sample sites.

Meadowbrook Golf Course		Wetland C					Wetland N					Wetland L					Meadowbrook Lake				
Scientific Name	**Common Name**	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13
Wetland and Upland Species																					
Acer ginnala	Amur maple					X															
Ajuga spp	Bugleweed					X															
Ambrosia trifida	Giant Ragweed		X																		
Andropogon gerardii	Big Bluestem		X		X					X									X		
Arctium minus	Burdock					X					X										
Asclepias incarnata	Marsh Milkweed		X			X					X										
Asclepias syriaca	Common Milkweed	X	X		X	X					X							X			
Aster lanceolatus	Marsh Aster	X		X						X		X		X							
Asteraceae sonchus	Sow Thistle															X					
Nintooa japonica	Blanket flower																				
Bromus spp	Brome Grass				X													X			
Carex spp	Sedge spp				X				X	X	X									X	
Carex meadii	Mead's Sedge					X															
Cirsium avense	Canadian Thistle		X	X	X	X				X			X		X	X					
Echinochloa crusgalli	Barnyardgrass		X	X				X	X												
Echinocystis lobata	Wild Cucumber															X				X	
Eleocharis acicularis	Needle spike-rush				X																
Eupatorium perfoliatum	Boneset								X												
Eupatorium purpureum	Joe Pye weed									X											
Fraxinus pennsylvanica	Green Ash					X												X	X		X
Helenium autumnale	Common Sneezeweed		X		X	X															
Helianthus grosseserratus	Sawtooth Sunflower				X																
Impatiens capensis	Orange Jewelweed												X	X	X	X			X		
Iris versicolor L.	Blue Flag Iris																	X			
Leersia oryzoides	Rice cutgrass									X											
Leonurus cariaca	Motherwort															X				X	
Lycopus americanus	American Bugleweed				X	X				X											
Lycopus spp.	Bugleweed										X										
Lythrum salicaria	Purple Loosestrife					X															
Melilotus albus medikus	Sweet White Clover					X								X							
Monarda	Bee Balm					X															
Parthenocissus quinquefolia	Virginia Creeper					X															X
Phalaris arundinacea	Reed Canary Grass		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Poa pratensis	Kentucky Bluegrass		X	X	X	X		X	X	X	X		X	X	X	X					
Polygonum amphibium	Water Smartweed	X	X				X			X		X			X						
Polygonum hydropier	Common Smartweed					X		X		X			X								
Polygonum persicaria	Ladies Thumb								X												
Populus deltoides	Eastern Cottonwood		X										X	X	X	X	X	X		X	X
Potentilla norvegica	Rough Cinquefoil								X	X								X			
Rhamnus cathartica	Buckthorn																		X	X	
Rubus strigosus	Raspberry					X															
Rudbeckia hirta	Black eyed susan				X	X								X							
Rumex crispus	Curled dock		X	X	X	X	X	X	X									X			
Salix exigua	Sandbar Willow			X	X							X	X		X	X		X		X	
Salix nigra	Black Willow					X							X	X	X	X				X	
Schoenoplectus acutus	Hardstem Bulrush										X										
Scirpus atrovirens	Green Bulrush				X	X				X	X			X							
Scirpus fluviatilis	River Bulrush																X		X		
Scirpus validus	Soft stem Bulrush						X			X							X				
Scutellaria galericulata	Marsh Skullcap									X	X										
Sedge spp.	Sedge spp					X	X														
Seteria viridis	Foxtail	X	X																		
Solanum dulcamara	Bittersweet Nightshade				X	X								X	X	X					
Solidago canadensis	Canada Goldenrod	X	X		X	X						X	X								
Sonchus oleraceus	Common Sow-thistle				X	X									X						
Sparganium eurycarpum	Common Bur-reed		X	X	X	X	X	X	X	X	X										
Spartina pectinata	Prairie cordgrass				X	X								X							
Typha angustifolia	Narrow leaved cattail	X	X				X	X			X						X	X	X		X
Typha latifolia	Broad-leaved cattail	X	X		X	X	X	X		X	X						X	X	X		X
Typha X glauca	Hybrid Cattail	X	X	X	X	X	X	X			X						X	X	X		X
Ulmis pumilla	Siberian Elm																X	X	X	X	X
Urtica dioica	Stinging Nettle		X		X	X				X	X		X	X		X		X			
Verbena hastata	Blue vervain				X																
Vicia cracca	Cow Vetch		X		X	X							X	X	X	X					
Vitus riparia	Riverbank Grape				X	X							X	X	X	X		X	X	X	X
Zizea aurea	Golden Alexanders										X										

Table 27-7B. Dominant aquatic plants within the Meadowbrook Golf Course sample sites.

Meadowbrook Golf Course		Wetland C					Wetland N					Wetland L					Meadowbrook Lake				
Scientific Name	**Common Name**	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13	Nov-09	Sep-10	Jun-11	Jul-12	Aug-13
Floating Species																					
Lemna minor	Lesser Duckweed	X	X	X	X	X		X	X		X	X					X	X	X	X	X
Spirodela polyrhiza	Big duckweed			X	X	X			X										X		X
Wolffia columbiana	Watermeal		X		X			X			X										
Submerged Species																					
Ceratophyllum demersum	Coontail			X														X	X	X	X
Elodea canadensis	Common Waterweed				X													X	X		
Myriophyllum spicatum	Eurasian Watermilfoil																	X			X
Potamogeton berchtoldii	Narrow leaved pondweed																			X	
Potamogeton crispus	Curly-leaf pondweed																		X		X
Potamogeton pectinatus	Sago Pondweed																			X	
Potamogeton zosteriformis	Flat-stem pondweed																			X	X
Vallisneria americana	Water celery																				X
Zosterella dubia	Water Stargrass																	X			

Water quality monitoring results for Meadowbrook Gold Course are shown in **Table 27-8**. Dissolved oxygen, dissolved oxygen percent, pH, and specific conductivity measurements were made in each pond with a Hydrolab 5a sonde. Chemical parameters, total phosphorus, ammonia, and nitrate/nitrite were analyzed by IRI, Inc.

Table 27-8. Water quality monitoring results for Meadowbrook Golf Course for 2008-2013. NS = no sample.

Meadowbrook Site	Date	Time	Temp øC	DO mg/l	DO% Sat	pH Units	SpCond µS/cm	TP mg/L	NH3 mg/L	NO3/NO2 mg/L
Meadowbrook Lake	8/26/2008	11:44	22.5	7.86	92.6	7.70	552	0.065	<0.500	<0.030
Meadowbrook Lake	11/3/2009	11:03	6.2	8.65	70.6	7.40	816	NS	NS	NS
Meadowbrook Lake	9/1/2010	9:10	24.3	4.07	49.7	7.43	412	0.059	<0.500	0.049
Meadowbrook Lake	6/30/2011	10:50	25.2	8.98	112	7.64	414	NS	NS	NS
Meadowbrook Lake	7/19/2012	9:45	26.1	5.04	63.7	7.39	493	0.104	0.313	0.093
Meadowbrook Lake	8/13/2013	9:25	22.9	5.13	60.9	7.59	445	0.030	0.714	<0.030
Wetland C	8/27/2008	11:00	17.2	2.73	28.9	7.52	357	0.105	<0.500	<0.030
Wetland C	11/3/2009	10:43	3.1	5.10	38.4	6.94	613	0.158	<0.500	0.344
Wetland C	9/1/2010	9:24	20.1	4.71	53.0	7.31	176	0.288	<0.500	<0.030
Wetland C	6/30/2011	10:30	22.6	1.23	14.6	6.81	286	0.133	<0.500	0.031
Wetland C	7/19/2012	8:55	22.8	0.330	3.90	6.66	347	0.235	1.34	<0.030
Wetland C	8/13/2013	9:00	18.7	0.210	2.30	6.83	218	0.130	0.794	<0.030
Wetland L	8/26/2008	11:59	16.5	1.20	12.5	7.04	903	0.085	1.38	0.034
Wetland L	11/3/2009	11:11	6.1	2.70	21.9	7.15	560	0.166	0.68	<0.030
Wetland L	9/1/2010	9:46	23.8	6.69	81.0	7.58	415	0.206	2.09	<0.030
Wetland L	6/30/2011	11:00	19.5	1.06	11.9	6.84	707	0.341	1.27	0.087
Wetland L	7/19/2012	9:45	19.8	0.610	6.80	7.16	823	0.353	2.59	<0.030
Wetland L	8/13/2013	9:35	16.1	0.340	3.50	6.98	875	0.206	2.29	0.131
Wetland N	8/26/2008	11:29	18.5	1.61	17.5	7.25	280	0.496	<0.500	<0.030
Wetland N	11/3/2009	10:57	4.3	0.910	7.10	6.83	279	0.339	<0.500	0.290
Wetland N	9/1/2010	9:33	20.7	5.280	60.2	7.57	254	0.662	0.792	0.034
Wetland N	6/30/2011	10:45	23.0	0.310	3.70	6.82	371	0.185	<0.500	<0.030
Wetland N	7/19/2012	9:15	23.2	0.330	4.00	6.95	335	0.811	1.48	<0.030
Wetland N	8/13/2013	9:15	19.3	0.450	5.00	6.99	373	0.201	0.771	<0.030

The Meadowbrook Golf Course wetlands typically have low levels of dissolved oxygen. Oxygen levels in 2013 were extremely low at all locations except Meadowbrook Lake. It is not unusual for wetlands to have anoxic environments.

Levels of NH_3 in all the sites have been highest in the last two years. While NH_3 levels are higher than in the past, they are slowly declining. All sites exhibited non-detectable amounts of NO_3/NO_2 except Wetland L which was an order of magnitude higher than years previous. In most years, Wetland L has had the highest conductivity and NH_3 values of all of the wetlands; this was true again in 2013. It is possible that groundwater is being pumped into Wetland L. If the groundwater is anaerobic, it can have concentrations around 3mg/L of NH_3.

THEODORE WIRTH GOLF COURSE

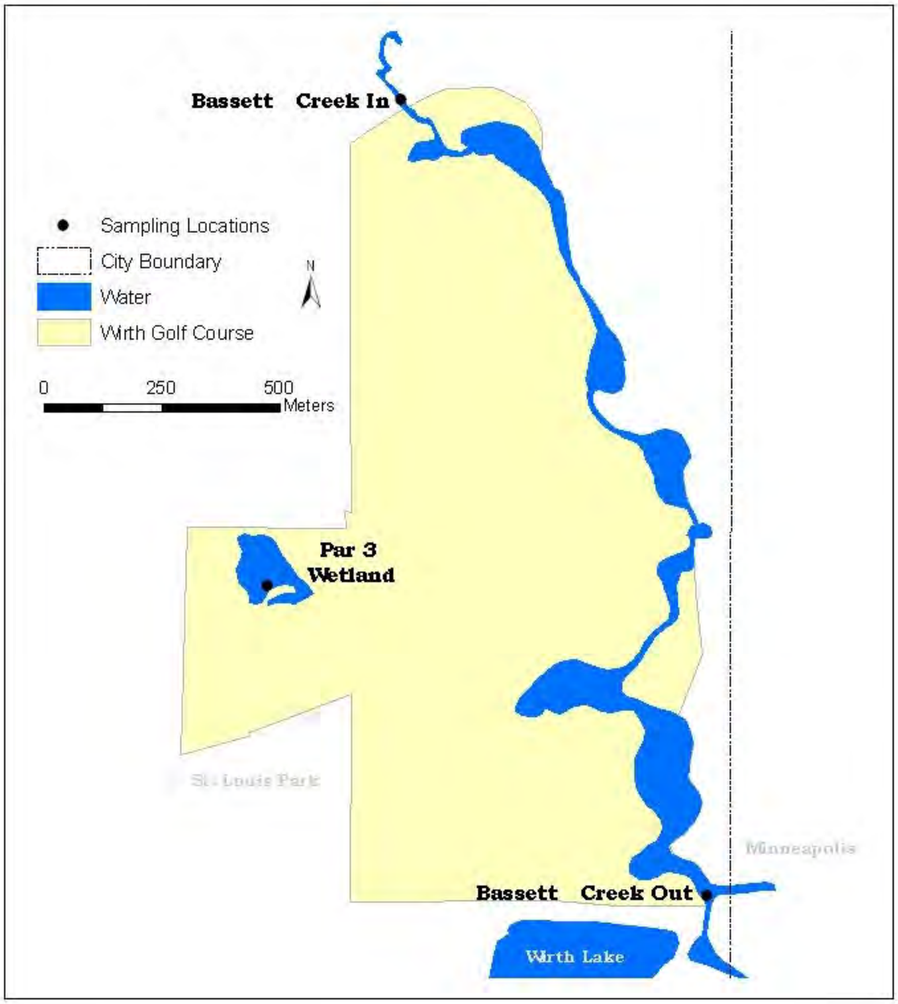


Figure 27-5. Wirth Golf Course water quality and vegetation monitoring locations.

The sampling sites at Wirth Golf Course include an inlet and an outlet of Bassett Creek as it enters and leaves the golf course, as well as an unconnected wetland. The two sampling sites on Bassett Creek were chosen to assess the effect the golf course has on the creek. The Par 3 wetland was chosen because it was not connected to Bassett Creek. The wetland is located in the golf course and a housing complex has recently been built to the north of it. The Par 3 wetland accepts stormwater from the adjacent housing complex and has had an increase in the volume of stormwater it accepts since monitoring began. **Figure 27-5** shows the location of the monitoring sites on the golf course.

2013 was the sixteenth year of sampling on the Wirth Golf Course. Aquatic, terrestrial, and wetland plants in the ponds and surrounding buffers were surveyed in mid-August. Dominant plants identified at the Wirth Golf Course ponds and buffer zones from the past five years are presented in **Tables 27-9**.

Table 27-9. Aquatic vegetation monitoring results for the Wirth Golf Course for 2009-2013.

Wirth Golf Course		Bassett IN					Bassett OUT					Par 3 Wetland				
Scientific Name	**Common Name**	Nov-09	Sep-10	Jun-11	Jul-12	13-Aug	Nov-09	Sep-10	Jun-11	Jul-12	13-Aug	Nov-09	Sep-10	Jun-11	Jul-12	13-Aug
Wetland and Upland Vegetation																
Acer negundo	Box Elder					X										
Achillea millefolia	Yarrow			X	X	X										
Ambrosia artemisiifolia	Ragweed				X	X					X				X	
Asclepias syriaca L.	Common Milkweed				X	X										
Bromus spp.	Smooth Brome			X		X	X	X		X						
Carex hystericina Muhl.	Porcupine Sedge				X											
Cirsium avense	Canadian Thistle		X	X	X	X										
Cyperus bipartitus	Umbrella Sedge							X								
Echinochloa crusgalli	Barnyardgrass		X													
Eleocharis obtusa	Blunt Spikerush							X								
Elymus repens	Quack Grass		X									X				
Impatiens pallida	Pale Jewelweed		X			X										
Leonurus cardiaca	Motherwort					X										
Linaria vulgaris	Butter and eggs					X										
Lythrum salicaria	Purple Loosestrife					X										
Parthenocissus quinquefolia	Virginia Creeper					X										
Phalaris arundinacea	Reed canary grass	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Poa pratensis	Kentucky Bluegrass	X	X	X	X	X						X		X		X
Polygonum amphibium	Water smartweed							X		X	X					
Polygonum persicaria	Lady's thumb					X				X	X					
Populus deltoides	Eastern cottonwood												X	X	X	X
Rhamnus cathartica	Buckthorn	X	X		X	X										
Ribes spp	Currant										X					
Salix babalonica	Weeping willow							X	X	X	X					
Salix exigua	Sandbar willow		X	X	X	X	X	X	X	X	X	X		X		X
Salix nigra	Black willow		X	X	X	X										
Scirpus fluviatilis	River bulrush						X									
Scirpus validus	Soft stem bulrush						X	X								
Seteria gracilis	Foxtail bristlegrass							X					X			
Solidago candidensis	Canada Goldenrod					X		X	X		X		X	X		
Solidago spp.	Goldenrod					X	X	X		X		X				
Sonchus arvensis	Sow Thistle									X						
Typha angustifolia	Narrow leaved cattail		X													
Typha latifolia	Broad leaved cattail											X	X	X	X	X
Typha X glauca	Hybrid cattail											X	X	X	X	X
Urtica dioica	Stinging nettle				X	X						X				
Vitus riparia	Riverbank Grape				X	X										
Floating Species																
Lemna minor	Lesser duckweed		X					X			X		X	X	X	X
Lemna trisulca	Star duckweed													X	X	X
Nymphaea odorata	White water lily										X					
Riccia fluitans	Floating slender liverwort												X	X	X	X
Spirodela polyrhiza	Big duckweed						X				X		X			X
Wolffia columbiana	Watermeal						X						X		X	X
Submerged Species																
Ceratophyllum demersum	Coontail							X	X		X					
Elodea canadensis	Common Waterweed		X					X			X					
Najas flexalis	Bushy Pondweed						X									
Potamogeton nodusus	Long leaved pondweed								X		X					
Potamogeton pectinatus	Sago pondweed						X				X					
Zosterella dubia	Water stargrass						X		X	X	X					

Water quality monitoring results for Wirth Golf Course are shown in **Table 27-10**. Dissolved oxygen, dissolved oxygen percent, pH, and specific conductivity measurements were made in each pond with a Hydrolab 5a sonde. Chemical parameters, total phosphorus, ammonia, and nitrate/nitrite were analyzed by IRI, Inc.

Table 27-10. Water quality monitoring results for Wirth Golf Course from 2008-2013.

Wirth Site	Date	Time	Temp	DO	DO%	pH	SpCond	TP	NH3	NO3/NO2
			øC	mg/l	Sat	Units	µS/cm	mg/L	mg/L	mg/L
Bassett In	7/31/2008	13:25	22.3	6.30	74.7	7.34	1098	0.144	<0.500	0.434
Bassett In	11/3/2009	12:18	4.5	7.41	69.8	8.94	820	0.076	<0.500	0.194
Bassett In	9/1/2010	11:33	21.4	7.17	83.1	7.38	667	0.130	<0.500	0.291
Bassett In	6/30/2011	9:06	22.8	6.86	82.0	7.23	742	0.097	<0.500	0.214
Bassett In	7/19/2012	11:00	23.7	6.32	76.5	7.71	502	0.188	0.879	0.221
Bassett In	8/13/2013	10:35	19.2	7.25	80.2	7.77	880	0.072	0.760	0.196
Bassett Out	7/31/2008	13:53	24.8	2.59	32.2	7.08	949	0.118	<0.500	<0.030
Bassett Out	11/3/2009	12:36	5.69	7.37	68.1	8.23	842	0.080	<0.500	0.223
Bassett Out	9/1/2010	11:59	23.4	4.58	55.1	7.42	621	0.138	<0.500	0.122
Bassett Out	6/30/2011	9:30	23.4	4.99	60.3	7.15	770	0.067	<0.500	0.097
Bassett Out	7/19/2012	11:25	24.8	3.40	42.0	7.73	471	0.153	0.274	0.158
Bassett Out	8/13/2013	11:15	22.0	3.36	39.3	7.45	867	0.085	0.840	0.11
Par 3 Wetland	7/31/2008	13:08	21.0	1.37	15.7	6.20	291	0.313	<0.500	<0.030
Par 3 Wetland	11/3/2009	12:02	5.7	6.22	45.7	5.67	335	0.454	<0.500	<0.030
Par 3 Wetland	9/1/2010	12:22	21.2	1.42	16.4	6.85	347	0.263	<0.500	0.122
Par 3 Wetland	6/30/2011	8:55	22.6	1.00	11.9	6.81	396	0.101	<0.500	0.037
Par 3 Wetland	7/19/2012	10:40	23.0	0.860	10.3	7.47	438	0.350	1.01	<0.030
Par 3 Wetland	8/13/2013	11:00	20.6	0.110	1.20	7.00	422	0.422	1.15	<0.030

Overall, the results at Wirth Golf Course were typical for urban streams and wetlands. The Bassett IN and Bassett OUT samples had similar conductivity and amounts of ammonia, similar to past sampling years. The OUT sample had higher phosphorus and nitrate/nitrite that the IN sample, suggesting that the water picks up nutrients as it travels though the golf course. The Par-3 wetland had lower nitrate/nitrite and oxygen, but higher phosphorus and ammonia levels than either of the creek samples.

28. CLIMATOLOGICAL SUMMARY

NATIONAL WEATHER SERVICE DATA

Annual climate data is tracked and reported due to its year to year variability and significant impact on water resources. **Table 28-1** shows total monthly precipitation and monthly average temperature for the year 2013 as recorded by the National Weather Service (NWS). In 2013, annual precipitation was above normal and temperature was slightly below normal. 2013 had a very wet spring (April-June) and drought in August – November. February through June, October, and December had above normal precipitation and the remaining five months had below normal precipitation. The wettest month of the year was May. The driest month of the year was November. The annual recorded rainfall total for 2013 was 32.77 inches, 2.64 inches above normal.

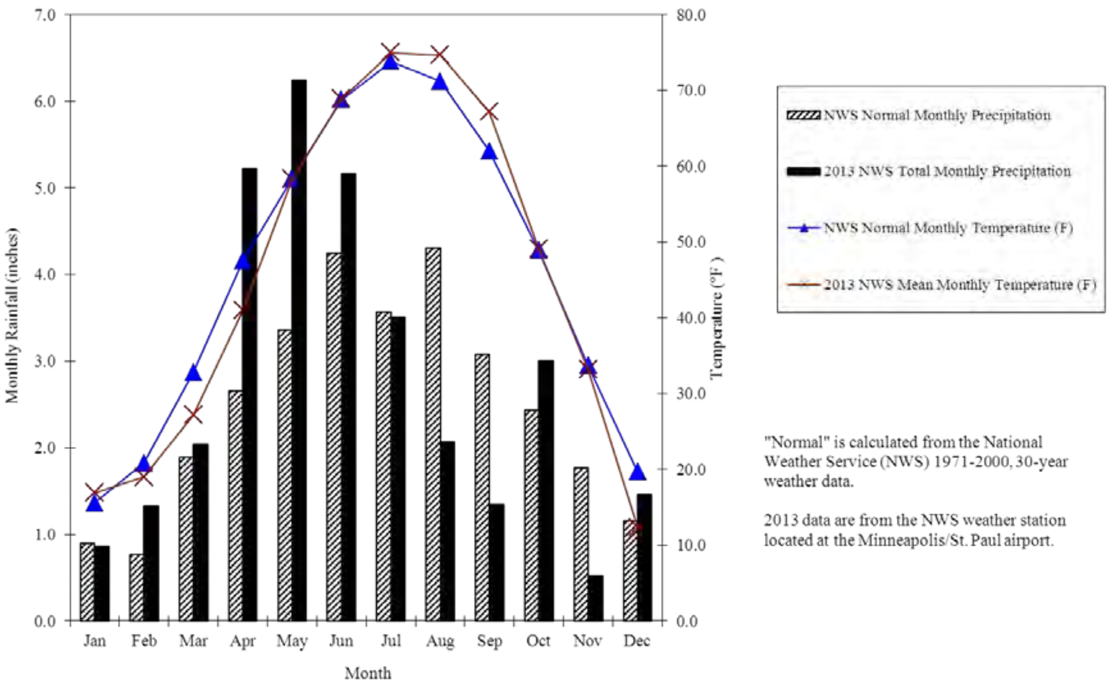
Table 28-1. Minneapolis precipitation, mean temperature and deviation from normal as recorded by the National Weather Service.

Year 2013	Total Precip. (inches)	"Normal" Comparison:	Mean Temp. (F)	"Normal" Comparison:
January	0.86	0.04" below normal	16.9	1.3 F above normal
February	1.33	0.56" above normal	19.0	1.8 F below normal
March	2.04	0.15" above normal	27.2	5.6 F below normal
April	5.22	2.56" above normal	41.0	6.5 F below normal
May	6.24	2.88" above normal	58.3	0.8 F below normal
June	5.17	0.92" above normal	68.9	0.1 F above normal
July	3.51	0.53" below normal	75.0	1.2 F above normal
August	2.07	2.23" below normal	74.7	3.5 F above normal
September	1.35	1.73" below normal	67.2	5.2 F above normal
October	3.00	0.57" above normal	49.1	0.2 F above normal
November	0.52	1.25" below normal	33.2	0.5 F below normal
December	1.46	0.30"above normal	12.4	7.3 F below normal
Annual Data	**32.77**	**2.64" above normal**	**45.2**	**0.90 F below normal**

The 2013 annual 2.64 inch departure from normal represents a near normal year, but individual months were above or below normal by up to 2-3 inches.

The 2013 NWS monthly data are plotted in **Figure 28-1**. In general the 2013 average monthly temperatures were above normal for January, and June through October. February through May, November and December temperatures were below normal. The average annual temperature for 2013 was 45.2° F which was 0.90° F below normal. In 2013 **Figure 28-1** shows a very wet April through June, followed by a very dry August, September and November.

All NWS data was obtained from http://www.ncdc.noaa.gov/IPS/lcd/lcd.html?_page=1&state=MN&stationID=14922&_target2=Next+%3E and the National Oceanic and Atmospheric Administration (NOAA) monthly publications.



"Normal" is calculated from the National Weather Service (NWS) 1971-2000, 30-year weather data.

2013 data are from the NWS weather station located at the Minneapolis/St. Paul airport.

Figure 28-1. Comparison showing the NWS 30-year "normal" with 2013 temperature and precipitation data.

TWIN CITIES RAIN GAUGE COMPARISON

In order to understand the local spatial pattern of precipitation, monthly NWS rainfall data were compared to the MPRB weather station.

The MPRB operates a tipping bucket rain gauge in southwest Minneapolis at its Southside Operations Center at 3800 Bryant Ave. South. The NWS rain gauge is located at the Twin Cities airport. The MPRB rain gauge is not heated and cannot measure snowmelt, and only totals for May through October were calculated with these instruments. The monthly precipitation differences between the MPRB and NWS and the standard deviations can be seen in **Table 28-2**. A power failure occurred at the MPRB weather station June 21-23, 2013 and some precipitation data were lost.

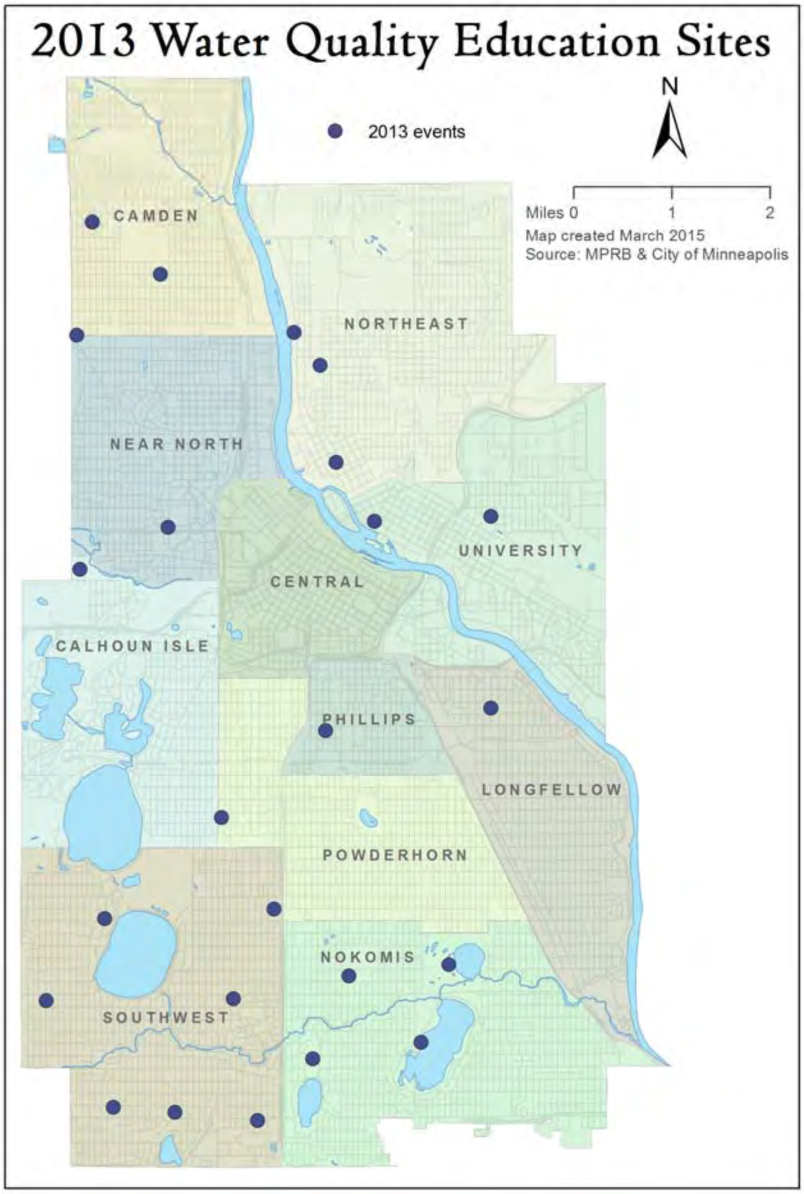
Table 28-2. Monthly totals for the 2013 growing season (May - October) recorded at the NWS, and MPRB rain gages (MPRB rain gauge down 6/21-23, missing ~3.30" of precip.)

Month	NWS (inches)	MPRB (inches)	Standard Deviation
May	6.24	5.83	0.29
June	5.17	2.19	2.11
July	3.51	3.92	0.29
August	2.07	1.39	0.48
September	1.35	1.07	0.20
October	3.00	3.68	0.48
Totals	**21.34**	**18.08**	**2.31**

29. WATER QUALITY EDUCATION

ACTIVITIES

In 2013, Minneapolis Park & Recreation Board (MPRB) staff provided water quality education programs throughout the City. Environmental Operations naturalist staff participated in 76 Minneapolis community festivals and neighborhood events (**List 29-1**), as well as concerts at Lake Harriet, Father Hennepin Park and Minnehaha Park. Hands-on water quality educational displays focused on neighborhood watersheds and how human activities impact local water bodies.



Map created March 2015
Source: MPRB & City of Minneapolis

List 29-1:

Neighborhood water quality education event sites. Some sites had multiple events.

- Armatage
- Bottineau
- Central Avenue Open Streets
- Creekview
- Dickman
- Folwell
- Fuller
- Kenny
- Lake Hiawatha
- Linden Hills
- Lowry Ave Open Streets
- Martin Luther King
- Matthews
- McRae
- MWMO
- Lake Nokomis
- Painter
- Pearl
- Pershing
- Swedish Institute
- Van Cleve
- Victory Memorial Parkway
- Windom South
- Wirth Park

CANINES for CLEAN WATER

CANINES FOR CLEAN WATER

More than 100,000 dogs reside in the City of Minneapolis. They generate an estimated 41,000 pounds of solid waste each day. A water quality education program targeting dog owners was piloted in 2009 called Canines for Clean Water, and we continue to build on this work.

In 2013 the Canines for Clean Water campaign continued to focus on Public Service Announcements (PSAs) shown at the Riverview Theatre located in south Minneapolis near the Mississippi River and Lakes Nokomis and Hiawatha. The PSAs focus on two main actions: getting pet owners to pick up after the dogs, and encouraging all property owners to stop or reduce their use of salt or chlorides. The PSAs had a simple message with images of the Mississippi River, Lake Nokomis, and Minnehaha Creek. The summer and fall message was to Protect the River, Protect the Lake, Protect the Creek: Grab a Bag and Scoop the Poop. For winter, the images featured winter scenes of the Mississippi River, Lake Nokomis, and dogs frolicking in the snow. The message here was to Protect the River, Protect the Lakes, Protect the Paws: Shovel, Don't Salt. The word *chloride* was not used in the PSA because more people understood ice melt as salt. However, detailed information about chlorides, their impacts, best practices for distribution was found on the Minneapolis Park & Recreation Board website www.minneapolisparks.org/dogs The same was true for information about the impact of dog poop on water quality

UPGRADE OF WATER EDUCATION MATERIALS

Work was completed on a series of portable mini-golf holes that feature water quality messages or best practices, such as reducing the use of fertilizer, redirecting the down spout, picking up after a pet, and keeping leaves and grass out of the street. Lawn signs accompany each hole and utilize simple graphics as well as text to encourage people to take action to protect water quality. The portable putt-putt course was utilized at neighborhood festivals and events like National Get Outdoors Day.

Fabrication was completed for a new self-directed on-the-water learning quest for use on Lake Nokomis. This activity targets people in canoes, kayaks, sailboats, and fishing boats, as well as those on stand-up paddle boards. A series of buoys will route people around the lake, bringing them close to storm water outlets, alluvial fans, algae blooms, erosion, etc. Water quality questions have been printed on the buoys. Answers can be found by pulling up on the attached wire. The buoys will be deployed in the summer of 2014.

THE MISSISSIPPI RIVER GREEN TEAM

The Mississippi River Green Team (Green Team) is made possible through a partnership between the Minneapolis Park and Recreation Board and the Mississippi Watershed Management Organization, with additional funding through City of Minneapolis STEP-UP.

The Green Team is a conservation-based teen crew engaged in daily hands-on environmental work throughout the summer. There are two crews of ten youth each that work in the natural areas of the Minneapolis park system, and mostly within the watershed of the Mississippi River. Typical work days include invasive species removal, weed wrenching, planting, watering, mulching, and citizen science work.
In 2013 the Green Team served as citizen scientists as part of the Minnesota Odonata Survey Project. Each week the teens helped catch and identify dragonflies at North Mississippi Park. They also surveyed dragonflies at eight other parks. Dragonflies are an indicator species for assessing habitat and water quality in a wetlands, riparian forests, and lakeshore habitats. You can read more about the Odonata Project here: http://www.mndragonfly.org

Blue Dasher. Photo by D. Thottungal

Other summer work sites included Heritage Park/Sumner Field, Audubon Park, Powderhorn Park, and Mill Ruins Park. The Green Team also worked at stormwater holding ponds owned by the City of Minneapolis including the Columbus Pond, Crystal Lake Cemetery, Columbia Golf Course, Mead Pond, and the Park Avenue ponds. The teens picked up trash, and removed invasive species and volunteer trees that sprouted in the wrong places. To support monarch butterflies and other pollinators at the BMPs, the crew installed a variety of native plants.

The Green Team worked with local artist Gita Ghei to create bronze medallions with water quality messages. The youth etched designs and words into wax which included Don't feed the Geese!, Stop Erosion, and Don't Litter. A mold was created from the wax which was then used to cast the bronze medallion. The medallions were embedded into the new concrete sidewalk that rings the lake at Powderhorn Park. The medallions help remind park users that their actions directly impact the water quality of Powderhorn Lake (see photo below).

Green Team youth completed training on Turfgrass Maintenance for Reduced Environmental Impacts. The training was funded by the Mississippi Watershed Management Organization. Another highlight of the season was working with students at Augsburg College to sample area lakes for Daphnia.

EARTH DAY CLEAN UP EVENT

The 2013 Earth Day Clean-Up was cancelled due to snow cover and poor weather.

30. QUALITY ASSURANCE ASSESSMENT REPORT

BACKGROUND

Environmental monitoring and management requires the collection of highly reliable data. Data accepted for inclusion in a database must be of known quality and must meet established criteria. A Quality Assurance Program is a defined protocol for sample collection, handling, and analysis to ensure that the quality of the data collected is quantified and tracked. Quality Assurance consists of two components (*Standard Methods*, 2005):

• Quality Assessment (QA)	Periodic evaluations of laboratory performance through the submission and analysis of externally provided blanks, standard solutions, duplicates, and split samples.
• Quality Control (QC)	Documented operator competence, recovery of known additions, and analysis of internally provided reagent blanks, proper equipment calibration, and maintenance of control charts.

DESCRIPTION

This Quality Assurance Project Plan (QAPP) describes the procedures and quality control measures used for water quality monitoring and laboratory analyses completed in 2013 for the Minneapolis Chain of Lakes monitoring, the National Pollutant Discharge Elimination Systems (NPDES) stormwater monitoring, and other studies. The project activities for lake sampling are detailed in the Lake Monitoring Program Overview, **Section 1**. Stormwater monitoring procedures are explained in the Stormwater Monitoring Program Manual (MPRB, 2001).

QA/QC definitions, as presented by T.A. Dillaha, et al. (1988) and *Standard Methods for the Examination of Water and Wastewater* (2005), are used in the presentation of the information in this document.

- *Precision* is a measure of the degree of agreement between independent measurements of some property. Precision is concerned with the closeness of the results and is usually expressed in terms of the standard deviation of the data for duplicate or replicate analyses. Precision is a measure of how close the results are together with respect to each other not how close they are to a “true value.”

- *Accuracy* is a measure of the degree of agreement of a measured value with an accepted reference or true value. It is usually expressed in terms of percent recovery of the expected value (standard solution) and is an expression of the amount of bias in the data. Accuracy is a measure of how close the results are to a known “true value.”

- *Representativeness* is a measure of the degree to which data accurately and precisely represent the characteristics of the population which is being monitored.
-
- *Completeness* is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct normal conditions. For example, a data set for a lake will not be complete if the laboratory did not analyze all expected parameters. Completeness is usually expressed as a percent of the "true value."

- *Comparability* expresses the confidence with which one data set, measuring system, or piece of equipment can be compared with another. Data can be considered comparable if they are similar to those reported by others in the literature, data from previous years, and if the analysis procedures produce results similar to those reported by other laboratories for split samples.

The frequencies of quality assessment and quality control activities are set forth to ensure the validity of the database is listed in **Table 30-1**. The QA/QC plan follows the recommendations of *Standard Methods for the Examination of Water and Wastewater* (2005).

Table 30-1. Summary and frequency of QA/QC activities.

Sample type	Description	Function	Frequency
Equipment Blank	Reagent-grade de-ionized water subject to sample collection, processing and analysis	Estimating background values due to sample collection, processing and analysis	End of sampling season
Bottle Blank/Field Blank	Reagent-grade de-ionized water subject to sample processing and analysis	Estimating background values due to sample processing and analysis; carried in the field	Each sampling trip
Field Duplicate	Duplicate of lake sampling procedures	Estimating lab batch and sampling procedure precision	Each sampling trip
Blind QA/QC Audit Standard	Synthetic sample to mimic a natural sample	Estimating overall batch precision and lab bias	Once/Month
Laboratory Calibration Standard	Standard solution from a source other than the control standard	Calibrate the instrument before samples are analyzed	One/lab batch (10% of samples)
Laboratory Calibration Blank	Reagent-grade de-ionized water	Identifying signal drift and contamination of samples	One/lab batch (10% of samples)
Laboratory Reagent Blank	Reagent-grade de-ionized water plus reagents	Identifying contamination of reagents	One/lab batch (10% of samples)
Laboratory Control Standard	Standard solution from a source other than calibration standard	Determining accuracy and consistency of instrument calibration	One/lab batch (10% of samples)
Split Samples	Split of lake sample sent to different laboratories for analysis	Determining comparability	2 different lakes, twice during sampling season
Laboratory Duplicate	Split of sample aliquot	Determining analytical precision within batches	10% of samples (at least one per batch)
Laboratory Matrix Spike/Matrix Spike Duplicate	Known spike of sample (recovery of known additions)	Determining percent recovery of parameter analyzed	10% of samples (at least one per batch)

OBJECTIVES

The primary objective of this QAPP is to ensure and identify the completeness, representativeness, precision, accuracy, and comparability of the data collected. The following pages summarize these data characteristics for results from both field measurements and parameters as analyzed by Instrumental Research Inc. (IRI) located in Fridley, MN. Metals analysis was performed by Legend Technical Services located in St. Paul, MN.

This program was designed to clearly establish which data were: 1) usable, 2) of questionable usability and needed to be flagged or 3) unusable. Quantitative data quality descriptions have been included to provide data users with background on why certain data were deemed to be questionable or unusable. This enables the data user to apply more or less stringent acceptance limits on defining usability to meet the objectives of their own analyses. Quantitative data quality indicators were calculated for each analysis method individually. In order to estimate quantitative data quality indicators on a method-by-method basis, all samples analyzed using a given method were treated as belonging to the same population (Fairless and Bates, 1989).

The QAPP set forth target frequencies for all QA/QC activities:

- Every sampling batch included analysis blanks, standards, and duplicates for each set of samples analyzed.
- Ten percent of all samples were run in duplicate.
- The fall sampling trip had equipment blanks associated with them.
- A bottle field blank was associated with every sampling trip.
- One laboratory reagent blank was analyzed for every ten samples run.
- Filter blanks were analyzed where appropriate.
- A matrix spike was analyzed with every ten samples.

Blind performance evaluation samples of known concentration were submitted monthly to the laboratory by the MPRB for analysis. The performance evaluation samples served as a quality assessment of monthly analytical runs. IRI used the following procedures during each analytical run:

- Blanks for water and reagents (one for each) were analyzed for every 10 samples run.
- A standard of known concentration was analyzed for each analytical run.
- One spike (recovery of known additions) was analyzed for every 10 samples run.
- One duplicate sample was analyzed for every 10 samples run, which included duplicate spikes.

Additional quality control measures used in the contract laboratory were as follows:

- Control charts were maintained for all routinely measured parameters and analyses were not performed unless control (reference) samples fell within the specified acceptance limits see **Table 30-2**.
- Experienced individuals trained technicians before they were allowed to conduct analyses by themselves and their supervisors routinely reviewed their performance.

Table 30-2. 2013 IRI analytical laboratory and Legend Technical Services reporting limits, the performance evaluation (PE) percent recovery acceptance limits, and relative percent difference (RPD) allowed with duplicates. *NA = Not Applicable.*

Parameter	**Abbreviation**	**IRI RL**	**Legend RL**	**PE % Rec Limits**	**Duplicate RPD Limits**
Alkalinity, Total	Alk	2.0 mg/L	NA	80-120	±10%
Ammonia, Un-ionized as N	NH_3	0.500 mg/L	NA	80-120	±10%
Biochemical Oxygen Demand, 5 Day carbonaceous	$_C$BOD	1.0 mg/L	NA	80-120	±10%
Calcium, Total	Ca	NA	1.0 mg/L	NA	±10%
Chloride, Total	Cl	2.0 mg/L	NA	80-120	±10%
Chlorophyll-*a*	Chl-*a*	5 µg/L	NA	NA	±25%
Conductivity	Cond	10µohms	NA	80-120	±25%
Copper, Total	Cu	NA	1.4 µg/L	80-120	±25%
Escherichia coli	*E. coli*	1mpn/100	NA	80-120	NA
Hardness	Hardness	1.0 mg/L	NA	80-120	±10%
Kjeldahl Nitrogen, Total	TKN	0.500 mg/L	NA	80-120	±10%
Lead, Total	Pb	NA	3 µg/L	80-120	±25%
Nitrite+Nitrate, Total as N	NO_X	0.030 mg/L	NA	80-120	±10%
Nitrogen, Total (persulfate)	TN	0.500 mg/L	NA	80-120	±10%
pH	pH	1.00 Std Units	NA	80-120	±10%
Phosphorus, Soluble Reactive	SRP	0.003 mg/L	NA	80-120	±25%
Phosphorus, Total	TP	0.010 mg/L	NA	70-130	±10%
Phosphorus, Total Dissolved	TDP	0.010 mg/L	NA	80-120	±10%
Silica, Reactive	Si	0.500 mg/L	NA	NA	±10%
Solids, Total Dissolved	TDS	2.0 mg/L	NA	80-120	±10%
Solids, Total Suspended	TSS	1.0 mg/L	NA	80-120	±10%
Solids, Volatile Suspended	VSS	2.0 mg/L	NA	NA	±10%
Sulfate	SO_4	15 mg/L	NA	80-120	±10%
Zinc, Total	Zn	NA	2 µg/L	80-120	±25%

METHODS

Laboratory results and field data were entered into a spreadsheet. Data were evaluated to determine usability according to the methods below. Data were categorized into one of three levels of usability: *fully usable*, *questionable usability*, or *unusable*. To be "fully usable" the data had to meet all of the data quality criteria: *completeness*, *representativeness*, *comparability*, *precision*, and *accuracy*. Data rated as "questionable usability" met all but one of the quality criteria. Unusable data were those that were known to contain significant errors or data that met fewer than four of the data quality criteria.

Completeness: Data sets were deemed to be complete if fewer than 5% of the data were missing or not analyzed appropriately.

Representativeness: Data sets were deemed to be representative if samples were collected according to the sampling schedule, and standard collection and handling methods were followed. Monitoring locations, frequencies and methods followed suggested protocol to ensure representativeness (Wedepohl et al., 1990).

Comparability: Data for a given parameter were deemed to be highly comparable if the laboratory split results from all three labs for that parameter had a relative percent difference of less than 20% and if reported values were consistent with past results. If the relative percent difference between labs for a given parameter was more than 20% but the majority of data reported were within 20% the data set for that parameter was deemed to be moderately comparable. Coefficient of variation (CV) was used as another measure of how close the laboratories were to each other.

Coefficient of Variation (CV) =

$$\frac{\text{standard deviation}}{\text{mean}}$$

Precision: Data sets were deemed precise if two criteria were met (*Standard Methods*, 2005):

1. The relative percent difference of results for each pair of duplicate analyses was within acceptance limits for each given parameter.
2. The percent recovery of known standard additions met the established acceptance limits for each parameter.

Percent Recovery (% Rec) =

$$\frac{\text{Observed Value}}{\text{Expected Value}} \text{ X } 100\%$$

Precision was further quantified by calculating the average range and standard deviation of results for duplicates.

