Big Blake Lake Aquatic Plant and Lake Management Plan, 2016-2021

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Big Blake Lake Protection and Rehabilitation District

We would like to thank the following for their contributions to this project. Asterisks indicate members of the Lake Planning Committee.

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Appendix Files

Purpose of the Study

In 2012, the Big Blake Lake Protection and Rehabilitation District applied for a Wisconsin Department of Natural Resources Aquatic Invasive Species Education, Prevention, and Planning Grant. The grant was awarded and data collection occurred in 2013, 2014, and 2015.

The main purpose of the grant was to address the following problems: aquatic invasive species, nuisance aquatic plant growth, algae blooms, impaired water clarity, and a lack of education and data.

Methods and activities completed through this grant award include:

- ✓ Lake resident survey
- ✓ In-lake physical and chemical monitoring
- ✓ Tributary monitoring
- ✓ Phytoplankton
- ✓ Zooplankton
- ✓ Aquatic plant point intercept surveys
- ✓ Curly-leaf pondweed biomass and turion monitoring
- ✓ Watershed delineation, land use determination, and modeling
- ✓ Participation in aquatic invasive species statewide programs: Citizen Lake Monitoring Network for AIS and Water Quality, Bait Dealer Initiative, and Clean Boats, Clean Waters
- ✓ Communication of information: the Blake Lake Bugle Newsletter, pontoon classrooms, and distribution of AIS flyers
- ✓ Development of Aquatic Plant Management Plan

In 2013, the Big Blake Lake Protection and Rehabilitation District applied for a Wisconsin Department of Natural Resources Large Scale Lake Management Planning Grant to collect a sediment core on Big Blake Lake.

Methods and activities completed through this grant award include:

- ✓ Sediment core collection
- ✓ Sediment phosphorus
- ✓ Diatom analysis
- ✓ Macrofossils
- ✓ Zooplankton
- ✓ Pigments
- ✓ Biogenic silica analysis
- ✓ Historical land use determination and modeling
- ✓ Development of a Lake Management Plan

The following report details the methods and activities completed through both grant awards.

Background Information on Lakes, Studies, and Management Plans

Lakes are a product of the landscape they are situated in and of the actions that take place on the land which surrounds them. Factors such as lake size, lake depth, water sources, and geology all cause inherent differences in lake quality. As a result, lakes situated within feet of others can differ profoundly in the uses they support.

A landscape can be divided into watersheds and subwatersheds. These areas define the land that drains to a particular lake, flowage, stream, or river. Watersheds that preserve native vegetation and minimize impervious surfaces (cement, concrete, and other materials that water can't permeate) are less likely to cause negative impacts on lakes, rivers, and streams. This arises because rain and melting snow eventually end up in lakes and streams through surface runoff or groundwater infiltration. Rain and melting snow entering a waterbody is not inherently problematic. However, water has the ability to carry nutrients, bacteria, sediments, and chemicals into a waterbody. These inputs can impact aquatic organisms such as insects, fish, and wildlife and—especially in the case of the nutrient phosphorus—fuel problematic algae blooms.

Lake studies often examine the underlying factors that impact a lake's health, such as lake size, depth, water sources, and the land use in a lake's watershed. Many forms of data can be collected and analyzed to gauge a lake's health including: physical data (oxygen, temperature, etc.), chemical data (including nutrients such a phosphorus and nitrogen), biological data (algae, zooplankton, and aquatic plants), and land use within a lake's watershed. Additionally, sediment cores can be used to determine how a lake has changed over the course of hundreds of years

Lake studies identify challenges and threats to a lake's health along with opportunities for improvement. These studies identify practices already being implemented by watershed residents to improve water quality and areas providing benefits to a lake's ecosystem. Additionally, these studies quantify practices or areas on the landscape that have the potential to negatively impact the health of a lake and identify best management practices for improvement.

The end product of a lake study is a **Lake Management Plan** which identifies goals, objectives, and action items to either maintain or improve the health of a lake. These goals should be realistic based on inherent lake characteristics (lake size, depth, etc.) and should align with the goals of watershed residents.

An **Aquatic Plant Management Plan** is similar to a Lake Management Plan, although the goals, objectives, and action items pertain specifically to aquatic plants.

Both types of management plans are designed to be working documents that are used to guide the actions which take place to manage a specific lake.

Introduction to Big Blake Lake

Big Blake Lake[1] is a 208 acre lake located in the Town of Georgetown[2] in Polk County, Wisconsin, approximately 80 miles northeast of the Twin Cities metropolitan area. The area of land that drains to a lake is called a watershed. Big Blake Lake is situated within the Upper Apple River Watershed, which is part of the St. Croix River Basin. The Upper Apple River Watershed is the largest watershed in Polk County, totaling approximately 125,074 acres in size.

On a smaller scale, the area of land that drains to Big Blake Lake, or the Big Blake Lake watershed, is 15,369 acres in size. The drainage basin: lake area ratio (DB: LA) compares the size of a lake's watershed to the size of a lake. If a lake has a relatively large DB: LA then surface water inflow (containing nutrients and sediments) occurs from a large area of land relative to the area of the lake. The DB: LA for Big Blake Lake is approximately 61:1.[3]

The main inlet for Big Blake Lake is a channel flowing directly from Little Blake Lake on the southeast end of the lake. Additionally, Big Blake Lake receives water from an inlet located on the north side of the lake. This tributary flows from Lost Lake and is called Lost Creek. The lake's outlet is located on the northwest side of Big Blake Lake and flows to the Apple River via Fox Creek.

Lakes are classified according to their primary source of water and how that water enters and leaves the system. Big Blake Lake is defined as a drainage lake, or a lake with an inlet and an outlet. Drainage lakes receive most of their water from the surrounding watershed in the form of stream drainage, have a prominent inlet and outlet that move water through the system, and commonly have high nutrient levels due to inputs from the watershed.

The residence time is the average amount of time water remains in a body of water. The residence time for Big Blake Lake is 0.10 year, meaning that water is replaced approximately every 36 days.[4]

There are two ramp public access sites on Big Blake Lake located on the northeast and southwest sides of the lake.

The Big Blake Lake Protection and Rehabilitation District was formed in 1976 in response to concerns about algae blooms and aquatic plant problems. The District includes two hundred twenty-two residences. The majority of the shoreline property on Big Blake Lake is parceled into 100 foot lots, although a moderate tract of forested land remains on the east side of the lake.

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[1] Waterbody ID (WBIC) 2627000
[2] T35N, R16 W, Sec. 22, 26, 27
[3] Blake Lake Polk County Feasibility Study Results: Management Alternatives; Wisconsin Department of Natural Resources Office of Inland Lakes Renewal, 1981
[4] Ibid

Lake Classification

Lake classification in Polk County is a relatively simple model that considers:

- ✓ Lake surface area
- ✓ Maximum depth
- ✓ Lake type
- ✓ Watershed area
- ✓ Shoreline irregularity
- ✓ Existing level of shoreline development

These parameters are used to classify lakes as class one, class two, or class three lakes. Big Blake Lake is classified as a class one lake.

Class one lakes are large and highly developed.
Class two lakes are less developed and more sensitive to development pressure.
Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

Big Blake Lake Characteristics

Big Blake Lake [5]

Area: 208 Acres

Maximum depth: 14 feet

Mean depth: 9 feet

Bottom: 55% sand, 0% gravel, 0% rock, and 45% muck

Hydrologic lake type: Drainage [6]

Total shoreline: 6.65 miles

Invasive species: Curly-leaf pondweed, Chinese mystery snail, and banded mystery snail

Fish: Musky, panfish, largemouth bass, northern pike, and walleye

Boat landings: 2

Trophic Status: Eutrophic

Oligotrophic lakes are generally clear, deep, and free of plants and large algae blooms.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have productive fisheries, healthy plant life, and occasional algae blooms.

Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually very productive and subject to frequent algae blooms. Lakes can also be hypereutrophic. Hypereutrophic lakes are characterized by dense algae communities and can experience heavy blooms throughout the summer.

[5] http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2627000&page=more

[6] A drainage lake is fed by streams, groundwater, precipitation, and runoff and drained by a stream

Designated Waters and Sensitive Areas

A designated water is a waterbody with special designations that affect permit requirements.

Big Blake Lake is designated as an Area of Special Natural Resource Interest (ASNRI) Endangered, Threatened, or Special Concern Lake. The Natural Heritage Inventory Program identifies waters or portions of waters inhabited by any endangered, threatened, special concern species, or unique ecological community identified in the Natural Heritage Inventory.

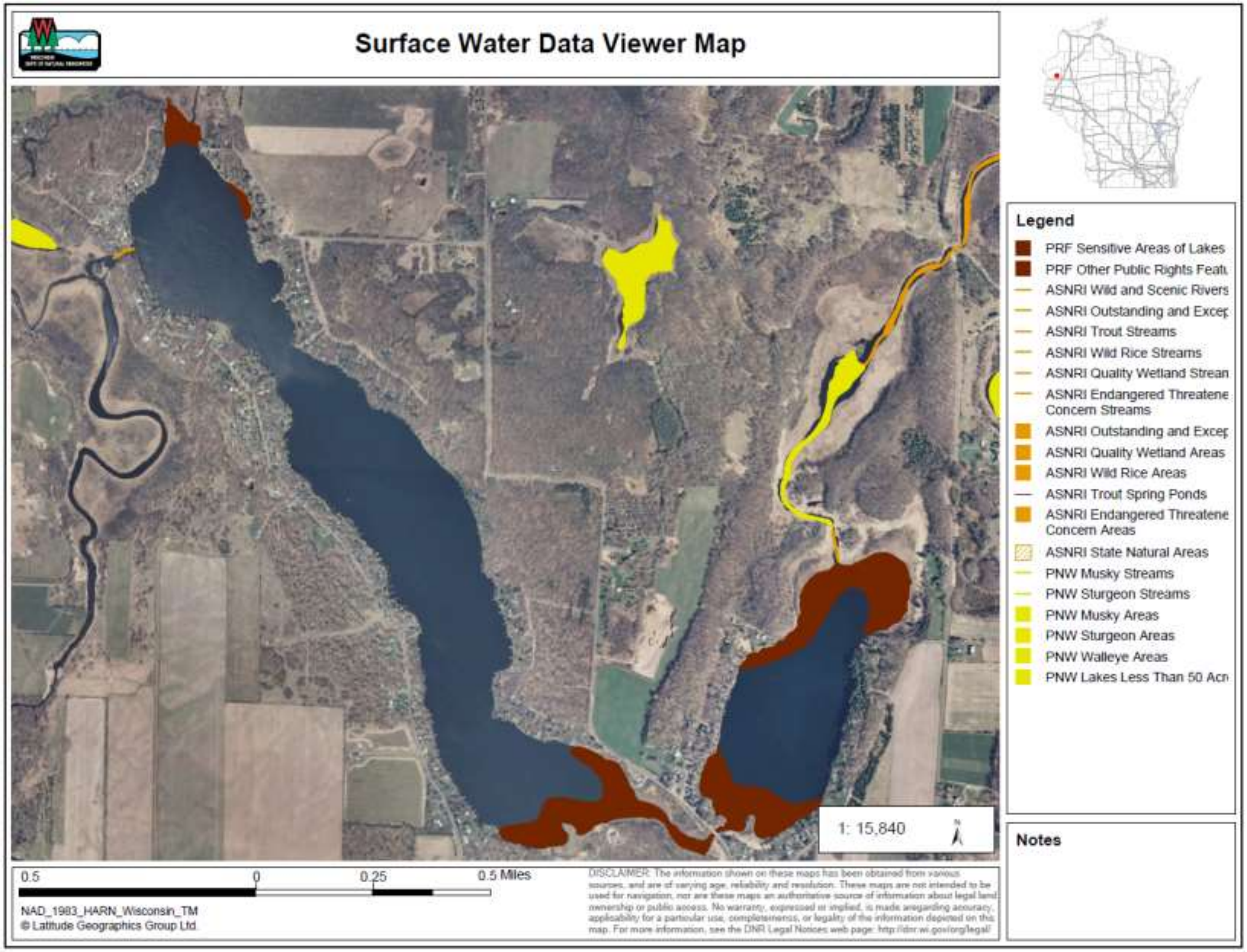
An Integrated Sensitive Area Survey Report was completed for Big Blake Lake in August, 2000. This survey identified three areas of Big Blake Lake that merit special protection of aquatic habitat. Sensitive area A is located on the northern end of Big Blake Lake and covers approximately 400 feet of shoreline and extends out as far as 100 feet, sensitive area B is located at the northeastern end of Big Blake Lake and covers approximately 400 feet of shoreline and extends out as far as 150 feet, and sensitive area C is located at the southeastern end of Big Blake Lake and the southwestern end of Little Blake Lake and encompasses the channel between the two lakes. [7]

Wild rice was documented in sensitive areas A and C. Big Blake Lake is recognized as a wild rice water in the Wisconsin Ceded Territory.[8]

Wild rice, white water lily, and yellow water lily in sensitive area A

[7] Blake and Little Blake Lake Sensitive Area Survey Report and Management Guidelines, Wisconsin Department of Natural Resources, 2000

[8] Wisconsin Ceded Territory Manoomin Inventory, GLIFWC Project Report, Peter David, 2010



Surface Water Data Viewer Map
Legend
PRF Sensitive Areas of Lakes
PRF Other Public Rights Featu
ASNRI Wild and Scenic Rivers
ASNRI Outstanding and Excep
ASNRI Trout Streams
ASNRI Wild Rice Streams
ASNRI Quality Wetland Stream
ASNRI Endangered Threatene Concern Streams
ASNRI Outstanding and Excep
ASNRI Quality Wetland Areas
ASNRI Wild Rice Areas
ASNRI Trout Spring Ponds
ASNRI Endangered Threatene Concern Areas
ASNRI State Natural Areas
PNW Musky Streams
PNW Sturgeon Streams
PNW Musky Areas
PNW Sturgeon Areas
PNW Walleye Areas
PNW Lakes Less Than 50 Acr
Notes
1: 15,840
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0.25
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© Latitude Geographics Group Ltd.
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Impaired Waters

Wisconsin lakes, rivers, and streams are managed to determine if their conditions are meeting state and federal water quality standards. Water samples are collected through monitoring studies and results are compared to guidelines designed to evaluate conditions as compared to state standards. General assessments place waters in four different categories: poor, fair, good, and excellent. The results of assessments can be used to determine which actions will ensure that water quality standards are being met (anti-degradation, maintenance, or restoration).

If a waterbody does not meet water quality standards, it is placed on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Every two years, the State of Wisconsin is required to submit list updates to the United States Environmental Protection Agency for approval.

Waterbodies can be listed as impaired based on pollutants such as total phosphorus, total suspended solids, and metals. Wisconsin waters are each assigned four uses (fish and aquatic life, recreation, public health and welfare, and wildlife) that carry with them a set of goals.

Impairment thresholds vary for each use and vary based on lake characteristics such as whether a waterbody is shallow versus deep and whether a waterbody is a drainage lake versus a seepage lake. Big Blake Lake is classified as a shallow drainage lake that does not stratify.[9]

Big Blake Lake was assessed during the 2016 listing cycle and proposed for listing for the pollutant total phosphorus and the impairment of excess algal growth. The general condition is suspected poor.

Total phosphorus sample data exceeded the 2016 Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) listing thresholds for recreational use (40 µg/L) but not for fish and aquatic life use (100 µg/L). Chlorophyll sample data exceeded the 2016 WisCALM listing thresholds for recreational use (30% of days in the sampling season have nuisance algal blooms with chlorophyll values greater than 20 µg/L) and fish and aquatic life use (60 µg/L).[10]

[9] Listing thresholds can be found in: Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, Wisconsin Department of Natural Resources, September 2013

[10] http://dnr.wi.gov/water/waterDetail.aspx?key=16558

Previous Lake Studies

Past studies on Big Blake Lake include:

- ✓ Blake Lake Polk County Feasibility Study Results: Management Alternatives, Wisconsin Department of Natural Resources Office of Inland Lake Renewal, 1981
- ✓ Blake Lake Macrophyte Surveys and Management Plan, Barr Engineering, 1998
- ✓ Blake and Little Blake Lake Sensitive Area Survey Report and Management Guidelines, Wisconsin Department of Natural Resources, 2000
- ✓ 2004 Big Blake Lake Water Quality and Technical Report, Aquatic Engineering, Inc., 2005
- ✓ 2004 Big Blake Lake Aquatic Plant Survey Technical Report and Management Plan, Aquatic Engineering, Inc., 2005
- ✓ Aquatic Macrophyte Surveys, Polk County Land and Water Resources Department, 2006-2012

Blake Lake Polk County Feasibility Study Results: Management Alternatives, 1981

Office of Inland Lake Renewal, Wisconsin Department of Natural Resources

The Big Blake Lake Protection and Rehabilitation District was formed in 1976. In response, a study of Big Blake Lake and its watershed was initiated by the Office of Inland Lake Renewal, Wisconsin Department of Natural Resources (November 1978-October 1979).

The three main objectives of this study were to: define a nutrient budget, define a water budget, and characterize in-lake chemistry and biological processes for Big Blake Lake.

The following sources of phosphorus loading were identified and used to develop a nutrient budget:

- ✓ Surface runoff: 1,190 kg/yr, 90%
  - *Approximately 70% of this loading originated from the Straight River Watershed*
- ✓ Groundwater: 72 kg/yr, 5%
- ✓ Septic system leachate: 38 kg/yr, 3%
- ✓ Atmospheric deposition: 30 kg/yr, 2%

Additionally, the study determined that the net release of phosphorus from sediments was 149 kg during the study period. Data indicated that Big Blake Lake was over half full of sediment, with a maximum sediment thickness of 25 feet.

The study classified Big Blake Lake as a productive, eutrophic body of water based on total phosphorus, secchi depth, and chlorophyll a. Dissolved oxygen remained adequate throughout the winter months and thermal stratification was not recorded during the summer months. The nitrogen to phosphorus ratio was 13:1, indicating that phosphorus is the most important nutrient for limiting algae populations.

At the time of this study, Big Blake Lake contained a diverse group of macrophytes including eight submerged species, three emergent species, and six floating leaf species. With the exception of dense curly-leaf pondweed in the northwest portion of the lake, macrophyte densities were light to moderate through June. However, by August macrophyte densities were elevated in many areas of the lake with curly-leaf pondweed beds being replaced with coontail. Approximately 10% (25 acres) of Big Blake Lake was covered with aquatic macrophytes during the study.

Management alternatives suggested in this study include: improving the water quality of Big Round Lake, chemically removing phosphorus from the Straight River, diverting the Straight River south to White Ash Lake, controlling weeds with herbicides or harvesting, and dredging.

Blake Lake Macrophyte Surveys and Management Plan, 1998
Barr Engineering
In 1996 the Big Blake Lake District approached the Wisconsin DNR to discuss options for plant management. In response, the DNR suggested that the District complete a macrophyte survey and a macrophyte management plan for the lake. As a result, Barr Engineering completed macrophyte surveys during June and July 1997.

Macrophytes were surveyed using a series of 29 transects at approximately 500 foot intervals along the shoreline. Each transect was divided into depth categories of 0-1.5 feet, 1.5-5 feet, and 5-10 feet (or the maximum rooting depth), with four rake samples taken at each depth category.

The study determined that the total area of macrophyte growth was 122 acres (49% of the lake surface area) in June and 120 acres (49% of the lake surface area) in July. This compares with macrophyte growth covering only 25 acres (10% of the lake surface area) in 1979. In the 18 years between the two surveys, macrophyte coverage in Big Blake Lake increased by nearly 100 acres.

A total of 21 species were found in Big Blake Lake with approximately 8-9 species being found in each transect. In general, each plant had a low individual density, but because there were a large number of species found at each site, overall plant growth was moderate to high. The study determined that diversity was similar when comparing 1979 and 1997 data. In both June and July 1997, the diversity index was 0.89.

Curly-leaf pondweed, the only invasive plant located in the survey, was found in approximately 52% of the sample transects during June and approximately 48% of the sample transects during July. In general, densities remained low, although occasionally curly-leaf pondweed was found at higher densities. The study indicated that native species were relatively successful in competing with curly-leaf pondweed.

Barr Engineering also surveyed members of the Big Blake Lake District to determine: resident understanding of functions and values of aquatic plants, uses of the lake, perceived impairment of lake uses by aquatic plants, and aquatic plant management preferences. Seventy-seven responses were received (31% response rate).

The primary uses for Big Blake Lake were fishing (94%), viewing (82%), swimming (70%), powerboating (47%), and canoeing (43%). The primary use impairments caused by plants were swimming (62%) and fishing (60%). Over half of respondents (56%) had removed or attempted to remove plants around their docks or along their shorelines. More respondents were opposed to the use of chemicals to remove aquatic plants from the lake (39%) as compared to mechanical harvesting of plants (23%). Over half of respondents (57%) indicated that the District should not own and operate a weed harvester. Most respondents (88%) recognized that aquatic plants have value, with high levels of importance for fish shelter and high to medium levels of importance for fish food.

The six aquatic plant management goals developed for Blake Lake included:

- Improve navigation within the lake through areas containing dense plant beds
- Remove or limit current exotic plants (i.e. curly-leaf pondweed)
- Preserve native species and prevent introduction of additional exotic species
- Preserve and/or improve fish and wildlife habitat
- Protect and/or improve quality of the resources for all to enjoy (i.e., people, fish, wildlife)
- Minimize disturbance of sensitive areas (i.e. fish and wildlife)

The management plan developed for Big Blake Lake was based upon the need to: provide reasonable access to the lake for residents living adjacent to very dense plant growth, control curly-leaf pondweed growth, preserve the current macrophyte community, and prevent the introduction of additional invasive species to Big Blake Lake.

The resulting management plan included:

- A harvesting plan for approximately 5 acres, with channel width restricted to 20 feet
- Herbicide treatment for approximately 60 acres of curly-leaf pondweed
- Education programs to increase understanding of the function and roles of native plant communities and the threat that invasive species pose
- A plan to control the introduction of invasive species including: boat inspections; littoral area inspections; informational meetings; and boat launch signage, bulletin boards and brochures with educational information
- Evaluation program to monitor the effectiveness of the plan and resurvey the plant community every five years

Blake and Little Blake Lake Sensitive Area Survey Report and Management Guidelines, 2000
Wisconsin Department of Natural Resources
A lake sensitive area survey was completed on Big Blake Lake on August 17th, 2000. The report indicated three sensitive areas in Big Blake Lake.

Sensitive area A is located at the northern end of Big Blake Lake and covers approximately 400 feet of shoreline and extends out as far as 100 feet. The area encompasses the alder thicket and open/shallow water wetland area north of the boat launch. The majority of the shoreline in this area is considered “wild” with little or no development and high scenic beauty.

Sensitive area B is located at the northeastern end of Big Blake Lake and covers approximately 400 feet of shoreline and extends out as far as 150 feet. The majority of the length is dominated by a shallow or open water wetland which has protected the area from the negative impacts of improperly developed shorelines.

Sensitive area C is located at the southeastern end of Big Blake Lake and the southwestern end of Little Blake Lake and encompasses the channel between the two lakes. The majority of the length is dominated by deep marsh and shallow or open water wetland which has protected the area from the negative impacts of improperly developed shorelines. However, some developed shorelines with minimal buffers do exist in the area. It is recommended that these shorelines should create suitable vegetative buffers for approximately 35 feet.

All three sensitive areas provide important habitat for bass, panfish, and northern pike spawning and nursery areas; forage species; and wildlife. Additionally, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from the valuable habitat in these sensitive areas.

Wild rice was documented in sensitive areas A and C and should be allowed to proliferate.

Sensitive Area A, north end of Big Blake Lake

The report recommended that chemical treatment and mechanical harvesting not be allowed in sensitive area A, and that these actions be limited to navigational channels in sensitive areas B and C.

2004 Big Blake Lake Water Quality and Technical Report, 2005

Aquatic Engineering, Inc.

In 2004, the District received a WDNR grant to collect physical and chemical water quality data, algae data, zooplankton data, and develop a phosphorus budget for Big Blake Lake. The final report was prepared by Aquatic Engineering, Inc.

Data indicated that Big Blake Lake was eutrophic and did not thermally stratify. The TN:TP ratio was approximately 12.5:1. In July and September the most common algae division was cyanophyta, or blue green algae. In August and September the zooplankton community was dominated by rotifers.

The Big Blake Lake watershed was determined as 798.37 acres and summed for each functional category. This study determined the largest land uses in the Big Blake Lake Watershed as forest (385.8 acres) and grassland (144.6 acres).[11]

Using the Wisconsin Lake Modeling Suite (WiLMS), it was determined that the most likely total annual phosphorus load to Big Blake Lake was 808 kg. This value includes 712 kg/year as point source load and 96 kg/year as non-point source load, but does not include internal loading or groundwater interactions. The study determined that the single largest load in 2004 came from the Straight River (85% of the total load or 703.7 kg/year).

[11] This study indicated that the Big Blake Lake Watershed was 798.37 acres in size. However, when all the land uses in the watershed are added the total equals 895.3 acres. Removing the lake surface area of 230 acres does not alleviate the discrepancy in acreage.

To improve the water quality of Big Blake Lake, the study recommended: public education and implementation of buffer strips and shoreline restoration, creating a committee to improve the Straight River Watershed, working with Polk County and towns as they create land use and zoning regulations, collecting in-lake data, reducing curly-leaf pondweed biomass, and adopting and implementing the 2005 Aquatic Plant Management Plan goals and recommendations.

2004 Big Blake Lake Aquatic Plant Survey Technical Report and Management Plan, 2005
Aquatic Engineering, Inc.
A second grant was awarded to the District to assess aquatic macrophytes and macroinvertebrates in conjunction with the water quality study. Project activities included an assessment of riparian land use, a lake resident survey, and updates to the current Lake Management Plan. The final report was prepared by Aquatic Engineering, Inc.

Macrophytes were surveyed in spring and summer using a series of thirty-four transects along the shoreline. Each transect was divided into depth categories of 0-1.5 feet, 1.5-5 feet, 5-10 feet, and 10 feet to the maximum rooting depth. Each sample area was divided into quadrants and sampled with a rake.

Seventeen species were identified in Big Blake Lake with 14 present in the spring and 12 present in the summer. The most common species found in the spring were curly-leaf pondweed (56.9%), coontail (16.9%), and flat stemmed pondweed (12.1%). The most common species in the summer were coontail (32%), flat stemmed pondweed (20.3%), and najas (13.1%).[12] The diversity value was 62.82 in the spring and 81.2 in the summer.

Curly-leaf pondweed was found at 87% of the sites sampled in the spring and 20% of the sites sampled in the summer.

Macroinvertebrates were collected in June and July at three different site conditions: curly-leaf pondweed dominated communities, moderate curly-leaf pondweed communities, and native plant communities. In general, diversity and richness did not differ significantly across sites.

At each point where the macrophyte transect intersected the shoreline, the riparian area was classified as natural or disturbed. Approximately three-fourths (79%) of the shoreline was classified as disturbed as compared to natural (21%).

A survey was distributed to all members of the District in the spring of 2005 to engage public participation and determine resident opinions and concerns. The survey had a 40% response rate (87 surveys completed out of 218). Over two-thirds of respondents (69%) were seasonal/part time residents. Respondents most frequently described their property immediately adjacent to the lake as mowed lawn leading to a pier. Over half (60%) of respondents felt that fertilizers and weed killer were not necessary to maintain lawns around the lake. Clear water received the most rankings as the issue of greatest importance. In the time since respondents have lived on Big Blake Lake, over half perceived the following conditions to have worsened: nuisance weed growth, algae growth, noise, personal watercraft traffic, motor boat traffic, and muckiness of lake bottom.

[12] Percentages for frequency of occurrence, relative percent

The vast majority of respondents felt that overall there were too many plants in Big Blake Lake (87%), that there are areas in the lake where aquatic plants became especially problematic (86%), and that the current weed management program was not effectively controlling nuisance plant growth (89%).

Over half of respondents believed that recreational activities and lake uses were occurring that were seriously jeopardizing the health and safety of Big Blake Lake (52%) and were in favor of expanding slow-no-wake times and/or locations to promote safety and protect sensitive habitat areas (56%).

The study outlined an implementation plan for Big Blake Lake with immediate, short range, and long-range actions. Immediate actions included education campaigns to inform residents about the value of aquatic plants and what they can do to help improve water quality. Short-range actions included harvesting curly-leaf pondweed throughout the lake in the spring and native plants in designated navigational channels in the summer. Long range actions included improving water quality by implementing best management practices in the Straight River Watershed and promoting the growth of native plants in sensitive areas.

Aquatic Macrophyte Surveys, 2006-2012

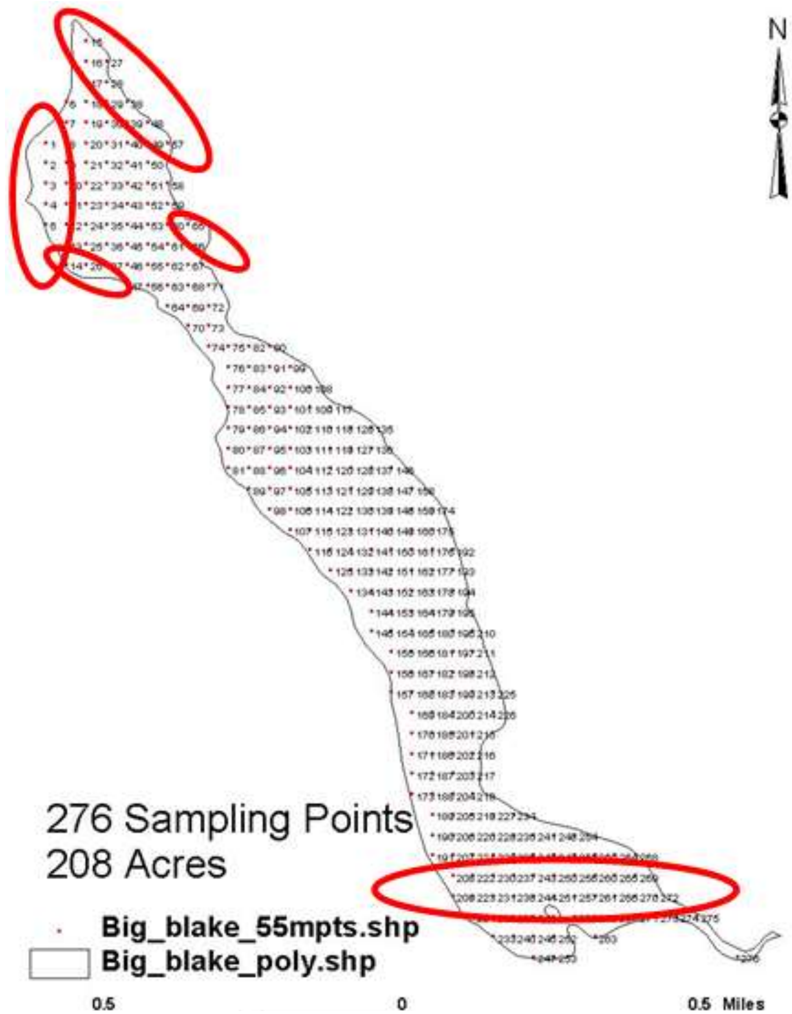
Polk County Land and Water Resources Department

The Polk County Land and Water Resources Department has completed aquatic plant surveys on Big Blake Lake since 2006. The surveys completed in 2006 sampled 40 points with early establishment of curly-leaf pondweed and the surveys completed in 2008-2010 occurred in two intensive management areas. Full spring and fall point intercept surveys were completed in 2007, 2011, and 2012 with data being summarized in the “Point Intercept Aquatic Macrophyte Surveys” section of this report.

May 2008 plant survey, rake shows curly leaf pondweed and coontail

In 2006, 2008, 2009, and 2010 curly-leaf pondweed was the dominant species in the spring being found at 98%, 100%, 95%, and 88% (respectively) of the sites sampled. Coontail was the only other common species found in all three years. Flat stem pondweed was fairly common in spring and fall 2006 and small pondweed was fairly common in spring 2010. The dominance of curly-leaf pondweed is not surprising given that the sampling points were chosen based on the presence of this species.

From 2008-2010, the Simpsons Diversity Index ranged from a high of 0.79 in October 2009 to a low of 0.53 in August 2008. Species richness, or the number of species found (including visuals), ranged from a high of 14 species in June 2010 to a low of 6 species in June 2009.



2006 sampling points

2008-2010 sampling points

Fisheries

The most recent fisheries survey on Big Blake Lake was completed in 2009 and included netting and shocking surveys.

Over a time period of 13 net nights, the total catch was highest for bluegill (103 fish, average length of 6.86 inches) followed by pumpkinseed (31 fish, average length of 7.25 inches). Fewer numbers of black crappie (13 fish, average length of 6.90 inches), northern pike (11 fish, average length of 22.34 inches), muskellunge (8 fish, average length of 37.31 inches), walleye (4 fish, average length of 23.13 inches), largemouth bass (3 fish, average length of 11.75 inches), and yellow perch (2 fish, average length of 6.50 inches) were caught.

Electroshocking occurred over one mile of shoreline on Big Blake Lake. The total catch was highest for bluegill (394 fish, average length of 6.36 inches) and largemouth bass (254 fish, average length of 11.53 inches). Fewer numbers of pumpkinseed (38 fish, average length of 7.24 inches), black crappie (8 fish, average length of 8.88 inches), northern pike (8 fish, average length of 23.63 inches), green sunfish (7 fish, average length of 6.68 inches), muskellunge (2 fish, average length of 35.00 inches), and yellow perch (1 fish, average length of 8.75 inches) were shocked.

Lake Resident Survey

A Wisconsin Department of Natural Resources approved survey was mailed to two hundred seventeen property owners on Big Blake Lake in May 2014. One hundred twenty-six surveys were returned (58% response rate) and data was entered by volunteers and analyzed.

Survey respondents have owned their property on Big Blake Lake for an average of 21 years. One third of survey respondents (33%) use their property as a year-round residence. The majority of respondents use their property part time, either as a weekend, vacation, and/or holiday residence (56%) or as a seasonal residence (continued occupancy months at a time) (10%). On average, properties on Big Blake Lake are used 148 days per year and occupied by 3.6 people.

The survey asked respondents to describe the area measuring 35 feet inland (beginning at the water's edge, shoreland towards the road). Survey respondents indicated that the vast majority of properties (91%) on Big Blake Lake contain mowed lawn in the 35 foot buffer area. Fewer respondents indicated that this area of their property contained shrubs/trees (44%), un-mowed vegetation (38%), and undisturbed woods (15%). A small minority of property owners have installed best management practices such as shoreline restorations (9%) and rain gardens (3%) in this area. Around half of respondents indicated their property has a dock/pier (48%) and stabilizing rock/rip rap (42%).

The survey asked respondents which activities they enjoy on Big Blake Lake. Activities enjoyed by over three-fourths of respondents include: enjoying peace and tranquility (93%), enjoying the scenic view (89%), open water fishing (83%), motorized boating (80%), and observing birds and wildlife (79%). Swimming is enjoyed by nearly three-fourths of respondents (70%), non-motorized boating (canoe/kayak) and ice fishing are enjoyed by around half of respondents (47% and 45%, respectively), and jet skiing/wakeboarding/waterskiing are enjoyed by one-fourth of respondents (27%). Fewer respondents enjoy cross country skiing/snowshoeing (17%), snowmobiling (16%), hunting/trapping (8%), and sailing/wind surfing (1%).

Most respondents keep watercraft on their property for use on Big Blake Lake, with only 7% of respondents noting that they do not have watercraft. Most survey respondents keep motorboats/pontoons on their property for use on Big Blake Lake. Nearly half of respondents keep motorboats/pontoons that are 21-50 HP (46%), approximately one-third keep motorboats/pontoons that are more than 50 HP (36%), and approximately one-fourth keep motorboats/pontoons that are 1-21 HP (26%). Nearly half of survey respondents keep canoes/kayaks and paddleboats/rowboats on their property (46% and 44% respectively). Fewer respondents keep jet skis (12%) and sailboats (3%) on their property for use on Big Blake Lake.

In an effort to quantify risk of spreading aquatic invasive species, survey respondents were asked if the watercrafts they use on Big Blake Lake are used on other waterbodies. Approximately one-fourth (23%) of boats kept on Big Blake Lake are used on other waterbodies.

Respondents were asked to rank their degree of concern with fifteen issues as high, medium, low, issue exists but isn't a concern, and issue doesn't exist. Responses for this question were analyzed using a point system. Each issue ranked as high received 4 points, as medium received 3 points, as low received 2 points, as exists but not a concern 1 point, and as not an issue received 0 points. Total points were averaged to determine a final rank.

Issues with a final ranking of medium concern included: excessive aquatic plant growth, expansion of current invasive species (curly-leaf pondweed), excessive algae blooms, decrease in overall lake health, lack of water clarity or quality, new invasive species entering the lake, and increased nutrient pollution. The remaining issues ranked as low concerns.

What is your degree of concern with each issue listed below?	**Rank**
Excessive aquatic plant growth	3.4
Expansion of current invasive species (curly-leaf pondweed)	3.4
Excessive algae blooms	3.4
Decrease in overall lake health	3.3
Lack of water clarity or quality	3.3
New invasive species entering the lake	3.3
Increased nutrient pollution	3.2
Decreased property values	2.9
Decreased fisheries	2.7
Unsafe use of motorized water craft	2.6
Loss of natural scenery/beauty	2.5
Disregard for slow-no-wake zones	2.4
Increased development	2.3
Decreased wildlife populations	2.2
Excessive noise level on the lake	2.1

The survey was mailed out to members of the Big Blake Lake Protection and Rehabilitation District just after the dam on the outlet blew out in May 2014. As a result, when the survey was mailed out water levels on Big Blake Lake were below average. Not surprisingly, at the time of the survey the majority of respondents (81%) described the lake level as too low.

Over half of respondents described the current water quality of Big Blake Lake as fair (54%). More respondents described the current water quality as good (26%) compared to poor (14%). Respondents were more divided in describing how the water quality has changed since they've lived on Big Blake

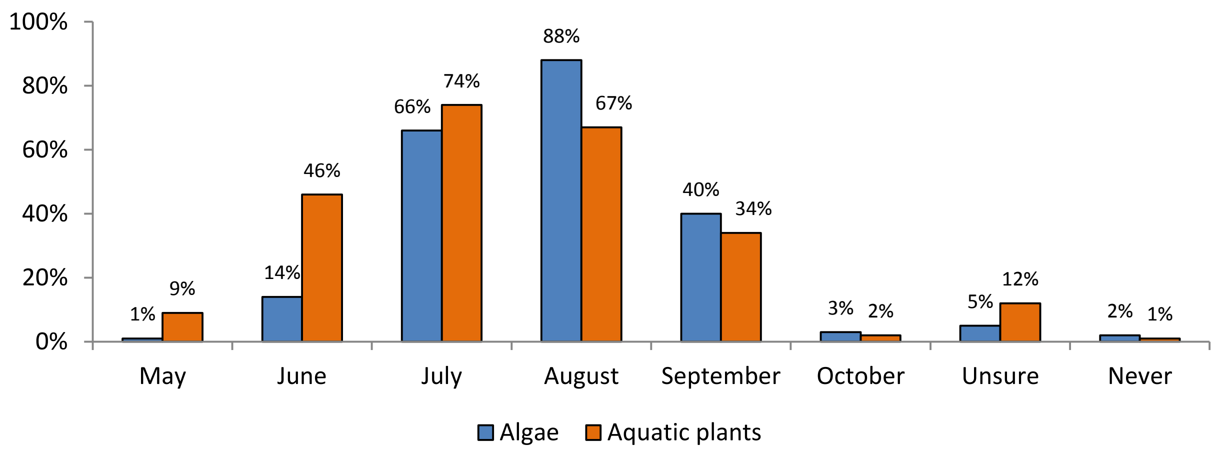
Lake. In general, more respondents described water quality as degrading in the time they'd lived on the lake (42%) as compared to improving (27%). However, approximately one-third of respondents (31%) were unsure how to describe the change or described the lake as unchanged.

The survey also asked a variety of questions regarding algae and aquatic plants. Respondents were asked to describe the amount of aquatic plants in Big Blake Lake, what months during the open water season algae and aquatic plants are a problem, and what uses are impaired as a result of algae and aquatic plants.

Algae are considered problematic by over three-fourths of respondents in August (88%), by two-thirds of respondents in July (66%), and by less than half of respondents in September (40%). A large majority of respondents indicated that swimming (92%) and overall enjoyment of the lake (84%) are limited by algae. Around half of respondents indicated that fishing (57%), boating (52%), and dogs/animals using the water (46%) were limited by algae.

The majority of respondents described the amount of aquatic plants as too many (69%). Fewer respondents described a healthy amount of plants (29%) and too few plants (2%). Aquatic plants are considered problematic by three-fourths of respondents in July (74%), by two-thirds of respondents in August (67%), by half of respondents in June (46%), and by one-third of respondents in September (34%). Approximately three-fourths of respondents indicated that swimming (83%), overall enjoyment of the lake (72%), and boating (71%) were limited by aquatic plants. Fewer respondents felt that fishing (63%) and navigation (43%) were limited.

Which months of the open water season do you consider algae and aquatic plants to be a problem on Big Blake Lake?



Curly-leaf pondweed is an invasive species that creates nuisance conditions in Big Blake Lake by forming dense beds of vegetation that interfere with lake uses in the spring. Nearly half of respondents (49%)

indicated that they would definitely recognize this invasive species and nearly one-fourth of respondents (20%) indicated that they would probably recognize this species.

Survey respondents were divided in describing if the current aquatic plant management program is effectively controlling nuisance aquatic plant growth (not including algae). More respondents felt that the program was effective (40%) as compared to ineffective (27%), although a third of respondents (33%) weren't sure how to describe the program. In a related question, the survey asked how satisfied residents were with the current aquatic plant harvesting program. Nearly two-thirds of respondents were satisfied with the program (63%), one-fourth of respondents were unsure or neutral (25%), and a minority were dissatisfied with the program (12%).

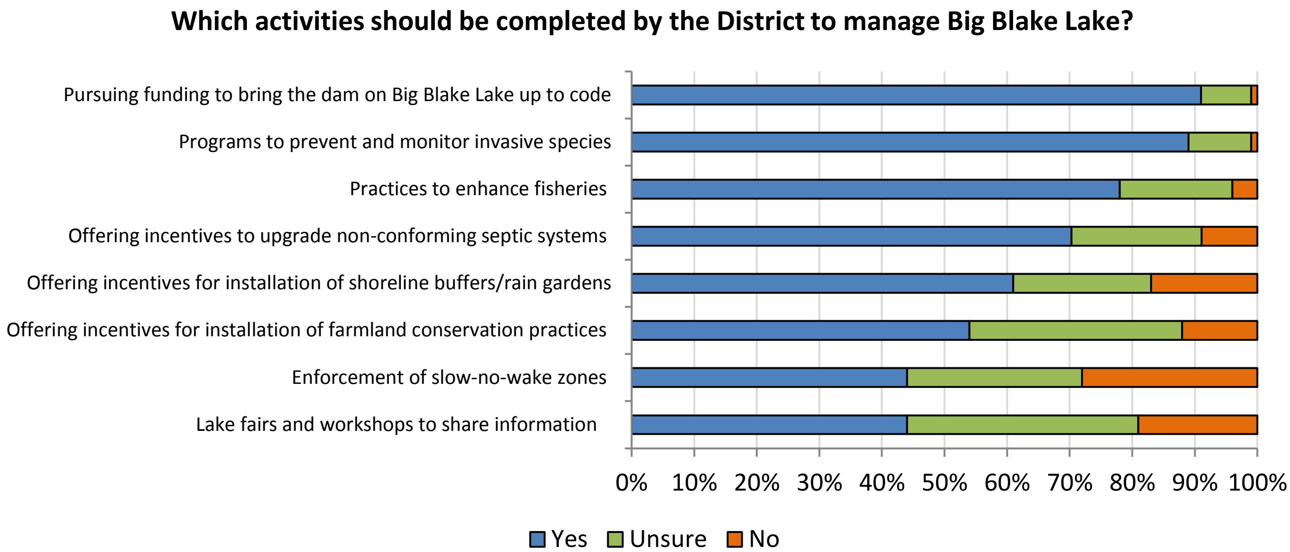
Earlier in the survey, 91% of respondents indicated that the area 35 feet back from their shoreline contained mowed lawn. Later, the survey asked respondents to describe the current amount of mowed lawn across the entire shoreline of Big Blake Lake. Nearly half of respondents described the amount of lawn as just right (47%), one-fourth described the amount of lawn as too much (24%), and another one-fourth were unsure (27%). Only 2% of respondents described the amount of lawn as not enough.

Overall the majority of respondents felt that shoreline buffers, rain gardens, and native plants were very important (37%) or somewhat important (34%) to the water quality of Big Blake Lake. A minority described them as not too important (10%) and not at all important (7%). However, earlier in the survey it was indicated that very few shoreline property owners had installed shoreline restorations and rain gardens (9% and 3%, respectively).

On a positive note, over half of respondents do not use fertilizer on their property (60%) and another one-third use zero phosphorus fertilizer (38%). A very small minority of respondents use fertilizer but are unsure of its phosphorus content (2%) or use multiple types of fertilizer that contain varying amounts of phosphorus (1%).

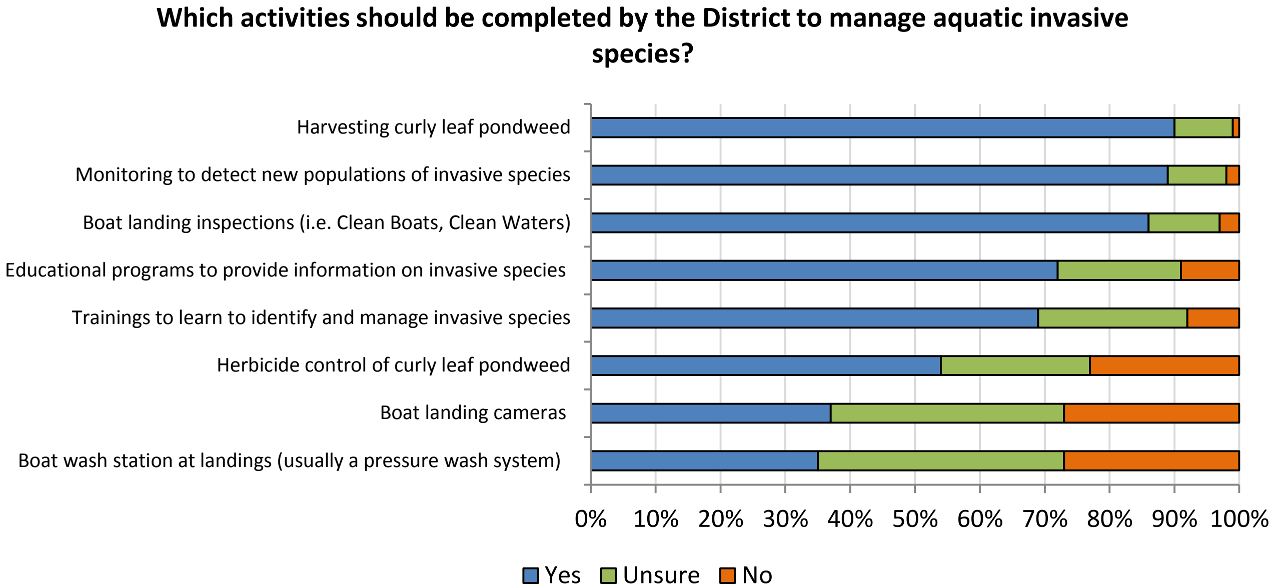
The survey asked respondents to indicate which actions should be completed by the District to manage Big Blake Lake. Over three-fourths of respondents supported: pursuing funding to bring the dam on Big

Blake Lake up to code (91%), programs to prevent and monitor invasive species (89%), and practices to enhance fisheries (78%). Over half of respondents supported offering incentives for: upgrades to non-conforming septic systems (71%), installation of shoreline buffers/rain gardens (61%), and installation of farmland conservation practices (54%). Fewer respondents supported the enforcement of slow-no-wake-zones (44%) and lake fairs and workshops to share information (44%).



The survey also asked respondents to indicate which actions should be completed by the District to manage aquatic invasive species. Over three-fourths of respondents supported: harvesting curly-leaf pondweed (90%), monitoring to detect new populations of invasive species (89%), and boat landing inspections (86%). Over half of respondents supported: educational programs to provide information on invasive species (72%), trainings to learn to identify and manage invasive species (69%), and herbicide control of curly-leaf pondweed (54%).

Fewer respondents supported boat landing cameras (37%) and boat wash stations at landings (35%). However, over one-third of respondents were unsure if the District should pursue these opportunities, indicating a potential need for information and education regarding these management practices.



Survey respondents were asked how they prefer to receive information from the Big Blake Lake District. Respondents indicated that the most preferred method of communication was the newsletter (85%), followed by email (51%), and the annual meeting (40%). Only one-fourth of respondents preferred to receive information through websites (24%) and a small minority preferred Facebook (6%).

Over half of survey respondents were not aware of the Big Blake Lake District Facebook page (55%) and one-third of respondents never visit the page (32%). Fewer respondents rarely (9%), and sometimes (4%) visit the page.