Relative Percent Difference (RPD) **=**

$$\frac{|X_1 - X_2|}{(X_1 + X_2)/2} \text{ X } 100\%$$

Where: X_1 and X_2 are duplicate pair values; sum for all duplicates

Average Range (R) =

$$\frac{\Sigma\,|X_1 - X_2|}{n}$$

Where: X_1 and X_2 are duplicate pair values; sum for all duplicates, and n = number of duplicate pairs

Standard Deviation (estimated) (SD) =

R / 1.128

R=Average Range

Accuracy: Data sets were deemed accurate if the percent recovery reported for performance evaluation standards fell within the established acceptance limits for each given parameter and had been deemed precise. The percent recovery estimates bias in the data set. Together, bias and precision reflect overall data set accuracy (*Standard Methods*, 2005). Low bias and high precision translates to high accuracy.

The standard solutions used for performance evaluation samples were manufactured by Environmental Resource Associates (ERA) located in Arvada, Colorado and diluted by MPRB staff to achieve the desired concentrations. ERA provided performance acceptance limits for the recovery of each analyte. These performance limits defined acceptable analytical results given the limitations of the United States Environmental Protection Agency (US EPA) approved and Standard Methods methodologies (US EPA Reports, 1980, 1985). The acceptance limits were based on data generated by laboratories in ERA's InterLab program and data from the US EPA and closely approximated the 95% confidence interval. If a laboratory failed a blind monthly performance standard all of the monthly data for that parameter were flagged as questionable. Laboratories were allowed ± 20% recovery for all parameters except soluble reactive phosphorus and total dissolved phosphorus data which were allowed ± 30% recovery due to the low phosphorus concentrations.

The contract laboratories provided minimum detection limits (MDL) and reporting limits (RL). The laboratory calculated the MDL based upon documented performance studies and the RL are two to five times the MDL. **Table 30-2** lists the reporting limits for analyses as provided by IRI.

RESULTS AND DISCUSSION

If the “blind” monthly performance standard failed to achieve the required percent recovery (±20%) and the error was greater than two times the reporting limit, the entire month’s data were flagged by underlining it. There were five data sets combined in March and August that were flagged in 2013. These include the March -conductivity, TKN, and TN, and in August –the conductivity and TSS.

Completeness

The data collected in 2013 was deemed to be complete. Missing data and improper analyses accounted for less than 1% of the samples collected. A minimum of 10% of the final data were checked by hand against the raw data sent by the laboratories to ensure there were no errors entering or transferring the data.

Representativeness

The 2013 lakes data were deemed to be representative of actual in-lake conditions. Samples were collected over the deepest point of each lake to create a profile at appropriate meter depths. The duration of monitoring, sampling frequency, site location, and depth intervals sampled met or exceeded the recommendations to collect representative data and to account for seasonal changes and natural variability (Wedepohl et al., 1990). Sample collection and handling followed established protocol for monitoring water quality as detailed in *Standard Methods for the Examination of Water and Wastewater* (2005). NPDES stormwater samples were collected in accordance with the Stormwater Monitoring Program Manual (MPRB, 2001).

Comparability

Between Years

The 2013 lakes data were deemed to be comparable to previous years' data. In reviewing box and whisker plots of total phosphorus, Secchi transparency, and chlorophyll-*a* data, reported values appeared to be consistent with values reported at the same times during the 2010 - 2011 monitoring seasons. The 2013 monitoring season was roughly comparable to the 2012 monitoring season. Stormwater data for 2013 appeared to be very comparable to other stormwater data, however, it should be noted that stormwater concentrations are highly variable.

Between Laboratories

To determine data comparability between laboratories lake samples were split in the field and shared with IRI, Minnehaha Creek Watershed District (MCWD), and Three Rivers Park District (TRPD). MCWD used RMB Environmental Laboratories, Detroit Lakes, MN as their laboratory and TRPD uses their own in-house laboratory. The 2013 lake split data set were deemed to be generally comparable to data analyzed by TRPD and MCWD as seen in **Table 30-3**. The MPRB shared "round-robin" format split samples with the participating laboratories from two sampling events on August 5th and September 23rd, 2013. The results from all agency split samples are summarized in **Table 30-3** and in **Figures 30-1** through **30-4**.

Data for a given parameter were deemed to be highly comparable if the laboratory split results for that parameter from all the laboratories had a coefficient of variation (CV) less than 20% and if reported values were consistent with past results. Generally if the CV between laboratories for a given parameter was more than 20% then the data set for that parameter was deemed to be moderately comparable. If a majority of the parameters tested for the data set had a laboratory outlier the comparability was deemed low. Care must be taken when interpreting these data at very low levels or near reporting limits. For example, the CV between 1 and 2 µg/L is 47%, but the CV between 10 and 11 µg/L is 7%. Both have a difference of 1 µg/L. In **Table 30-3** the SRP values reported below reporting limits did not have CV's calculated if more than two laboratories were below reporting limits.

In 2013 the TRPD SRP split data are of concern as they were the outliers in four of five samples. Also the MPRB Chl-*a* split data show its lab to be low in four out of seven samples. A fact finding effort should be undertaken to determine the sources of TRPD's SRP and MPRB's Chl-*a* errors.

The comparability of the inter-laboratory split sample within each of the parameters differed considerably. **Table 30-4** details the variability within parameters and lists the determined level of comparability for each. The comparability between years was determined by comparing 2013 values to previous year's data. The 2013 data set were somewhat comparable to previous years. The final CV calculated for SRP should not be used if many are below or near detection limit values.

Table 30-3. Summary of 2013 split sample results reported by IRI, MCWD, and TRPD.

Sample ID	Parameter	Units	Depth	Lake	MPRB	MCWD	TRPD	CV
1	Chla	mg/M3	0-2	Wirth	13	22	23	30%
2	Chla	mg/M3	0-2	STG	17	29	30	29%
3	Chla	mg/M3	0-2	LPI01T	3	4	5	27%
4	Chla	mg/M3	0-2	*Wirth*	4	15	20	62%
5	Chla	mg/M3	0-2	*WT-S*	8	20	21	43%
6	Chla	mg/M4	0-3	*ZM-B*	nc	1	nc	nc
7	Chla	mg/M3	0-2	*LAL01*	2	3	3	25%
8	TP	mg/l	0-2	Wirth	0.035	0.028	0.035	12%
9	TP	mg/l	7	Wirth	0.691	0.560	0.453	21%
10	TP	mg/l	0-2	STG	0.037	0.031	0.035	9%
11	TP	mg/l	4	STG	0.058	0.061	0.053	7%
12	TP	mg/l	8	STG	0.088	0.058	0.078	20%
13	TP	mg/l	0-2	LPI01T	0.023	0.015	0.023	23%
14	TP	mg/l	7.5	LPI01B	0.079	0.065	0.073	10%
15	TP	mg/l	0-2	AUB	0.182	0.177	0.167	4%
16	TP	mg/l	0-2	*Wirth*	0.035	0.028	0.032	11%
17	TP	mg/l	7	*Wirth*	1.30	1.25	0.448	48%
18	TP	mg/l	0-2	*WT-S*	0.070	0.087	0.047	30%
19	TP	mg/l	6	*WT-S*	0.074	0.067	0.047	22%
20	TP	mg/l	12	*ZM-B*	0.241	0.355	0.240	24%
21	TP	mg/l	0-2	*LAL01 T*	0.019	0.015	0.016	13%
22	TP	mg/l	13	*LAL01 13*	0.106	0.082	0.070	21%
23	SRP	mg/l	0-2	Wirth	0.005	0.003	0.008	47%
24	SRP	mg/l	7	Wirth	0.043	0.012	0.088	80%
25	SRP	mg/l	0	STG	0.004	0.003	0.010	67%
26	SRP	mg/l	4	STG	0.010	0.003	0.098	143%
27	SRP	mg/l	8	STG	0.037	0.033	0.067	41%
28	SRP	mg/l	0-2	LPI01T	0.003	0.003	0.008	62%
29	SRP	mg/l	7.5	LPI01B	0.009	0.003	0.009	49%
30	SRP	mg/l	0-2	AUB	0.049	0.003	0.059	81%
31	SRP	mg/l	0-2	*Wirth*	0.003	0.003	0.019	110%
32	SRP	mg/l	7	*Wirth*	0.014	0.022	0.044	58%
33	SRP	mg/l	0-2	*WT-S*	0.003	0.003	0.010	74%
34	SRP	mg/l	6	*WT-S*	0.009	0.003	0.008	48%
35	SRP	mg/l	12	*ZM-B*	0.058	0.081	0.068	17%
36	SRP	mg/l	0-2	*LAL01 T*	0.003	0.003	0.008	58%
37	SRP	mg/l	13	*LAL01 13*	0.027	0.031	0.043	25%
38	TN	mg/l	0-2	Wirth	0.500	0.499	0.690	20%
39	TN	mg/l	0-2	STG	0.992	1.36	1.10	16%
40	TN	mg/l	0-2	LPI01T	0.504	0.746	1.03	35%
41	TN	mg/L	0-2	AUB	1.46	1.52	1.67	7%
42	TN	mg/l	0-2	*Wirth*	0.550	0.663	0.570	10%
43	TN	mg/l	0-2	*WT-S*	1.64	1.86	1.75	6%
44	TN	mg/l	0-2	*ZM-B*	2.48	0.300	2.65	72%
45	TN	mg/l	0-2	*LAL01*	0.627	0.709	0.640	7%
46	Cl	mg/l	0-2	Wirth	152	141	0	87%
47	Cl	mg/l	7	Wirth	337	361	335	4%
48	Cl	mg/l	0-2	STG	68	66	66	1%
49	Cl	mg/l	4	STG	68	66	69	2%
50	Cl	mg/l	8	STG	63	69	69	5%
51	Cl	mg/l	0-2	LPI01T	23	29	32	17%
52	Cl	mg/l	7.5	LPI01B	23	31	32	17%
53	Cl	mg/l	0-2	*Wirth*	154	156	148	3%
54	Cl	mg/l	7	*Wirth*	340	363	340	4%
55	Cl	mg/l	0-2	*WT-S*	8	19	17	41%
56	Cl	mg/l	0-2	*LAL01 T*	53	54	50	4%

Notes: CV = Coefficient of Variation. Underlined data are less than values. nc = not calculated.

Table 30-4. 2013 comparability of parameters analyzed as a part of the inter-laboratory split sample program and compared to previous years' data. Values listed are the range and mean for the coefficient of variation between labs.

	Coefficient of Variation		Comparability	
Parameter	**2013 Range**	**2013 Mean %**	**Between labs**	**Between years**
Chl-*a*	25%-62%	36%	Low	Moderate
TP	4%-48%	18%	Moderate	Moderate
SRP	17%-143%	64%	Low	Moderate
TN	6%-72%	22%	Moderate	Moderate
Cl	1%-87%	17%	High	High

The split samples for chlorophyll-*a* were moderately comparable as seen in **Figure 30-1**. All laboratories used a spectrophotometer. In 2013 four chlorophyll-*a* lake data points had suspect samples. The outliers are sample ID numbers 1, 2, 4, and 5. The MPRB appears to be a consistent outlier. Further investigation will need to take place to understand the reasons why. Since there are no Chlorophyll-*a* standards, the MRPB should seriously consider using HPLC to determine the "true" Chlorophyll-*a* concentration of each sample. Chlorophyll-*a* concentrations can be extremely variable due to inherent sampling limitations and plankton patchiness as well as the difficulty in laboratory grinding and analysis. The average CV for chlorophyll-*a* was 36%.

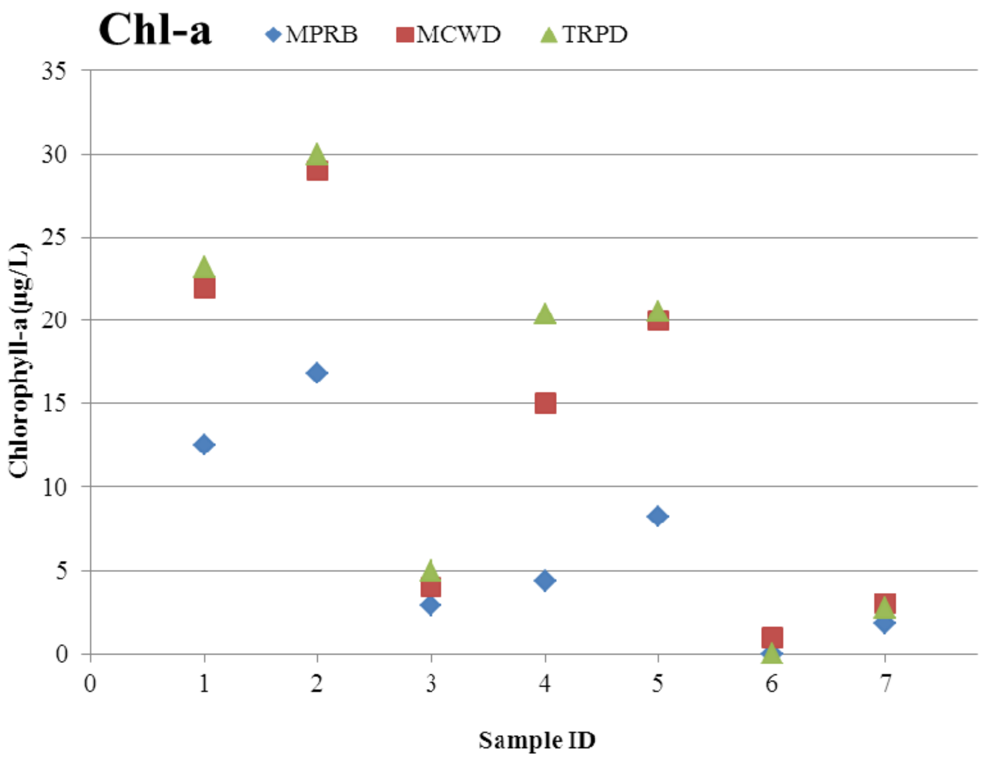


Figure 30-1. Plot of chlorophyll-*a* split sample results reported for 2013. See Table 30-3 to reference ID numbers with sample descriptions and results.

Total phosphorus splits were highly comparable as seen in **Figure 30-2**. Most of the samples were moderate to lower level samples but none were at detection limit. The two outliers were sample ID numbers 17 and 20, analyzed by TRPD and MCWD respectively. Phosphorus is an important and limiting aquatic nutrient and accuracy for this element is critical. The average CV for TP was 18%.

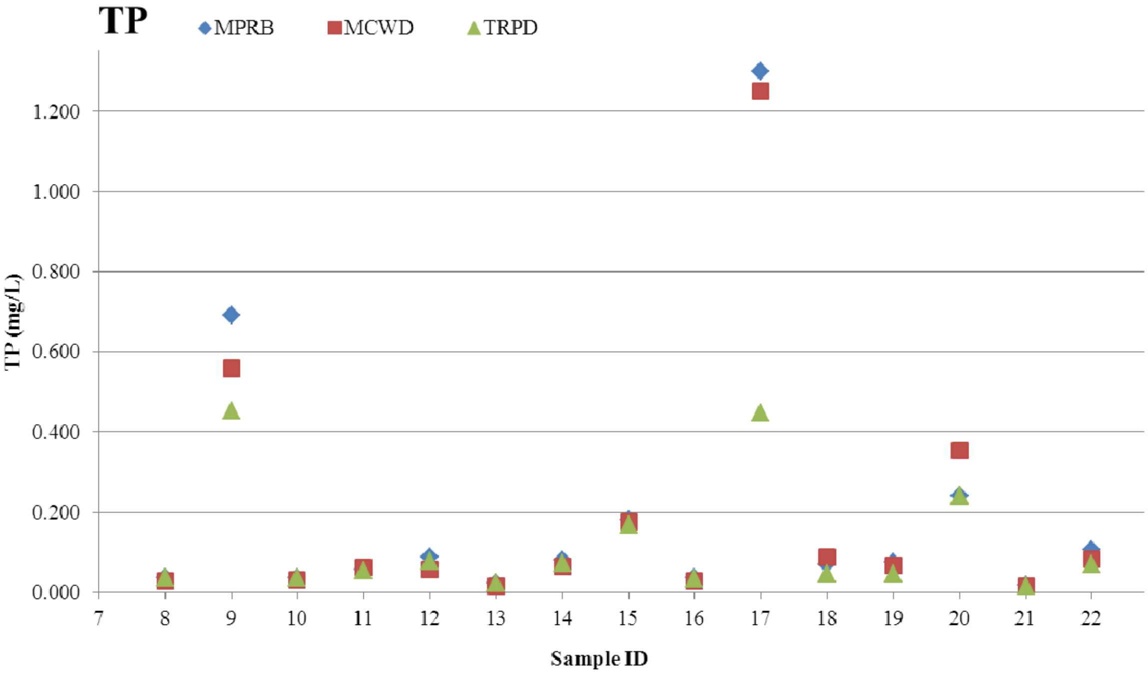


Figure 30-2. Scatter plot of total TP split sample results reported for 2013. See Table 30-3 to reference ID numbers with descriptions and results.

Many concentrations of the submitted SRP split samples were near lab reporting limits and a few analyses were reported at or near detection levels as seen in **Figure 30-3**. The data were graphed on a log scale for visibility. There were five outlier samples; ID numbers 24, 26, 27, 30, and 31. Four of the five outliers were analyzed by TRPD, and the remaining one by MCWD. IRI and MCWD (RMB laboratory) had a reporting limit of 0.003 mg/L. TRPD has a reporting limit of 0.006 mg/L. The split SRP data must be deemed of questionable comparability especially at concentrations below 0.006 mg/L. Users of these data must decide if this loss of resolution at low concentrations is of significant concern for any given data application. The average CV for SRP was 64%.

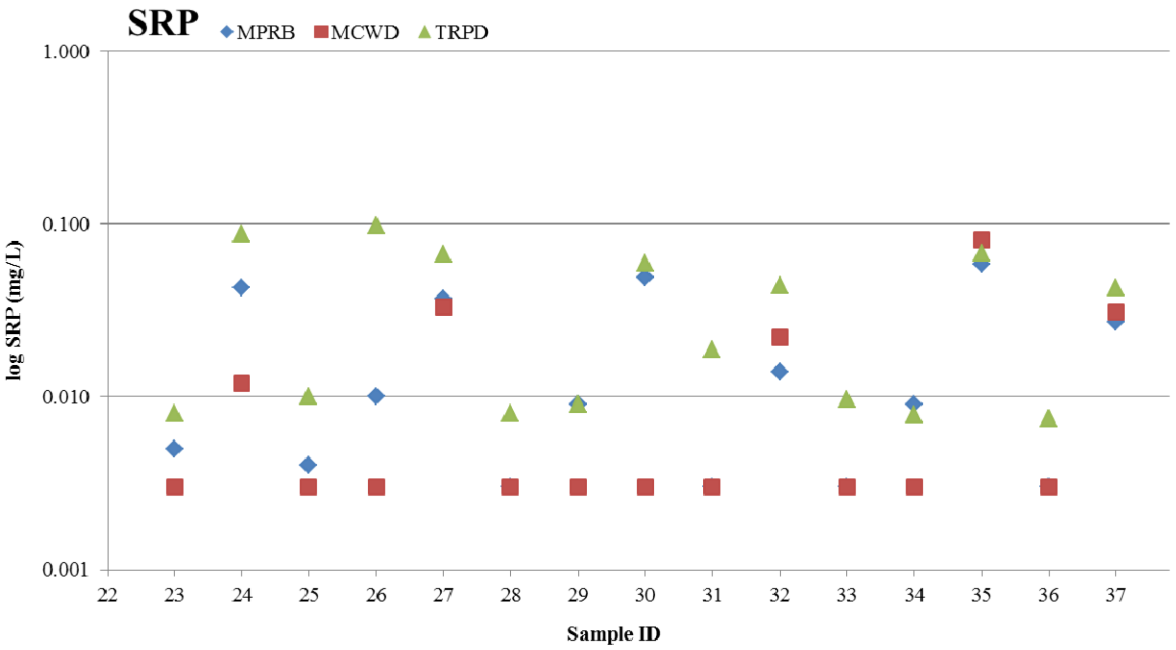


Figure 30-3. Scatter plot of SRP split sample results reported for 2013. See Table 30-3 to reference sample ID numbers with descriptions and results.

Total nitrogen splits were completed by IRI, TRPD and MCWD as seen in **Figure 30-4**. The significant outliers for TN were sample ID numbers 39 and 44, analyzed by MCWD. Sample number 40 had an equal spread among the labs but the error could not be determined. TRPD and IRI perform a persulfate digestion and MCWD (RMB laboratory) performs a sum of the nitrogen species TKN and NO_3NO_2. The average CV for TN was 22%.

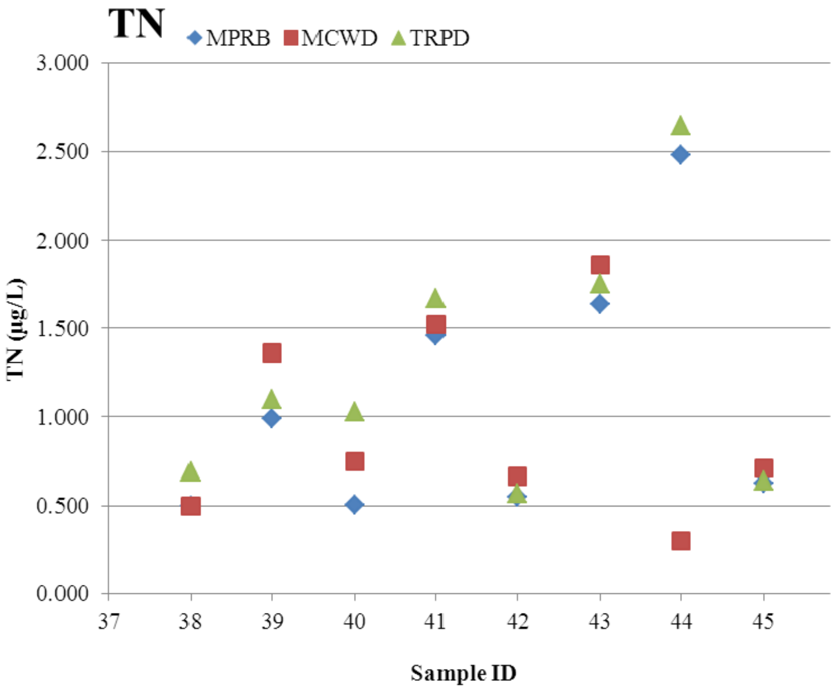


Figure 30-4. Scatter plot of TN split sample results reported for 2013. See Table 30-3 to reference ID numbers with descriptions and results.

Chloride splits were completed by IRI, TRPD and MCWD as seen in **Figure 30-5**. Sample ID numbers 46, 47, and 54 had outliers. Sample ID number 46 was a clear outlier analyzed by TRPD. Sample ID numbers 47 and 54 were slight outliers analyzed by MCWD. Chloride is an extremely stable test and there was generally little variability between laboratories. The average CV for chloride was 17%.

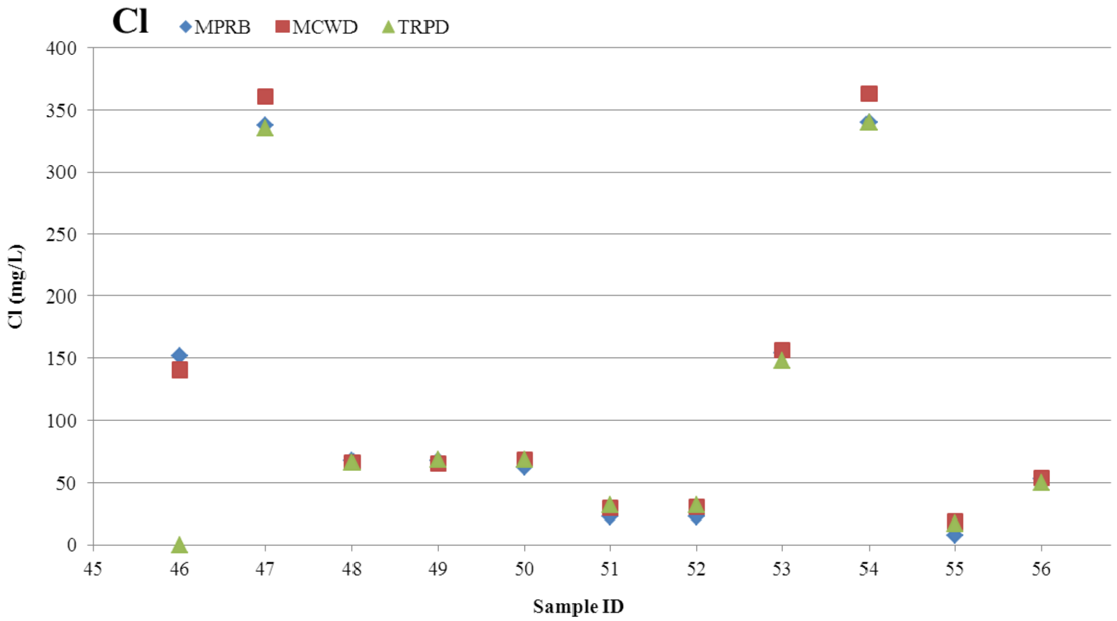


Figure 30-5. Scatter plot of Cl split sample results reported for 2013. See Table 30-3 to reference ID numbers with descriptions and results.

With the exception of chlorophyll-*a* and SRP, the split data show no laboratory as a consistent and significant outlier in the split samples. With the exception of SRP the data sets appear moderately comparable because all parameters had some outliers. Depending on the parameter, 2013 saw both more and less scatter among the splits than in 2012.

Precision

The first criterion used for assessing data precision was the relative percent difference (RPD) between duplicates. For reporting and calculation purposes, the average of duplicate samples was used.

Field Duplicates

Field duplicates test the reproducibility of field methods and also lake uniformity. **Table 30-5** summarizes the results from field duplicate samples in 2013. The goal is to have the average RPD for parameters to be 10% or less. When values are near the reporting limit the RPD calculations are skewed but most times the data are considered acceptable. There were ten sampling trip field duplicate failures of significance as defined by being greater than 20%.

- Isles (0-2M, 5/24/13) had TP (mg/L) values of 0.030 and 0.043 resulting in a RPD of 35%.
- Isles (5M, 5/24/13) had TP (mg/L) values of 0.099 and 0.062 resulting in a RPD of 46%.

- Harriet (6 M, 6/18/13) had SRP(mg/L) values of 0.011 and 0.019 resulting in a RPD of 53%.
- Harriet (20M, 6/18/13) had SRP, TP, and Cl (mg/L) values of 0.188 and 0.005, 0.210 and 0.033, 166 and 126 resulting in a RPD of 190%, 145%, and 27% all respectively.
- Diamond (0M, 7/10/13) had Chl-*a*, TP, and SRP (mg/L) values of 18.7 and 23.6, 0.145 and 0.201, 0.007 and 0.009 resulting in a RPD of 23%, 32%, and 25% all respectively.
- Isles (0-2M, 9/9/13) had a Sulfate values of 9.7 and 5.7 resulting in a RPD of 52%.

The difference in some samples may also be the result of lake or pond sediment being disturbed by a boat anchor , water sampling device such as the Kemmerer sampler, or particles in the epilimnion. Further investigation should look into the cause(s). Finally, the Diamond 7/10/13 SRP values of 0.007 and 0.009 a RPD of 25% should not be considered a true duplicate failure but rather a statistical anomaly.

Lab Duplicates
IRI reported all internal QA/QC results to the MPRB. The reported RPD values for duplicate analyses were within acceptance limits. All duplicate analyses were deemed acceptable.

Table 30-5. 2013 summary of field duplicate sample results and acceptability for IRI Laboratory.

Parameter	Units	Average Relative % Difference	Average Range	Std. Dev. (estimated)	Acceptable
Chl-a	µg/L	9.14	1.24	1.10	Yes
Silica	mg/L	1.71	0.063	0.056	Yes
TP	mg/L	12.9	0.013	0.012	No
SRP	mg/L	10.0	0.007	0.007	No
TKN	mg/L	5.39	0.088	0.078	Yes
TN	mg/L	3.64	0.040	0.035	Yes
NO_2NO_3	mg/L	4.18	0.010	0.009	Yes
Alk	mg/L	1.33	1.33	1.18	Yes
Hard	mg/L	2.77	2.67	2.36	Yes
Cl	mg/L	3.37	5.46	4.84	Yes

Performance Evaluation Samples
The second criterion for assessing data precision was percent recovery of performance evaluation samples. Performance evaluation standards were purchased from ERA. MPRB water quality staff used prepared standards mixed to “real world” concentrations for submission to the contract laboratory. The “rule of sensibility” was used to evaluate the data and whether to flag it or not. **Table 30-6** and **Figures 30-6** through **30-11** summarize the performance evaluation sample results for each parameter. Of the performance parameters tested none fell outside the recovery limits. No data points (parameters) were flagged in 2013. All performance evaluation samples fell within acceptance limits.

Table 30-6. Summary of performance evaluation samples analyzed by IRI in 2013. Results in bold are outside acceptance limits.

Sample ID	Date	Parameter	Calc. Value	IRI Value	% Recovery
1	2/12/2013	**Alk**	46.9	47.0	100%
2	4/25/2013	**Alk**	69.4	66.0	95%
3	5/13/2013	**Alk**	71.5	67.0	94%
4	6/7/2013	**Alk**	32.1	30.0	93%
5	7/12/2013	**Alk**	71.6	68.0	95%
6	8/8/2013	**Alk**	109	101	93%
7	9/12/2013	**Alk**	34.0	31.0	91%
8	10/10/2013	**Alk**	41.2	39.0	95%
9	2/12/2013	**BOD5C**	6.46	6.80	105%
10	4/25/2013	**BOD5C**	13.7	13.3	97%
11	5/13/2013	**BOD5C**	13.7	12.4	91%
12	6/7/2013	**BOD5C**	13.7	13.4	98%
13	7/12/2013	**BOD5C**	13.7	12.9	94%
14	8/8/2013	**BOD5C**	13.7	12.5	91%
15	9/12/2013	**BOD5C**	6.18	7.20	117%
16	10/10/2013	**BOD5C**	6.18	6.90	112%
17	2/12/2013	**Cl**	53.0	54.9	104%
18	4/25/2013	**Cl**	75.2	71.1	95%
19	5/13/2013	**Cl**	85.3	84.0	98%
20	6/7/2013	**Cl**	57.5	65.0	113%
21	7/12/2013	**Cl**	84.4	87.0	103%
22	8/8/2013	**Cl**	60.4	57.4	95%
23	9/12/2013	**Cl**	59.9	55.9	93%
24	10/10/2013	**Cl**	104	104	100%
25	2/12/2013	**Cond**	366	365	100%
26	4/25/2013	**Cond**	483	508	105%
27	5/13/2013	**Cond**	492	480	98%
28	6/7/2013	**Cond**	322	314	98%
29	7/12/2013	**Cond**	519	530	102%
30	8/8/2013	**Cond**	409	400	98%
31	9/12/2013	**Cond**	309	321	104%
32	10/10/2013	**Cond**	526	524	100%
33	2/12/2013	**Cu**	520	560	108%
34	4/25/2013	**Cu**	147	140	95%
35	5/13/2013	**Cu**	147	150	102%
36	6/7/2013	**Cu**	147	160	109%
37	7/12/2013	**Cu**	147	160	109%
38	8/8/2013	**Cu**	147	150	102%
39	9/12/2013	**Cu**	314	320	102%
40	10/10/2013	**Cu**	314	340	108%

Table 30-6. (continued) Summary of performance evaluation samples analyzed by IRI in 2013. Results in bold are outside acceptance limits.

Sample ID	Date	Parameter	Calc. Value	IRI Value	% Recovery
41	4/25/2013	**Ecoli -Quarterly**	1070(537-2120)	980	100%
42	4/25/2013	**Ecoli -Quarterly**	<1	<1	100%
43	6/7/2013	**Ecoli -Quarterly**	96.2 (47-194)	83	100%
44	6/7/2013	**Ecoli -Quarterly**	<1	<1	100%
45	8/8/2013	**Ecoli -Quarterly**	1650 (832-3270)	1553	100%
46	8/8/2013	**Ecoli -Quarterly**	<1	<1	100%
47	2/12/2013	**NH3**	1.62	1.72	106%
48	4/25/2013	**NH3**	3.18	3.12	98%
49	5/13/2013	**NH3**	3.18	3.25	102%
50	6/7/2013	**NH3**	3.18	3.21	101%
51	7/12/2013	**NH3**	3.18	3.20	101%
52	8/8/2013	**NH3**	3.18	3.29	103%
53	9/12/2013	**NH3**	1.04	1.08	104%
54	10/10/2013	**NH3**	1.04	1.12	108%
55	2/12/2013	**Nox**	3.02	2.87	95%
56	4/25/2013	**Nox**	1.73	1.69	98%
57	5/13/2013	**Nox**	1.73	1.82	105%
58	6/7/2013	**Nox**	1.73	1.79	104%
59	7/12/2013	**Nox**	1.73	1.74	101%
60	8/8/2013	**Nox**	1.73	1.66	96%
61	9/12/2013	**Nox**	7.24	8.57	118%
62	10/10/2013	**Nox**	7.24	7.84	108%
63	2/12/2013	**Ortho-p**	0.053	0.055	103%
64	4/25/2013	**Ortho-p**	0.047	0.048	103%
65	5/13/2013	**Ortho-p**	0.047	0.047	101%
66	6/7/2013	**Ortho-p**	0.023	0.019	83%
67	7/12/2013	**Ortho-p**	0.023	0.023	100%
68	8/8/2013	**Ortho-p**	0.023	0.021	91%
69	9/12/2013	**Ortho-p**	0.026	0.027	104%
70	10/10/2013	**Ortho-p**	0.026	0.027	104%
71	2/12/2013	**Pb**	7.92	8.00	101%
72	4/25/2013	**Pb**	33.7	35.0	104%
73	5/13/2013	**Pb**	33.7	34.0	101%
74	6/7/2013	**Pb**	33.7	36.0	107%
75	7/12/2013	**Pb**	33.7	34.0	101%
76	8/8/2013	**Pb**	33.7	32.0	95%
77	9/12/2013	**Pb**	35.5	36.0	101%
78	10/10/2013	**Pb**	35.5	34.0	96%

Table 30-6. (continued) Summary of performance evaluation samples analyzed by IRI in 2013. Results in bold are outside acceptance limits.

Sample ID	Date	Parameter	Calc. Value	IRI Value	% Recovery
79	2/12/2013	**SO4**	21.9	19.1	87%
80	4/25/2013	**SO4**	39.1	40.8	104%
81	5/13/2013	**SO4**	30.3	33.1	109%
82	6/7/2013	**SO4**	19.0	18.4	97%
83	7/12/2013	**SO4**	35.8	39.8	111%
84	8/8/2013	**SO4**	5.57	<15	100%
85	9/12/2013	**SO4**	9.52	<15	100%
86	10/10/2013	**SO4**	34.8	36.6	105%
87	2/12/2013	**SRP**	0.053	0.055	103%
88	4/25/2013	**SRP**	0.047	0.047	101%
89	5/13/2013	**SRP**	0.047	0.046	99%
90	6/7/2013	**SRP**	0.023	0.022	96%
91	7/12/2013	**SRP**	0.023	0.022	96%
92	8/8/2013	**SRP**	0.023	0.021	91%
93	9/12/2013	**SRP**	0.026	0.027	104%
94	10/10/2013	**SRP**	0.026	0.027	104%
95	2/12/2013	**TDP**	0.053	0.053	99%
96	4/25/2013	**TDP**	0.047	0.047	101%
97	5/13/2013	**TDP**	0.047	0.047	101%
98	6/7/2013	**TDP**	0.023	0.022	96%
99	7/12/2013	**TDP**	0.023	0.023	100%
100	8/8/2013	**TDP**	0.023	0.024	104%
101	9/12/2013	**TDP**	0.026	0.028	108%
102	10/10/2013	**TDP**	0.026	0.027	104%
103	2/12/2013	**TDS**	223	223	100%
104	4/25/2013	**TDS**	342	355	104%
105	5/13/2013	**TDS**	343	342	100%
106	6/7/2013	**TDS**	198	197	99%
107	7/12/2013	**TDS**	358	346	97%
108	8/8/2013	**TDS**	346	349	101%
109	9/12/2013	**TDS**	187	180	96%
110	10/10/2013	**TDS**	319	313	98%
111	2/12/2013	**TKN**	1.09	1.11	102%
112	4/25/2013	**TKN**	1.16	1.18	102%
113	5/13/2013	**TKN**	1.16	1.14	99%
114	6/7/2013	**TKN**	1.16	0.939	81%
115	7/12/2013	**TKN**	1.16	1.08	93%
116	8/8/2013	**TKN**	1.16	1.18	102%
117	9/12/2013	**TKN**	5.06	5.19	103%
118	10/10/2013	**TKN**	5.06	5.17	102%

Table 30-6. (continued) Summary of performance evaluation samples analyzed by IRI in 2013. Results in bold are outside acceptance limits.

Sample ID	Date	Parameter	Calc. Value	IRI Value	% Recovery
119	2/12/2013	TN	1.09	1.16	106%
120	4/25/2013	TN	1.16	1.06	92%
121	5/13/2013	TN	1.16	1.06	92%
122	6/7/2013	TN	1.16	1.26	109%
123	7/12/2013	TN	1.16	1.00	87%
124	8/8/2013	TN	1.16	0.983	85%
125	9/12/2013	TN	5.06	5.15	102%
126	10/10/2013	TN	5.06	5.01	99%
127	2/12/2013	Total Hardness	154	154	100%
128	4/25/2013	Total Hardness	117	112	96%
129	5/13/2013	Total Hardness	120	112	93%
130	6/7/2013	Total Hardness	77.7	76.0	98%
131	7/12/2013	Total Hardness	308	288	94%
132	8/8/2013	Total Hardness	215	192	89%
133	9/12/2013	Total Hardness	362	344	95%
134	10/10/2013	Total Hardness	178	172	97%
135	2/12/2013	TP01	0.239	0.237	99%
136	4/25/2013	TP01	0.173	0.164	95%
137	5/13/2013	TP01	0.173	0.166	96%
138	6/7/2013	TP01	0.173	0.187	108%
139	7/12/2013	TP01	0.173	0.162	94%
140	8/8/2013	TP01	0.173	0.161	93%
141	9/12/2013	TP01	0.172	0.172	100%
142	10/10/2013	TP01	0.172	0.176	102%
143	2/12/2013	TP02	0.954	0.990	104%
144	4/25/2013	TP02	0.692	0.722	104%
145	5/13/2013	TP02	0.692	0.660	95%
146	6/7/2013	TP02	0.692	0.741	107%
147	7/12/2013	TP02	0.689	0.689	100%
148	8/8/2013	TP02	0.692	0.660	95%
149	9/12/2013	TP02	0.688	0.677	98%
150	10/10/2013	TP02	0.688	0.740	108%
151	2/12/2013	TSS	43.9	43.3	99%
152	4/25/2013	TSS	58.6	50.0	85%
153	5/13/2013	TSS	31.2	30.0	96%
154	6/7/2013	TSS	65.0	60.0	92%
155	7/12/2013	TSS	62.9	56.0	89%
156	8/8/2013	TSS	58.8	52.7	90%
157	9/12/2013	TSS	75.5	72.0	95%
158	10/10/2013	TSS	65.1	64.0	98%

Table 30-6. (continued) Summary of performance evaluation samples analyzed by IRI in 2013. Results in bold are outside acceptance limits.

Sample ID	Date	Parameter	Calc. Value	IRI Value	% Recovery
159	2/12/2013	**Zn**	568	660	116%
160	4/25/2013	**Zn**	216	220	102%
161	5/13/2013	**Zn**	216	220	102%
162	6/7/2013	**Zn**	216	230	107%
163	7/12/2013	**Zn**	216	220	102%
164	8/8/2013	**Zn**	216	230	107%
165	9/12/2013	**Zn**	676	630	93%
166	10/10/2013	**Zn**	676	670	99%

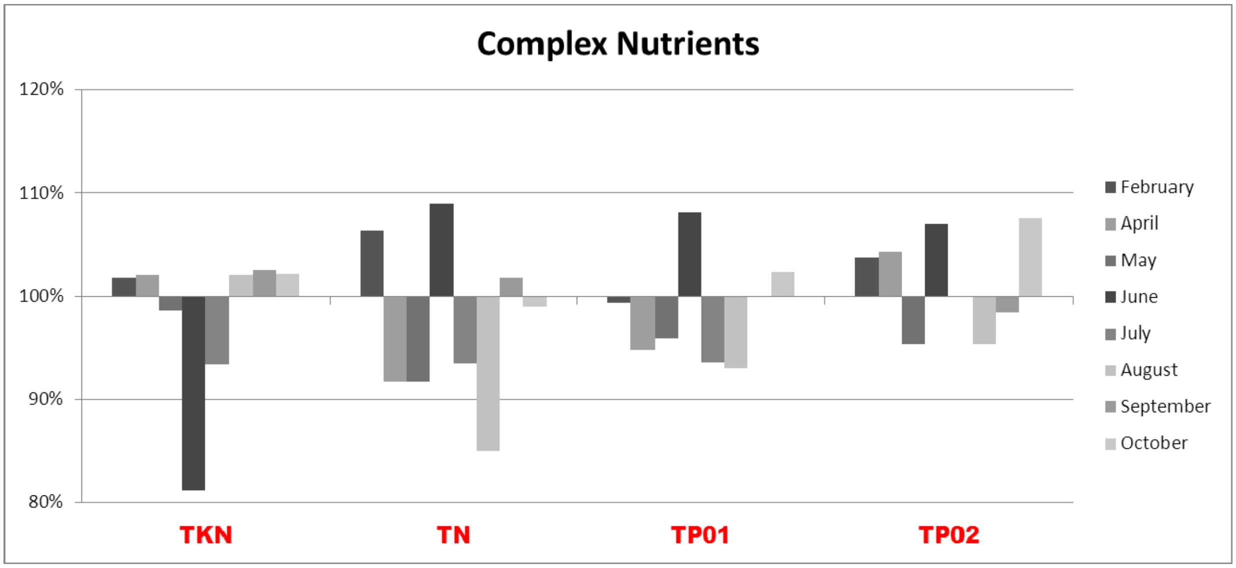


Figure 30-6. Bar chart of reported percent recoveries for (TKN, TN, TP01, and TP02) performance evaluation samples in 2013.

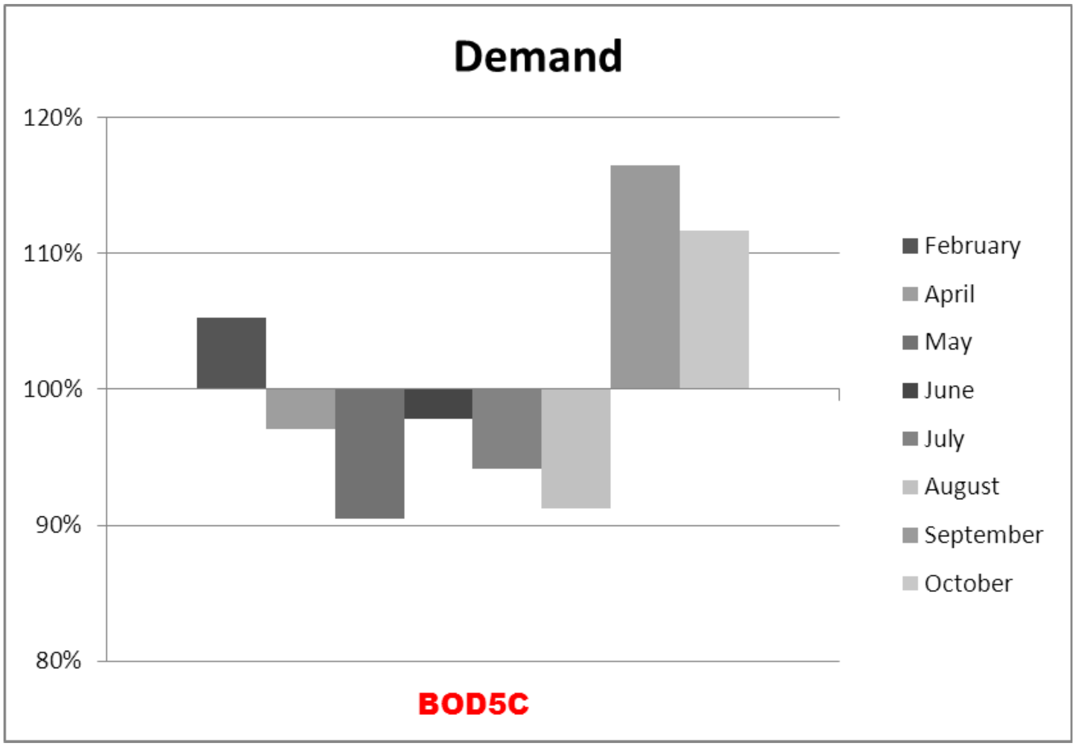


Figure 30-7. Bar chart of reported percent recoveries for (BOD5C) performance evaluation samples in 2013.

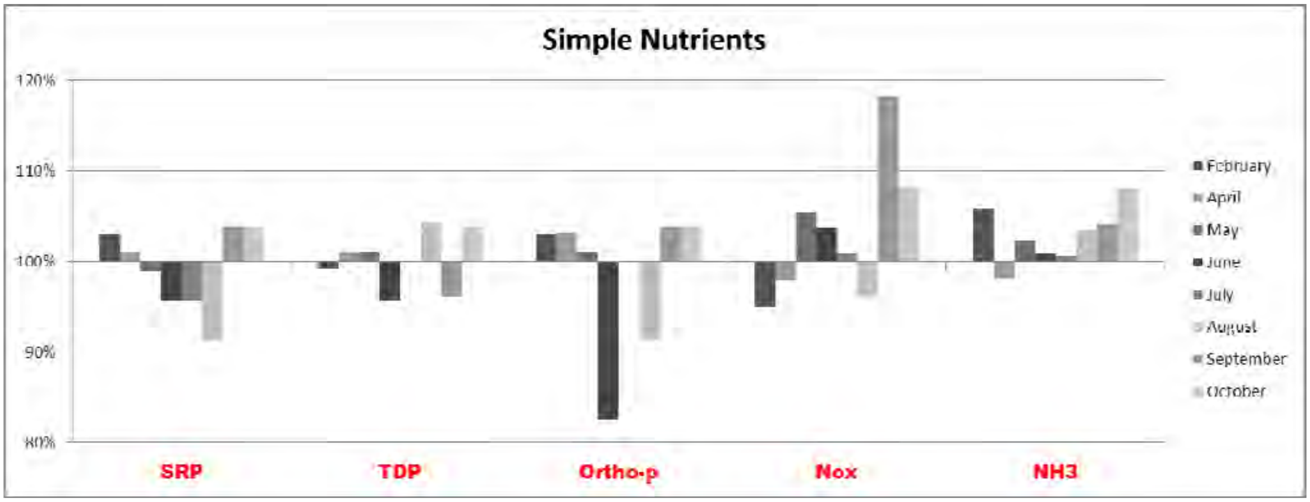


Figure 30-8. Bar chart of reported percent recoveries for (SRP, TDP, Ortho-p, NO_x, and NH_3) performance evaluation samples in 2013.

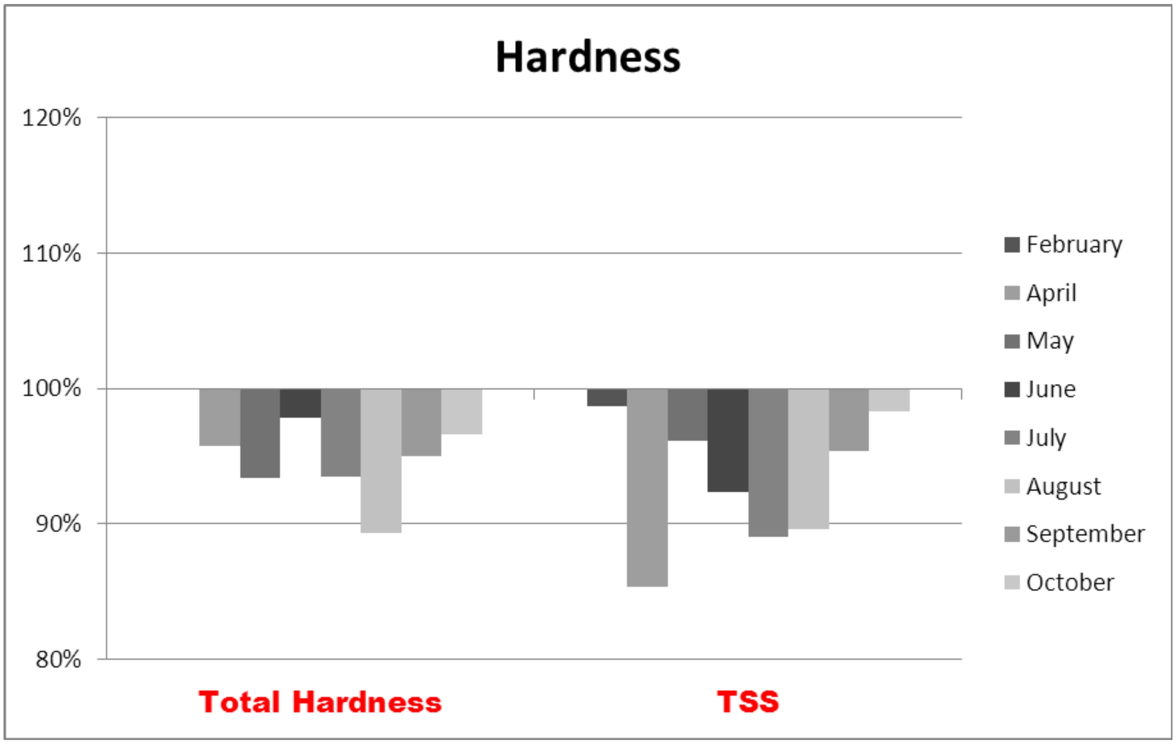


Figure 30-9. Bar chart of reported percent recoveries for (Total Hardness and TSS) performance evaluation samples in 2013.

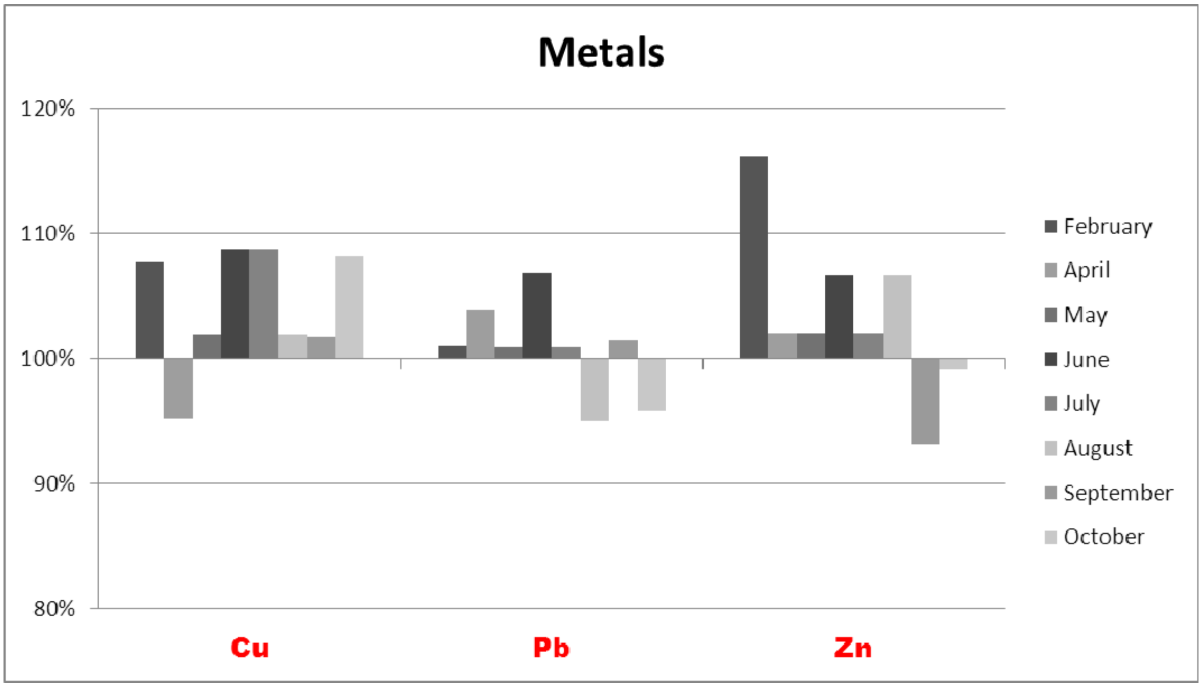


Figure 30-10. Bar chart of reported percent recoveries for (Cu, Pb, and Zn) performance evaluation samples in 2013.

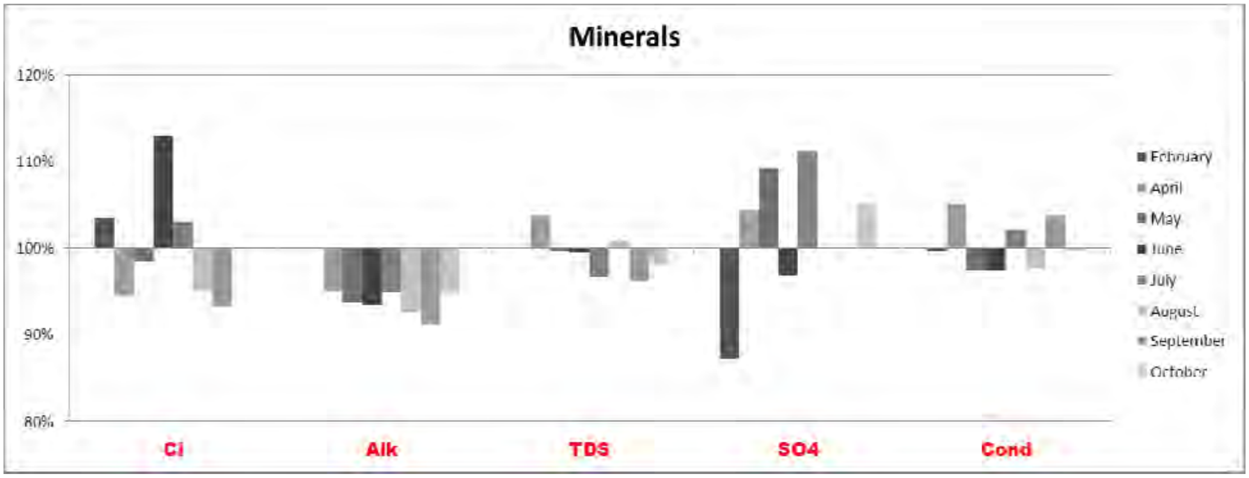


Figure 30-11. Bar chart of reported percent recoveries for (Cl, Alk, TDS, SO_4, and Cond.) performance evaluation samples in 2013.

All of the performance evaluation standards were acceptable for all months. Alkalinity, chloride, hardness, pH, TDS, and TSS are pre-made and are the only standards that do not require dilution. The remaining standards were diluted before they were submitted to the lab.

E. coli standards were acceptable. The performance acceptance limits for *E coli* supplied by ERA are much wider than for the other parameters, (+/- 50%). The coliform standards are shipped directly to the (MPRB laboratory) IRI from ERA.

SRP and TDP performance evaluation samples were mixed to low concentrations approximately 10-20 times the minimum detection limit. *Standard Methods* (2005) recommends that performance evaluation samples be mixed to a minimum concentration of 5 times the minimum detection limit. Because of the low concentrations the acceptance limit for SRP and TDP were widened from the recommended 80-120% range to 70-130% recovery. All SRP samples were acceptable in both the 70-130% and 80-120% range.

No data were flagged in 2013.

Analysis of Equipment Blanks and Field Blanks

Equipment blanks were run for lake water and stormwater sampling equipment. Results from lake and stormwater equipment blanks for 2013 yielded non-detects for all parameters. The 2013 results from the bottle/field blanks which were carried in the field unopened yielded non-detects for all parameters. Reagent blanks run by IRI laboratories during batch analyses resulted in no detectable levels for all parameters analyzed.

Recovery of Known Additions and Internally Supplied Standard Solutions

All of the recovery values for spike samples (known additions) reported by IRI were within acceptance limits. All of the reported recoveries for internally supplied standards of known concentration were within acceptance limits.

FINAL ASSESSMENT OF DATA USABILITY

Table 30-7 lists the overall completeness, representativeness, comparability, and precision determined for the 2013 data by parameter. All additional parameters not analyzed by IRI and collected in the field (dissolved oxygen, temperature, conductivity, pH, and Secchi transparency) were deemed to be fully usable. These measurements followed standard methods and protocols for collection and daily equipment calibration.

The 2013 data designated as “questionable usability” may still meet the data quality needs of some analyses. Users of these data should assess if the data quality indicators discussed in this document meet their needs. Much of the data designated as questionably usable are categorized as such because of a missed performance evaluation standard or split samples with low comparability.

The parameters listed on **Table 30-7** as questionably usable are only so for the months that they failed monthly performance standards or for split comparability. No parameters in 2013 failed performance standards. When reviewing the monthly performance samples the “rule of sensibility” must be applied and percent recovery must be viewed in relation to the values (low or high), stability of the test and multiple of the reporting limit (2X) used to qualify the data.

Table 30-7. Summary of 2013 data usability by parameter. ‘+’ denotes that acceptance criteria were met, ‘○’ denotes that some of the data were of questionable usability, ‘+’ denotes that data were not within acceptable range.

Parameter	Completeness (<5% missing data)	Representativeness (representative of natural samples)	Comparability (splits, 2013 data)	Precision (lab field dups, performance)
Alkalinity	+	+	+	+
Ammonia	+	+	+	+
BOD 5 day	+	+	+	+
Conductivity	+	+	+	+
Chloride	+	+	+	+
Chlorophyll-*a*	+	+	+	+
Copper	+	+	+	+
E. coli	+	+	+	+
Hardness	+	+	+	+
Lead	+	+	+	+
Nitrate+Nitrite	+	+	+	+
Ortho-P	+	+	+	+
pH	+	+	+	+
Silica	+	+	+	+
Soluble Reactive Phosphorus	+	+	○	○
Sulfate	+	+	+	+
Total Dissolved Phosphorus	+	+	+	+
Total Dissolved Solids	+	+	+	+
Total Kjeldahl Nitrogen	+	+	○	+
Total Nitrogen	+	+	○	+
Total Phosphorus	+	+	+	○
Total Suspended Solids	+	+	+	+
Zinc	+	+	+	+

31. ADDITIONAL SOURCES OF WATER QUALITY INFORMATION

Minneapolis Park and Recreation Board

Water Quality Homepage
https://www.minneapolisparks.org/park_care__improvements/water_resources
612.230.6400

City of Minneapolis

Storm and Surface Water Management Website
http://www.ci.minneapolis.mn.us/stormwater/

Results Minneapolis
Lake water quality
http://www.ci.minneapolis.mn.us/results/env/waterquality

Minneapolis Sustainability Report: Greenprint
Online environmental and sustainability indicators
http://www.ci.minneapolis.mn.us/sustainability/reports/sustainability_minneapolisgreenprint

Watershed Management Organizations

Bassett Creek Watershed Management Commission
http://www.bassettcreekwmo.org/

Minnehaha Creek Watershed District
http://www.minnehahacreek.org/
952.471.0590

Mississippi Watershed Management Organization
http://www.mwmo.org/
651-287-0948

Shingle Creek Watershed Management Commission
http://www.shinglecreek.org/
763-553-1144

Hennepin County or Metro Resources

Hennepin County Environmental Services
http://www.hennepin.us/residents#environment
612.348.3777

Minnesota Wetland Health Evaluation Project (WHEP)
http://www.mnwhep.org/

Metropolitan Council – Environmental Services
http://www.metrocouncil.org/environment/environment.htm
651.602.1000

State of Minnesota Resources

Minnesota Department of Natural Resources
Information on lake surveys, maps, fish stocking, fish advisories and more.
http://www.dnr.state.mn.us/lakefind/
651.296.6157

Aquatic Invasive Species
http://www.dnr.state.mn.us/invasives/index_aquatic.html

Minnesota Pollution Control Agency
Information on environmental monitoring, clean-up, and more.
http://www.pca.state.mn.us/water/index.html
651.296.6300

Minnesota Department of Health
http://www.health.state.mn.us/

Minnesota Lake Superior Beach Monitoring Program
http://www.mnbeaches.org

Minnesota Department of Agriculture – Water & Land
http://www.mda.state.mn.us/protecting.aspx
651.297.2200

Minnesota Extension Service
http://www.extension.umn.edu/

Minnesota Sea Grant
http://www.seagrant.umn.edu

US Federal Government

US Army Corps of Engineers St. Paul District
http://www.mvp-wc.usace.army.mil/

US Geological Survey – Minnesota
Stream data and links to the national website
http://mn.water.usgs.gov/
763.783.3100

US Geological Survey – Nonindigenous Aquatic Species
Information and maps of invasive aquatic plants and animals
http://nas.er.usgs.gov/default.aspx

Other Resources

Minnesota Climatology Working Group
http://climate.umn.edu/

Ice On/Out Information
From Environment Canada
https://www.naturewatch.ca/icewatch/

Midwest Invasive Plant Network
http://www.mipn.org

Minnesota Invasive Species Advisory Council
http://www.mda.state.mn.us/misac/

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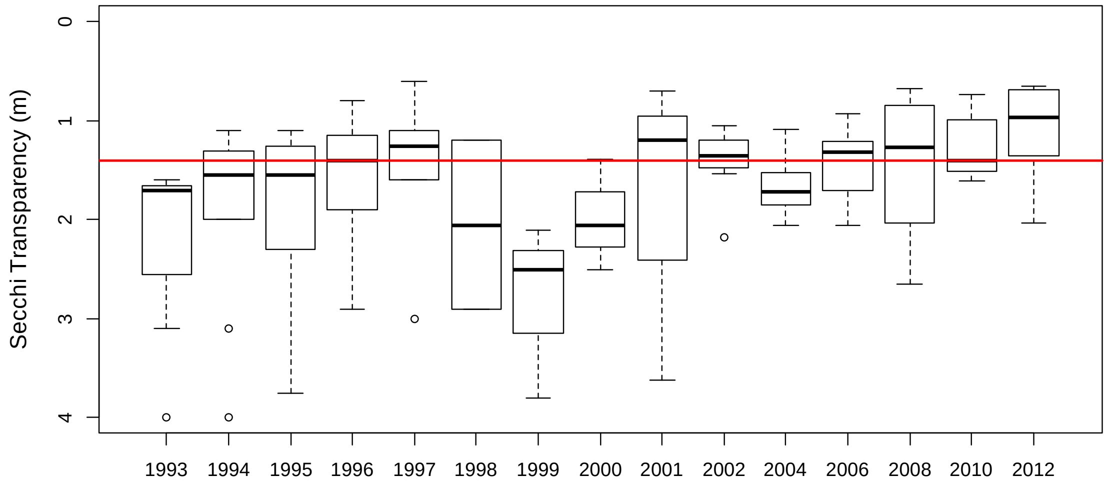
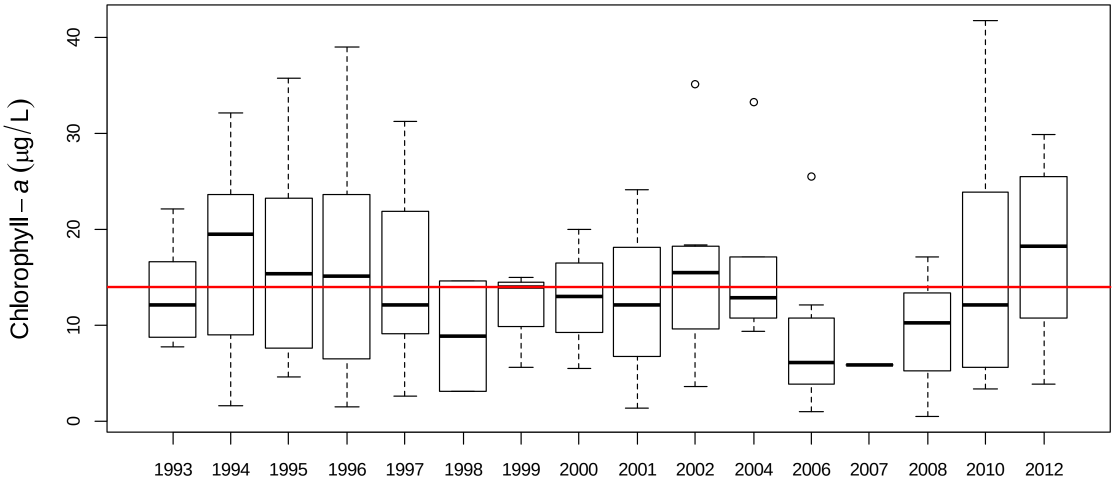
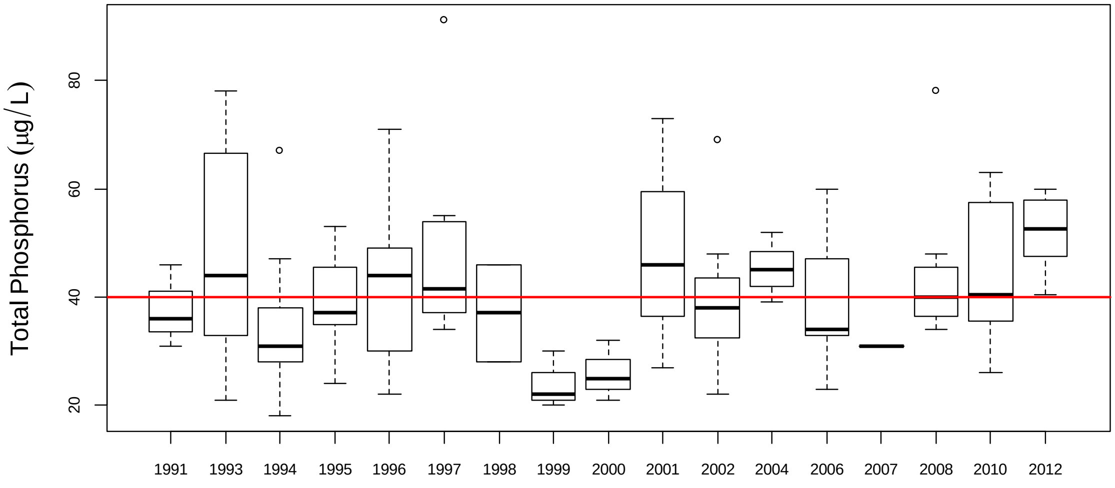
APPENDIX A

This section contains box-and-whisker plots for each of the regularly monitored Minneapolis lakes for the entire period of record. A detailed explanation of box-and-whisker plots can be found in **Section 1**.

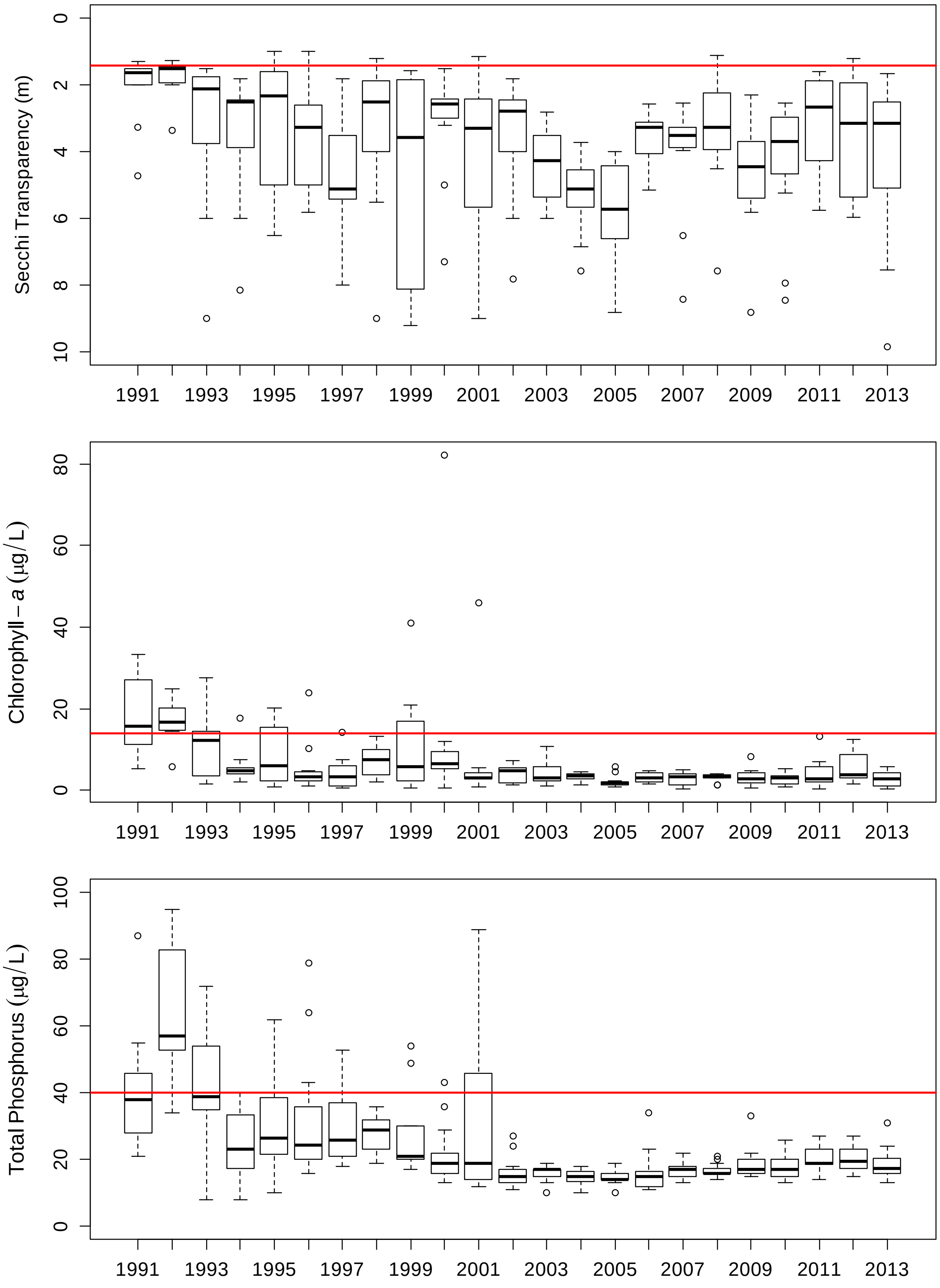
Brownie Lake 1991-2012 – note different year span on TP graph.