The survey asked respondents which activities they were interested in participating in to improve Big Blake Lake. Around one-third of respondents were interested in learning to identify invasive species (36%), installing a shoreline buffer on their property (32%), and learning how to monitor for aquatic invasive species (29%). Approximately one-fourth of respondents were interested in learning how to monitor water quality (28%) and installing a rain garden on their property (28%). Fewer respondents were interested in serving on a committee to develop an action plan for improving Big Blake Lake (12%).

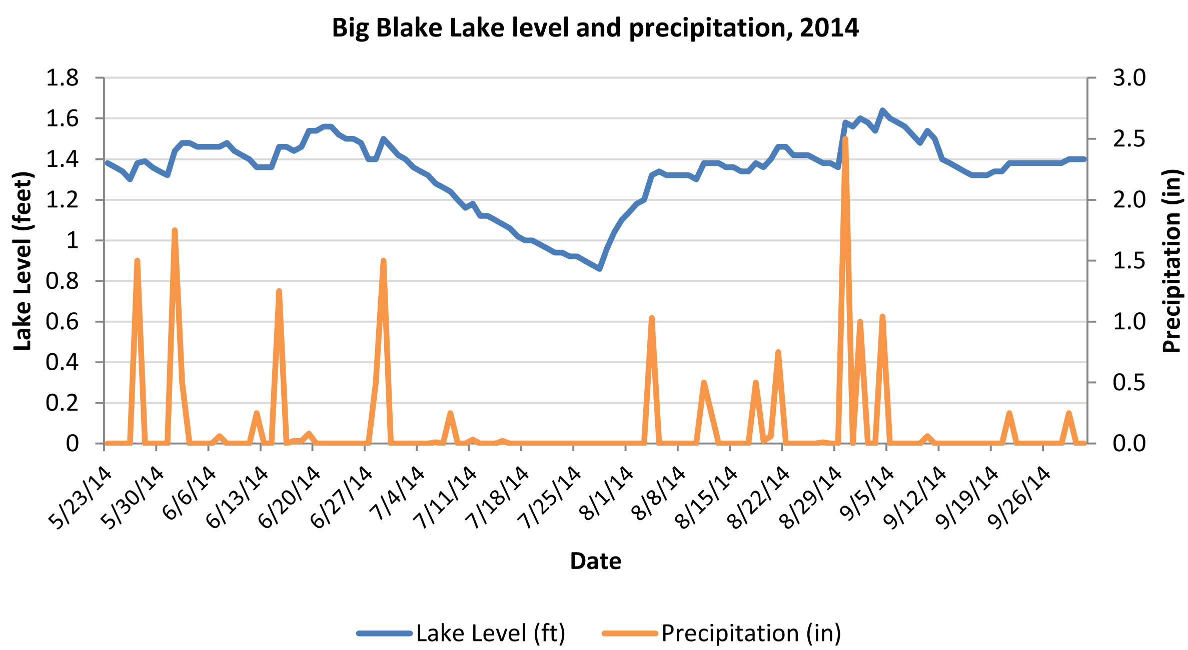
Lake Level and Precipitation Monitoring

Lake water-level fluctuations are important to lake managers, lakeshore property owners, developers, and recreational users because they can have significant impacts on lake water quality and usability. Although lake levels naturally change from year to year, extreme high or low levels can present problems such as restricted water access, flooding, shoreline and structure damage, and changes in near shore vegetation.

Records of lake water elevations can be very useful in understanding changes that may occur in lakes. While some lakes respond almost immediately to precipitation, other lakes do not reflect changes in precipitation until months later.

Volunteers monitored lake level and precipitation on Big Blake Lake in 2014 in response to the dam failure. Polk County Land and Water Resources Department provided training on data collection methods and installed staff and rain gauges. Monitoring began on May 23rd and continued through October 10th.

Seasonal precipitation on Big Blake Lake totaled 17.71 inches. Lake level did respond to precipitation events, with levels increasing following rainfall events. Lake levels were lowest on July 28th and highest on September 4th, with a variation of 0.78 feet.



Lake Mixing and Stratification: Background Information

Water quality is affected by the degree to which the water in a lake mixes. Within a lake, mixing is most directly impacted by the temperature-density relationship of water. When comparing why certain lakes mix differently than others, lake area, depth, shape, and position in the landscape become important factors to consider.

Water reaches its greatest density at 3.9°C (39°F) and becomes less dense as temperatures increase and decrease. Compared to other liquids, the temperature-density relationship of water is unusual: liquid water is more dense than water in its solid form (ice). As a result, ice floats on liquid water.

When ice melts in the early spring, the temperature and density of the water will be constant from the top to the bottom of the lake. This uniformity in density allows a lake to completely mix. As a result, oxygen is brought to the bottom of a lake, and nutrients are re-suspended from the sediments. This event is termed **spring turnover**.

As the sun's rays warm the surface waters in the spring, the water becomes less dense and remains at the surface. Warmer water is mixed deeper into the water column through wind and wave action. However, these forces can only mix water to a depth of approximately twenty to thirty feet. Generally, in a shallow lake, the water may remain mixed all summer. However, a deeper lake usually experiences layering based on temperature differences, called **stratification**.

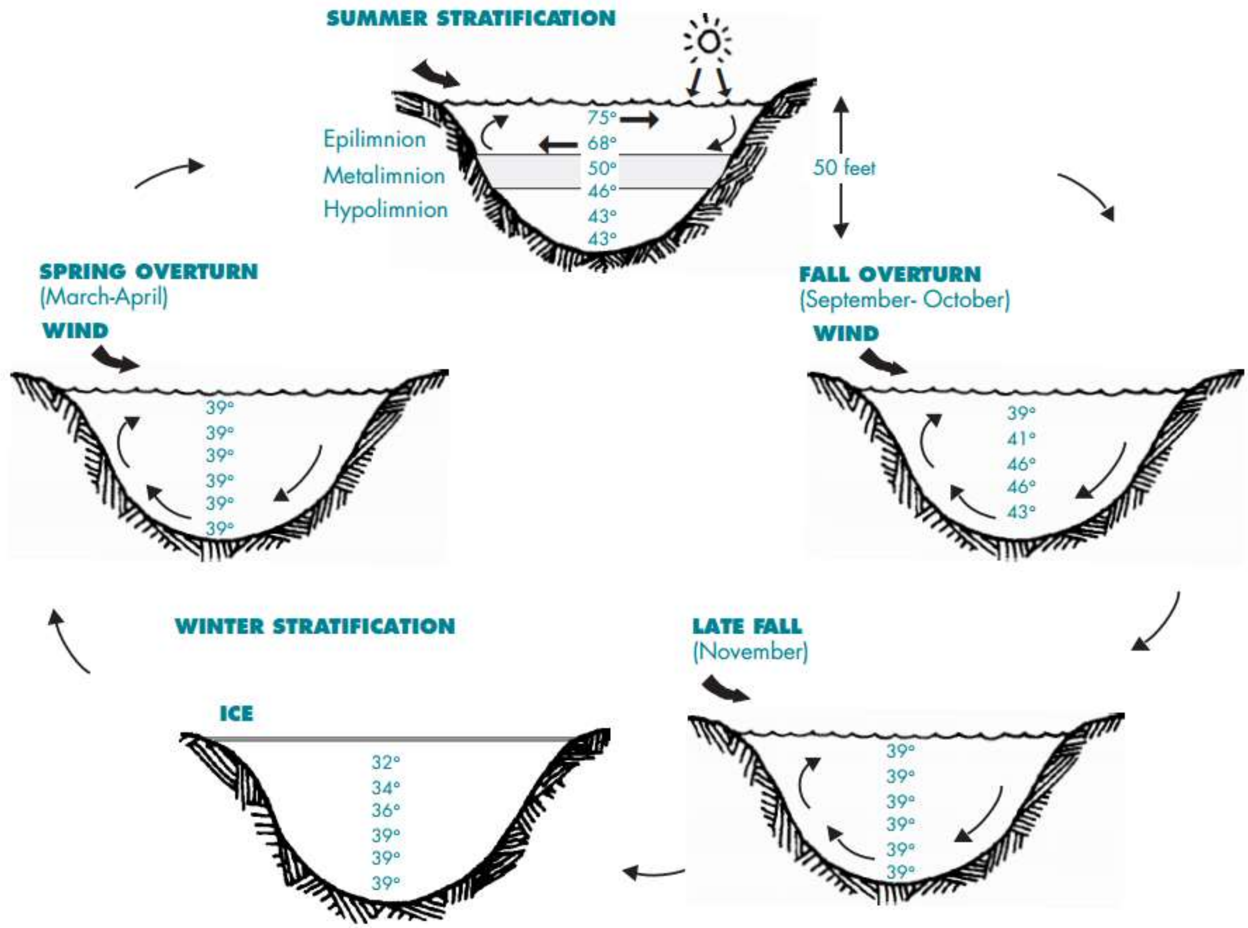
During the summer, lakes have the potential to divide into three distinct zones: the **epilimnion**, **thermocline** or **metalimnion**, and the **hypolimnion**. The epilimnion describes the warmer surface layer of a lake and the hypolimnion describes the cooler bottom area of a lake. The thermocline, or metalimnion, describes the transition area between the epilimnion and hypolimnion.

As surface waters cool in the fall, they become more dense and sink until the water temperature evens out from top to bottom. This process is called **fall turnover** and allows for a second mixing event to occur. Occasionally, algae blooms can occur at fall overturn when nutrients from the hypolimnion are made available throughout the water column.

Variations in density arising from differences in water temperatures can prevent warmer water from mixing with cooler water. As a result, nutrients released from the sediments can become trapped in the hypolimnion of a lake that stratifies. Additionally, since mixing is one of the main ways oxygen is distributed throughout a lake, lakes that don't mix have the potential to have very low levels of oxygen in the hypolimnion.

The absence of oxygen in the hypolimnion can have adverse effects on fisheries. Species of cold water fishes require the cooler waters that result from stratification. Cold water holds more oxygen as compared to warm water. As a result, the cooler waters of the hypolimnion can provide a refuge for cold water fisheries in the summer as long as oxygen is present. Respiration by plants, animals, and especially bacteria is the primary way oxygen is removed from the hypolimnion. A large algae bloom can cause oxygen depletion in the hypolimnion as algae die, sink, and decay.

In the winter, stratification remains constant because ice cover prevents mixing by wind action.



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[13] Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Deep Hole Sampling Procedure

In-lake data were collected by the Polk County Land and Water Resources Department at the deep hole of Big Blake Lake at spring and fall turnover events and bi-weekly between the months of May through September from 2013-2015.

Lake profile monitoring

Dissolved oxygen, temperature, conductivity, specific conductance, and pH were recorded at meter increments with a Hanna Instruments 9828 multi-parameter probe.

Secchi depth

Secchi depth was recorded with an eight inch diameter round disk with alternating black and white quadrants called a secchi disk. To record secchi depth, the disk was lowered into the lake on the shady side of a boat until just before it disappeared from sight. This depth was measured in feet and recorded as the secchi depth. Data were collected biweekly to correspond with lake profile monitoring readings.

Chemistry and chlorophyll a

Top and bottom samples were collected once monthly with a Van Dorn sampler and analyzed at the Wisconsin State Lab of Hygiene. Top samples were analyzed for total phosphorus, soluble reactive phosphorus, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, sulfate, total suspended solids, and chlorophyll a. Bottom samples were analyzed for total phosphorus and soluble reactive phosphorus.

Dissolved Oxygen

Oxygen is required by all aquatic organisms for survival. The amount of oxygen dissolved in water depends on temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake.

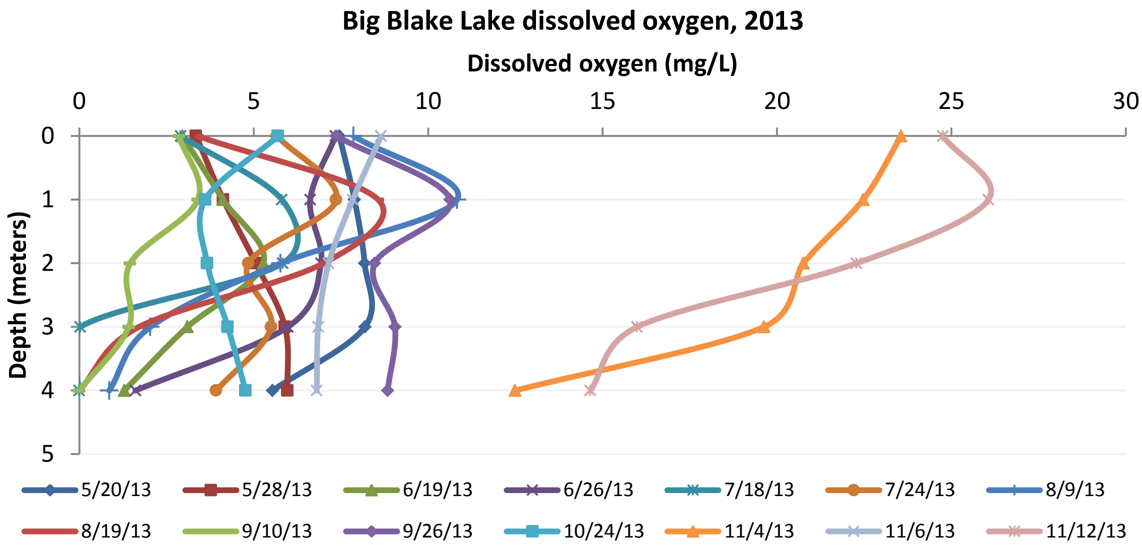
In a process called photosynthesis, plants use carbon, water, and the sun's energy to produce simple sugars and oxygen. Chlorophyll, the pigment in plants that captures the light energy necessary for photosynthesis, is the site where oxygen is produced. Since photosynthesis requires light, the oxygen producing process only occurs during the daylight hours and only at depths where sunlight can penetrate. Plants and animals also use oxygen in a process called respiration. During respiration, sugar and oxygen are used by plants and animals to produce carbon dioxide and water.

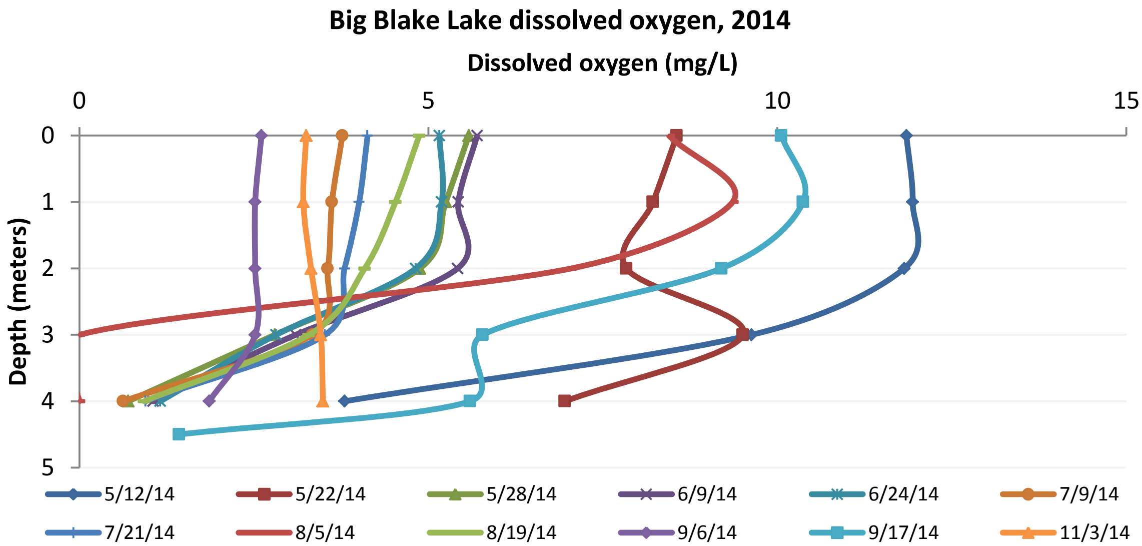
Cold water has a higher capacity for oxygen than warm water. However, although temperatures are coolest in the deepest part of a lake, these waters often do not contain the most oxygen. This arises because in the deepest parts of lakes, oxygen producing photosynthesis is not occurring, mixing is unable to introduce oxygen, and the only reaction occurring is oxygen consuming respiration. Therefore, it is not uncommon for oxygen depletion to occur in the hypolimnion.

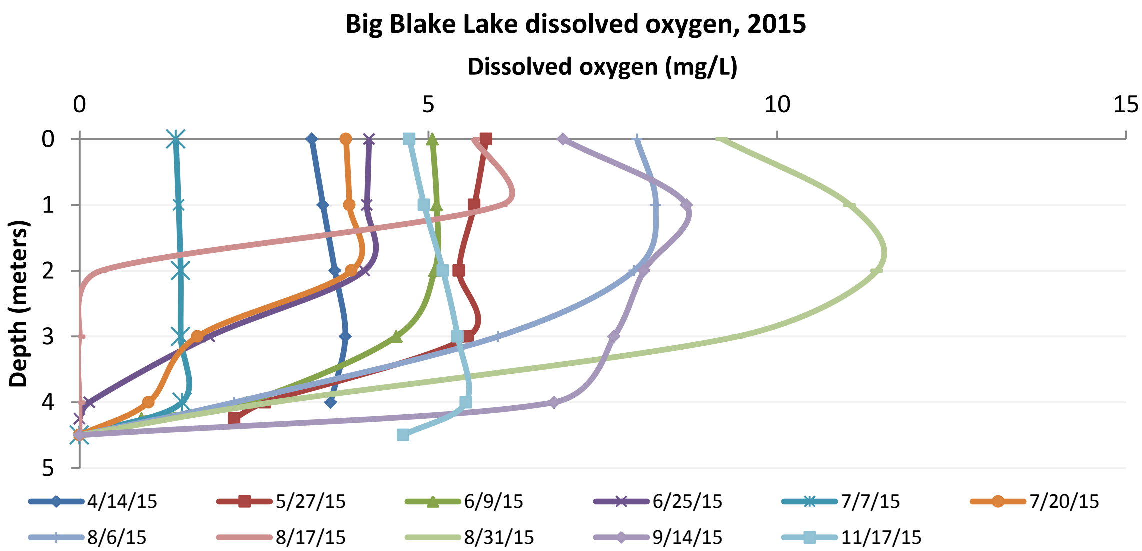
During the sunlight hours, when photosynthesis is occurring, dissolved oxygen levels at a lake's surface may be quite high. Conversely, at night or early in the morning (when photosynthesis is not occurring), the dissolved oxygen values can be expected to be lower.

A water quality standard for dissolved oxygen in warm water lakes and streams is set at 5 mg/L. This standard is based on the minimum amount of oxygen required by fish for survival and growth. For cold water lakes supporting trout, the standard is set even higher at 7 mg/L.

Dissolved oxygen levels at the surface of Big Blake Lake were below 5 mg/L on 15 of the 37 days data was collected. Dissolved oxygen levels at the surface were below 5 mg/L in July and July in 2013, 2014, and 2015.


Big Blake Lake dissolved oxygen, 2013
Dissolved oxygen (mg/L)
0
5
10
15
20
25
30
Depth (meters)
0
1
2
3
4
5
5/20/13
5/28/13
6/19/13
6/26/13
7/18/13
7/24/13
8/9/13
8/19/13
9/10/13
9/26/13
10/24/13
11/4/13
11/6/13
11/12/13

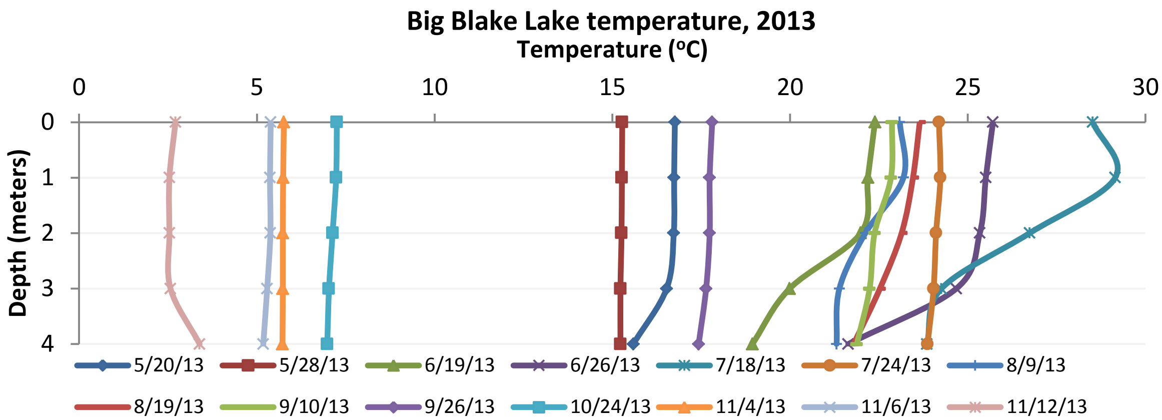

Big Blake Lake dissolved oxygen, 2014
Dissolved oxygen (mg/L)
0
5
10
15
Depth (meters)
0
1
2
3
4
5
5/12/14
5/22/14
5/28/14
6/9/14
6/24/14
7/9/14
7/21/14
8/5/14
8/19/14
9/6/14
9/17/14
11/3/14

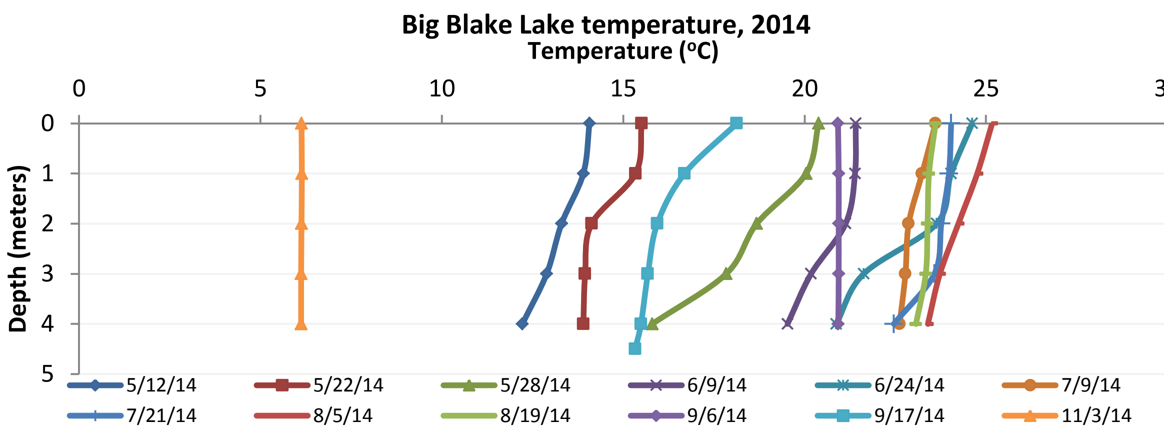

Big Blake Lake dissolved oxygen, 2015
Dissolved oxygen (mg/L)
0
5
10
15
Depth (meters)
0
1
2
3
4
5
4/14/15
5/27/15
6/9/15
6/25/15
7/7/15
7/20/15
8/6/15
8/17/15
8/31/15
9/14/15
11/17/15

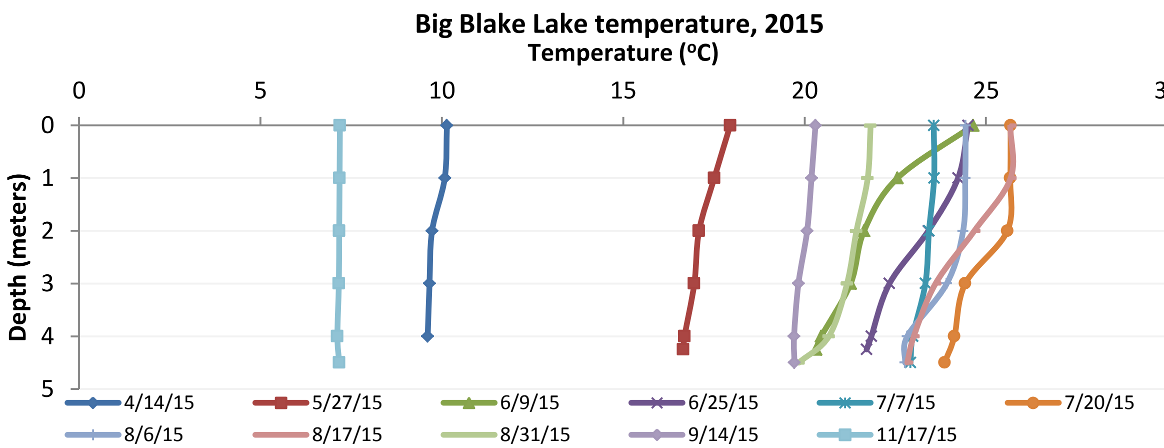
Temperature

Big Blake Lake reached its warmest surface temperature (28.52°C) on July 18th, 2013. In 2014, the warmest surface temperature recorded was 25.17°C on August 5th and in 2015 the warmest surface temperature recorded was 25.68°C on July 20th.

Big Blake Lake did weakly stratify, or set up density dependent layers, in all three sampling years. Generally stratification occurred in May, June, and July.



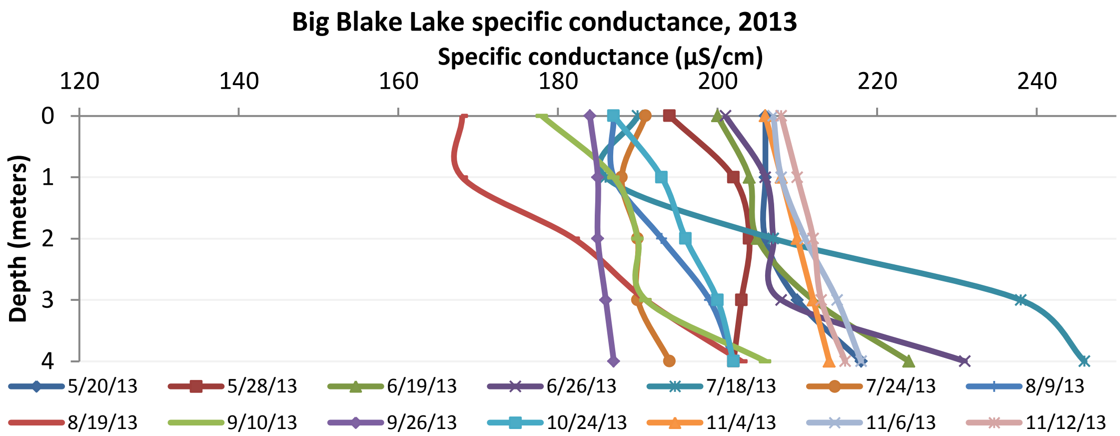


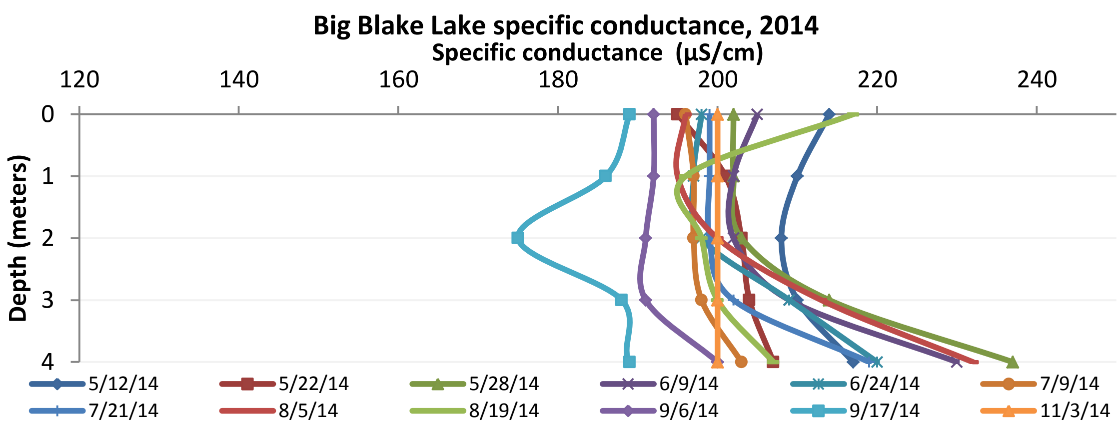


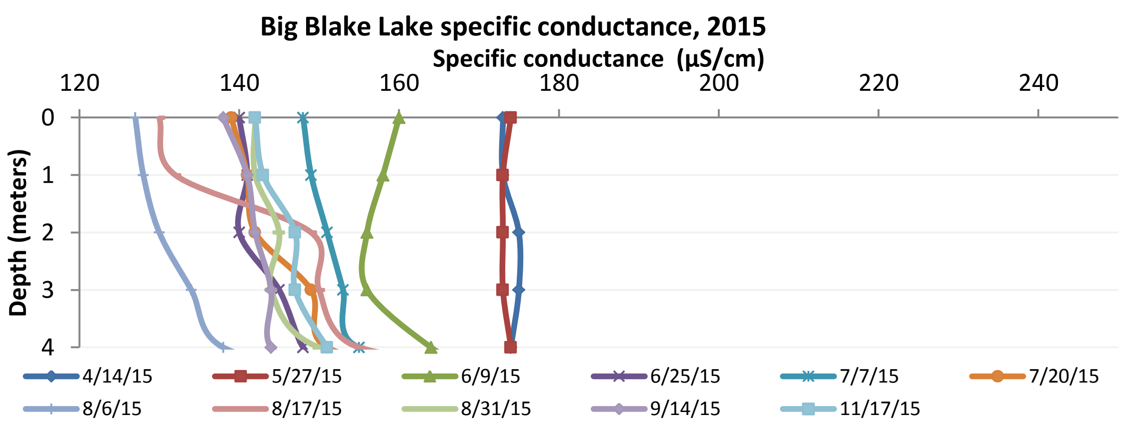
Specific Conductance (Conductivity)

Conductivity is the measure of the ability of water to conduct an electrical current and serves as an indicator of the concentration of total dissolved inorganic chemicals in the water. Since conductivity is temperature related, reported values are normalized at 25°C and termed specific conductance. Specific conductance increases as the concentration of dissolved minerals in a lake increase.

In general, specific conductance values were between 160 and 240 µS/cm in 2013 and 2014. However, in 2015 specific conductance values were much lower, falling between 130 and 180 µS/cm. Values generally increased towards the bottom of the lake and were highest in the spring/early summer.







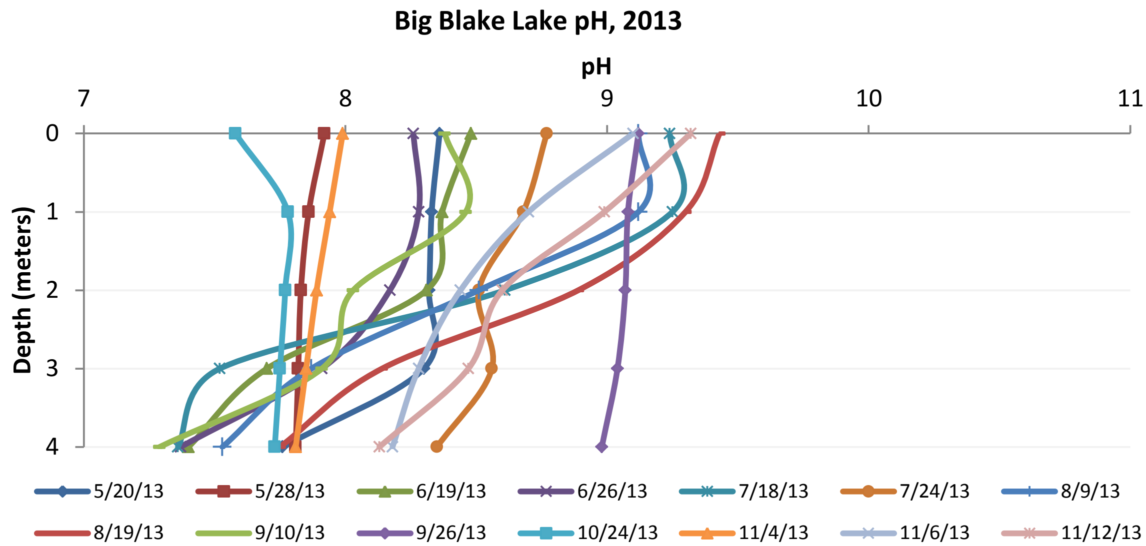
pH

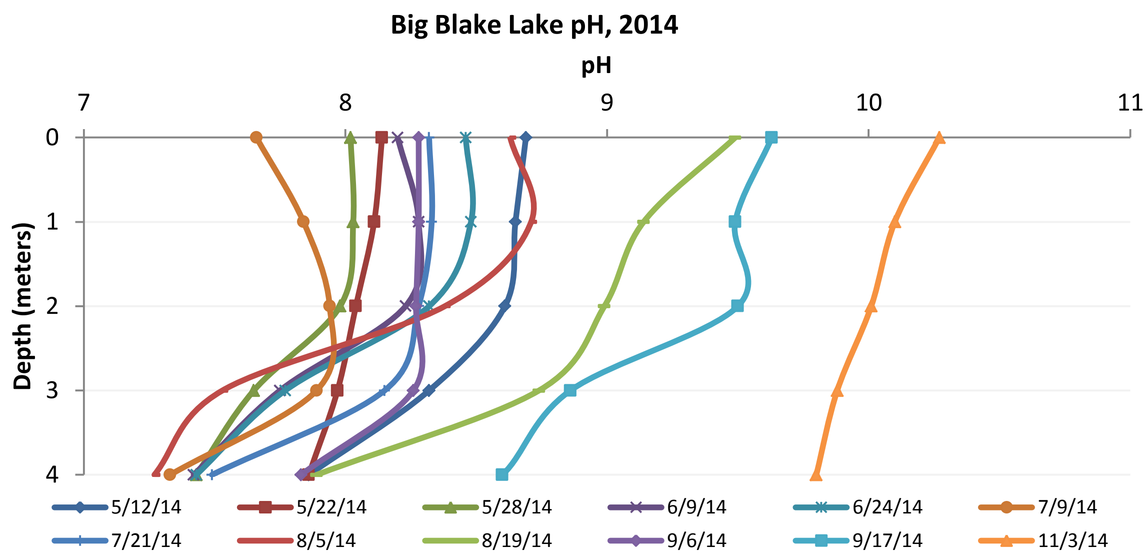
An indicator of acidity, pH is the negative logarithm of the hydrogen ion (H+) concentration. Lower pH waters have more hydrogen ions and are more acidic, and high pH waters have less hydrogen ions and are less acidic.

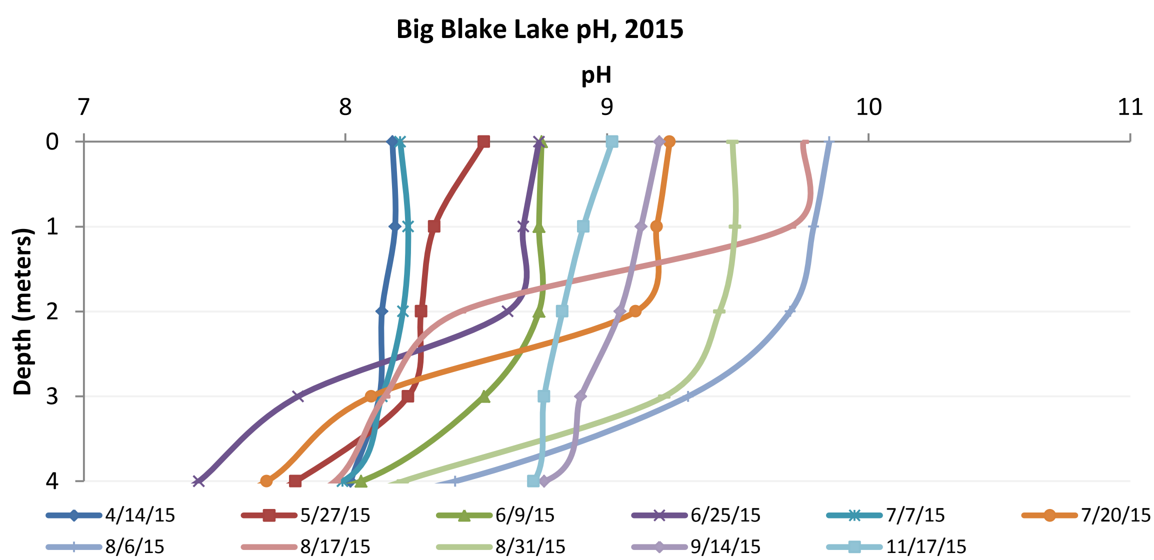
A pH value of seven is considered neutral. Values less than seven indicate acidic conditions; whereas, values greater than seven indicate alkaline conditions. A single pH unit change represents a tenfold change in the concentration of hydrogen ions. As a result, a lake with a pH value of eight is ten times less acidic than a lake with a pH value of seven. Across Wisconsin lakes, pH values can range from 4.5 (acid bog lakes) to 8.4 (hard water, marl lakes).

Through the removal of CO_2 from the water column, photosynthesis has the effect of increasing pH. As a result, pH generally increases during the day and decreases at night. Under conditions such as high temperature, high nutrients, and dense algae blooms, pH levels can increase.

In general pH levels on Big Blake Lake were between 8 and 10, with values decreasing towards the bottom of the lake. Values for pH were highest in the late summer and early fall.


Big Blake Lake pH, 2013
pH
7
8
9
10
11
0
1
2
3
4
Depth (meters)
5/20/13
5/28/13
6/19/13
6/26/13
7/18/13
7/24/13
8/9/13
8/19/13
9/10/13
9/26/13
10/24/13
11/4/13
11/6/13
11/12/13


Big Blake Lake pH, 2014
pH
7
8
9
10
11
0
1
2
3
4
Depth (meters)
5/12/14
5/22/14
5/28/14
6/9/14
6/24/14
7/9/14
7/21/14
8/5/14
8/19/14
9/6/14
9/17/14
11/3/14


Big Blake Lake pH, 2015
pH
7
8
9
10
11
0
1
2
3
4
Depth (meters)
4/14/15
5/27/15
6/9/15
6/25/15
7/7/15
7/20/15
8/6/15
8/17/15
8/31/15
9/14/15
11/17/15

Secchi Depth

The depth which light can penetrate into lakes is affected by suspended particles, dissolved pigments, and absorbance by water. Often, the ability of light to penetrate the water column is determined by the abundance of algae or other photosynthetic organisms in a lake.

One method of measuring light penetration is with a secchi disk. A secchi disk is an eight inch diameter round disk with alternating black and white quadrants that is used to provide a rough estimate of water clarity. The depth at which the secchi disk is just visible is defined as the secchi depth. A greater secchi depth indicates greater water clarity.

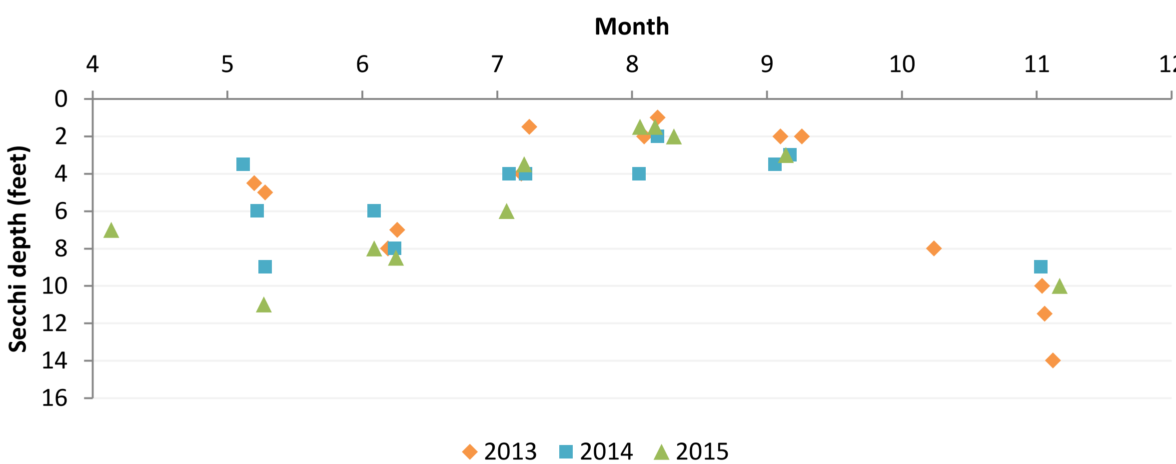
For the majority of the summer months (July through September) secchi depth was below 4 feet.

Secchi depth ranged from a low of one foot on August 19th, 2013 to a high of fourteen feet on November 12th, 2013.

Growing season average secchi depth (April-November) was between five and six feet in all three sampling years (6 feet in 2013, 5 feet in 2014, and 6 feet in 2015).

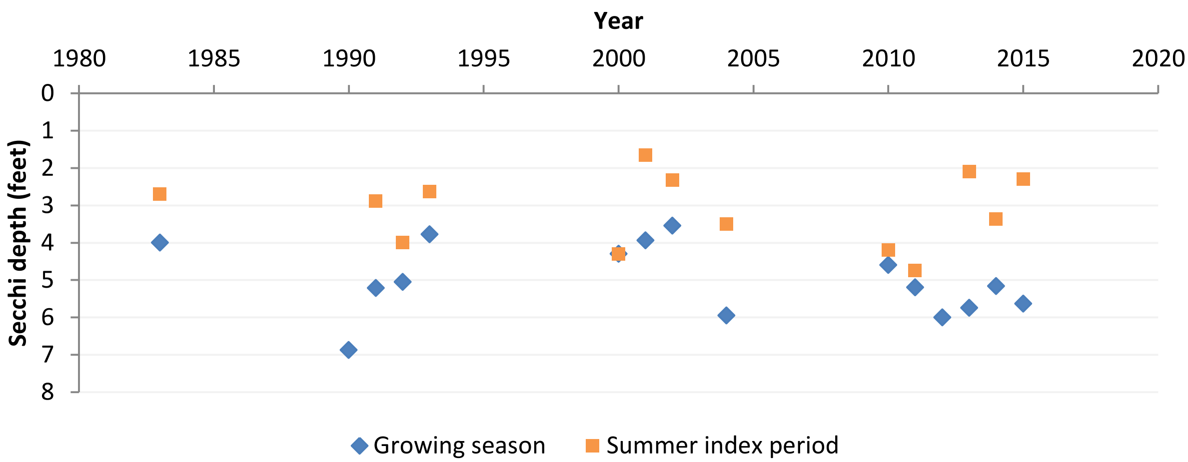
Summer index period average secchi depth (July 15-September 15) ranged from two to three feet in all three sampling years (2 feet in 2013, 3 feet in 2014, and 2 feet in 2015).

Big Blake Lake secchi depth, 2013-2015

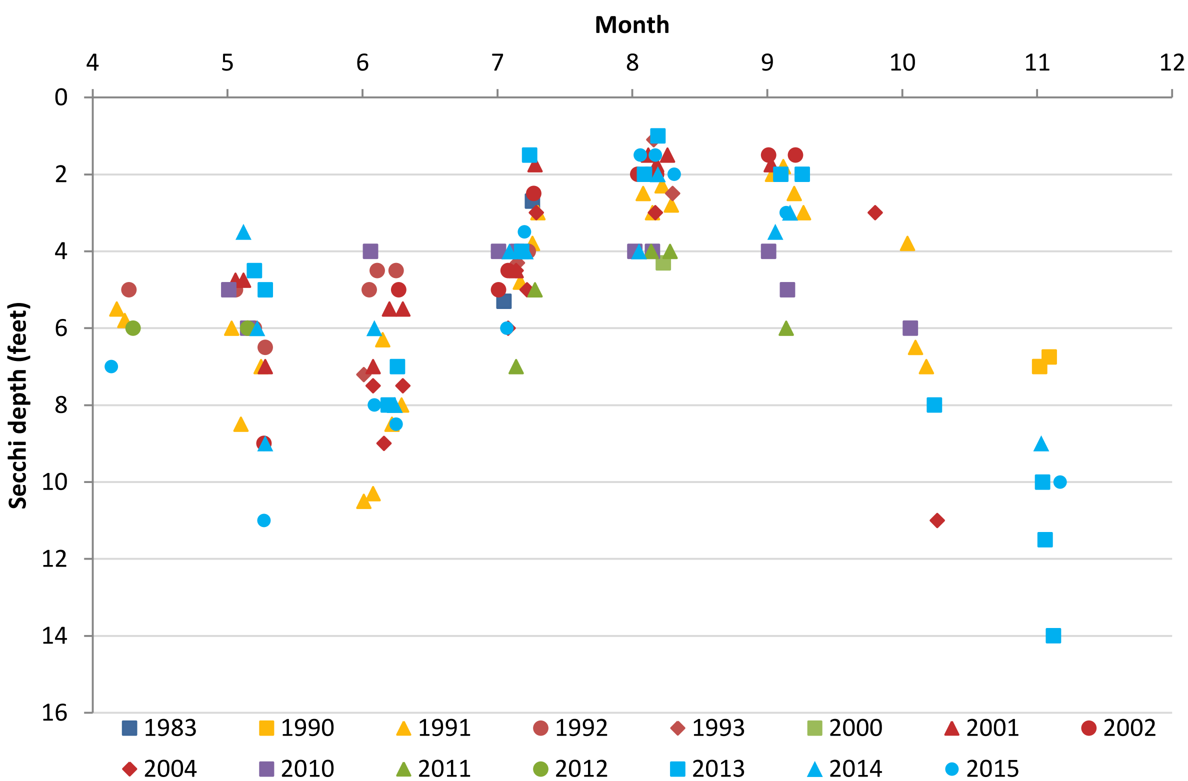


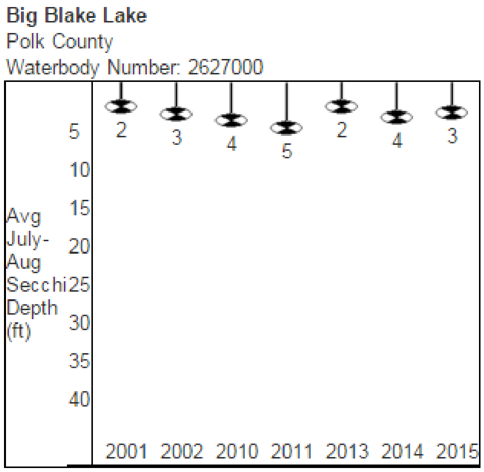
Average growing season and summer index period secchi depth has varied since 1983. In most years, the summer index period secchi depth was less than four feet. Over this same time period, secchi depth has been lowest in the months of July, August, and September.

Big Blake Lake average secchi depth, 1983-2015



Big Blake Lake secchi depth, 1983-2015





Past secchi averages in feet (July and August only).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
2001	2.2	1.5	4.5	5
2002	3.14	2	5	7
2010	4	4	4	4
2011	5	4	7	4
2013	2.13	1	4	4
2014	3.5	2	4	4
2015	2.9	1.5	6	5

The Wisconsin Department of Natural Resources website provides historic secchi depth averages for the months of July and August. This data exists for Big Blake Lake for 2001, 2002, and 2010-2015. Averages over this time period range from a low of 2 feet to a high of 5 feet.

Over the three years this study took place, average summer secchi depth (July-August) was 2.1 feet in 2013, 3.5 feet in 2014, and 2.9 feet in 2015.

The average summer secchi depth (July and August) for the Northwest geo-region was 8.6 feet in 2013, 8.5 feet in 2014, and 8.4 feet in 2015.

In all three years, secchi depth for Big Blake Lake was well below the Northwest georegion average.

Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil and rocks and in the atmosphere in the form of dust. Phosphorus can make its way into lakes through groundwater and human induced disturbances such as soil erosion. Additional sources of phosphorus inputs into a lake can include external sources such as fertilizer runoff from urban and agricultural settings and internal sources such as release from lake bottom sediments.

Phosphorus does not readily dissolve in water, instead it forms insoluble precipitates with calcium, iron, manganese, sulfur, and aluminum. If oxygen is available in the hypolimnion, iron forms sediment particles that store phosphorus in the sediments. However, when lakes lose oxygen in the winter or when the hypolimnion becomes anoxic in the summer, these particles dissolve and phosphorus is redistributed throughout the water column with strong wind action or turnover events.

Phosphorus is necessary for plant and animal growth. Excessive amounts can lead to an overabundance of growth which can decrease water clarity and lead to nutrient pollution in lakes.