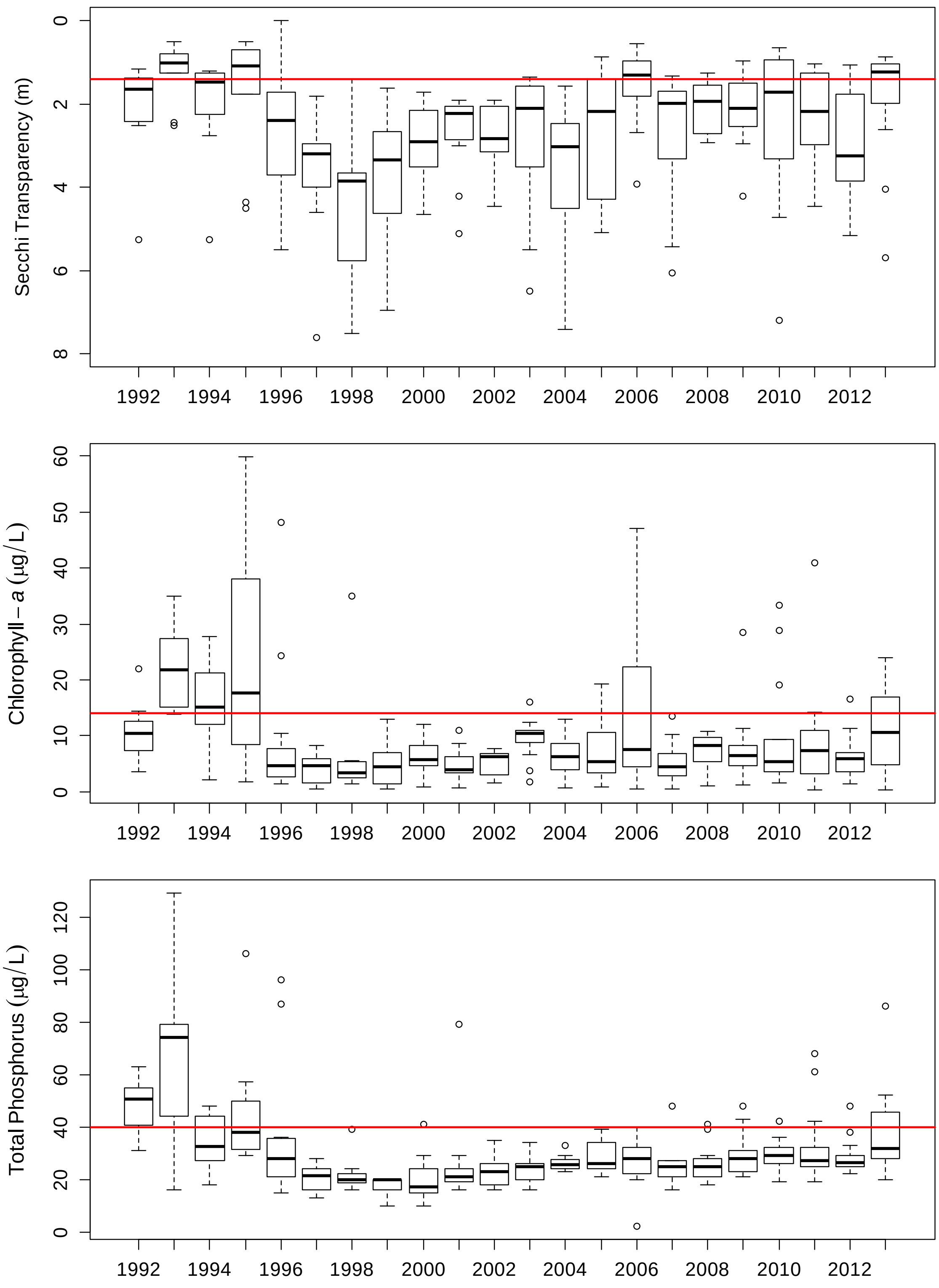




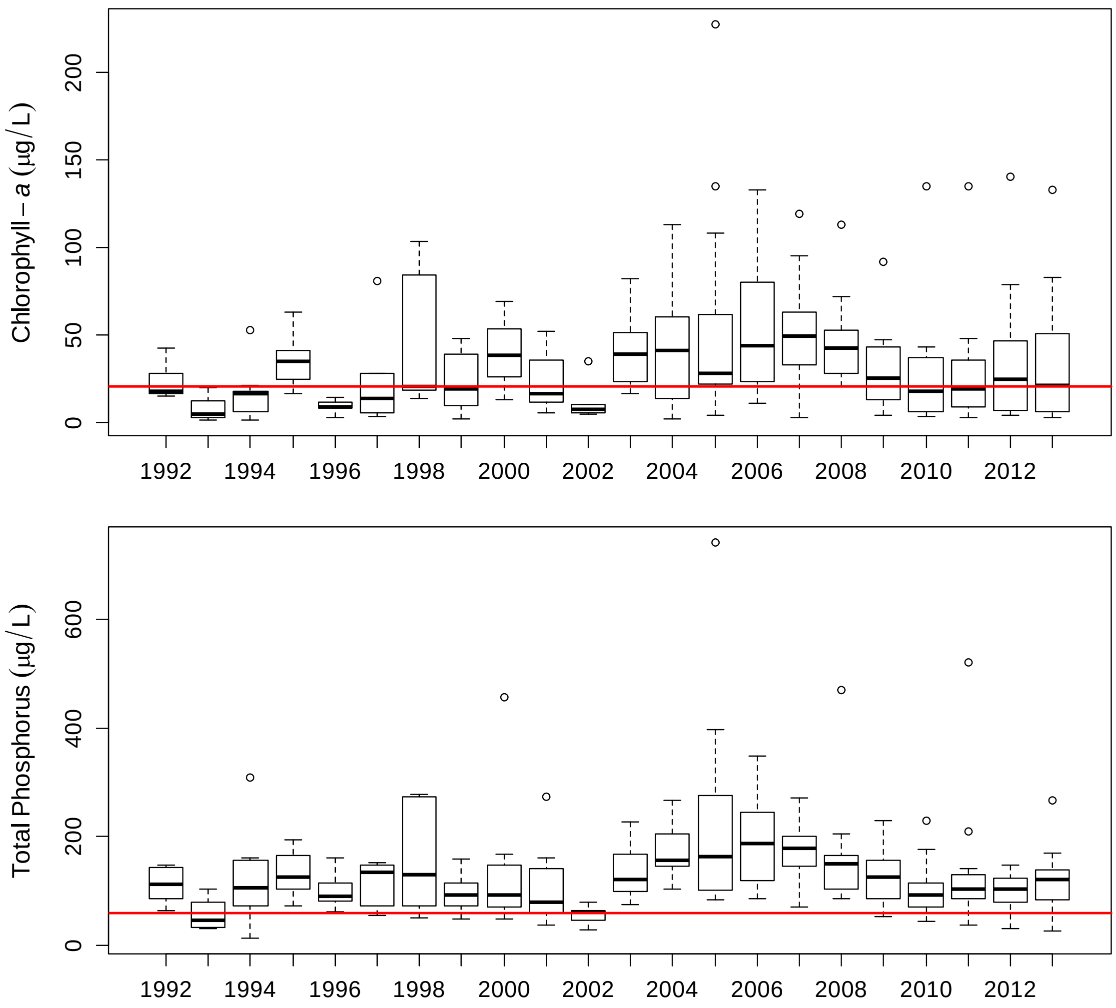
Lake Calhoun 1991-2013



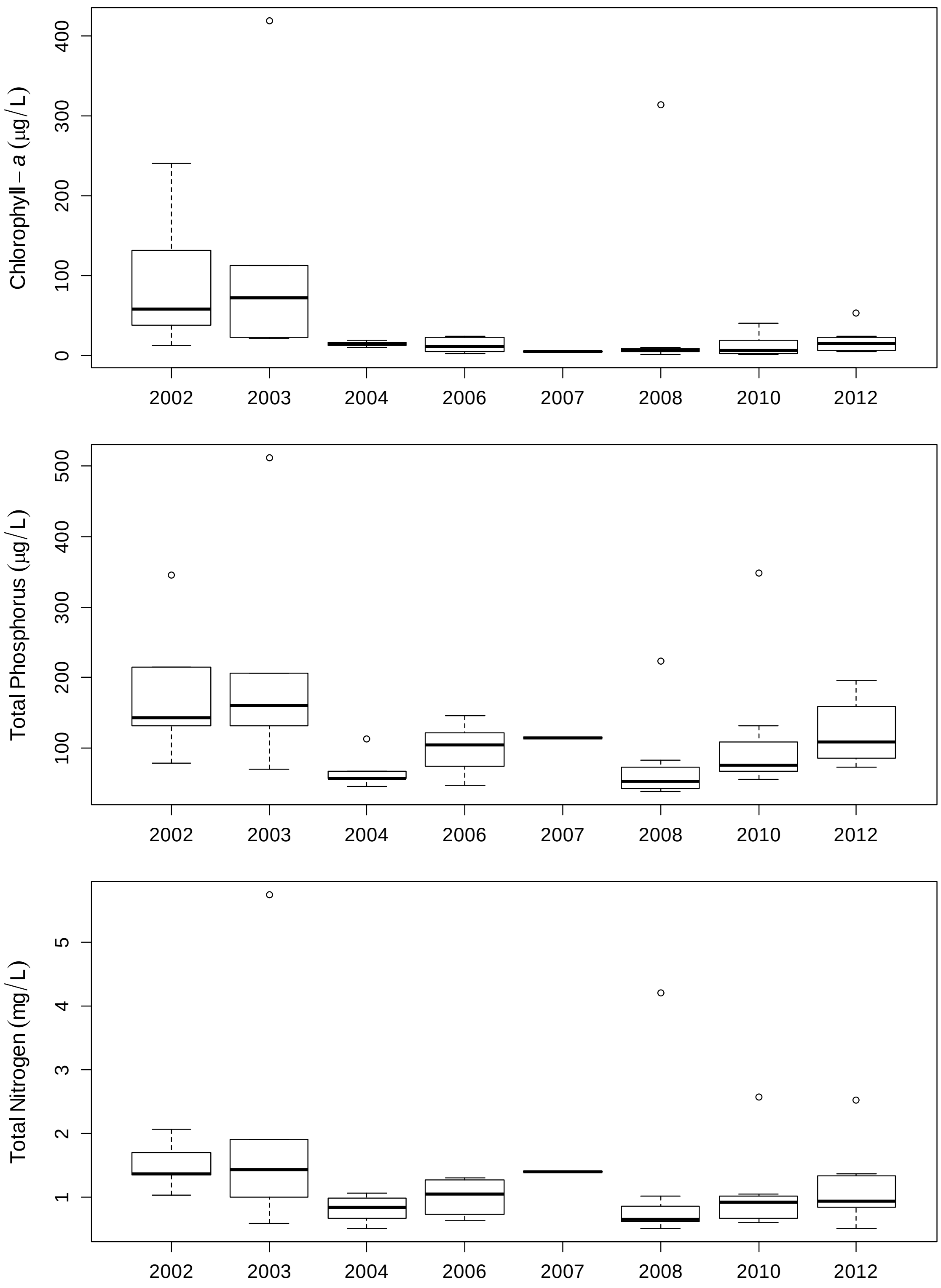
Cedar Lake 1992-2013



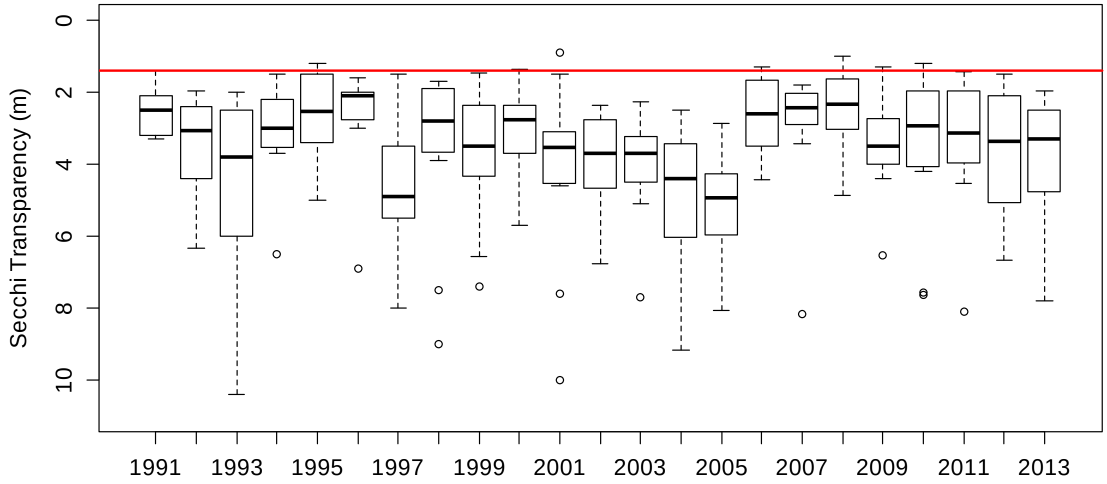
Diamond Lake 1992-2013

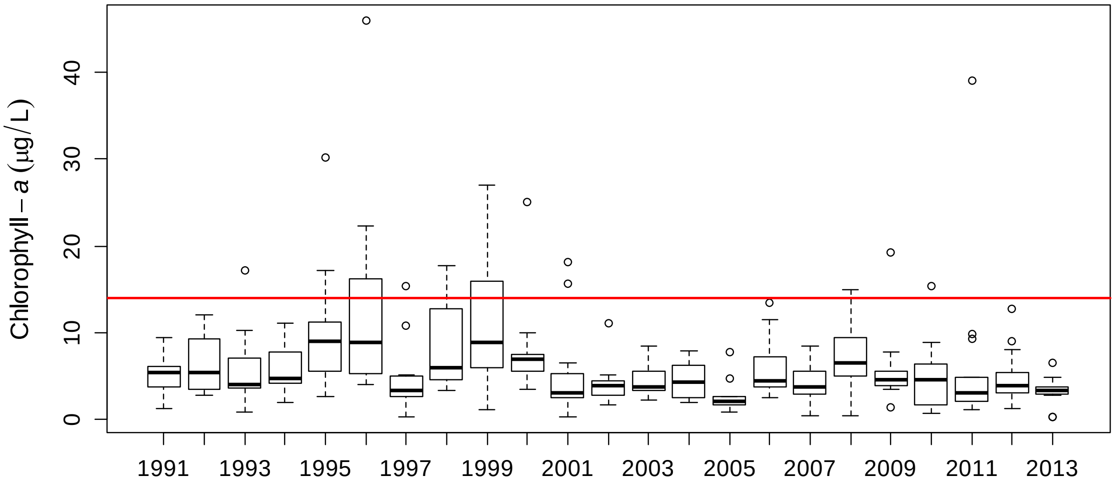


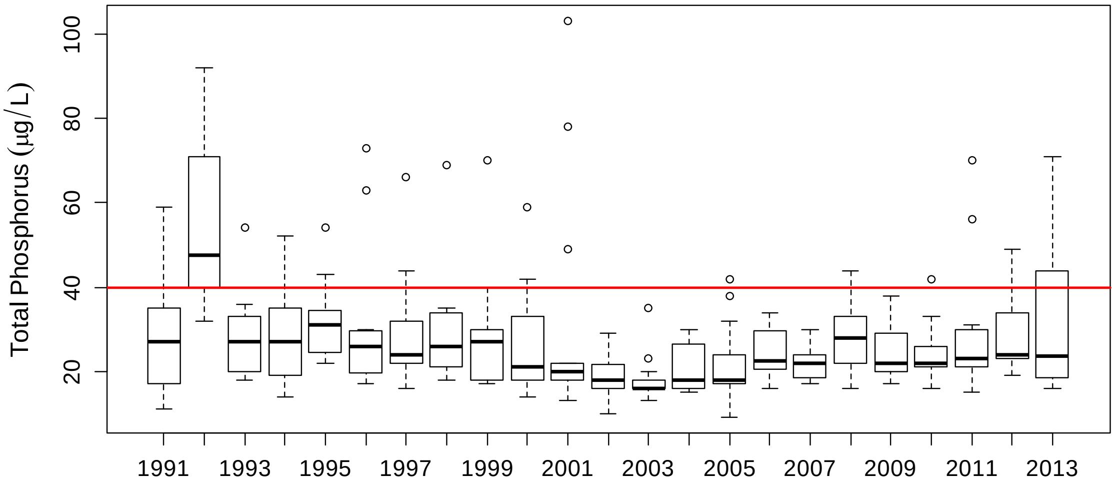
Grass Lake 2002-2012



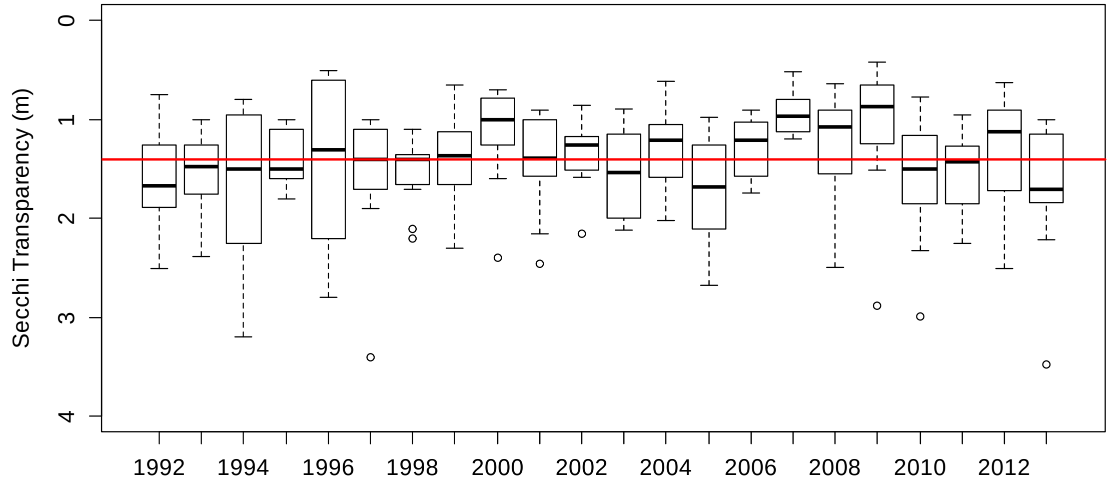
Lake Harriet 1991-2013

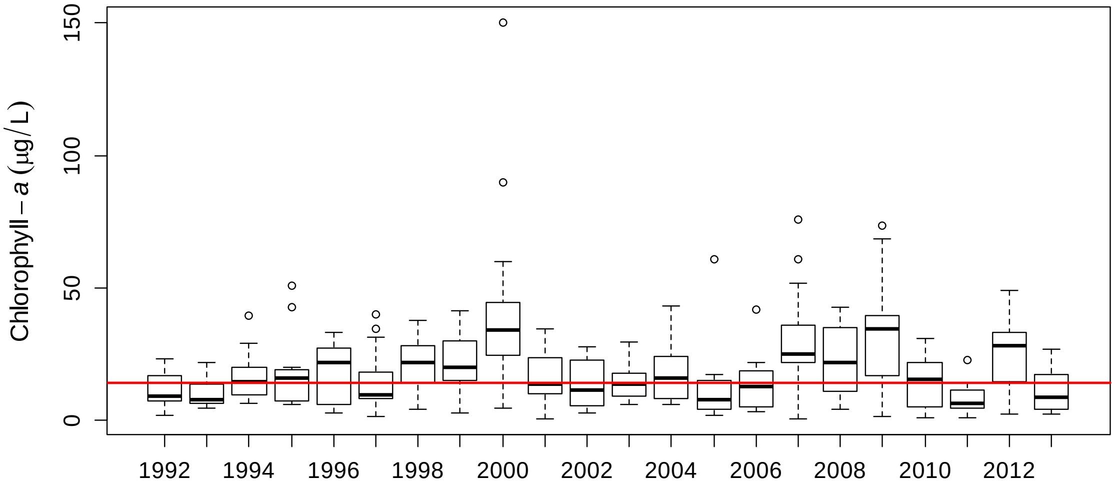


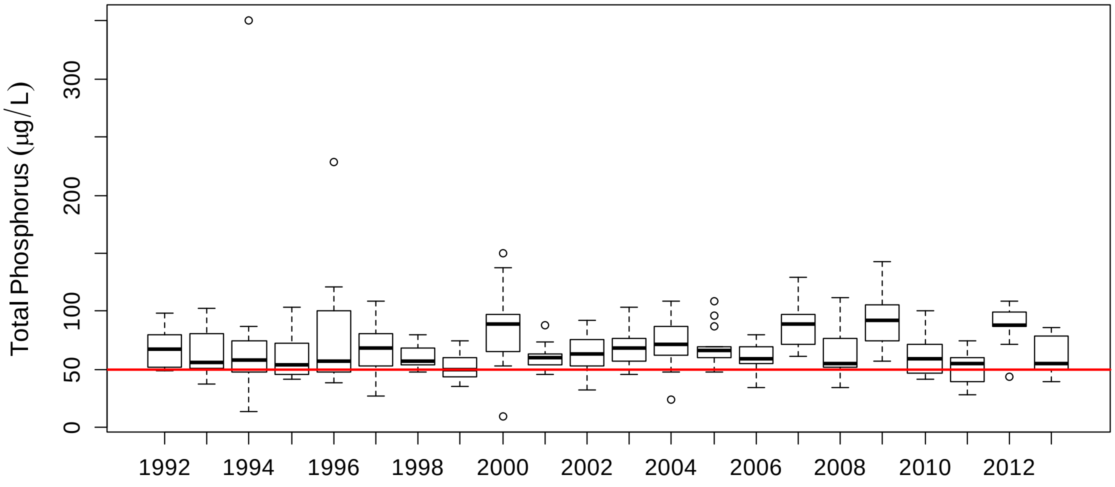




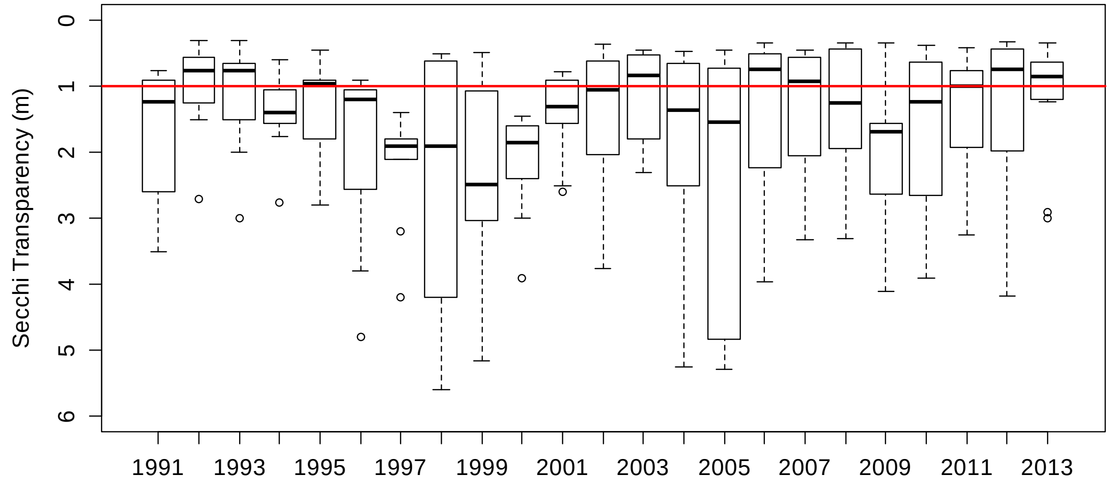
Lake Hiawatha 1992-2013

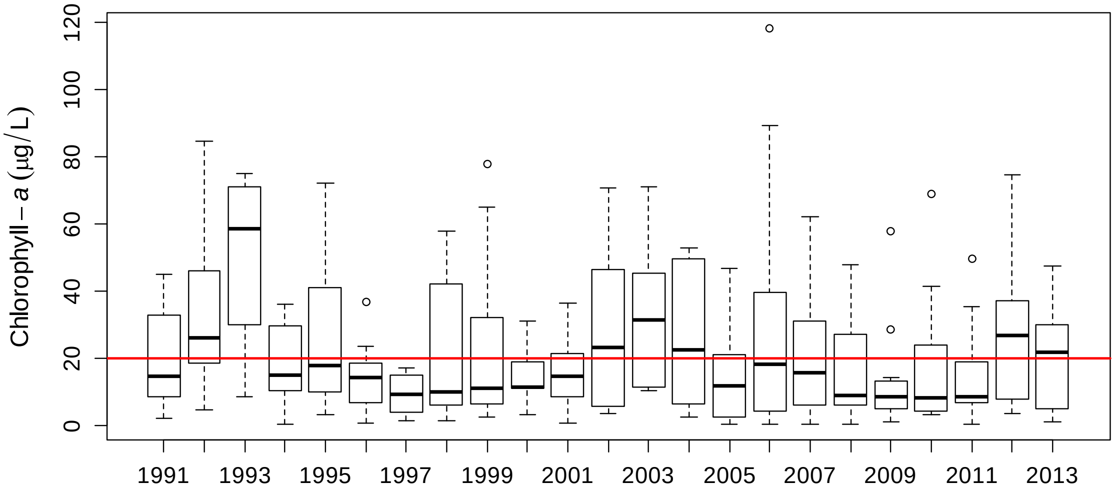


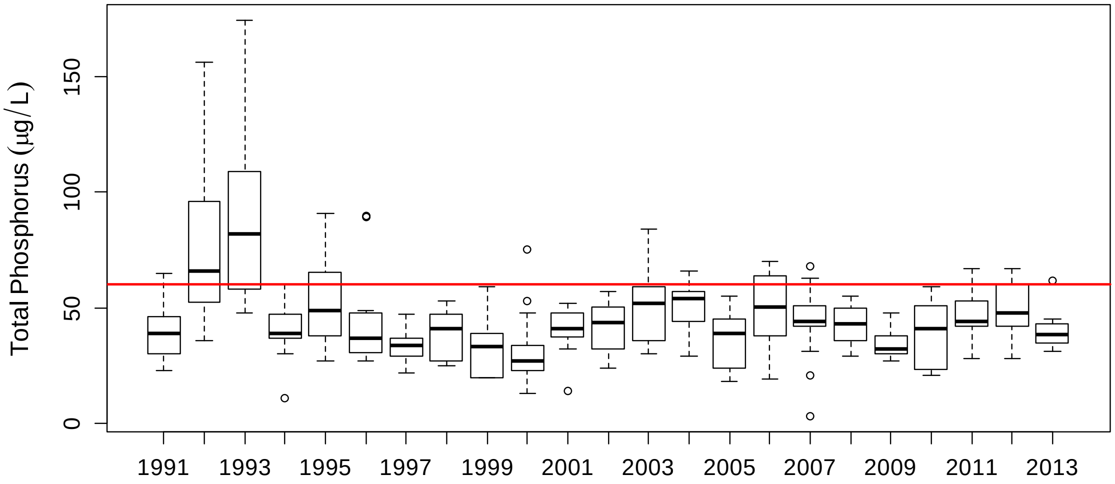




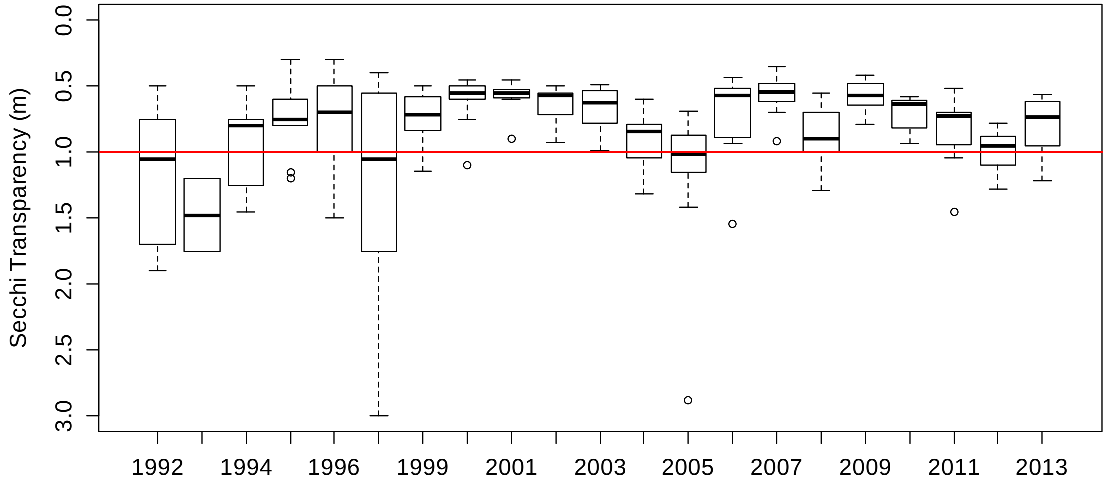
Lake of the Isles 1991-2013

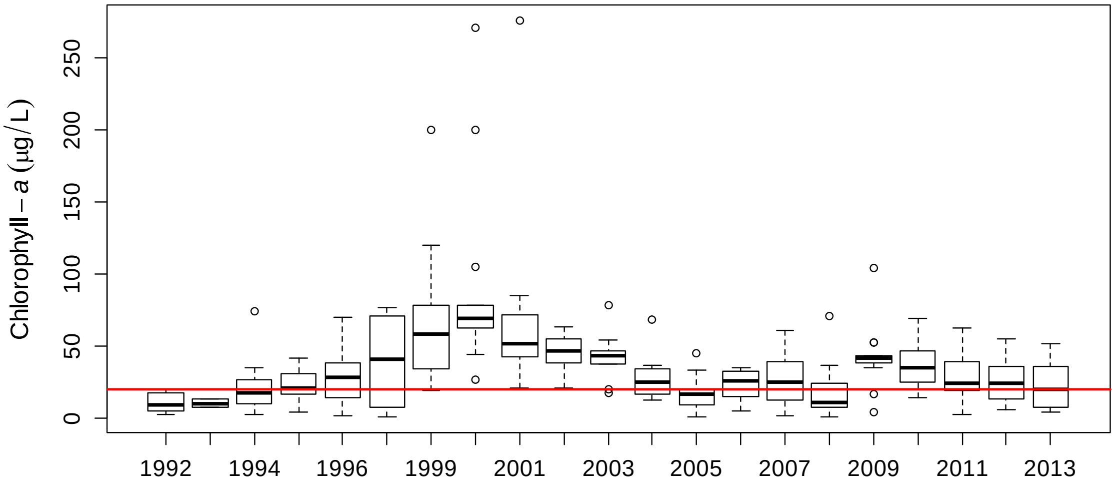


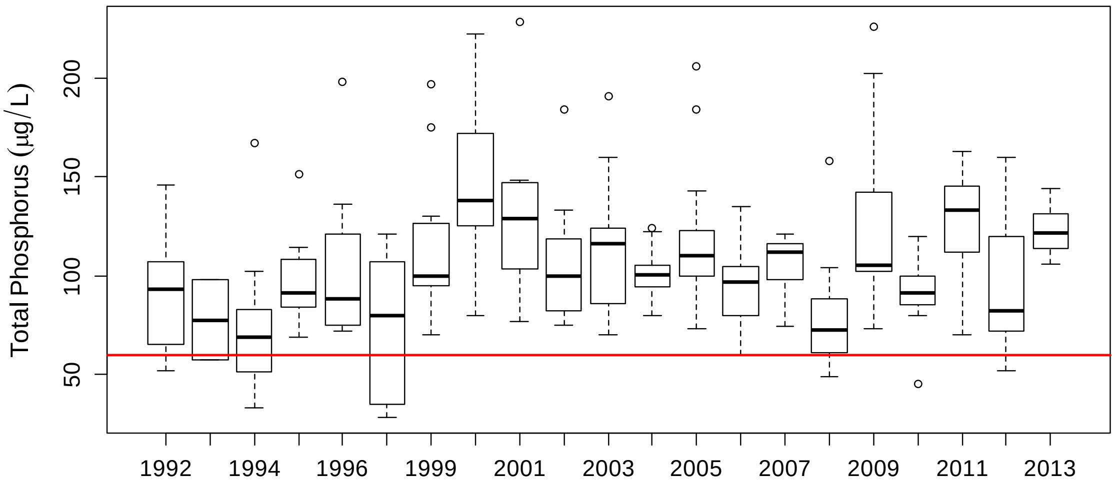




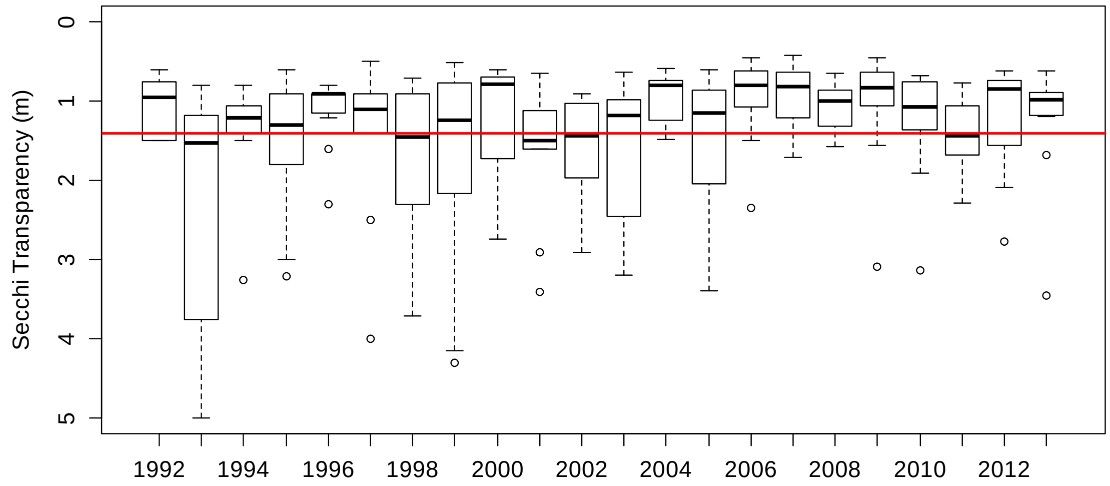
Loring Pond 1992-2013, Note: Loring was not sampled in 1997.

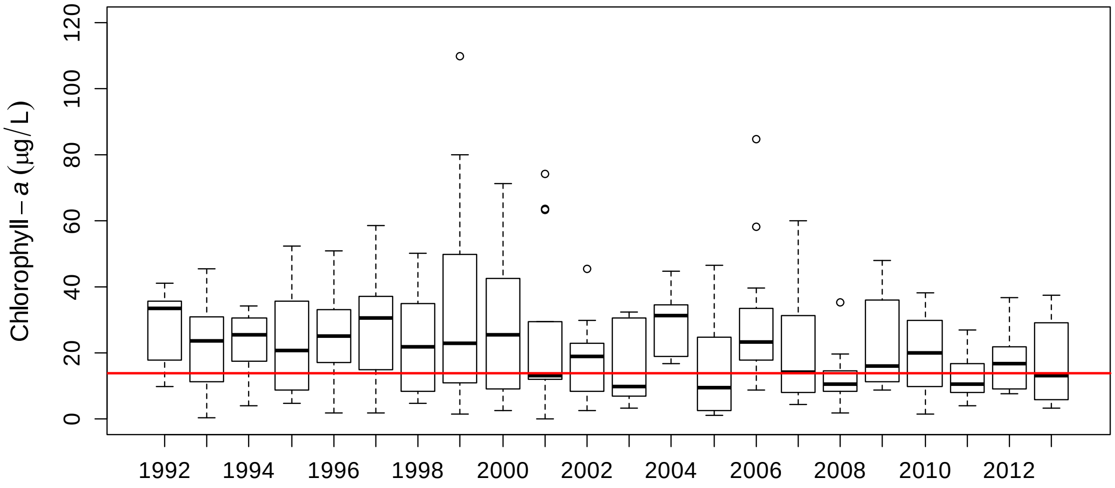


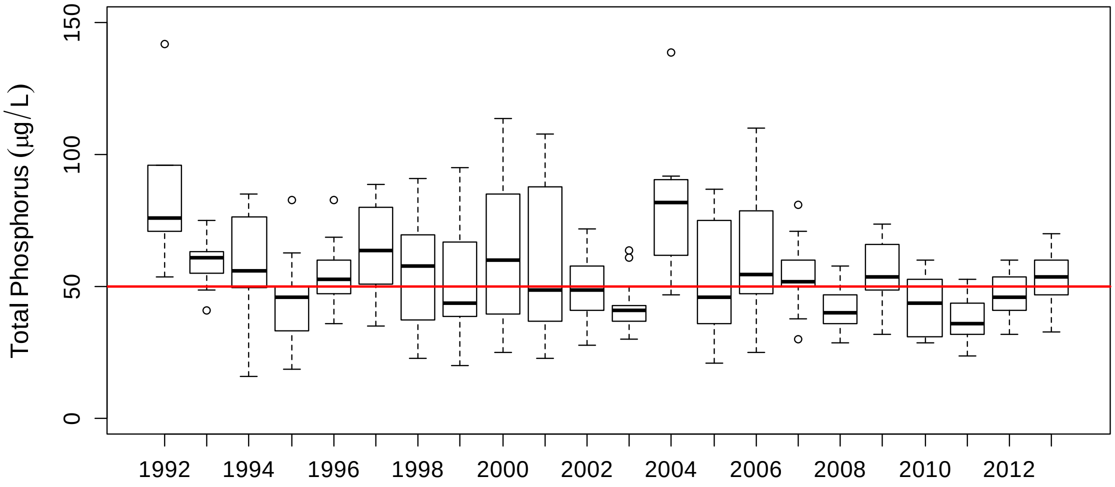




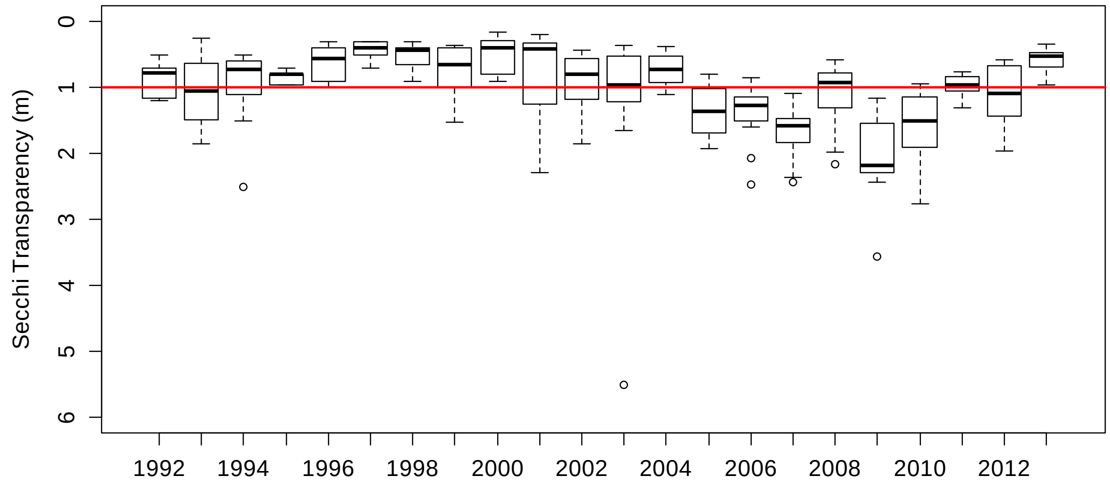
Lake Nokomis 1992-2013

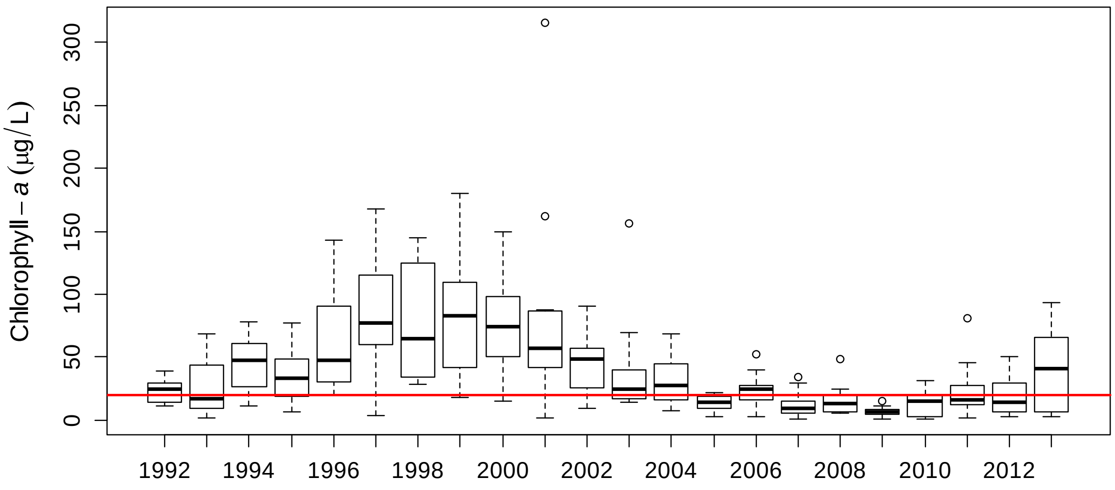


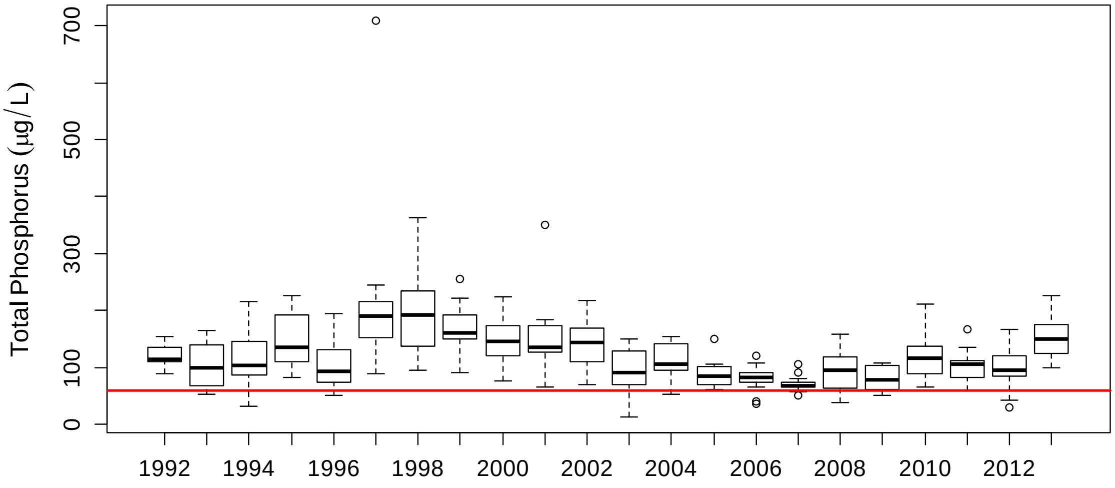




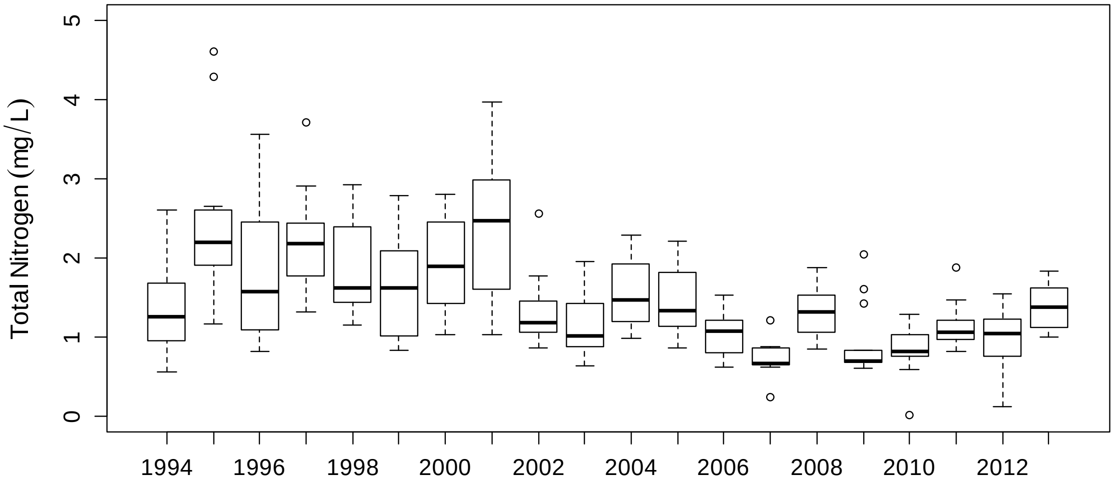
Powderhorn Lake 1992-2013



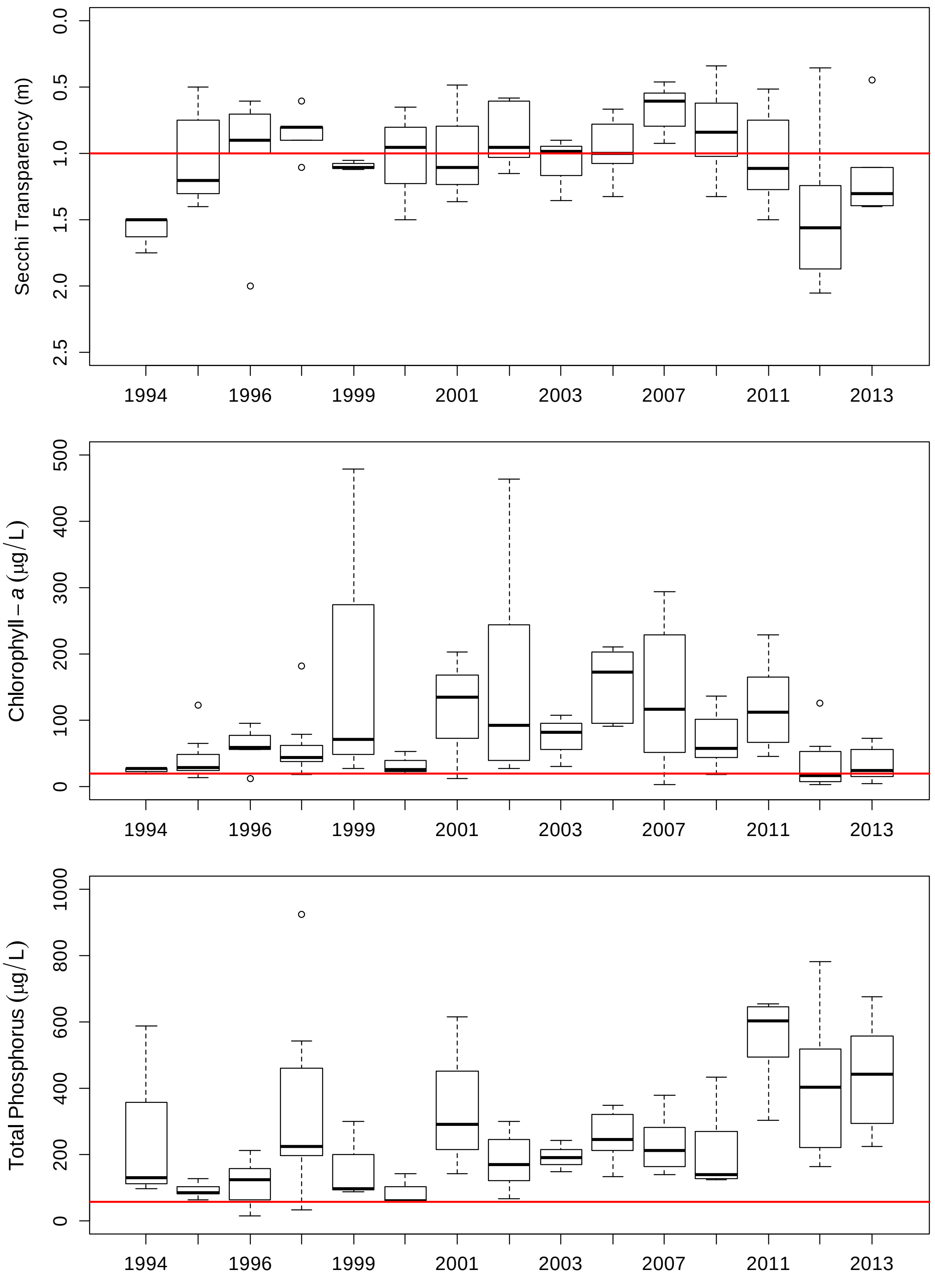




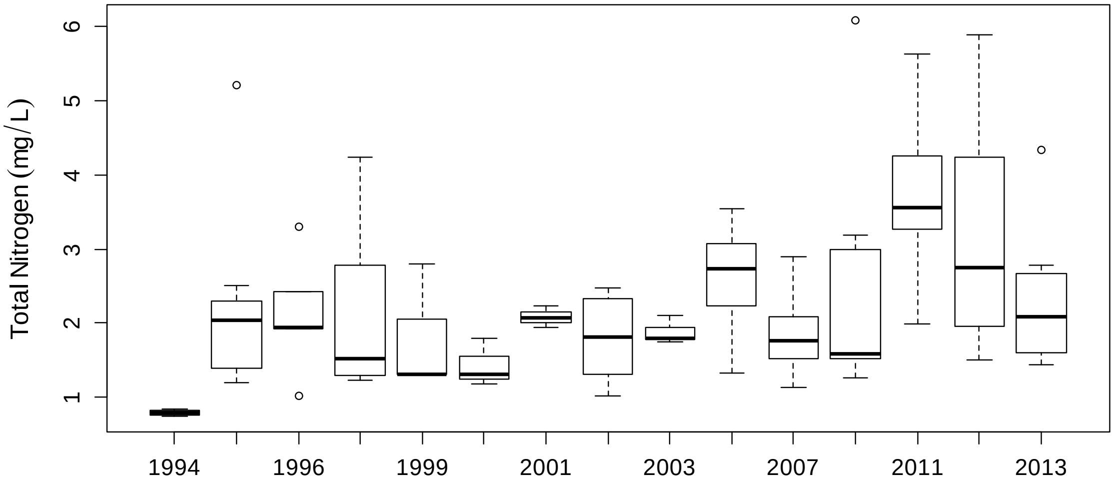
Powderhorn Lake Nitrogen 1994-2013



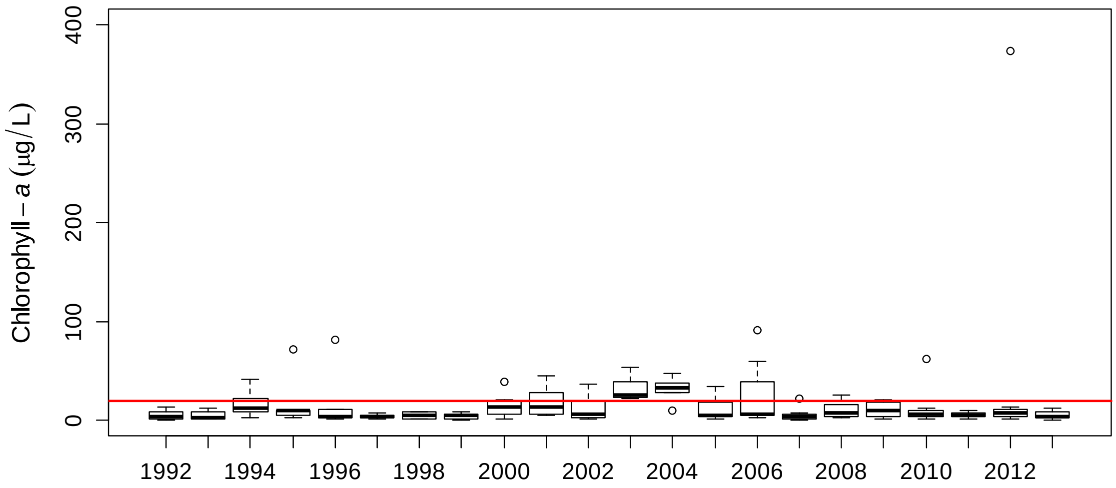
Spring Lake 1994-2013

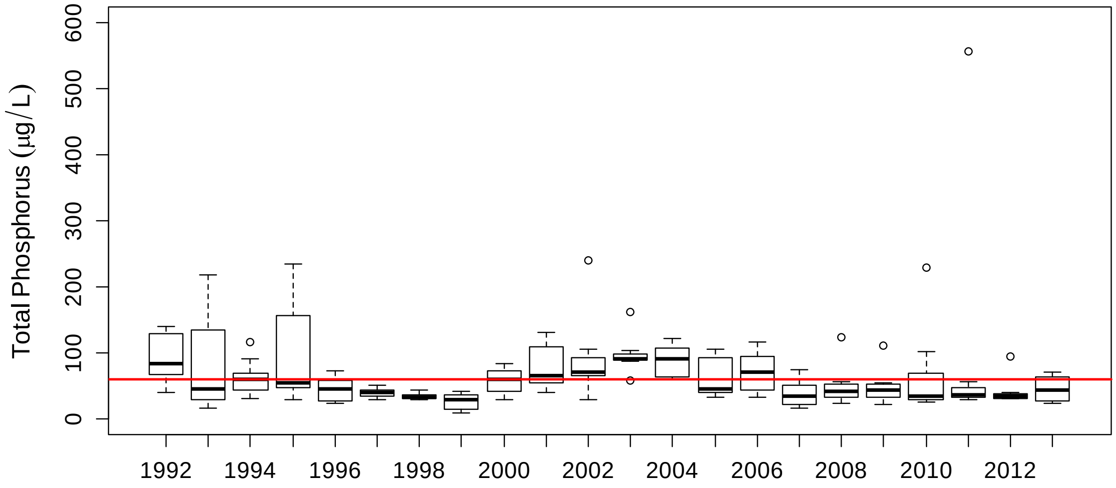


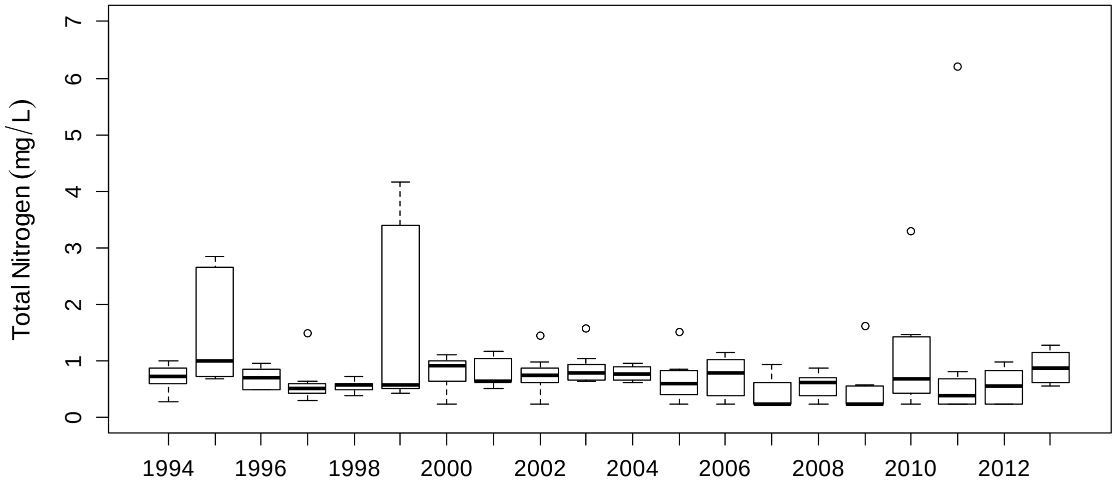
Spring Lake 1994- 2013 Nitrogen



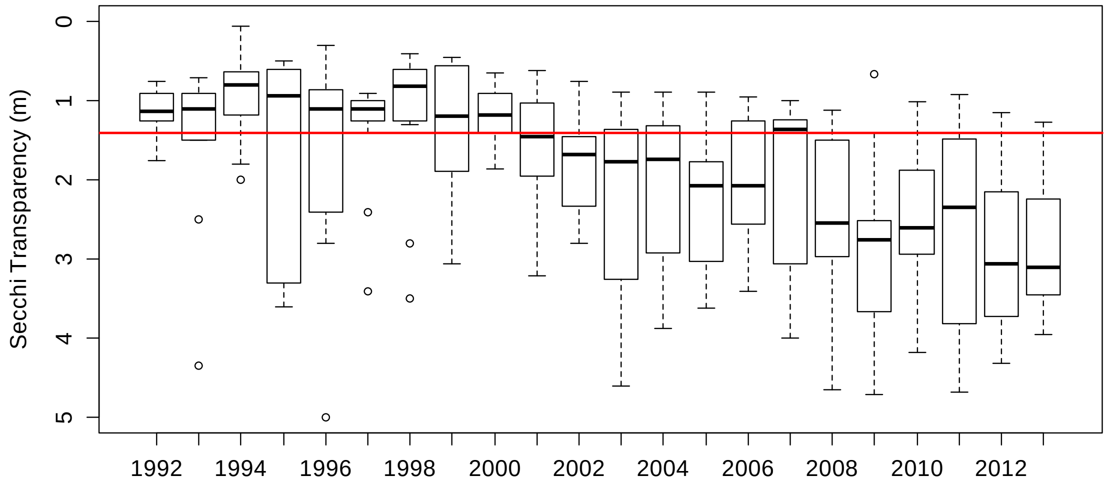
Webber Pond 1992-2013

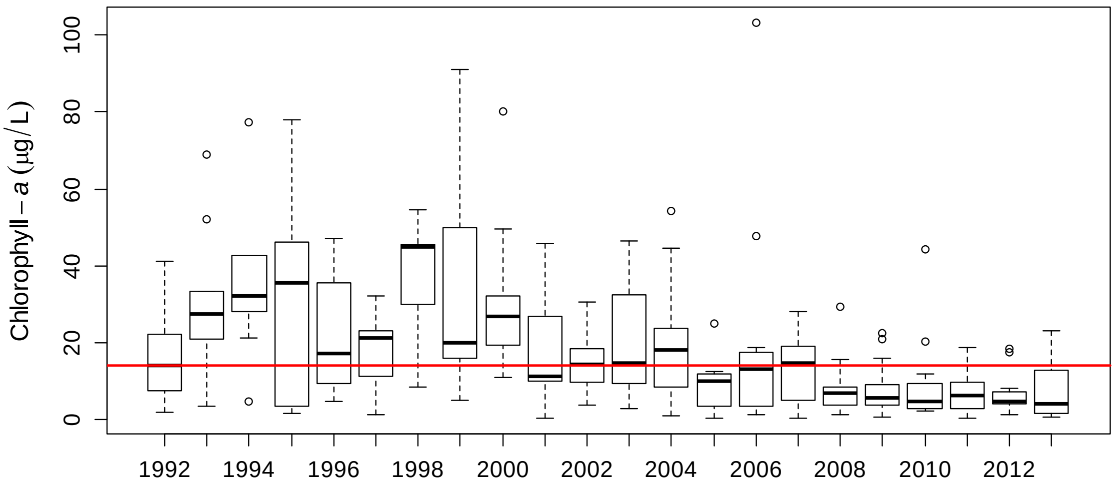


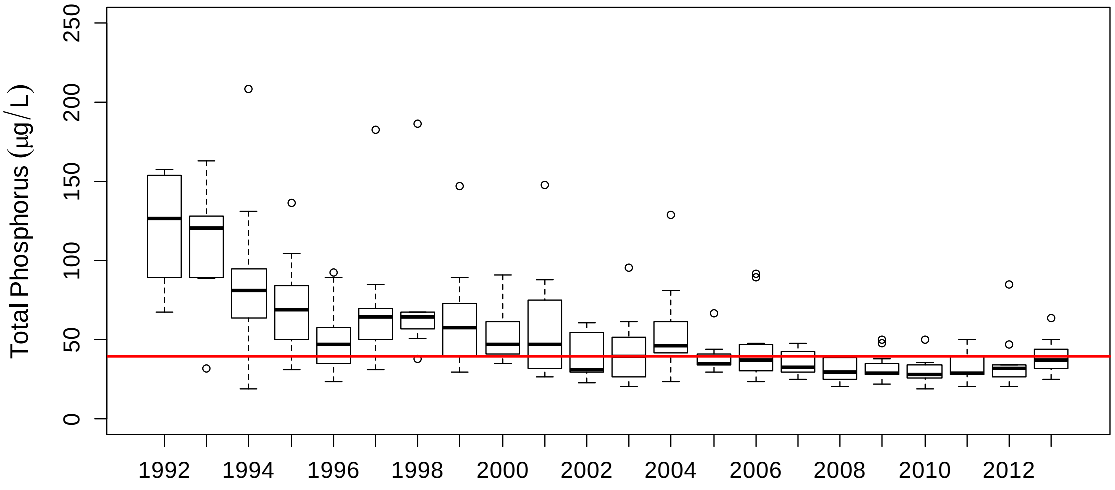




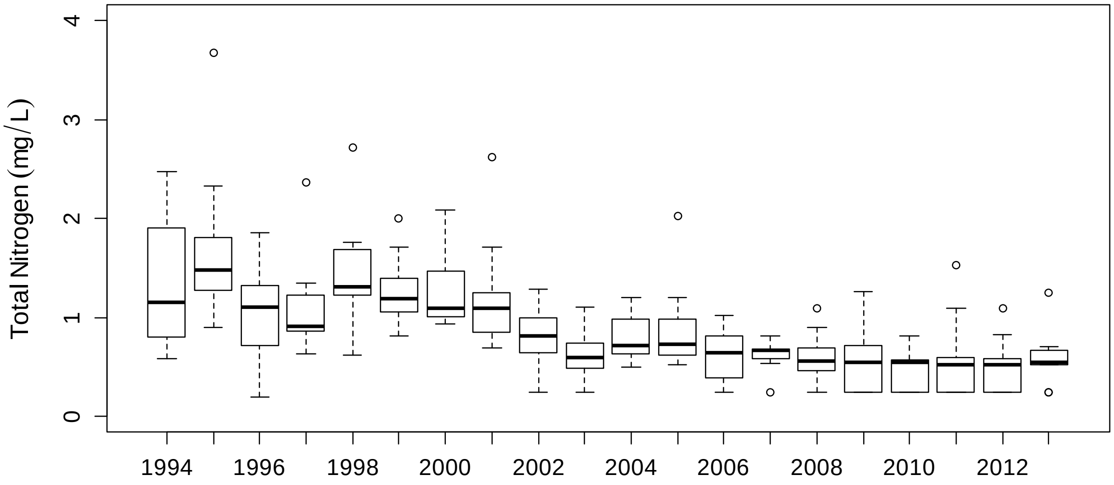
Wirth Lake 1992-2013







Wirth Lake 1994-2013 Nitrogen



Appendix B

This section contains lake monitoring data for 2013.