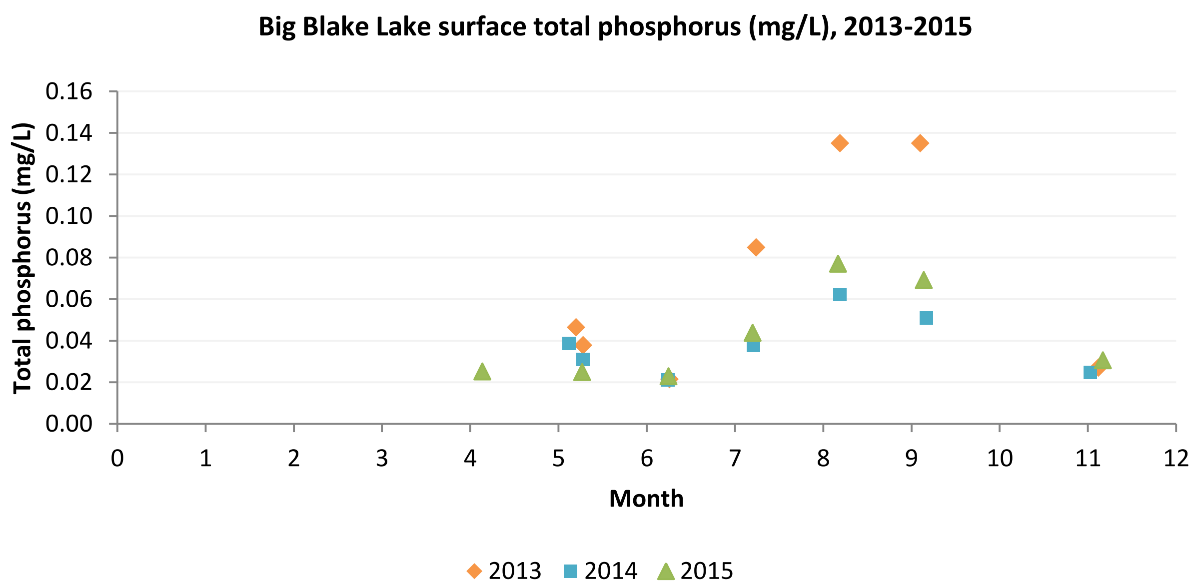
Total phosphorus (TP) is a measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle.

In lakes, a "healthy" limit of total phosphorus is set at 0.02 mg/L. If a value is above the healthy limit, it is more likely that a lake could support nuisance algae blooms. Total phosphorus concentrations were above 0.02 mg/L on all twenty-one sampling dates.

Growing season average[14] surface total phosphorus exceeded the healthy limit in 2013 (0.08 mg/L), 2014 (0.04mg/L), and 2015 (0.05mg/L).

Summer index period average surface total phosphorus (July 15-September 15) exceeded the healthy limit in 2013 (0.12 mg/L), 2014 (0.05 mg/L), and 2015 (0.06mg/L).

Surface total phosphorus concentrations were approximately twice as high in 2013 as compared to 2014 and 2015. As the growing season progressed, a general trend of increasing phosphorus was evident through September. By November (fall turnover), total phosphorus levels had returned to what they had been in April/May (spring turnover). However, in 2013 and 2014 total phosphorus levels exhibited a slight decrease in June as compared to May, which would align with the time that harvesting of curly-leaf pondweed occurred. With warmers temperatures in 2015, harvesting began earlier (May) which may explain why total phosphorus levels remained fairly constant from April through June.



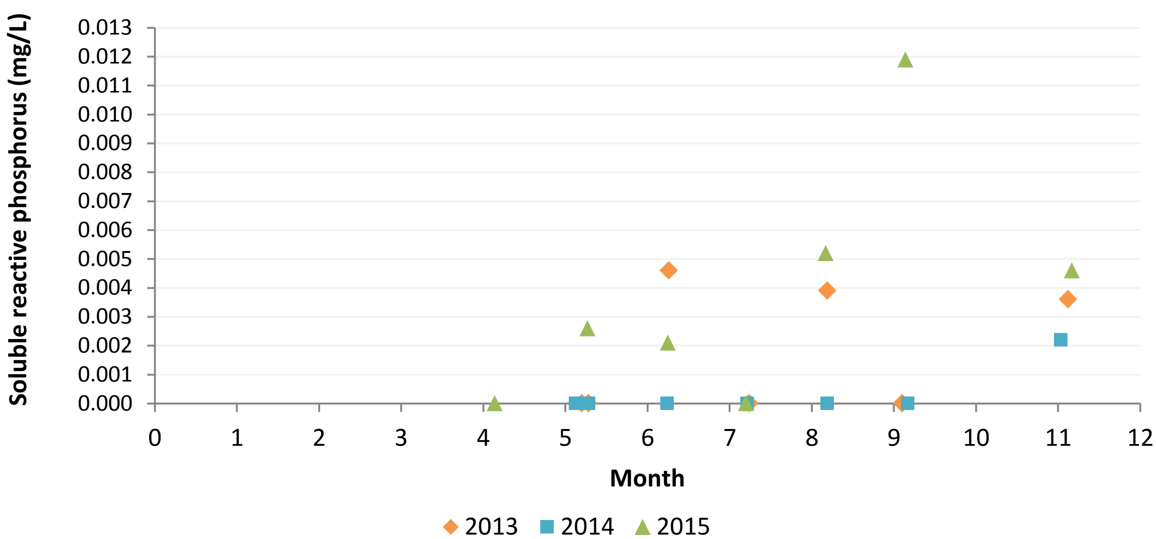
[14] Excludes turnover

Soluble reactive phosphorus (SRP) includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic macrophytes (plants).

In lakes, a "healthy" limit of soluble reactive phosphorus is set at 0.01 mg/L. If a value is above the healthy limit it is more likely that a lake could support nuisance algae blooms.

Surface soluble reactive phosphorus concentrations were below 0.01 mg/L on all sampling dates with the exception of September 14th, 2015. On twelve of the twenty-one dates where samples were taken (57%), soluble reactive phosphorus was below the limit of detection.[15] Soluble reactive phosphorus concentrations were the highest in 2015, with only one of the seven samples being below the limit of detection. Soluble reactive phosphorus concentrations were lowest in 2014, with only one of the seven samples being above the limit of detection.

Big Blake Lake surface soluble reactive phosphorus (mg/L), 2013-2015



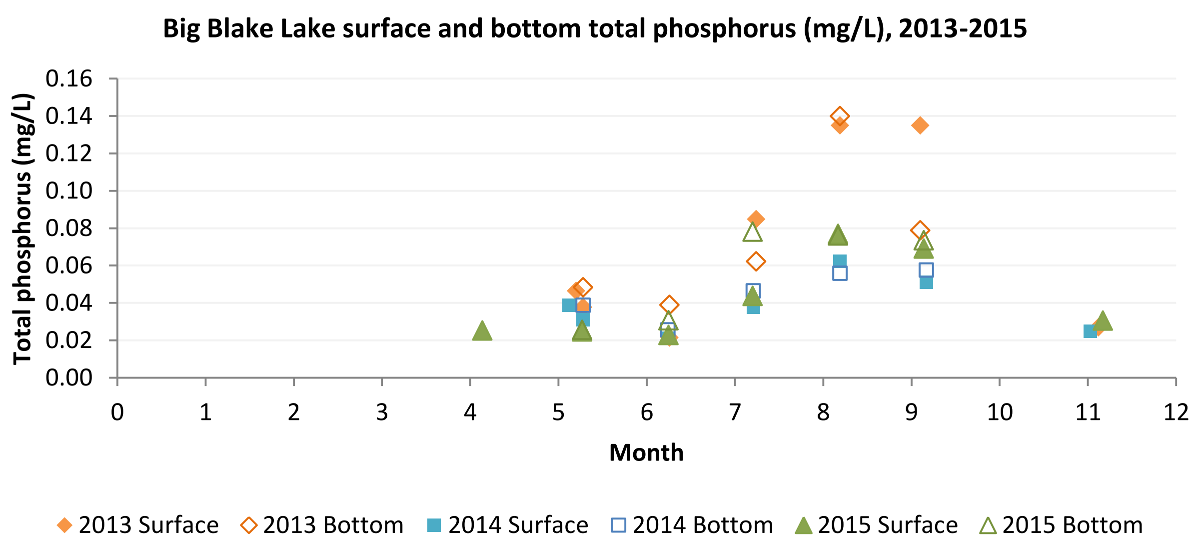
16

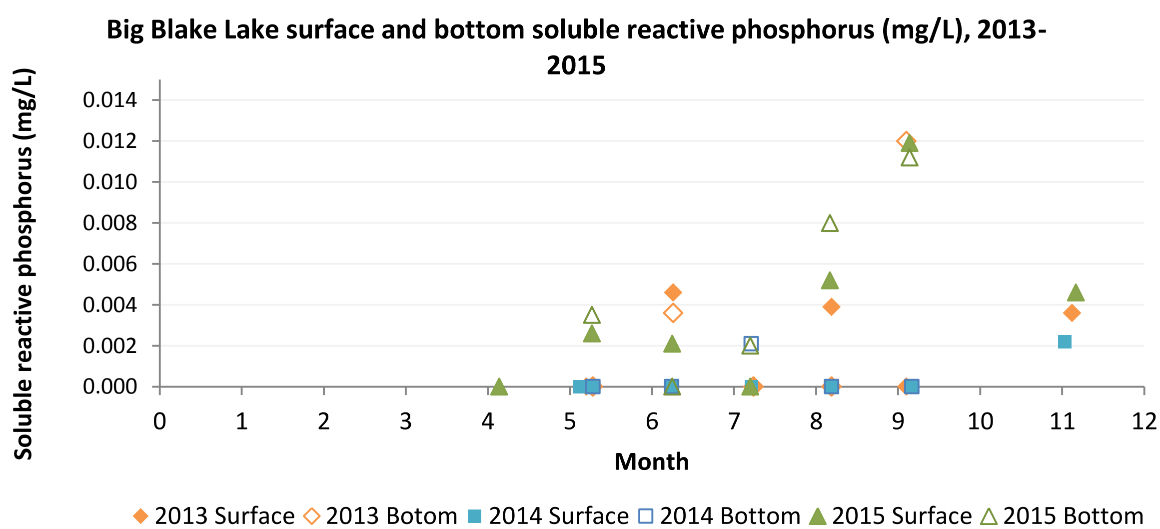
[15] Averages were not calculated for surface soluble reactive phosphorus because over half the samples were below the limit of detection

[16] Values of zero represent sample dates were soluble reactive phosphorus was below the limit of detection

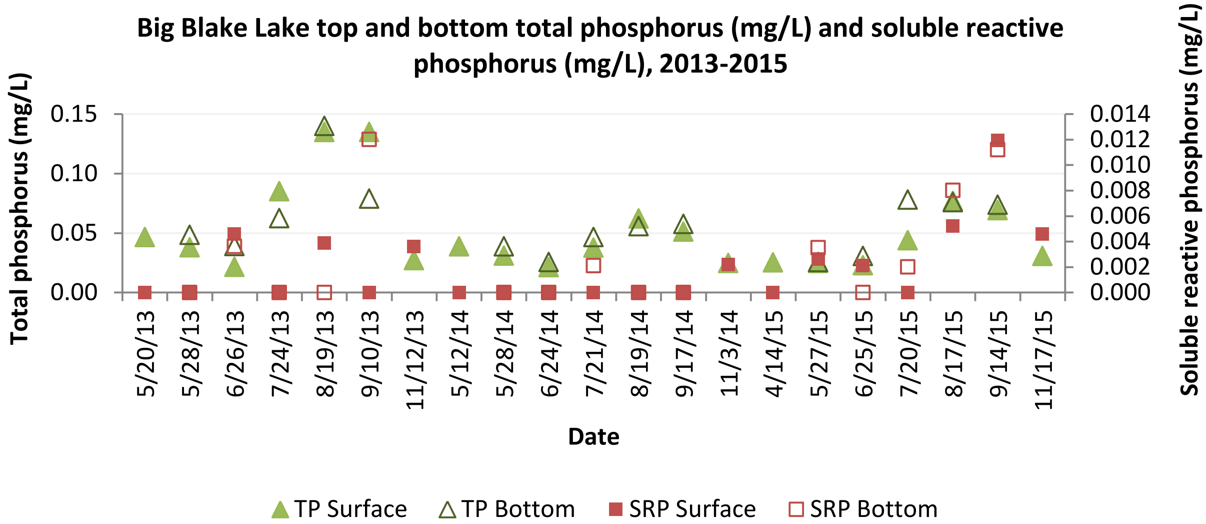
Bottom samples were also collected and analyzed for total phosphorus and soluble reactive phosphorus. Surface and bottom total phosphorus and soluble reactive phosphorus levels were fairly consistent, suggesting that Big Blake Lake is fairly well mixed.

Similar to the top samples, bottom samples for soluble reactive phosphorus were below the limit of detection on eight of the fifteen days where samples were taken (53%). On all but two sampling dates soluble reactive phosphorus concentrations were below 0.01 mg/L (September 10th, 2013 and September 14th, 2015).[17]





[17] Averages were not calculated for bottom soluble reactive phosphorus because over half the samples were below the limit of detection



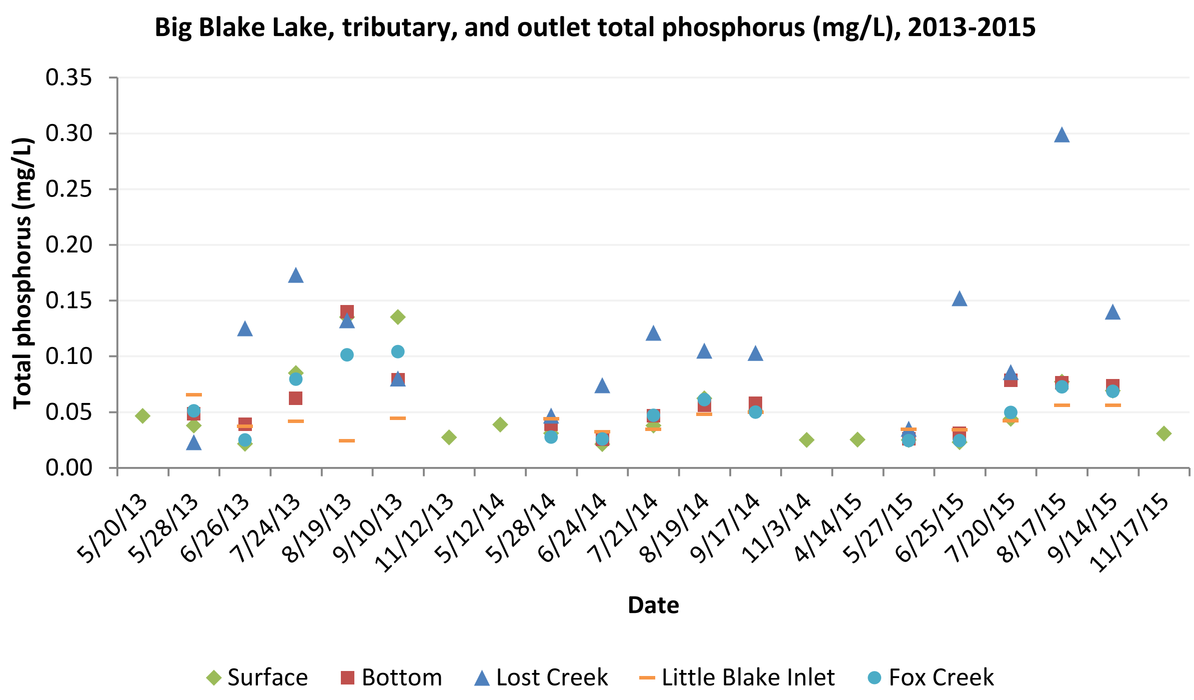
Big Blake Lake top and bottom total phosphorus (mg/L) and soluble reactive phosphorus (mg/L), 2013-2015
Total phosphorus (mg/L)
0.15
0.10
0.05
0.00
Soluble reactive phosphorus (mg/L)
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
5/20/13
5/28/13
6/26/13
7/24/13
8/19/13
9/10/13
11/12/13
5/12/14
5/28/14
6/24/14
7/21/14
8/19/14
9/17/14
11/3/14
4/14/15
5/27/15
6/25/15
7/20/15
8/17/15
9/14/15
11/17/15
Date
TP Surface
TP Bottom
SRP Surface
SRP Bottom

Tributary and Outlet Phosphorus

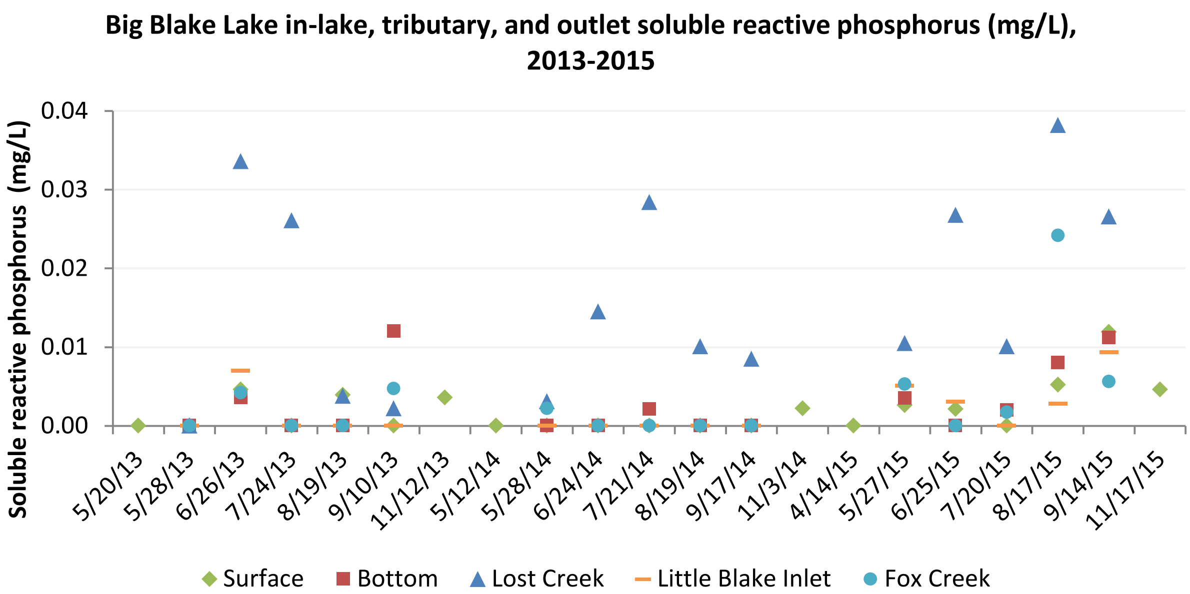
Data was collected on the two tributaries to Big Blake Lake and the outlet: Lost Creek, the inlet from Little Blake Lake, and Fox Creek. Flow data was collected bi-weekly at each tributary with a March McBirney Flo-Mate ™ velocity flowmeter. At each foot interval across each of the streams, depth (ft) and velocity (m/s) were measured. Grab samples were collected once monthly at each site. Samples were analyzed at the State Lab of Hygiene for total phosphorus, soluble reactive phosphorus, nitrate/nitrite, ammonium, total Kjeldahl nitrogen, and total suspended solids.

Average total phosphorus concentrations were always greater in Lost Creek as compared to the Little Blake Lake inlet. The average total phosphorus concentration in the water leaving Big Blake Lake through Fox Creek was similar to the average total phosphorus concentration of Big Blake Lake.

Average total phosphorus (mg/L)			
	2013	**2014**	**2015**
Surface of Big Blake Lake	0.08	0.04	0.05
Bottom of Big Blake Lake	0.07	0.04	0.06
Lost Creek	0.11	0.09	0.14
Little Blake Lake Inlet	0.04	0.04	0.04
Fox Creek	0.07	0.04	0.05



Tributary and outlet soluble reactive phosphorus followed the same general trend as in-lake soluble reactive phosphorus, with the majority of 2013 and 2014 sampling dates being below the limit of detection. Lost Creek was the exception, with all but one sampling date being above the limit of detection over the same time period. In 2015 soluble reactive phosphorus was above the limit of detection at all sites on the majority of sampling dates, with concentrations being highest in Lost Creek.



Tributary and Outlet Phosphorus Budget

The phosphorus data collected on Lost Creek, the inlet from Little Blake Lake, and Fox Creek is specific to date and location and can be used to theoretically determine how much phosphorus is entering and leaving Big Blake Lake through inlets and outlets. Values for phosphorus influxes are established by multiplying the phosphorus concentration at a specific location by the volume of water that moves through a specific location, or the discharge in cubic feet per second. To determine the average instantaneous load of phosphorus (in mg/s), the average phosphorus concentration is multiplied by the average seasonal discharge. Units are then converted and expressed as lb/yr.

The analysis of this data allows for areas of highest phosphorus loading to be identified. Once areas of highest phosphorus loading are identified, the land use and geology of these areas can be investigated for their total phosphorus contribution and best management recommendations can be made.

On average, Little Blake Lake contributes nearly three times the amount of phosphorus to Big Blake Lake as compared to Lost Creek (17,335 pounds/year as compared to 5,955 pounds/year). On an annual basis, an average of 26,545 pounds of phosphorus leaves Big Blake Lake through the outlet at Fox Creek.[18]

Site	TP (mg/L)	Area (m^2)	Discharge (l/s)	Phosphorus (lb/yr)
2013 Fox Creek	0.0720	4.11	4,942	24,755
2014 Fox Creek	0.0422	5.72	10,696	31,402
2015 Fox Creek	0.0477	4.08	7,075	23,479
2013 Lost Creek	0.1065	5.90	360	2,667
2014 Lost Creek	0.0899	7.22	1,227	7,674
2015 Lost Creek	0.1423	8.26	760	7,524
2013 Little Blake Inlet	0.0424	10.37	4,571	13,484
2014 Little Blake Inlet	0.0415	8.17	7,487	21,616
2015 Little Blake Inlet	0.0445	8.21	5,460	16,904

In all three years discharge, or the amount of water flowing through each stream, was substantially elevated in 2014 as compared to 2013 and 2015. This increase could be partly explained by the dam failure that occurred in May 2014. Discharge was also substantially lower in all three tributaries in 2013 which could be a result of climate. In 2013 only 25-30 inches of rain fell near Big Blake Lake as compared to 35-40 inches in 2014 and 2015.[19]

[18] Values are averages for 2013, 2014, and 2015
[19] National Weather Service precipitation data at http://water.weather.gov/precip/#

Nitrogen

Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen sources in a lake can vary widely. Nitrogen does not occur naturally in soil minerals; however, it is a major component of all plant and animal matter. The decomposition of plant and animal matter releases ammonia, which is converted to nitrate in the presence of oxygen. This reaction accelerates when water temperatures increase. Nitrogen can also be introduced to a lake through rainfall, in the form of nitrate and ammonium, and through groundwater in the form of nitrate.

In most instances, the amount of nitrogen in a lake corresponds to land use. Nitrogen can enter a lake from surface runoff or groundwater sources as a result of fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants. During spring and fall turnover events, nitrogen is recycled back into the water column, which can cause spikes in ammonia levels. Under low oxygen circumstances, nitrogen can be lost from a lake system through a process called denitrification. Under these conditions nitrate is converted to nitrogen gas. Additionally, nitrogen can be lost through permanent sedimentation.

Nitrogen comprises the majority (78%) of the gases in the Earth's atmosphere. As with other gases, nitrogen is more soluble in cooler water as compared to warmer water. Nitrogen gas is not readily available to most aquatic plants, with the exception of blue green algae.

Similar to phosphorus, nitrogen is divided into many components. In this study nitrate/nitrite (NO_3 and NO_2), ammonium (NH_4), and total Kjeldahl nitrogen (TKN) were analyzed.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/L can support summer algae blooms.

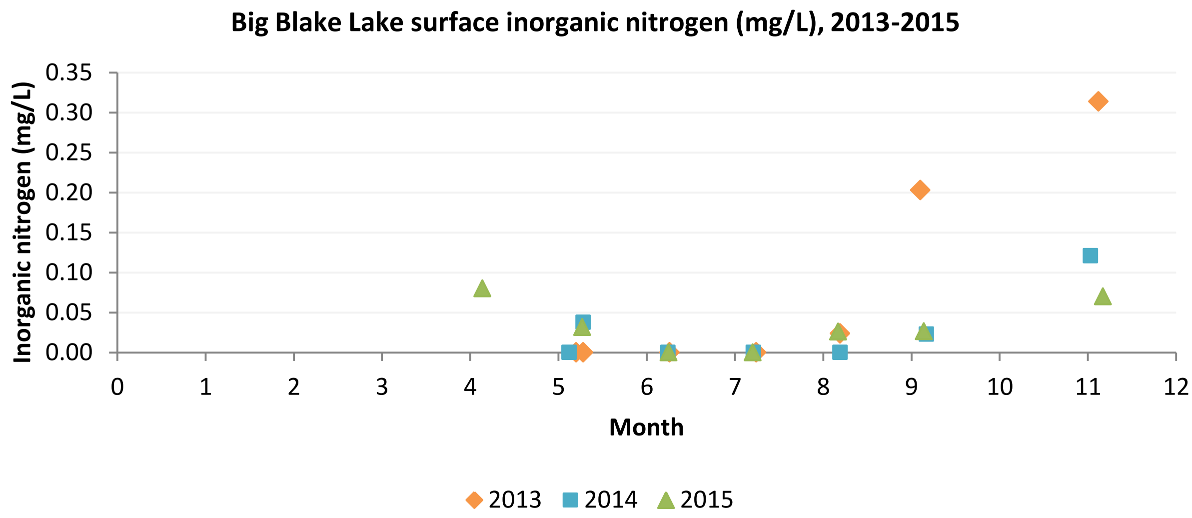
Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from TKN, the organic nitrogen concentration found in plants and algal material can be found.

Nitrate/nitrite concentrations were below the limit of detection on all sampling dates with the exception of fall turnover (2013-2015) and spring turnover (2015). Ammonium concentrations were below the limit of detection in ten of the twenty-one sampling dates (47%). Inorganic nitrogen was below the healthy limit of 0.3 mg/L on all sampling dates with the exception of November 12th, 2013.[20] In all three sampling years, inorganic nitrogen was below the limit of detection in June and July.

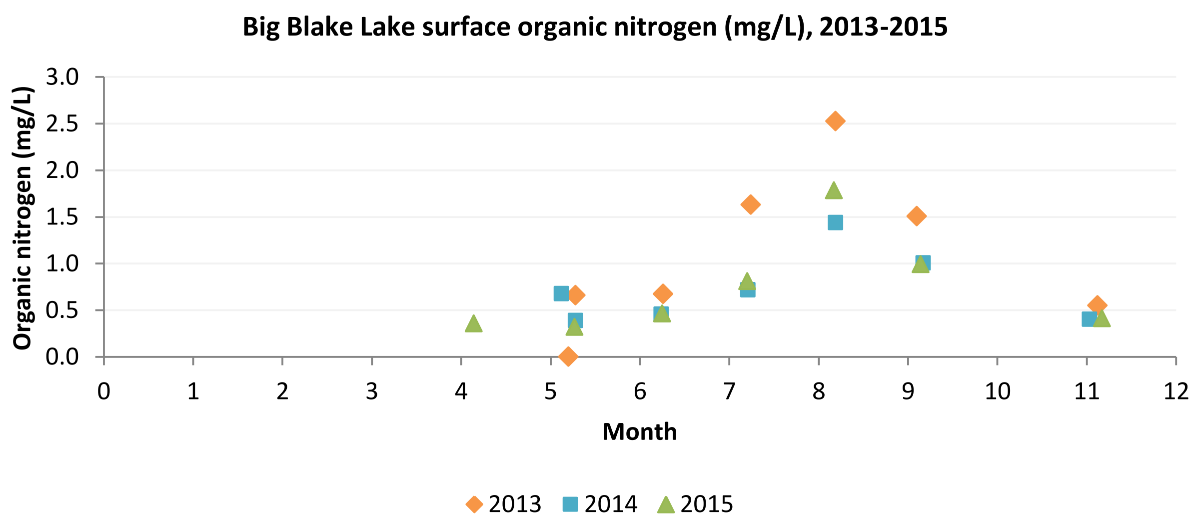
Growing season average[21] surface organic nitrogen was highest in 2013 (1.40mg/L) as compared to 2014 (0.80 mg/L) and 2015 (0.88 mg/L). Summer index period average surface organic nitrogen (July 15-September 15) was also highest in 2013 (1.89 mg/L) as compared to 2014 (1.08 mg/L) and 2015 (1.20 mg/L). In general, organic nitrogen levels in Big Blake Lake increased through August, after which time they began to decrease.

[20] Averages were not calculated for surface inorganic nitrogen because nearly half the samples were below the limit of detection

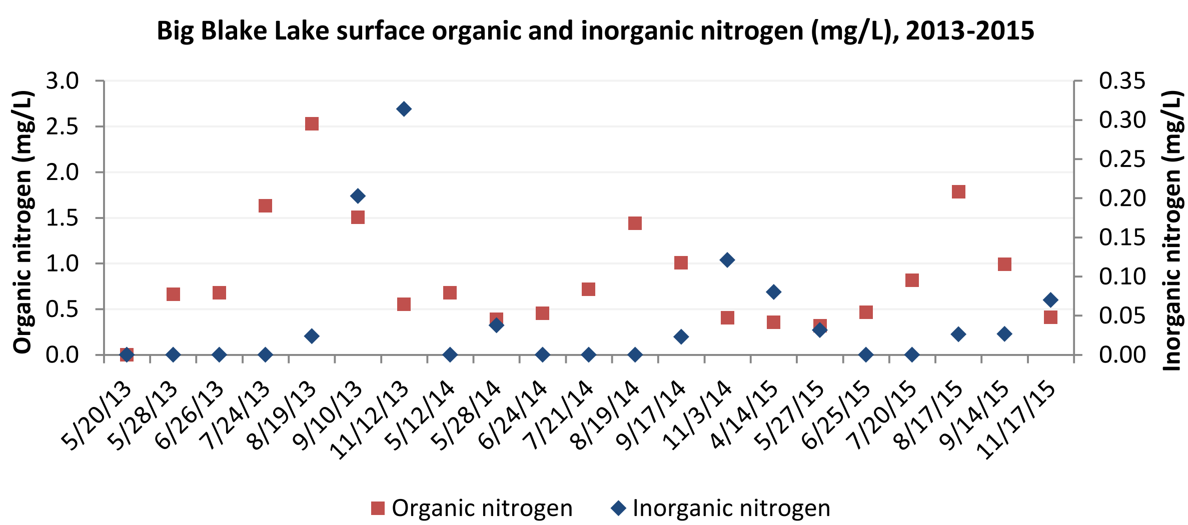
[21] Excludes turnover



Big Blake Lake surface inorganic nitrogen (mg/L), 2013-2015
Inorganic nitrogen (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0 1 2 3 4 5 6 7 8 9 10 11 12
Month
2013 2014 2015



Big Blake Lake surface organic nitrogen (mg/L), 2013-2015
Organic nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12
Month
2013 2014 2015



Big Blake Lake surface organic and inorganic nitrogen (mg/L), 2013-2015
Organic nitrogen (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Inorganic nitrogen (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5/20/13 5/28/13 6/26/13 7/24/13 8/19/13 9/10/13 11/12/13 5/12/14 5/28/14 6/24/14 7/21/14 8/19/14 9/17/14 11/3/14 4/14/15 5/27/15 6/25/15 7/20/15 8/17/15 9/14/15 11/17/15
Organic nitrogen
Inorganic nitrogen

Tributary and Outlet Nitrogen

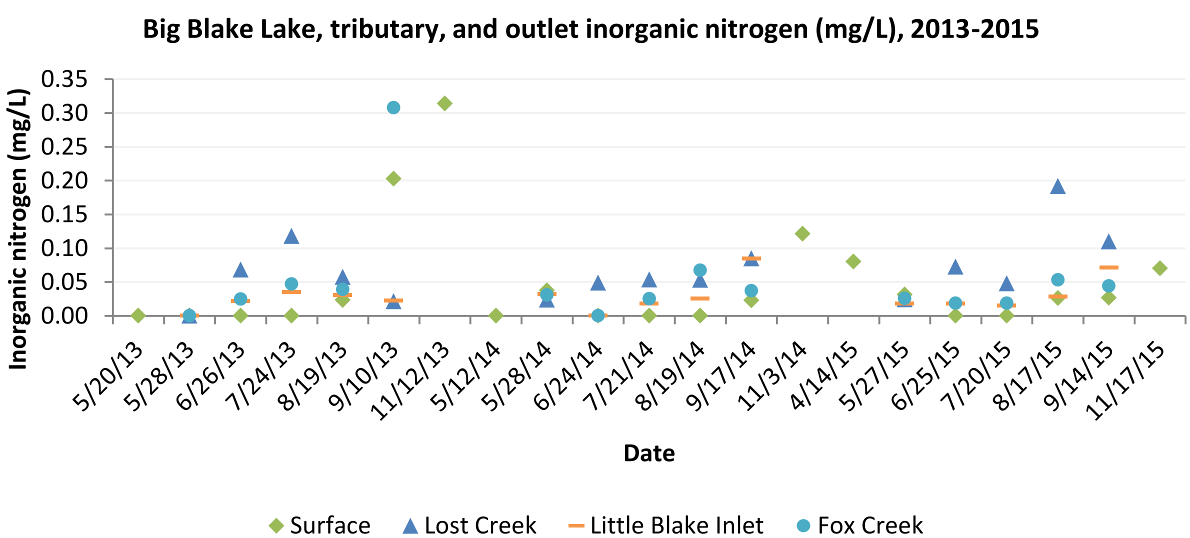
Nitrate/nitrite concentrations were below the limit of detection on all sampling dates in all tributaries with the exception of the Little Blake Lake Inlet on September 17th, 2014.

Growing season average inorganic nitrogen and organic nitrogen were greater in Lost Creek as compared to the Little Blake Lake Inlet in all three sampling years. The concentration of inorganic and organic nitrogen leaving Big Blake Lake via Fox Creek was similar to the in-lake concentration in 2014 and 2015. However, in 2013, the concentration of inorganic and organic nitrogen leaving Big Blake Lake via Fox Creek was less than the in-lake concentration.

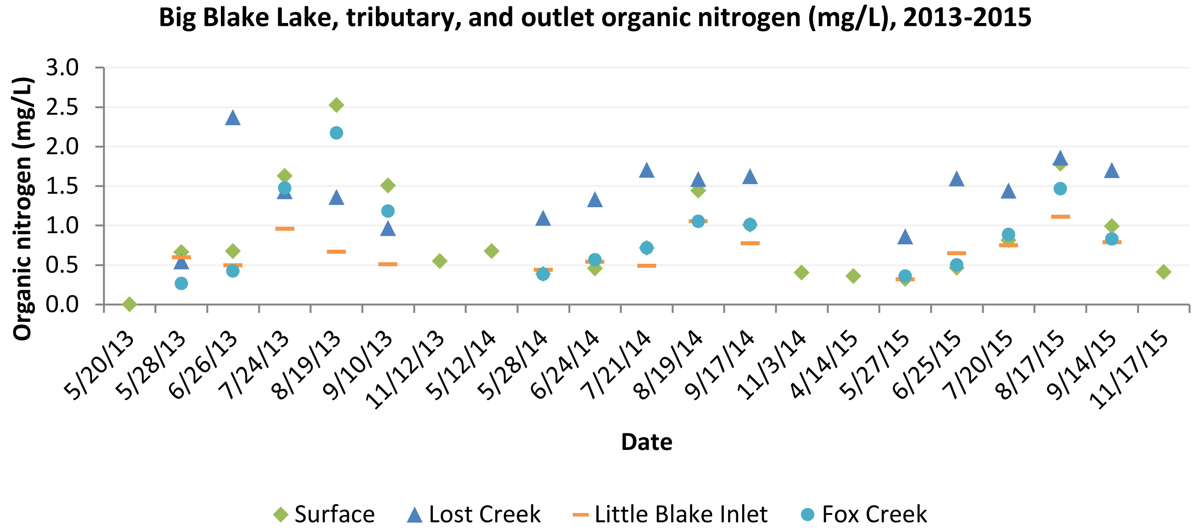
Average inorganic nitrogen (mg/L)			
	2013	**2014**	**2015**
Surface of Big Blake Lake	0.113	0.030	0.028
Lost Creek	0.053	0.053	0.089
Little Blake Lake Inlet	0.022	0.032	0.030
Fox Creek	0.084	0.032	0.032

Average organic nitrogen (mg/L)			
	2013	**2014**	**2015**
Surface of Big Blake Lake	1.40	0.80	0.88
Lost Creek	1.34	1.47	1.49
Little Blake Lake Inlet	0.64	0.66	0.72
Fox Creek	1.10	0.75	0.81

Inorganic nitrogen, or the nitrogen available for plants and algae, was below the healthy limit of 0.3 mg/L on all sampling dates at all sites with the exception of September 10, 2013 in Fox Creek and November 12th, 2013 at the surface of Big Blake Lake. In general inorganic nitrogen concentrations were lowest in the spring and increased towards the end of the growing season.



Growing season average organic nitrogen, or the amount of nitrogen in plants and algae, was highest in Lost Creek followed by Fox Creek and the Little Blake Lake Inlet in all three sampling years. In general, organic nitrogen increased over the course of the growing season through August in all three sampling years.



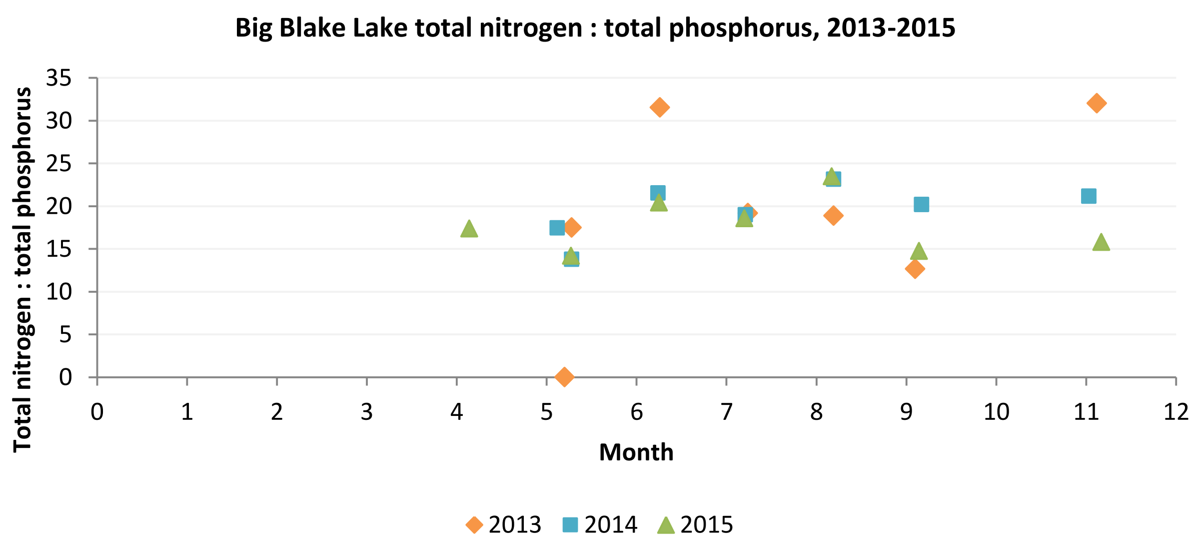
Total Nitrogen to Total Phosphorus Ratio

The total nitrogen to total phosphorus ratio (TN: TP) is a calculation that depicts which nutrient limits algae growth in a lake.

Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs, when TN: TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN: TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient, either nitrogen or phosphorus, is limiting algae growth.

Total nitrogen is found by adding nitrate/nitrite to total Kjeldahl nitrogen. As previously mentioned, nitrate/nitrite concentrations were below the limit of detection on all sampling dates with the exception of fall turnover (2013-2015) and spring turnover (2015). As a result, total nitrogen is largely reflective of TKN.

With the exception of spring turnover in 2013, data indicate that overall Big Blake Lake is phosphorus limited. In May of 2014 and 2015 and September of 2013 and 2015, data indicate a transitional state. In May of 2013, total nitrogen was below the limit of detection, resulting in a ratio of zero.

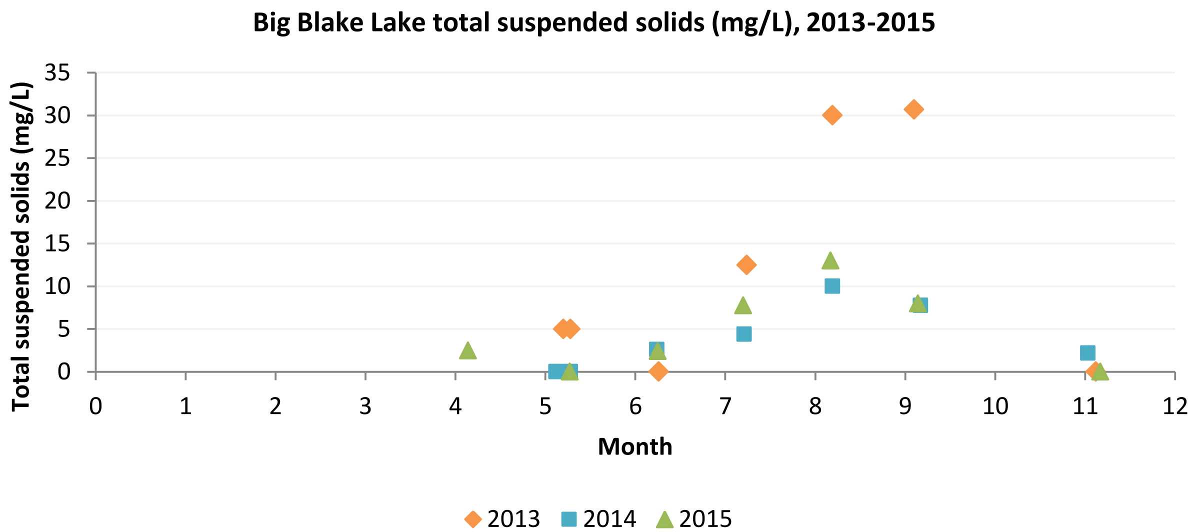


Total Suspended Solids

Total suspended solids (TSS) quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency.

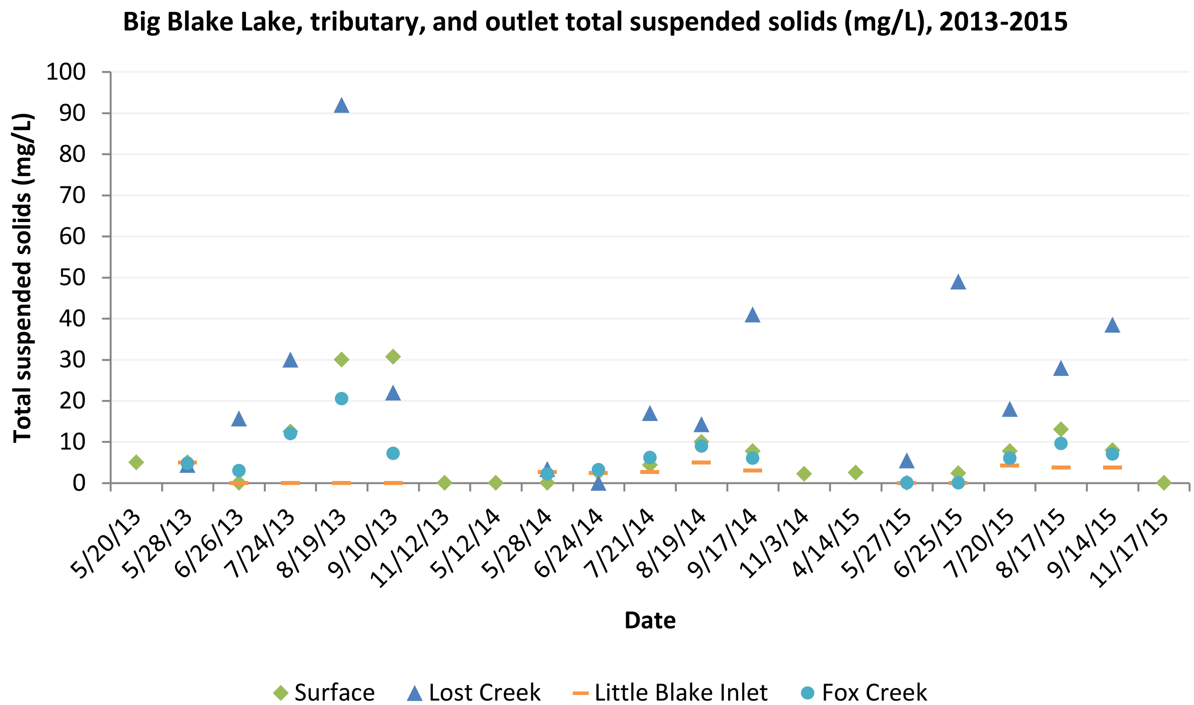
Summer index period average surface total suspended solids (July 15-September 15) were highest in 2013 (24.4 mg/L) as compared to 2014 (7.20 mg/L) and 2015 (9.6 mg/L).

Total suspended solids remained fairly low through June and increased in July and August in all three years data was collected. By November (fall turnover), total suspended solids had returned to what they had been in April/May (spring turnover).



Tributary and Outlet Total Suspended Solids

In all three sampling years, average total suspended solids were highest in Lost Creek, followed by Fox Creek and the Little Blake Inlet. Total suspended solids increased through the growing season through August and September. In all three sampling years average total suspended solids were highest in 2013, followed by 2015 and 2014 in each tributary and the outlet.



Chlorophyll

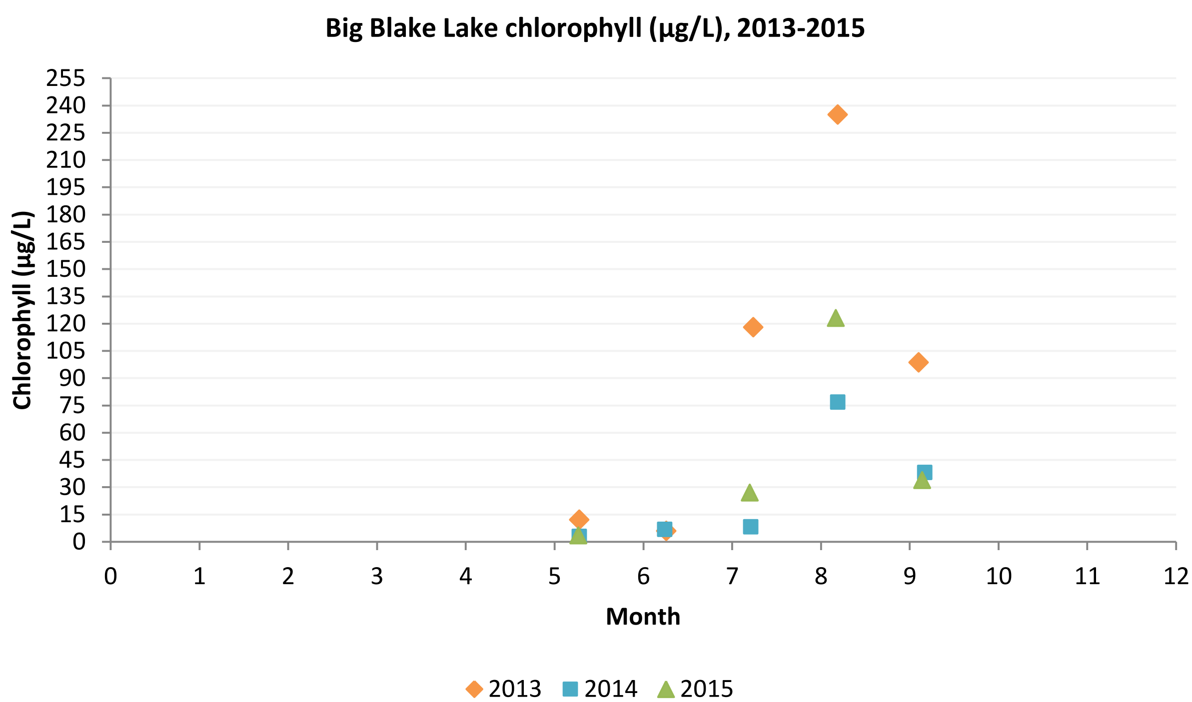
Chlorophyll is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. Chlorophyll gives a general indication of the amount of algae growth in a lake, with greater values for chlorophyll indicating greater amounts of algae. However, since chlorophyll is present in sources other than algae— such as decaying plants— it does not serve as a direct indicator of algae biomass.

Chlorophyll seems to have the greatest impact on water clarity when levels exceed 30 µg/L. Lakes which appear clear generally have chlorophyll levels less than 15 µg/L.

Growing season average[22] surface chlorophyll exceeded the healthy limit in 2013 (94 µg/L) and 2015 (47 µg/L). Growing season average surface chlorophyll was just below the threshold in 2014 (27 µg/L).

Summer index period average surface chlorophyll (July 15-September 15) exceeded the healthy limit in 2013 (151 µg/L), 2014 (42 µg/L) and 2015 (61 µg/L).

In 2013 chlorophyll levels remained below 15 µg/L through June and in 2014 they remained below 15 µg/L through July. In 2015 chlorophyll levels remained below 15 µg/L through May and below 30 µg/L through July. [23]



[22] Excludes turnover

[23] The lab did not run the chlorophyll sample for June 25th, 2015 so a data point does not exist for this date

Trophic State Index

Lakes are divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity.

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often poor in nutrients and are unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support a large number of plants and animals. They are usually very productive and subject to frequent algae blooms. Eutrophic lakes often support large fish populations, but are susceptible to oxygen depletion.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

All lakes experience a natural aging process which causes a change from an oligotrophic to a eutrophic state. Human influences that introduce nutrients into a lake (agriculture, lawn fertilizers, and septic systems) can accelerate the process by which lakes age and become eutrophic.

[24]

A common method of determining a lake's trophic state is to compare total phosphorus (important for algae growth), chlorophyll (an indicator of the amount of algae present), and secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between total phosphorus, chlorophyll, and secchi disk readings is the basis of comparison for the trophic state index (TSI).

TSI is determined using a mathematic formula and ranges from 0 to 110. Lakes with the lowest numbers are oligotrophic and lakes with the highest values are eutrophic.

[24] Figure from Understanding Lake Data (G3582), UW-Extension, Byron Shaw, Christine Mechenich, and Lowell Klessig, 2004

Three equations for summer index period TSI were examined for Big Blake Lake.

TSI (P) = 14.42 * Ln [TP] + 4.15 (where TP is in µg/L)
TSI (C) = 30.6 + 9.81 Ln [Chlor-a] (where the chlorophyll is in µg/L)
TSI (S) = 60-14.41 * Ln [Secchi] (where the secchi depth is in meters)

<u>Big Blake Lake 2013</u>
Average summer index period TSI (total phosphorus) = 73
Average summer index period TSI (chlorophyll) = 80
Average summer index period TSI (secchi depth) = 66
Average summer index period TSI = 73 = hypereutrophic

<u>Big Blake Lake 2014</u>
Average summer index period TSI (total phosphorus) = 61
Average summer index period TSI (chlorophyll) = 67
Average summer index period TSI (secchi depth) = 59
Average summer index period TSI = 62 = eutrophic

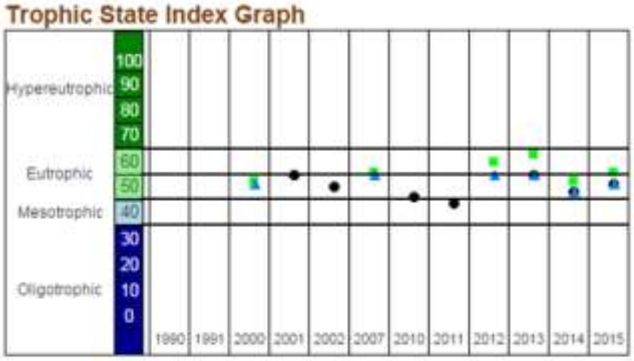
<u>Big Blake Lake 2015</u>
Average summer index period TSI (total phosphorus) = 64
Average summer index period TSI (chlorophyll) = 71
Average summer index period TSI (secchi depth) = 65
Average summer index period TSI = 67 = eutrophic

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year/lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have macrophyte problem, warm-water fisheries only
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth, full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate

Monitoring the trophic state index of a lake gives stakeholders a method by which to gauge lake productivity over time. TSI data for phosphorus and chlorophyll exist for 2000, 2007, and 2012 and TSI data for secchi exist for 2001, 2002, 2010, and 2011. Complete TSI data exist for 2013-2015.

The majority of the historic TSI data falls between 50 and 70, indicating a eutrophic state. TSI secchi data for 2010 and 2011 indicate a mesotrophic state.

Trophic State Index Graph



Monitoring Station: Big Blake Lake - Deep Hole/Main Basin, Polk County
Past Summer (July-August) Trophic State Index (TSI) averages.

● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

TSI	TSI Description
TSI < 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
TSI > 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Trophic state index (TSI) is determined using a mathematical formula (Wisconsin has its own version). The TSI is a score from 0 to 110, with lakes that are less fertile having a low TSI. We base the overall TSI on the Chlorophyll TSI when we have Chlorophyll data. If we don't have chemistry data, we use TSI Secchi. We do this rather than averaging, because the TSI is used to predict biomass. This makes chlorophyll the best indicator. Visit Bob Carlson's website, dipin.kent.edu/tsi.htm, for more info.
[25]

[25] https://dnrx.wisconsin.gov/swims/public/reporting.do?type=33&action=post&format=html&stationNo=493144

Phytoplankton

Algae, also called phytoplankton, are microscopic plants that convert sunlight and nutrients into biomass. They can live on bottom sediments and substrate, in the water column, and on plants and leaves. Algae are the primary producers in an aquatic ecosystem and can vary in form. Zooplankton, are small aquatic organisms that feed on algae. The size and shape of algae determine which types of zooplankton—if any—can consume them.

Algae have short life cycles. As a result, changes in water quality are often reflected by changes in the algal community within a few days or weeks. The number and types of algae in a waterbody can provide useful information for environmental monitoring programs, impairment assessments, and the identification of best management strategies.

The types of algae in a lake will change over the course of a year. Typically, there is less algae in winter and spring because of ice cover and cold temperatures. As a lake warms up and sunlight increases, algae communities begin to increase. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics.

The types of algae present in a lake are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake. When high levels of nutrients are available, blue green algae often become predominant.

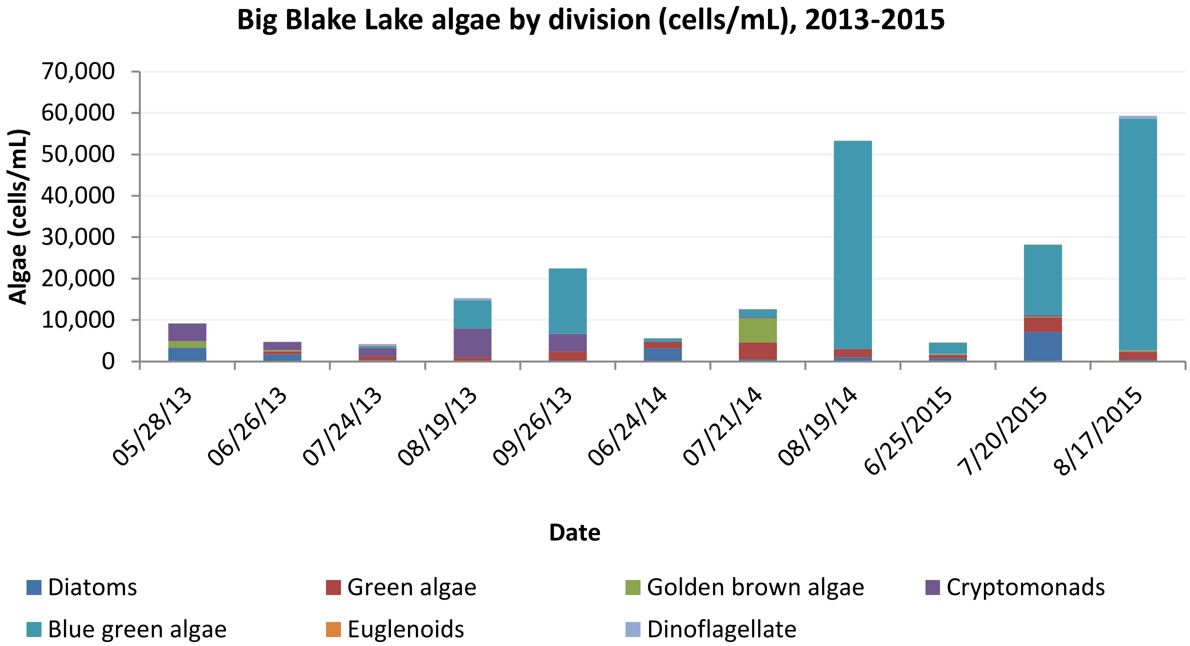
Chlorophyll is a pigment in plants and algae that is necessary for photosynthesis. Chlorophyll gives a general indication of the amount of algae growth in the water column; however, it is not directly correlated with algae biomass. To obtain accurate algae data, composite samples from a two meter water column were collected monthly, preserved with glutaraldehyde, placed on ice, and sent to the State Lab of Hygiene (2013) and UW-Oshkosh (2014 and 2015) for identification and enumeration of algae species.

Algae were identified to genus, and a relative concentration and natural unit count was made to describe the algae community throughout the growing season. This method of sampling also allows the identification of any species of concern which might be present.

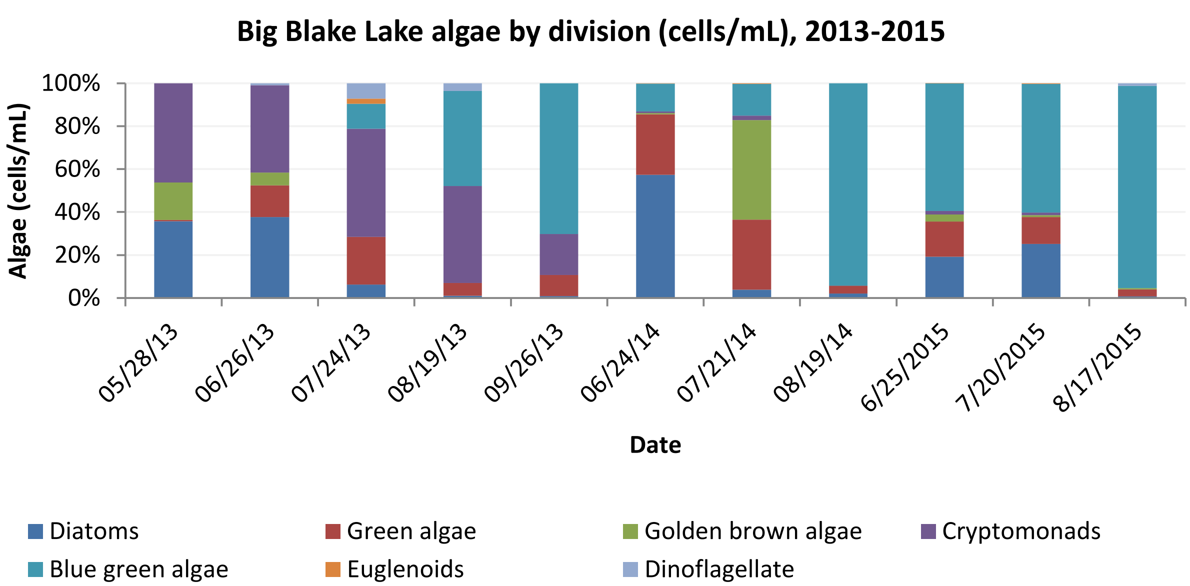
There are twelve divisions of algae found in typical lakes of Wisconsin. Seven divisions were found in Big Blake Lake.

Algal Division	Common Name	Characteristics
Bacillariophyta	Diatoms	Have a siliceous frustule that makes up the external covering. Sensitive to chloride, pH, color, and total phosphorus (TP) in water. As TP increases, see a decrease in diatoms. Generally larger in size. Tend to be highly present in spring and late spring. Can be benthic or planktonic.
Chlorophyta	Green algae	Have a true starch and provide high nutritional value to consumers. Can be filamentous and intermingle with macrophytes.
Chrysophyta	Golden brown algae	Organisms which bear two unequal flagella. A genus of single-celled algae in which the cells are ovoid. Contain chlorophyll a, c_1 and c_2, generally masked by abundant accessory pigment, fucoxanthin, imparting distinctive golden color to cells.
Cryptophyta	Cryptomonads	Have a true starch. Planktonic. Bloom forming, are not known to produce any toxins and are used to feed small zooplankton. Cryptomonads frequently dominate the phytoplankton assemblages of the Great Lakes.
Cyanophyta	Blue green algae	Prevail in nutrient-rich standing waters. Blooms can be toxic to zooplankton, fish, livestock, and humans. Can be unicellular, colonial, planktonic, or filamentous. Can live on almost any substrate. More prevalent in late to mid-summer.
Euglenophyta	Euglenoids	One of the best-know groups of flagellates, commonly found in freshwater that is rich in organic materials. Most are unicellular.
Pyrrhophyta	Dinoflagellate	A large group of protists with brownish pigments. Cells are single and large and can be toxic. Red tides, which occur in marine waters, are explosions of dinoflagellates. In freshwater systems, blooms are more brown than red.

In general, algae populations increased over the course of the sampling season in all three years of the study. Algae populations were greatest in August and September of 2013, August of 2014, and July and August of 2015. On these sampling dates, blue green algae began to dominate the algal community making up 44% of the algal community in August 2013, 70% of the algal community in September 2013, and 94% of the algal community in August 2014. In 2015, blue green algae dominated the algal community on all three sampling dates, making up 59% of the algal community in June, 60% of the algal community in July and 94% of the algal community in August.



Diatoms were present across the growing season in all three years of the study, making up a larger percentage of the algal community in May and June of 2013, June of 2014, and June and July of 2015. In 2013 (with the exception of September) cryptomonads made up nearly 40% of the algal community. However, in 2014 and 2015 cryptomonads were a very minimal component of the algal community. Golden brown algae were fairly absent in the algal community with the exception of May 2013 and July 2014 when they made up 17% and 47%of the algal community, respectively. Blue green algae became a dominant component of the algae community beginning in August of 2013 and 2014 and were dominant during the entire 2015 growing season.



Blue Green Algae

Blue green algae, or cyanobacteria, have been around for billions of years and typically bloom during the summer months. However, blue-green algae blooms become more frequent as a result of increased nutrient concentrations.

Blue green algae are of specific concern because of their ability to produce toxins, that when ingested or inhaled, can cause short and long term health effects. Effects range from tingling, burning, numbness, drowsiness, and dermatitis to liver or respiratory failure possibly leading to death.

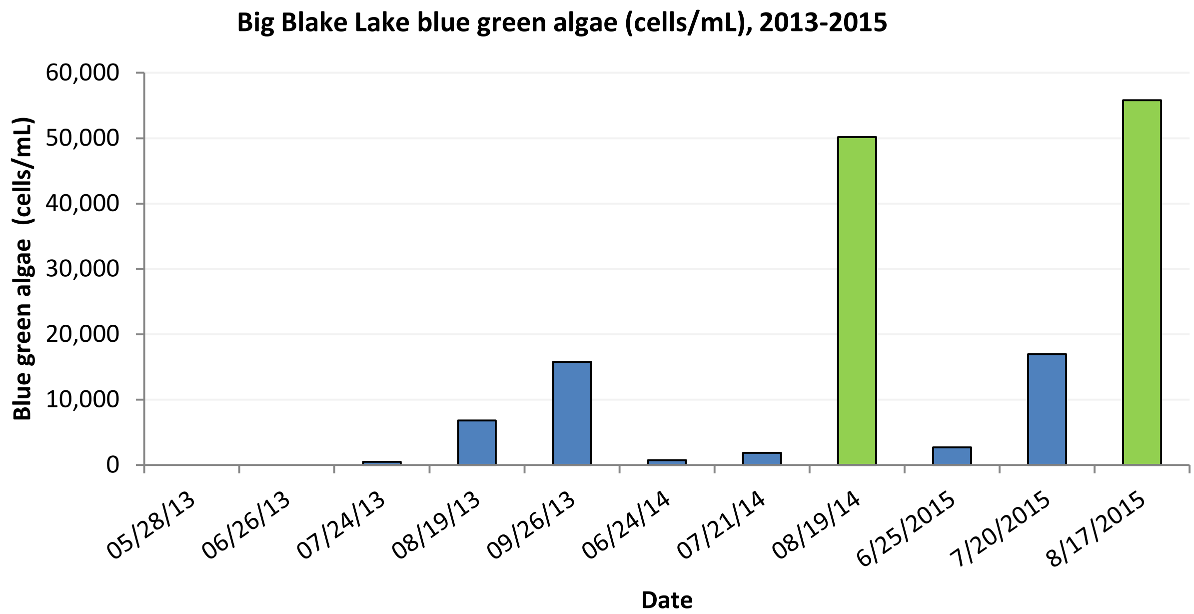
It is not known which environmental conditions cause the production of cyanotoxins, but scientists have found that when blue green algae is present at concentrations over 100,000 cells/mL toxin production is more likely to occur.

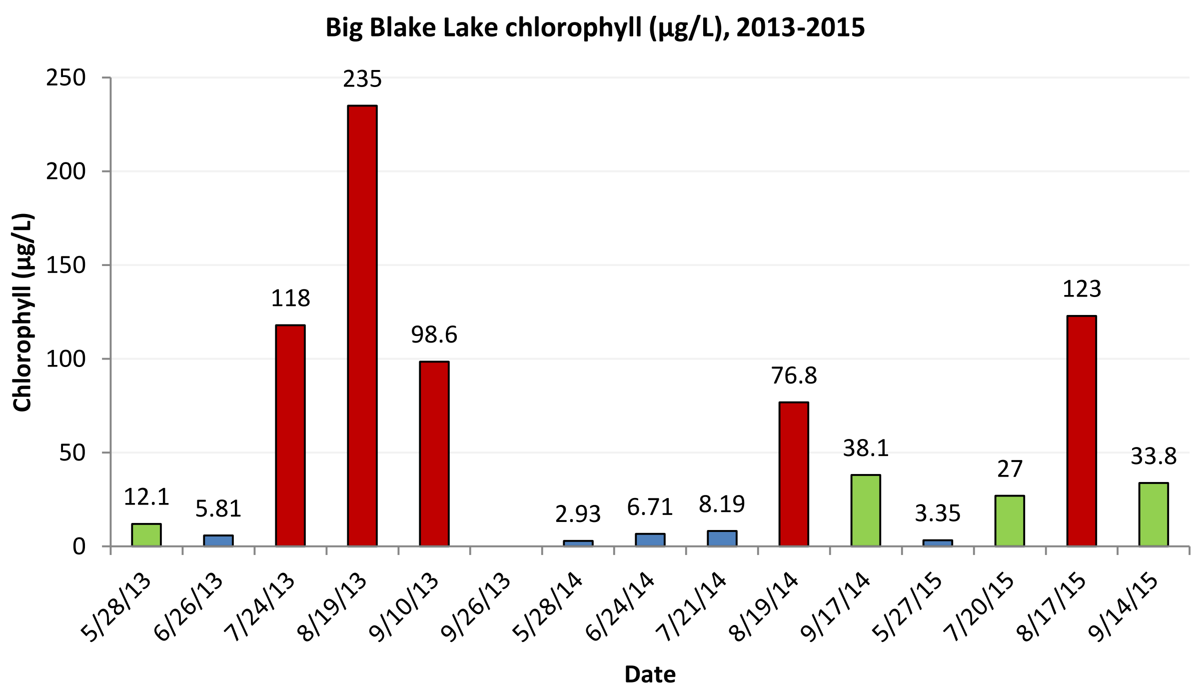
Federal guidelines for blue green algae cell densities and chlorophyll concentrations do not exist. The Wisconsin Harmful Algal Bloom (HAB) Surveillance Program uses guidelines of the World Health Organization to determine risks from blue green algae.

Blue green algae cell density (cells/mL)	**Chlorophyll (µg/L)**	**Risk**
Less than 20,000	Less than 10	**Low**
20,000 to 100,000	10 to 50	**Moderate**
Greater than 100,000	Greater than 50	**High**

Based on blue green algae cell density, the risks from blue green algae were low on all sampling dates with the exception of August 2014 and August 2015, when the risk increased to moderate.

Based on chlorophyll, the risk from blue green algae was high in July, August, and September of 2013, July of 2014, and August of 2015. Additionally, the risk was moderate in May 2013, September 2014, and July and September 2015.


Big Blake Lake blue green algae (cells/mL), 2013-2015
Blue green algae (cells/mL)
60,000
50,000
40,000
30,000
20,000
10,000
0
05/28/13
06/26/13
07/24/13
08/19/13
09/26/13
06/24/14
07/21/14
08/19/14
6/25/2015
7/20/2015
8/17/2015
Date


Big Blake Lake chlorophyll (µg/L), 2013-2015
Chlorophyll (µg/L)
250
200
150
100
50
0
12.1
5.81
118
235
98.6
2.93
6.71
8.19
76.8
38.1
3.35
27
123
33.8
5/28/13
6/26/13
7/24/13
8/19/13
9/10/13
9/26/13
5/28/14
6/24/14
7/21/14
8/19/14
9/17/14
5/27/15
7/20/15
8/17/15
9/14/15
Date

Zooplankton

Zooplankton are small aquatic animals that feed on algae and are eaten by fish. They are divided into three main components: rotifers, copepods, and cladocerans.

Rotifers eat algae, other zooplankton, and sometimes each other. Due to their small size, rotifers are not capable of significantly reducing algal biomass although they are able to shift the algae community to favor larger species.

Copepods feed on algae and other plankton. They are eaten by larger plankton and are preyed heavily upon by pan fish, minnows, and the fry of larger fish.

Cladocerans are filter feeders that play an important part in the food web. Species of cladocerans (particularly Daphnia) are well known for their ability to reduce algal biomass and help maintain clear water in lake ecosystems.

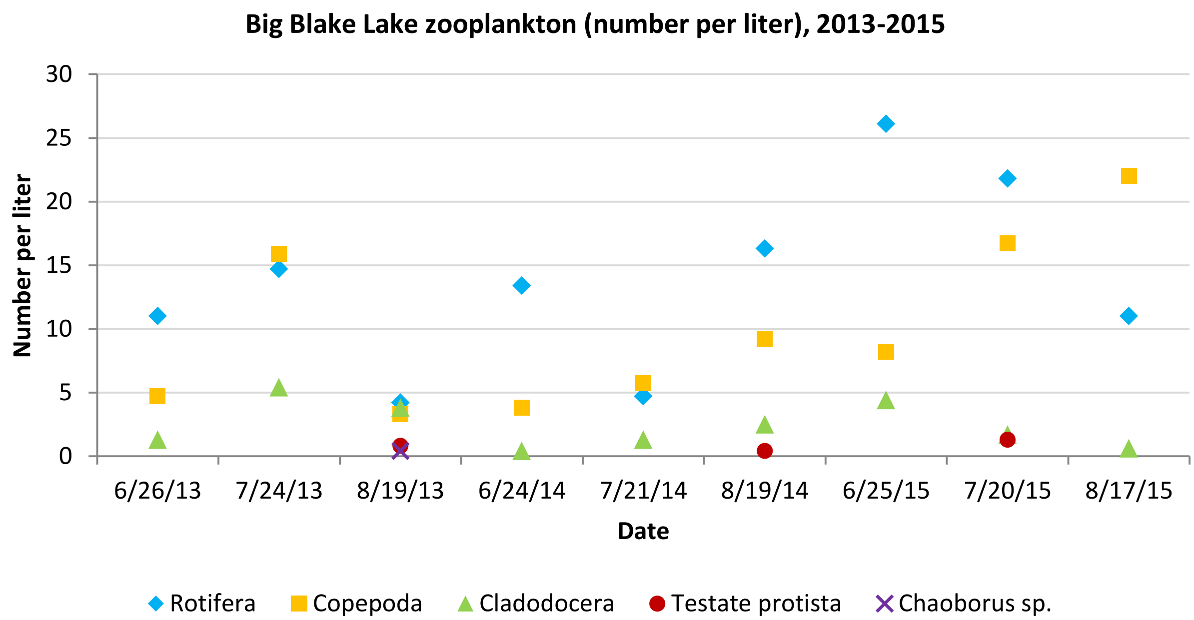
Zooplankton are often overlooked as a component of aquatic systems, but their role in a lake is extremely important. Lake systems are valued primarily for water clarity, fishing, or other recreation, all of which are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the "bottom up" processes and "top down" processes of the lake ecosystem.

"Bottom up" processes include factors such as increased nutrients, which can cause noxious algal blooms. Zooplankton have the ability to mediate algae blooms by heavy grazing. Conversely, shifts in algal composition, which can be caused by increased nutrients, can change the composition of the zooplankton community. If the composition shifts to favor smaller species of zooplankton, for example, algal blooms can be intensified, planktivorous fish can become stressed, and the development of fry can be negatively impacted.

"Top down" processes include factors such as increased fish predation. Increases in planktivorous fishes (pan fish) can dramatically reduce zooplankton populations and lead to algal blooms. In some lakes, biomanipulation is utilized to manage this effect and improve water clarity. Piscivorous fish (fish that eat other fish) are used to reduce planktivorous fish. This in turn increases zooplankton populations and ultimately reduces algae populations.

Changes in the aquatic plant community and shoreland habitat can impact zooplankton populations. This occurs especially in shallow lakes where zooplankton are more likely to have the ability to migrate horizontally to avoid predation from fish and other invertebrates. In general, a diverse shoreland habitat (substrate, plant species, and woody debris) will support a diverse zooplankton community.

Composite samples from a two meter water column were collected monthly, preserved with denatured ethanol, placed on ice, and sent to Dr. Toben Lafrancois for identification and enumeration of zooplankton species. This analysis shows the abundance of the major zooplankton groups—cladocera, copepoda, and rotifer—in Big Blake Lake. The analysis also includes the abundance of Chaoborus (phantom midge) and protozoa in Big Blake Lake. Protists are single celled organisms living either as single cells or as simple colonies of cells that are divided into animal like organisms (protozoa) and photosynthetic organisms (algae). Protozoans provide a critical link in returning energy and nutrients from bacteria and detritus to higher trophic levels.



"Big Blake Lake shows some interesting patterns in 2013, where a typical phenological pattern appears in June and July with a crash in August. This crash is someone unexpected since August tends to be a very productive year. Environmental factors need to be analyzed to explain this change, which would typically occur later in October or November. The 2014 trends show a more typical response with an unexpected drop in rotifers in July but otherwise a slow increase into the most productive months. In 2015 there was a major increase in copepods over the summer, with a decline in rotifers that could be associated with copepod predation, and a decrease in cladocerans. The cladoceran decrease could be due to either fish pressure or a change in algal community structure. The concurrent increase in copepods suggests that a bottom-up mechanism is more likely, since planktivorous fish tend to favor cladocerans but also enjoy copepods, being mostly size selective." [26]

[26] Excerpted directly from: Lafrançois, T. 2016. Zooplankton of Big Blake and Lotus Lakes, Polk County (WI) 2013-2016. Final report to Polk County Land & Water Resources Department, Polk Co. WI.

Harvesting and Curly-leaf Pondweed

The Big Blake Lake Protection and Rehabilitation District formed in 1976 in response to concerns about algae blooms and aquatic plants. In the 1980's and 1990's aquatic plants were managed with harvesting (contracted) and chemical treatments by individual property owners.

Efforts to address curly-leaf pondweed, an aquatic invasive species, began in earnest in 1997. Barr Engineering completed a macrophyte survey and Macrophyte Management Plan in 1998 and The Limnological Institute (TLI) completed a macrophyte survey in 2004 that helped the District develop a Lake Management Plan. TLI's plan led to the obtainment of an ACEI Aquatic Invasives Control grant through the WDNR which provided a fifty-percent match for aquatic plant management through harvesting. The District has used harvesting to manage curly-leaf pondweed since 2007.

Curly-leaf pondweed is an exotic plant present in many Wisconsin lakes. Curly-leaf pondweed begins growing in the fall as native plants die off for the year. Curly-leaf pondweed tolerates cold water and low light conditions and continues to grow throughout the winter months under ice cover. It completes its reproductive cycle with the formation of turions, or seeds, in the early summer and dies off in late June through mid-July.

Since curly-leaf pondweed die off occurs when water temperatures are relatively high, biological organisms are very active. As curly-leaf pondweed decays, nutrients released into the water column are available for uptake by algae.

Later in the growing season, coontail reaches nuisance levels in Big Blake Lake. Coontail is a free floating native aquatic plant.

During the course of this study, aquatic plant growth was the most robust in 2015, with 143 total loads of curly-leaf pondweed and 28 loads of coontail being removed from Big Blake Lake. Additionally, due to a warm spring, harvesting for curly-leaf pondweed began about a month earlier in 2015 as compared to 2013 and 2014. In 2012, (prior to this study) 85 loads of curly-leaf pondweed were harvested.

Curly-leaf pondweed harvesting information

	Harvesting start date	Harvesting end date	Loads of curly-leaf pondweed removed
2013	June 16	July 3	8
2014	June 8	July 14	30
2015	May 19	July 1	143

Coontail harvesting information

	Harvesting start date	Harvesting end date	Loads of coontail removed
2013	July 18	September 17	14
2014	August 14	September 18	6
2015	July 22	September 3	28

Curly-leaf Pondweed Biomass and Turion Sampling

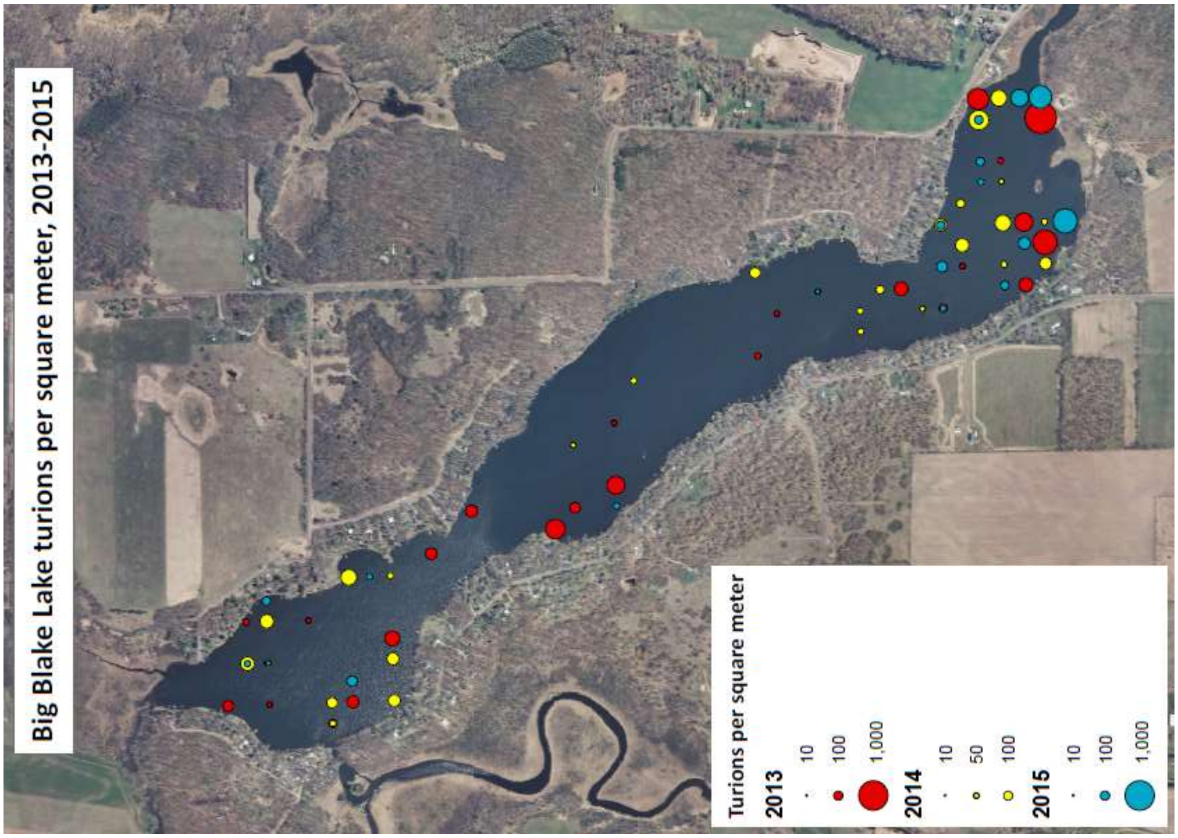
A Petite Ponar Grab Sampler was used to sample the surface sediments at fifty randomly selected points on the point intercept grid. The number of viable turions in the surface sediments were counted at each site. Numbers were extrapolated to determine number of turions per square meter.

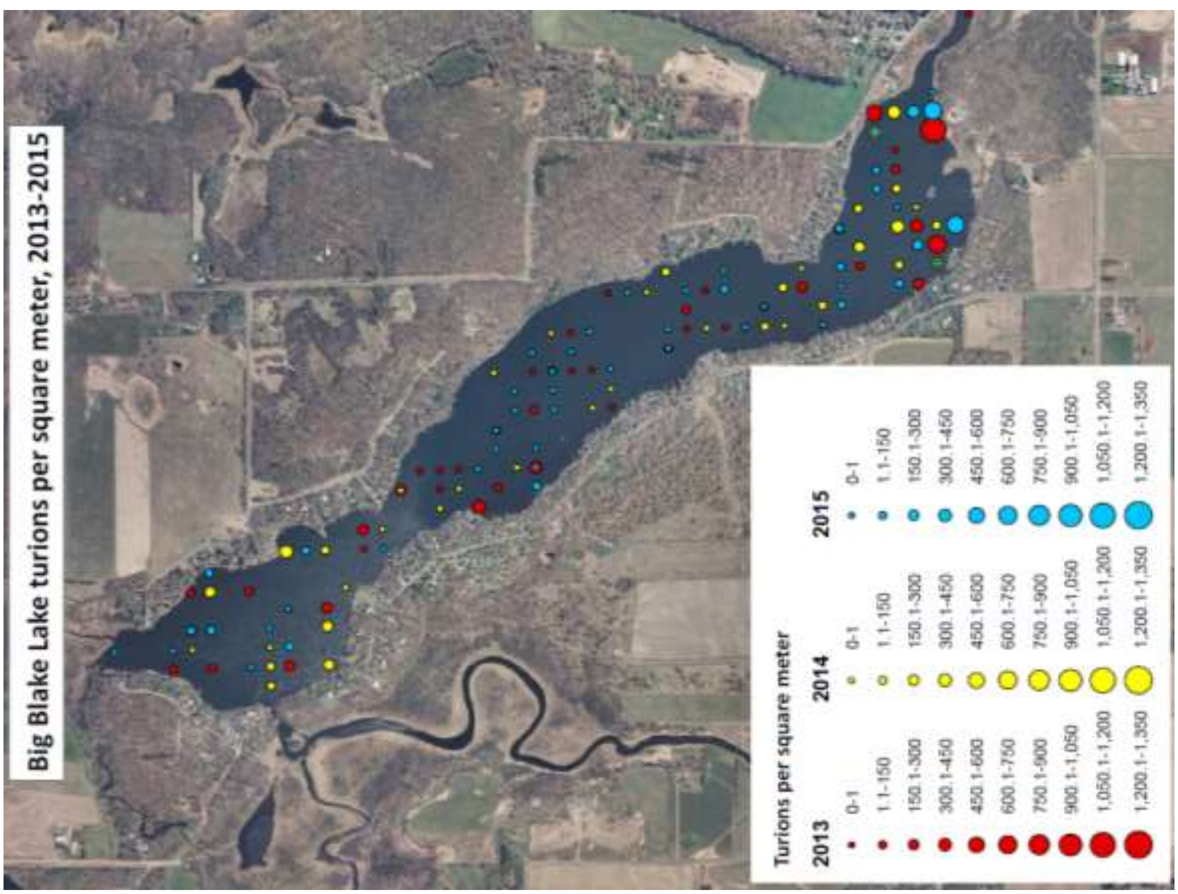
Average number of turions per dredge sample and number of turions per square meter decreased each year of the study. However, at many of the sites on the south end where points were revisited, the number of turions per square meter increased in 2015 as compared to 2013 and 2014.

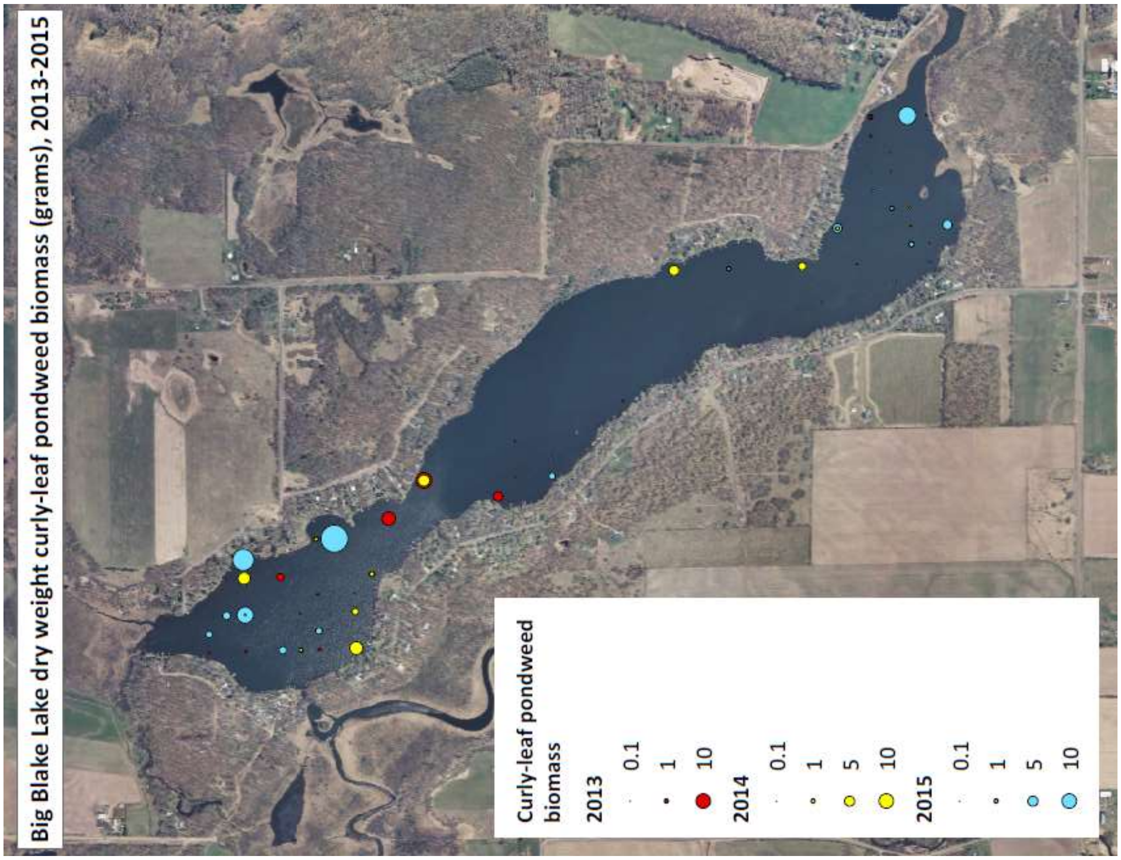
Number of turions per site was greatest on the south end of Big Blake Lake. Turions were not present in the sediments of many of the sites in the middle of Big Blake Lake.

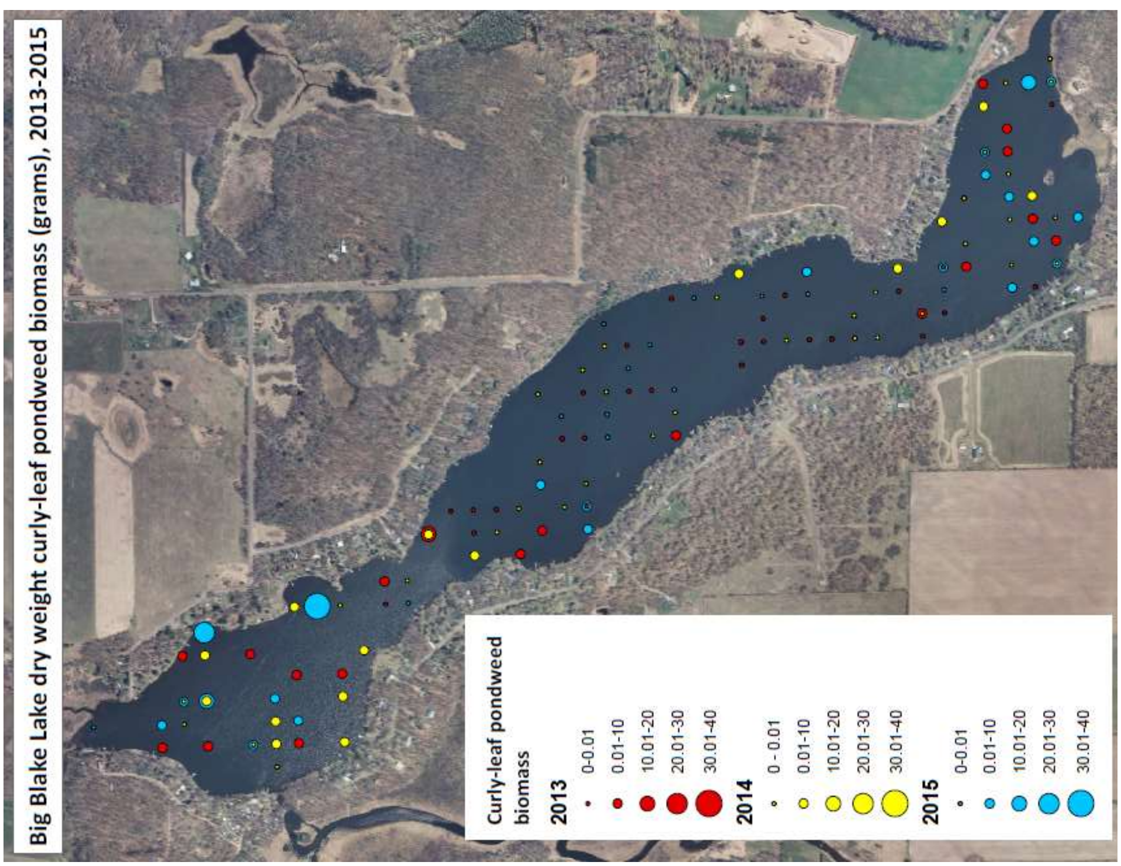
At each of the fifty randomly selected points, a rake was used to sample biomass. Biomass samples were dried and weighed. Average dry weight biomass was greatest in 2015 followed by 2014 and 2013. In general, biomass was greatest in the north and south ends of the lake with much less curly-leaf pondweed being found in the middle of the lake.

Year	Turions per dredge sample	Turions per square meter	Curly-leaf pondweed biomass (grams)
2013	2.7	117	0.656
2014	1.9	83	0.768
2015	1.3	56	2.272


Big Blake Lake turions per square meter, 2013-2015
Turions per square meter
2013
10
100
1,000
2014
10
50
100
2015
10
100
1,000


Big Blake Lake turions per square meter, 2013-2015
Turions per square meter
2013
0-1
1.1-150
150.1-300
300.1-450
450.1-600
600.1-750
750.1-900
900.1-1,050
1,050.1-1,200
1,200.1-1,350
2014
0-1
1.1-150
150.1-300
300.1-450
450.1-600
600.1-750
750.1-900
900.1-1,050
1,050.1-1,200
1,200.1-1,350
2015
0-1
1.1-150
150.1-300
300.1-450
450.1-600
600.1-750
750.1-900
900.1-1,050
1,050.1-1,200
1,200.1-1,350


Big Blake Lake dry weight curly-leaf pondweed biomass (grams), 2013-2015
Curly-leaf pondweed biomass
2013
0.1
1
10
2014
0.1
1
5
10
2015
0.1
1
5
10


Big Blake Lake dry weight curly-leaf pondweed biomass (grams), 2013-2015
Curly-leaf pondweed biomass
2013
0-0.01
0.01-10
10.01-20
20.01-30
30.01-40
2014
0 - 0.01
0.01-10
10.01-20
20.01-30
30.01-40
2015
0-0.01
0.01-10
10.01-20
20.01-30
30.01-40

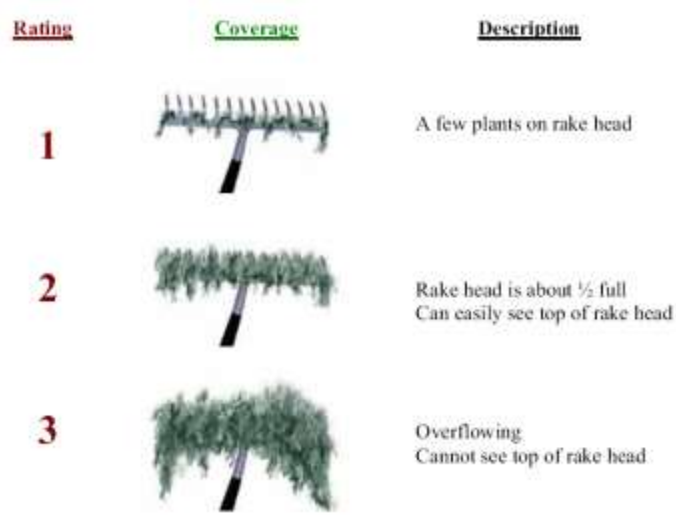
Point Intercept Aquatic Macrophyte Surveys

Spring and fall aquatic macrophyte surveys were conducted on Big Blake Lake in 2013, 2014, and 2015 using the Jessen and Lound Rake Method.

Two hundred seventy six sampling points were established in and around the lake using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total lake acres. Points were generated in ArcView and downloading to a GPS unit. These points were then sampled in field.

During the aquatic macrophyte survey, each sampling point was located using a handheld mapping GPS unit. The depth at each sampling point was recorded using a depth finder. At each sampling point a pole rake was used to sample the plant community of an approximately 1 meter section of the benthos.

All plants on the rake, as well as any that were dislodged by the rake, were identified to species and assigned a rake fullness value of 1 to 3 to estimate abundance. Visual sightings of plants within six feet of the sample point were also recorded. The lake bottom type, or substrate, was also assigned at each sampling point where the bottom was visible or it could be reliably determined using the rake. Data was collected at each sampling point, with the exception of those that were too shallow or terrestrial. Shallow communities were characterized visually.



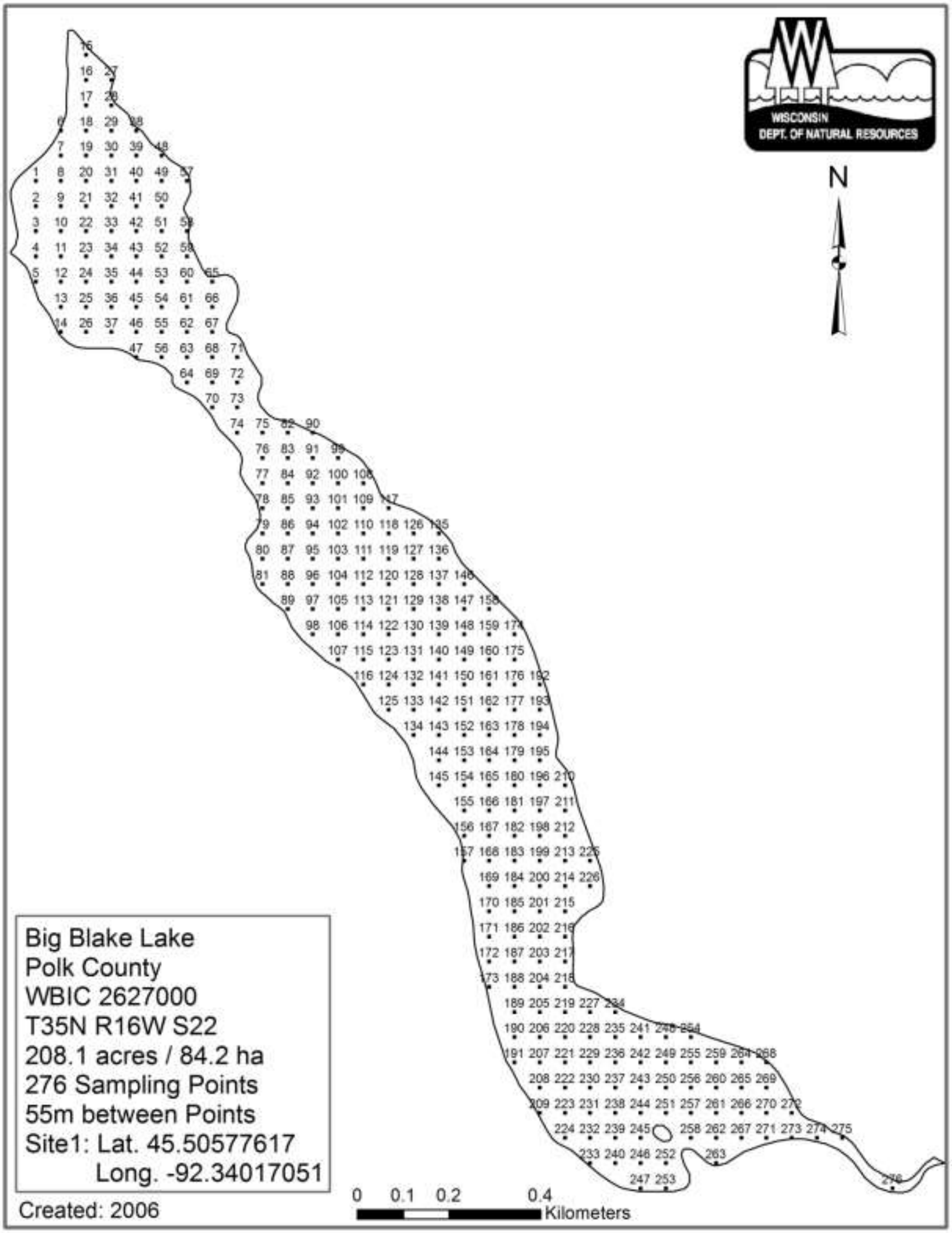
Although two hundred seventy six sampling points were established in Big Blake Lake, it was not possible to reach all sampling points (some were terrestrial).

Twice annual aquatic macrophyte surveys were conducted on Big Blake Lake in 2007 and 2011 and a fall point intercept survey was conducted in 2012. Surveys completed in 2008-2010 represented two intensive management units rather than the full point intercept grid. This summary will include data from 2007 and 2011-2015.