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	**Temp** °C	**DO** mg/L	%DO	**pH** units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	NO3NO2 mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0031	Calhoun	2/12/2013	12:38:53	NA	0	0.480	12.9	91.8	7.50	702	7.30	0.740	0.610	<0.500	0.024	0.006	0.770	0.806	0.081	131	168	142	8.40												
27-0031	Calhoun	2/12/2013	12:38:31		1	2.46	12.6	94.4	7.49	699	7.10																								
27-0031	Calhoun	2/12/2013	12:37:44		2	2.67	12.5	94.7	7.48	699	7.80																								
27-0031	Calhoun	2/12/2013	12:36:42		3	2.69	12.6	95.0	7.46	700	7.60																								
27-0031	Calhoun	2/12/2013	12:35:41		4	2.69	12.5	94.6	7.45	700	7.40																								
27-0031	Calhoun	2/12/2013	12:34:13		5	2.70	12.5	94.4	7.43	700	7.40																								
27-0031	Calhoun	2/12/2013	12:32:45		6	2.73	12.4	93.7	7.40	701	7.40				0.022	0.006																			
27-0031	Calhoun	2/12/2013	12:31:39		7	2.78	12.2	92.5	7.38	702	7.30																								
27-0031	Calhoun	2/12/2013	12:30:06		8	2.84	11.9	90.1	7.35	704	7.60																								
27-0031	Calhoun	2/12/2013	12:28:52		9	2.86	11.5	87.5	7.33	705	7.60																								
27-0031	Calhoun	2/12/2013	12:27:35		10	2.90	11.3	85.7	7.31	709	7.60																								
27-0031	Calhoun	2/12/2013	12:26:21		11	2.93	10.8	82.3	7.28	713	7.70																								
27-0031	Calhoun	2/12/2013	12:25:28		12	2.95	10.3	78.3	7.26	717	7.70				0.016	0.007																			
27-0031	Calhoun	2/12/2013	12:24:19		13	2.99	10.0	76.6	7.25	720	7.70																								
27-0031	Calhoun	2/12/2013	12:23:27		14	3.00	9.66	73.7	7.23	722	7.70																								
27-0031	Calhoun	2/12/2013	12:22:18		15	3.03	8.18	62.5	7.21	728	7.80																								
27-0031	Calhoun	2/12/2013	12:21:03		16	3.03	8.12	62.0	7.20	740	7.70																								
27-0031	Calhoun	2/12/2013	12:18:48		17	2.99	7.17	54.7	7.16	769	7.40																								
27-0031	Calhoun	2/12/2013	12:17:32		18	3.05	7.09	54.2	7.13	790	8.40				0.047	0.022																			
27-0031	Calhoun	2/12/2013	12:16:02		19	3.10	4.68	35.8	7.09	841	7.30																								
27-0031	Calhoun	2/12/2013	12:14:33		20	3.19	1.83	14.0	7.07	862	7.10																								
27-0031	Calhoun	2/12/2013	12:12:42		21	3.26	0.790	6.10	7.06	876	7.20																								
27-0031	Calhoun	2/12/2013	12:11:30		22	3.31	0.660	5.10	7.06	883	6.80				0.118	0.087						182	10.5												
27-0031	Calhoun	2/12/2013	12:10:10		23	3.43	0.780	6.00	7.04	888	7.80																								
27-0031	Calhoun	5/6/2013	10:00:00	3.15	0	8.94	11.6	102	7.52	678	6.30	2.03	<0.500	0.745	0.031	<0.003	0.558	0.749	0.262	116	140	140													
27-0031	Calhoun	5/6/2013	10:00:00		1	7.71	11.9	102	7.65	682	6.60																								
27-0031	Calhoun	5/6/2013	10:00:00		2	7.11	12.0	101	7.60	681	7.30																								
27-0031	Calhoun	5/6/2013	10:00:00		3	6.64	11.8	98.8	7.59	677	7.40																								
27-0031	Calhoun	5/6/2013	10:00:00		4	6.16	11.6	95.2	7.55	681	7.10																								
27-0031	Calhoun	5/6/2013	10:00:00		5	6.06	11.3	92.9	7.52	680	7.50																								
27-0031	Calhoun	5/6/2013	10:00:00		6	6.00	11.0	90.6	7.57	682	7.70				0.022	<0.003																			
27-0031	Calhoun	5/6/2013	10:00:00		7	5.77	10.8	87.8	7.52	683	7.60																								
27-0031	Calhoun	5/6/2013	10:00:00		8	5.51	10.2	83.1	7.52	693	8.10																								
27-0031	Calhoun	5/6/2013	10:00:00		9	5.33	9.67	78.0	7.51	713	7.60																								
27-0031	Calhoun	5/6/2013	10:00:00		10	5.21	9.41	75.7	7.50	705	7.80																								
27-0031	Calhoun	5/6/2013	10:00:00		11	5.12	9.27	74.4	7.54	709	7.80																								
27-0031	Calhoun	5/6/2013	10:00:00		12	4.93	8.45	67.5	7.55	722	7.90				0.024	<0.003																			
27-0031	Calhoun	5/6/2013	10:00:00		13	4.78	8.06	64.1	7.56	724	8.10																								
27-0031	Calhoun	5/6/2013	10:00:00		14	4.51	7.00	55.3	7.57	733	8.00																								
27-0031	Calhoun	5/6/2013	10:00:00		15	3.57	2.96	22.8	7.54	837	8.20																								
27-0031	Calhoun	5/6/2013	10:00:00		16	3.53	2.45	18.9	7.55	844	7.90																								
27-0031	Calhoun	5/6/2013	10:00:00		17	3.52	2.37	18.2	7.56	850	7.70																								
27-0031	Calhoun	5/6/2013	10:00:00		18	3.48	2.16	16.6	7.61	857	7.70				0.055	0.029																			
27-0031	Calhoun	5/6/2013	10:00:00		19	3.52	1.95	15.0	7.63	863	7.20																								
27-0031	Calhoun	5/6/2013	10:00:00		21	3.51	1.81	13.9	7.71	871	7.60																								
27-0031	Calhoun	5/6/2013	10:00:00		22	3.65	1.70	13.2	7.79	874	7.50				0.065	0.035						198													
27-0031	Calhoun	5/24/2013	10:00:53	7.53	0	14.4	9.25	91.7	8.00	755		<0.500	<0.500		0.021	0.004		0.910				123													
27-0031	Calhoun	5/24/2013	10:00:18		1	14.4	9.09	90.0	8.01	755																									
27-0031	Calhoun	5/24/2013	9:59:22		2	14.4	9.07	89.8	8.01	756																									
27-0031	Calhoun	5/24/2013	9:58:50		3	14.3	9.15	90.4	8.00	757																									
27-0031	Calhoun	5/24/2013	9:58:10		4	14.3	9.21	91.0	7.97	760																									
27-0031	Calhoun	5/24/2013	9:57:27		5	12.9	9.47	90.7	7.88	772																									
27-0031	Calhoun	5/24/2013	9:56:42		6	9.94	9.47	84.8	7.79	780					0.030	0.004																			
27-0031	Calhoun	5/24/2013	9:55:57		7	8.90	9.02	78.8	7.66	783																									
27-0031	Calhoun	5/24/2013	9:54:48		8	8.27	8.53	73.4	7.57	787																									
27-0031	Calhoun	5/24/2013	9:54:12		9	7.52	7.61	64.3	7.47	797																									
27-0031	Calhoun	5/24/2013	9:53:28		10	6.91	6.61	55.0	7.39	805																									
27-0031	Calhoun	5/24/2013	9:52:39		11	6.64	6.65	55.0	7.36	809																									
27-0031	Calhoun	5/24/2013	9:51:52		12	6.39	6.51	53.5	7.33	812					0.022	0.004																			
27-0031	Calhoun	5/24/2013	9:51:07		13	6.01	6.26	51.0	7.28	818																									
27-0031	Calhoun	5/24/2013	9:50:18		14	5.81	5.88	47.6	7.24	822																									
27-0031	Calhoun	5/24/2013	9:49:33		15	5.58	5.37	43.3	7.20	829																									
27-0031	Calhoun	5/24/2013	9:48:45		16	5.55	5.50	44.2	7.18	830																									
27-0031	Calhoun	5/24/2013	9:48:06		17	5.52	5.39	43.3	7.16	831																									
27-0031	Calhoun	5/24/2013	9:47:25		18	5.50	5.19	41.7	7.14	832					0.024	0.006																			
27-0031	Calhoun	5/24/2013	9:46:42		19	5.46	5.10	41.0	7.11	833																									
27-0031	Calhoun	5/24/2013	9:45:58		20	5.45	5.25	42.1	7.08	834																									
27-0031	Calhoun	5/24/2013	9:45:10		21	5.43	5.20	41.7	7.03	835																									
27-0031	Calhoun	5/24/2013	9:44:10		22	5.44	4.92	39.5	6.98	835					0.031	0.007						153													
27-0031	Calhoun	6/3/2013	10:35:20	9.85	0	17.5	10.2	109	8.35	685	7.30	1.32	0.500	<0.500	0.018	<0.003		0.880				148													
27-0031	Calhoun	6/3/2013	10:35:00		1	17.2	10.2	108	8.34	683	79.8																								
27-0031	Calhoun	6/3/2013	10:34:35		2	16.9	10.2	108	8.32	684	7.50																								
27-0031	Calhoun	6/3/2013	10:33:57		3	16.8	10.1	107	8.30	683	9.40																								
27-0031	Calhoun	6/3/2013	10:33:25		4	16.3	10.0	105	8.24	682	7.30																								
27-0031	Calhoun	6/3/2013	10:32:57		5	15.7	10.1	104	8.17	687	7.70																								
27-0031	Calhoun	6/3/2013	10:32:02		6	14.6	9.54	95.9	8.01	689	7.80				0.033	0.003																			
27-0031	Calhoun	6/3/2013	10:31:06		7	10.4	8.25	75.5	7.72	700	9.40																								
27-0031	Calhoun	6/3/2013	10:30:37		8	8.37	7.56	66.0	7.67	712	9.10																								
27-0031	Calhoun	6/3/2013	10:30:04		9	7.81	7.52	64.7	7.65	713	8.70																								
27-0031	Calhoun	6/3/2013	10:29:17		10	7.44	7.52	64.1	7.62	713	8.80																								
27-0031	Calhoun	6/3/2013	10:28:38		11	7.00	6.78	57.2	7.59	720	8.80																								
27-0031	Calhoun	6/3/2013	10:28:05		12	6.79	6.53	54.8	7.57	722	8.80				0.037	0.013																			
27-0031	Calhoun	6/3/2013	10:27:28		13	6.58	6.04	50.5	7.54	726	8.10																								
27-0031	Calhoun	6/3/2013	10:26:50		14	6.21	5.68	47.0	7.53	732	8.80																								
27-0031	Calhoun	6/3/2013	10:26:10		15	6.06	5.33	43.9	7.51	736	8.10																								
27-0031	Calhoun	6/3/2013	10:25:05		16	5.98	4.91	40.4	7.51	738	8.30																								
27-0031	Calhoun	6/3/2013	10:24:35		17	5.90	4.71	38.7	7.51	739	8.40																								
27-0031	Calhoun	6/3/2013	10:24:06		18	5.78	4.38	35.8	7.50	741	8.10				0.041	0.013																			
27-0031	Calhoun	6/3/2013	10:23:22		19	5.75	4.29	35.1	7.50	743	8.70																								

Underlined data indicates monthly performance standard failure.

Lake ID	**Lake Name**	**Date** MM/DD/YYY	**Time** HH:MM:SS	**Secchi** meters	**Depth** meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	**SpCond** µS/cm	**TurbSC** NTU	**Chl-a** mg/M3	**Pheo-a** mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	**NO3NO2** mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	**E. Coli** mpn/100m	**Ca** mg/L	**Tot Al** µg/L	**Sol Al** µg/L	**As** µg/L	**Cd** µg/L	**Cu** µg/L	**Pb** µg/L	**Mn** µg/L	**Ni** µg/L	**Zn** µg/	**F. Coli** cfu/10
27-0031	Calhoun	6/3/2013	10:22:45		20	5.75	4.24	34.7	7.51	743	7.70																								
27-0031	Calhoun	6/3/2013	10:21:56		21	5.80	4.18	34.2	7.52	743	7.60																								
27-0031	Calhoun	6/3/2013	10:21:28		22	5.81	4.20	34.4	7.53	748	7.90				0.038	0.017						163													
27-0031	Calhoun	6/3/2013	10:20:57		23	5.85	4.27	35.0	7.55	753	7.50																								
27-0031	Calhoun	6/18/2013	10:29:12	5.95	0	20.8	9.92	113	8.67	688	7.30	1.36	<0.500		0.016	0.003		<0.500				151													
27-0031	Calhoun	6/18/2013	10:28:40		1	20.6	9.96	113	8.65	691	10.3																								
27-0031	Calhoun	6/18/2013	10:28:18		2	20.6	9.93	113	8.63	689	7.20																								
27-0031	Calhoun	6/18/2013	10:27:50		3	20.4	9.90	112	8.59	690	7.50																								
27-0031	Calhoun	6/18/2013	10:27:09		4	17.9	9.44	102	8.34	694	8.40																								
27-0031	Calhoun	6/18/2013	10:26:26		5	16.8	9.03	95.2	8.23	695	7.40																								
27-0031	Calhoun	6/18/2013	10:25:39		6	14.8	8.54	86.4	7.99	705	18.0				0.019	0.005																			
27-0031	Calhoun	6/18/2013	10:24:55		7	12.4	7.07	67.7	7.82	711	8.60																								
27-0031	Calhoun	6/18/2013	10:24:29		8	9.19	6.45	57.4	7.76	723	8.50																								
27-0031	Calhoun	6/18/2013	10:23:22		9	8.25	6.03	52.4	7.72	728	8.80																								
27-0031	Calhoun	6/18/2013	10:22:27		10	7.57	5.46	46.7	7.69	732	8.80																								
27-0031	Calhoun	6/18/2013	10:21:54		11	7.05	5.16	43.5	7.67	734	8.90																								
27-0031	Calhoun	6/18/2013	10:21:17		12	6.77	4.84	40.5	7.65	736	8.50				0.033	0.022																			
27-0031	Calhoun	6/18/2013	10:20:35		13	6.35	3.97	32.9	7.62	743	8.30																								
27-0031	Calhoun	6/18/2013	10:19:58		14	6.19	3.51	29.0	7.61	745	8.60																								
27-0031	Calhoun	6/18/2013	10:19:30		15	6.00	3.04	25.0	7.60	750	8.40																								
27-0031	Calhoun	6/18/2013	10:18:29		16	5.89	2.43	19.9	7.59	752	8.50																								
27-0031	Calhoun	6/18/2013	10:18:02		17	5.88	2.38	19.5	7.60	752	8.60																								
27-0031	Calhoun	6/18/2013	10:17:27		18	5.84	2.30	18.8	7.59	752	8.70				0.052	0.038																			
27-0031	Calhoun	6/18/2013	10:17:02		19	5.83	2.24	18.3	7.60	752	8.50																								
27-0031	Calhoun	6/18/2013	10:16:31		20	5.88	2.19	18.0	7.61	752	8.00																								
27-0031	Calhoun	6/18/2013	10:15:26		21	5.82	2.12	17.4	7.61	753	8.00																								
27-0031	Calhoun	6/18/2013	10:15:04		22	5.97	2.08	17.1	7.62	751	7.80				0.053	0.040						161													
27-0031	Calhoun	6/18/2013	10:12:57		23	6.07	2.11	17.4	7.66	752	7.70																								
27-0031	Calhoun	7/9/2013	11:10:09	4.22	0	26.0	9.41	120	8.70	670	9.60	3.60	<0.500	1.23	0.017	<0.003	0.555	0.631	0.071	107	124	140													
27-0031	Calhoun	7/9/2013	11:09:28		1	25.9	9.45	120	8.69	670	14.8																								
27-0031	Calhoun	7/9/2013	11:08:59		2	25.6	9.52	121	8.65	671	9.30																								
27-0031	Calhoun	7/9/2013	11:08:29		3	25.3	9.49	120	8.57	672	8.60																								
27-0031	Calhoun	7/9/2013	11:08:01		4	23.8	9.07	111	8.37	674	8.90																								
27-0031	Calhoun	7/9/2013	11:07:34		5	21.6	8.88	104	8.08	691	10.3																								
27-0031	Calhoun	7/9/2013	11:07:01		6	16.1	8.04	84.6	7.75	706	10.3				0.033	<0.003																			
27-0031	Calhoun	7/9/2013	11:06:31		7	11.6	5.09	48.4	7.67	723	7.90																								
27-0031	Calhoun	7/9/2013	11:06:05		8	10.2	4.42	40.8	7.67	729	8.80																								
27-0031	Calhoun	7/9/2013	11:05:28		9	9.18	3.83	34.5	7.66	734	8.00																								
27-0031	Calhoun	7/9/2013	11:04:46		10	8.64	2.67	23.7	7.65	738	8.80																								
27-0031	Calhoun	7/9/2013	11:04:03		11	8.01	3.10	27.1	7.65	740	8.90																								
27-0031	Calhoun	7/9/2013	11:03:22		12	7.59	3.45	29.9	7.65	741	8.90				0.031	0.020																			
27-0031	Calhoun	7/9/2013	11:02:42		13	7.20	3.15	27.0	7.65	743	9.00																								
27-0031	Calhoun	7/9/2013	11:02:05		14	6.88	2.79	23.7	7.65	745	8.50																								
27-0031	Calhoun	7/9/2013	11:01:11		15	6.56	1.93	16.3	7.64	749	8.30																								
27-0031	Calhoun	7/9/2013	11:00:34		16	6.49	1.76	14.9	7.65	750	8.50																								
27-0031	Calhoun	7/9/2013	10:59:31		17	6.40	1.35	11.3	7.65	751	8.50																								
27-0031	Calhoun	7/9/2013	10:58:51		18	6.37	1.06	8.90	7.65	752	8.20				0.077	0.058																			
27-0032	Calhoun	7/9/2013			19																														
27-0033	Calhoun	7/9/2013			20																														
27-0034	Calhoun	7/9/2013			21																														
27-0035	Calhoun	7/9/2013			22										0.086	0.074						155													
27-0031	Calhoun	7/23/2013	9:40:07	3.09	0	25.7	8.71	110	8.88	644	7.40	3.60	0.560		0.015	<0.003		1.04				125													
27-0031	Calhoun	7/23/2013	9:39:38		1	25.7	8.70	110	8.88	644	7.80																								
27-0031	Calhoun	7/23/2013	9:39:11		2	25.7	8.72	110	8.86	644	8.40																								
27-0031	Calhoun	7/23/2013	9:38:35		3	25.6	8.67	109	8.83	644	8.30																								
27-0031	Calhoun	7/23/2013	9:37:35		4	25.6	8.68	109	8.72	644	7.50																								
27-0031	Calhoun	7/23/2013	9:37:05		5	25.5	8.55	107	8.56	642	9.40																								
27-0031	Calhoun	7/23/2013	9:36:15		6	19.3	7.57	84.4	7.98	695	11.3				0.020	<0.003																			
27-0031	Calhoun	7/23/2013	9:35:21		7	14.7	5.70	57.7	7.79	716	9.80																								
27-0031	Calhoun	7/23/2013	9:34:02		8	10.9	3.67	34.1	7.76	730	10.7																								
27-0031	Calhoun	7/23/2013	9:32:19		9	9.56	2.40	21.6	7.74	735	9.00																								
27-0031	Calhoun	7/23/2013	9:31:30		10	8.75	1.63	14.4	7.73	738	9.10																								
27-0031	Calhoun	7/23/2013	9:30:42		11	8.12	1.16	10.1	7.74	740	9.50																								
27-0031	Calhoun	7/23/2013	9:30:09		12	7.86	1.50	12.9	7.74	741	9.50				0.015	<0.003																			
27-0031	Calhoun	7/23/2013	9:29:34		13	7.55	1.82	15.6	7.75	740	9.30																								
27-0031	Calhoun	7/23/2013	9:28:30		14	7.13	1.43	12.2	7.76	744	8.90																								
27-0031	Calhoun	7/23/2013	9:26:36		15	6.78	0.520	4.40	7.78	747	9.20																								
27-0031	Calhoun	7/23/2013	9:26:03		16	6.58	0.190	1.60	7.78	749	8.20																								
27-0031	Calhoun	7/23/2013	9:25:12		17	6.43	0	0	7.80	751	8.80																								
27-0031	Calhoun	7/23/2013	9:24:03		18	6.37	0	0	7.83	752	8.40				0.073	0.060																			
27-0031	Calhoun	7/23/2013	9:23:28		19	6.35	0	0	7.85	752	8.60																								
27-0031	Calhoun	7/23/2013	9:22:55		20	6.33	0	0	7.87	752	7.80																								
27-0031	Calhoun	7/23/2013	9:22:26		21	6.31	0	0	7.89	752	8.50																								
27-0031	Calhoun	7/23/2013	9:21:56		22	6.30	0	0	7.92	753	8.50				0.098	0.087						154													
27-0031	Calhoun	7/23/2013	9:21:12		23	6.29	0.010	0.100	7.98	754	8.40																								
27-0031	Calhoun	7/23/2013	9:20:28		24	6.37	0.050	0.400	8.01	754	23.9																								
27-0031	Calhoun	8/6/2013	10:11:28	1.66	0	22.7	9.85	118	8.72	643	10.0	5.70	0.534	1.14	0.020	<0.003		<0.500				129		1											
27-0031	Calhoun	8/6/2013	10:10:59		1	22.7	9.80	117	8.69	642	11.0																								
27-0031	Calhoun	8/6/2013	10:10:24		2	22.6	9.75	116	8.64	642	10.7																								
27-0031	Calhoun	8/6/2013	10:09:51		3	22.6	9.67	116	8.57	642	11.1																								
27-0031	Calhoun	8/6/2013	10:08:59		4	22.4	9.24	110	8.42	642	11.1																								
27-0031	Calhoun	8/6/2013	10:08:13		5	22.1	8.83	104	8.22	644	12.0																								
27-0031	Calhoun	8/6/2013	10:07:18		6	20.3	5.84	66.8	7.85	666	9.50				0.025	<0.003																			
27-0031	Calhoun	8/6/2013	10:06:03		7	15.6	3.12	32.4	7.60	723	10.5																								
27-0031	Calhoun	8/6/2013	10:05:01		8	11.4	0.710	6.70	7.57	732	10.2																								
27-0031	Calhoun	8/6/2013	10:03:57		9	9.66	0.040	0.400	7.57	737	9.30																								
27-0031	Calhoun	8/6/2013	10:02:38		10	8.79	0.340	3.00	7.55	736	8.80																								
27-0031	Calhoun	8/6/2013	10:01:23		11	8.26	0.020	0.200	7.57	737	8.80																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0031	Calhoun	8/6/2013	10:00:12		12	7.79	0.340	3.00	7.58	738	9.00				0.018	<0.003																			
27-0031	Calhoun	8/6/2013	9:59:28		13	7.34	0.130	1.10	7.58	739	8.80																								
27-0031	Calhoun	8/6/2013	9:58:44		14	6.99	0.160	1.40	7.58	742	9.10																								
27-0031	Calhoun	8/6/2013	9:57:47		15	6.64	0	0	7.58	746	8.70																								
27-0031	Calhoun	8/6/2013	9:57:01		16	6.47	0	0	7.57	748	8.30																								
27-0031	Calhoun	8/6/2013	9:56:21		17	6.41	0	0	7.59	748	9.20																								
27-0031	Calhoun	8/6/2013	9:55:41		18	6.38	0	0	7.59	749	9.30				0.094	0.081																			
27-0031	Calhoun	8/6/2013	9:55:02		19	6.36	0	0	7.60	750	8.40																								
27-0031	Calhoun	8/6/2013	9:54:09		20	6.38	0	0	7.61	749	8.50																								
27-0031	Calhoun	8/6/2013	9:53:14		21	6.35	0	0	7.63	751	8.00																								
27-0031	Calhoun	8/6/2013	9:52:08		22	6.37	0	0	7.66	751	9.10				0.131	0.104						149													
27-0031	Calhoun	8/6/2013	9:51:20		23	6.48	0.010	0.100	7.70	750	9.00																								
27-0031	Calhoun	8/6/2013	9:50:05		24	6.62	0	0	7.68	752	23.5																								
27-0031	Calhoun	8/19/2013	9:36:45	1.74	0	23.2	9.50	114	9.01	643	1.80	4.77	0.755		0.018	0.003		0.500				135													
27-0031	Calhoun	8/19/2013	9:36:20		1	23.2	9.45	114	9.00	643	26.2																								
27-0031	Calhoun	8/19/2013	9:35:39		2	23.2	9.43	113	8.98	643	24.2																								
27-0031	Calhoun	8/19/2013	9:35:05		3	23.2	9.40	113	8.95	643	25.4																								
27-0031	Calhoun	8/19/2013	9:34:25		4	23.1	9.44	113	8.90	643	37.4																								
27-0031	Calhoun	8/19/2013	9:33:46		5	22.7	8.43	100	8.68	643	3.80																								
27-0031	Calhoun	8/19/2013	9:33:08		6	20.2	3.19	36.2	7.89	675	3.20				0.025	0.003																			
27-0031	Calhoun	8/19/2013	9:32:25		7	14.9	0.060	0.600	7.63	740	2.00																								
27-0031	Calhoun	8/19/2013	9:32:02		8	12.3	0.040	0.400	7.55	743	4.60																								
27-0031	Calhoun	8/19/2013	9:31:38		9	9.80	0.030	0.300	7.47	747	4.70																								
27-0031	Calhoun	8/19/2013	9:31:12		10	8.54	0.060	0.500	7.42	748	0																								
27-0031	Calhoun	8/19/2013	9:30:41		11	8.00	0	0	7.41	750	2.50																								
27-0031	Calhoun	8/19/2013	9:30:07		12	7.52	0	0	7.37	750	6.00				0.018	0.003																			
27-0031	Calhoun	8/19/2013	9:29:42		13	7.04	0	0	7.34	753	14.8																								
27-0031	Calhoun	8/19/2013	9:29:22		14	6.71	0	0	7.31	753	0																								
27-0031	Calhoun	8/19/2013	9:29:00		15	6.55	0	0	7.29	755	0																								
27-0031	Calhoun	8/19/2013	9:28:39		16	6.36	0	0	7.27	758	0																								
27-0031	Calhoun	8/19/2013	9:28:18		17	6.27	0	0	7.25	758	0																								
27-0031	Calhoun	8/19/2013	9:27:59		18	6.21	0.010	0.100	7.23	760	0				0.088	0.072																			
27-0031	Calhoun	8/19/2013	9:27:44		19	6.17	0.020	0.100	7.22	762	0																								
27-0031	Calhoun	8/19/2013	9:26:57		20	6.18	0	0	7.16	761	0																								
27-0031	Calhoun	8/19/2013	9:26:38		21	6.19	0	0	7.14	761	0																								
27-0031	Calhoun	8/19/2013	9:26:19		22	6.13	0	0	7.12	762	0				0.149	0.114						157													
27-0031	Calhoun	8/19/2013	9:25:44		23	6.15	0	0	7.08	761	0																								
27-0031	Calhoun	9/9/2013	10:16:43	2.08	0	23.8	8.40	103	8.66	651	78.9	3.90	0.550	1.33	0.013	<0.003		<0.500				135	10.2												
27-0031	Calhoun	9/9/2013	10:16:21		1	23.8	8.41	103	8.66	651	108																								
27-0031	Calhoun	9/9/2013	10:15:45		2	23.8	8.36	102	8.65	651	302																								
27-0031	Calhoun	9/9/2013	10:15:11		3	23.8	8.33	102	8.63	651	3.90																								
27-0031	Calhoun	9/9/2013	10:14:32		4	23.7	8.13	99.5	8.58	652	24.2																								
27-0031	Calhoun	9/9/2013	10:14:10		5	23.6	7.78	94.9	8.51	652	21.3																								
27-0031	Calhoun	9/9/2013	10:13:14		6	21.4	2.80	32.8	7.70	675	24.8				0.015	<0.003																			
27-0031	Calhoun	9/9/2013	10:12:37		7	15.9	0.090	0.900	7.41	737	26.4																								
27-0031	Calhoun	9/9/2013	10:12:10		8	11.8	0.020	0.200	7.27	748	29.4																								
27-0031	Calhoun	9/9/2013	10:11:41		9	10.0	0.030	0.300	7.21	756	0																								
27-0031	Calhoun	9/9/2013	10:11:13		10	9.16	0.090	0.800	7.17	756	0																								
27-0031	Calhoun	9/9/2013	10:10:42		11	8.45	0.100	0.900	7.15	756	0																								
27-0031	Calhoun	9/9/2013	10:10:14		12	7.78	0.030	0.300	7.15	755	0				0.017	<0.003																			
27-0031	Calhoun	9/9/2013	10:09:50		13	7.43	0	0	7.13	756	0																								
27-0031	Calhoun	9/9/2013	10:09:08		14	6.99	0	0	7.10	759	0																								
27-0031	Calhoun	9/9/2013	10:08:43		15	6.67	0	0	7.08	760	0																								
27-0031	Calhoun	9/9/2013	10:08:01		16	6.51	0	0	7.06	762	0																								
27-0031	Calhoun	9/9/2013	10:07:13		17	6.44	0	0	7.04	763	0																								
27-0031	Calhoun	9/9/2013	10:06:39		18	6.35	0	0	7.02	765	0				0.084	0.055																			
27-0031	Calhoun	9/9/2013	10:06:13		19	6.30	0	0	7.02	765	0																								
27-0031	Calhoun	9/9/2013	10:05:52		20	6.27	0	0	7.01	766	0																								
27-0031	Calhoun	9/9/2013	10:05:24		21	6.31	0	0	7.00	765	0																								
27-0031	Calhoun	9/9/2013	10:05:02		22	6.34	0	0	6.99	766	0				0.111	0.085						145	9.8												
27-0031	Calhoun	9/9/2013	10:04:41		23	6.36	0	0	6.97	766	0																								
27-0031	Calhoun	9/9/2013	10:04:12		24	6.27	0	0	6.97	772	0																								
27-0031	Calhoun	9/24/2013	9:08:58	2.95	0	18.4	8.42	92.3	8.45	663	7.60	4.70	1.29		0.017	<0.003		<0.500				127													
27-0031	Calhoun	9/24/2013	9:08:17		1	18.4	8.44	92.4	8.44	662	0																								
27-0031	Calhoun	9/24/2013	9:07:49		2	18.4	8.46	92.7	8.43	662	0																								
27-0031	Calhoun	9/24/2013	9:07:20		3	18.3	8.50	92.9	8.43	662	0																								
27-0031	Calhoun	9/24/2013	9:06:55		4	18.3	8.51	93.1	8.42	662	0																								
27-0031	Calhoun	9/24/2013	9:06:28		5	18.3	8.52	93.1	8.42	661	0																								
27-0031	Calhoun	9/24/2013	9:05:58		6	18.2	8.50	92.7	8.42	662	0				0.017	<0.003																			
27-0031	Calhoun	9/24/2013	9:05:14		7	17.9	7.88	85.5	8.32	668	0																								
27-0031	Calhoun	9/24/2013	9:04:07		8	13.2	0	0	7.42	749	0																								
27-0031	Calhoun	9/24/2013	9:03:37		9	10.2	0	0	7.34	755	0																								
27-0031	Calhoun	9/24/2013	9:02:57		10	9.02	0	0	7.30	754	0																								
27-0031	Calhoun	9/24/2013	9:02:25		11	8.34	0	0	7.25	755	0																								
27-0031	Calhoun	9/24/2013	9:01:38		12	7.67	0	0	7.27	754	0				0.021	<0.003																			
27-0031	Calhoun	9/24/2013	9:01:14		13	7.23	0	0	7.23	757	0																								
27-0031	Calhoun	9/24/2013	9:00:53		14	6.59	0	0	7.16	761	0																								
27-0031	Calhoun	9/24/2013	9:00:32		15	6.37	0	0	7.11	764	0																								
27-0031	Calhoun	9/24/2013	9:00:06		16	6.33	0	0	7.09	766	0																								
27-0031	Calhoun	9/24/2013	8:59:41		17	6.33	0	0	7.08	766	0																								
27-0031	Calhoun	9/24/2013	8:59:20		18	6.33	0	0	7.06	767	0				0.109	0.081																			
27-0031	Calhoun	9/24/2013	8:58:59		19	6.31	0	0	7.05	767	0																								
27-0031	Calhoun	9/24/2013	8:58:27		20	6.34	0	0	7.03	767	0																								
27-0031	Calhoun	9/24/2013	8:57:38		21	6.34	0	0	6.98	768	0																								
27-0031	Calhoun	9/24/2013	8:57:06		22	6.29	0	0	6.96	770	0				0.140	0.120						157													
27-0031	Calhoun	9/24/2013	8:56:08		23	6.57	0	0	6.86	768	22.7																								
27-0031	Calhoun	10/7/2013	10:16:55	3.14	0	16.2	8.54	89.4	8.40	672	0	<0.500	<0.500	1.29	0.016	0.003	<0.500	0.528	<0.030	102	128	143													
27-0031	Calhoun	10/7/2013	10:16:18		1	16.1	8.55	89.5	8.40	672	61.4																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0031	Calhoun	10/7/2013	10:15:43		2	16.1	8.53	89.3	8.36	672	48.1																								
27-0031	Calhoun	10/7/2013	10:15:11		3	16.1	8.48	88.7	8.38	678	40.2																								
27-0031	Calhoun	10/7/2013	10:14:39		4	16.1	8.48	88.7	8.39	671	41.1																								
27-0031	Calhoun	10/7/2013	10:14:15		5	16.1	8.53	89.2	8.37	672	100																								
27-0031	Calhoun	10/7/2013	10:13:36		6	16.1	8.45	88.3	8.37	673	174				0.014	0.003																			
27-0031	Calhoun	10/7/2013	10:13:03		7	16.0	8.43	88.0	8.35	672	47.2																								
27-0031	Calhoun	10/7/2013	10:12:31		8	15.7	8.43	87.5	8.33	674	19.2																								
27-0031	Calhoun	10/7/2013	10:11:06		9	13.3	0	0	7.47	757	46.8																								
27-0031	Calhoun	10/7/2013	10:10:34		10	9.51	0	0	7.42	766	68.9																								
27-0031	Calhoun	10/7/2013	10:10:07		11	8.50	0	0	7.40	764	0																								
27-0031	Calhoun	10/7/2013	10:09:34		12	7.59	0	0	7.38	762	0				0.021	<0.003																			
27-0031	Calhoun	10/7/2013	10:09:12		13	6.90	0	0	7.32	768	0																								
27-0031	Calhoun	10/7/2013	10:08:40		14	6.70	0	0	7.29	768	0																								
27-0031	Calhoun	10/7/2013	10:08:19		15	6.50	0	0	7.26	772	0																								
27-0031	Calhoun	10/7/2013	10:07:59		16	6.44	0	0	7.25	772	0																								
27-0031	Calhoun	10/7/2013	10:07:43		17	6.41	0	0	7.25	772	0																								
27-0031	Calhoun	10/7/2013	10:07:19		18	6.39	0	0	7.25	773	0				0.126	0.097																			
27-0031	Calhoun	10/7/2013	10:06:54		19	6.39	0	0	7.25	772	0																								
27-0031	Calhoun	10/7/2013	10:06:24		20	6.40	0	0	7.24	772	0																								
27-0031	Calhoun	10/7/2013	10:05:52		21	6.47	0	0	7.24	772	0																								
27-0031	Calhoun	10/7/2013	10:05:21		22	6.42	0	0	7.26	774	12.1				0.149	0.117						153													
27-0039	Cedar	2/6/2013	11:30:38	NA	0	2.46	11.0	82.8	6.65	671	14.0	16.7	6.63	0.745	0.086	0.011	1.41	1.67	0.254	135	168	127	11.2												
27-0039	Cedar	2/6/2013	11:30:10		1	3.38	10.6	81.3	6.63	669	14.2																								
27-0039	Cedar	2/6/2013	11:29:24		2	3.39	10.6	81.1	6.63	669	14.3																								
27-0039	Cedar	2/6/2013	11:28:50		3	3.39	10.6	80.9	6.62	669	14.0																								
27-0039	Cedar	2/6/2013	11:28:14		4	3.39	10.5	80.6	6.61	669	7.80																								
27-0039	Cedar	2/6/2013	11:27:28		5	3.39	10.5	80.5	6.60	669	7.90				0.049	0.014																			
27-0039	Cedar	2/6/2013	11:26:41		6	3.39	10.5	80.6	6.59	669	7.60																								
27-0039	Cedar	2/6/2013	11:25:57		7	3.39	10.5	80.7	6.57	669	8.00																								
27-0039	Cedar	2/6/2013	11:24:58		8	3.39	10.2	78.5	6.57	669	7.70																								
27-0039	Cedar	2/6/2013	11:23:42		9	3.40	8.57	65.8	6.56	670	7.50																								
27-0039	Cedar	2/6/2013	11:22:45		10	3.50	2.54	19.6	6.54	686	7.60				0.037	0.018																			
27-0039	Cedar	2/6/2013	11:21:32		11	3.54	1.47	11.3	6.55	691	7.20																								
27-0039	Cedar	2/6/2013	11:20:17		12	3.56	1.05	8.10	6.57	702	7.30																								
27-0039	Cedar	2/6/2013	11:19:11		13	3.60	1.88	14.5	6.61	723	8.50																								
27-0039	Cedar	2/6/2013	11:18:31		14	3.58	2.56	19.7	6.63	739	9.50				0.117	0.090						132	9.40												
27-0039	Cedar	2/6/2013	11:17:43		15	3.88	1.03	8.00	6.67	774	30.0																								
27-0039	Cedar	5/6/2013	11:15	1.05	0	10.2	14.3	130	8.13	645	126	6.78	2.71	0.811	0.044	<0.003	0.564	0.872	0.238	117	140	130													
27-0039	Cedar	5/6/2013	11:15		1	9.35	14.4	128	8.10	641	8.70																								
27-0039	Cedar	5/6/2013	11:15		2	7.49	13.5	115	8.03	635	8.80																								
27-0039	Cedar	5/6/2013	11:15		3	7.23	12.8	108	7.90	636	9.40																								
27-0039	Cedar	5/6/2013	11:15		4	6.78	11.7	98.2	7.81	649	7.90																								
27-0039	Cedar	5/6/2013	11:15		5	6.58	11.2	93.1	7.81	652	7.70				0.035	<0.003																			
27-0039	Cedar	5/6/2013	11:15		6	6.26	9.51	78.5	7.81	659	7.30																								
27-0039	Cedar	5/6/2013	11:15		7	5.03	3.51	28.1	7.77	721	8.20																								
27-0039	Cedar	5/6/2013	11:15		8	4.59	2.41	19.1	7.88	740	7.80																								
27-0039	Cedar	5/6/2013	11:15		9	4.36	1.53	12.0	7.92	754	7.80																								
27-0039	Cedar	5/6/2013	11:15		10	4.16	0.440	3.5	7.93	770	7.50				0.081	0.051																			
27-0039	Cedar	5/6/2013	11:15		11	4.01	0.300	2.4	8.03	788	8.20																								
27-0039	Cedar	5/6/2013	11:15		12	3.90	0.320	2.5	8.08	810	9.60																								
27-0039	Cedar	5/6/2013	11:15		13	3.91	0.370	2.9	8.11	823	10.9																								
27-0039	Cedar	5/6/2013	11:15		14	3.90	0.510	3.9	8.18	840	11.0				0.192	0.144						177													
27-0039	Cedar	5/24/2013	10:57:45	5.70	0	16.0	8.40	86.1	8.44	712		<0.500	<0.500		0.052	0.006		1.07				118													
27-0039	Cedar	5/24/2013	10:56:40		1	15.9	8.54	87.4	8.43	715																									
27-0039	Cedar	5/24/2013	10:55:40		2	15.8	8.46	86.4	8.44	713																									
27-0039	Cedar	5/24/2013	10:54:08		3	15.6	8.31	84.4	8.42	715																									
27-0039	Cedar	5/24/2013	10:52:56		4	12.7	8.32	79.4	8.20	728																									
27-0039	Cedar	5/24/2013	10:51:47		5	9.58	6.99	62.0	7.76	736					0.036	0.010																			
27-0039	Cedar	5/24/2013	10:50:44		6	8.16	5.60	48.0	7.55	751																									
27-0039	Cedar	5/24/2013	10:49:29		7	7.21	4.72	39.5	7.44	757																									
27-0039	Cedar	5/24/2013	10:48:13		8	6.13	2.88	23.5	7.30	785																									
27-0039	Cedar	5/24/2013	10:46:44		9	5.11	0.270	2.20	7.17	828																									
27-0039	Cedar	5/24/2013	10:45:54		10	4.98	0.270	2.20	7.16	834					0.083	0.029																			
27-0039	Cedar	5/24/2013	10:44:01		11	4.77	0.030	0.300	7.14	844																									
27-0039	Cedar	5/24/2013	10:43:22		12	4.67	0.340	2.60	7.14	850																									
27-0039	Cedar	5/24/2013	10:42:40		13	4.47	0.120	1.00	7.13	864																									
27-0039	Cedar	5/24/2013	10:41:37		14	4.36	0.330	2.60	7.12	874					0.152	0.089						153													
27-0039	Cedar	5/24/2013	10:40:59		15	4.37	0.330	2.60	7.13	877																									
27-0039	Cedar	6/3/2013	12:41:26	4.04	0	20.3	10.0	114	8.52	646	4.60	2.88	0.952	<0.500	0.048	0.005		1.04				133													
27-0039	Cedar	6/3/2013	12:40:47		1	18.9	10.4	114	8.60	644	71.8																								
27-0039	Cedar	6/3/2013	12:39:58		2	18.3	10.4	114	8.59	646	9.10																								
27-0039	Cedar	6/3/2013	12:39:16		3	17.9	9.25	99.8	8.42	645	8.70																								
27-0039	Cedar	6/3/2013	12:38:32		4	15.8	8.20	84.7	8.19	654	9.00																								
27-0039	Cedar	6/3/2013	12:36:41		5	10.8	5.81	53.7	7.68	669	10.4				0.057	0.017																			
27-0039	Cedar	6/3/2013	12:35:52		6	8.19	3.49	30.3	7.49	678	9.70																								
27-0039	Cedar	6/3/2013	12:35:19		7	7.13	2.11	17.9	7.41	690	9.10																								
27-0039	Cedar	6/3/2013	12:34:42		8	6.22	0.110	0.900	7.34	716	9.40																								
27-0039	Cedar	6/3/2013	12:34:03		9	5.63	0	0	7.34	735	10.9																								
27-0039	Cedar	6/3/2013	12:33:05		10	5.35	0	0	7.30	744	13.0				0.090	0.046																			
27-0039	Cedar	6/3/2013	12:32:02		11	4.94	0	0	7.25	759	15.7																								
27-0039	Cedar	6/3/2013	12:31:10		12	4.84	0	0	7.23	762	14.7																								
27-0039	Cedar	6/3/2013	12:30:31		13	4.82	0	0	7.19	767	15.3																								
27-0039	Cedar	6/3/2013	12:30:31		14	ND	ND	ND	ND	ND	ND				0.205	0.145						158													
27-0039	Cedar	6/3/2013	12:28:38		15	4.69	0.200	1.60	7.17	781	18.2																								
27-0039	Cedar	6/18/2013	11:24:38	2.60	0	22.3	11.9	140	9.22	634	10.7	9.09	<0.500		0.034	0.003		<0.500				116													
27-0039	Cedar	6/18/2013	11:23:48		1	21.7	12.4	144	9.21	636	12.1																								
27-0039	Cedar	6/18/2013	11:23:12		2	20.9	12.7	146	9.17	636	12.6																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	**SpCond** µS/cm	**TurbSC** NTU	**Chl-a** mg/M3	**Pheo-a** mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	**NO3NO2** mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	**E. Coli** mpn/100m	**Ca** mg/L	**Tot Al** µg/L	**Sol Al** µg/L	**As** µg/L	**Cd** µg/L	**Cu** µg/L	**Pb** µg/L	**Mn** µg/L	**Ni** µg/L	**Zn** µg/	**F. Coli** cfu/10
27-0039	Cedar	6/18/2013	11:22:41		3	18.9	9.69	107	8.49	643	12.3																								
27-0039	Cedar	6/18/2013	11:21:53		4	16.0	4.27	44.2	7.70	648	9.40																								
27-0039	Cedar	6/18/2013			5	ND	ND	ND	ND	ND	ND				0.036	0.003																			
27-0039	Cedar	6/18/2013	11:21:09		6	9.04	2.90	25.6	7.58	687	9.50																								
27-0039	Cedar	6/18/2013	11:20:33		7	7.39	0.780	6.70	7.52	705	8.20																								
27-0039	Cedar	6/18/2013	11:19:35		8	6.51	0	0	7.47	723	11.3																								
27-0039	Cedar	6/18/2013	11:19:04		9	5.73	0	0	7.45	747	14.4																								
27-0039	Cedar	6/18/2013	11:18:22		10	5.34	0	0	7.42	760	17.2				0.114	0.060																			
27-0039	Cedar	6/18/2013	11:17:51		11	5.16	0.010	0.100	7.41	764	14.7																								
27-0039	Cedar	6/18/2013	11:17:12		12	5.02	0.020	0.100	7.41	770	14.4																								
27-0039	Cedar	6/18/2013	11:16:32		13	4.90	0.030	0.300	7.42	776	15.5																								
27-0039	Cedar	6/18/2013	11:15:53		14	5.16	0.070	0.500	7.44	776	15.7				0.158	0.121						151													
27-0039	Cedar	6/18/2013	11:15:09		15	5.22	0.190	1.50	7.48	783	16.2																								
27-0039	Cedar	7/8/2013	11:45:13	0.85	0	26.3	10.9	139	9.14	585	36.6	23.9	0.750	1.62	0.040	<0.003	1.02	1.11	<0.030	90.0	104	85.0													
27-0039	Cedar	7/8/2013	11:44:30		1	26.0	11.0	139	9.13	584	52.2																								
27-0039	Cedar	7/8/2013	11:43:40		2	25.5	10.3	129	9.01	583	19.8																								
27-0039	Cedar	7/8/2013	11:42:43		3	23.3	1.99	24.0	7.86	609	12.0																								
27-0039	Cedar	7/8/2013	11:41:42		4	18.2	0.680	7.40	7.74	666	11.6																								
27-0039	Cedar	7/8/2013	11:40:49		5	13.7	0.010	0.100	7.68	686	9.80				0.038	<0.003																			
27-0039	Cedar	7/8/2013	11:40:00		6	9.86	0.010	0.100	7.66	709	12.0																								
27-0039	Cedar	7/8/2013	11:38:59		7	8.49	0	0	7.63	714	21.6																								
27-0039	Cedar	7/8/2013	11:37:47		8	7.19	0	0	7.59	728	12.4																								
27-0039	Cedar	7/8/2013	11:37:03		9	6.48	0	0	7.56	743	12.0																								
27-0039	Cedar	7/8/2013	11:36:14		10	5.96	0	0	7.53	756	14.6				0.148	0.111																			
27-0039	Cedar	7/8/2013	11:35:41		11	5.65	0	0	7.53	760	12.9																								
27-0039	Cedar	7/8/2013	11:34:47		12	5.37	0	0	7.52	768	14.0																								
27-0039	Cedar	7/8/2013	11:34:06		13	5.24	0.010	0.100	7.53	781	13.3																								
27-0039	Cedar	7/8/2013	11:33:19		14	5.08	0.020	0.200	7.55	780	14.7				0.224	0.182						110													
27-0039	Cedar	7/22/2013	10:04:50	1.10	0	26.6	7.82	101	8.70	564	11.6	18.2	1.98		0.029	<0.003		0.750				101													
27-0039	Cedar	7/22/2013	10:04:23		1	26.6	7.76	100	8.68	564	13.0																								
27-0039	Cedar	7/22/2013	10:03:20		2	26.4	7.61	97.9	8.59	563	13.0																								
27-0039	Cedar	7/22/2013	10:01:49		3	26.1	6.84	87.5	8.16	566	15.1																								
27-0039	Cedar	7/22/2013	9:59:47		4	20.8	0.020	0.300	7.46	637	419																								
27-0039	Cedar	7/22/2013	9:58:43		5	14.7	0.070	0.700	7.45	690	11.9				0.025	<0.003																			
27-0039	Cedar	7/22/2013	9:57:00		6	10.4	0	0	7.42	710	15.2																								
27-0039	Cedar	7/22/2013	9:55:36		7	8.84	0	0	7.42	714	17.5																								
27-0039	Cedar	7/22/2013	9:52:51		8	7.50	0	0	7.36	729	11.2																								
27-0039	Cedar	7/22/2013	9:51:44		9	6.63	0	0	7.34	744	11.2																								
27-0039	Cedar	7/22/2013	9:50:05		10	6.03	0	0	7.32	757	19.1				0.146	0.102																			
27-0039	Cedar	7/22/2013	9:47:39		11	5.82	0	0	7.33	761	12.1																								
27-0039	Cedar	7/22/2013	9:46:56		12	5.65	0	0	7.34	764	12.3																								
27-0039	Cedar	7/22/2013	9:45:55		13	5.40	0	0	7.34	773	12.6																								
27-0039	Cedar	7/22/2013	9:44:54		14	5.43	0	0	7.30	774	12.4				0.223	0.168						144													
27-0039	Cedar	7/22/2013	9:44:01		15	5.64	0.030	0.200	7.27	772	12.5																								
27-0039	Cedar	8/6/2013	11:13:57	1.35	0	23.1	9.14	110	8.66	577	9.30	9.14	2.16	1.78	0.028	0.003		0.741				104		2											
27-0039	Cedar	8/6/2013	11:13:30		1	22.9	9.13	110	8.62	576	9.40																								
27-0039	Cedar	8/6/2013	11:12:38		2	22.6	8.91	106	8.49	576	9.60																								
27-0039	Cedar	8/6/2013	11:09:58		3	22.2	5.12	60.7	7.94	581	10.3																								
27-0039	Cedar	8/6/2013	11:08:41		4	19.4	0.380	4.30	7.74	625	9.30																								
27-0039	Cedar	8/6/2013	11:07:33		5	15.1	0.500	5.10	7.69	687	8.50				0.032	0.003																			
27-0039	Cedar	8/6/2013	11:06:23		6	10.8	0.010	0.100	7.66	702	22.4																								
27-0039	Cedar	8/6/2013	11:05:08		7	8.49	0	0	7.63	716	11.2																								
27-0039	Cedar	8/6/2013	11:04:05		8	7.52	0	0	7.61	727	11.5																								
27-0039	Cedar	8/6/2013	11:02:49		9	6.68	0	0	7.60	743	11.9																								
27-0039	Cedar	8/6/2013	11:01:20		10	6.04	0	0	7.60	755	11.7				0.170	0.122																			
27-0039	Cedar	8/6/2013	10:59:40		11	5.83	0	0	7.61	761	14.0																								
27-0039	Cedar	8/6/2013	10:58:23		12	5.53	0	0	7.64	770	12.3																								
27-0039	Cedar	8/6/2013	10:57:11		13	5.51	0	0	7.68	773	12.8																								
27-0039	Cedar	8/6/2013	10:55:47		14	5.34	0.020	0.100	7.76	779	12.6				0.276	0.225						142													
27-0039	Cedar	8/6/2013	10:54:53		15	5.49	0.020	0.200	7.86	778	12.5																								
27-0039	Cedar	8/19/2013	10:48:10	1.36	0	23.9	9.19	112	8.69	588	147	12.6	<0.500		0.028	<0.003		0.608				120													
27-0039	Cedar	8/19/2013	10:47:46		1	23.8	9.14	111	8.69	588	141																								
27-0039	Cedar	8/19/2013	10:47:05		2	23.7	9.01	109	8.66	588	3.40																								
27-0039	Cedar	8/19/2013	10:46:22		3	23.7	8.85	107	8.59	588	3.30																								
27-0039	Cedar	8/19/2013	10:43:52		4	21.0	0.760	8.80	7.30	604	0																								
27-0039	Cedar	8/19/2013	10:42:49		5	14.4	0.180	1.90	7.15	699	0				0.032	<0.003																			
27-0039	Cedar	8/19/2013	10:42:01		6	10.7	0.160	1.50	7.07	711	15.9																								
27-0039	Cedar	8/19/2013	10:40:55		7	8.52	0	0	7.06	726	0																								
27-0039	Cedar	8/19/2013	10:39:47		8	7.48	0	0	7.03	738	0																								
27-0039	Cedar	8/19/2013	10:38:52		9	6.47	0	0	6.99	754	0																								
27-0039	Cedar	8/19/2013	10:37:20		10	6.00	0	0	6.95	764	0				0.177	0.134																			
27-0039	Cedar	8/19/2013	10:36:15		11	5.73	0	0	6.89	768	0																								
27-0039	Cedar	8/19/2013	10:35:05		12	5.53	0	0	6.84	773	0																								
27-0039	Cedar	8/19/2013	10:33:08		13	5.20	0	0	6.77	789	1.20																								
27-0039	Cedar	8/19/2013	10:32:14		14	5.27	0	0	6.89	792	1.90				0.289	0.240						155													
27-0039	Cedar	8/19/2013	10:31:21		15	5.09	0	0	7.07	796	2.70																								
27-0039	Cedar	9/9/2013	11:11:10	0.99	0	23.9	8.46	104	5.56	609	52.0	17.0	0.850	2.35	0.020	<0.003		0.959				95.0	<15.0												
27-0039	Cedar	9/9/2013	11:10:33		1	23.9	8.38	103	5.62	609	7.50																								
27-0039	Cedar	9/9/2013	11:09:44		2	23.9	8.32	102	5.74	609	5.90																								
27-0039	Cedar	9/9/2013	11:09:14		3	23.9	8.26	101	5.85	609	6.40																								
27-0039	Cedar	9/9/2013	11:06:44		4	21.1	0.020	0.200	7.06	630	0																								
27-0039	Cedar	9/9/2013	11:05:43		5	14.4	0.010	0.100	6.85	712	8.80				0.034	<0.003																			
27-0039	Cedar	9/9/2013	11:05:07		6	10.6	0	0	6.71	724	0.600																								
27-0039	Cedar	9/9/2013	11:04:27		7	8.80	0	0	6.69	732	0																								
27-0039	Cedar	9/9/2013	11:03:42		8	7.11	0	0	6.58	754	0																								
27-0039	Cedar	9/9/2013	11:02:57		9	6.49	0	0	6.53	763	0																								
27-0039	Cedar	9/9/2013	11:02:23		10	6.18	0	0	6.47	771	0				0.216	0.170																			