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

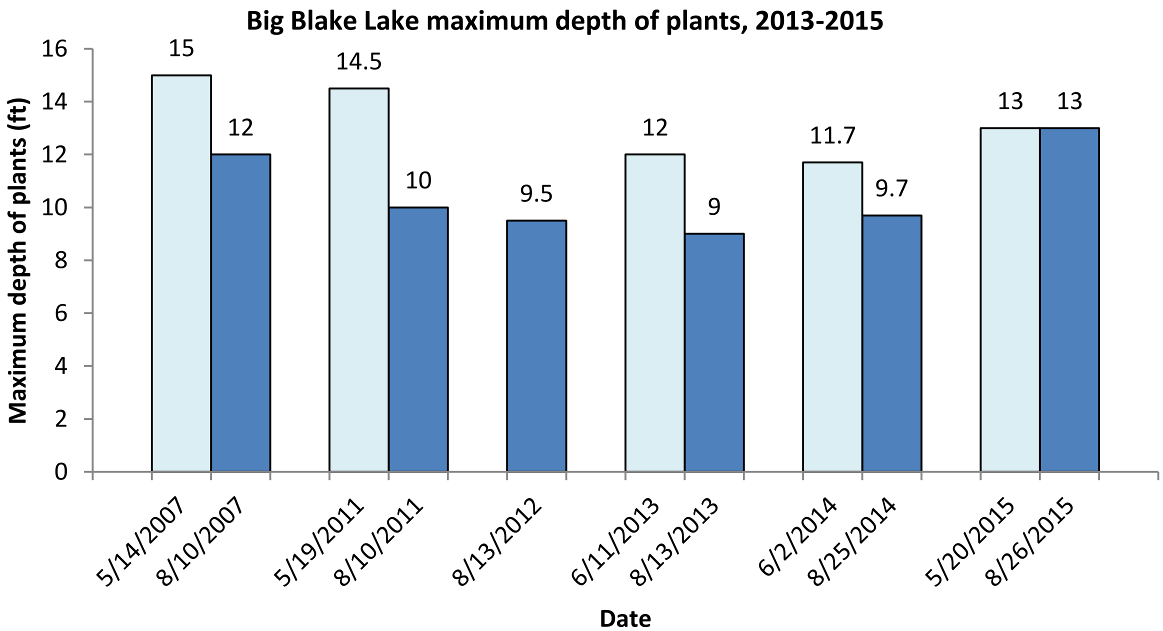
- Maximum depth of plants
- Frequency of occurrence
- Relative frequency
- Sample points with vegetation
- Species richness
- Simpson's Diversity Index
- Floristic Quality Index

Following are explanations of the various analysis values with data from Big Blake Lake.



Maximum Depth of Plants

In lakes, plant growth is limited to certain depths based on availability of light. With greater water clarity, light can penetrate to greater depths and be used by plants for growth. In Big Blake Lake the maximum depth of plants was generally greater in the spring as compared to the fall (12 versus 9 feet in 2013 and 11.7 versus 9.7 feet in 2014, respectively). In 2015, the maximum depth of plants (13 feet) was the same in both spring and fall.



Frequency of Occurrence

Two values are computed for frequency of occurrence: the frequency of occurrence within vegetated areas and the frequency of occurrence at sites shallower than the maximum depth of plants. The maximum depth of plants is the depth of the deepest site sampled at which vegetation was present (maximum depth of plants).

Frequency of occurrence within vegetated areas is defined as the number of times a species was seen in a vegetated area divided by the total number of vegetated sites. This value shows how often the plant would be encountered everywhere vegetation was found in the lake. The greater the value, the more frequently the plant would be encountered in the lake.

In the spring, within vegetated areas, curly-leaf pondweed was the most frequently encountered plant species being found at 100% of sites in 2007, 93% of sites in 2011, 73% of sites in 2013, 59% of sites in 2014, and 93% of sites in 2015. Other frequent species included small pondweed, coontail, forked duckweed, and flat-stem pondweed.

In the fall, within vegetated areas, coontail was the most frequently encountered plant species being found at 86% of sites in 2007, 92% of sites in 2011, 86% of sites in 2012, 82% of sites in 2013, 73% of sites in 2014, and 85% of sites in 2015. Other frequent species included flat-stem pondweed, forked duckweed, and small pondweed.

Spring frequency of occurrence within vegetated areas, 2007, 2011, and 2013-2015					
	5/14/07	5/19/11	6/11/13	6/2/14	5/20/15
Ceratophyllum demersum, coontail	19.52	25.64	34.11	31.6	19.44
Filamentous algae	8.37	5.13	3.88	17.39	4.86
Heteranthera dubia, water star-grass			1.55		0.69
Lemna minor, small duckweed			2.33		
Lemna trisulca, forked duckweed	1.99	12.31	15.5	29.57	5.56
Myriophyllum sibiricum, northern water milfoil		2.05	0.78	2.61	4.17
Nitella sp., nitella					0.69
Nuphar variegata, spatterdock		1.03	0.78	3.48	1.39
Nymphaea odorata, white water lily		0.51	2.33	1.74	0.69
Potamogeton crispus, curly-leaf pondweed	100.00	93.33	72.87	59.13	93.06
Potamogeton praelongis, white-stem pondweed		0.51	3.1	1.74	1.39
Potamogeton pulcher, spotted pondweed		0.51			
Potamogeton pusillus, small pondweed	1.20	13.85	35.66	39.13	18.75
Potamogeton zosteriformis, flat-stem pondweed	2.39	4.10	16.28	13.04	5.56
Ranunculus aquatilis, white water crowfoot			3.1		1.39
Vallisneria americana, wild celery			0.78		
Wolffia columbiana, common watermeal			1.55		
Zizania palustris, northern wild rice			0.78	1.74	1.39

Fall frequency of occurrence within vegetated areas, 2007 and 2011-2015						
	8/10/07	8/10/11	8/13/12	8/13/13	8/25/14	8/26/15
Ceratophyllum demersum, coontail	85.87	91.89	85.71	82.14	73.24	85.29
Chara sp., Muskgrasses						1.47
Elodea canadensis, common waterweed	1.09					4.41
Filamentous algae	8.70		5.36	8.93	9.86	11.76
Heteranthera dubia, water star-grass	1.09	2.70		3.57	7.04	2.94
Lemna minor, small duckweed	3.26	6.76		1.79	5.63	4.41
Lemna trisulca, forked duckweed	14.13	43.24	30.36	28.57	38.03	44.12
Myriophyllum sibiricum, northern water milfoil	3.26	8.11	14.29	8.93	12.68	11.76
Najas flexilis, bushy pondweed	1.09	4.05		1.79	8.45	
Nitella sp., nitella	1.09					
Nuphar variegata, spatterdock		6.76	1.79		4.23	1.47
Nymphaea odorata, white water lily	2.17	4.05	7.14	8.93	5.63	7.35
Potamogeton amplifolius, large-leaf pondweed					1.41	
Potamogeton crispus, curly-leaf pondweed	1.09	1.35	1.79	1.79	1.41	1.47
Potamogeton illinoensis, Illinois pondweed	3.26					
Potamogeton praelongis, white-stem pondweed		2.70		3.57		4.41
Potamogeton pusillus, small pondweed	1.09	8.11		17.86	11.27	2.94
Potamogeton richardsonii, clasping-leaf pondweed	2.17	2.70	1.79	8.93	1.41	4.41
Potamogeton zosteriformis, flat-stem pondweed	15.22	31.08	26.79	48.21	28.17	35.29
Ranunculus aquatilis, white water crowfoot		1.35		1.79	1.41	2.94
Sparganium angustifolium, narrow-leaved bur-reed			8.93			
Spirodela polyrhiza, large duckweed	1.09	6.76		1.79		
Stuckenia pectinata, sago pondweed	1.09					
Vallisneria americana, wild celery		1.35	3.57	5.36		2.94
Wolffia columbiana, common watermeal		1.35		1.79	1.41	4.41
Zizania palustris, northern wild rice		1.35				

Frequency of occurrence at sites shallower than the maximum depth of plants is defined as the number of times a species was seen divided by the total number of sites shallower than the maximum depth of plants. This value shows how often the plant would be encountered within the depths plants can potentially grow (maximum depth of plants). The greater the value, the more frequently the plant would be encountered in the lake.

In the spring, at sites shallower than the maximum depth of plants, curly-leaf pondweed was the most frequently encountered plant species being found at 97% of sites in 2007, 67% of sites in 2011, 53% of sites in 2013, 32% of sites in 2014, and 51% of sites in 2015. Other frequent species included small pondweed, coontail, and forked duckweed.

In the fall, at sites shallower than the maximum depth of plants, coontail was the most frequently encountered plant species being found at 31% of sites in 2007, 52% of sites in 2011, 44% of sites in 2012, 51% of sites in 2013, 42% of sites in 2014, and 22% of sites in 2015. Other frequent species included flat-stem pondweed and forked duckweed.

[27]

[27] Rake of coontail, August 10th, 2007

Spring frequency of occurrence at sites shallower than the maximum depth of plants, 2007, 2011, and 2013-2015					
	5/14/07	5/19/11	6/11/13	6/2/14	5/20/15
Ceratophyllum demersum, coontail	18.85	18.38	25.00	16.74	10.73
Filamentous algae	8.08	3.68	2.84	9.30	2.68
Heteranthera dubia, water star-grass			1.14		0.38
Lemna minor, small duckweed			1.70		
Lemna trisulca, forked duckweed	1.92	8.82	11.36	15.81	3.07
Myriophyllum sibiricum, northern water milfoil		1.47	0.57	1.40	2.30
Nitella sp., nitella					0.38
Nuphar variegata, spatterdock		0.74	0.57	1.86	0.77
Nymphaea odorata, white water lily		0.37	1.70	0.93	0.38
Potamogeton crispus, curly-leaf pondweed	96.54	66.91	53.41	31.63	51.34
Potamogeton praelongis, white-stem pondweed		0.37	2.27	0.93	0.77
Potamogeton pulcher, spotted pondweed		0.37			
Potamogeton pusillus, small pondweed	1.15	9.93	26.14	20.93	10.34
Potamogeton zosteriformis, flat-stem pondweed	2.31	2.94	11.93	6.98	3.07
Ranunculus aquatilis, white water crowfoot			2.27		0.77
Vallisneria americana, wild celery			0.57		
Wolffia columbiana, common watermeal			1.14		
Zizania palustris, northern wild rice			0.57	0.93	0.77

Fall frequency of occurrence at sites shallower than the maximum depth of plants, 2007 and 2011-2015						
	8/10/07	8/10/11	8/13/12	8/13/13	8/25/14	8/26/15
Ceratophyllum demersum, coontail	31.10	52.31	43.64	51.11	41.94	22.22
Chara sp., Muskgrasses						0.38
Elodea canadensis, common waterweed	0.39					1.15
Filamentous algae	3.15		2.73	5.56	5.65	3.07
Heteranthera dubia, water star-grass	0.39	1.54		2.22	4.03	0.77
Lemna minor, small duckweed	1.18	3.85		1.11	3.23	1.15
Lemna trisulca, forked duckweed	5.12	24.62	15.45	17.78	21.77	11.49
Myriophyllum sibiricum, northern water milfoil	1.18	4.62	7.27	5.56	7.26	3.07
Najas flexilis, bushy pondweed	0.39	2.31		1.11	4.84	
Nitella sp., nitella	0.39					
Nuphar variegata, spatterdock		3.85	0.91		2.42	0.38
Nymphaea odorata, white water lily	0.79	2.31	3.64	5.56	3.23	1.92
Potamogeton amplifolius, large-leaf pondweed					0.81	
Potamogeton crispus, curly-leaf pondweed	0.39	0.77	0.91	1.11	0.81	0.38
Potamogeton illinoensis, Illinois pondweed	1.18					
Potamogeton praelongis, white-stem pondweed		1.54		2.22		1.15
Potamogeton pusillus, small pondweed	0.39	4.62		11.11	6.45	0.77
Potamogeton richardsonii, clasping-leaf pondweed	0.79	1.54	0.91	5.56	0.81	1.15
Potamogeton zosteriformis, flat-stem pondweed	5.51	17.69	13.64	30.00	16.13	9.20
Ranunculus aquatilis, white water crowfoot		0.77		1.11	0.81	0.77
Sparganium angustifolium, narrow-leaved bur-reed			4.55			
Spirodela polyrhiza, large duckweed	0.39	3.85		1.11		
Stuckenia pectinata, sago pondweed	0.39					
Vallisneria americana, wild celery		0.77	1.82	3.33		0.77
Wolffia columbiana, common watermeal		0.77		1.11	0.81	1.15
Zizania palustris, northern wild rice		0.77				

Relative Frequency

Relative frequency is the frequency of a particular plant species relative to other plant species. This value is independent of the number of points sampled. Relative frequency can be used to show which plants are the dominant species in a lake. The higher the value a species has for relative frequency, the more common the species is compared to others. The relative frequency of all plants will always add up to 100%. If species A had a relative frequency of 30%, this species occurred 30% of the time compared to all the species sampled or makes up 30% of all species sampled.

Relative frequency example:
Suppose we were sampling 10 points in a very small lake and got the following results:
Plant A present at 3 of 10 sites
Plant B present at 5 of 10 sites
Plant C present at 2 of 10 sites
Plant D present at 6 of 10 sites

Plant D is the most frequently sampled at all points, with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency of Plant D is compared to other plants, without taking into account the number of sites. This value is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can calculate the relative frequency by dividing by the individual frequency.

Plant A = 3/16 = 0.1875 or 18.75%
Plant B = 5/16 = 0.3125 or 31.25%
Plant C = 2/16 = 0.125 or 12.5%
Plant D = 6/16 = 0.375 or 37.5%

Now we can compare the plants to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%) because, although we sampled Plant D at 6 of 10 sites, we were sampling many other plants too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

In the spring, the most dominant plant in Big Blake Lake as indicated by relative frequency was curly-leaf pondweed. Curly-leaf pondweed made up 75% of the plant community in 2007, 61% in 2011, 38% in 2013, 32% in 2014, and 60% in 2015. Other dominant plants, as indicated by relative frequency included small pondweed, coontail, and forked duckweed.

In the fall, the most dominant plant in Big Blake Lake as indicated by relative frequency was coontail. Coontail made up 59% of the plant community in 2007, 41% in 2011, 46% in 2012, 36% in 2013, 36% in 2014, and 38% in 2015. Other dominant plants, as indicated by relative frequency included flat-stem pondweed and forked duckweed.

Spring relative frequency, 2007, 2011, and 2013-2015					
	5/14/07	5/19/11	6/11/13	6/2/14	5/20/15
Ceratophyllum demersum, coontail	14.6	16.7	17.8	17.1	12.6
Filamentous algae	6.3				
Heteranthera dubia, water star-grass			0.8		0.5
Lemna minor, small duckweed			1.2		
Lemna trisulca, forked duckweed	1.5	8.0	8.1	16.1	3.6
Myriophyllum sibiricum, northern water milfoil		1.3	0.4	1.4	2.7
Nitella sp., nitella					0.5
Nuphar variegata, spatterdock		0.7	0.4	1.9	0.9
Nymphaea odorata, white water lily		0.3	1.2	0.9	0.5
Potamogeton crispus, curly-leaf pondweed	74.9	60.7	38.1	32.2	60.4
Potamogeton praelongis, white-stem pondweed		0.3	1.6	0.9	0.9
Potamogeton pulcher, spotted pondweed		0.3			
Potamogeton pusillus, small pondweed	0.9	9.0	18.6	21.3	12.2
Potamogeton zosteriformis, flat-stem pondweed	1.8	2.7	8.5	7.1	3.6
Ranunculus aquatilis, white water crowfoot			1.6		0.9
Vallisneria americana, wild celery			0.4		
Wolffia columbiana, common watermeal			0.8		
Zizania palustris, northern wild rice			0.4	0.9	0.9

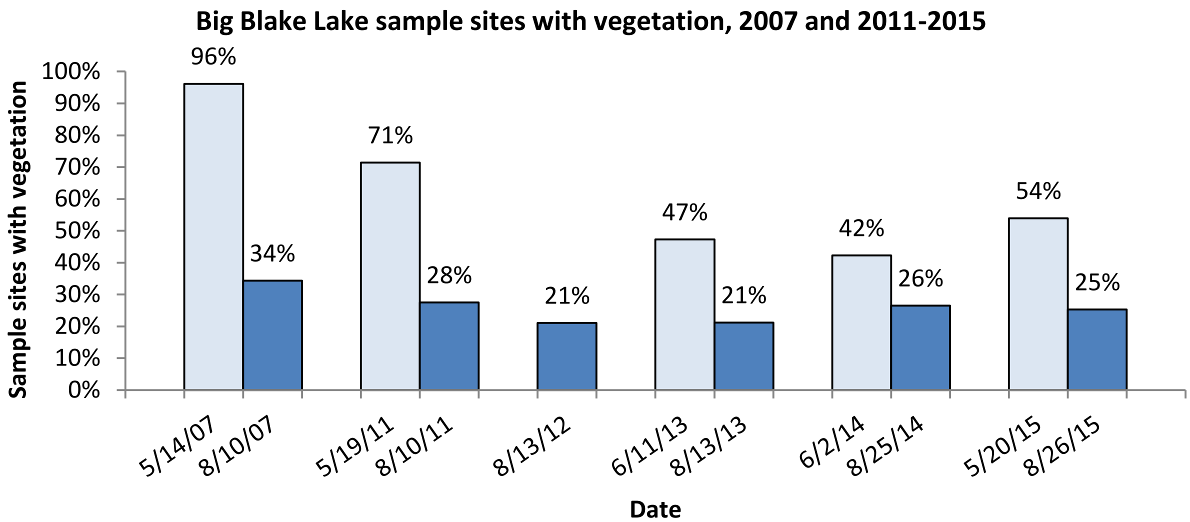
Fall relative frequency, 2007, 2011, and 2013-2015						
	8/10/07	8/10/11	8/13/12	8/13/13	8/25/14	8/26/15
Ceratophyllum demersum, coontail	58.5	40.7	45.7	36.2	36.4	38.4
Chara sp., Muskgrasses						0.7
Elodea canadensis, common waterweed	0.7					2.0
Filamentous algae	5.9		2.9			
Heteranthera dubia, water star-grass	0.7	1.2		1.6	3.5	1.3
Lemna minor, small duckweed	2.2	3.0		0.8	2.8	2.0
Lemna trisulca, forked duckweed	9.6	19.2	16.2	12.6	18.9	19.9
Myriophyllum sibiricum, northern water milfoil	2.2	3.6	7.6	3.9	6.3	5.3
Najas flexilis, bushy pondweed	0.7	1.8		0.8	4.2	
Nitella sp., nitella	0.7					
Nuphar variegata, spatterdock		3.0	1.0		2.1	0.7
Nymphaea odorata, white water lily	1.5	1.8	3.8	3.9	2.8	3.3
Potamogeton amplifolius, large-leaf pondweed					0.7	
Potamogeton crispus, curly-leaf pondweed	0.7	0.6	1.0	0.8	0.7	0.7
Potamogeton illinoensis, Illinois pondweed	2.2					
Potamogeton praelongis, white-stem pondweed		1.2		1.6		2.0
Potamogeton pusillus, small pondweed	0.7	3.6		7.9	5.6	1.3
Potamogeton richardsonii, clasping-leaf pondweed	1.5	1.2	1.0	3.9	0.7	2.0
Potamogeton zosteriformis, flat-stem pondweed	10.4	13.8	14.3	21.3	14.0	15.9
Ranunculus aquatilis, white water crowfoot		0.6		0.8	0.7	1.3
Sparganium angustifolium, narrow-leaved burreed			4.8			
Spirodela polyrhiza, large duckweed	0.7	3.0		0.8		
Stuckenia pectinata, sago pondweed	0.7					
Vallisneria americana, wild celery		0.6	1.9	2.4		1.3
Wolffia columbiana, common watermeal		0.6		0.8	0.7	2.0
Zizania palustris, northern wild rice		0.6				

Sample Points with Vegetation

This value shows the number of sites where plants were actually collected and gives an approximation of the plant coverage of a lake. If 10% of all sample points had vegetation, then it is implied that approximately 10% of the lake is covered with plants.

In all sample years the percent of Big Blake Lake that is covered with plants was greater in spring as compared to fall. Overall, plant coverage has decreased when comparing the earliest sampling years (2007 and 2011) to the later sampling years. The decrease is much more pronounced in the spring sampling period.

In the years with the most dense curly-leaf pondweed growth (2007, 2011, and 2015), the percent of the lake covered with plants in the spring was also the greatest. This arises because the majority of the plants sampled in these years were curly-leaf pondweed.

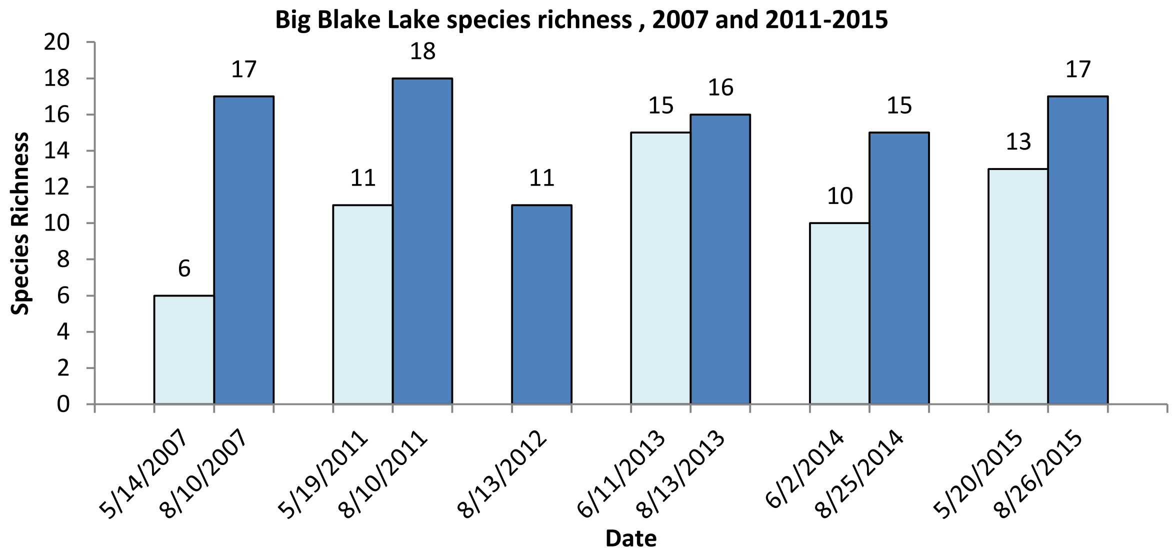


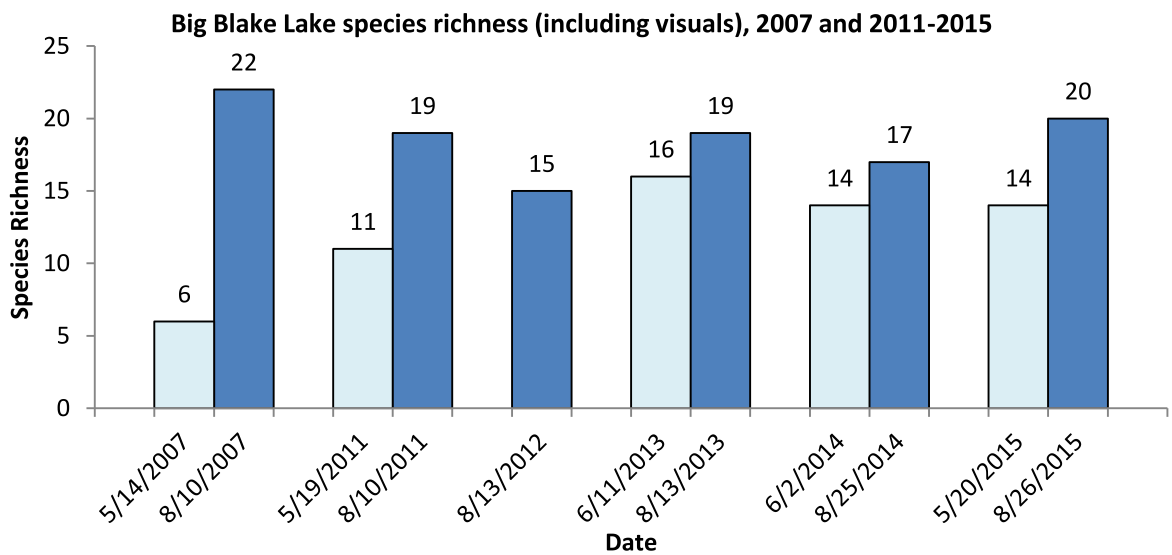
Species Richness

Species richness is a measure of the number of different individual species found in a lake. Species richness can be computed based on plants sampled or based on plants sampled/visually seen during the survey.

In all sampling years, species richness was greater in the fall as compared to the spring.

Species richness was notably lower in spring 2007 as compared with all other sampling years. This was the year curly-leaf pondweed growth was the most prolific. However, across all other years species richness has remained fairly constant, with the exception of fall 2012.





Simpson's Diversity Index

Simpson's Diversity Index (D) is used to determine how diverse the plant community in a lake is by measuring the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). This value ranges from zero to one, with greater values representing more diverse plant communities. In theory, the value for Simpson's Diversity Index is the chance that two species that are sampled will be different. An Index of one means that the two plants sampled will *always* be different (very diverse) and an Index of zero means that the two plants sampled will *never* be different. Simpson's Diversity Index can be calculated by using the equation

$$D = \frac{\sum n(n-1)}{N(N-1)};$$

Where: D = Simpson's Diversity Index;
n= the total number of organisms of a particular species; and
N=the total number of organisms of all species.

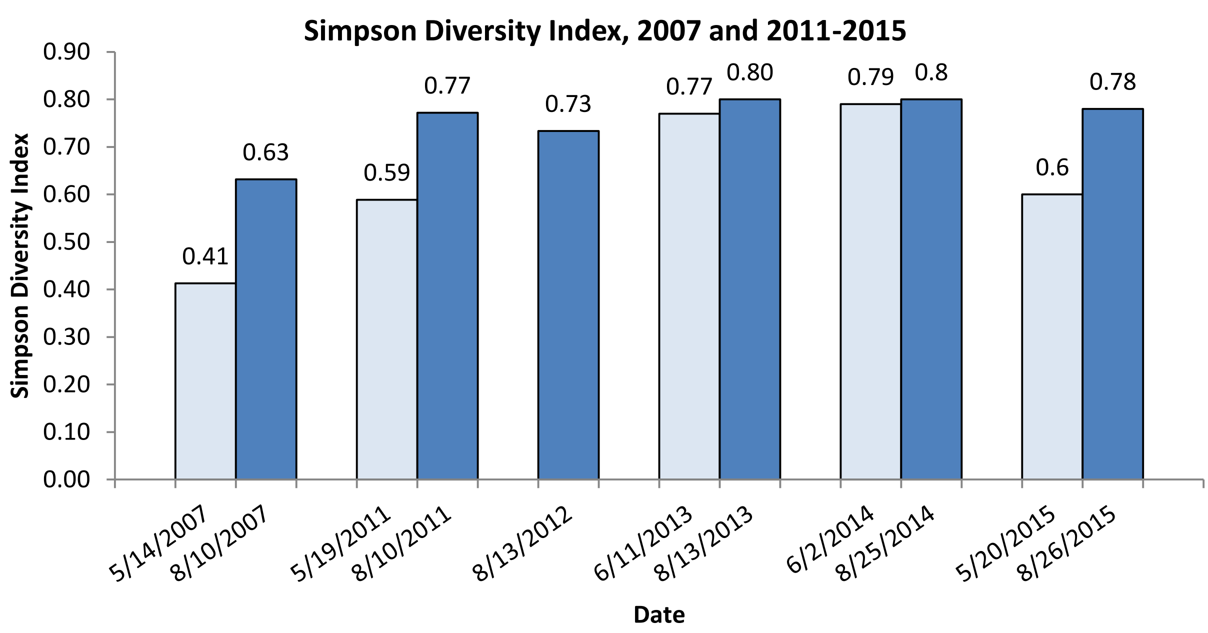
Simpson's Diversity Index example:

If one went into a lake and found just one plant, the Simpson's Diversity Index would be "0." This is because if two plants were sampled randomly, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's Diversity Index would be "1." This is because if two plants were sampled randomly, there would be a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they do make the point. The greater the Simpson's Diversity Index is for a lake, the greater the diversity since it represents a greater chance of two randomly sampled plants being different.

Diversity in Big Blake Lake has remained relatively constant since 2012. In 2007 spring and fall diversity values were notably lower as compared to all other sampling years. Additionally, low spring diversity values occurred in the years curly-leaf pondweed growth was the most prolific.



Floristic Quality Index

The Floristic Quality Index (FQI) is designed to evaluate the closeness of the flora in an area to that of an undisturbed condition. It can be used to identify natural areas, compare the quality of different sites or locations within a single lake, monitor long-term floristic trends, and monitor habitat restoration efforts. This is an important assessment in Wisconsin because of the demand by the Department of Natural

Resources (DNR), local governments, and riparian landowners to consider the integrity of lake plant communities for planning, zoning, sensitive area designation, and aquatic plant management decisions.

The FQI takes into account the species of aquatic plants found and their tolerance for changing water quality and habitat modification using the equation $I = \overline{C}\sqrt{N}$

Where I is the Floristic Quality Index;
$\overline{C}$ is the average coefficient of conservation (http://www.botany.wisc.edu/wisflora/FloristicR.asp);
and $\sqrt{N}$ is the square root of the number of species.

The Index uses a conservatism value assigned to various plants ranging from 1 to 10. A high conservatism value indicates that a plant is intolerant of change while a lower value indicates a plant is tolerant of change. Those plants with higher values are more apt to respond adversely to water quality and habitat changes. The FQI is calculated using the number of species and the average conservatism value of all species used in the Index. Therefore, a higher FQI indicates a healthier lake plant community. It should be noted that invasive species have a conservatism value of 0.

Summary of North Central Hardwood Forest values for Floristic Quality Index

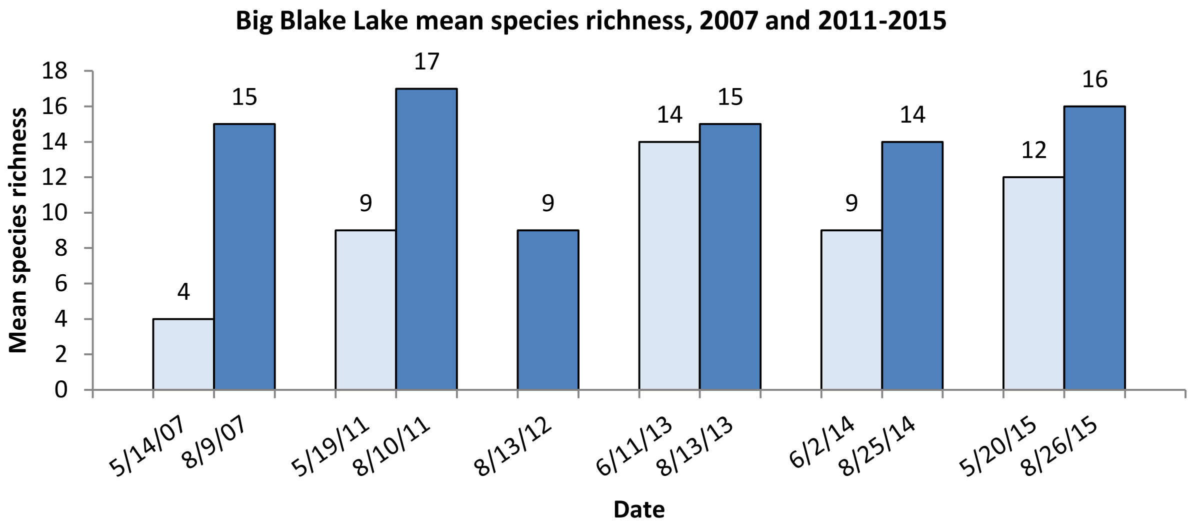
Mean species richness = 14
Mean average conservatism = 5.6
Mean Floristic Quality = 20.9*

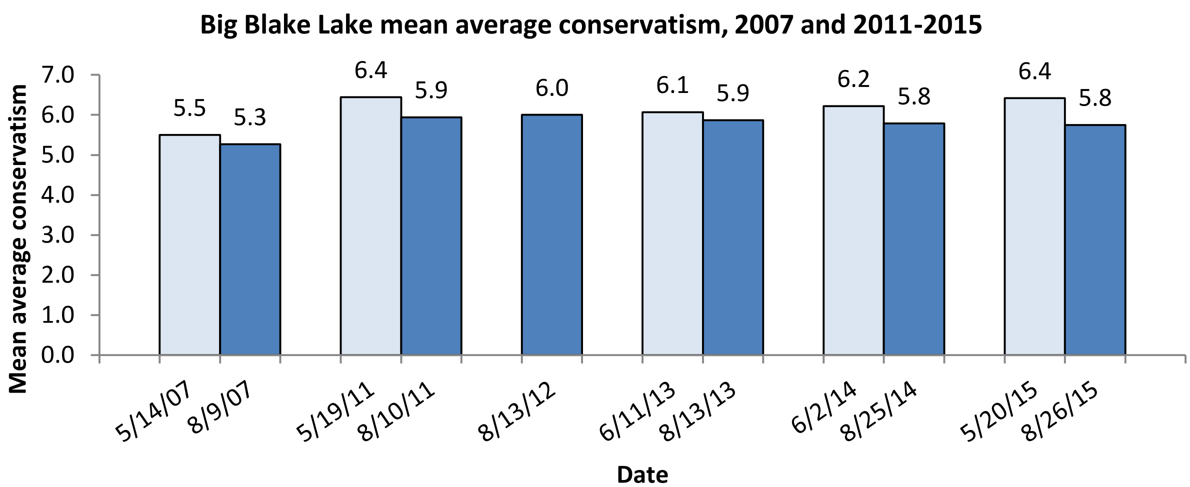
**Floristic Quality has a significant correlation with area of lake (+), alkalinity (-), conductivity (-), pH (-) and secchi depth (+). With a positive correlation, as that value rises so will FQI. With a negative correlation, as a value rises, the FQI will decrease.*

Using data from 2007 and 2011-2015, the mean species richness for Big Blake Lake is 12, which is below the mean value for the North Central Hardwood Forest. The mean average conservatism value for Big Blake Lake is 5.9, which is above the mean value for the North Central Hardwood Forest. The mean Floristic Quality value for Big Blake Lake is 20.4 which is just below the mean value for the North Central Hardwood Forest.

Using data from only the past three years during which the study took place (2013-2015), the mean species richness for Big Blake Lake is 13, which remains below the mean value for the North Central Hardwood Forest. However, the mean average conservatism value (6.0) and the mean Floristic Quality (21.8) are both above the value for the North Central Hardwood Forest.

Mean species richness, mean average conservatism, and mean floristic quality for spring of 2007 were substantially lower as compared with spring 2011-2015.


Big Blake Lake mean species richness, 2007 and 2011-2015
Mean species richness
Date
0
2
4
6
8
10
12
14
16
18
4
15
9
17
9
14
15
9
14
12
16
5/14/07
8/9/07
5/19/11
8/10/11
8/13/12
6/11/13
8/13/13
6/2/14
8/25/14
5/20/15
8/26/15


Big Blake Lake mean average conservatism, 2007 and 2011-2015
Mean average conservatism
Date
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
5.5
5.3
6.4
5.9
6.0
6.1
5.9
6.2
5.8
6.4
5.8
5/14/07
8/9/07
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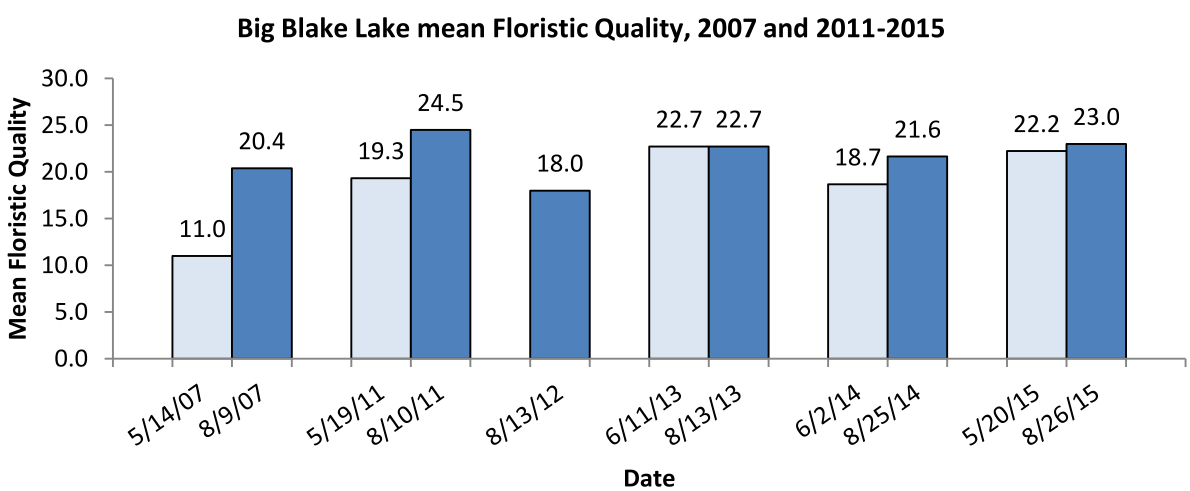
8/25/14
5/20/15
8/26/15


Big Blake Lake mean Floristic Quality, 2007 and 2011-2015
Mean Floristic Quality
Date
0.0
5.0
10.0
15.0
20.0
25.0
30.0
11.0
20.4
19.3
24.5
18.0
22.7
22.7
18.7
21.6
22.2
23.0
5/14/07
8/9/07
5/19/11
8/10/11
8/13/12
6/11/13
8/13/13
6/2/14
8/25/14
5/20/15
8/26/15

Land Use and Water Quality

The health of water resources depends largely on the decisions that landowners make on their properties. When waterfront lots are developed, a shift from native plants and trees to impervious surfaces and lawn often occurs. Impervious surfaces are hard, man-made surfaces such as rooftops, paved driveways, and concreate patios that make it impossible for rain to infiltrate into the ground.

By making it impossible for rainwater to infiltrate into the soil, impervious surfaces increase the volume of rainwater that washes over the soil surface and runs off directly into lakes and streams. Rainwater runoff can carry pollutants such as sediment, lawn fertilizers, and car oils directly into a lake. Native vegetation can slow the speed of rainwater, giving it time to soak into the soil where it is filtered by soil microbes.

In extreme precipitation events, erosion and gullies can result. The signs of erosion are unattractive and can cause decreases in property values. Sediment can also have negative impacts on aquatic life: fish eggs will die when covered with sediment and sediment influxes to a lake can decrease water clarity making it difficult for predator fish species to locate food.

Increases in impervious surfaces and lawns cause a loss of habitat for birds and other wildlife. Over ninety percent of all lake life is born, raised, and fed in the area where land and water meet. Overdeveloped shorelines remove critical habitat which species such as loons, frogs, songbirds, ducks, otters, and mink depend on. Impervious surfaces and lawns can be thought of as biological desserts which lack food and shelter for birds and wildlife. Nuisance species such as Canada geese favor lawns over taller native grasses and flowers. Lawns provide geese with a ready food source (grass) and a sense of security from predators (open views).

Additionally, fish species depend on the area where land and water meet for spawning. The removal of coarse woody habitat, or trees and braches that fall into a lake, cause decreases in fisheries habitat.

Common lawn species, such as Kentucky bluegrass, are often dependent on chemical fertilizers and require mowing. Excess chemical fertilizers are washed directly into the adjacent water during precipitation events. The phosphorus and other nutrients in fertilizers, which produce lush vegetative growth on land, are the same nutrients which fuel algae blooms and decrease water clarity in a lake. Additionally, since common lawn species have very shallow root systems, when lawns are located on steep slopes, soil capacity is reduced and the impacts of erosion can be intensified.

Avoiding establishing lawns can provide direct positive impacts on lake water quality. The creation of a buffer zone of native grasses, wildflowers, shrubs, and trees where the land meets the water can provide numerous benefits for water quality and restore valuable bird and wildlife habitat.

In Polk County, all new constructions on lakeshore properties require that a shoreland protection area be in place. A shoreland protection area is required to be 35 feet in depth as measured from the ordinary high water mark, which is defined as the point on the bank or shore up to which the water leaves a distinct mark (erosion, change in vegetation, etc.). These rules are in place largely to protect water quality and also provide benefits in terms of natural beauty and bird and wildlife viewing opportunities. Additionally, shoreline protection areas allow for a 35 foot maximum viewing corridor (per 100 feet of frontage).

Historical Land Use in the Big Blake Lake Watershed

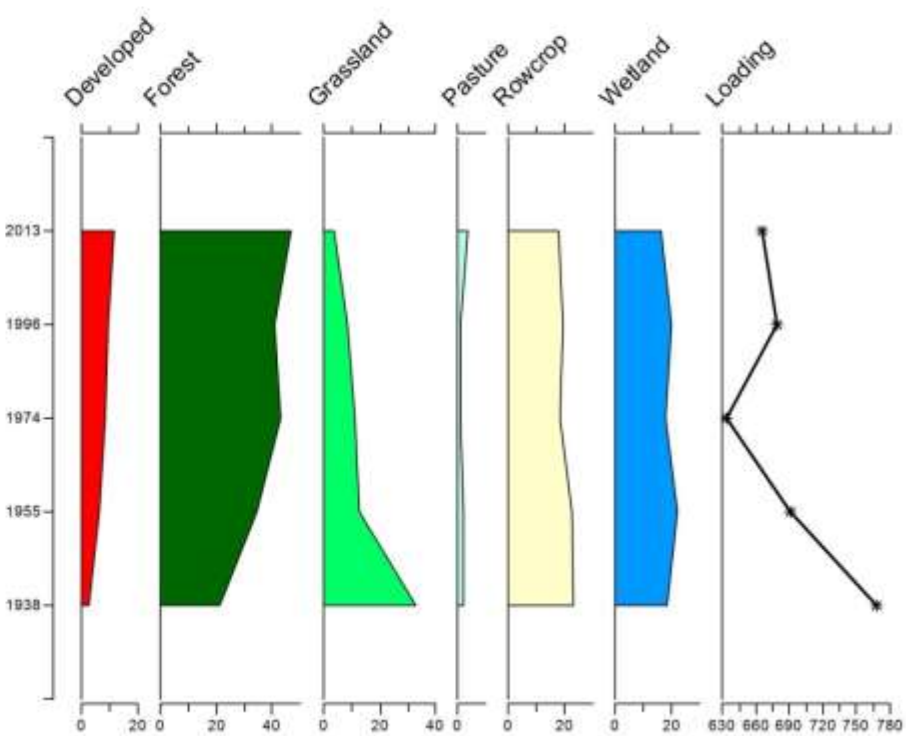
The area of land that drains to a lake is called a watershed. A student from the University of Wisconsin-River Falls delineated the land use in the Big Blake Lake watershed for the years 1938, 1955, 1974, 1996, and 2013. Land use was categorized as developed, forest, grassland, pasture, row crop, and wetland.

Over this timeframe, the amount of pasture, row crop, and wetland has remained fairly consistent; the amount of grassland has decreased (33% to 4%); and the amount of forest and developed land has increased (21% to 47% and 3% to 12%, respectively).

The Wisconsin Lakes Modeling Suite (WiLMS) was used to model conditions for Big Blake Lake each year and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algae growth in most waterbodies.

This data indicated that based on land use, phosphorus loading was greatest in 1938 (769 lbs/yr), followed by 1955 (691 lbs/yr), 1996 (679 lbs/yr), 2013 (666 lbs/yr), and 1974 (634 lbs/yr).

Date	Developed (acres)	Forest (acres)	Grassland (acres)	Pasture (acres)	Row crop (acres)	Wetland (acres)	Phosphorus loading (lbs/yr)
1938	57, (3%)	451, (21%)	705, (33%)	40, (2%)	490, (23%)	391, (18%)	769
1955	132, (6%)	753, (35%)	279, (13%)	40, (2%)	489, (23%)	474, (22%)	691
1974	179, (8%)	922, (43%)	244, (11%)	26, (1%)	392, (18%)	379, (18%)	634
1996	204, (10%)	873, (41%)	177, (8%)	28, (1%)	417, (20%)	421, (20%)	679
2013	250, (12%)	1004, (47%)	80, (4%)	80, (4%)	390, (18%)	348, (16%)	666

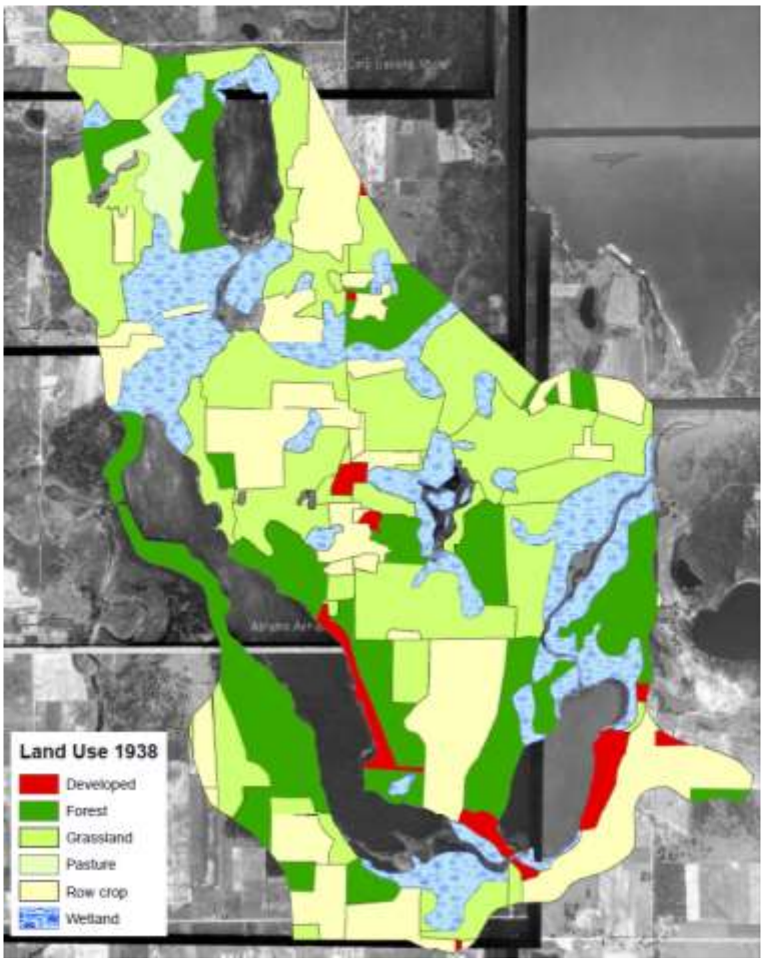


Historic Land Use and Nutrient Loading in the Big Blake Lake Watershed

The area of land that drains towards a lake is called a watershed. The Wisconsin Lakes Modeling Suite (WiLMS) was used to model historic and current conditions for Big Blake Lake, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

Land Use and Nutrient Loading – 1938

In 1938 the watershed for Big Blake was delineated at 2133.4 acres with a total watershed phosphorus load of 769 pounds.



The most common land use in 1938 was pasture/grass (32%) followed by row crop (21%), forest (19%), and wetland (17%). At this point in time, rural residential development accounted for only 2% of the land use in the Big Blake Lake watershed.

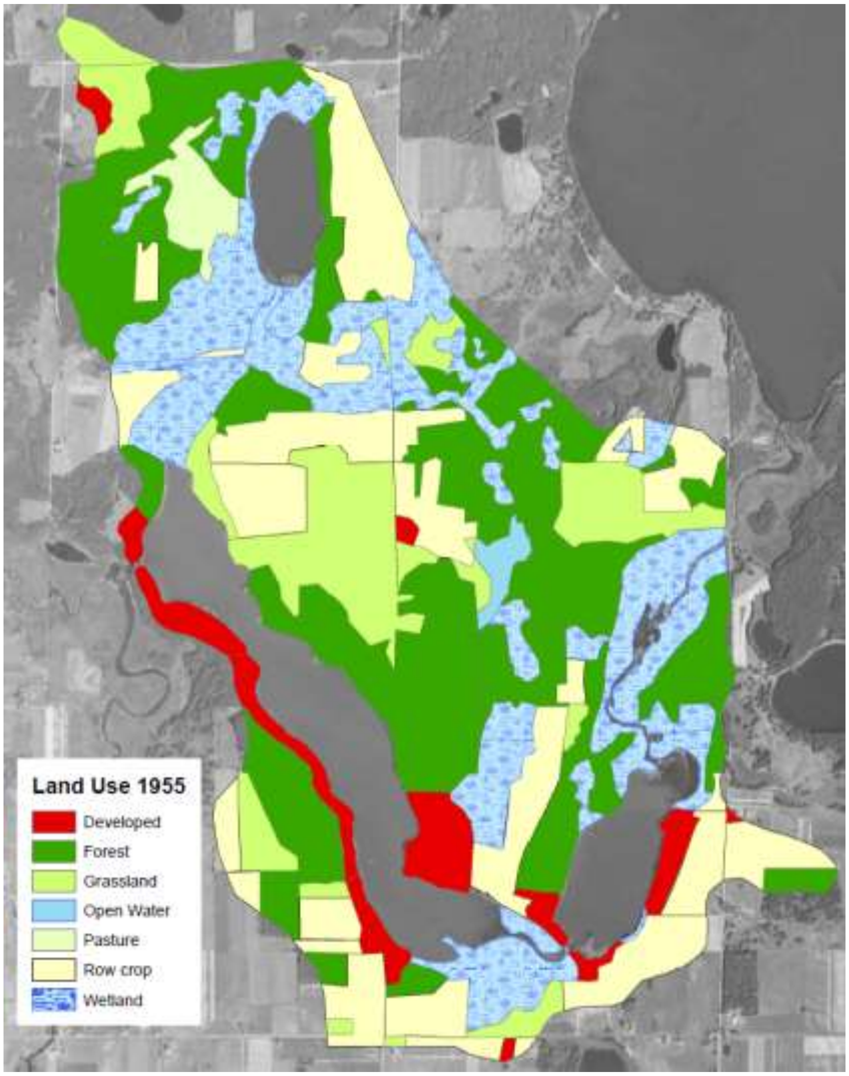
The largest contributor of phosphorus to Big Blake Lake was row crop (57%) followed by pasture/grass (26%). Precipitation to the surface of the lake contributed 7% of the total phosphorus load and natural state land uses such as forest and wetlands each contributed 5% of the total phosphorus load. Residential contributed only 1% of the total watershed phosphorus load.

1938 Land Use and Nutrient Loading

	Total Acres	Percent Acres (%)	Total Loading (lb P/yr)	Loading %
Row crop	490.1	21%	437	57%
Pasture/grass	744.7	32%	198	26%
Rural residential	56.9	2%	4	1%
Wetlands	391.1	17%	35	5%
Forest	450.6	19%	35	5%
Lake surface	208	9%	55	7%

Land Use and Nutrient Loading – 1955

In 1955 the watershed for Big Blake was delineated at 2165.5 acres with a total watershed phosphorus load of 691 pounds.



The most common land use in 1955 was forest (32%) followed by row crop (21%), wetland (20%), and pasture/grass (13%). At this point in time, residential development accounted for 6% of the land use in the Big Blake Lake watershed.

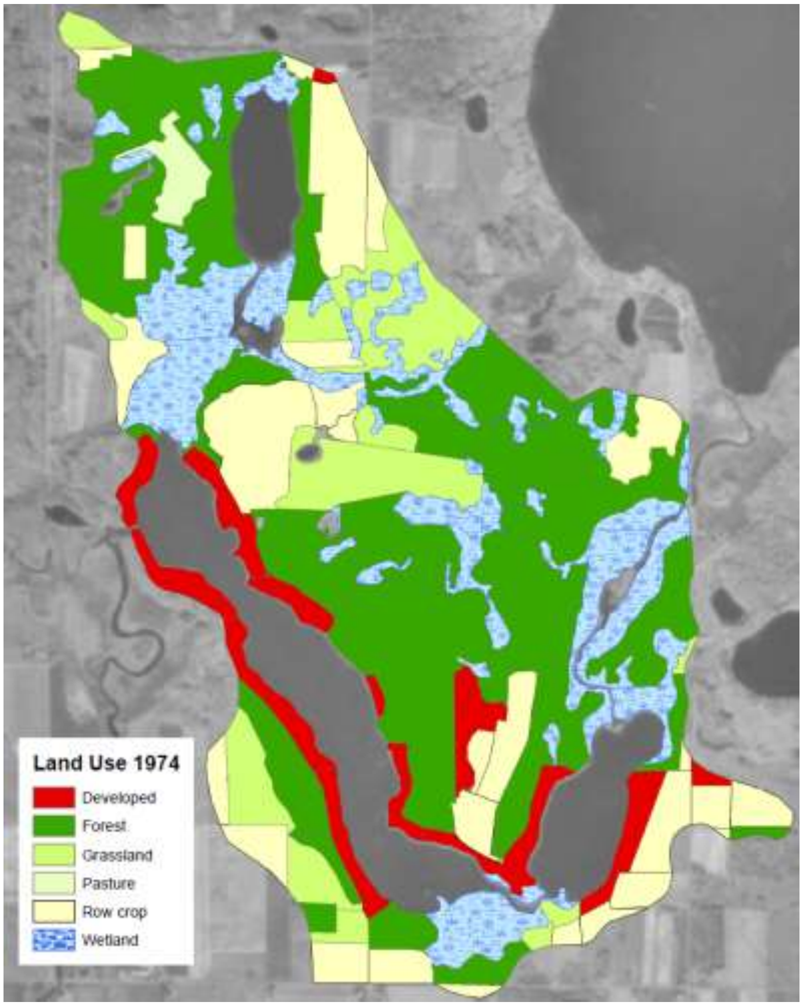
The largest contributor of phosphorus to Big Blake Lake was row crop (63%) followed by pasture/grass (12%). Precipitation to the surface of the lake contributed 8% of the total phosphorus load and natural state land uses such as forest and wetlands contributed 9% and 6% of the total phosphorus load, respectively. Rural residential contributed only 2% of the total watershed phosphorus load.

1955 Land Use and Nutrient Loading

	Total Acres	Percent Acres (%)	Total Loading (lb P/yr)	Loading %
Row crop	488.5	21%	437	63%
Pasture/grass	318.5	13%	86	12%
Rural residential	131.7	6%	11	2%
Wetlands	474.1	20%	42	6%
Forest	752.7	32%	60	9%
Lake surface	208	9%	55	8%

Land Use and Nutrient Loading – 1974

In 1974 the watershed for Big Blake was delineated at 2142.3 acres with a total watershed phosphorus load of 634 pounds.



The most common land use in 1974 was forest (39%) followed by row crop (17%), wetland (16%), and pasture/grass (12%). At this point in time, residential development accounted for 8% of the land use in the Big Blake Lake watershed.

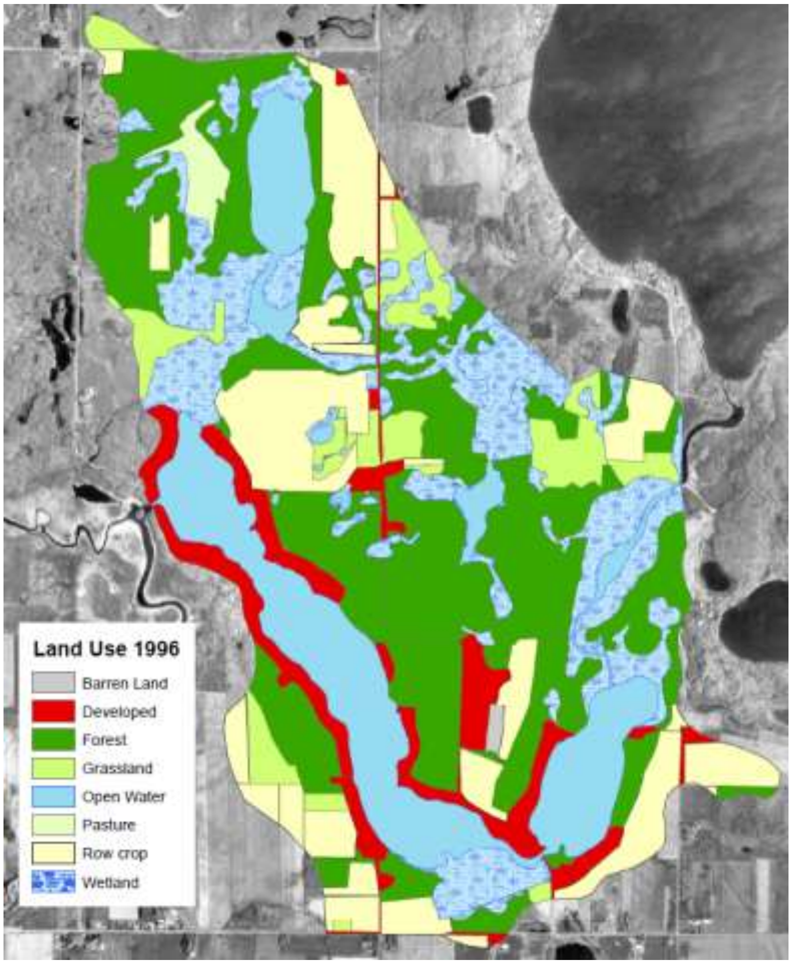
The largest contributor of phosphorus to Big Blake Lake was row crop (55%) followed by forest (12%), and pasture/grass (11%). Precipitation to the surface of the lake contributed 9% of the total phosphorus load. Wetlands contributed 5% of the total phosphorus load. By 1974, residential contributed 7% of the total watershed phosphorus load.

1974 Land Use and Nutrient Loading

	Total Acres	Percent Acres (%)	Total Loading (lb P/yr)	Loading %
Row crop	392.2	17%	351	55
Pasture/grass	270.4	12%	73	11
Medium density residential	89.7	4%	40	6
Rural residential	89.7	4%	9	1
Wetlands	378.9	16%	33	5
Forest	921.6	39%	75	12
Lake surface	208	9%	55	9

Land Use and Nutrient Loading – 1996

In 1996 the watershed for Big Blake was delineated at 2119.1 acres with a total watershed phosphorus load of 679 pounds.



The most common land use in 1996 was forest (37%) followed by row crop (18%), and wetland (18%). Pasture/grass made up 9% of the land use in the Big Blake Lake watershed. At this point in time, residential development accounted for 9% of the land use in the Big Blake Lake watershed.

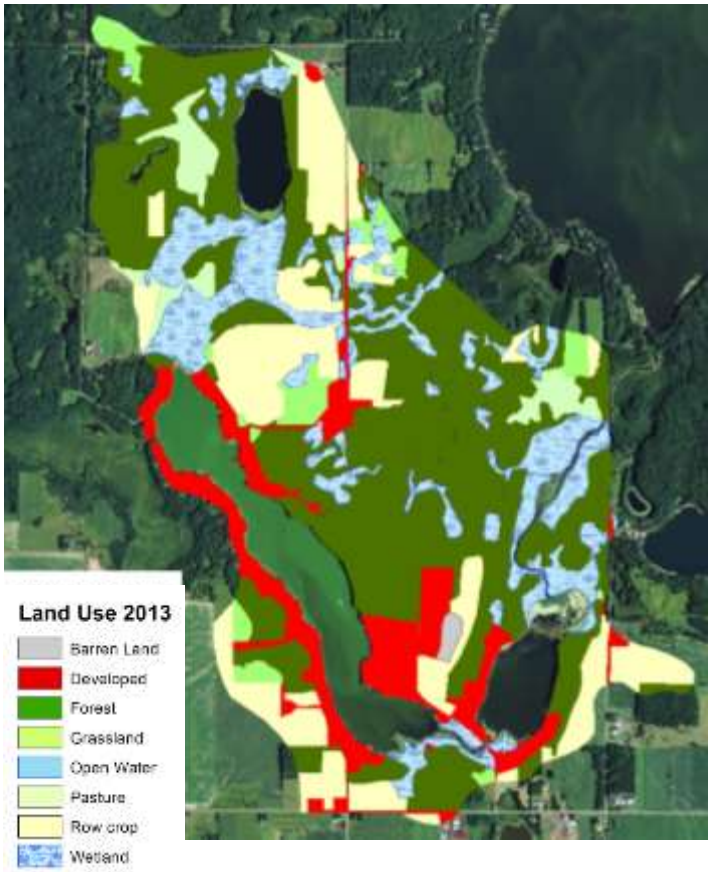
The largest contributor of phosphorus to Big Blake Lake was row crop (55%) followed by forest (10%), and pasture/grass (8%). Precipitation to the surface of the lake contributed 8% of the total phosphorus load and wetlands contributed 5% of the total phosphorus load. By 1996, residential contributed 13% of the total watershed phosphorus load.

1996 Land Use and Nutrient Loading

	Total Acres	Percent Acres (%)	Total Loading (lb P/yr)	Loading %
Row crop	416.6	18%	373	54.7
Pasture/grass	204.5	9%	55	8.1
Medium density residential	200	9%	88	13.1
Rural residential	4.2	0%	0	0.1
Wetlands	421.1	18%	37	5.5
Forest	872.6	37%	71	10.3
Lake surface	208	9%	55	8.2

Land Use and Nutrient Loading – 2013

In 2013 the watershed for Big Blake was delineated at 2150.7 acres with a total watershed phosphorus load of 666 pounds.



The most common land use in 2013 was forest (43%) followed by row crop (17%), and wetland (15%). Pasture/grass made up 7% of the land use in the Big Blake Lake watershed. At this point in time, residential development accounted for 10% of the land use in the Big Blake Lake watershed.

The largest contributor of phosphorus to Big Blake Lake was row crop (52%) followed by residential (16%), and forest (12%). Precipitation to the surface of the lake contributed 8% of the total phosphorus load, pasture/grass contributed 6% of the total phosphorus load, and wetlands contributed 5% of the total phosphorus load.

2013 Land Use and Nutrient Loading

	Total Acres	Percent Acres (%)	Total Loading (lb P/yr)	Loading %
Row crop	390.5	17%	348	52%
Pasture/grass	159.2	7%	42	6%
Medium density residential	240	10%	108	16%
Rural residential	9.7	0%	0	0.1%
Wetlands	347.8	15%	31	5%
Forest	1003.6	43%	82	12%
Lake surface	208	9%	55	8%

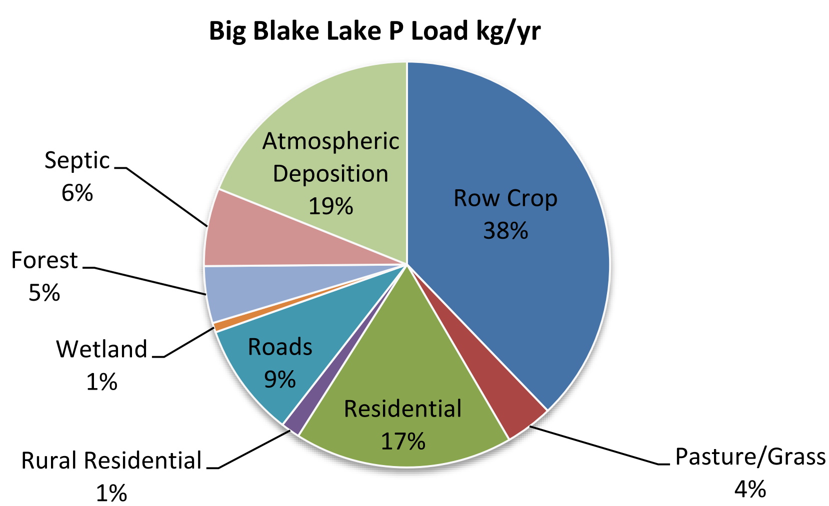
Watershed and Lake Modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions for Big Blake Lake, verify monitoring, and estimate land use nutrient loading for the watershed. Phosphorus is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

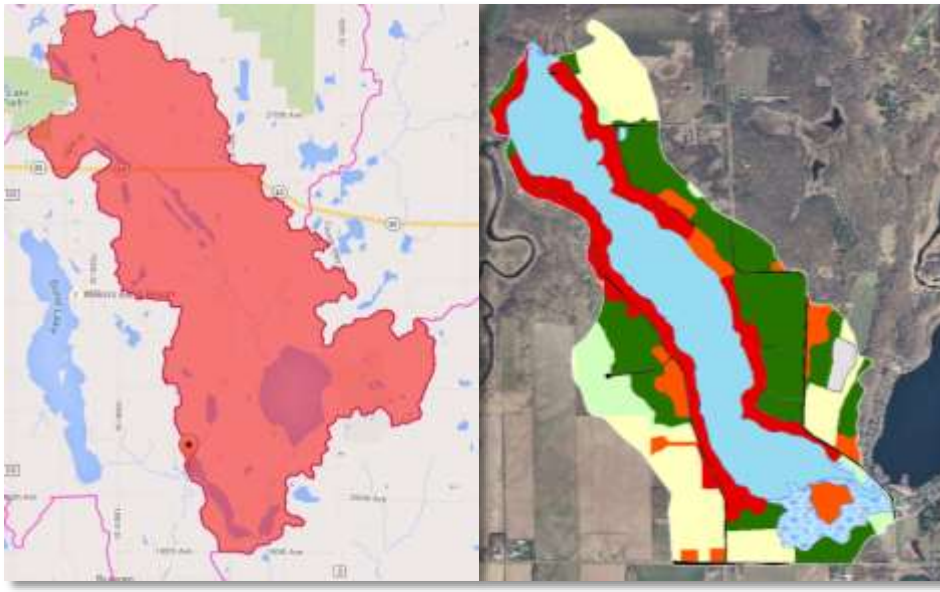
Based on average evaporation, precipitation, and runoff coefficients for Polk County soils and land use, WiLMS determined the annual nonpoint source load of phosphorus to Big Blake Lake as 7,432 kilograms per year (16,380 pounds), the direct drainage to the lake minus the tributaries was calculated to be 132 kilograms per year (291 pounds).

Big Blake Lake Nutrient Budget

Source	Phosphorus load (kg/yr)
Row Crop	50
Pasture/Grass	5
Residential	23
Rural Residential	2
Roads	12
Wetland	1
Forest	6
Septic	8.22
Atmospheric Deposition	25
Lost Creek	1218.5
Straight River	6081.2



The land use for the entire watershed was obtained from Purdue University Agricultural Biological Engineering Department's Long Term Hydrologic Impact Analysis (L-THIA). ArcGIS was then used to clip the subwatersheds of the basin and the direct drainage to the lake was modeled using in-situ phosphorus loading from the tributaries modeled as a point sources and the direct drainage land use. Because the outlet of the lake was breeched in 2014, scenarios were modeled for the three years of the study with several different scenarios.



L-THIA watershed vs. the direct drainage to Big Blake Lake

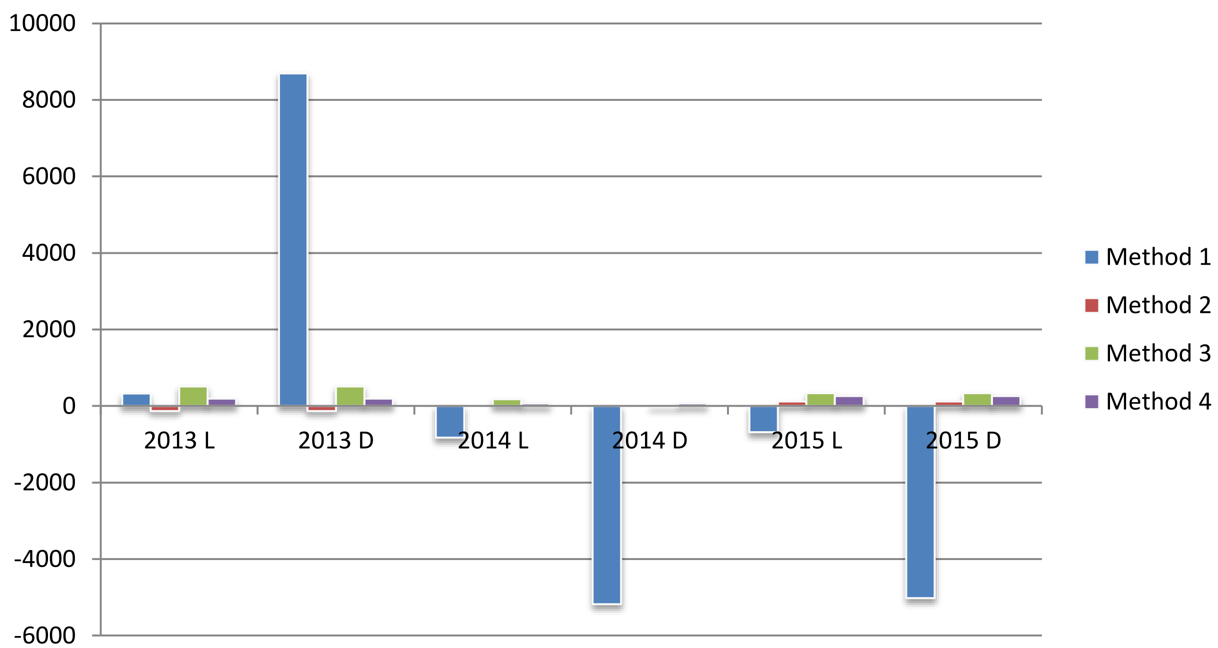
The internal load for Big Blake Lake was estimated using in-situ data and four methods were used to estimate internal loading.

The first method was a complete total phosphorus mass budget. This method calculated the annual internal phosphorus load under the L-THIA scenario to be 149 kg (327 lbs.) in 2013, -375 kg (-827 lbs) in 2014, and -311 kg (-686 lbs.) in 2015. The annual internal phosphorus load under the direct drainage scenario was estimated to be 3,943 kg (8,649 lbs.) in 2013, -2,350 kg (-5,181 lbs.) in 2014, and -2,275 kg (-5,016 lbs.) in 2015.

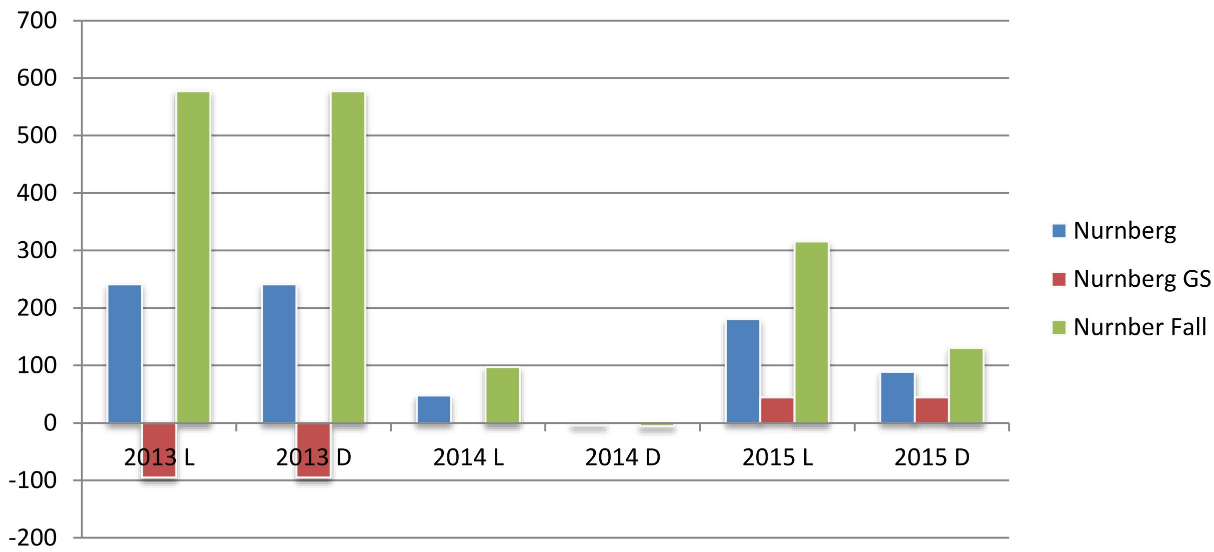
In the second method the internal load was estimated from growing season *in situ* phosphorus increases. This method estimated a sediment release rate of -2.8 mg/m^2-day in 2013, 0.00 mg/m^2-day in 2014, and 1.9 mg/m^2-day in 2015. The internal load was calculated annually in both the L-THIA and direct drainage scenarios to be -57 kg (-127 lbs.) in 2013, 0 kg (0 lbs) in 2014, and 53 kg (117 lbs.) in 2015.

The third method estimated the internal load from in situ phosphorus increases in the fall. The annual load was calculated to be 233 kg (513 lbs.) with a sediment release rate of 17 mg/m^2-day in both the 2013 L-THIA and direct drainage scenarios. In 2014 the L-THIA scenario estimated the sediment phosphorus release rate to be 4.9 mg/m^2-day with an annual internal load of 82 kg (180 lbs.) annually. In the 2014 direct drainage scenario the sediment release rate was calculated to be -0.3 mg/m^2-day with an annual loading rate of -5 kg (-11 lbs.). The 2015 L-THIA model calculated a sediment phosphorus release rate of 13.5 mg/m^2-day with an annual load of 153 kg (337 lbs.), while the 2015 direct drainage model predicted an annual internal load of 64 kg (140 lbs.) with a sediment release rate of 5.6 mg/m^2-day.

The fourth method used the average of the calculated phosphorus release rates (7.1 mg/m^2-day) and anoxic sediment area. This calculated the internal load to be 87 kg (193 lbs.) of phosphorus annually in both 2013 scenarios. The release rate for the 2014 L-THIA model was calculated to be 2.4 mg/m^2-day with a loading rate of 33 kg (73 lbs.) annually. In the 2014 direct drainage scenario the sediment release rate was calculated to be -0.2 mg/m^2-day, however, the model predicted the annual loading rate to be the same. The release rate for the 2015 L-THIA model was calculated to be 7.7 mg/m^2-day with a loading rate of 119 kg (263 lbs.) annually. In the 2015 direct drainage scenario the sediment release rate was calculated to be 3.8 mg/m^2-day and also predicted the annual loading rate to be the same. This is unlikely an invalid method for Big Blake Lake.



The 1984 Nurnberg model is commonly used to estimate the effects of the internal load for a lake. The Nurnberg total phosphorus model is ($P = \frac{L_{Ext}}{q_s}(1-R) + \frac{L_{Int}}{q_s}$ where $R = \frac{15}{18+q_s}$) where P is the predicted mixed lake total phosphorus concentration, L is the areal total phosphorus load (mg/m^2-yr.), R is the fraction of inflow total phosphorus retained in the lake, and q_s is the areal water loading or surface overflow rate. The model predicts the internal load to be between 577 kg to -95 kg (or burying phosphorus in the sediment), these numbers were derived by using annual, growing season, and fall increases in water column phosphorus concentrations.



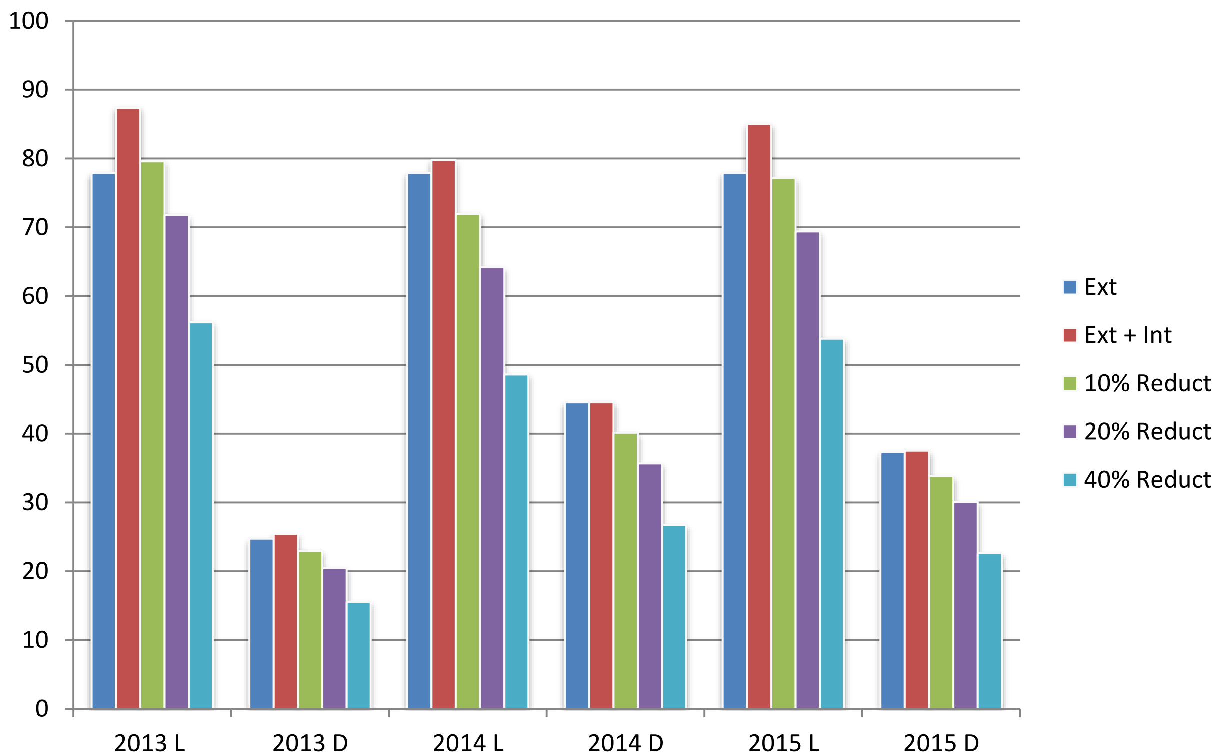
The Osgood Index of mixing $I = z/\sqrt{km^2}$ (where z is mean depth) is a measure of the lake volume in relation to wind fetch. The chance for mixing hypolimnetic (bottom water) with epilimnetic (surface water) increases as the ratio of volume to fetch decreases. Lakes with an Osgood Index of less than 6-7 usually have a summer surface water total phosphorus that exceeds the concentration predicted from external loading. Big Blake Lake has an Osgood Index of 3.

The likely scenario is that the internal loading varies both seasonally and annually depending on growth of curly-leaf pondweed (*Potamogeton crispus)* and residence time of the water. Because the outlet was breached and the lake stratified at different depths and different times the internal loading calculations proved to be problematic. However, taking all calculations and scenarios into account, the internal load on Big Blake Lake likely is between 40-120 kg on an annual basis.

The data derived from the different loading scenarios can be used to predict the average concentration of phosphorus in the lake's water column.

The model that fit every scenario was the 1977 Reckhow model $P = \frac{L}{0.17z+1.13z/T_w}$ where P is the predicted mixed lake total phosphorus concentration, L is the areal total phosphorus load (mg/m^2-yr.), T_w is the lakes hydraulic retention time, and z is the lakes mean depth. The model fit best in the 2014 direct drainage scenario, likely because the hydraulic retention time was greatly reduced and there was less mixing. The model was used to run several scenarios across all three of the lake study years using the nonpoint and point source loading to the lake and 10, 20, and 40 % reductions in total phosphorus inputs to the water column.

	2013 L	2013 D	2014 L	2014 D	2015 L	2015 D
External	77.91	24.76	77.91	44.57	77.91	37.3
External + Internal	87.37	25.43	79.78	44.57	84.98	37.55
10% Reduction	79.58	22.96	71.98	40.12	77.19	33.82
20% Reduction	71.79	20.48	64.19	35.66	69.4	30.09
40% Reduction	56.21	15.53	48.61	26.74	53.81	22.63



Because the water chemistry and hydraulic loading and retention time were so different from 2013-2015 combined models were put together and run for both the direct drainage scenario and the L-THIA scenario. It was determined that the combined L-THIA model would be used to address nutrient reductions and management scenarios as the hydraulic loading was normalized.

In the combined L-THIA scenario the 1979 Reckhow general lake model fit best. The general lake model is $P = \frac{1000L}{11.6+1.2q_s}$ where L is the areal loading in mg/m^2-yr. and q_s is the annual areal water loading or surface overflow rate.

The internal load using this scenario was determined to be 68.9 kg (151.8 lbs). When this value was input into the model and phosphorus values were back calculated there was a 2% difference between the predicted versus the observed phosphorus values (57 µg/l vs. 56 µg/l). This can be used to determine appropriate nutrient reduction scenarios.

When there is a 15% nonpoint source phosphorus reduction the water column total phosphorus is predicted to be reduced to 48 µg/l. When a 20% nonpoint source reduction is achieved, the model predicts the water column total phosphorus concentration to be 45 µg/l. Finally with a 30% reduction the predicted water column concentration is 40 µg/l. Phosphorus values under 45 would reduce both chlorophyll *a* and the presence of cyanobacteria blooms based on in-situ data collected and paleolimnological analysis.

Calculations from the 2003 Long Lake Barr Engineering report were used to calculate reductions in the internal phosphorus load from curly-leaf pondweed senescence in Big Blake Lake. This report estimated that the internal load attributed to curly leaf pondweed senescence is 3.73 pounds of phosphorus per acre of curly leaf pondweed.

Using this value it was determined that pre harvesting internal load attributed to curly leaf pondweed senescence was 744.81 pounds of phosphorus. Using 2015 curly leaf pondweed acreage, the post harvesting internal load attributed to curly leaf pondweed senescence was estimated at 462 pounds of phosphorus. This would indicate a reduction of nearly 300 pounds of phosphorus as a result of harvesting.

Calculations from the 2010 Bone Lake Ecological Integrity Service, LLC report were also used to calculate reductions in the internal phosphorus load from curly-leaf pondweed senescence in Big Blake Lake.

This report estimated that 21.3% of the phosphorus in curly-leaf pondweed is released into the water column at senescence. Using these calculations it was determined that 158.64 pounds of phosphorus were released into the water column under pre harvesting conditions in Big Blake Lake. Using 2015 post harvesting curly leaf pondweed acreage, it was determined that 98.52 pounds of phosphorus were released into the water column. This would indicate a reduction of approximately 60 pounds of phosphorus due to harvesting.

Paleolimnoligical Study of Big Blake Lake

A pair of sediment cores were recovered from the north basin of Big Blake Lake on September 12th, 2013. The full report "A Paleolimnoligical Study of Big Blake Lake, Polk County, Wisconsin" can be found in Appendix J. The executive summary follows.

Paired sediment cores were recovered from the northern basin of Big Blake Lake, Polk County, Wisconsin, in September 2013 and analyzed to reconstruct a historical record of sedimentation, ecological change, and water quality from the early 1800s to present. Management concerns for Big Blake Lake are centered on the prevalence of *Potamogeton crispus*, cyanobacterial blooms, elevated nutrient levels, response to and prevention of aquatic invasive species, and sustaining high quality recreational and fishing opportunities in the lake.

Sediment cores were subjected to multiple analyses including radioisotopic dating with Pb-210 to establish a date-depth relationship and sedimentation rates for the core site, loss-on-ignition to determine major sediment constituents, biogenic silica to estimate historical diatom productivity, diatom communities to identify ecological changes and estimate historical water column phosphorus, extraction and determination of sediment phosphorus fractions to determine past nutrient loading and threat of internal loading, and analysis of macrofossils including chironomid head capsules, zooplankton fossils, aquatic macrophyte remains to identify ecological shifts that have occurred in Big Blake Lake.

Sedimentation rates in the lake increased following Euroamerican settlement, and current sedimentation rates are approximately five times greater than pre-settlement levels.

Loss-on-ignition analysis showed that inorganics are the predominant fraction of Big Blake Lake sediments followed by organic components and then carbonates. Inorganic components show increased accumulation after 1900, likely reflecting changes in sediment loading following logging, land clearance, and development of the shoreline, while organic constituents decreased.

Biogenic silica concentrations in the cores, a marker of diatom algae abundance, are high compared to most lakes in the Midwest and represent 8-14% of the dry weight of Big Blake Lake sediment. Accumulation rates of biogenic silica show diatom growth has increased in the last two decades.

The concentration and accumulation rates of phosphorus fractions in the Big Blake Lake sediment core show general increases toward the top of the core. Mobile (labile) forms of phosphorus including exchangeable and NaOH-extractable forms of phosphorus are most abundant in the top few cm of sediment. This provides a readily available source of phosphorus during period of internal loading. Internal loading appears to be more significant in recent decades when bottom water go anoxic during *Potamogeton crispus* senescence and periodic breakdowns of stratification throughout the summer months which can initiate cyanobacteria blooms.

The diatom communities preserved in Big Blake Lake's sediment are dominated by six species. A significant diatom community shift occurs in the 1920-30s, a time when cottage and resort communities were expanding and agricultural practices were likely shifting in the region. This time period shows a decrease in the planktonic mesotrophic indicator *Aulacoseira ambigua* and benthic diatoms *Staurosira* *construens* and *S. venter* coincident with an increase in the dominance of the eutrophic species *Aulacoseira granulata*.

Estimates of historical total phosphorus were generated using a diatom-total phosphorus model based on species environmental relationships in 89 Minnesota lakes. The model suggests that Big Blake Lake has shifted from a mesotrophic lake to a eutrophic system. Diatom-inferred total phosphorus estimates increase following European settlement, increase further in the 1940s to peak levels in the 1960s through present day. Modeled total phosphorus estimates for the last ten years (49-52 µg/l) are similar to monitored values taken during the growing season (40-80 µg/l total phosphorus) when cyanobacterial blooms can occur. Diatom reconstructed total phosphorus values are almost identical to the mean annual total phosphorus levels based on a comprehensive monitoring program from 2013-2015 (49.9 µg/l), and predictions modeled using the Wisconsin Lakes Modeling Suite (43-50 µg/l).

Pigment analysis of different algae groups showed that algae, including cyanobacteria, have increased in recent decades. Evidence suggests that nitrogen-fixing, and possibly toxic, forms of cyanobacteria (via aphanizophyll), have increased dramatically over the last three decades.

Analysis of zooplankton remains shows a general decrease in cladocerans since the 1960s and 1970s. There is a sharp reduction in both *Eurycercus sp*. and *Alona sp*. since the 1960s. These species are often associated with aquatic plants in the littoral zones of ponds and lakes in North America and Europe and their decline corresponds to decline of the native aquatic plant community in Big Blake Lake since the 1960s.

Chironomid head capsules shows sharp decrease in littoral species after the 1950s similar to changes in zooplankton composition, again reflecting changes in ecosystem quality associated with the loss of the native aquatic plant community.

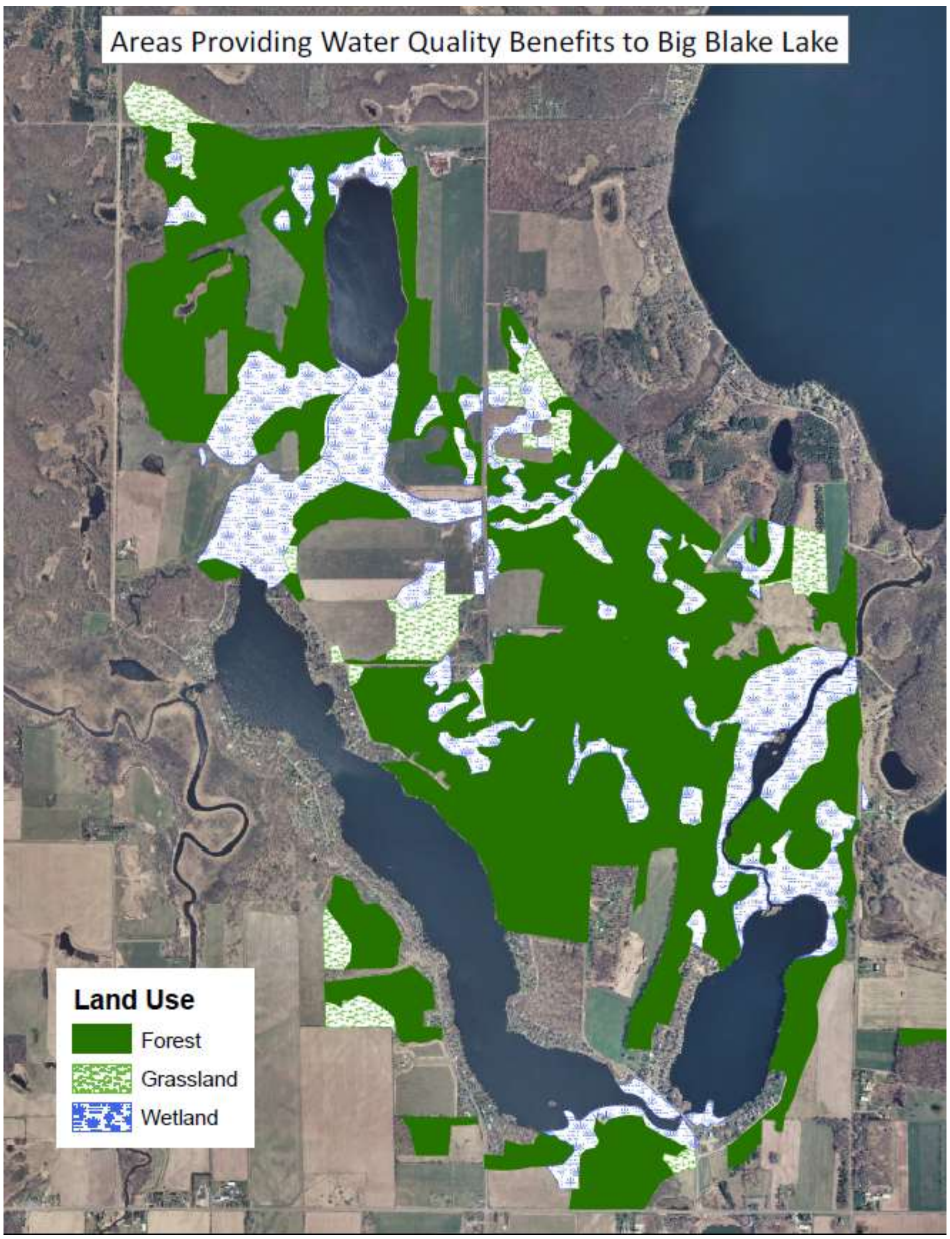
Aquatic macrophyte fossils show a loss in both species richness and total number of indigenous species since the 1960s. Fossils of the aquatic invasive species *Potamogeton crispus* appear in the 1980s.

Paleolimnology-based management recommendations and additional analysis are provided in the Big Blake Lake comprehensive Lake Management Plan.

Areas Providing Water Quality Benefits to Big Blake Lake

Natural areas such as forests, grasslands, and wetlands allow for more infiltration of precipitation when compared with row cropped fields and developed residential sites containing lawns, rooftops, sidewalks, and driveways. This occurs because dense vegetation lessens the impact of raindrops on the soil surface, thereby reducing erosion and allowing for greater infiltration of water. Additionally, wetlands provide extensive benefits through their ability to filter nutrients and allow sediments to settle out before reaching lakes and rivers.

Forests make up the largest land use in the Big Blake Lake watershed (47%) and wetlands make up the third largest land use (16%). Grasslands make up only 4% of the land use in the Big Blake Lake watershed. These areas should be considered sensitive areas and preserved for the benefits they provide to the lake.



Information and Education[28]

The Big Blake Lake Protection and Rehabilitation District is actively providing information and education opportunities to their membership. The District communicates with their membership during their spring and fall meetings, through their newsletter and mailings, and through direct contact with their volunteers. Additionally, Polk County Land and Water Resources Department staff attended the District Spring and Fall meetings in 2013, 2014, and 2015 and communicated grant updates to attendees.

2013 Information and Education Summary

A total of 42 volunteers signed up to assist with the Big Blake Lake Clean Boats, Clean Waters program in 2013. New supplies were ordered for volunteers and current literature, forms, shirts, and supplies were refreshed and distributed. Weekly contact was made with each volunteer through email or phone in June and July. Volunteers spent 379 hours at the north access and inspected 45 boats and contacted 93 people. Volunteers spent 38 hours at the west access and inspected 11 boats and contacted 17 people.

A volunteer cookout was organized to coordinate with the July 4th Landing Blitz. Sixteen volunteers attended. Photo opportunities for a press release were organized in June to promote the Landing Blitz. A press release for the Landing Blitz was distributed to 5 media outlets. The press release and photo were published in the Polk County Leader and a county-wide release which mentioned Big Blake Lake was published in the Amery Free Press.

All 212 members of the District received two direct mailings which included AIS information. The Blake Lake Bugle Newsletter contained one page of information on Clean Boats, Clean Waters and AIS. Another mailing included: the Wisconsin Boating Regulations pamphlet and the Clean Boats, Clean Waters flyer. Additionally, AIS flyers and brochures were distributed at area bait shops and places where bait is sold.

[28] Information and photos provided by Peggy Lauritsen, Clean Boats, Clean Waters Volunteer Coordinator

2014 Information and Education Summary

A total of 52 volunteers signed up to assist with the Big Blake Lake Clean Boats, Clean Waters program in 2014, which was a 20% increase from the previous year. New supplies were ordered for volunteers and current literature, forms, shirts, and supplies were refreshed and distributed. Contact was made with each volunteer through email or phone in June and July. Volunteers spent 202 hours at the north access and inspected 38 boats and contacted 75 people over the course of the boating season. Volunteers spent 205 hours at the west access and inspected 42 boats and contacted 70 people over the course of the boating season.

At the May 17th Spring District Meeting, a Clean Boats, Clean Waters display was set up and a flyer was circulated to all attendees. The Drain Campaign was also announced to attendees. Approximately 150 people attended the meeting.

For the first time, the District participated in the statewide Drain Campaign which took place on June 14th and 15th. On June 14th, Katelin Holm with the Polk County Land and Water Resources Department provided a special AIS training session for members of the Big Blake Lake District. Ten people attended this supplementary training.

The District participated in the 2014 statewide Landing Blitz over the 4th of July weekend. A press release for the Landing Blitz was distributed to 3 media outlets and was published in The Leader. A county-wide press release which mentioned Big Blake Lake was also published in area newspapers.

Similar to 2013, the Big Blake Lake Bugle Newsletter contained one page of information on Clean Boats, Clean Waters and AIS.

Three volunteers of the Big Blake Lake Protection and Rehabilitation District attended a county-wide Aquatic Invasive Species Citizen Lake Monitoring Network Training on June 11th, 2014. The training included a hands-on session to view specimens of AIS with a focus on native as well and invasive plants.

Additionally, AIS flyers and brochures were distributed at area bait shops and places where bait is sold.

2015 Information and Education Summary

A total of 40 volunteers signed up to assist with the Big Blake Lake Clean Boats, Clean Waters program in 2015. New supplies were ordered for volunteers and current literature, forms, shirts, and supplies were refreshed and distributed. Weekly contact was made with each volunteer through email or phone in June and July. Clean Boats, Clean Waters volunteers spent 276 hours at the north access and inspected 24 boats and contacted 35 people over the course of the boating season. Volunteers spent 132 hours at the west access and inspected 8 boats and contacted 13 people over the course of the boating season.

At the Spring and Fall District Meetings, a Clean Boats, Clean Waters display was set up and a packet of AIS information, including the Big Blake Lake waterproof AIS flyer was circulated to all attendees. The latest information from state and county sources was also provided.

A total of seventeen volunteers attended trainings on Saturday, June 6th and Saturday, June 13th as part of the WDNR Drain Campaign. Polk County Land and Water Resources Department staff attended the June 13th training and provided supplemental AIS information. As in years past, the District also participated in the statewide Landing Blitz and authored a press release which was published in the Inter-County Leader.

Additionally, AIS flyers and brochures were distributed at area bait shops and places where bait is sold.

On Thursday, July 2nd a pontoon classroom was held by the Polk County Land and Water Resources Department for members of the Big Blake Lake Protection and Rehabilitation District. The classroom was attended by eight members of the District. During the pontoon classroom participants had the opportunity to collect physical and chemical data, zooplankton samples, algae samples, sediment samples, and plant samples. Data were explained and participants saw zooplankton and examined aquatic plants (native and invasive). Preserved specimens of common aquatic invasive species were also shown to attendees. A brief overview of all the projects included in the grant was also provided. Topics of conversation included aquatic plants, wild rice, and lake sediments.

Summary of Rules and Legislation

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2009. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features.

Plan information is available online at http://www.co.polk.wi.us <Departments < Land Information < Comprehensive Plan

Town, City and Village Comprehensive Plans are available at:
http://www.co.polk.wi.us < Departments < Land Information < Comprehensive Plan < City, Village, and Town Comprehensive Plans

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- ✓ Issues and opportunities
- ✓ Housing
- ✓ Transportation
- ✓ Utilities and community facilities
- ✓ Agricultural, natural, and cultural resources
- ✓ Economic development
- ✓ Intergovernmental cooperation
- ✓ Land use
- ✓ Implementation
- ✓ Polk County added "Energy and Sustainability"

Polk County Comprehensive Land Use Ordinance

Polk County's oldest portions of the current zoning code are over 40 years old. Over the years, there have been numerous revisions to the original code. However, the current zoning code is in need of a comprehensive rewrite in order to address current and future issues in Polk County and to implement the vision set forth in the County's adopted comprehensive plan. Recognizing this, the County began a rewrite process in March 2010. A Zoning Citizen Advisory Committee (CAC) met to review the existing ordinances and make suggestions on how to appropriately rewrite them for the past 3+ years.

The State of Wisconsin's Administrative Rule NR115 dictates that counties must regulate lands within 1,000 feet of a lake, pond or flowage and 300 feet of a river or stream. The Shoreland Protection Zoning

Ordinance is also currently being rewritten as a part of the Comprehensive Land Use Ordinance due to the Comprehensive Plan and the State of Wisconsin passing a new version of NR 115 in 2010.

After reviewing the input of the advisory committees, public hearings and other changes, the Conservation, Development, Recreation and Education (CDRE) Committee, at their September 2, 2015 meeting, recommended that the ordinance be moved on to the County Board's agenda for consideration of passage at the September 15, 2015 meeting. At the September 15th, 2015 Polk County Board of Supervisors Meeting, the ordinance below was adopted.

Now that the ordinance has been passed, each Town within Polk County will have one calendar year to decide if they want to adopt county zoning or not. Each town participating in county zoning will be responsible for developing the zoning map for their town. Staff from the Land Information Department will be assisting the towns in this process over the next year.