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0039	Cedar	9/9/2013	11:01:47		11	5.85	0	0	6.45	775	0																								
27-0039	Cedar	9/9/2013	11:01:11		12	5.64	0	0	6.41	778	0																								
27-0039	Cedar	9/9/2013	11:00:33		13	5.44	0	0	6.37	787	0																								
27-0039	Cedar	9/9/2013	11:00:02		14	5.30	0	0	6.33	794	0				0.316	0.231						135	11.2												
27-0039	Cedar	9/9/2013	10:59:38		15	5.26	0	0	6.30	798	0																								
27-0039	Cedar	9/24/2013	10:01:22	0.89	0	18.4	8.85	96.8	8.59	627	8.00	11.9	1.30		0.028	<0.003		0.893				122													
27-0039	Cedar	9/24/2013	10:00:51		1	18.3	8.81	96.4	8.61	627	8.20																								
27-0039	Cedar	9/24/2013	9:59:48		2	18.3	8.77	95.8	8.60	627	9.10																								
27-0039	Cedar	9/24/2013	9:58:40		3	18.2	8.72	95.1	8.59	628	7.80																								
27-0039	Cedar	9/24/2013	9:57:49		4	18.2	8.58	93.5	8.57	626	7.80																								
27-0039	Cedar	9/24/2013	9:56:50		5	16.7	2.44	25.8	7.63	653	3.80				0.029	<0.003																			
27-0039	Cedar	9/24/2013	9:55:50		6	11.5	0	0	7.30	727	3.50																								
27-0039	Cedar	9/24/2013	9:55:02		7	9.12	0	0	7.26	733	0																								
27-0039	Cedar	9/24/2013	9:53:26		8	7.53	0	0	7.19	749	0																								
27-0039	Cedar	9/24/2013	9:52:39		9	6.73	0	0	7.15	761	0																								
27-0039	Cedar	9/24/2013	9:52:05		9	6.73	0	0	7.15	761	0																								
27-0039	Cedar	9/24/2013	9:51:13		10	6.20	0	0	7.11	771	0				0.198	0.145																			
27-0039	Cedar	9/24/2013	9:50:38		11	5.92	0	0	7.11	774	0																								
27-0039	Cedar	9/24/2013	9:50:05		12	5.66	0	0	7.07	780	0																								
27-0039	Cedar	9/24/2013	9:49:07		13	5.55	0	0	7.05	786	0																								
27-0039	Cedar	9/24/2013	9:48:13		14	5.40	0	0	7.02	793	0.300				0.310	0.298						127													
27-0040	Cedar	9/24/2013	9:46:43		15	5.33	0	0	6.98	800	184																								
27-0039	Cedar	10/7/2013	11:10:48	1.23	0	16.2	7.09	74.3	8.21	648	6.20	<0.500	<0.500	2.26	0.028	0.003	0.756	0.821	<0.030	103	144	123													
27-0039	Cedar	10/7/2013	11:10:11		1	15.9	6.95	72.3	8.20	648	34.3																								
27-0039	Cedar	10/7/2013	11:09:15		2	15.8	6.92	71.9	8.20	647	40.8																								
27-0039	Cedar	10/7/2013	11:08:39		3	15.8	6.73	69.9	8.14	646	4.20																								
27-0039	Cedar	10/7/2013	11:07:10		5	15.5	6.36	65.7	8.08	648	5.20				0.028	<0.003																			
27-0039	Cedar	10/7/2013	11:06:01		6	15.0	3.79	38.8	7.72	657	4.50																								
27-0039	Cedar	10/7/2013	11:05:25		7	9.75	0	0	7.35	738	0																								
27-0039	Cedar	10/7/2013	11:04:45		8	7.67	0	0	7.27	757	0																								
27-0039	Cedar	10/7/2013	11:04:18		9	6.72	0	0	7.22	771	0																								
27-0039	Cedar	10/7/2013	11:03:56		10	6.31	0	0	7.20	777	0				0.220	0.188																			
27-0039	Cedar	10/7/2013	11:03:25		11	5.98	0	0	7.18	783	0																								
27-0039	Cedar	10/7/2013	11:02:59		12	5.77	0	0	7.16	789	0																								
27-0039	Cedar	10/7/2013	11:02:33		13	5.59	0	0	7.13	796	0																								
27-0039	Cedar	10/7/2013	11:02:10		14	5.61	0	0	7.11	800	0				0.344	0.306						143													
27-0039	Cedar	10/7/2013	11:01:37		15	5.50	0.030	0.200	7.11	805	0.100																								
27-0022	Diamond	5/10/2013	9:24:04	0.70	0	12.2	6.98	66.6	7.43	1196		7.66	3.21	1.54	0.087	0.004	0.635	0.692	<0.030	52.0	60.0	329													
27-0022	Diamond	5/22/2013	9:26:55	0.80	0	17.0	5.86	62.9	7.28	981		3.81	2.70		0.122	0.011		1.13				204													
27-0022	Diamond	5/22/2013	9:25:55		1	17.0	3.98	42.7	7.33	987																									
27-0022	Diamond	6/5/2013	10:26:05	0.73	0	17.8	6.50	70.2	7.65	884	8.60	7.90	1.22	1.42	0.131	0.037		1.18				239													
27-0022	Diamond	6/19/2013	9:46:08	NA	0	23.3	9.31	112	7.96	821	5.30	2.19	1.24		0.078	0.018		<0.500				213													
27-0022	Diamond	6/19/2013	9:46:44		1	23.1	9.79	117	8.07	821	364																								
27-0022	Diamond	7/10/2013	9:44:33	NA	0	23.7	1.72	20.8	7.20	558	17.5	21.2	6.64	2.48	0.028	0.001	0.008	0.733	<0.030	51.0	52.0	144													
27-0022	Diamond	7/10/2013	9:44:13		1	23.7	0.650	7.80	7.15	581	82.0																								
27-0022	Diamond	7/24/2013	9:21:20		0	21.9	1.39	16.3	7.45	473	10.8	23.2	3.98		0.106	0.004		1.08				108													
27-0022	Diamond	7/24/2013	9:20:54		1	21.8	1.38	16.1	7.49	471	111																								
27-0022	Diamond	8/7/2013	11:08:36	0.64	0	21.6	4.06	47.4	6.90	345	4.10	27.9	6.19	1.58	0.081	<0.003		0.571				73.8		1733											
27-0022	Diamond	8/7/2013	11:07:59		1	21.4	3.73	43.3	6.89	300	8.20																								
27-0022	Diamond	8/20/2013	10:02:16		0	22.5	3.47	41.3	6.50	456	149	82.6	6.62		0.122	<0.003		1.03				100													
27-0022	Diamond	8/20/2013	10:00:51		0	21.0	0.050	0.600	6.26	476	107																								
27-0022	Diamond	9/11/2013	8:53:12		0	22.3	1.72	20.3	6.98	626	0	133	17.5	3.41	0.267	0.015		1.86				150	7.4												
27-0022	Diamond	9/11/2013	8:52:04		0	22.3	0.870	9.80	7.07	628	0																								
27-0022	Diamond	9/25/2013	10:22:45		0	17.9	8.85	95.7	7.58	604	11.2	73.5	9.76		0.170	0.009		1.61				138													
27-0022	Diamond	10/9/2013	9:33:04		0	14.1	8.47	84.4	7.38	566	5.80	3.70	<0.500	2.07	0.146	<0.003	1.16	1.27	<0.030	77.0	80.0	120													
27-0022	Diamond	10/9/2013	9:32:15		1	14.1	0.170	1.70	6.76	569	21.8																								
27-0016	Harriet	2/14/2013	11:45:12	NA	0	1.32	13.5	99.2	7.44	633	8.00	3.10	1.91	<0.500	0.071	0.048	1.00	1.09	0.185	122	160	127	8.80												
27-0016	Harriet	2/14/2013	11:44:19		1	2.75	12.7	96.8	7.42	630	7.40																								
27-0016	Harriet	2/14/2013	11:43:46		2	3.01	12.7	97.6	7.42	630	7.40																								
27-0016	Harriet	2/14/2013	11:43:11		3	3.03	12.7	97.8	7.40	630	7.80																								
27-0016	Harriet	2/14/2013	11:42:30		4	3.03	12.7	97.8	7.39	630	7.80																								
27-0016	Harriet	2/14/2013	11:41:58		5	3.04	12.7	97.7	7.37	630	7.50																								
27-0016	Harriet	2/14/2013	11:41:05		6	3.04	12.7	97.4	7.35	630	7.70				0.059	0.048																			
27-0016	Harriet	2/14/2013	11:40:29		7	3.05	12.5	96.4	7.34	631	7.60																								
27-0016	Harriet	2/14/2013	11:39:42		8	3.11	12.0	92.8	7.31	632	7.70																								
27-0016	Harriet	2/14/2013	11:38:31		9	3.17	11.4	88.4	7.29	634	7.40																								
27-0016	Harriet	2/14/2013	11:37:33		10	3.22	11.0	85.3	7.27	634	7.40																								
27-0016	Harriet	2/14/2013	11:35:55		11	3.19	9.38	72.4	7.23	640	7.40																								
27-0016	Harriet	2/14/2013	11:34:50		12	3.25	8.62	66.6	7.22	642	7.70				0.078	0.066																			
27-0016	Harriet	2/14/2013	11:33:57		13	3.23	7.48	57.8	7.20	647	7.50																								
27-0016	Harriet	2/14/2013	11:33:01		14	3.27	6.46	50.0	7.20	654	7.40																								
27-0016	Harriet	2/14/2013	11:31:55		15	3.30	5.24	40.5	7.18	659	7.30				0.096	0.081																			
27-0016	Harriet	2/14/2013	11:30:42		16	3.38	3.41	26.5	7.18	666	7.00																								
27-0016	Harriet	2/14/2013	11:29:37		17	3.42	1.58	12.3	7.18	672	6.70																								
27-0016	Harriet	2/14/2013	11:28:48		18	3.45	0.660	5.10	7.18	680	6.70																								
27-0016	Harriet	2/14/2013	11:28:11		19	3.48	0.410	3.20	7.18	686	6.60																								
27-0016	Harriet	2/14/2013	11:27:39		20	3.51	0.380	2.90	7.18	699	6.60				0.236	0.209						137	8.50												
27-0016	Harriet	2/14/2013	11:26:50		21	3.51	0.520	4.10	7.18	731	7.00																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	**SpCond** µS/cm	**TurbSC** NTU	**Chl-a** mg/M3	**Pheo-a** mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	**NO3NO2** mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	**E. Coli** mpn/100m	**Ca** mg/L	**Tot Al** µg/L	**Sol Al** µg/L	**As** µg/L	**Cd** µg/L	**Cu** µg/L	**Pb** µg/L	**Mn** µg/L	**Ni** µg/L	**Zn** µg/	**F. Coli** cfu/10
27-0016	Harriet	2/14/2013	11:25:59		22	3.55	0.600	4.70	7.17	759	10.0																								
27-0016	Harriet	2/14/2013	11:25:09		23	3.63	0.570	4.50	7.16	778	9.60																								
27-0016	Harriet	2/14/2013	11:24:10		24	3.71	0.960	7.50	7.17	784	34.2																								
27-0016	Harriet	5/7/2013	10:48:50	2.38	0	13.0	13.2	128	8.22	613		6.54	1.63	0.347	0.060	0.016	0.506	0.660	0.194	111	132	114													
27-0016	Harriet	5/7/2013	10:48:50		1	9.80	15.1	136	8.30	602																									
27-0016	Harriet	5/7/2013	10:48:14		2	8.07	15.2	131	8.28	601																									
27-0016	Harriet	5/7/2013	10:47:38		3	6.53	14.4	120	8.14	600																									
27-0016	Harriet	5/7/2013	10:46:58		4	6.17	13.0	107	7.96	600																									
27-0016	Harriet	5/7/2013	10:46:20		5	6.03	12.3	101	7.88	600																									
27-0016	Harriet	5/7/2013	10:45:44		6	5.93	11.9	97.3	7.81	599					0.066	0.030																			
27-0016	Harriet	5/7/2013	10:45:14		7	5.90	12.0	97.9	7.80	600																									
27-0016	Harriet	5/7/2013	10:44:32		8	5.87	11.6	95.1	7.76	600																									
27-0016	Harriet	5/7/2013	10:43:20		9	5.86	11.6	94.5	7.70	603																									
27-0016	Harriet	5/7/2013	10:42:31		10	5.63	9.92	80.8	7.45	611																									
27-0016	Harriet	5/7/2013	10:41:44		11	5.22	8.54	68.8	7.25	628																									
27-0016	Harriet	5/7/2013	10:41:06		12	4.97	7.23	57.9	7.17	639					0.099	0.061																			
27-0016	Harriet	5/7/2013	10:40:33		13	4.78	6.60	52.6	7.12	649																									
27-0016	Harriet	5/7/2013	10:39:42		14	4.55	4.74	37.5	7.05	663																									
27-0016	Harriet	5/7/2013	10:39:12		15	4.32	3.75	29.6	7.02	675					0.139	0.103																			
27-0016	Harriet	5/7/2013	10:38:40		16	4.18	2.57	20.1	6.98	686																									
27-0016	Harriet	5/7/2013	10:38:07		17	4.08	2.09	16.4	6.97	695																									
27-0016	Harriet	5/7/2013	10:37:46		18	4.06	2.00	15.6	6.96	697																									
27-0016	Harriet	5/7/2013	10:37:09		19	4.05	1.87	14.7	6.96	698																									
27-0016	Harriet	5/7/2013	10:36:34		20	4.02	1.58	12.4	6.96	701					0.171	0.144						135													
27-0016	Harriet	5/7/2013	10:36:10		21	4.02	1.59	12.4	6.96	701																									
27-0016	Harriet	5/7/2013	10:35:47		22	3.99	1.33	10.4	6.96	705																									
27-0016	Harriet	5/7/2013	10:35:23		23	3.99	1.29	10.1	6.97	706																									
27-0016	Harriet	5/7/2013	10:34:38		24	3.98	0.920	7.10	7.00	708																									
27-0016	Harriet	5/21/2013	11:18:54	7.80	0	16.0	9.95	106	8.61	633		<0.500	<0.500		0.047	0.014		0.860				101													
27-0016	Harriet	5/21/2013	11:18:02		1	16.0	9.95	106	8.60	634																									
27-0016	Harriet	5/21/2013	11:17:05		2	15.9	9.88	105	8.59	635																									
27-0016	Harriet	5/21/2013	11:16:25		3	15.7	9.91	105	8.58	639																									
27-0016	Harriet	5/21/2013	11:15:50		4	14.0	10.4	106	8.56	649																									
27-0016	Harriet	5/21/2013	11:14:51		5	11.2	10.9	104	8.47	656																									
27-0016	Harriet	5/21/2013	11:13:54		6	9.79	11.0	102	8.34	658					0.059	0.022																			
27-0016	Harriet	5/21/2013	11:13:04		7	8.38	10.4	93.4	8.15	660																									
27-0016	Harriet	5/21/2013	11:12:06		8	7.37	9.92	86.6	7.96	663																									
27-0016	Harriet	5/21/2013	11:11:14		9	7.00	9.57	82.7	7.84	666																									
27-0016	Harriet	5/21/2013	11:10:21		10	6.43	8.41	71.7	7.67	672																									
27-0016	Harriet	5/21/2013	11:09:29		11	6.15	7.81	66.1	7.60	676																									
27-0016	Harriet	5/21/2013	11:08:09		12	5.88	7.15	60.1	7.52	681					0.071	0.055																			
27-0016	Harriet	5/21/2013	11:07:17		13	5.58	5.98	49.9	7.45	688																									
27-0016	Harriet	5/21/2013	11:06:34		14	5.48	5.73	47.7	7.43	690																									
27-0016	Harriet	5/21/2013	11:05:34		15	5.43	5.86	48.8	7.42	692					0.098	0.085																			
27-0016	Harriet	5/21/2013	11:04:31		16	5.42	5.86	48.7	7.41	692																									
27-0016	Harriet	5/21/2013	11:03:25		18	5.35	5.45	45.2	7.40	694																									
27-0016	Harriet	5/21/2013	11:02:04		19	5.25	5.32	44.0	7.36	698																									
27-0016	Harriet	5/21/2013	11:00:46		20	5.23	5.10	42.2	7.36	699					0.125	0.098						112													
27-0016	Harriet	5/21/2013	10:59:44		21	5.21	5.08	42.0	7.34	700																									
27-0016	Harriet	5/21/2013	10:58:51		22	5.18	4.88	40.3	7.34	701																									
27-0016	Harriet	5/21/2013	10:57:55		23	5.25	4.99	41.3	7.33	700																									
27-0016	Harriet	5/21/2013	10:57:10		24	5.18	4.91	40.6	7.34	702																									
27-0016	Harriet	6/7/2013	10:17:33	6.07	0	16.4	9.97	104	8.70	592	7.20	3.65	0.965	<0.500	0.041	0.004		0.730				111													
27-0016	Harriet	6/7/2013	10:16:46		1	16.2	10.0	105	8.71	591	7.30																								
27-0016	Harriet	6/7/2013	10:16:04		2	16.2	10.0	104	8.71	592	7.40																								
27-0016	Harriet	6/7/2013	10:15:02		3	16.2	10.1	105	8.71	592	8.20																								
27-0016	Harriet	6/7/2013	10:14:22		4	16.1	10.0	105	8.71	592	8.20																								
27-0016	Harriet	6/7/2013	10:13:33		5	16.1	9.90	103	8.66	590	7.60																								
27-0016	Harriet	6/7/2013	10:12:37		6	12.8	8.79	85.1	8.21	603	7.70				0.045	0.014																			
27-0016	Harriet	6/7/2013	10:11:06		7	9.31	9.53	85.0	8.10	612	8.60																								
27-0016	Harriet	6/7/2013	10:10:16		8	7.91	8.89	76.7	7.97	616	8.50																								
27-0016	Harriet	6/7/2013	10:09:18		9	7.03	7.63	64.4	7.83	621	8.80																								
27-0016	Harriet	6/7/2013	10:08:29		10	6.58	6.64	55.4	7.76	626	9.20																								
27-0016	Harriet	6/7/2013	10:07:18		11	6.25	5.79	47.9	7.71	628	8.90																								
27-0016	Harriet	6/7/2013	10:06:29		12	5.97	4.77	39.2	7.67	634	8.80				0.117	0.090																			
27-0016	Harriet	6/7/2013	10:05:41		13	5.86	4.25	34.8	7.65	636	8.90																								
27-0016	Harriet	6/7/2013	10:05:04		14	5.82	3.91	32.0	7.64	636	8.70																								
27-0016	Harriet	6/7/2013	10:04:21		15	5.66	3.12	25.5	7.62	639	8.90				0.148	0.110																			
27-0016	Harriet	6/7/2013	10:03:32		16	5.59	2.44	19.8	7.60	641	8.70																								
27-0016	Harriet	6/7/2013	10:02:41		17	5.55	1.97	16.0	7.59	642	8.70																								
27-0016	Harriet	6/7/2013	10:01:46		18	5.53	1.66	13.5	7.59	643	8.70																								
27-0016	Harriet	6/7/2013	10:01:21		19	5.52	1.58	12.9	7.59	643	8.60																								
27-0016	Harriet	6/7/2013	10:00:49		20	5.53	1.44	11.7	7.60	643	8.50				0.176	0.147						117													
27-0016	Harriet	6/7/2013	9:59:57		21	5.54	1.37	11.1	7.60	643	9.30																								
27-0016	Harriet	6/7/2013	9:59:12		22	5.50	1.16	9.40	7.61	644	8.60																								
27-0016	Harriet	6/7/2013	9:58:07		23	5.53	0.880	7.10	7.63	644	9.00																								
27-0016	Harriet	6/7/2013	9:57:25		24	5.54	0.760	6.20	7.64	648	9.20																								
27-0016	Harriet	6/18/2013	13:41:31	5.51	0	22.0	10.3	120	8.81	599	9.40	2.77	<0.500		0.023	0.004		0.513				116													
27-0016	Harriet	6/18/2013	13:40:34		1	21.4	10.2	118	8.78	597	9.30																								
27-0016	Harriet	6/18/2013	13:39:47		2	21.0	10.4	120	8.78	596	9.40																								
27-0016	Harriet	6/18/2013	13:39:12		3	20.5	10.4	118	8.76	596	10.2																								
27-0016	Harriet	6/18/2013	13:38:17		4	17.9	8.89	95.9	8.36	599	8.50																								
27-0016	Harriet	6/18/2013	13:37:26		5	16.0	8.18	84.8	8.10	605	8.70																								
27-0016	Harriet	6/18/2013	13:36:42		6	13.5	7.84	76.9	7.87	606	10.3				0.043	0.016																			
27-0016	Harriet	6/18/2013	13:35:44		7	9.71	8.08	72.7	7.72	616	9.50																								
27-0016	Harriet	6/18/2013	13:35:05		8	7.87	7.30	62.9	7.62	624	9.80																								
27-0016	Harriet	6/18/2013	13:34:01		9	7.13	5.98	50.5	7.52	628	10.0																								
27-0016	Harriet	6/18/2013	13:33:02		10	6.64	4.75	39.7	7.44	633	10.0																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0016	Harriet	6/18/2013	13:32:13		11	6.25	3.80	31.4	7.39	637	9.80																								
27-0016	Harriet	6/18/2013	13:31:16		12	6.09	3.27	26.9	7.36	639	9.90				0.132	0.120																			
27-0016	Harriet	6/18/2013	13:30:20		13	5.91	2.55	20.9	7.33	642	9.20																								
27-0016	Harriet	6/18/2013	13:29:37		14	5.89	2.34	19.1	7.31	642	9.40																								
27-0016	Harriet	6/18/2013	13:28:29		15	5.82	1.90	15.5	7.28	643	9.20				0.157	0.146																			
27-0016	Harriet	6/18/2013	13:27:47		16	5.81	1.60	13.1	7.27	644	8.80																								
27-0016	Harriet	6/18/2013	13:27:05		17	5.77	0.910	7.40	7.26	644	8.50																								
27-0016	Harriet	6/18/2013	13:26:35		18	5.72	0.480	3.90	7.23	646	8.60																								
27-0016	Harriet	6/18/2013	13:26:03		19	5.66	0.250	2.00	7.22	647	8.50																								
27-0016	Harriet	6/18/2013	13:25:34		20	5.70	0.220	1.80	7.22	647	8.60				0.210	0.188						166													
27-0016	Harriet	6/18/2013	13:24:54		21	5.69	0.170	1.40	7.21	647	8.50																								
27-0016	Harriet	6/18/2013	13:24:17		22	5.72	0.090	0.700	7.18	647	10.5																								
27-0016	Harriet	6/18/2013	13:23:52		23	5.65	0.110	0.900	7.16	650	9.70																								
27-0016	Harriet	7/8/2013	10:42:26	4.00	0	25.8	9.02	114	9.00	591	8.80	3.40	0.530	0.934	0.024	<0.003	0.646	0.678	<0.030	98.0	112	95.0													
27-0016	Harriet	7/8/2013	10:41:27		1	25.8	9.01	114	8.98	591	8.90																								
27-0016	Harriet	7/8/2013	10:40:44		2	25.3	9.07	114	8.97	590	9.50																								
27-0016	Harriet	7/8/2013	10:40:02		3	24.8	9.11	113	8.89	589	9.60																								
27-0016	Harriet	7/8/2013	10:39:06		4	23.7	7.54	91.6	8.48	587	13.2																								
27-0016	Harriet	7/8/2013	10:37:58		5	20.7	5.09	58.3	7.88	596	16.6																								
27-0016	Harriet	7/8/2013	10:36:38		6	13.6	5.89	58.3	7.80	617	15.7				0.046	<0.003																			
27-0016	Harriet	7/8/2013	10:36:03		7	11.3	5.97	56.0	7.77	620	20.5																								
27-0016	Harriet	7/8/2013	10:35:22		8	9.58	5.78	52.1	7.75	624	9.60																								
27-0016	Harriet	7/8/2013	10:34:32		9	8.15	4.84	42.2	7.72	631	9.00																								
27-0016	Harriet	7/8/2013	10:33:35		10	7.59	4.02	34.5	7.69	634	9.70																								
27-0016	Harriet	7/8/2013	10:32:46		11	7.20	3.42	29.0	7.66	635	9.50																								
27-0016	Harriet	7/8/2013	10:32:08		12	6.89	2.58	21.8	7.66	638	9.50				0.139	0.119																			
27-0016	Harriet	7/8/2013	10:31:36		13	6.59	2.27	19.1	7.66	639	9.50																								
27-0016	Harriet	7/8/2013	10:30:41		14	6.39	1.40	11.7	7.65	641	9.10																								
27-0016	Harriet	7/8/2013	10:30:07		15	6.20	0.740	6.20	7.65	643	9.00				0.163	0.154																			
27-0016	Harriet	7/8/2013	10:29:09		16	6.11	0.120	1.00	7.64	644	8.70																								
27-0016	Harriet	7/8/2013	10:28:01		17	6.03	0	0	7.65	645	8.60																								
27-0016	Harriet	7/8/2013	10:27:09		18	6.00	0	0	7.66	646	8.70																								
27-0016	Harriet	7/8/2013	10:26:33		19	6.00	0	0	7.67	646	8.60																								
27-0016	Harriet	7/8/2013	10:25:31		20	6.00	0	0	7.69	646	8.30				0.217	0.200						95.0													
27-0016	Harriet	7/8/2013	10:24:12		21	5.95	0	0	7.71	647	8.50																								
27-0016	Harriet	7/8/2013	10:22:43		22	5.96	0	0	7.74	647	8.80																								
27-0016	Harriet	7/8/2013	10:21:50		23	5.96	0	0	7.75	648	8.50																								
27-0016	Harriet	7/8/2013	10:21:03		24	5.93	0	0	7.77	648	9.00																								
27-0016	Harriet	7/8/2013	10:19:29		25	6.12	0.070	0.600	7.83	645	9.20																								
27-0016	Harriet	7/23/2013	10:31:11	3.80	0	25.8	8.13	102	8.79	585	8.10	3.00	<0.500		0.018	<0.003		0.650				101													
27-0016	Harriet	7/23/2013	10:30:47		1	25.8	8.10	102	8.78	584	8.40																								
27-0016	Harriet	7/23/2013	10:30:21		2	25.8	8.12	102	8.75	585	8.40																								
27-0016	Harriet	7/23/2013	10:29:41		3	25.7	8.10	102	8.68	585	7.70																								
27-0016	Harriet	7/23/2013	10:29:08		4	25.7	7.90	99.3	8.52	584	7.20																								
27-0016	Harriet	7/23/2013	10:28:27		5	22.3	4.94	58.4	7.91	584	8.40																								
27-0016	Harriet	7/23/2013	10:27:58		6	15.2	4.90	50.1	7.84	620	9.10				0.028	<0.003																			
27-0016	Harriet	7/23/2013	10:27:21		7	11.8	4.70	44.6	7.83	625	9.60																								
27-0016	Harriet	7/23/2013	10:26:51		8	9.46	4.09	36.7	7.81	630	8.70																								
27-0016	Harriet	7/23/2013	10:26:11		9	7.93	2.96	25.6	7.80	636	8.70																								
27-0016	Harriet	7/23/2013	10:25:32		10	7.27	1.67	14.2	7.79	638	8.70																								
27-0016	Harriet	7/23/2013	10:25:05		11	6.93	1.16	9.80	7.79	641	8.50																								
27-0016	Harriet	7/23/2013	10:24:25		12	6.66	0.330	2.80	7.79	643	8.10				0.174	0.166																			
27-0016	Harriet	7/23/2013	10:23:58		13	6.50	0	0	7.79	644	8.50																								
27-0016	Harriet	7/23/2013	10:23:32		14	6.34	0	0	7.79	645	8.50																								
27-0016	Harriet	7/23/2013	10:23:07		15	6.22	0	0	7.80	646	9.10				0.201	0.192																			
27-0016	Harriet	7/23/2013	10:22:39		16	6.17	0	0	7.80	647	9.00																								
27-0016	Harriet	7/23/2013	10:22:07		17	6.10	0	0	7.81	649	8.70																								
27-0016	Harriet	7/23/2013	10:21:34		18	6.09	0	0	7.84	648	9.10																								
27-0016	Harriet	7/23/2013	10:20:56		19	6.16	0.010	0.100	7.86	648	8.80																								
27-0016	Harriet	7/23/2013	10:20:35		20	6.18	0.020	0.100	7.89	648	8.90				0.257	0.217						120													
27-0016	Harriet	7/23/2013	10:20:05		21	6.17	0.040	0.400	7.92	648	10.5																								
27-0016	Harriet	7/23/2013	10:19:44		22	6.20	0.060	0.500	7.95	649	11.0																								
27-0016	Harriet	7/23/2013	10:19:23		23	6.14	0.110	0.900	7.99	651	10.8																								
27-0016	Harriet	7/23/2013	10:19:07		24	6.21	0.160	1.300	8.03	649	10.3																								
27-0016	Harriet	8/9/2013	9:33:56	2.54	0	22.9	9.20	110	9.02	587	27.3	3.81	1.05	1.27	0.019	<0.003		<0.500				109		12											
27-0016	Harriet	8/9/2013	9:33:27		1	22.8	9.22	110	9.02	586	27.1																								
27-0016	Harriet	8/9/2013	9:33:04		2	22.8	9.17	109	9.01	586	32.8																								
27-0016	Harriet	8/9/2013	9:32:39		3	22.7	9.19	109	9.00	587	0																								
27-0016	Harriet	8/9/2013	9:31:54		4	22.7	9.12	108	8.97	587	0																								
27-0016	Harriet	8/9/2013	9:31:12		5	22.2	7.98	94.0	8.77	589	0																								
27-0016	Harriet	8/9/2013	9:29:56		6	18.9	3.23	35.7	7.88	609	0				0.033	<0.003																			
27-0016	Harriet	8/9/2013	9:28:45		7	13.4	3.00	29.5	7.69	629	0																								
27-0016	Harriet	8/9/2013	9:27:48		8	10.3	2.93	26.8	7.76	635	0																								
27-0016	Harriet	8/9/2013	9:26:43		9	8.23	0.830	7.20	7.69	643	0																								
27-0016	Harriet	8/9/2013	9:26:02		10	7.34	0.260	2.20	7.68	644	0																								
27-0016	Harriet	8/9/2013	9:25:29		11	6.81	0	0	7.68	648	0																								
27-0016	Harriet	8/9/2013	9:24:56		12	6.48	0	0	7.68	648	0				0.203	0.180																			
27-0016	Harriet	8/9/2013	9:24:36		13	6.31	0	0	7.68	650	0																								
27-0016	Harriet	8/9/2013	9:24:17		14	6.20	0	0	7.67	651	0																								
27-0016	Harriet	8/9/2013	9:23:57		15	6.16	0	0	7.66	651	0				0.238	0.210																			
27-0016	Harriet	8/9/2013	9:23:35		16	6.09	0	0	7.65	652	0																								
27-0016	Harriet	8/9/2013	9:23:12		17	6.07	0	0	7.64	652	0																								
27-0016	Harriet	8/9/2013	9:22:44		18	6.04	0	0	7.63	654	0																								
27-0016	Harriet	8/9/2013	9:22:15		19	5.94	0	0	7.60	655	0																								
27-0016	Harriet	8/9/2013	9:21:40		20	5.95	0	0	7.56	655	0				0.287	0.262						119													
27-0016	Harriet	8/9/2013	9:21:10		21	5.97	0	0	7.52	655	0																								
27-0016	Harriet	8/9/2013	9:20:45		22	5.92	0	0	7.51	656	0																								
27-0016	Harriet	8/9/2013	9:20:18		23	5.95	0	0	7.48	655	0																								
27-0016	Harriet	8/9/2013	9:19:52		24	6.01	0	0	7.41	656	0																								

Underlined data indicates monthly performance standard failure.