The current Comprehensive Zoning Ordinance is available at:
http://www.co.polk.wi.us < Departments < Land Information < Ordinances (Zoning)

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2005, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance requires most new plats to incorporate storm water management practices with no net increase in runoff from development.

The ordinance is available online at:
http://www.co.polk.wi.us < Departments < Land Information < Ordinances (Zoning)

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in January 2000. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006.

The ordinance is available online at:
http://www.co.polk.wi.us < Departments < Land & Water Resources < Ordinances.

Storm Water and Erosion Control

This ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

The ordinance is available online at:
http://www.co.polk.wi.us < Departments < Land & Water Resources < Ordinances.

WI Non-Agricultural Performance Standards (NR 151)
Construction Sites >1 acre – must control 80% of sediment load from sites
Storm water management plans (>1 acre) Total suspended solids Peak discharge rate Infiltration Buffers around water
Developed urban areas (>1000 persons/square mile) Public education Yard waste management Nutrient management Reduction of suspended solids

Polk County Land and Water Resources Management Plan
The Polk County Land and Water Resources Management Plan describes the strategy the Land and Water Resources Department (LWRD) will employ from 2010-2018 to address agriculture and non-agriculture runoff management, stormwater discharge, shoreline management, soil conservation, invasive species and other environmental degradation that affects the natural resources of Polk County. The plan specifies how LWRD will implement NR 151 (Runoff Management). It involves identifying critical sites, offering cost-share and other programs, identifying BMP's monitoring and evaluating projects for compliance, conducting enforcement activities, tracking progress, and providing information and education.

Polk County has local shoreland protection, zoning, subdivision, animal waste, and non-metallic mining ordinances. Enforcing these rules and assisting other agencies with programs are part of LWRD's ongoing activities. Other activities to implement the NR 151 Standards include information and education strategies, write nutrient management plans, provide technical assistance to landowners and lakeshore owners, perform lake studies, collaborate with other agencies, work on a rivers classification system, set up demonstration sites of proper BMP's, control invasive species, and revise ordinances to offer better protection of resources.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops

- ✓ Meet "T" on cropped fields
- ✓ Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock

- ✓ No direct runoff from feedlots or stored manure into state waters
- ✓ No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover
- ✓ Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure

- ✓ Maintain a structure to prevent overflow, leakage, and structural failure
- ✓ Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- ✓ Close a structure according to accepted standards
- ✓ Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)

- ✓ Do not stack manure in unconfined piles
- ✓ Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

Boating Regulations

The Department of Natural Resources regulates boating in the state of Wisconsin.[29] Wisconsin conservation wardens enforce boating regulations. A few highlights of boating regulations are:

- ✓ Personal watercrafts (PWCs) may not operate from sunset to sunrise.
- ✓ PWC operators must be at least 12 years old.
- ✓ There are 100-foot restrictions between boats or PWCs and water skiers, towropes, and boats towing skiers.
- ✓ It is unlawful to operate within 100 feet of shore or of any dock, raft, pier, or buoyed restricted area at a speed in excess of "slow-no-wake."
- ✓ Speed must be reasonable and prudent under existing conditions to avoid colliding with any object or person.

A town or village may delegate the authority to adopt lake use regulations to a lake district. These may include regulation of boating equipment, use, or operation; aircraft; and travel on ice-bound lakes.[30] Local ordinances may now extend the slow-no-wake zone to within 200 feet of shore with passage of WI Act 31.

Dredging Regulations (Sec 30.20 Wis. Stats.) [31]

A general permit or an individual permit is required to dredge material from the bed of a navigable waterway. Local zoning permits and U.S. Army Corps of Engineers permits may also be required.

Wisconsin Transport Laws for Boaters and Anglers

In 2001, the Wisconsin Legislature directed the Department of Natural Resources to establish a statewide program to control invasive species and to promulgate rules to identify, classify, and control invasive species for purposes of the program. By 2004, the Wisconsin Council on Invasive Species formed to assist WDNR with this task.

As a result, on September 1, 2009 the WDNR created Wisconsin's Invasive Species Identification, Classification, and Control Rule, Chapter NR 40, Wisconsin Administrative Code. The rule helps citizens learn to identify and minimize the spread of plants, animals and diseases that can invade our lands and waters and cause significant damage.

The invasive species rule creates a comprehensive, science-based system with criteria to classify invasive species into two categories: prohibited and restricted. With certain exceptions, the transport, possession, transfer, and introduction of prohibited species is banned. Restricted species are also subject to a ban on transport, transfer, and introduction, although possession is allowed, with the exception of fish and crayfish.

Wisconsin has various laws in place to prevent the introduction and control the spread of AIS and diseases in Wisconsin.

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[29] Boating regulations may be found online at www.dnr.wi.us/org/es/enforcement/docs/boating regs.pdf.
[30] Chapter 33. Wisconsin State Statutes.
[31] Information from http://dnr.wi.gov.org/water/fhp/waterway/dredging.

Wisconsin Transport Laws for Boaters and Anglers

- ✓ INSPECT your boat, trailer and equipment.
- ✓ REMOVE any attached aquatic plants or animals (before launching, after loading and before transporting on a public highway).
- ✓ DRAIN all water from boats, motors, and all equipment.
- ✓ NEVER MOVE live fish away from a waterbody.
- ✓ DISPOSE of unwanted bait in the trash.
- ✓ BUY minnows from a Wisconsin bait dealer. You may take leftover minnows away from any state water and use them again on that same water. You may use leftover minnows on other waters only if no lake or river water, or other fish were added to their container.

Amended Illegal Transport of Aquatic Plants and Invasive Animals

In 2008, the Polk County Illegal Transport of Aquatic Plants and Invasive Animals Ordinance was adopted, making it illegal to operate or transport equipment with aquatic plants or invasive animals attached. Public input into the decision making process was sought through public meetings which were advertised in local papers. The Ordinance was amended in 2011 to include language regarding liability of a vehicle, watercraft, trailer, or equipment of the owner or lessor.

The ordinance is available online at:
http://www.co.polk.wi.us < Departments < Land & Water Resources < Ordinances.

Aquatic Plant Laws and Rules

[32] [33]

Nearly all aquatic plant management options require a permit from the Wisconsin Department of Natural Resources. Permits are needed to protect diverse communities of native aquatic plants and limit the spread of aquatic invasive plants. The two primary permit programs regulating aquatic plant management in Wisconsin include cutting and harvesting [34] and chemical treatment. [35]

Permits for aquatic plant management are needed when:

- ✓ Chemicals are used
- ✓ Biological controls are used[36]
- ✓ Physical techniques such as drawdowns or bottom plant barriers are used
- ✓ Wild rice is involved
- ✓ Plants are removed mechanically
- ✓ Plants are removed manually from an area greater than 30 feet in width along the shoreline

There are two circumstances when aquatic plant management activities are exempt from permit requirements. The first is when individuals manually remove vegetation from an area no wider than 30 feet directly out from a use area (dock or swim area). Manual removal requires a person's muscle power to remove plants and could include tools such as rakes or hand cutting tools. The second circumstance allows for manual removal of aquatic invasive plants as long as native species are not damaged or eliminated. In both circumstances, any plants cut or raked must be removed from the lake and shoreline.

[32] http://dnr.wi.gov/lakes/plants/
[33] Aquatic Plant Management in Wisconsin http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/APMguideFull2010.pdf
[34] Administrative Code Chapter NR 109, Aquatic Plants: Introduction, Manual Removal, and Mechanical Control Regulations
[35] Administrative Code Chapter NR 107, Aquatic Plant Management
[36] The use of grass carp and rusty crayfish is prohibited as a biocontrol

Management Options for Aquatic Plants

A number of management options exist for aquatic plants. These options are summarized in a Wisconsin Department of Natural Resources handout which includes the option, if a permit is needed, how the options works, and the pros and cons of each option. The handout can be found in Appendix L or online. [37]

Options summarized include:

- ✓ No management
- ✓ Mechanical control
  - Handpulling/manual raking
  - Harvesting
- ✓ Biological control
  - Weevils on EWM
  - Pathogens
  - Allelopathy
  - Native plantings
- ✓ Physical control
  - Fabrics/bottom barriers
  - Drawdown
  - Dredging
  - Dyes
  - Non-point source nutrient control
- ✓ Chemical control
  - 2,4-D
  - Endothall
  - Diquat
  - Fluridone
  - Glyphosate
  - Triclopyr
  - Copper compounds

[37] http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/Appendix-E.pdf

Lake Management Plan

Lake management plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. Lake management plans identify concerns of importance and set realistic goals, objectives, and action items to address each concern. Additionally, lake management plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake management plans are living documents which are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitments, and the needs of lake stakeholders.

The vision statement, guiding principles, and lake management plan goals presented below were created through collaborative efforts using current and past water quality data, a 2014 sociological survey regarding the needs of Big Blake Lake residents, and a series of four meetings by the Big Blake Lake Management Plan Committee. Key findings of the study and draft goals were presented at the 2013, 2014, and 2015 District Spring and Annual Meetings.

The draft plan was posted on the Big Blake Lake and Polk County Land and Water Resources websites and opened for a 30 day public comment period ending on November 21st, 2016. A notice of public comment was published in the Polk County Leader on October 19th and 26th, 2016. No public comments were received. The plan was approved by the Big Blake Lake Protection and Rehabilitation Board on *** and by the Wisconsin Department of Natural Resources on ***.

One objective of the plan is to form teams to ensure that the goals of the plan are met. The first task given to each team will be to complete the lake management plan chart for each goal.

***<u>Vision:</u>* an overall statement for what you want Big Blake Lake to look like**

Big Blake Lake is a sustainable, healthy environment for people, recreation, wildlife, and native plants. Engaged and informed stakeholders protect the lake and its watershed.

***<u>Guiding Principles:</u>* provide guidance on how the lake management plan will be implemented**

Lake management decisions are data driven and evidence-based to incorporate an analysis of past, present, and future data and are implemented in a manner that will limit unintended negative environmental impacts.

Member education, engagement, and neighbor-to-neighbor communications for all generations are important to meet the vision of and manage the future of Big Blake Lake.

Clear and concise multi-channel communications to members express the ever evolving nature of lake management and the complexity of issues.

Goal 1: Reduce nuisance algae and plant growth by reducing watershed and internal sources of phosphorus

Big Blake Lake is currently on Wisconsin's Impaired Waters List under the Federal Clean Water Act, Section 303(d). Watershed and internal sources of phosphorus should be reduced such that Big Blake Lake is removed from the Impaired Waters List as indicated by an in-lake average seasonal total phosphorus concentration of 40 µg/L and in-lake chlorophyll value of less than 20 µg/L for 30% of the days in the sampling season. Harvesting of curly leaf pondweed removes nutrients from Big Blake Lake which would otherwise contribute to internal sources of phosphorus.

Objective 1. Support harvesting of curly leaf pondweed to remove nutrients from Big Blake Lake

- *Develop and deliver an educational message to explain the relationship between harvesting and phosphorus removal from Big Blake Lake*
- *Review and update the Big Blake Lake harvesting plan on an annual basis*
- *Complete and submit Form 3200-113:Mechanical/Manual Aquatic Plant Control Application*

Objective 2. Install at least 10 shoreline native plantings/restorations, diversion practices, rock infiltration practices or rain gardens per year

- *Provide an educational message regarding the importance of native vegetation, diversion practices, and rock infiltration practices to reduce watershed sources of phosphorus*
- *Organize an educational session highlighting simple changes to properties that will improve Big Blake Lake*
- *Offer free annual Healthy Lakes property audits to identify property owners interested in installing practices*
- *Prepare a Healthy Lakes Grant application to provide technical assistance and cost sharing to fund practices by 75%*
- *Determine a 25% match for the Healthy Lakes Grant (District on behalf of individual property owners or individual property owners)*
- *Recognize shoreline property owners who have installed practices*
- *Organize a tour of properties where successful practices have been installed*

Objective 3. Evaluate the purchase of highly erodible/ecologically sensitive land if option arises

- *Research and explore the formation of a conservancy*
- *Research and explore grant opportunities for acquiring land*
- *Form a subteam to oversee the purchase of high erodible/ecologically sensitive land*
- *If possible, provide recreational uses if land is purchased*

Objective 4. Engage the agricultural community as a partner in reducing watershed runoff

- *Work with the Polk County Land and Water Resources Department to identify agricultural producers in the Big Blake Lake watershed*

- *Develop a program to incentivize the installation of farmland best management practices*
- *Develop and deliver an educational message to explain the need and purpose of the program*
- *Recognize agricultural producers who have participated in the program*
- *Prepare a Lake Planning Grant application to fund soil sampling on agricultural fields in the watershed and determine a match for the grant*

Objective 5. Ensure that stakeholders understand the relationship between boat traffic and phosphorus release from the sediment

- *Develop and deliver an educational message to members of the District*
- *Develop and deliver an educational message to anglers in fishing tournaments*

Objective 6. Upgrade non-compliant septic systems by engaging and educating 100% of shoreline property owners

- *Develop and deliver an educational message regarding the relationship between failing septic systems and increased watershed sources of phosphorus*
- *Conduct a septic survey to determine the impact of septic systems on the lake and identify non-compliant septic systems*
- *Identify shoreline property owners willing to upgrade their septic system*
- *Prepare a Lake Protection Grant to fund upgrades to septic systems*
- *Determine a match for a Lake Protection Grant (District or individual property owners)*
- *Recognize shoreline property owners who have participated in the program*

Goal 2: Reduce curly-leaf pondweed coverage and density to restore reasonable uses of the lake while promoting the recovery of the beneficial native plant community and protecting sensitive areas from disturbances

The current harvesting program should be continued with the goal of reducing curly-leaf pondweed sample site frequency of occurrence at sites shallower than the maximum depth of plants to 60% in harvested areas or an average density of 1. As a measure of the recovery of the native plant community, FQI should be maintained at 20 or greater.

The harvesting program will follow the guidelines of the Big Blake Lake Aquatic Invasive Species Management Plan, 2007-2011. At the time this plan was written, harvesting was not allowed within 100 feet of the shoreline. In 2008, the Big Blake Lake Aquatic Plant Management Plan was amended as a result of concerns regarding navigational issues. At this time the change was made to allow harvesting towards the shore to a minimum depth of 36 inches, with no minimum distance from shore. Additionally, in allowing harvesting near shore, no chemical herbicide permits will be considered as harvesting to minimum depths of 36 inches should allow adequate navigational opportunities.

Objective 1. Ensure that the timing and location of harvesting is appropriate

- *Complete and submit Form 3200-113:Mechanical/Manual Aquatic Plant Control Application*
- *Notify Aquatic Plant Specialist, Mark Sundeen at 715-635-4074, 4 working days prior to anticipated start of the harvesting operation, or provide a schedule of harvesting on request*
- *Mechanical harvesting is only allowed in the areas specified and approved in the annual permit letter from WDNR and as they appear on the map submitted in the permit application*
- *Harvesting does not include sensitive areas and areas with a water depth of less than 36 inches*
- *Harvesting should occur before turion formation and deposition*
- *Harvesting will occur in the intensive management sites designated in the 2007 study regardless of apparent extend of CLP as a basis to measure progress of the program*
- *All late season cutting (that allowed in the permit after June 15th) should be allowed only at a depth greater than 5-feet of the lake nearest the rice beds.*
- *During or after the spring CLP harvesting is completed, harvesting will be allowed in navigation channels to be selected and agreed on by the Lake District, its' plant monitoring consultant, and the DNR.*
- *Nuisance mid-summer native plant coverage, primarily coontail, may be harvested*
- *All aquatic plants cut must be removed immediately from the water and disposal of the harvested aquatic plants must be located in department approved areas and must be in accordance with any applicable county and local regulations.*

Objective 2. Allow individual riparian owners to manually remove vegetation if adequate navigational opportunities are not provided with the harvester

- *Manual removal will be done by hand or hand-held devices without the use or aid of external or auxiliary power*

- *Manual removal cannot exceed 30 feet in width and can only be done where the shore is being used for a dock or swim raft*
- *The 30 foot wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed*
- *Wild rice may not be manually removed*

Objective 3. Monitor the success of the harvesting program

- *The WDNR harvesting permit, all maps of sensitive areas, identified navigation channels, and of the intensive management sites will be carried on board the harvester while operating at all times.*
- *GPS coordinates will be established to delineate all harvesting sites, and the harvesting record will be maintained and provided or made available at the end of the season.*
- *Annual spring and summer point intercept surveys and a turion study will be completed to determine if CLP reduction goals are being met and to assess improvements in the native plant community*
- *If goals aren't being met, a committee will convene and adapt the goals and objectives as necessary*

Objective 4. Plant control will prevent harm to important fish spawning and nursery habitat and prevent direct removal or indirect harm to wild rice

- *Sensitive area A will have no active management*
- *Sensitive area B may have a primary navigation channel cut into it (4 finger channels branching from a primary channel to 4 properties, 25 feet wide at maximum) after Memorial Day when fish have completed spawning*
- *Sensitive area C includes vegetation that may include wild rice and will have no active management until after a site survey is made to determine what if any effects management may have on wild rice and after a consultation about the effects of management on wild rice is done with the Voigt Task Force*
- *Inspection of Sensitive Area C will take place in June by DNR and St. Croix Tribal DNR to determine potential impacts on wild rice growing in that area if harvesting of navigational lanes to riparian areas were permitted*
- *Harvesting will not take place in areas with water depth of less than 36 inches*

Goal 3: Provide information and education with the intent of changing stakeholder behaviors to protect Big Blake Lake

Objective 1. Use existing channels to deliver at least one focused educational message per year to meet the goals of this plan

- *Articles in the Big Blake Lake Bugle*
- *Webpages on the Big Blake Lake website*
- *Emails to the Big Blake Lake list serve*
- *Presentations and brochures at the Big Blake Lake Spring and Annual Meeting*
- *Press releases in local newspapers*
- *Special educational sessions such as pontoon classrooms, Healthy Lakes workshops, and CBCW trainings*
- *Posts on the Big Blake Lake Facebook page*

Objective 2. Explore new and innovative methods to provide information and education

- *For each focused educational message, develop at least one new method to communicate information*
    - *Example: Tour of properties that have installed shoreline buffers and rain gardens*
    - *Example: Stickers or signs to symbolize participation in a program as a way to start a conversation with neighbors*

Goal 4: Prevent the introduction of new invasive species and eradicate newly introduced invasive species

Objective 1. Ensure that lake residents and users understand the steps necessary to prevent invasive species

- *Continue a successful Clean Boats, Clean Water monitoring and education program at each boat landing using volunteers and paid inspectors*
- *Participate in additional WDNR statewide programs including the Landing Blitz and Drain Campaign*
- *Ensure that signage at the boat landings is in place each year and updated as necessary*
- *Distribute brochures and the waterproof Big Blake Lake map with aquatic invasive species information*
- *Work with the Polk County Sheriff's Department to encourage enforcement of the Do Not Transport Ordinance*

Objective 2. Implement an annual monitoring program to quickly identify the introduction of new invasive species

- *Attend the Polk County Citizen Lake Monitoring Network Training for invasive species which trains volunteers to identify and monitor for aquatic invasive species*
- *Provide training for harvester operators regarding new aquatic invasive species identification*
- *Form a committee of volunteers to monitor for invasive species over the course of the growing season with a focus on boat landings and other areas with high potential for introduction*
- *Contract with professionals to implement a monitoring program for aquatic invasive species*
- *Develop and implement a rapid response plan so that new populations are addressed quickly and efficiently*

Goal 5: Evaluate the progress of lake management efforts and needs through monitoring

Objective 1. Continue current data collection efforts to evaluate progress

- *Ensure that Citizen Lake Monitoring Volunteer is in place each year to collect phosphorus, chlorophyll, and secchi data*
- *Conduct yearly spring and summer aquatic plant point intercept surveys to determine if CLP reduction goals are being met and if the native plant community is improving*

Objective 2. Expand data collection efforts depending on needs

- *Monitor culverts to determine phosphorus loads and identify the need for sediment basins*
- *Conduct a shoreline inventory to document areas of natural vegetation, lawn, and erosion along the shoreline of Big Blake Lake*
- *Repeat the 2013-15 water quality study in five to ten years*
- *Collect a sediment core in the south basin*
- *Implement a turion study to document effectiveness of reducing CLP with harvesting*
- *Implement a septic survey on all septic systems on the lake*

Goal 6: Protect, maintain, and enhance fish and wildlife habitat

Objective 1. Maintain and enhance desirable populations of game fish in Big Blake Lake by installing 5 habitat improvements such as fish sticks

- *Work with fisheries biologist to determine locations for fish sticks and other habitat improvements*
- *Identify property owners interested in installing fish sticks and other habitat improvements*
- *Prepare a Healthy Lakes Grant application to fund the installation of fish sticks*
- *Recognize shoreline property owners who have installed fish sticks and other habitat improvements*
- *Develop and deliver an educational message regarding the importance of leaving trees and branches that fall into the lake for the habitat they provide to fish*
- *Promote the growth of native aquatic plants*
- *Explore stocking options for Big Blake Lake*

Objective 2. Restore 10 developed shorelines to more native habitats per year

- *Provide an educational message regarding the importance of native vegetation for fish and wildlife habitat*
- *Conduct a shoreline inventory to document areas of natural vegetation, lawn, and erosion along the shoreline of Big Blake Lake and prioritize sites for projects*
- *Develop a program to provide incentives to property owners who quit mowing a portion of their shoreline*
- *See actions under Goal 1, Objective 2*

Goal 7: Sustain the implementation of the plan

Objective 1. Form teams to ensure that the goals of the plan are met

- *Water quality team*
    - *Land acquisition subteam*
    - *Healthy Lakes subteam*
- *Fish and wildlife team*
- *Information and education team*
- *Aquatic invasive species team*
- *Aquatic plant team*

Objective 2. Continue to seek funding to implement the Big Blake Lake Management Plan

- *Apply for WDNR Lake Planning, Lake Protection, and Aquatic Invasive Species Grants*
- *Leverage current partner efforts to strengthen grant applications*
- *Identify additional funding*

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
<u>Goal 1: Reduce nuisance algae and plant growth by reducing watershed and internal sources of phosphorus</u>					
Objective 1. Support harvesting of curly leaf pondweed to remove nutrients from Big Blake Lake	Ongoing, annual				
Develop and deliver an educational message to explain the relationship between harvesting and phosphorus removal from Big Blake Lake				Information and education team	
Review and update the Big Blake Lake harvesting plan on an annual basis				Aquatic plant team	
Complete and submit Form 3200-113:Mechanical/Manual Aquatic Plant Control Application				Aquatic plant team	
Objective 2. Install at least 10 shoreline native plantings/restorations, diversion practices, rock infiltration practices or rain gardens per year				Healthy lakes subteam	
Provide an educational message regarding the importance of native vegetation, diversion practices, and rock infiltration practices to reduce watershed sources of phosphorus	2016				
Organize an educational session highlighting simple changes to properties that will improve Big Blake Lake	2016				
Offer free annual Healthy Lakes property audits to identify property owners interested in installing practices	2016				
Prepare a Healthy Lakes Grant application to provide technical assistance and cost sharing to fund practices by 75%	Due Feb 1, 2017				Healthy Lakes Grant
Determine a 25% match for the Healthy Lakes Grant (District on behalf of individual property owners or individual property owners)	2016				
Recognize shoreline property owners who have installed practices	2017/2018				
Organize a tour of properties where successful practices have been installed	2017/2018				

Objective 3. Evaluate the purchase of highly erodible/ecologically sensitive land if option arises	As opportunity arises			Land acquisition subteam	
Research and explore the formation of a conservancy					
Research and explore grant opportunities for acquiring land					
Form a subteam to oversee the purchase of high erodible/ecologically sensitive land					
If possible, provide recreational uses if land is purchased					
Objective 4. Engage the agricultural community as a partner in reducing watershed runoff				Water quality team	
Work with the Polk County Land and Water Resources Department to identify agricultural producers in the Big Blake Lake watershed				Polk County LWRD	
Develop a program to incentivize the installation of farmland best management practices					
Develop and deliver an educational message to explain the need and purpose of the program					
Recognize agricultural producers who have participated in the program					
Prepare a Lake Planning Grant application to fund soil sampling on agricultural fields in the watershed and determine a match for the grant	2018				Lake Planning Grant
Objective 5. Ensure that stakeholders understand the relationship between boat traffic and phosphorus release from the sediment	Ongoing, annual			Information and education team	
Develop and deliver an educational message to members of the District					
Develop and deliver an educational message to anglers in fishing tournaments					
Objective 6. Upgrade non-compliant septic systems by engaging and educating 100% of shoreline property owners				Water quality team	

Develop and deliver an educational message regarding the relationship between failing septic systems and increased watershed sources of phosphorus	Ongoing, annual			Information and education team	
Conduct a septic survey to determine the impact of septic systems on the lake and identify non-compliant septic systems using lake water testing	2021				Lake Planning Grant
Identify shoreline property owners willing to upgrade their septic system	2021				
Prepare a Lake Protection Grant to fund upgrades to septic systems	2021				Lake Protection Grant
Determine a match for a Lake Protection Grant (District or individual property owners)	2021				
Recognize shoreline property owners who have participated in the program	2022				

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
Goal 2: Reduce curly-leaf pondweed coverage and density to restore reasonable uses of the lake while promoting the recovery of the beneficial native plant community and protecting sensitive areas from disturbances					
Objective 1. Ensure that the timing and location of harvesting is appropriate	Ongoing, annual			Aquatic plant team	
Complete and submit Form 3200-113:Mechanical/Manual Aquatic Plant Control Application	Winter prior to harvesting				
Notify Aquatic Plant Specialist, Mark Sundeen at 715-635-4074, 4 working days prior to anticipated start of the harvesting operation, or provide a schedule of harvesting on request	4 days prior to harvesting				
Mechanical harvesting is only allowed in the areas specified and approved in the annual permit letter from WDNR and as they appear on the map submitted in the permit application					
Harvesting does not include sensitive areas and areas with a water depth of less than 36 inches					
Harvesting should occur before turion formation and deposition					
Harvesting will occur in the intensive management sites designated in the 2007 study regardless of apparent extend of CLP as a basis to measure progress of the program					
All late season cutting (that allowed in the permit after June 15th) should be allowed only at a depth greater than 5-feet of the lake nearest the rice beds.					
During or after the spring CLP harvesting is completed, harvesting will be allowed in navigation channels to be selected and agreed on by the Lake District, its' plant monitoring consultant, and the DNR.					
Nuisance mid-summer native plant coverage, primarily coontail, may be harvested					

All aquatic plants cut must be removed immediately from the water and disposal of the harvested aquatic plants must be located in department approved areas and must be in accordance with any applicable county and local regulations.					
Objective 2. Allow individual riparian owners to manually remove vegetation if adequate navigational opportunities are not provided with the harvester	Ongoing, annual			Aquatic plant team	
Manual removal will be done by hand or hand-held devices without the use or aid of external or auxiliary power					
Manual removal cannot exceed 30 feet in width and can only be done where the shore is being used for a dock or swim raft					
The 30 foot wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed					
Wild rice may not be manually removed					
Objective 3. Monitor the success of the harvesting program	Ongoing, annual			Aquatic plant team	
The WDNR harvesting permit, all maps of sensitive areas, identified navigation channels, and of the intensive management sites will be carried on board the harvester while operating at all times.					
GPS coordinates will be established to delineate all harvesting sites, and the harvesting record will be maintained and provided or made available at the end of the season.					
Annual spring and summer point intercept surveys and a turion study will be completed to determine if CLP reduction goals are being met and to assess improvements in the native plant community	Spring and summer, yearly				Lake Planning Grant
If goals aren't being met, a committee will convene and adapt the goals and objectives as necessary	Fall/winter, as needed				
Objective 4. Plant control will prevent harm to important fish spawning and nursery habitat and prevent direct removal or indirect harm to wild rice	Ongoing, annual			Aquatic plant team	

Sensitive area A will have no active management					
Sensitive area B may have a primary navigation channel cut into it (4 finger channels branching from a primary channel to 4 properties, 25 feet wide at maximum) after Memorial Day when fish have completed spawning					
Sensitive area C includes vegetation that may include wild rice and will have no active management until after a site survey is made to determine what if any effects management may have on wild rice and after a consultation about the effects of management on wild rice is done with the Voigt Task Force					
Inspection of Sensitive Area C will take place in June by DNR and St. Croix Tribal DNR to determine potential impacts on wild rice growing in that area if harvesting of navigational lanes to riparian areas were permitted	June, annually				
Harvesting will not take place in areas with water depth of less than 36 inches					

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
<u>Goal 3: Provide information and education with the intent of changing stakeholder behaviors to protect Big Blake Lake</u>					
Objective 1. Use existing channels to deliver at least one focused educational message per year to meet the goals of this plan	Ongoing, annual			Information and education team	
Articles in the Big Blake Lake Bugle					
Webpages on the Big Blake Lake website					
Emails to the Big Blake Lake list serve					
Presentations and brochures at the Big Blake Lake Spring and Annual Meeting					
Press releases in local newspapers					
Special educational sessions such as pontoon classrooms, Healthy Lakes workshops, and CBCW trainings					
Posts on the Big Blake Lake Facebook page					
Objective 2. Explore new and innovative methods to provide information and education	Ongoing, annual			Information and education team	
For each focused educational message, develop at least one new method to communicate information					
Example: Tour of properties that have installed shoreline buffers and rain gardens					
Example: Stickers or signs to symbolize participation in a program as a way to start a conversation with neighbors					

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
Goal 4: Prevent the introduction of new invasive species and eradicate newly introduced invasive species					
Objective 1. Ensure that lake residents and users understand the steps necessary to prevent invasive species	Yearly, ongoing			Aquatic invasive species team	AIS Education, Prevention, & Planning Grant
Continue a successful Clean Boats, Clean Water monitoring and education program at each boat landing using volunteers and paid inspectors					Clean Boats, Clean Waters Grant
Participate in additional WDNR statewide programs including the Landing Blitz and Drain Campaign					
Ensure that signage at the boat landings is in place each year and updated as necessary					
Distribute brochures and the waterproof Big Blake Lake map with aquatic invasive species information					
Work with the Polk County Sheriff's Department to encourage enforcement of the Do Not Transport Ordinance	2017				
Objective 2. Implement an annual monitoring program to quickly identify the introduction of new invasive species				Aquatic invasive species team	AIS Education, Prevention, & Planning Grant
Attend the Polk County Citizen Lake Monitoring Network Training for invasive species which trains volunteers to identify and monitor for aquatic invasive species	Yearly, ongoing				
Provide training for harvester operators regarding new aquatic invasive species identification	2017, annually				

Form a committee of volunteers to monitor for invasive species over the course of the growing season with a focus on boat landings and other areas with high potential for introduction	After AIS team forms				
Contract with professionals to implement a monitoring program for aquatic invasive species	2017, annually				
Develop and implement a rapid response plan so that new populations are addressed quickly and efficiently	2017				

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
Goal 5: Evaluate the progress of lake management efforts and needs through monitoring					
Objective 1. Continue current data collection efforts to evaluate progress	Ongoing, annual			Water quality team	Lake Planning Grant
Ensure that Citizen Lake Monitoring Volunteer is in place each year to collect phosphorus, chlorophyll, and secchi data	Annual				Citizen Lake Monitoring Network Program
Conduct yearly spring and summer aquatic plant point intercept surveys to determine if CLP reduction goals are being met and if the native plant community is improving	Spring and summer, annual			Polk County LWRD or consultant	Lake Planning Grant
Objective 2. Expand data collection efforts depending on needs				Water quality team	Lake Planning Grant
Monitor culverts to determine phosphorus loads and identify the need for sediment basins	2017-2018				
Conduct a shoreline inventory to document areas of natural vegetation, lawn, and erosion along the shoreline of Big Blake Lake	2017-2018				
Repeat the 2013-15 water quality study in five to ten years	2021-2026				
Collect a sediment core in the south basin					
Implement a turion study to document effectiveness of reducing CLP with harvesting	2017-2018				
Implement a septic survey on all septic systems on the lake	2021				

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
Goal 6: Protect, maintain, and enhance fish and wildlife habitat					
Objective 1. Maintain and enhance desirable populations of game fish in Big Blake Lake by installing 5 habitat improvements such as fish sticks				Fish and wildlife team	
Work with fisheries biologist to determine locations for fish sticks and other habitat improvements					
Identify property owners interested in installing fish sticks and other habitat improvements	2016				
Prepare a Healthy Lakes Grant application to fund the installation of fish sticks	Due February 1, 2017				
Recognize shoreline property owners who have installed fish sticks and other habitat improvements					
Develop and deliver an educational message regarding the importance of leaving trees and branches that fall into the lake for the habitat they provide to fish	Ongoing				
Promote the growth of native aquatic plants					
Explore stocking options for Big Blake Lake					
Objective 2. Restore 10 developed shorelines to more native habitats per year				Healthy lakes team	
Provide an educational message regarding the importance of native vegetation for fish and wildlife habitat	2016			Information and education team	
Conduct a shoreline inventory to document areas of natural vegetation, lawn, and erosion along the shoreline of Big Blake Lake and prioritize sites for projects	2017-2018				
Develop a program to provide incentives to property owners who quit mowing a portion of their shoreline					
See actions under Goal 1, Objective 2					

	Timeline	$ Estimate	Volunteer hours (annual)	Responsible parties and partners	Funding sources
<u>**Goal 7: Sustain the implementation of the plan**</u>					
Objective 1. Form teams to ensure that the goals of the plan are met	Annual meeting 2016, ongoing			District Board	
Water quality team					
-Land acquisition subteam					
-Healthy Lakes subteam					
Fish and wildlife team					
Information and education team					
Aquatic invasive species team					
Aquatic plant team					
Objective 2. Continue to seek funding to implement the Big Blake Lake Management Plan	As needed, ongoing			District Board	
Apply for WDNR Lake Planning, Lake Protection, and Aquatic Invasive Species Grants					
Leverage current partner efforts to strengthen grant applications					
Identify additional funding sources and partners to expand opportunities for action					

Appendix A

Lake Resident Survey and Results

Big Blake Lake Resident Survey

The following survey is a component of a grant which was received to study Big Blake Lake. The survey should take approximately 5-10 minutes to complete. Responses will remain confidential. Final results will be compiled and used to guide management decisions for Big Blake Lake. Feel free to contact the Polk County Land and Water Resources Department with any questions at 715-485-8699. Surveys should be returned by June 1st to:

LWRD
100 Polk County Plaza- Suite 120
Balsam Lake, WI 54810

Thank you again for your participation!

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1. How many years have you owned property on Big Blake Lake? Note: If you own more than one property, please answer all questions for the property you have owned the longest.

   _______________years

2. Which of the following best describes how you use your property?
   ___Year-round residence
   ___Seasonal residence (continued occupancy for months at a time)
   ___Weekend, vacation, and/or holiday residence
   ___Rental property/resort
   ___Other, please specify_______________

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.
   _______________days per year

4. On the average day that your property is occupied, how many people occupy the property?
   _______________people

5. Do you own shoreline property (including shared access points) on Big Blake Lake?
   ___No, please skip to question 7 ___Yes

6. Beginning at the water's edge, how would you describe the area measuring 35 feet inland (shoreline towards the road)? If you don't own shoreline property, please skip this question. Please check all that apply.
   ___Mowed lawn
   ___Un-mowed vegetation
   ___Shrubs/trees
   ___Undisturbed woods
   ___Stabilizing rock/rip rap
   ___Pier/dock
   ___Buffer zone/shoreline restoration
   ___Rain garden

7. What activities do you enjoy on Big Blake Lake? Please check all that apply.

____Swimming
____Peace and tranquility
____Scenic view
____Jet skiing/wakeboarding/waterskiing
____Non-motorized boating (canoe/kayak)
____Motorized boating
____Sailing or wind surfing
____Hunting/trapping
____Observing birds/wildlife
____Open water fishing
____Ice fishing
____Snowmobiling
____Cross country skiing/snowshoeing
____Other, please list______________

8. Which of the following watercraft are kept on your property for use on Big Blake Lake? Please check all that apply.

____Jet skis
____Motorboats/pontoons (1-20 HP)
____Motorboats/pontoons (21-50 HP)
____Motorboats/pontoons (more than 50 HP)
____Canoes/kayaks
____Paddleboats/rowboats
____Sailboat
____Seaplane
____No watercrafts are kept at my property, skip to question 10

9. Are the watercrafts that you use on Big Blake Lake used on other waterbodies?

____Yes ____No

10. What is your degree of concern with each issue listed below? If you believe the issue doesn't exist check the first column; if you believe the issue exists but is not a concern check the second column; and if the issue concerns you please rank your concern as low, medium, or high.

	Issue doesn't exist	Exists, but not a concern	Low concern	Medium concern	High concern
New invasive species entering the lake					
Expansion of current invasive species (curly leaf pondweed)					
Excessive aquatic plant growth					
Excessive algae blooms					
Lack of water clarity or quality					
Loss of natural scenery/beauty					
Excessive noise level on the lake					
Decreased wildlife populations					
Decreased fisheries					
Unsafe use of motorized water craft					
Disregard for slow-no-wake zones					
Decreased property values					
Increased development					
Increased nutrient pollution					
Decrease in overall lake health					

11. How would you describe the current lake level of Big Blake Lake?
    ____Too high
    ____Just right
    ____Too Low
    ____Unsure

12. How would you describe the current water quality of Big Blake Lake?
    ____Poor
    ____Fair
    ____Good
    ____Excellent
    ____Unsure

13. How has the water quality changed in Big Blake Lake in the time you've lived on the lake?
    ____Severely degraded
    ____Somewhat degraded
    ____Remained unchanged
    ____Somewhat improved
    ____Greatly improved
    ____Unsure

14. Algae growth varies through the open water season. Which month(s) of the open water season do you consider <u>algae growth</u> (not including plants) to be a problem on Big Blake Lake. Please check all that apply.
    ____May
    ____June
    ____July
    ____August
    ____September
    ____October
    ____Unsure
    ____Algae growth is never a problem, please skip to question 16

15. Please indicate which of the following uses you believe are impaired by <u>algae</u> (not including plants) on Big Blake Lake. If you are unsure, please check the last column.

	Yes	No	Unsure
Swimming			
Fishing			
Boating			
Navigation			
Dogs/animals using the water			
Overall enjoyment of the lake			

16. Overall, how would you describe the amount of <u>aquatic plants</u> (not including algae) in Big Blake Lake?
    ____Too few plants
    ____Healthy amount of plants
    ____Too many plants

17. Aquatic plant growth varies throughout the open water season. Which month(s) of the open water season do you consider <u>aquatic plant growth</u> (not including algae) to be a problem in Big Blake Lake? Please check all that apply.
    ____May
    ____June
    ____July
    ____August
    ____September
    ____October
    ____Unsure
    ____Aquatic plants are never a problem, please skip to question 20

18. On the map (right), please mark the areas where aquatic plants (not including algae) are a problem in Big Blake Lake. Additionally, feel free to use the space below to describe where aquatic plants are a problem in Big Blake Lake.

____
____
____
____
____
____

19. Please indicate which of the following uses you believe are limited by aquatic plants (not including algae) on Big Blake Lake. If you are unsure, please check the last column.

	Yes	No	Unsure
Swimming			
Fishing			
Boating			
Navigation			
Overall enjoyment of the lake			

20. Curly leaf pondweed is an invasive species that creates nuisance conditions in Big Blake Lake by forming dense beds of vegetation that interfere with lake uses in the spring. Do you think you would recognize curly leaf pondweed if you saw it?

____Definitely yes
____Probably yes
____Unsure
____Probably no
____Definitely no

21. Do you feel the current aquatic plant management program is effectively controlling nuisance aquatic plant growth (not including algae)? If no, please explain.

____Yes
____No, please use the space below to explain
____Unsure

____
____
____

22. How satisfied are you with the current aquatic plant harvesting program?

____Very satisfied
____Somewhat satisfied
____Neutral
____Somewhat dissatisfied
____Very dissatisfied
____Unsure

23. How would you describe the current amount of mowed lawn across the entire shoreline of Big Blake Lake?

___Too much
___Just right
___Not enough
___Unsure

24. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of Big Blake Lake?

___Not at all important
___Not too important
___Somewhat important
___Very important
___Unsure

25. How would you describe the use of fertilizer on your property?

___I don't use any fertilizer on my property
___I use zero phosphorus fertilizer on my property
___I use fertilizer on my property but I'm unsure of its phosphorus content
___I use fertilizer on my property that contains phosphorus
___I use multiple types of fertilizers on my property that contain varying amounts of phosphorus

26. Please indicate which of the following actions should be completed by the District to manage Big Blake Lake. Most activities are eligible for grant funding.

	Yes	No	Unsure
Offering incentives for installation of shoreline buffers and rain gardens			
Offering incentives for installation of farmland conservation practices			
Lake fairs and workshops to share information			
Enforcement of slow-no-wake zones			
Practices to enhance fisheries			
Offering incentives to upgrade non-conforming septic systems			
Pursuing funding to bring the dam on Big Blake Lake up to code			
Programs to prevent and monitor invasive species			

27. Please indicate which of the following activities should be completed by the District to manage aquatic invasive species.

	Yes	No	Unsure
Harvesting curly leaf pondweed			
Herbicide control of curly leaf pondweed			
Boat landing inspections (i.e. Clean Boats, Clean Waters)			
Boat landing cameras (Big Round, Bone, Half Moon, and Church Pine are Polk County lakes that currently have cameras)			
Monitoring to detect new populations of invasive species			
Boat wash station at landings (usually a pressure wash system)			
Educational programs to provide information on invasive species			
Trainings to learn to identify and manage invasive species			

28. How would you prefer to receive information from the Big Blake Lake District? Please check all that apply.

___Newsletter
___Email
___Website
___Facebook
___Annual Meeting
___Prefer not to receive information
___Other, please specify____________

29. How often do you visit the Big Blake Lake District Facebook page?

___I wasn't aware of the Facebook page
___Never
___Rarely
___Sometimes
___Often

30. From the list below, which activities are you interested in participating in to improve Big Blake Lake? Responses will be considered as a measure of interest rather than a commitment.

___Learning to identify aquatic invasive species
___Learning how to monitor for aquatic invasive species
___Learning how to monitor water quality
___Serving on a committee to develop an action plan for improving Big Blake Lake
___Installing a shoreline buffer on your property
___Installing a rain garden on your property
___None of the above

If you're interested in participating in any of the above activities and would like more information, please list your contact information below. This information will be kept separate from your responses to ensure confidentiality.

____

If you have any comments you would like to make, please use the space below.

Thank you for your time and your answers!

Big Blake Lake Resident Survey

Surveys mailed: 217
Surveys returned: 126
Response rate: 58%

1. How many years have you owned property on Big Blake Lake? Note: If you own more than one property, please answer all questions for the property you have owned the longest.

   124 respondents, 98% **Average years: 21**

2. Which of the following best describes how you use your property?

   125 respondents, 99%

___Year-round residence	**41 respondents, 33%**
___Seasonal residence (continued occupancy for months at a time)	**13 respondents, 10%**
___Weekend, vacation, and/or holiday residence	**70 respondents, 56%**
___Rental property/resort	**1 respondent, 1%**
___Other, please specify_____________	**9 respondents, 7%**

- *Occasionally during the week*
- *Family owned for 74 years, personally owned for 3*
- *20-30 days occupied by family/visitors*
- *Occasional visits*
- *One of our sons lives there full time*
- *Only own land - no residence*
- *Land only*
- *Personally owned for 3 years, family owned for 60*
- *Just retired, will stay longer*

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.

   123 respondents, 98% **Average days per year: 147.8**

4. On the average day that your property is occupied, how many people occupy the property?

   125 respondents, 99% **Average people: 3.6**

5. Do you own shoreline property (including shared access points) on Big Blake Lake?

   124 respondents, 98%

___No, please skip to question 7	**7 respondents, 6%**
___ Yes	**117 respondents, 94%**

6. Beginning at the water's edge, how would you describe the area measuring 35 feet inland (shoreline towards the road)? If you don't own shoreline property, please skip this question. Please check all that apply.

117 respondents, 93%

___Mowed lawn	**106 respondents, 91%**
___Un-mowed vegetation	**44 respondents, 38%**
___Shrubs/trees	**52 respondents, 44%**
___Undisturbed woods	**17 respondents, 15%**
___Stabilizing rock/rip rap	**49 respondents, 42%**
___Pier/dock	**57 respondents, 49%**
___Buffer zone/shoreline restoration	**11 respondents, 9%**
___Rain garden	**4 respondents, 3%**

7. What activities do you enjoy on Big Blake Lake? Please check all that apply.

122 respondents, 97%

___Swimming	**85 respondents, 70%**
___Peace and tranquility	**113 respondents, 93%**
___Scenic view	**108 respondents, 89%**
___Jet skiing/wakeboarding/waterskiing	**33 respondents, 27%**
___Non-motorized boating (canoe/kayak)	**57 respondents, 47%**
___Motorized boating	**97 respondents, 80%**
___Sailing or wind surfing	**1 respondent, 1%**
___Hunting/trapping	**10 respondents, 8%**
___Observing birds/wildlife	**96 respondents, 79%**
___Open water fishing	**101 respondents, 83%**
___Ice fishing	**55 respondents, 45%**
___Snowmobiling	**20 respondents, 16%**
___Cross country skiing/snowshoeing	**21 respondents, 17%**
___Other, please list______________	**3 respondents, 2%**

- *I simply live on my 12 acre backlot. I do not, at present, use the lake. I just live here. No longer use the boat, not useable.*
- *Ice Skating*
- *Tubing*

8. Which of the following watercraft are kept on your property for use on Big Blake Lake? Please check all that apply.

123 respondents, 98%

___Jet skis	**15 respondents, 12%**
___Motorboats/pontoons (1-20 HP)	**32 respondents, 26%**
___Motorboats/pontoons (21-50 HP)	**57 respondents, 46%**
___Motorboats/pontoons (more than 50 HP)	**44 respondents, 36%**
___Canoes/kayaks	**56 respondents, 46%**
___Paddleboats/rowboats	**54 respondents, 44%**
___Sailboat	**4 respondents, 3%**
___Seaplane	**0 respondents, 0%**
___No watercrafts are kept at my property, skip to question 10	**9 respondents, 7%**

9. Are the watercrafts that you use on Big Blake Lake used on other waterbodies?

116 respondents, 92%

___Yes	**27 respondents, 23%**
___No	**89 respondents, 77%**

10. What is your degree of concern with each issue listed below? If you believe the issue doesn't exist check the first column; if you believe the issue exists but is not a concern check the second column; and if the issue concerns you please rank your concern as low, medium, or high.
113 respondents, 90%

	Issue doesn't exist	Exists, but not a concern	Low concern	Medium concern	High concern
New invasive species entering the lake **113, 90%**	2, 2%	4, 4%	13, 12%	33, 29%	61, 54%
Expansion of current invasive species (curly leaf pondweed) **120, 100%**	2, 2%	5, 4%	7, 6%	32, 25%	74, 59%
Excessive aquatic plant growth **117, 93%**	2, 2%	3, 3%	8, 7%	34, 29%	70, 60%
Excessive algae blooms **120, 95%**	2, 2%	2, 2%	13, 11%	34, 28%	69, 58%
Lack of water clarity or quality **119, 94%**	3, 3%	4, 3%	12, 10%	34, 29%	66, 55%
Loss of natural scenery/beauty **112, 89%**	12, 11%	11, 10%	28, 25%	36, 32%	25, 22%
Excessive noise level on the lake **117,93%**	16, 14%	18, 15%	37, 32%	27, 23%	19, 16%
Decreased wildlife populations **115. 91%**	21, 18%	11, 10%	36, 31%	23, 20%	24, 21%
Decreased fisheries **114, 90%**	13, 11%	5, 4%	24, 21%	37, 32%	35, 31%
Unsafe use of motorized water craft **117, 93%**	7, 6%	12, 10%	39, 33%	23, 20%	36, 31%
Disregard for slow-no-wake zones **119, 94%**	10, 8%	15, 13%	40, 34%	23, 19%	31, 26%
Decreased property values **115, 91%**	8, 7%	7, 6%	22, 19%	27, 23%	51, 44%
Increased development **115, 91%**	13, 11%	22, 19%	29, 25%	25, 22%	26, 23%
Increased nutrient pollution **111, 88%**	1, 1%	7, 6%	20, 18%	29, 26%	54, 49%
Decrease in overall lake health **116, 92%**	2, 2%	5, 4%	8, 7%	37, 22%	64, 55%

11. How would you describe the current lake level of Big Blake Lake?

120 respondents, 95%

___Too high	**1 respondent, 1%**
___Just right	**11 respondents, 9%**
___Too Low	**97 respondents, 81%**
___Unsure	**11 respondents, 9%**

12. How would you describe the current water quality of Big Blake Lake?

116 respondents, 92%

___Poor	**16 respondents, 14%**
___Fair	**63 respondents, 54%**
___Good	**30 respondents, 26%**
___Excellent	**0 respondents, 0%**
___Unsure	**7 respondents, 6%**

13. How has the water quality changed in Big Blake Lake in the time you've lived on the lake?

119 respondents, 94%

___Severely degraded	**14 respondents, 12%**
___Somewhat degraded	**36 respondents, 30%**
___Remained unchanged	**25 respondents, 21%**
___Somewhat improved	**26 respondents, 22%**
___Greatly improved	**6 respondents, 5%**
___Unsure	**12 respondents, 10%**

14. Algae growth varies through the open water season. Which month(s) of the open water season do you consider algae growth (not including plants) to be a problem on Big Blake Lake. Please check all that apply.