Lake ID	**Lake Name**	**Date** MM/DD/YYY	**Time** HH:MM:SS	**Secchi** meters	**Depth** meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	**SpCond** µS/cm	**TurbSC** NTU	**Chl-a** mg/M3	**Pheo-a** mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	**NO3NO2** mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	**E. Coli** mpn/100m	**Ca** mg/L	**Tot Al** µg/L	**Sol Al** µg/L	**As** µg/L	**Cd** µg/L	**Cu** µg/L	**Pb** µg/L	**Mn** µg/L	**Ni** µg/L	**Zn** µg/	**F. Coli** cfu/10
27-0016	Harriet	8/19/2013	12:04:59	1.94	0	23.5	9.50	115	9.52	594	0.100	4.85	0.630		0.024	<0.003		<0.500				120													
27-0016	Harriet	8/19/2013	12:04:35		1	23.5	9.52	115	9.53	594	0																								
27-0016	Harriet	8/19/2013	12:03:33		2	23.5	9.45	114	9.52	594	0																								
27-0016	Harriet	8/19/2013	12:02:46		3	23.5	9.44	114	9.49	594	0																								
27-0016	Harriet	8/19/2013	12:01:41		4	22.9	8.57	102	9.30	597	0																								
27-0016	Harriet	8/19/2013	12:00:48		5	21.9	7.89	92.4	9.09	600	0																								
27-0016	Harriet	8/19/2013	11:59:53		6	18.9	2.36	26.1	8.15	615	0				0.028	<0.003																			
27-0016	Harriet	8/19/2013	11:59:07		7	13.2	1.46	14.3	7.91	632	0																								
27-0016	Harriet	8/19/2013	11:58:36		8	10.2	1.40	12.8	7.89	638	0																								
27-0016	Harriet	8/19/2013	11:58:02		9	8.17	0.070	0.600	7.81	643	0																								
27-0016	Harriet	8/19/2013	11:57:38		10	7.48	0.010	0.100	7.82	646	0																								
27-0016	Harriet	8/19/2013	11:56:59		11	6.93	0	0	7.81	650	0																								
27-0016	Harriet	8/19/2013	11:56:10		12	6.63	0	0	7.82	651	0				0.257	0.230																			
27-0016	Harriet	8/19/2013	11:55:39		13	6.37	0	0	7.81	653	0																								
27-0016	Harriet	8/19/2013	11:55:15		14	6.18	0	0	7.81	654	0																								
27-0016	Harriet	8/19/2013	11:54:59		15	6.03	0	0	7.80	656	0																								
27-0016	Harriet	8/19/2013	11:54:41		16	6.04	0	0	7.80	656	0																								
27-0016	Harriet	8/19/2013	11:54:25		17	6.02	0	0	7.80	657	0																								
27-0016	Harriet	8/19/2013	11:54:05		18	5.92	0	0	7.79	658	0																								
27-0016	Harriet	8/19/2013	11:53:38		19	5.93	0	0	7.78	659	0																								
27-0016	Harriet	8/19/2013	11:53:21		20	5.91	0	0	7.79	659	0				0.320	0.303						110													
27-0016	Harriet	8/19/2013	11:53:00		21	5.93	0	0	7.79	659	0																								
27-0016	Harriet	8/19/2013	11:52:37		22	6.05	0	0	7.79	657	0																								
27-0016	Harriet	8/19/2013	11:52:09		23	5.99	0.010	0.100	7.79	656	0																								
27-0016	Harriet	8/19/2013	11:51:35		24	5.96	0	0	7.79	658	0																								
27-0016	Harriet	9/10/2013	9:01:51	2.41	0	24.3	8.40	103	8.69	591	0	3.70	0.580	1.29	0.017	0.003		0.549				115	9.2												
27-0016	Harriet	9/10/2013	9:01:17		1	24.3	8.36	103	8.68	591	0																								
27-0016	Harriet	9/10/2013	9:00:46		2	24.3	8.39	103	8.67	591	0																								
27-0016	Harriet	9/10/2013	9:00:27		3	24.3	8.33	103	8.67	591	0																								
27-0016	Harriet	9/10/2013	8:59:57		4	24.2	8.15	100	8.64	591	0																								
27-0016	Harriet	9/10/2013	8:59:03		5	23.8	7.52	91.8	8.48	593	0																								
27-0016	Harriet	9/10/2013	8:58:04		6	19.6	0.430	4.80	7.39	621	0				0.023	0.003																			
27-0016	Harriet	9/10/2013	8:57:31		7	14.8	0.080	0.800	7.22	642	0																								
27-0016	Harriet	9/10/2013	8:57:06		8	9.75	0.110	1.00	7.10	636	0																								
27-0016	Harriet	9/10/2013	8:56:35		9	8.63	0.050	0.400	7.06	638	0																								
27-0016	Harriet	9/10/2013	8:56:14		10	7.68	0.030	0.200	7.04	642	0																								
27-0016	Harriet	9/10/2013	8:55:45		11	7.10	0.040	0.300	7.02	644	0																								
27-0016	Harriet	9/10/2013	8:55:21		12	6.74	0.070	0.600	6.99	645	0				0.211	0.204																			
27-0016	Harriet	9/10/2013	8:54:55		13	6.59	0.030	0.200	6.98	646	0																								
27-0016	Harriet	9/10/2013	8:54:20		14	6.39	0.010	0.100	6.97	648	0																								
27-0016	Harriet	9/10/2013	8:53:49		15	6.36	0.060	0.500	6.96	648	0				0.281	0.270																			
27-0016	Harriet	9/10/2013	8:53:18		16	6.29	0.080	0.700	6.95	648	0																								
27-0016	Harriet	9/10/2013	8:52:45		17	6.25	0.070	0.600	6.95	649	0																								
27-0016	Harriet	9/10/2013	8:52:17		18	6.22	0.070	0.600	6.94	650	0																								
27-0016	Harriet	9/10/2013	8:51:41		19	6.23	0.040	0.300	6.95	649	0																								
27-0016	Harriet	9/10/2013	8:51:11		20	6.21	0.110	0.900	6.95	650	0				0.346	0.316						120	8.7												
27-0016	Harriet	9/10/2013	8:50:42		21	6.21	0.070	0.600	6.95	650	0																								
27-0016	Harriet	9/10/2013	8:50:06		22	6.21	0.080	0.700	6.96	650	0																								
27-0016	Harriet	9/10/2013	8:49:38		23	6.20	0.070	0.600	6.98	650	0																								
27-0016	Harriet	9/10/2013	8:49:06		24	6.20	0.100	0.800	7.02	650	0																								
27-0016	Harriet	9/25/2013	9:30:18	2.84	0	18.7	9.39	103	8.71	599	1.10	3.30	0.740		0.021	<0.003		0.521				118													
27-0016	Harriet	9/25/2013	9:29:12		1	18.7	9.38	103	8.72	599	0																								
27-0016	Harriet	9/25/2013	9:28:44		2	18.7	9.38	103	8.72	599	0																								
27-0016	Harriet	9/25/2013	9:28:03		3	18.7	9.36	103	8.71	599	0																								
27-0016	Harriet	9/25/2013	9:27:27		4	18.6	9.37	103	8.71	599	0																								
27-0016	Harriet	9/25/2013	9:26:30		5	18.5	9.19	101	8.70	599	0																								
27-0016	Harriet	9/25/2013	9:25:50		6	18.4	9.00	98.5	8.68	598	0				0.024	<0.003																			
27-0016	Harriet	9/25/2013	9:25:01		7	17.7	7.29	78.5	8.41	607	0																								
27-0016	Harriet	9/25/2013	9:22:11		8	10.9	0.070	0.700	7.47	639	0																								
27-0016	Harriet	9/25/2013	9:21:37		9	8.55	0	0	7.38	646	0																								
27-0016	Harriet	9/25/2013	9:21:05		10	7.77	0	0	7.35	647	0																								
27-0016	Harriet	9/25/2013	9:20:37		11	7.18	0	0	7.34	651	0																								
27-0016	Harriet	9/25/2013	9:19:55		12	6.72	0	0	7.34	651	0				0.217	0.206																			
27-0016	Harriet	9/25/2013	9:19:16		13	6.47	0	0	7.31	654	0																								
27-0016	Harriet	9/25/2013	9:18:52		14	6.35	0	0	7.30	654	0																								
27-0016	Harriet	9/25/2013	9:18:31		15	6.26	0	0	7.30	655	0				0.284	0.284																			
27-0016	Harriet	9/25/2013	9:17:52		16	6.21	0	0	7.28	656	0																								
27-0016	Harriet	9/25/2013	9:17:26		17	6.17	0	0	7.27	656	0																								
27-0016	Harriet	9/25/2013	9:16:54		18	6.14	0	0	7.26	657	0																								
27-0016	Harriet	9/25/2013	9:16:26		19	6.11	0	0	7.26	657	0																								
27-0016	Harriet	9/25/2013	9:15:47		20	6.09	0	0	7.25	658	0				0.336	0.328						123													
27-0016	Harriet	9/25/2013	9:15:22		21	6.11	0	0	7.24	658	0																								
27-0016	Harriet	9/25/2013	9:14:48		22	6.09	0	0	7.24	658	0																								
27-0016	Harriet	9/25/2013	9:14:22		23	6.11	0	0	7.24	659	0																								
27-0016	Harriet	9/25/2013	9:13:51		24	6.16	0	0	7.23	660	0																								
27-0016	Harriet	10/8/2013	9:53:14	3.30	0	16.2	9.07	95.0	8.59	599	0	<0.500	<0.500	1.00	0.016	0.003	<0.500	0.515	<0.030	100	116	189													
27-0016	Harriet	10/8/2013	9:52:42		1	16.2	9.02	94.4	8.59	599	0																								
27-0016	Harriet	10/8/2013	9:52:05		2	16.2	9.02	94.4	8.59	599	0																								
27-0016	Harriet	10/8/2013	9:51:32		3	16.2	8.98	94.0	8.58	599	0																								
27-0016	Harriet	10/8/2013	9:50:53		4	16.2	8.94	93.6	8.58	599	0																								
27-0016	Harriet	10/8/2013	9:49:56		5	16.2	8.93	93.5	8.56	599	0																								
27-0016	Harriet	10/8/2013	9:49:25		6	16.1	8.91	93.2	8.55	598	0				0.020	0.003																			
27-0016	Harriet	10/8/2013	9:48:25		7	15.9	7.82	81.4	8.37	602	0																								
27-0016	Harriet	10/8/2013	9:47:36		8	14.6	2.13	21.6	7.68	621	0																								
27-0016	Harriet	10/8/2013	9:46:55		9	9.74	0	0	7.42	646	0																								
27-0016	Harriet	10/8/2013	9:46:08		10	8.01	0	0	7.36	649	0																								
27-0016	Harriet	10/8/2013	9:45:33		11	7.36	0	0	7.34	651	0																								
27-0016	Harriet	10/8/2013	9:45:08		12	6.87	0	0	7.30	653	0				0.220	0.191																			

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0016	Harriet	10/8/2013	9:44:46		13	6.41	0	0	7.27	655	0																							
27-0016	Harriet	10/8/2013	9:44:13		14	6.35	0	0	7.26	655	0																							
27-0016	Harriet	10/8/2013	9:43:52		15	6.29	0	0	7.25	656	0				0.334	0.319																		
27-0016	Harriet	10/8/2013	9:43:27		16	6.24	0	0	7.24	657	0																							
27-0016	Harriet	10/8/2013	9:43:03		17	6.19	0	0	7.23	657	0																							
27-0016	Harriet	10/8/2013	9:42:35		18	6.14	0	0	7.23	658	0																							
27-0016	Harriet	10/8/2013	9:42:03		19	6.16	0	0	7.22	657	0																							
27-0016	Harriet	10/8/2013	9:41:43		20	6.14	0	0	7.22	658	0				0.388	0.370						178													
27-0016	Harriet	10/8/2013	9:41:20		21	6.16	0	0	7.22	658	0																							
27-0016	Harriet	10/8/2013	9:40:46		22	6.11	0	0	7.23	659	0																							
27-0016	Harriet	10/8/2013	9:40:21		23	6.10	0	0	7.23	659	0																							
27-0016	Harriet	10/8/2013	9:40:02		24	6.09	0	0	7.25	659	0																							
27-0018	Hiawatha	2/21/2013	11:46:59	NA	0	0.450	8.84	61.9	7.88	871	45.1	23.8	8.86	10.7	0.074	0.007	2.10	2.44	0.362	171	230	182	17.5												
27-0018	Hiawatha	2/21/2013	11:46:25		1	2.62	5.62	41.8	7.72	893	41.8																							
27-0018	Hiawatha	2/21/2013	11:45:23		2	3.07	4.55	34.3	7.79	911	40.4																							
27-0018	Hiawatha	2/21/2013	11:44:06		3	3.37	2.40	18.2	7.88	1009	8.70																							
27-0018	Hiawatha	2/21/2013	11:42:25		4	3.59	0.990	7.60	7.78	1484	11.4				0.121	0.031						287	15.6												
27-0018	Hiawatha	2/21/2013	11:40:57		5	3.46	1.04	7.90	7.78	1832	11.6																							
27-0018	Hiawatha	2/21/2013	11:39:57		6	3.44	0.950	7.20	7.82	1969	12.8																							
27-0018	Hiawatha	2/21/2013	11:38:46		7	3.66	0.760	5.90	7.89	1994	12.9																							
27-0018	Hiawatha	5/13/2013	11:01:05	1.00	0	12.1	11.4	109	8.39	1122		15.1	2.68	2.93	0.057	<0.003	0.687	0.903	0.141	133	196	210													
27-0018	Hiawatha	5/13/2013	11:00:20		1	12.0	11.3	108	8.37	1123																								
27-0018	Hiawatha	5/13/2013	10:59:46		2	12.0	11.0	105	8.33	1122																								
27-0018	Hiawatha	5/13/2013	10:58:40		3	11.7	9.91	93.4	8.08	1118																								
27-0018	Hiawatha	5/13/2013	10:57:40		4	9.55	5.47	49.0	7.27	1118					0.067	0.003						231													
27-0018	Hiawatha	5/13/2013	10:56:27		5	7.23	1.01	8.60	6.84	1478																								
27-0018	Hiawatha	5/13/2013	10:55:29		6	4.52	0.280	2.30	6.47	2918																								
27-0018	Hiawatha	5/13/2013	10:54:30		7	4.33	0.390	3.10	6.21	3134																								
27-0018	Hiawatha	5/13/2013	10:53:48		9	4.68	0.850	6.80	5.91	3190																								
27-0018	Hiawatha	5/28/2013	11:39:54	1.80	0	15.2	7.73	79.8	7.80	787		3.92	2.42		0.086	0.016		1.72				128													
27-0018	Hiawatha	5/28/2013	11:39:16		1	15.1	7.63	78.7	7.79	786																								
27-0018	Hiawatha	5/28/2013	11:38:08		2	15.1	7.46	76.8	7.77	786																								
27-0018	Hiawatha	5/28/2013	11:37:01		3	14.9	7.26	74.5	7.75	781																								
27-0018	Hiawatha	5/28/2013	11:35:43		4	14.7	6.88	70.3	7.69	773					0.061	0.020						133													
27-0018	Hiawatha	5/28/2013	11:34:20		5	13.1	0.230	2.30	7.31	979																								
27-0018	Hiawatha	5/28/2013	11:33:17		6	6.33	0.460	3.90	7.05	2550																								
27-0018	Hiawatha	5/28/2013	11:32:14		7	4.83	0.360	2.90	6.97	2950																								
27-0018	Hiawatha	5/28/2013	11:31:16		8	4.91	0.530	4.40	6.91	3036																								
27-0018	Hiawatha	6/11/2013	11:59:02	3.47	0	18.8	7.09	78.4	7.71	600	8.10	3.31	0.736	2.20	0.070	0.028		1.03				86.0													
27-0018	Hiawatha	6/11/2013	11:58:19		1	18.2	6.82	74.4	7.68	601	22.2																							
27-0018	Hiawatha	6/11/2013	11:57:41		2	17.5	5.94	63.9	7.61	601	8.20																							
27-0018	Hiawatha	6/11/2013	11:56:25		3	17.3	5.61	60.2	7.59	604	8.10																							
27-0018	Hiawatha	6/11/2013	11:55:31		4	16.6	4.21	44.4	7.53	611	9.50				0.081	0.035						88.5													
27-0018	Hiawatha	6/11/2013	11:54:19		5	15.2	0.020	0.200	7.42	765	12.9																							
27-0018	Hiawatha	6/11/2013	11:53:30		6	9.42	0.010	0.100	7.23	2085	28.3																							
27-0018	Hiawatha	6/11/2013	11:51:55		7	5.82	0.000	0.000	7.10	2747	23.3																							
27-0018	Hiawatha	6/11/2013	11:50:59		8	5.43	0.030	0.200	7.01	2864	17.8																							
27-0018	Hiawatha	6/11/2013	11:49:52		9	5.84	0.010	0.100	6.87	2964	28.0																							
27-0018	Hiawatha	6/21/2013	11:44:07	1.55	0	23.7	7.50	91.3	7.91	573	10.9	11.9	0.940		0.086	0.019		0.803				87.0													
27-0018	Hiawatha	6/21/2013	11:43:12		1	23.3	6.97	84.2	7.81	566	11.4																							
27-0018	Hiawatha	6/21/2013	11:42:21		2	22.9	6.29	75.5	7.73	511	15.9																							
27-0018	Hiawatha	6/21/2013	11:41:21		3	22.8	5.78	69.2	7.65	570	11.0																							
27-0018	Hiawatha	6/21/2013	11:40:28		4	22.0	4.34	51.1	7.56	504	15.7				0.130	0.041						82.0													
27-0018	Hiawatha	6/21/2013	11:38:19		5	18.0	0.010	0.100	7.38	627	11.1																							
27-0018	Hiawatha	6/21/2013	11:37:32		6	13.4	0.010	0.100	7.34	1087	13.8																							
27-0018	Hiawatha	6/21/2013	11:36:23		7	7.98	0.010	0.100	7.15	2490	19.8																							
27-0018	Hiawatha	6/21/2013	11:35:19		8	5.74	0	0	7.03	2813	17.9																							
27-0018	Hiawatha	7/11/2013	10:25:47	ND	0	26.2	5.12	64.7	7.61	477	8.10	3.90	1.05	4.48	0.083	0.039	0.685	0.707	<0.030	131	164	74.0													
27-0018	Hiawatha	7/11/2013	10:24:51		1	25.7	4.63	57.9	7.59	476	8.30																							
27-0018	Hiawatha	7/11/2013	10:23:57		2	25.6	4.52	56.4	7.59	477	8.20																							
27-0018	Hiawatha	7/11/2013	10:23:26		3	25.4	4.56	56.8	7.60	479	8.30																							
27-0018	Hiawatha	7/11/2013	10:22:36		4	25.3	5.14	63.8	7.62	476	9.90				0.079	0.035						69.0													
27-0018	Hiawatha	7/11/2013	10:21:35		5	25.1	4.61	57.1	7.60	478	10.9																							
27-0018	Hiawatha	7/11/2013	10:19:52		6	15.3	0.030	0.300	7.44	1115	17.9																							
27-0018	Hiawatha	7/11/2013	10:19:01		7	9.92	0.030	0.200	7.34	2439	21.4																							
27-0018	Hiawatha	7/29/2013	10:18:44	2.21	0	21.3	7.60	87.5	7.71	476	12.1	7.70	0.680		0.052	0.016		0.670				68.0													
27-0018	Hiawatha	7/29/2013	10:18:12		1	21.1	7.57	86.9	7.69	474	26.9																							
27-0018	Hiawatha	7/29/2013	10:17:16		2	20.9	7.52	85.9	7.67	472	11.8																							
27-0018	Hiawatha	7/29/2013	10:15:52		3	20.8	7.14	81.5	7.65	474	12.9																							
27-0018	Hiawatha	7/29/2013	10:15:02		4	20.7	7.14	81.4	7.61	474	12.3				0.056	0.018						63.0													
27-0018	Hiawatha	7/29/2013	10:13:37		5	20.6	7.13	81.0	7.64	474	16.4																							
27-0018	Hiawatha	7/29/2013	10:12:16		6	20.6	6.38	72.4	7.68	476	17.6																							
27-0018	Hiawatha	7/29/2013	10:10:42		7	11.8	0.040	0.400	7.25	2315	34.4																							
27-0018	Hiawatha	7/29/2013	10:09:43		8	9.29	0.140	1.20	7.18	2573	65.0																							
27-0018	Hiawatha	8/12/2013	12:29:48	1.78	0	23.0	7.31	87.3	7.87	446	0	4.89	5.07	2.39	0.039	0.008		0.586				63.9		52											
27-0018	Hiawatha	8/12/2013	12:29:23		1	22.8	7.35	87.5	7.86	446	0																							
27-0018	Hiawatha	8/12/2013	12:28:56		2	22.7	7.25	86.1	7.83	446	0																							
27-0018	Hiawatha	8/12/2013	12:28:14		3	22.5	6.71	79.4	7.75	449	0																							
27-0018	Hiawatha	8/12/2013	12:27:16		4	22.4	5.62	66.1	7.61	450	0				0.051	0.012						68.9													
27-0018	Hiawatha	8/12/2013	12:26:30		5	22.2	4.96	58.4	7.52	451	0																							
27-0018	Hiawatha	8/12/2013	12:25:03		6	19.1	0.140	1.60	7.22	695	0																							
27-0018	Hiawatha	8/12/2013	12:24:05		7	13.5	0.200	2.00	7.08	2007	0																							
27-0018	Hiawatha	8/21/2013	10:54:02	1.84	0	24.9	9.77	122	7.85	493	0.400	9.61	1.60		0.041	<0.003		0.500				67.1													

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0018	Hiawatha	8/21/2013	10:53:26		1	24.6	9.79	121	7.85	492	0																								
27-0018	Hiawatha	8/21/2013	10:52:37		2	23.9	8.28	101	7.49	497	0.500																								
27-0018	Hiawatha	8/21/2013	10:51:32		3	23.6	7.69	93.6	7.44	494	1.20																								
27-0018	Hiawatha	8/21/2013	10:50:58		4	23.2	5.99	72.2	7.23	490	2.50				0.046	0.004						67.1													
27-0018	Hiawatha	8/21/2013	10:50:07		5	21.6	0.150	1.70	6.88	515	2.30																								
27-0018	Hiawatha	8/21/2013	10:49:45		6	18.8	0.170	1.90	6.84	841	3.40																								
27-0018	Hiawatha	9/13/2013	9:50:51	1.11	0	22.2	7.60	88.6	8.00	553	0	19.5	3.42	2.35	0.050	<0.003		0.898				80.2	8.8												
27-0018	Hiawatha	9/13/2013	9:50:12		1	22.2	7.44	86.7	7.96	553	0																								
27-0018	Hiawatha	9/13/2013	9:48:58		2	22.2	7.31	85.2	7.93	554	0																								
27-0018	Hiawatha	9/13/2013	9:47:21		3	22.2	7.08	82.5	7.91	554	0																								
27-0018	Hiawatha	9/13/2013	9:46:40		4	21.7	6.89	79.6	7.86	555	0				0.050	0.004						80.2	10.2												
27-0018	Hiawatha	9/13/2013	9:44:28		5	21.5	6.67	76.6	7.78	559	0																								
27-0018	Hiawatha	9/13/2013	9:43:10		6	17.5	0.240	2.60	7.18	1226	0																								
27-0018	Hiawatha	9/13/2013	9:42:00		7	12.1	0.330	3.10	7.00	2379	0																								
27-0018	Hiawatha	10/1/2013	9:56:45	1.15	0	17.9	9.35	101	8.29	563	506	26.8	1.92		0.051	0.003		0.969				82.3													
27-0018	Hiawatha	10/1/2013	9:56:07		1	17.9	9.25	100	8.26	563	13.9																								
27-0018	Hiawatha	10/1/2013	9:55:21		2	17.9	9.12	98.7	8.25	563	15.7																								
27-0018	Hiawatha	10/1/2013	9:54:28		3	17.8	8.89	96.2	8.22	564	13.1																								
27-0018	Hiawatha	10/1/2013	9:53:49		4	17.6	7.97	85.9	7.97	570	10.6				0.048	0.004						82.3													
27-0018	Hiawatha	10/1/2013	9:52:51		5	17.5	7.04	75.7	7.85	574	9.90																								
27-0018	Hiawatha	10/1/2013	9:52:10		6	17.0	0.840	8.90	7.35	730	6.30																								
27-0018	Hiawatha	10/1/2013	9:51:27		7	14.7	0.070	0.700	7.03	1744	15.2																								
27-0018	Hiawatha	10/10/2013	11:33:50	1.63	0	15.8	8.03	83.0	8.03	473	16.6	2.00	<0.500	2.16	0.049	0.002	0.839	1.07	0.062	131	164	77.2													
27-0018	Hiawatha	10/10/2013	11:33:16		1	15.7	8.13	83.8	7.98	468	20.0																								
27-0018	Hiawatha	10/10/2013	11:32:32		2	15.6	8.00	82.4	7.98	467	21.6																								
27-0018	Hiawatha	10/10/2013	11:31:44		3	15.5	7.63	78.5	7.96	468	5.40																								
27-0018	Hiawatha	10/10/2013	11:31:05		4	15.3	4.60	47.0	7.58	474	111				0.054	0.006						82.3													
27-0018	Hiawatha	10/10/2013	11:30:01		5	15.0	3.95	40.1	7.57	493	4.50																								
27-0018	Hiawatha	10/10/2013	11:28:50		6	14.9	1.98	20.1	7.48	549	5.20																								
27-0018	Hiawatha	10/10/2013	11:28:09		7	14.8	1.32	13.4	7.44	606	6.60																								
27-0040	Isles	2/6/2013	12:30:53	NA	0	0.720	12.8	91.8	7.17	856	15.1	31.0	8.35	4.27	0.062	0.003	1.51	1.59	0.169	158	198	182	7.90												
27-0040	Isles	2/6/2013	12:29:34		1	3.40	11.1	85.1	7.15	863	8.30																								
27-0040	Isles	2/6/2013	12:28:55		2	3.43	11.1	85.3	7.15	864	8.60																								
27-0040	Isles	2/6/2013	12:27:46		3	3.47	10.8	82.8	7.13	864	8.30																								
27-0040	Isles	2/6/2013	12:26:53		4	3.54	10.4	80.1	7.12	867	7.60																								
27-0040	Isles	2/6/2013	12:25:33		5	3.60	8.59	66.4	7.11	876	7.40				0.034	0.004																			
27-0040	Isles	2/6/2013	12:23:58		6	3.61	8.17	63.1	7.11	880	7.90																								
27-0040	Isles	2/6/2013	12:21:33		7	3.57	7.75	59.8	7.10	887	7.60																								
27-0040	Isles	2/6/2013	12:20:28		8	3.58	7.49	57.8	7.10	893	8.50				0.038	0.011						182	7.10												
27-0040	Isles	2/6/2013	12:19:23		9	3.50	6.26	48.2	7.10	898	9.70																								
27-0040	Isles	5/6/2013	10:40	1.18	0	10.9	12.4	115	8.05	677	124	5.90	1.17	1.01	0.033	<0.003	0.794	1.04	0.220	107	128	151													
27-0040	Isles	5/6/2013	10:40		1	10.1	12.6	114	8.04	680	14.5																								
27-0040	Isles	5/6/2013	10:40		2	8.68	12.8	112	8.00	680	10.6																								
27-0040	Isles	5/6/2013	10:40		3	8.04	12.3	106	7.96	674	9.70																								
27-0040	Isles	5/6/2013	10:40		4	7.36	7.91	67.2	7.83	836	9.50																								
27-0040	Isles	5/6/2013	10:40		5	4.65	0.540	4.30	7.81	1005	10.5				0.035	<0.003																			
27-0040	Isles	5/6/2013	10:40		6	4.33	0.320	2.50	7.89	1030	7.40																								
27-0040	Isles	5/6/2013	10:40		7	4.22	0.370	2.90	7.89	1048	6.60																								
27-0040	Isles	5/6/2013	10:40		8	4.11	0.480	3.70	8.04	1058	8.00				0.052	<0.003						250													
27-0040	Isles	5/6/2013	10:40		9	4.23	0.780	6.10	8.11	1074	9.70																								
27-0040	Isles	5/24/2013	10:22:44	1.22	0	16.4	10.2	105	8.64	729		1.29	1.20		0.036	<0.003		0.800				136													
27-0040	Isles	5/24/2013	10:22:14		1	16.4	9.99	103	8.63	730																									
27-0040	Isles	5/24/2013	10:21:38		2	16.3	10.2	105	8.61	733																									
27-0040	Isles	5/24/2013	10:20:58		3	16.2	9.64	99.2	8.53	737																									
27-0040	Isles	5/24/2013	10:20:14		4	11.9	6.55	61.4	7.67	828																									
27-0040	Isles	5/24/2013	10:18:55		5	7.09	0.040	0.300	7.09	1069					0.080	<0.003																			
27-0040	Isles	5/24/2013	10:18:08		6	5.80	0.160	1.30	7.05	1118																									
27-0040	Isles	5/24/2013	10:17:34		7	5.29	0.200	1.60	7.04	1136																									
27-0040	Isles	5/24/2013	10:16:32		8	4.90	0.530	4.20	7.05	1150					0.041	<0.003						224													
27-0040	Isles	5/24/2013	10:15:54		9	4.59	0.670	5.20	7.06	1169																									
27-0040	Isles	6/3/2013	12:09:29	2.90	0	20.4	10.5	120	8.52	653	8.40	4.54	0.711	0.567	0.034	<0.003		0.850				138													
27-0040	Isles	6/3/2013	12:08:21		1	19.3	10.5	117	8.48	649	7.60																								
27-0040	Isles	6/3/2013	12:07:14		2	18.8	10.4	114	8.41	653	8.30																								
27-0040	Isles	6/3/2013	12:05:21		3	17.1	6.14	65.2	7.72	669	9.60																								
27-0040	Isles	6/3/2013	12:03:44		4	13.1	2.89	28.1	7.33	735	9.90																								
27-0040	Isles	6/3/2013	12:02:26		5	7.97	0.530	4.60	7.12	949	13.9				0.050	<0.003																			
27-0040	Isles	6/3/2013	12:01:28		6	6.45	0.010	0.100	7.06	996	10.5																								
27-0040	Isles	6/3/2013	12:00:34		7	5.99	0.020	0.100	7.04	1006	10.2																								
27-0040	Isles	6/3/2013	11:59:30		8	5.70	0.110	0.900	7.01	1016	9.90				0.064	<0.003						224													
27-0040	Isles	6/3/2013	11:58:44		9	5.23	0.410	3.30	7.03	1036	9.80																								
27-0040	Isles	6/18/2013	10:58:53	3.00	0	22.2	10.8	126	9.01	634	7.70	5.30	1.16		0.031	0.003		0.557				136													
27-0040	Isles	6/18/2013	10:58:06		1	22.0	10.7	125	9.00	636	18.7																								
27-0040	Isles	6/18/2013	10:56:59		2	21.1	10.3	119	8.77	641	10.8																								
27-0040	Isles	6/18/2013	10:56:05		3	18.5	7.93	86.5	8.14	668	8.50																								
27-0040	Isles	6/18/2013	10:54:21		4	14.8	2.24	22.6	7.65	724	9.90																								
27-0040	Isles	6/18/2013	10:52:40		5	9.10	0.030	0.200	7.47	945	10.4				0.055	0.003																			
27-0040	Isles	6/18/2013	10:51:14		6	6.90	0.010	0.100	7.44	1005	12.9																								
27-0040	Isles	6/18/2013	10:50:33		7	6.31	0.040	0.300	7.44	1015	13.8																								
27-0040	Isles	6/18/2013	10:49:26		8	5.86	0.060	0.500	7.44	1025	13.9				0.054	0.003						225													
27-0040	Isles	6/18/2013	10:48:30		9	5.31	0.110	0.900	7.39	1049	12.2																								
27-0040	Isles	7/9/2013	11:47:32	1.16	0	27.4	10.6	138	8.94	597	13.8	20.5	<0.500	1.40	0.038	<0.003	0.550	0.612	<0.030	85.0	104	75.0													
27-0040	Isles	7/9/2013	11:46:55		1	27.3	10.7	139	8.92	597	14.5																								
27-0040	Isles	7/9/2013	11:45:52		2	25.2	5.88	74.0	8.27	616	18.8																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0040	Isles	7/9/2013	11:44:24		3	22.6	0.280	3.40	7.64	652	15.2																								
27-0040	Isles	7/9/2013	11:43:27		4	15.5	0.020	0.200	7.58	787	11.1																								
27-0040	Isles	7/9/2013	11:41:44		5	11.5	0.030	0.300	7.53	906	15.0				0.040	0.003																			
27-0040	Isles	7/9/2013	11:40:52		6	8.76	0	0	7.53	979	11.3																								
27-0040	Isles	7/9/2013	11:40:01		7	7.69	0	0	7.53	997	12.3																								
27-0040	Isles	7/9/2013	11:39:05		8	7.29	0.030	0.300	7.58	1009	13.0				0.068	0.005						219													
27-0040	Isles	7/22/2013	10:33:52	0.58	0	26.6	9.40	121	9.00	556	23.2	33.7	<0.500		0.039	<0.003		1.00				111													
27-0040	Isles	7/22/2013	10:33:10		1	26.5	9.32	120	8.94	556	22.9																								
27-0040	Isles	7/22/2013	10:31:36		2	26.1	6.25	80.0	8.51	562	22.0																								
27-0040	Isles	7/22/2013	10:29:55		3	23.5	0.030	0.300	7.78	578	10.3																								
27-0040	Isles	7/22/2013	10:28:49		4	18.3	0.020	0.200	7.68	726	13.8																								
27-0040	Isles	7/22/2013	10:27:26		5	12.1	0.010	0.100	7.62	904	14.7				0.046	<0.003																			
27-0040	Isles	7/22/2013	10:26:21		6	8.82	0.010	0.100	7.60	980	13.3																								
27-0040	Isles	7/22/2013	10:25:42		7	7.81	0.010	0.100	7.61	999	12.2																								
27-0040	Isles	7/22/2013	10:24:40		8	7.18	0.010	0.100	7.66	1009	12.6				0.066	0.006						102													
27-0040	Isles	7/22/2013	10:23:57		9	6.49	0.050	0.400	7.73	1033	13.2																								
27-0040	Isles	8/6/2013	10:37:35	0.68	0	22.8	10.6	128	8.97	565	51.1	29.3	1.89	1.93	0.045	<0.003		1.04				109		8											
27-0040	Isles	8/6/2013	10:36:56		1	22.3	11.2	132	8.91	562	23.8																								
27-0040	Isles	8/6/2013	10:36:05		2	22.2	9.43	112	8.59	565	21.9																								
27-0040	Isles	8/6/2013	10:35:04		3	21.7	0.030	0.300	7.77	601	11.8																								
27-0040	Isles	8/6/2013	10:34:18		4	17.9	0.010	0.200	7.67	737	15.1																								
27-0040	Isles	8/6/2013	10:33:35		5	11.6	0.010	0.100	7.59	921	13.1				0.044	<0.003																			
27-0040	Isles	8/6/2013	10:32:43		6	8.77	0	0	7.58	988	12.4																								
27-0040	Isles	8/6/2013	10:31:27		7	7.93	0	0	7.61	996	12.6																								
27-0040	Isles	8/6/2013	10:30:10		8	7.23	0	0	7.66	1010	13.1				0.111	0.046																			
27-0040	Isles	8/6/2013	10:29:23		9	6.79	0.010	0	7.71	1028	22.0																								
27-0040	Isles	8/19/2013	10:16:14	0.69	0	23.6	8.49	103	9.05	578	11.9	23.2	1.93		0.041	<0.003		0.831				115													
27-0040	Isles	8/19/2013	10:15:45		1	23.5	8.29	100	9.00	578	10.4																								
27-0040	Isles	8/19/2013	10:14:56		2	23.4	7.93	95.7	8.88	578	9.60																								
27-0040	Isles	8/19/2013	10:13:24		3	21.9	0.030	0.400	7.55	609	1.30																								
27-0040	Isles	8/19/2013	10:12:32		4	17.5	0.020	0.200	7.32	735	1.50																								
27-0040	Isles	8/19/2013	10:11:51		5	12.3	0.010	0.100	7.21	927	2.10				0.034	<0.003																			
27-0040	Isles	8/19/2013	10:11:10		6	9.09	0	0	7.15	996	0																								
27-0040	Isles	8/19/2013	10:10:20		7	7.77	0	0	7.14	1012	0																								
27-0040	Isles	8/19/2013	10:09:44		8	6.97	0	0	7.12	1027	0				0.101	0.030						229													
27-0040	Isles	8/19/2013	10:09:06		9	6.24	0	0	7.04	1069	354																								
27-0040	Isles	9/9/2013	10:37:26	0.33	0	23.7	9.26	113	9.06	579	50.4	47.6	2.06	3.14	0.044	0.003		1.58				120	7.7												
27-0040	Isles	9/9/2013	10:37:03		1	23.7	9.26	113	9.04	579	67.6																								
27-0040	Isles	9/9/2013	10:36:18		2	23.6	8.86	108	8.95	578	29.3																								
27-0040	Isles	9/9/2013	10:35:33		3	21.5	0.030	0.300	7.63	616	8.40																								
27-0040	Isles	9/9/2013	10:35:06		4	16.4	0.020	0.200	7.28	800	0.200																								
27-0040	Isles	9/9/2013	10:34:38		5	11.5	0	0	7.11	971	0.100				0.032	<0.003																			
27-0040	Isles	9/9/2013	10:34:11		6	9.41	0.010	0.100	7.07	1004	0																								
27-0040	Isles	9/9/2013	10:33:48		7	8.13	0	0	7.06	1021	0																								
27-0040	Isles	9/9/2013	10:33:15		8	7.14	0.020	0.100	7.03	1044	0.600				0.102	0.038						214	7.0												
27-0040	Isles	9/9/2013	10:32:51		9	6.94	0.060	0.500	7.00	1084	6.40																								
27-0040	Isles	9/24/2013	9:33:45	0.48	0	17.8	9.26	100	8.74	615	23.1	23.8	4.21		0.042	<0.003		1.29				122													
27-0040	Isles	9/24/2013	9:33:13		1	17.8	9.18	99.2	8.74	615	23.2																								
27-0040	Isles	9/24/2013	9:32:32		2	17.8	9.09	98.2	8.72	615	20.3																								
27-0040	Isles	9/24/2013	9:31:37		3	17.7	8.86	95.5	8.69	615	22.8																								
27-0040	Isles	9/24/2013	9:30:41		4	17.5	6.74	72.5	8.31	620	16.6																								
27-0040	Isles	9/24/2013	9:29:22		5	13.2	0	0	7.19	946	1.50				0.036	<0.003																			
27-0040	Isles	9/24/2013	9:28:36		6	9.63	0	0	7.08	1012	0.100																								
27-0040	Isles	9/24/2013	9:28:06		7	8.41	0	0	7.04	1026	0.400																								
27-0040	Isles	9/24/2013	9:27:27		8	7.37	0	0	6.96	1048	1.70				0.142	0.105						222													
27-0040	Isles	9/24/2013	9:26:52		9	6.87	0.010	0.100	6.87	1082	3.40																								
27-0040	Isles	10/7/2013	10:44:15	0.84	0	15.5	6.70	69.1	8.19	636	228	1.00	<0.500	1.44	0.037	0.003	1.05	1.19	<0.030	97.0	116	133													
27-0040	Isles	10/7/2013	10:43:45		1	15.3	6.68	68.6	8.18	634	239																								
27-0040	Isles	10/7/2013	10:42:49		2	15.2	6.56	67.3	8.16	632	9.60																								
27-0040	Isles	10/7/2013	10:41:43		3	15.2	6.37	65.3	8.13	630	9.90																								
27-0040	Isles	10/7/2013	10:41:30		3	15.2	6.35	65.0	8.11	631	9.90																								
27-0040	Isles	10/7/2013	10:40:35		4	15.0	5.86	59.9	8.06	632	10.0																								
27-0040	Isles	10/7/2013	10:39:34		5	14.6	4.58	46.3	7.75	675	2.90				0.053	<0.003																			
27-0040	Isles	10/7/2013	10:37:41		6	10.3	0	0	7.19	1015	0.500																								
27-0040	Isles	10/7/2013	10:37:00		7	8.68	0.010	0.100	7.15	1036	0																								
27-0040	Isles	10/7/2013	10:35:56		8	7.57	0	0	7.07	1058	1.40				0.092	0.048						209													
27-655	Loring	2/26/2013	10:34:27	NA	0	0.640	0.270	1.90	7.06	1465	6.10	6.86	1.52	2.57	0.113	0.073	1.83	2.06	0.110	246	384	373	28.1												
27-655	Loring	2/26/2013	10:33:43		1	2.44	0.260	2.00	7.07	1649	8.10																								
27-655	Loring	2/26/2013	10:33:01		2	3.10	0.300	2.30	7.03	2436	14.8																								
27-655	Loring	2/26/2013	10:32:10		3	3.85	0.300	2.30	6.94	3809	18.4																								
27-655	Loring	2/26/2013	10:31:05		4	5.30	0.480	4.00	6.67	8836	25.0				0.178	0.138						1224	24.2												
27-655	Loring	5/10/2013	11:08:31	1.21	0	13.4	10.7	105	8.06	2487		37.0	9.93	3.39	0.133	0.004	1.59	1.68	<0.030	175	268	645													
27-655	Loring	5/10/2013	11:07:55		1	13.3	10.6	104	8.06	2486																									
27-655	Loring	5/10/2013	11:06:12		2	13.0	10.0	97.8	7.95	2491																									
27-655	Loring	5/10/2013	11:05:16		3	12.9	9.70	94.4	7.90	2489																									
27-655	Loring	5/10/2013	11:04:19		4	12.6	8.49	82.2	7.76	2489					0.142	0.006						661													
27-655	Loring	5/22/2013	11:17:31	NA	0	17.5	3.43	37.4	7.54	2399		3.63	3.55		0.115	0.014		1.25				564													
27-655	Loring	5/22/2013	11:17:01		1	17.5	3.64	39.7	7.54	2403																									
27-655	Loring	5/22/2013	11:16:19		2	17.5	3.42	37.3	7.53	2404																									
27-655	Loring	5/22/2013	11:15:38		3	17.5	3.50	38.2	7.52	2407																									
27-655	Loring	5/22/2013	11:14:45		4	17.4	3.02	32.8	7.47	2412					0.109	0.015						549													
27-655	Loring	6/6/2013	10:23:41	0.95	0	17.7	2.63	28.4	7.38	2181	12.0	7.87	8.11	2.37	0.140	0.060		1.85				592													

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	**Temp** °C	**DO** mg/L	%DO	**pH** units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	NO3NO2 mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-655	Loring	6/6/2013	10:22:09		1	17.7	2.67	28.9	7.39	2181	11.8																								
27-655	Loring	6/6/2013	10:21:16		2	17.6	2.65	28.6	7.40	2198	12.5																								
27-655	Loring	6/6/2013	10:17:45		3	17.6	2.65	28.6	7.42	2181	12.2				0.152	0.065						592													
27-655	Loring	6/6/2013	10:15:57		4	17.5	2.25	24.2	7.44	2185	704																								
27-655	Loring	6/19/2013	11:27:32	1.04	0	22.2	7.38	87.2	7.49	2119	12.3	14.6	3.93		0.124	0.046		0.581				487													
27-655	Loring	6/19/2013	11:26:54		1	21.9	6.71	78.8	7.45	2118	12.4																								
27-655	Loring	6/19/2013	11:26:18		2	21.7	6.27	73.5	7.42	2116	13.3																								
27-655	Loring	6/19/2013	11:25:33		3	21.6	5.34	62.4	7.38	2115	12.8																								
27-655	Loring	6/19/2013	11:24:39		4	21.5	4.60	53.7	7.36	2113	56.3				0.137	0.046						526													
27-655	Loring	7/10/2013	11:55:30	0.66	0	26.7	4.23	54.3	7.31	1981	14.1	22.6	10.8	5.60	0.144	0.068	1.09	1.11	<0.030	176	240	527													
27-655	Loring	7/10/2013	11:55:09		1	26.6	3.60	46.1	7.29	1978	14.4																								
27-655	Loring	7/10/2013	11:54:37		2	26.3	2.24	28.6	7.25	1962	13.9																								
27-655	Loring	7/10/2013	11:53:49		3	26.2	1.51	19.3	7.23	1965	15.1																								
27-655	Loring	7/10/2013	11:53:19		4	26.1	1.03	13.0	7.23	1965	15.6				0.223	0.074						496													
27-655	Loring	7/24/2013	11:04:17	0.72	0	25.7	2.30	29.0	7.28	1962	12.1	17.1	10.3		0.129	0.047		0.920				460													
27-655	Loring	7/24/2013	11:03:46		1	25.7	2.14	27.0	7.28	1962	11.9																								
27-655	Loring	7/24/2013	11:03:16		2	25.7	2.08	26.3	7.29	1961	11.5																								
27-655	Loring	7/24/2013	11:03:02		2	25.7	2.08	26.2	7.29	1962	11.3																								
27-655	Loring	7/24/2013	11:02:35		3	25.6	2.12	26.7	7.30	1962	13.0																								
27-655	Loring	7/24/2013	11:02:03		4	25.5	1.93	24.2	7.31	1968	3000				0.121	0.047						479													
27-655	Loring	8/7/2013	12:07:06	0.61	0	23.7	6.28	76.7	7.71	1959	6.30	39.2	10.9	6.34	0.123	0.016		0.963				492		1986											
27-655	Loring	8/7/2013	12:06:15		1	23.0	4.42	53.3	7.59	1954	6.80																								
27-655	Loring	8/7/2013	12:04:45		2	22.9	3.68	44.2	7.52	1974	5.80																								
27-655	Loring	8/7/2013	12:03:50		3	22.8	3.42	41.1	7.50	1959	6.20																								
27-655	Loring	8/7/2013	12:01:52		4	22.7	1.94	23.3	7.31	1952	5.40				0.118	0.020						492													
27-655	Loring	8/21/2013	9:39:19	0.75	0	25.0	4.42	55.6	7.32	2025	7.20	33.4	13.9		0.114	0.008		0.889				472													
27-655	Loring	8/21/2013	9:38:29		1	25.0	4.61	57.6	7.35	2023	6.50																								
27-655	Loring	8/21/2013	9:37:15		2	24.9	4.47	56.0	7.35	2028	6.70																								
27-655	Loring	8/21/2013	9:36:06		3	24.8	4.25	53.2	7.33	2032	7.50																								
27-655	Loring	8/21/2013	9:34:20		4	24.0	0.040	0.500	7.13	2021	30.9				0.142	0.011						492													
27-655	Loring	9/11/2013	10:39:41	0.56	0	24.3	5.51	67.8	7.73	2086	0	51.1	12.2	7.52	0.106	0.004		1.17				516	7.4												
27-655	Loring	9/11/2013	10:39:05		1	24.2	5.27	64.9	7.71	2085	0																								
27-655	Loring	9/11/2013	10:38:05		2	24.2	4.22	51.8	7.63	2087	0																								
27-655	Loring	9/11/2013	10:37:28		3	24.1	3.61	44.3	7.57	2085	0																								
27-655	Loring	9/11/2013	10:36:55		4	24.0	3.16	38.7	7.51	2087	0				0.147	0.005						536	16.3												
27-655	Loring	9/26/2013	9:20:59	0.58	0	18.4	7.61	83.7	7.92	2087	916	33.6	15.0		0.111	0.003		1.24				543													
27-655	Loring	9/26/2013	9:20:41		1	18.4	7.79	85.6	7.96	2089	788																								
27-655	Loring	9/26/2013	9:20:05		2	18.3	7.70	84.6	7.95	2088	425																								
27-655	Loring	9/26/2013	9:19:17		3	18.3	7.70	84.5	7.95	2088	8.70																								
27-655	Loring	9/26/2013	9:18:08		4	18.3	7.33	80.4	7.91	2087	12.6				0.058	0.003						548													
27-655	Loring	10/9/2013	11:03:06	0.79	0	15.9	7.54	78.5	7.91	1965	5.50	4.60	0.500	5.84	0.120	0.006	1.28	1.62	0.062	197	256	530													
27-655	Loring	10/9/2013	11:02:42		1	15.6	7.31	75.6	7.87	1964	6.00																								
27-655	Loring	10/9/2013	11:02:07		2	15.6	7.03	72.6	7.85	1963	5.50																								
27-655	Loring	10/9/2013	11:01:29		3	15.5	6.72	69.4	7.84	1962	6.10																								
27-655	Loring	10/9/2013	11:00:35		4	15.5	5.66	58.5	7.76	1965	13.3				0.112	0.011						515													
27-0019	Nokomis	2/15/2013	12:51:00	NA	0	0.660	15.2	108	7.48	622	16.1	29.9	1.60	12.9	0.033	0.003	1.43	1.77	0.358	140	164	102	7.50												
27-0019	Nokomis	2/15/2013	12:50:30		1	2.53	13.9	103	7.38	657	17.4																								
27-0019	Nokomis	2/15/2013	12:49:34		2	3.78	11.2	85.8	7.32	609	17.1																								
27-0019	Nokomis	2/15/2013	12:47:55		3	4.11	7.17	55.6	7.08	616	14.9																								
27-0019	Nokomis	2/15/2013	12:47:00		4	4.19	5.92	46.0	7.04	651	10.3				0.026	0.003																			
27-0019	Nokomis	2/15/2013	12:46:03		5	4.20	4.99	38.8	7.18	656	9.40																								
27-0019	Nokomis	2/15/2013	12:45:01		6	4.24	4.33	33.7	7.19	703	9.50																								
27-0019	Nokomis	2/15/2013	12:44:06		7	4.33	4.54	35.5	7.29	752	11.3				0.030	0.003						127	7.20												
27-0019	Nokomis	2/15/2013	12:43:21		8	4.25	5.22	40.7	7.22	817	9.30																								
27-0019	Nokomis	5/13/2013	9:59:06	0.90	0	11.6	11.8	110	8.52	620		15.0	1.07	11.7	0.049	<0.003	0.778	0.905	0.079	120	132	88.4													
27-0019	Nokomis	5/13/2013	9:58:39		1	11.5	11.6	109	8.53	620																									
27-0019	Nokomis	5/13/2013	9:57:43		2	11.2	11.6	108	8.50	620																									
27-0019	Nokomis	5/13/2013	9:56:55		3	11.1	11.5	106	8.48	621																									
27-0019	Nokomis	5/13/2013	9:55:43		4	10.7	10.7	98.1	8.35	622					0.050	<0.003																			
27-0019	Nokomis	5/13/2013	9:54:52		5	10.6	10.5	96.5	8.32	623																									
27-0019	Nokomis	5/13/2013	9:53:58		6	10.6	10.4	95.1	8.31	623																									
27-0019	Nokomis	5/13/2013	9:53:13		7	10.5	10.1	92.2	8.32	623					0.044	<0.003						85.8													
27-0019	Nokomis	5/28/2013	10:37:27	1.19	0	15.2	9.49	97.9	8.48	587		3.45	2.70		0.063	<0.003		1.21				82.3													
27-0019	Nokomis	5/28/2013	10:37:00		1	15.2	9.44	97.3	8.47	587																									
27-0019	Nokomis	5/28/2013	10:36:18		2	15.1	9.39	96.8	8.45	587																									
27-0019	Nokomis	5/28/2013	10:35:26		3	15.1	9.36	96.5	8.44	587																									
27-0019	Nokomis	5/28/2013	10:34:39		4	15.1	9.18	94.6	8.42	587					0.051	<0.003																			
27-0019	Nokomis	5/28/2013	10:33:43		5	14.4	3.84	38.9	7.63	602																									
27-0019	Nokomis	5/28/2013	10:32:41		6	12.6	0.560	5.50	7.40	621																									
27-0019	Nokomis	5/28/2013	10:31:40		7	11.3	0.470	4.40	7.40	622					0.061	0.004						87.3													
27-0019	Nokomis	5/28/2013	10:31:00		8	10.8	0.440	4.10	7.28	706																									
27-0019	Nokomis	6/11/2013	10:02:52	1.68	0	18.8	9.48	104	8.37	ND	11.6	8.12	0.479	7.00	0.057	<0.003		0.970				91.0													
27-0019	Nokomis	6/11/2013	10:02:13		1	18.5	10.5	115	8.45	554	13.9																								
27-0019	Nokomis	6/11/2013	10:01:26		2	17.9	10.2	111	8.42	554	15.3																								
27-0019	Nokomis	6/11/2013	10:00:39		3	17.2	8.56	91.5	8.16	556	15.3																								
27-0019	Nokomis	6/11/2013	9:59:47		4	16.8	6.10	64.7	7.79	560	18.3				0.065	<0.003																			
27-0019	Nokomis	6/11/2013	9:58:35		5	16.5	3.51	37.0	7.60	566	12.1																								
27-0019	Nokomis	6/11/2013	9:57:40		6	16.4	2.56	26.9	7.55	568	11.6																								
27-0019	Nokomis	6/11/2013	9:56:18		7	14.6	0.080	0.800	7.47	573	10.1				0.069	0.005						86.0													

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0019	Nokomis	6/21/2013	10:38:34	3.45	0	22.8	7.82	93.7	8.31	551	162	3.50	<0.500		0.056	0.003		0.732				91.0													
27-0019	Nokomis	6/21/2013	10:37:50		1	22.7	7.83	93.5	8.30	550	21.3																								
27-0019	Nokomis	6/21/2013	10:36:55		2	22.2	7.75	91.7	8.26	551	8.60																								
27-0019	Nokomis	6/21/2013	10:35:51		3	21.4	6.93	80.9	8.05	553	10.0																								
27-0019	Nokomis	6/21/2013	10:34:35		4	18.6	3.36	37.0	7.63	567	51.8				0.054	0.004																			
27-0019	Nokomis	6/21/2013	10:33:05		5	17.6	1.60	17.3	7.51	570	13.8																								
27-0019	Nokomis	6/21/2013	10:31:37		6	17.5	1.30	14.0	7.46	572	13.4																								
27-0019	Nokomis	6/21/2013	10:30:33		7	16.2	0.130	1.30	7.39	573	13.9				0.108	0.005						91.0													
27-0019	Nokomis	6/21/2013	10:29:32		8	12.7	0.140	1.40	7.25	609	14.7																								
27-0019	Nokomis	7/11/2013	9:24:24	1.09	0	26.0	8.54	108	8.37	527	14.3	11.6	2.35	6.97	0.042	<0.003	0.745	0.780	<0.030	107	120	90.0													
27-0019	Nokomis	7/11/2013	9:22:20		1	25.8	8.61	108	8.31	527	14.6																								
27-0019	Nokomis	7/11/2013	9:21:17		2	25.7	8.21	103	8.21	527	11.9																								
27-0019	Nokomis	7/11/2013	9:20:27		3	25.5	8.22	102	8.09	528	14.5																								
27-0019	Nokomis	7/11/2013	9:18:54		4	23.1	0.020	0.300	7.51	545	13.5				0.062	<0.003																			
27-0019	Nokomis	7/11/2013	9:18:23		5	21.6	0.020	0.200	7.49	555	16.2																								
27-0019	Nokomis	7/11/2013	9:17:43		6	18.6	0.040	0.400	7.48	568	14.9																								
27-0019	Nokomis	7/11/2013	9:16:50		7	15.8	0.030	0.400	7.44	572	12.0																								
27-0019	Nokomis	7/11/2013	9:15:57		8	13.4	0.120	1.20	7.37	614	16.4				0.160	0.091						95.0													
27-0019	Nokomis	7/25/2013	11:18:52	1.16	0	26.0	7.88	99.8	8.19	522	306	10.9	6.17		0.049	<0.003		0.870				87.0													
27-0019	Nokomis	7/25/2013	11:18:14		1	25.7	7.56	95.1	8.10	522	15.0																								
27-0019	Nokomis	7/25/2013	11:17:23		2	25.4	7.04	88.0	7.99	522	14.7																								
27-0019	Nokomis	7/25/2013	11:16:27		3	25.3	6.17	77.1	7.82	523	28.6																								
27-0019	Nokomis	7/25/2013	11:15:33		4	25.2	4.24	52.9	7.63	524	20.9				0.057	<0.003																			
27-0019	Nokomis	7/25/2013	11:13:10		5	24.1	0.020	0.300	7.40	540	23.9																								
27-0019	Nokomis	7/25/2013	11:12:04		6	19.3	0.020	0.200	7.38	579	12.6																								
27-0019	Nokomis	7/25/2013	11:10:36		7	16.2	0.040	0.400	7.31	581	12.8				0.265	0.076						77.0													
27-0019	Nokomis	7/25/2013	11:09:37		8	13.8	0.090	0.900	7.22	620	14.3																								
27-0019	Nokomis	8/12/2013	11:33:05	0.98	0	24.1	10.4	126	8.70	492	0	15.4	<0.500	6.47	0.045	<0.003		1.16				93.8		2											
27-0019	Nokomis	8/12/2013	11:32:31		1	24.1	10.6	129	8.68	492	0																								
27-0019	Nokomis	8/12/2013	11:31:23		2	23.9	9.69	118	8.58	494	0																								
27-0019	Nokomis	8/12/2013	11:30:44		3	23.1	6.33	75.8	7.98	504	0																								
27-0019	Nokomis	8/12/2013	11:29:58		4	23.0	3.73	44.5	7.62	507	0				0.053	<0.003																			
27-0019	Nokomis	8/12/2013	11:29:18		5	22.6	0.650	7.70	7.40	515	0																								
27-0019	Nokomis	8/12/2013	11:28:41		6	21.8	0.100	1.20	7.39	523	0																								
27-0019	Nokomis	8/12/2013	11:28:20		7	18.5	0.130	1.40	7.32	582	0				0.223	0.048						93.8													
27-0019	Nokomis	8/12/2013	11:27:53		8	14.1	0.200	2.00	7.07	649	0																								
27-0019	Nokomis	8/21/2013	13:25:34	0.86	0	25.3	10.3	129	8.26	512	12.2	28.4	1.94		0.067	<0.003		0.896				76.8													
27-0019	Nokomis	8/21/2013	13:24:49		1	25.2	10.3	129	8.26	511	13.1																								
27-0019	Nokomis	8/21/2013	13:23:37		2	24.8	8.49	106	8.02	513	13.4																								
27-0019	Nokomis	8/21/2013	13:22:27		3	23.7	6.29	76.7	7.56	515	11.3																								
27-0019	Nokomis	8/21/2013	13:20:28		4	23.2	2.96	35.6	7.15	518	8.20				0.068	<0.003																			
27-0019	Nokomis	8/21/2013	13:19:35		5	23.0	0.490	5.90	6.99	520	12.3																								
27-0019	Nokomis	8/21/2013	13:18:27		6	22.4	0.030	0.400	7.02	533	10.4																								
27-0019	Nokomis	8/21/2013	13:17:18		7	17.8	0.030	0.300	6.89	620	10.9				0.202	0.036						76.8													
27-0019	Nokomis	8/21/2013	13:16:31		8	15.2	0.020	0.200	6.69	675	18.6																								
27-0019	Nokomis	9/12/2013	12:11:46	0.80	0	23.8	7.11	85.5	8.31	ND	0	37.6	1.98	8.01	0.054	0.003		1.13				90.1	7.8												
27-0019	Nokomis	9/12/2013	12:11:20		1	23.8	6.98	84.2	8.30	506	0																								
27-0019	Nokomis	9/12/2013	12:10:40		2	23.8	6.83	82.3	8.27	506	0																								
27-0019	Nokomis	9/12/2013	12:10:13		3	23.7	6.68	80.4	8.22	507	0																								
27-0019	Nokomis	9/12/2013	12:09:35		4	23.7	6.47	78.0	8.18	507	0				0.058	<0.003																			
27-0019	Nokomis	9/12/2013	12:08:51		5	23.7	6.37	76.7	8.16	507	0																								
27-0019	Nokomis	9/12/2013	12:08:08		6	23.6	6.31	75.9	8.14	507	0																								
27-0019	Nokomis	9/12/2013	12:07:01		7	17.5	0.240	2.50	7.10	655	0				0.473	0.030						75.2	5.1												
27-0019	Nokomis	9/27/2013	10:00:06	0.62	0	19.2	9.01	100	8.63	510	61.9	29.9	2.77		0.054	<0.003		1.17				118													
27-0019	Nokomis	9/27/2013	9:59:29		1	19.2	8.97	100	8.63	510	79.9																								
27-0019	Nokomis	9/27/2013	9:58:38		2	19.2	8.85	98.6	8.60	510	22.3																								
27-0019	Nokomis	9/27/2013	9:57:53		3	19.1	7.86	87.5	8.46	511	23.4																								
27-0019	Nokomis	9/27/2013	9:56:57		4	19.0	7.36	81.7	8.36	512	19.7				0.054	0.003																			
27-0019	Nokomis	9/27/2013	9:56:08		5	18.8	6.76	74.7	8.22	512	19.2																								
27-0019	Nokomis	9/27/2013	9:55:16		6	18.8	5.75	63.5	8.06	515	20.6																								
27-0019	Nokomis	9/27/2013	9:54:42		7	18.7	5.71	63.0	8.04	515	22.7				0.065	0.003						92.0													
27-0019	Nokomis	10/16/2013	10:45:38	0.95	0	14.1	5.94	59.5	7.91	520	25.1	3.40	<0.500	8.91	0.070	0.004	1.30	1.65	0.062	107	116	85.0													
27-0019	Nokomis	10/16/2013	10:45:12		1	14.1	5.94	59.5	7.93	523	15.1																								
27-0019	Nokomis	10/16/2013	10:44:43		2	14.1	5.97	59.8	7.92	518	14.1																								
27-0019	Nokomis	10/16/2013	10:44:04		3	14.1	5.95	59.6	7.93	521	66.3																								
27-0019	Nokomis	10/16/2013	10:43:32		4	14.1	5.97	59.8	7.92	518	13.6				0.072	0.003																			
27-0019	Nokomis	10/16/2013	10:42:09		5	14.1	6.00	60.0	7.91	518	13.9																								
27-0019	Nokomis	10/16/2013	10:39:25		6	14.1	6.10	61.0	7.92	518	14.8																								
27-0019	Nokomis	10/16/2013	10:38:26		7	14.0	6.11	61.1	7.91	517	14.5				0.074	0.003						85.0													
27-0019	Nokomis	10/16/2013	10:37:25		8	14.0	6.15	61.4	7.91	518	10.7																								
27-0014	Powderhorn	2/7/2013	11:09:29	NA	0	0.470	3.31	23.5	7.26	789	10.8	4.22	2.98	5.90	0.100	0.046	1.78	1.84	0.252	142	192	157	19.3												
27-0014	Powderhorn	2/7/2013	11:08:10		1	3.02	2.26	17.2	7.30	784	9.90																								
27-0014	Powderhorn	2/7/2013	11:06:14		2	3.66	0.640	5.00	7.29	946	9.30																								
27-0014	Powderhorn	2/7/2013	11:04:35		3	3.74	2.12	16.5	7.21	1379	9.20																								
27-0014	Powderhorn	2/7/2013	11:03:00		4	3.80	5.17	40.3	7.15	1721	11.6				0.138	0.080																			
27-0014	Powderhorn	2/7/2013	11:01:04		5	3.70	0.340	2.60	7.10	1967	15.1																								
27-0014	Powderhorn	2/7/2013	11:00:02		6	4.02	0.450	3.60	7.02	2290	17.1				0.260	0.078						536	16.6												
27-0014	Powderhorn	5/10/2013	10:11:47	0.55	0	12.7	15.4	148	9.11	1317		93.1	33.8	2.20	0.179	0.012	1.04	1.13	<0.030	75.0	100	340													
27-0014	Powderhorn	5/10/2013	10:11:20		1	12.7	15.6	150	9.12	1315																									
27-0014	Powderhorn	5/10/2013	10:10:36		2	12.6	15.6	150	9.13	1315																									
27-0014	Powderhorn	5/10/2013	10:09:32		3	12.6	15.0	144	9.06	1315																									
27-0014	Powderhorn	5/10/2013	10:08:17		4	12.5	14.6	140	9.00	1314					0.185	0.013																			
27-0014	Powderhorn	5/10/2013	10:06:56		5	12.5	14.5	140	9.00	1314																									

Underlined data indicates monthly performance standard failure.

Lake ID	**Lake Name**	**Date** MM/DD/YYY	**Time** HH:MM:SS	**Secchi** meters	**Depth** meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	**SpCond** µS/cm	**TurbSC** NTU	**Chl-a** mg/M3	**Pheo-a** mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	**NO3NO2** mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	**E. Coli** mpn/100m	**Ca** mg/L	**Tot Al** µg/L	**Sol Al** µg/L	**As** µg/L	**Cd** µg/L	**Cu** µg/L	**Pb** µg/L	**Mn** µg/L	**Ni** µg/L	**Zn** µg/	**F. Coli** cfu/10
27-0014	Powderhorn	5/10/2013	10:04:39		6	12.5	14.0	135	8.95	1312					0.186	0.014						334													
27-0014	Powderhorn	5/22/2013	10:22:46	0.95	0	17.6	3.62	39.3	7.35	1056		2.67	1.05		0.153	0.046		1.41				230													
27-0014	Powderhorn	5/22/2013	10:23:17		1	17.6	3.61	39.3	7.32	1057																									
27-0014	Powderhorn	5/22/2013	10:23:43		2	17.6	3.50	38.0	7.35	1056																									
27-0014	Powderhorn	5/22/2013	10:24:12		3	17.6	3.36	36.6	7.34	1054																									
27-0014	Powderhorn	5/22/2013	10:24:44		4	17.6	3.44	37.5	7.34	1053					0.141	0.046																			
27-0014	Powderhorn	5/22/2013	10:25:13		5	17.6	3.38	36.8	7.33	1052																									
27-0014	Powderhorn	5/22/2013	10:25:44		6	17.6	3.26	35.4	7.33	1052					0.157	0.046						225													
27-0014	Powderhorn	6/5/2013	12:06:48	0.80	0	18.8	6.10	67.2	7.37	906	112	37.3	17.8	0.995	0.118	0.005		1.21				234													
27-0014	Powderhorn	6/5/2013	12:05:26		1	18.8	6.03	66.4	7.38	903	13.7																								
27-0014	Powderhorn	6/5/2013	12:03:50		2	18.8	6.06	66.7	7.40	903	14.3																								
27-0014	Powderhorn	6/5/2013	12:02:45		3	18.8	6.05	66.6	7.41	903	14.5																								
27-0014	Powderhorn	6/5/2013	12:01:39		4	18.8	6.08	67.0	7.42	903	12.9				0.123	0.005																			
27-0014	Powderhorn	6/5/2013	11:59:31		5	18.7	6.26	68.9	7.46	903	12.4																								
27-0014	Powderhorn	6/5/2013	11:57:03		6	18.7	6.19	68.1	7.52	902	11.2				0.133	0.005						229													
27-0014	Powderhorn	6/19/2013	10:24:12	0.87	0	22.4	1.16	13.7	7.04	819	14.4	4.95	4.01		0.173	0.067		1.44				204													
27-0014	Powderhorn	6/19/2013	10:22:55		1	22.4	1.15	13.6	7.07	819	14.5																								
27-0014	Powderhorn	6/19/2013	10:21:39		2	22.4	1.13	13.3	7.11	819	15.9																								
27-0014	Powderhorn	6/19/2013	10:20:26		3	22.3	1.02	12.0	7.16	819	14.2																								
27-0014	Powderhorn	6/19/2013	10:20:42		3	22.3	1.02	12.0	7.14	819	14.1																								
27-0014	Powderhorn	6/19/2013	10:19:58		4	22.2	1.00	11.8	7.18	819	11.7				0.178	0.070																			
27-0014	Powderhorn	6/19/2013	10:19:14		5	22.2	1.00	11.8	7.23	819	11.7																								
27-0014	Powderhorn	6/19/2013	10:18:34		6	22.2	0.880	10.4	7.27	820	12.8				0.179	0.072						194													
27-0014	Powderhorn	7/10/2013	11:02:10	0.49	0	26.8	1.53	19.6	7.17	637	20.6	29.0	18.8	3.84	0.225	0.046	1.53	1.69	<0.030	59.0	68.0	157													
27-0014	Powderhorn	7/10/2013	11:01:34		1	26.8	1.30	16.7	7.18	637	19.2																								
27-0014	Powderhorn	7/10/2013	11:00:46		2	26.8	1.25	16.0	7.22	636	20.0																								
27-0014	Powderhorn	7/10/2013	11:00:00		3	26.7	1.21	15.4	7.24	636	21.3																								
27-0014	Powderhorn	7/10/2013	10:59:19		4	26.7	1.18	15.1	7.28	636	23.3				0.227	0.050																			
27-0014	Powderhorn	7/10/2013	10:58:49		5	26.7	1.09	13.9	7.31	636	1156																								
27-0014	Powderhorn	7/10/2013	10:58:09		6	26.7	0.540	6.90	7.37	636	1213				0.179	0.051						151													
27-0014	Powderhorn	7/24/2013	10:18:02	0.55	0	26.5	5.85	74.4	7.40	534	15.4	56.8	17.6		0.148	0.004		1.11				116													
27-0014	Powderhorn	7/24/2013	10:17:31		1	26.5	5.76	73.3	7.40	533	16.6																								
27-0014	Powderhorn	7/24/2013	10:16:51		2	26.5	5.74	73.2	7.41	534	16.8																								
27-0014	Powderhorn	7/24/2013	10:16:21		3	26.5	5.75	73.2	7.42	534	16.2																								
27-0014	Powderhorn	7/24/2013	10:15:38		4	26.4	5.74	73.0	7.44	534	18.7				0.152	0.004																			
27-0014	Powderhorn	7/24/2013	10:14:59		5	26.4	5.70	72.5	7.46	533	18.5																								
27-0014	Powderhorn	7/24/2013	10:14:25		6	26.2	5.79	73.4	7.47	535	19.3				0.154	0.003						120													
27-0014	Powderhorn	8/8/2013	10:21:12	0.47	0	23.3	7.35	88.3	7.74	528	48.5	74.5	30.9	2.36	0.152	<0.003		1.08				109		157											
27-0014	Powderhorn	8/8/2013	10:20:36		1	23.3	7.35	88.3	7.89	527	46.8																								
27-0014	Powderhorn	8/8/2013	10:19:49		2	23.3	7.33	88.0	7.90	526	16.8																								
27-0014	Powderhorn	8/8/2013	10:19:09		3	23.3	7.34	88.1	7.89	530	14.3																								
27-0014	Powderhorn	8/8/2013	10:18:32		4	23.3	7.31	87.8	7.91	526	16.4				0.163	<0.003																			
27-0014	Powderhorn	8/8/2013	10:17:51		5	23.3	7.33	88.0	7.81	526	13.2																								
27-0014	Powderhorn	8/8/2013	10:17:04		6	23.3	7.12	85.4	7.87	526	14.3				0.158	<0.003																			
27-0014	Powderhorn	8/20/2013	11:40:03	0.44	0	24.6	5.61	69.5	7.02	543	17.8	47.3	26.8		0.149	0.006		1.01				120													
27-0014	Powderhorn	8/20/2013	11:39:25		1	24.6	5.65	69.9	7.03	543	15.2																								
27-0014	Powderhorn	8/20/2013	11:38:48		2	24.6	5.48	67.7	7.03	543	15.1																								
27-0014	Powderhorn	8/20/2013	11:37:59		3	24.5	5.62	69.4	7.06	544	18.5																								
27-0014	Powderhorn	8/20/2013	11:37:02		4	24.5	6.08	75.1	7.10	542	16.9				0.146	0.007																			
27-0014	Powderhorn	8/20/2013	11:36:29		5	24.5	5.50	67.9	7.05	543	12.8																								
27-0014	Powderhorn	8/20/2013	11:34:56		6	24.4	4.65	57.3	7.07	544	18.2				0.148	0.007						120													
27-0014	Powderhorn	9/11/2013	9:39:18	0.33	0	24.5	5.91	72.7	7.42	547	0	84.6	25.8	5.00	0.185	0.006		1.66				115	10.7												
27-0014	Powderhorn	9/11/2013	9:38:53		1	24.5	5.87	72.3	7.43	547	0																								
27-0014	Powderhorn	9/11/2013	9:38:27		2	24.5	5.81	71.4	7.42	547	0																								
27-0014	Powderhorn	9/11/2013	9:38:01		3	24.5	5.74	70.6	7.43	547	0																								
27-0014	Powderhorn	9/11/2013	9:37:37		4	24.5	5.66	69.5	7.42	547	0				0.145	0.007																			
27-0014	Powderhorn	9/11/2013	9:37:07		5	24.4	5.64	69.3	7.46	547	0																								
27-0014	Powderhorn	9/11/2013	9:36:32		6	24.4	5.64	69.3	7.48	547	0				0.176	0.007						115	9.1												
27-0014	Powderhorn	9/25/2013	10:57:23	0.43	0	18.6	10.3	113	8.62	529	45.0	45.0	15.4		0.129	0.007		1.36				103													
27-0014	Powderhorn	9/25/2013	10:56:52		1	18.6	10.2	111	8.59	529																									
27-0014	Powderhorn	9/25/2013	10:56:19		2	18.6	10.1	111	8.57	529																									
27-0014	Powderhorn	9/25/2013	10:55:50		3	18.6	10.1	110	8.57	529																									
27-0014	Powderhorn	9/25/2013	10:55:22		4	18.6	9.97	109	8.52	530					0.132	0.004																			
27-0014	Powderhorn	9/25/2013	10:54:51		5	18.6	10.1	111	8.57	529																									
27-0014	Powderhorn	9/25/2013	10:54:00		6	18.5	10.1	111	8.58	529					0.132	0.003						118													
27-0014	Powderhorn	10/9/2013	10:11:29	0.51	0	15.8	7.60	78.6	7.64	457	17.2	7.60	0.880	2.84	0.104	0.010	1.47	1.60	<0.030	82.0	80.0	105													
27-0014	Powderhorn	10/9/2013	10:11:01		1	15.8	7.55	78.0	7.65	457	17.1																								
27-0014	Powderhorn	10/9/2013	10:10:39		2	15.8	7.51	77.6	7.50	459	15.7																								
27-0014	Powderhorn	10/9/2013	10:10:14		3	15.8	7.53	77.8	7.61	457	13.4																								
27-0014	Powderhorn	10/9/2013	10:09:42		4	15.8	7.52	77.7	7.60	457	16.6				0.119	0.003																			
27-0014	Powderhorn	10/9/2013	10:09:16		5	15.8	7.47	77.2	7.61	457	16.7																								
27-0014	Powderhorn	10/9/2013	10:08:28		6	15.8	7.51	77.7	7.62	457	13.3				0.125	0.003						105													
27-654	Spring	2/26/2013	11:02:31	NA	0	0.720	0.220	1.60	6.81	3679	11.4	16.2	11.4	29.0	0.677	0.501	4.65	4.34	<0.030	376	676	993	82.3												
27-654	Spring	2/26/2013	11:01:33		1	1.71	0.250	1.80	6.82	3705	11.9																								
27-654	Spring	2/26/2013	11:00:38		2	2.83	0.260	2.00	6.78	3742	11.3																								
27-654	Spring	2/26/2013	10:59:40		3	4.59	0.280	2.30	6.73	4037	20.8																								
27-654	Spring	2/26/2013	10:58:39		4	5.74	0.380	3.10	6.69	4501	25.1				2.93	2.70																			
27-654	Spring	2/26/2013	10:57:20		5	6.72	0.340	2.90	6.71	4765	31.1																								
27-654	Spring	2/26/2013	10:56:03		6	7.22	0.400	3.50	6.80	5019	36.5				5.29	5.20						1229	71.2												
27-654	Spring	2/26/2013	10:55:05		7	7.26	0.550	4.80	6.92	5276	54.5																								

Underlined data indicates monthly performance standard failure.

		Date	Time	Secchi	Depth					SpCond	TurbSC	Chl-a	Pheo-a						NO3NO2					E. Coli	Ca	Tot Al	Sol Al	As	Cd	Cu	Pb	Mn	Ni	Zn	F. Coli
Lake ID	**Lake Name**	MM/DD/YYY	HH:MM:SS	meters	meters	**Temp** °C	**DO** mg/L	**%DO**	**pH** units	µS/cm	NTU	mg/M3	mg/M3	**Silica** mg/L	**TP** mg/L	**SRP** mg/L	**TKN** mg/L	**TN** mg/L	mg/L	**Alk** mg/L	**Hard** mg/L	**Cl** mg/L	**SO4** mg/L	mpn/100m	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/	cfu/10
27-654	Spring	5/10/2013	11:53:41	1.35	0	14.0	9.84	98.4	7.60	3155		64.5	20.4	24.4	0.639	0.113	2.63	2.78	<0.030	321	592	878													
27-654	Spring	5/10/2013	11:52:31		1	9.28	8.52	76.6	6.93	4163																									
27-654	Spring	5/10/2013	11:51:30		2	3.73	0.310	2.40	6.56	4359																									
27-654	Spring	5/10/2013	11:50:38		3	4.03	0.180	1.40	6.42	4734																									
27-654	Spring	5/10/2013	11:49:49		4	4.80	0.130	1.10	6.21	4951					3.82	3.30																			
27-654	Spring	5/10/2013	11:48:58		5	5.73	0.240	2.00	6.15	5203																									
27-654	Spring	5/10/2013	11:47:54		6	6.38	0.330	2.80	6.09	5309					5.04	4.88						1374													
27-654	Spring	5/10/2013	11:47:08		7	6.73	0.440	3.80	6.09	5698																									
27-654	Spring	6/6/2013	11:37:36	1.40	0	16.4	1.20	12.6	7.32	2725	8.50	4.61	1.98	16.2	0.476	0.378		2.57				811													
27-654	Spring	6/6/2013	11:36:41		1	16.3	0.050	0.500	7.04	3365	8.50																								
27-654	Spring	6/6/2013	11:35:19		2	8.85	0.040	0.400	6.88	3998	16.6																								
27-654	Spring	6/6/2013	11:34:09		3	4.82	0.040	0.300	6.57	4400	28.3																								
27-654	Spring	6/6/2013	11:32:55		4	4.94	0.050	0.400	6.51	4598	28.5				3.34	3.34																			
27-654	Spring	6/6/2013	11:31:20		5	5.67	0.060	0.500	6.45	4824	34.0																								
27-654	Spring	6/6/2013	11:29:20		6	6.35	0.070	0.600	6.42	5028	35.0				5.10	4.92						1265													
27-654	Spring	6/6/2013	11:27:49		7	6.68	0.200	1.70	6.43	5176	40.2																								
27-654	Spring	7/15/2013	10:09:46	1.10	0	24.9	1.01	12.4	7.09	1783	6.10	13.6	8.98	12.0	0.301	0.231	1.36	1.49	<0.030	270	480	650													
27-654	Spring	7/15/2013	10:08:02		1	21.2	0.050	0.500	6.81	2916	358																								
27-654	Spring	7/15/2013	10:07:05		2	12.7	0.060	0.600	6.73	4114	306																								
27-654	Spring	7/15/2013	10:06:23		3	6.93	0.060	0.500	6.68	4461	80.1																								
27-654	Spring	7/15/2013	10:05:45		4	5.63	0.050	0.400	6.62	4698	54.8				3.39	3.26																			
27-654	Spring	7/15/2013	10:05:05		5	5.94	0.050	0.400	6.58	4899	33.2																								
27-654	Spring	7/15/2013	10:04:19		6	6.46	0.050	0.400	6.54	5089	39.0				4.84	4.67						1280													
27-654	Spring	7/15/2013	10:03:39		7	6.98	0.050	0.400	6.49	5217	47.2																								
27-654	Spring	8/8/2013	11:36:20	1.25	0	21.2	1.38	16.0	5.29	2163	0	73.5	43.5	13.8	0.292	0.186		1.44				672		147											
27-654	Spring	8/8/2013	11:35:27		1	20.8	0.380	4.30	5.13	2520	0.700																								
27-654	Spring	8/8/2013	11:33:48		2	12.8	0.050	0.500	4.63	4199	12.4																								
27-654	Spring	8/8/2013	11:32:40		3	7.50	0.040	0.300	4.26	4556	20.4																								
27-654	Spring	8/8/2013	11:31:52		4	5.91	0.030	0.200	4.11	4774	34.2				4.00	3.77																			
27-654	Spring	8/8/2013	11:29:41		5	5.89	0.040	0.400	4.03	4950	19.9																								
27-654	Spring	8/8/2013	11:28:29		6	6.33	0.050	0.400	4.33	5105	20.6				5.80	5.38																			
27-654	Spring	8/8/2013	11:27:40		7	6.71	0.020	0.200	5.27	5217	22.5																								
27-654	Spring	9/12/2013	9:11:17	1.39	0	21.4	0.760	8.80	7.21	2650	0	49.2	24.6	13.0	0.225	0.131		1.69				655	77.0												
27-654	Spring	9/12/2013	9:09:43		1	20.7	0.100	1.20	6.86	3103	0																								
27-654	Spring	9/12/2013	9:07:29		2	12.7	0.110	1.10	6.44	4384	0																								
27-654	Spring	9/12/2013	9:06:48		3	8.55	0.100	0.800	6.27	4645	0																								
27-654	Spring	9/12/2013	9:05:01		4	6.87	0.190	1.60	6.20	4827	0				3.74	3.64																			
27-654	Spring	9/12/2013	9:04:14		5	6.32	0.180	1.50	6.17	5063	0																								
27-654	Spring	9/12/2013	9:03:17		6	6.37	0.250	2.10	6.16	5185	0				5.41	5.02						1305	87.6												
27-654	Spring	9/12/2013	9:02:35		7	6.47	0.320	2.70	6.17	5267	0																								
27-654	Spring	10/23/2013	13:41:30	0.44	0	8.11	11.8	104	7.41	3052	35.3	24.6	2.49	16.4	0.445	0.172	1.99	2.09	<0.030	299	516	740													
27-654	Spring	10/23/2013	13:40:41		1	8.11	9.55	83.6	7.31	3055	1593																								
27-654	Spring	10/23/2013	13:40:00		2	8.12	8.90	77.9	7.29	3065	91.1																								
27-654	Spring	10/23/2013	13:38:21		3	10.4	0.040	0.400	6.53	4552	21.6																								
27-654	Spring	10/23/2013	13:37:36		4	8.34	0.020	0.200	6.46	4744	22.7				4.00	3.85																			
27-654	Spring	10/23/2013	13:37:06		5	6.81	0.010	0.100	6.41	4975	19.3																								
27-654	Spring	10/23/2013	13:36:39		6	6.49	0.010	0.100	6.37	5128	21.1				5.17	4.97						1230													
27-654	Spring	10/23/2013	13:35:59		7	6.50	0.170	1.40	6.35	5247	24.4																								
27-1118	Webber	5/6/2013	13:45:17		0	22.2	13.8	161	8.59	518	6.10	4.60	1.15	2.20	0.031	0.003	<0.500	0.549	<0.030	170	232	30.8													
27-1118	Webber	6/11/2013	14:45:00		0	23.6	12.6	153	8.60	448	8.40	4.49	1.64	18.2	0.072	0.003		1.03				37.0													
27-1118	Webber	7/11/2013	11:53:08		0	27.5	6.38	82.4	8.55	255	6.80	0.800	0.750	25.3	0.025	<0.003	0.685	0.708	<0.030	88.0	112	13.0													
27-1118	Webber	8/9/2013	11:05:30		0	23.9	7.89	95.7	9.51	244	0	12.3	1.37	15.9	0.058	<0.003		1.27				14.0		4											
27-0037	Wirth	2/5/2013	11:55:04	NA	0	0.710	13.3	96.0	6.79	834	617	19.9	4.33	8.11	0.050	0.003	0.920	1.25	0.288	181	280	172	13.9												
27-0037	Wirth	2/5/2013	11:54:31		1	3.40	11.8	91.9	6.76	841	300																								
27-0037	Wirth	2/5/2013	11:53:36		2	3.46	10.7	83.6	6.74	841	125																								
27-0037	Wirth	2/5/2013	11:52:03		3	3.72	4.88	38.3	6.69	841	16.4																								
27-0037	Wirth	2/5/2013	11:50:22		4	3.89	1.99	15.7	6.67	846	17.3				0.036	0.004																			
27-0037	Wirth	2/5/2013	11:48:20		5	4.02	1.57	12.4	6.67	872	7.00																								
27-0037	Wirth	2/5/2013	11:47:00		6	4.21	0.370	2.90	6.69	966	7.30																								
27-0037	Wirth	2/5/2013	11:45:52		7	4.51	0.570	4.60	6.71	1180	15.2				0.032	0.004						177	16.1												
27-0037	Wirth	5/7/2013	11:42:49	1.26	0	15.0	11.6	118	7.93	855		3.70	1.05	9.29	0.037	0.004	<0.500	0.560	<0.030	175	256	146													
27-0037	Wirth	5/7/2013	11:42:03		1	12.4	11.7	112	7.90	849																									
27-0037	Wirth	5/7/2013	11:40:53		2	8.78	11.9	104	7.87	839																									
27-0037	Wirth	5/7/2013	11:39:04		3	7.99	10.8	93.2	7.74	846																									
27-0037	Wirth	5/7/2013	11:37:42		4	6.25	0.450	3.70	7.09	963					0.061	0.003																			
27-0037	Wirth	5/7/2013	11:36:23		5	4.41	0.360	2.80	7.03	1110																									
27-0037	Wirth	5/7/2013	11:35:26		6	4.56	0.500	3.90	6.96	1425																									
27-0037	Wirth	5/7/2013	11:33:56		7	4.76	0.650	5.20	6.91	2156					0.258	0.010						349													
27-0037	Wirth	5/23/2013	10:31:33	3.23	0	15.4	7.64	77.7	7.97	912		0.580	<0.500		0.040	0.003		0.710				137													
27-0037	Wirth	5/23/2013	10:29:28		1	15.4	7.71	78.4	7.96	913																									
27-0037	Wirth	5/23/2013	10:28:12		2	15.3	7.56	76.8	7.93	916																									
27-0037	Wirth	5/23/2013	10:27:00		3	11.7	6.22	58.4	7.63	952																									
27-0037	Wirth	5/23/2013	10:25:48		4	9.26	0.450	4.00	7.23	999					0.063	0.007																			
27-0037	Wirth	5/23/2013	10:24:47		5	5.15	0.140	1.10	7.10	1232																									
27-0037	Wirth	5/23/2013	10:23:08		6	4.89	0.380	3.10	7.05	1542																									
27-0037	Wirth	5/23/2013	10:21:53		7	4.90	0.330	2.60	6.99	2031					0.301	0.005						302													
27-0037	Wirth	5/23/2013	10:18:43		8	4.99	0.500	4.00	6.84	2867																									
27-0037	Wirth	6/7/2013	11:58:09	3.15	0	17.3	7.96	84.9	8.14	850	8.20	1.98	1.34	1.55	0.039	0.002		0.710				152													
27-0037	Wirth	6/7/2013	11:57:27		1	16.8	8.14	85.9	8.17	848	8.20																								

Underlined data indicates monthly performance standard failure.

Lake ID	Lake Name	Date MM/DD/YYY	Time HH:MM:SS	Secchi meters	Depth meters	Temp °C	DO mg/L	%DO	pH units	SpCond µS/cm	TurbSC NTU	Chl-a mg/M3	Pheo-a mg/M3	Silica mg/L	TP mg/L	SRP mg/L	TKN mg/L	TN mg/L	NO3NO2 mg/L	Alk mg/L	Hard mg/L	Cl mg/L	SO4 mg/L	E. Coli mpn/100m	Ca mg/L	Tot Al µg/L	Sol Al µg/L	As µg/L	Cd µg/L	Cu µg/L	Pb µg/L	Mn µg/L	Ni µg/L	Zn µg/	F. Coli cfu/10
27-0037	Wirth	6/7/2013	11:56:34		2	16.8	7.74	81.7	8.12	848	9.80																								
27-0037	Wirth	6/7/2013	11:55:49		3	16.2	5.79	60.3	7.88	855	13.0																								
27-0037	Wirth	6/7/2013	11:54:37		4	10.4	0.530	4.90	7.52	940	12.2				0.062	0.007																			
27-0037	Wirth	6/7/2013	11:53:42		5	6.71	0.040	0.300	7.43	1106	18.1																								
27-0037	Wirth	6/7/2013	11:52:57		6	5.40	0.020	0.200	7.37	1427	35.7																								
27-0037	Wirth	6/7/2013	11:51:43		7	5.22	0.030	0.200	7.29	1957	25.2				0.640	0.030						382													
27-0037	Wirth	6/20/2013	9:29:57	3.95	0	22.9	9.29	111	8.24	801	6.80	1.59	<0.500		0.029	0.003		<0.500				150													
27-0037	Wirth	6/20/2013	9:29:00		1	22.9	9.24	110	8.21	800	7.60																								
27-0037	Wirth	6/20/2013	9:27:41		2	21.1	6.88	79.4	7.70	863	6.00																								
27-0037	Wirth	6/20/2013	9:26:09		3	17.0	4.79	50.9	7.58	879	7.00																								
27-0037	Wirth	6/20/2013	9:24:13		4	12.3	5.03	48.2	7.48	954	14.9				0.041	0.004																			
27-0037	Wirth	6/20/2013	9:22:17		5	7.57	0.040	0.300	7.27	1128	19.6																								
27-0037	Wirth	6/20/2013	9:21:14		6	5.71	0.050	0.400	7.23	1451	23.2																								
27-0037	Wirth	6/20/2013	9:20:04		7	5.62	0.180	1.50	7.11	1917	21.1				0.688	0.012						394													
27-0037	Wirth	7/8/2013	12:33:03	3.68	0	25.9	8.20	104	8.28	775	7.40	1.70	1.35	4.61	0.025	<0.003	0.517	0.521	<0.030	143	212	140													
27-0037	Wirth	7/8/2013	12:32:12		1	25.7	7.94	100	8.21	774	7.60																								
27-0037	Wirth	7/8/2013	12:31:17		2	24.5	7.54	93.0	8.06	782	10.3																								
27-0037	Wirth	7/8/2013	12:30:29		3	21.4	7.21	83.8	7.94	848	8.70																								
27-0037	Wirth	7/8/2013	12:28:13		4	14.3	13.9	140	8.09	988	9.40				0.032	<0.003																			
27-0037	Wirth	7/8/2013	12:26:55		5	9.56	6.68	60.3	7.60	1126	21.9																								
27-0037	Wirth	7/8/2013	12:25:24		6	6.36	0.010	0.100	7.38	1540	21.3																								
27-0037	Wirth	7/8/2013	12:24:15		7	5.91	0.010	0.100	7.31	1904	40.6				0.241	0.013						308													
27-0037	Wirth	7/8/2013	12:23:11		8	5.92	0.070	0.600	7.27	2172	125																								
27-0037	Wirth	7/22/2013	12:55:07	2.51	0	26.4	8.25	106	8.18	746	8.40	7.50	<0.500		0.037	0.004		0.540				125													
27-0037	Wirth	7/22/2013	12:53:58		1	26.3	8.36	107	8.17	745	8.30																								
27-0037	Wirth	7/22/2013	12:52:57		2	26.1	8.53	109	8.12	744	9.20																								
27-0037	Wirth	7/22/2013	12:52:00		3	22.6	11.7	140	7.93	786	15.9																								
27-0037	Wirth	7/22/2013	12:50:54		4	16.4	8.87	93.9	7.56	986	12.1				0.059	<0.003																			
27-0037	Wirth	7/22/2013	12:50:22		5	11.8	1.26	12.0	7.43	1100	14.5																								
27-0037	Wirth	7/22/2013	12:49:21		6	7.19	0.070	0.600	7.35	1486	18.8																								
27-0037	Wirth	7/22/2013	12:48:37		7	6.08	0.220	1.80	7.31	1937	22.1				0.253	0.032						321													
27-0037	Wirth	8/5/2013	10:16:56	2.55	0	22.3	9.15	108	8.27	757	9.10	12.5	0.920	2.61	0.035	0.005		<0.500				152		<1											
27-0037	Wirth	8/5/2013	10:16:28		1	22.0	9.12	108	8.21	757	8.80																								
27-0037	Wirth	8/5/2013	10:15:27		2	21.9	9.00	106	8.06	756	12.7																								
27-0037	Wirth	8/5/2013	10:14:12		3	20.8	1.94	22.3	7.52	797	17.3																								
27-0037	Wirth	8/5/2013	10:12:50		4	18.1	0.090	1.00	7.45	927	9.30																								
27-0037	Wirth	8/5/2013	10:10:55		5	12.6	0.020	0.200	7.44	1084	12.9																								
27-0037	Wirth	8/5/2013	10:09:27		6	8.08	0	0	7.33	1477	28.3																								
27-0037	Wirth	8/5/2013	10:08:20		7	6.79	0.030	0.300	7.21	1907	27.8																								
27-0037	Wirth	8/20/2013	9:08:01	1.73	0	23.9	8.70	106	8.16	772	1.00	23.0	<0.500		0.064	0.007		0.522				152													
27-0037	Wirth	8/20/2013	9:07:19		1	23.8	8.73	106	8.13	772	1.40																								
27-0037	Wirth	8/20/2013	9:06:40		2	23.7	8.60	104	8.11	770	4.40																								
27-0037	Wirth	8/20/2013	9:05:13		3	22.2	2.15	25.5	7.30	797	4.30																								
27-0037	Wirth	8/20/2013	9:03:40		4	19.2	0.120	1.30	7.02	896	5.20				0.064	0.006																			
27-0037	Wirth	8/20/2013	9:02:48		5	12.3	0	0	6.80	1118	12.9																								
27-0037	Wirth	8/20/2013	9:02:21		6	8.38	0	0	6.71	1548	13.5																								
27-0037	Wirth	8/20/2013	9:01:38		7	6.62	0.120	1.00	6.63	1950	13.9				1.67	0.019						397													
27-0037	Wirth	9/10/2013	9:51:04	1.95	0	24.5	7.45	92.2	8.29	794	0	13.3	0.980	9.07	0.049	0.005		0.627				145	16.3												
27-0037	Wirth	9/10/2013	9:50:30		1	24.5	7.37	91.0	8.25	794	0																								
27-0037	Wirth	9/10/2013	9:50:02		2	24.4	6.89	85.1	8.13	794	0																								
27-0037	Wirth	9/10/2013	9:49:16		3	23.0	1.15	13.8	7.41	812	0																								
27-0037	Wirth	9/10/2013	9:48:38		4	19.4	0.780	8.70	7.18	910	0				0.063	0.004																			
27-0037	Wirth	9/10/2013	9:48:16		5	13.5	0.670	6.60	6.98	1118	0																								
27-0037	Wirth	9/10/2013	9:47:47		6	8.53	0.260	2.30	6.78	1658	0																								
27-0037	Wirth	9/10/2013	9:47:22		7	7.29	0.260	2.30	6.61	1943	0				1.04	0.177						328	5.7												
27-0037	Wirth	9/23/2013	9:57:36	3.10	0	18.5	8.38	91.6	8.10	814	0	4.35	1.18		0.035	<0.003		0.547				154													
27-0037	Wirth	9/23/2013	9:57:09		1	18.5	8.43	92.5	8.09	814	0																								
27-0037	Wirth	9/23/2013	9:56:24		2	18.5	8.30	91.1	8.08	814	0																								
27-0037	Wirth	9/23/2013	9:55:35		3	18.5	8.26	90.6	8.04	814	0																								
27-0037	Wirth	9/23/2013	9:54:45		4	18.4	6.53	71.4	7.80	818	0				0.041	<0.003																			
27-0037	Wirth	9/23/2013	9:53:17		5	14.8	0.130	1.30	6.99	1100	0																								
27-0037	Wirth	9/23/2013	9:52:12		6	9.60	0.200	1.80	6.84	1554	0				1.30	0.014						340													
27-0037	Wirth	9/23/2013	9:51:23		7	7.56	0.340	2.90	6.63	1929	0																								
27-0037	Wirth	10/8/2013	11:01:51	3.92	0	15.6	6.36	65.8	7.87	841	0	0.657	<0.500	8.88	0.025	0.005	<0.500	0.594	0.042	155	240	168													
27-0037	Wirth	10/8/2013	11:01:29		1	15.6	6.34	65.7	7.93	831	0																								
27-0037	Wirth	10/8/2013	11:00:56		2	15.6	6.32	65.4	7.93	832	0																								
27-0037	Wirth	10/8/2013	11:00:18		3	15.6	6.25	64.7	7.91	830	0																								
27-0037	Wirth	10/8/2013	10:59:11		4	15.5	5.93	61.2	7.84	832	0				0.031	0.006																			
27-0037	Wirth	10/8/2013	10:57:45		5	14.4	0	0	7.39	932	2.30																								
27-0037	Wirth	10/8/2013	10:57:22		6	9.96	0	0	7.05	1595	13.6																								
27-0037	Wirth	10/8/2013	10:56:46		7	8.03	0	0	6.87	1917	13.6				0.959	0.188						305													
27-0037	Wirth	10/8/2013	10:56:25		8	7.45	0	0	6.74	2050	81.0																								