121 respondents, 96%

___May	**1 respondent, 1%**
___June	**17 respondents, 14%**
___July	**80 respondents, 66%**
___August	**107 respondents, 88%**
___September	**49 respondents, 40%**
___October	**4 respondents, 3%**
___Unsure	**6 respondents, 5%**
___Algae growth is never a problem, please skip to question 16	**3 respondents, 2%**

15. Please indicate which of the following uses you believe are impaired by algae (not including plants) on Big Blake Lake. If you are unsure, please check the last column.

	Yes	No	Unsure
Swimming **114, 90%**	105, 92%	2, 2%	7, 6%
Fishing **101, 80%**	58, 57%	16, 16%	27, 27%
Boating **100, 79%**	52, 52%	35, 35%	13, 13%
Navigation **94, 75%**	19, 20%	53, 56%	22, 23%
Dogs/animals using the water **106, 84%**	49, 46%	21, 20%	36, 34%
Overall enjoyment of the lake **108, 86%**	91, 84%	5, 5%	12, 11%

16. Overall, how would you describe the amount of aquatic plants (not including algae) in Big Blake Lake?
114 respondents, 90%

___Too few plants **2 respondents, 2%**
___Healthy amount of plants **33 respondents, 29%**
___Too many plants **79 respondents, 69%**

17. Aquatic plant growth varies throughout the open water season. Which month(s) of the open water season do you consider aquatic plant growth (not including algae) to be a problem in Big Blake Lake? Please check all that apply.

118 respondents, 94%
___May **11 respondents, 9%**
___June **54 respondents, 46%**
___July **87 respondents, 74%**
___August **79 respondents, 67%**
___September **40 respondents, 34%**
___October **2 respondents, 2%**
___Unsure **14 respondents, 12%**
___Aquatic plants are never a problem, **1 respondent, 1%**
please skip to question 20

18. On the map (right), please mark the areas where aquatic plants (not including algae) are a problem in Big Blake Lake. Additionally, feel free to use the space below to describe where aquatic plants are a problem in Big Blake Lake.

89 respondents, 71%

- *Shorelines and both ends of lake*
- *Northeast shoreline, north by Richardson Court, southeast corner of lake*
- *Southeast corner*
- *Center of lake – 2*
- *N and S bays – 15*
- *NW end center, NW area of center lake, center lake, SE end center*
- *NW area of center of lake towards western shore*
- *NW end center and western shore, SE end center*
- *W shore of center lake*
- *NW by N bay. E bays N of the narrows*
- *All of lake*
- *NW bay, SE bay - 2*
- *SE bay, entire W shore*

- *W shore of the S bay*
- *NW bay, NW of center of lake near W shore, SE bay*
- *E and W shores, center lake, NW bay, SE bay*
- *Lower SE bay, Blake Lake Court*
- *Near the narrows of N end of lake and both bays*
- *We see them mainly on the North end. Once you get through the narrows, it's not so bad*
- *NW bay just off shore, SE bay*
- *W shore between center lake and N bay*
- *Whole N & S bays*
- *Northern most shore of N bay, W & E shores of S bay*
- *Lower end of the North bay*
- *N and S bays. "North end of lake quick sand like sediment much where boats get stuck"*
- *Entire length of the center of the lake. "Mouth at straight river (fox creek), west end of lake"*
- *Western half of the North bay*
- *Worst areas are the N and S ends. The entire lake can have an excessive amount of aquatic plants. Mowing has been good.*
- *N and S bays, NE area of center lake*
- *E and W banks of the lower portion of North bay*
- *Western shore of S bay, SE shore of center lake*
- *Nearly entire shoreline where depth is 5 ft. of less*
- *Outlet gets plugged by cut plants*
- *Most of the lake during June and July*
- *By Bystrom Lake boat landing and W shoreline; bay just N of Baker Lane landing; Channel by and bay by inlet from L Blake*
- *All bays*
- *N shore of N bay. W shore of center lake, entire S bay*
- *NE end*
- *West shore of the north bay*
- *All along the shoreline on the west side; unsure about east side*
- *Mouth of the S bay*
- *NE area of N bay; E and W shore of S bay*
- *Whole length of western shore*
- *N and S bays trailing towards center lake*
- *N and S bays; center lake*
- *South bay -2*
- *N and S bays, "It's a lot better since harvesting."*
- *N and S bays; esp. SE shore of S bay. "I have observed water flowing across road that has flowed from a farmer's field. I have taken pictures at that time."*
- *N and S bays, "Bystrom. Richardson Ct."*
- *"The entire lake is prone to curly leaf. Without the harvester it would be a major problem"*
- *Western shore of North bay*
- *NW corner*
- *N and S bays – eastern shore of center lake*
- *"South East end of lake and the channel between Big + Little Blake Lakes. Both ends of lake get very weedy"*
- *S bay - 2*
- *Whole lake has problems. Especially the north end*
- *Eastern shore of North bay*
- *North bay, NW and SE shores of center lake*
- *Ends of lake. Richardson Bay. Beyond ledge, Blake Lake Ct.*
- *S bay extending into Little Blake Lake*
- *Northern shore of North bay, NW + SE shores of center lake. Eastern area of South bay*
- *South bay. NW center lake. "Actually the whole lake if we didn't harvest them"*
- *"Mostly on west side of lake and in the two ends – shallow areas"*
- *SE shore center lake*
- *North and NW shore of North bay extending to western shore towards center lake*
- *N and S bays. Northern center lake*
- *NW area of North bay, South bay, "Cove that empties Big into Little Blake. Area by Sherards dam site*
- *N and S bays, eastern shore center lake*
- *Least problem seems to be along East side (least developed) (least of bogus septic operations). Shallow far south is pretty bad too*
- *N and S bays, western shore b/t N bay and center lake*
- *Unsure*
- *All the areas less than 6' deep, then floating plants go where the current and wind takes it. All the lake is a problem sometimes*

19. Please indicate which of the following uses you believe are limited by aquatic plants (not including algae) on Big Blake Lake. If you are unsure, please check the last column.

	Yes	No	Unsure
Swimming **109, 87%**	90, 83%	8, 7%	11, 10%
Fishing **104, 83%**	65, 63%	20, 19%	19, 18%
Boating **106, 84%**	75, 71%	17, 16%	14, 13%
Navigation **100, 79%**	43, 43%	27, 27%	30, 30%
Overall enjoyment of the lake **105, 85%**	76, 72%	15, 14%	14, 13%

20. Curly leaf pondweed is an invasive species that creates nuisance conditions in Big Blake Lake by forming dense beds of vegetation that interfere with lake uses in the spring. Do you think you would recognize curly leaf pondweed if you saw it?
114 respondents, 90%

___Definitely yes **56 respondents, 49%**
___Probably yes **23 respondents, 20%**
___Unsure **15 respondents, 13%**
___Probably no **13 respondents, 11%**
___Definitely no **7 respondents, 6%**

21. Do you feel the current aquatic plant management program is effectively controlling nuisance aquatic plant growth (not including algae)? If no, please explain.

111 respondents, 88%

___Yes **44 respondents, 40%**
___No, please use the space below to explain **30 respondents, 27%**
___Unsure **37 respondents, 33%**

- *Not exactly sure what plan is currently. Would be nice if lake weed harvesting could be done by county more often by shoreline as opposed to citizens having to private pay. Taxes very high, should provide for more exclusive lake services.*
- *No significant difference.*
- *Helps, but problem still exists*
- *The harvesting cleans it up but does nothing to get rid of it or limit it's growth.*
- *Yes! Harvester made a big difference!*
- *This are better with Harvey the harvester than without, HOWEVER, way too little is done at North end along Breezy Road cabins to catch floating cut plants before they wash up on shore. TONS! Operators need to be aware of what they miss & not dawdle to catch floaters. Harvey the machine was a great purchase.*

22. How satisfied are you with the current aquatic plant harvesting program?

115 respondents, 91%

___Very satisfied **22 respondents, 19%**
___Somewhat satisfied **51 respondents, 44%**
___Neutral **19 respondents, 17%**
___Somewhat dissatisfied **12 respondents, 10%**
___Very dissatisfied **2 respondents, 2%**
___Unsure **9 respondents, 8%**

23. How would you describe the current amount of mowed lawn across the entire shoreline of Big Blake Lake?

115 respondents, 91%

___Too much **28 respondents, 24%**
___Just right **54 respondents, 47%**
___Not enough **2 respondents, 2%**
___Unsure **31 respondents, 27%**

24. How would you describe the importance of shoreline buffers, rain gardens, and native plants to the water quality of Big Blake Lake?

115 respondents, 91%

___Not at all important **8 respondents, 7%**
___Not too important **12 respondents, 10%**
___Somewhat important **39 respondents, 34%**
___Very important **42 respondents, 37%**
___Unsure **14 respondents, 12%**

25. How would you describe the use of fertilizer on your property?

114 respondents, 90%

___I don't use any fertilizer on my property **68 respondents, 60%**
___I use zero phosphorus fertilizer on my property **43 respondents, 38%**
___I use fertilizer on my property but I'm unsure of its phosphorus content **2 respondents, 2%**
___I use fertilizer on my property that contains phosphorus **0 respondents, 0%**
___I use multiple types of fertilizers on my property that contain varying amounts of phosphorus **1 respondent, 1%**

26. Please indicate which of the following actions should be completed by the District to manage Big Blake Lake. Most activities are eligible for grant funding.

	Yes	No	Unsure
Offering incentives for installation of shoreline buffers and rain gardens **109, 87%**	66, 61%	19, 17%	24, 22%
Offering incentives for installation of farmland conservation practices **109, 87%**	59, 54%	13, 12%	37, 34%
Lake fairs and workshops to share information **106, 84%**	47, 44%	20, 19%	39, 37%
Enforcement of slow-no-wake zones **109, 87%**	48, 44%	31, 28%	30, 28%
Practices to enhance fisheries **109, 87%**	85, 78%	4, 4%	20, 18%
Offering incentives to upgrade non-conforming septic systems **112, 89%**	79, 71%	10, 9%	23, 21%
Pursuing funding to bring the dam on Big Blake Lake up to code **115, 91%**	105, 91%	1, 1%	9, 8%
Programs to prevent and monitor invasive species **113, 1%**	101, 89%	1, 1%	11, 10%

27. Please indicate which of the following activities should be completed by the District to manage aquatic invasive species.

	Yes	No	Unsure
Harvesting curly leaf pondweed **115, 91%**	104, 90%	1, 1%	10, 9%
Herbicide control of curly leaf pondweed **111, 88%**	60, 54%	25, 23%	26, 23%
Boat landing inspections (i.e. Clean Boats, Clean Waters) **114, 90%**	98, 86%	3, 3%	13, 11%
Boat landing cameras (Big Round, Bone, Half Moon, and Church Pine are Polk County lakes that currently have cameras) **107, 85%**	40, 37%	29, 27%	38, 36%
Monitoring to detect new populations of invasive species **114, 90%**	102, 89%	2, 2%	10, 9%
Boat wash station at landings (usually a pressure wash system) **113, 90%**	39, 35%	31, 27%	43, 38%
Educational programs to provide information on invasive species **114, 90%**	82, 72%	10, 9%	22, 19%
Trainings to learn to identify and manage invasive species **114, 90%**	79, 69%	9, 8%	26, 23%

28. How would you prefer to receive information from the Big Blake Lake District? Please check all that apply.
122 respondents, 97%

___Newsletter **104 respondents, 85%**
___Email **62 respondents, 51%**
___Website **29 respondents, 24%**
___Facebook **7 respondents, 6%**
___Annual Meeting **49 respondents, 40%**
___Prefer not to receive information **1 respondent, 1%**
___Other, please specify___________ **0 respondents, 0%**

29. How often do you visit the Big Blake Lake District Facebook page?

120 respondents, 95%

___I wasn't aware of the Facebook page **66 respondents, 55%**
___Never **38 respondents, 32%**
___Rarely **11 respondents, 9%**
___Sometimes **5 respondents, 4%**
___Often **0 respondents, 0%**

30. From the list below, which activities are you interested in participating in to improve Big Blake Lake? Responses will be considered as a measure of interest rather than a commitment.

109 respondents, 87%

___Learning to identify aquatic invasive species **39 respondents, 36%**
___Learning how to monitor for aquatic invasive species **32 respondents, 29%**
___Learning how to monitor water quality **30 respondents, 28%**
___Serving on a committee to develop an action plan for improving Big Blake Lake **13, 12%**
___Installing a shoreline buffer on your property **35 respondents, 32%**
___Installing a rain garden on your property **30 respondents, 28%**
___None of the above **38 respondents, 35%**

If you have any comments you would like to make, please use the space below.

Thank you for your time and your answers!

- *Most important issue is rebuilding the dam*
- *As a lake resident, the lake is most important. All actions to help lake Me good! We support it even if tax increase or Lake Association dues*
- *I'd like to do the pontoon classroom and the class at the government center*
- *Anyone looking to buy I'm selling!*
- *Take culvert out that feeds run off from the field on 78th St.*
- *Better inspection of boats coming from other waters. Closer monitoring of boat speed, jet ski operations, young people operating boats/jet skis.*
- *Do not understand why the DNR thinks it's such a big deal to throw a few rocks on the dam for a temporary fix to hold the water level until a new dam can be put in place. It has only been done this way for 100 years. A safety issue. REALLY!! What a bunch of bullshit.*
- *Fix the dam, if not let the people fix it!*
- *I am very concerned about the dam washout at Fox Creek. We need to make sure this gets rebuilt or we will have nothing but a mud puddle.*
- *I believe the lake has too much traffic for its size compared to other lakes in the area. Jet skis are changing the shore line by too much use.*
- *Is there a list somewhere of who lives where around the lake?*
- *Limit jet ski hours. We do not need a no wake zone.*
- *Live too far away to participate*
- *We are 1000 ft. back from Blake Lake! None of these questions apply to us!*
- *Re: #7 Jet skiing - forbid #22 Just before holidays don't come up to shoreline to cut & harvest weeds! #30 Get rid of harvester. Use spray. Ones that want swimming and fishing negotiate treatment to their property on the subject. It's hard to do manually for older residents. Get a contact person to run Harvester all summer/year*
- *Re: #25 My neighbors do and I'm not sure if it's the right product #26 re: Dam funding - if water keeps flowing where dam use to be we will have a dry lake bed. #30 I'm selling my cabin because of all the problems with the Lake Association.*
- *Lake is "way too low". Poor condition all summer, good condition in spring and winter. The lake "smells really bad"*
- *Re #10: No one adheres to [the no wake zones] re #25: Never use fertilizers. Would rather have good water conditions than green grass. re #30: I have this [buffer] now for the last 25 years*
- *Re #12: water quality poor in summer, good spring to July re #23: [Mown lawn] is too much, but is less concern than failed/ failing / borderline septics. re#26: [Offering incentives to upgrade septic systems] is the most important question on entire survey. [Pursuing funding to repair dam] 2nd most important although most urgent re#27: Not persuaded herbicide is safe.*
- *Re:#12: Natural, same as in the 50's, 60's, 70's, 80's, 90's. re #14: It happens every year, it's normal. re #30: Keep cutting the weeds and leave the lake alone. It's been fine for the 70 years I've been there.*
- *Re: #1: Develop stewardship group that includes 2 generations. Favor involvement of area student groups paired with adults. Engagement program.*
- *Emphatic #11 & #26 (Funding)*
- *Re: #30 "Too old!"*

Appendix B

Lake Level and Precipitation Monitoring

Date	Lake Level (ft)	Precipitation (in)	Comments
5/23/14	138	0	
5/24/14	136	0	
5/25/14	134	0	
5/26/14	130	0	
5/27/14	138	1.5	
5/28/14	139	0	
5/29/14	136	0	
5/30/14	134	0	
5/31/14	132	0	
6/1/14	144	1.75	
6/2/14	148	0.5	
6/3/14	148	0	
6/4/14	146	0	
6/5/14	146	0	
6/6/14	146	0	
6/7/14	146	0.06	
6/8/14	148	0	
6/9/14	144	0	
6/10/14	142	0	
6/11/14	140	0	
6/12/14	136	0.25	
6/13/14	136	0	
6/14/14	136	0	
6/15/14	146	1.25	
6/16/14	146	0	
6/17/14	144	0.02	
6/18/14	146	0.02	
6/19/14	154	0.08	
6/20/14	154	0	
6/21/14	156	0	
6/22/14	156	0	
6/23/14	152	0	
6/24/14	150	0	
6/25/14	150	0	
6/26/14	148	0	
6/27/14	140	0	
6/28/14	140	0.5	
6/29/14	150	1.5	
6/30/14	146	0	
7/1/14	142	0	
7/2/14	140	0	
7/3/14	136	0	
7/4/14	134	0	
7/5/14	132	0	
7/6/14	128	0.01	
7/7/14	126	0	
7/8/14	124	0.25	
7/9/14	120	0	
7/10/14	116	0	
7/11/14	118	0.03	
7/12/14	112	0	
7/13/14	112	0	
7/14/14	110	0	
7/15/14	108	0.02	
7/16/14	106	0	
7/17/14	102	0	
7/18/14	100	0	
7/19/14	100	0	
7/20/14	98	0	
7/21/14	96	0	
7/22/14	94	0	
7/23/14	94	0	
7/24/14	92	0	
7/25/14	92	0	
7/26/14	90	0	
7/27/14	88	0	
7/28/14	86	0	
7/29/14	96	0	
7/30/14	104	0	
7/31/14	110	0	rocks placed
8/1/14	114	0	
8/2/14	118	0	
8/3/14	120	0	
8/4/14	132	1.03	
8/5/14	134	0	
8/6/14	132	0	
8/7/14	132	0	
8/8/14	132	0	
8/9/14	132	0	
8/10/14	130	0	
8/11/14	138	0.5	
8/12/14	138	0.25	
8/13/14	138	0	
8/14/14	136	0	
8/15/14	136	0	
8/16/14	134	0	
8/17/14	134	0	
8/18/14	138	0.5	

8/19/14	136	0.02	
8/20/14	140	0.06	
8/21/14	146	0.75	
8/22/14	146	0	
8/23/14	142	0	
8/24/14	142	0	
8/25/14	142	0	
8/26/14	140	0	
8/27/14	138	0.01	
8/28/14	138	0	
8/29/14	136	0	
8/30/14	158	2.5	
8/31/14	156	0	
9/1/14	160	1	
9/2/14	158	0	
9/3/14	154	0	
9/4/14	164	1.04	
9/5/14	160	0	
9/6/14	158	0	
9/7/14	156	0	
9/8/14	152	0	
9/9/14	148	0	
9/10/14	154	0.06	
9/11/14	150	0	
9/12/14	140	0	
9/13/14	138	0	
9/14/14	136	0	
9/15/14	134	0	
9/16/14	132	0	
9/17/14	132	0	
9/18/14	132	0	
9/19/14	134	0	
9/20/14	134	0	
9/21/14	138	0.25	
9/22/14	138	0	
9/23/14	138	0	
9/24/14	138	0	
9/25/14	138	0	
9/26/14	138	0	
9/27/14	138	0	
9/28/14	138	0	
9/29/14	140	0.25	
9/30/14	140	0	
10/1/14	140	0	
10/2/14	146	0.75	

10/3/14	146	0.25	
10/4/14	150	0.75	
10/5/14	152	0	
10/6/14	150	0	
10/7/14	150	0	
10/8/14	150	0	
10/9/14	148	0	
10/10/14	146	0	

Appendix C

Deep Hole Chemical and Physical Data

Big Blake Lake Surface, all units mg/L unless otherwise noted								
Date	Phosphate Ortho Diss	Total Phosphorus	Nitrogen NO3+NO2 Diss	Nitrogen Kjeldahl Total	Nitrogen NH3-N Diss	Total Suspended Solids	Total Sulfate	Chlorophyll a (ug/L)
5/20/13	ND	0.0464	ND	ND	ND	5.00	ND	
5/28/13	ND	0.0378	ND	0.661	ND	5.00	ND	12.1
6/26/13	0.00460	0.0214	ND	0.675	ND	ND	ND	5.81
7/24/13	ND	0.0849	ND	1.63	ND	12.5	ND	118
8/19/13	0.0039	0.135	ND	2.55	0.0236	30.00	ND	235
9/10/13	ND	0.135	ND	1.71	0.203	30.70	ND	98.6
11/12/13	0.0036	0.027	0.182	0.683	0.132	ND		
5/12/14	ND	0.0387	ND	0.676	ND	ND	ND	
5/28/14	ND	0.0308	ND	0.425	0.0377	ND	ND	2.93
6/24/14	ND	0.0212	ND	0.457	ND	2.60	ND	6.71
7/21/14	ND	0.0377	ND	0.717	ND	4.40	ND	8.19
8/19/14	ND	0.0622	ND	1.44	ND	10.00	ND	76.8
9/17/14	ND	0.051	ND	1.03	0.023	7.75	ND	38.1
11/3/14	0.0022	0.0247	0.103	0.42	0.0182	2.20	ND	
4/14/15	ND	0.0252	0.0644	0.374	0.0157	2.50	4.84	
5/27/15	0.0026	0.0248	ND	0.352	0.0316	ND	5.28	3.35
6/25/15	0.0021	0.0228	ND	0.466	ND	2.40	ND	
7/20/15	ND	0.0437	ND	0.812	ND	7.8	ND	27
8/17/15	0.0052	0.077	ND	1.81	0.0262	13.00	4.72	123
9/14/15	0.0119	0.0691	ND	1.02	0.0265	8.00	ND	33.8
11/17/15	0.0046	0.0305	0.051	0.431	0.0191	ND	5.33	

Big Blake Lake Bottom, units mg/L		
Date	Phosphate Ortho Diss	Phosphorus Total
5/28/13	ND	0.0484
6/26/13	0.00360	0.0389
7/24/13	ND	0.0623
8/19/13	ND	0.14
9/10/13	0.012	0.0788
5/28/14	ND	0.0388
6/24/14	ND	0.0255
7/21/14	0.0021	0.0464
8/19/14	ND	0.0558
9/17/14	ND	0.0576
5/27/15	0.0035	0.0256
6/25/15	ND	0.0307
7/20/15	0.002	0.0781
8/17/15	0.00800	0.076
9/14/15	0.0112	0.0736

Big Blake Lake, deep hole

Date	Depth (m)	DO (mg/l)	SpCond (ms/s)	Conduct (ms/s)	Temp (oC)	Salinity (ppt)	pH	ORP	TDS	Secchi (ft)	Comments
5/20/13	0	7.46	206	173	16.76	0.10	8.36	-44.1		4.5	Turnover, 11:44 am
	1	7.89	206	173	16.74	0.10	8.33	-43.2			cloudy, breezy, humid
	2	8.18	206	173	16.73	0.10	8.32	-43.7			storms over weekend
	3	8.19	210	177	16.53	0.10	8.30	-44.3			CLP immature, loon
	4	5.54	218	179	15.59	0.10	7.76	-43.7			depth 16 feet
5/28/13	0	3.35	194	159	15.28	0.09	7.92	-72.8		5	overcast, calm
	1	4.13	202	164	15.27	0.10	7.86	-71.0			low/mid 60's, slight breeze
	2	5.06	204	167	15.26	0.10	7.83	-70.7			bottom: 13 ft, top: 1 ft
	3	5.90	203	165	15.23	0.10	7.82	-70.8			zooplankton: 13 ft
	4	5.97	202	164	15.23	0.10	7.81	-70.9			algae: 2 meter composite
6/19/13	0	2.96	200	191	22.39	0.09	8.48	-97.9		8	clear, calm breeze, 70's
	1	4.12	204	193	22.19	0.10	8.37	-93.1			
	2	5.28	205	193	21.99	0.10	8.31	-92.3			
	3	3.10	212	191	19.99	0.10	7.70	-92.8			
	4	1.29	224	199	18.94	0.11	7.40	-94.9			
6/26/13	0	7.35	201	204	25.71	0.09	8.26	-78.9		7	calm, humid, then storm arrived
	1	6.62	206	208	25.51	0.10	8.28	-78.9			top at 2 PM bottom at 2:07 PM
	2	6.93	207	209	25.34	0.10	8.17	-75.2			
	3	5.98	208	207	24.68	0.10	7.91	-75.7			
	4	1.61	231	216	21.64	0.11	7.37	-83.1			
7/18/13	0	2.91	190	201	28.52	0.09	9.24	-95.7		4	90's, sunny, light breeze 11:55 AM
	1	5.81	186	201	29.15	0.09	9.25	-95.1			
	2	5.83	207	214	26.74	0.10	8.61	-88.8			
	3	0.03	238	234	24.26	0.11	7.52	-105.9			
	4	0.00	246	240	23.85	0.12	7.36	-115.6			
7/24/13	0	5.67	191	188	24.19	0.09	8.77	-88.4		1.5	blue-green alage bloom

	1	7.37	188	185	24.23	0.09	8.68	-86.7		overcast, calm, high 60's
	2	4.85	190	187	24.11	0.09	8.51	-89.0		10:10AM
	3	5.50	190	187	24.04	0.09	8.56	-88.7		
	4	3.93	194	190	23.87	0.09	8.35	-89.6		
8/9/13	0	7.86	187	181	23.09	0.09	9.12	-81.0	2	sunny, partly cloudy, light breeze
	1	10.83	187	181	23.19	0.09	9.12	-78.0		low 70's, 1:40 PM
	2	5.77	193	182	22.12	0.09	8.51	-73.9		
	3	2.04	199	185	21.39	0.09	7.87	-75.7		
	4	0.86	202	188	21.31	0.10	7.53	-83.3		
8/19/13	0	3.40	168	163	23.65	0.08	9.43	-66.0	1	overcast, calm, slight breeze
	1	8.57	168	163	23.46	0.08	9.30	-64.6		10:16 AM
	2	7.00	182	176	23.14	0.09	8.89	-62.7		
	3	1.71	191	182	22.53	0.09	8.14	-64.0		
	4	0.00	203	191	21.79	0.10	7.75	-65.0		
9/10/13	0	2.86	178	170	22.87	0.09	8.38	-43.2	2	raining, calm, 12:05 PM
	1	3.40	187	180	22.84	0.09	8.46	-44.1		
	2	1.46	190	181	22.38	0.09	8.03	-44.7		
	3	1.42	191	181	22.24	0.09	7.91	-45.1		
	4	0.00	206	194	21.88	0.10	7.29	-50.7		
9/26/13	0	7.37	184	159	17.81	0.09	9.12	-14.9	2	very windy, sunny, high 70's
	1	10.63	185	159	17.74	0.09	9.08	-14.5		12:20 PM
	2	8.47	185	160	17.74	0.09	9.07	-15.1		
	3	9.05	186	160	17.64	0.09	9.04	-15.0		
	4	8.84	187	160	17.43	0.09	8.98	-15.2		
10/24/13	0	5.70	187	124	7.25	0.09	7.58	-2.5	8	crisp breeze, overcast
	1	3.61	193	128	7.23	0.09	7.78	-2.5		flurries earlier in day
	2	3.67	196	129	7.13	0.09	7.77	-3.3		
	3	4.26	200	132	7.03	0.10	7.75	-5.4		
	4	4.77	202	133	6.98	0.10	7.73	-6.2		

11/4/13	0	23.56	206	131	5.76	0.10	7.99	-46.9		10	drizzle, gusty, overcast
	1	22.47	208	132	5.74	0.10	7.94	-45.1			
	2	20.76	210	133	5.73	0.10	7.89	-43.1			
	3	19.63	212	134	5.73	0.10	7.85	-41.2			
	4	12.49	214	136	5.72	0.10	7.81	-39.4			
11/6/13	0	8.65	207	130	5.39	0.10	9.10	-23.1		11.5	lake fairly calm, chill breeze
	1	7.84	208	130	5.37	0.10	8.70	-22.9			sunny, snow last night
	2	7.15	211	132	5.38	0.10	8.44	-22.8			
	3	6.85	215	135	5.29	0.10	8.28	-23.1			
	4	6.81	218	136	5.18	0.10	8.18	-23.0			
11/12/13	0	24.76	208	119	2.71	0.10	9.32	-50.8		14	sunny, calm
	1	26.06	210	120	2.54	0.10	8.99	-50.3			secchi touched bottom
	2	22.28	212	122	2.54	0.10	8.60	-47.4			Turnover chemistry
	3	15.99	213	122	2.57	0.10	8.47	-46.8			
	4	14.65	216	128	3.39	0.10	8.13	-51.2			
5/12/14	0	11.85	214	170	14.07	0.10	8.69	20.5		3.5	Turnover
	1	11.94	210	165	13.9	0.10	8.65	21.0			Slight breeze, overcast
	2	11.82	208	162	13.3	0.10	8.61	21.4			Storm previous night
	3	9.63	210	161	12.89	0.10	8.32	21.9			Dam blew in spring
	4	3.80	217	164	12.22	0.10	7.86	21.6			
5/22/14	0	8.56	195	159	15.51	0.09	8.14	28.9	97	6	Sunny, calm, beautiful day
	1	8.22	201	164	15.34	0.10	8.11	29.0	100		Installed staff gauge at Denny's
	2	7.84	203	161	14.13	0.10	8.04	29.6	102		
	3	9.51	204	161	13.95	0.10	7.97	29.7	102		
	4	6.96	207	163	13.9	0.10	7.86	29.1	103		
5/28/14	0	5.58	202	185	20.39	0.10	8.02	-23.7	101	9	Large rain on 5/27/14
	1	5.25	202	183	20.04	0.10	8.03	-23.4	101		Sunny, calm, beautiful day
	2	4.88	203	178	18.68	0.10	7.98	-23.0	101		Chemistry
	3	2.80	214	185	17.84	0.10	7.65	-21.8	107		11AM

	4	0.70	237	196	15.8	0.11	7.43	-20.0	119		
6/9/14	0	5.70	205	191	21.41	0.10	8.20	-25.8	102	6	overcast, calm
	1	5.43	202	189	21.39	0.10	8.28	-24.7	101		
	2	5.42	202	187	21.13	0.10	8.23	-23.4	101		
	3	3.10	209	190	20.18	0.10	7.75	-23.4	105		
	4	1.06	230	207	19.53	0.11	7.42	-24.8	105		
6/24/14	0	5.16	198	197	24.62	0.09	8.46	-18.5	99	8	Beautiful day, calm, sunny
	1	5.19	197	194	24.04	0.09	8.48	-18.5	99		Harvesting
	2	4.82	198	193	23.64	0.09	8.32	-18.5	99		Chemistry, algae, zooplankton
	3	2.82	209	196	21.63	0.10	7.77	-19.1	105		
	4	1.16	220	203	20.87	0.10	7.43	-21.8	110		
7/9/14	0	3.77	196	191	23.61	0.09	7.66	-18.2	99	4	Sunny, calm, 70's, perfect day
	1	3.62	197	191	23.24	0.09	7.84	-17.3	99		10:46AM
	2	3.56	197	189	22.87	0.09	7.94	-17.0	99		
	3	3.34	198	189	22.78	0.09	7.89	-15.1	99		
	4	0.63	203	194	22.62	0.10	7.33	-25.0	102		
7/21/14	0	4.13	199	195	24.04	0.09	8.32	-54.1	99	4	Sunny, light breeze
	1	4.01	199	195	23.98	0.09	8.33	-53.1	99		Heat advisory
	2	3.80	199	195	23.77	0.09	8.28	-52.1	100		10:33AM
	3	3.52	202	196	23.58	0.09	8.15	-50.8	101		Chemistry, algae, zooplankton
	4	0.95	219	208	22.46	0.10	7.49	-63.0	110		
8/5/14	0	8.45	196	197	25.17	0.09	8.63	-32.6	98	4	Partly cloudy, mostly calm
	1	9.36	195	194	24.76	0.09	8.71	-32.7	97		
	2	7.05	200	198	24.24	0.09	8.38	-31.3	100		
	3	0.00	213	208	23.73	0.10	7.53	-33.0	107		
	4	0.00	232	219	23.4	0.11	7.27	-44.4	112		
8/19/14	0	4.87	217	206	23.61	0.10	9.49	8.2	102	2	Overcast, slight breeze
	1	4.53	196	190	23.43	0.09	9.14	6.4	98		
	2	4.09	198	192	23.39	0.09	8.99	5.3	99		

	3	3.29	200	194	23.34	0.09	8.74	5.8	100		
	4	0.93	207	200	23.07	0.10	7.89	-6.8	106		
9/6/14	0	2.61	192	177	20.92	0.09	8.28	-55.8	96	3.5	Overcast, windy, cold
	1	2.52	192	177	20.94	0.09	8.28	-57.7	96		
	2	2.52	191	177	20.94	0.09	8.27	-57.9	96		
	3	2.52	191	176	20.94	0.09	8.26	-58.9	96		
	4	1.86	200	185	20.93	0.09	7.83	-73.2	99		
9/17/14	0	10.06	189	164	18.13	0.09	9.63	-63.2	94	3	Mostly sunny, calm, beautiful
	1	10.37	186	156	16.69	0.09	9.49	-64.0	93		
	2	9.20	175	145	15.94	0.09	9.50	-64.1	91		
	3	5.78	188	154	15.68	0.09	8.86	-63.6	94		
	4	5.60	189	155	15.49	0.09	8.60	-64.2	94		
	4.5	1.43	196	160	15.33	0.09	8.34	-65.3	98		
11/3/14	0	3.25	200	128	6.13	0.10	10.27	-57.0	100	9	Turnover, slight breeze
	1	3.21	200	128	6.14	0.10	10.10	-58.0	100		Overcast, cold
	2	3.32	200	129	6.13	0.10	10.01	-59.1	100		
	3	3.46	200	128	6.12	0.10	9.88	-58.3	100		
	4	3.49	200	128	6.12	0.10	9.80	-59.3	100		
4/14/15	0	3.33	173	124	10.14	0.08	8.18	52.0	86	7	Clear, calm breeze, sunny
	1	3.49	173	124	10.08	0.08	8.19	53.1	86		Turnover
	2	3.66	175	125	9.73	0.08	8.14	54.4	88		
	3	3.81	175	124	9.66	0.08	8.13	55.7	87		
	4	3.60	174	123	9.61	0.08	8.02	56.3	87		
5/27/15	0	5.83	174	151	17.95	0.08	8.53	10.0	87	11	
	1	5.66	173	149	17.51	0.08	8.34	13.3	87		
	2	5.44	173	147	17.09	0.08	8.29	16.9	87		
	3	5.57	173	147	16.96	0.08	8.24	19.5	87		
	4	2.66	174	146	16.69	0.08	7.81	16.5	87		
	4 1/4	2.22	174	146	16.66	0.08	7.57	15.0	87		

6/9/15	0	5.06	160	159	24.65	0.07	8.75	15.0	80	8	harvesting
	1	5.12	158	151	22.56	0.07	8.74	17.6	78		
	2	5.09	156	146	21.64	0.07	8.74	19.6	78		
	3	4.54	156	145	21.27	0.07	8.53	21.4	78		
	4	2.40	164	150	20.46	0.08	8.06	18.9	82		
	4 1/4	0.89	168	153	20.32	0.08	7.45	11.4	84		
6/25/15	0	4.15	140	139	24.51	0.07	8.74	21.4	70	8.5	breezy, cloudy, warm
	1	4.12	141	139	24.23	0.07	8.68	23.3	70		
	2	4.08	140	136	23.41	0.07	8.62	27.5	70		
	3	1.86	145	138	22.34	0.07	7.82	22.9	73		
	4	0.14	148	139	21.84	0.07	7.44	14.7	74		
	4 1/4	0.00	151	142	21.71	0.07	7.28	12.3	75		
7/7/15	0	1.38	148	144	23.56	0.07	8.21	29.2	74	6	breezy, partly cloudy
	1	1.42	149	145	23.57	0.07	8.24	30.6	75		Close to 3" rain Sunday night to Monday
	2	1.45	151	147	23.43	0.07	8.22	32.0	76		
	3	1.45	153	148	23.33	0.07	8.14	35.2	77		
	4	1.47	155	149	22.98	0.07	7.99	36.1	78		
	4.5	0.00	179	172	22.92	0.08	7.31	9.1	80		
7/20/15	0	3.82	139	141	25.68	0.06	9.24	22.7	70	3.5	windy, partly cloudy
	1	3.87	141	143	25.67	0.07	9.19	25.6	70		
	2	3.90	142	143	25.59	0.07	9.11	28.7	70		
	3	1.69	149	148	24.43	0.07	8.10	22.4	74		
	4	0.99	151	149	24.13	0.07	7.70	17.0	76		
	4.5	0.00	168	165	23.86	0.08	7.27	29.5	83		
8/6/15	0	7.99	127	126	24.44	0.06	9.85	49.5	63	1.5	breezy, overcast, water - green - bloom
	1	8.26	128	127	24.43	0.06	9.79	49.4	64		
	2	7.95	130	129	24.37	0.06	9.70	52.4	65		
	3	6.00	134	131	23.92	0.06	9.31	56.9	67		
	4	2.22	138	132	22.83	0.06	8.42	60.9	69		

	4.5	0.00	154	148	22.77	0.07	7.46	51.5	77		
8/17/15	0	5.65	130	132	25.67	0.06	9.75	-25.7	65	1.5	mostly cloudy, slight breeze
	1	6.05	132	133	25.68	0.06	9.70	-29.2	66		
	2	0.31	149	148	24.68	0.07	8.44	-43.5	74		
	3	0.00	150	146	23.61	0.07	8.15	-54.9	75		
	4	0.00	155	149	23.01	0.07	7.96	-96.8	77		
	4.5	0.00	184	176	22.83	0.09	7.58	-113.9	92		
8/31/15	0	9.21	142	133	21.82	0.07	9.48	-49.6	71	2	windy, breezy, cloudy, partly sunny
	1	11.04	142	133	21.74	0.07	9.49	-42.3	71		
	2	11.43	145	135	21.43	0.07	9.43	-37.8	72		
	3	9.43	144	134	21.17	0.07	9.22	-36.6	72		
	4	2.77	150	138	20.67	0.07	8.22	-45.9	75		
	4.5	0.00	172	156	19.84	0.08	7.76	-92.5	86		
9/14/15	0	6.93	138	125	20.3	0.06	9.20	-74.1	69	3	breezy, sunny
	1	8.70	141	129	20.19	0.07	9.13	-64.6	71		
	2	8.09	142	129	20.07	0.07	9.05	-60.8	71		
	3	7.66	144	129	19.83	0.07	8.90	-59.7	72		
	4	6.80	144	129	19.71	0.07	8.76	-58.9	72		
	4.5	0.00	152	137	19.72	0.07	7.59	-192.7	76		
11/17/15	0	4.73	142	94	7.19	0.07	9.02	-13.4	71	10	
	1	4.94	143	95	7.18	0.07	8.91	-9.9	72		
	2	5.21	147	97	7.17	0.07	8.83	-5.8	73		
	3	5.42	147	97	7.16	0.07	8.76	-2.8	74		
	4	5.54	151	100	7.12	0.07	8.72	0.1	75		
	4.5	4.64	154	102	7.17	0.07	8.42	3.3	77		

Appendix D

Tributary and Outlet Chemical and Physical Data

Fox Creek, all units mg/L unless otherwise noted

Date	Phosphate Ortho Diss	Total Phosphorus	Nitrogen NO3+NO2 Diss	Nitrogen Kjeldahl Total	Nitrogen NH3-N Diss	Total Suspended Solids	Chlorophyll a (ug/L)
5/28/13	ND	0.0510	ND	0.266	ND	4.80	
6/26/13	0.00420	0.0247	ND	0.449	0.0250	3.00	
7/24/13	ND	0.0794	ND	1.52	0.0470	12.0	91.9
8/19/13	ND	0.101	ND	2.21	0.039	20.50	
9/10/13	0.0047	0.104	ND	1.49	0.308	7.20	
5/28/14	0.0022	0.0274	ND	0.412	0.0311	2.20	
6/24/14	ND	0.0257	ND	0.564	ND	3.20	
7/21/14	ND	0.047	ND	0.742	0.0251	6.20	
8/19/14	ND	0.0611	ND	1.12	0.0674	9.0	
9/17/14	ND	0.0498	ND	1.05	0.0372	6.00	
5/27/15	0.0053	0.0241	ND	0.385	0.0257	ND	
6/25/15	ND	0.0242	ND	0.518	0.0186	ND	
7/20/15	0.0017	0.0496	ND	0.903	0.0187	6.00	
8/17/15	0.0242	0.0723	ND	1.52	0.0532	9.60	
9/14/15	0.0056	0.0685	ND	0.872	0.0442	7.00	

Lost Creek, all units mg/L unless otherwise noted

Date	Phosphate Ortho Diss	Total Phosphorus	Nitrogen NO3+NO2 Diss	Nitrogen Kjeldahl Total	Nitrogen NH3-N Diss	Total Suspended Solids	Chlorophyll a (ug/L)
5/28/13	ND	0.0227	ND	0.545	ND	4.4	
6/26/13	0.0336	0.125	ND	2.44	0.0682	15.7	
7/24/13	0.0261	0.173	ND	1.55	0.118	30.0	29.1
8/19/13	0.0038	0.132	ND	1.42	0.0576	92.0	
9/10/13	0.0022	0.0799	ND	0.989	0.0217	22.0	
5/28/14	0.0031	0.0467	ND	1.12	0.0237	3.4	
6/24/14	0.0145	0.0738	ND	1.38	0.0487	ND	
7/21/14	0.0284	0.121	ND	1.76	0.0539	17.0	
8/19/14	0.0101	0.105	ND	1.64	0.0532	14.3	
9/17/14	0.0085	0.103	ND	1.71	0.0849	41.0	
5/27/15	0.0105	0.0349	ND	0.886	0.0245	5.5	
6/25/15	0.0268	0.152	ND	1.67	0.0726	49.0	
7/20/15	0.0101	0.0855	ND	1.49	0.0479	18.0	
8/17/15	0.0382	0.299	ND	2.05	0.192	28.0	
9/14/15	0.0266	0.14	ND	1.81	0.11	38.5	

Little Blake Inlet, all units mg/L unless otherwise noted

Date	Phosphate Ortho Diss	Total Phosphorus	Nitrogen NO3+NO2 Diss	Nitrogen Kjeldahl Total	Nitrogen NH3-N Diss	Total Suspended Solids	Chlorophyll a (ug/L)
5/28/13	ND	0.0652	ND	0.595	ND	5.00	
6/26/13	0.00700	0.0370	ND	0.516	0.0214	ND	
7/24/13	ND	0.0415	ND	0.992	0.0345	ND	17.6
8/19/13	ND	0.0240	ND	0.698	0.0309	ND	
9/10/13	ND	0.0441	ND	0.53	0.0225	ND	
5/28/14	ND	0.0436	ND	0.469	0.0325	2.60	
6/24/14	ND	0.0319	ND	0.537	ND	2.40	
7/21/14	ND	0.0343	ND	0.507	0.018	2.60	
8/19/14	ND	0.0481	ND	1.08	0.0254	5.00	
9/17/14	ND	0.0494	0.0383	0.822	0.0464	3.00	
5/27/15	0.00510	0.0345	ND	0.337	0.0176	ND	
6/25/15	0.00300	0.0340	ND	0.668	0.0182	ND	
7/20/15	ND	0.0419	ND	0.764	0.015	4.20	
8/17/15	0.00280	0.0560	ND	1.14	0.0288	3.67	
9/14/15	0.00930	0.0559	ND	0.859	0.0714	3.80	

Little Blake Inlet

Date	Foot	Depth (ft)	Flow (m/s)
5/28/13	0	0.7	0.02
	1	1.0	0.05
	2	1.1	0.07
	3	1.1	0.11
	4	1.5	0.20
	5	1.7	0.25
	6	2.4	0.23
	7	2.5	0.19
	8	2.6	0.24
	9	2.5	0.27
	10	2.7	0.26
	11	2.7	0.21
	12	2.5	0.21
	13	2.6	0.27
	14	2.5	0.24
	15	2.3	0.18
	16	2.2	0.17
	17	2.0	0.15
	18	2.1	0.12
	19	1.9	0.08
	20	1.7	0.01
	21	1.4	0.00
	22	1.4	0.00
	23	0.7	0.00
	24	0.4	0.00
6/19/13	0	0.8	0.00
	1	1.0	0.00
	2	1.0	0.13
	3	0.8	0.22
	4	1.6	0.41
	5	2.3	0.69
	6	2.1	1.03
	7	2.5	1.02
	8	2.6	1.14
	9	2.6	1.20
	10	2.6	1.13
	11	2.5	1.18
	12	2.4	1.13
	13	2.4	0.99
	14	2.2	0.81
	15	2.1	0.62
	16	2.0	0.58
	17	2.0	0.55
	18	1.7	0.23
	19	1.6	0.05
	20	1.4	0.01
	21	1.2	0.01
	22	0.5	0.00
	23	0.2	0.00
6/26/13	0	0.8	0.00
	1	0.7	0.03
	2	0.8	0.10
	3	0.9	0.16
	4	1.6	0.44
	5	2.1	0.61
	6	2.3	0.75
	7	2.4	1.05
	8	2.5	1.05
	9	2.3	0.92
	10	2.5	0.77
	11	2.5	0.83
	12	2.5	0.86
	13	2.4	0.89
	14	2.3	0.80
	15	2.2	0.69
	16	2.0	0.52
	17	2.0	0.43
	18	2.0	0.24
	19	1.7	0.10
	20	1.5	0.03
	21	1.3	0.01
	22	1.0	0.01
	23	0.5	0.02
7/18/13	0	0.5	0.06
	1	0.4	0.02
	2	0.6	0.04
	3	1.1	0.06
	4	1.1	0.18
	5	0.9	0.21
	6	2.0	0.40
	7	2.1	0.49
	8	2.2	0.49
	9	2.2	0.64
	10	2.4	0.42
	11	2.2	0.41
	12	2.1	0.47
	13	1.6	0.60
	14	2.1	0.46
	15	2.0	0.39
	16	1.9	0.23
	17	1.7	0.20
	18	1.7	0.09
	19	1.6	0.09
	20	1.4	0.01
	21	1.3	0.00
	22	0.9	0.00
	23	0.3	0.00
	24	0.1	0.00
7/24/13	0	0.3	0.00
	1	0.5	0.00
	2	0.6	0.02
	3	1.4	0.04
	4	1.1	0.19
	5	1.3	0.32
	6	1.9	0.34
	7	2.1	0.42
	8	2.2	0.33
	9	2.0	0.48
	10	2.2	0.36
	11	2.2	0.37
	12	2.1	0.35
	13	2.1	0.38
	14	2.0	0.37
	15	2.0	0.35
	16	1.8	0.20
	17	1.7	0.09
	18	1.5	0.14
	19	1.4	0.04
	20	1.4	0.00
	21	1.2	0.03
	22	0.8	0.00
	23	0.2	0.00
8/9/13	0	0.2	0.98
	1	0.3	0.81
	2	0.3	0.80
	3	0.2	1.34
	4	0.2	1.16
	5	0.2	0.75
	6	0.2	1.24
	7	0.2	1.13
	8	0.1	0.00
	9	0.0	0.00
	10	0.1	0.01
	11	0.3	0.57
	12	0.3	0.88

	13	0.3	1.12
	14	0.3	1.85
	15	0.4	1.45
	16	0.4	2.54
	17	0.5	2.17
	18	0.3	2.44
	19	0.4	0.88
	20	0.5	1.65
	21	0.5	1.60
	22	0.4	1.00
	23	0.5	1.22
	24	0.5	2.95
	25	0.5	3.10
	26	0.4	1.88
8/19/13	0	0.4	0.07
	1	0.2	0.04
	2	0.6	0.09
	3	0.6	0.07
	4	1.2	0.24
	5	1.2	0.41
	6	2.0	0.44
	7	1.8	0.44
	8	2.3	0.80
	9	2.3	0.54
	10	2.4	0.56
	11	2.4	0.68
	12	2.1	0.76
	13	2.2	0.71
	14	2.2	0.72
	15	2.1	0.63
	16	1.9	0.45
	17	1.7	0.54
	18	1.7	0.36
	19	1.7	0.26
	20	1.4	0.14
	21	1.0	0.06
	22	1.0	0.05
	23	0.4	0.04
	24	0.1	0.00
9/10/13	0	0.4	0.02
	1	0.3	0.00
	2	1.2	0.10
	3	1.3	0.11
	4	1.0	0.20
	5	1.1	0.25
	6	1.8	0.29
	7	2.1	0.57
	8	1.2	0.28
	9	2.0	0.50
	10	2.2	0.37
	11	2.2	0.44
	12	2.0	0.36
	13	2.0	0.40
	14	2.0	0.46
	15	1.9	0.38
	16	1.7	0.32
	17	1.6	0.30
	18	1.6	0.36
	19	1.3	0.18
	20	1.0	0.11
	21	1.0	0.07
	22	0.2	0.00
	23	0.1	0.00
9/26/13	0	0.2	0.04
	1	0.4	0.05
	2	0.6	0.11
	3	0.5	0.17
	4	1.1	0.36
	5	1.1	0.45
	6	1.9	0.46
	7	2.1	0.62
	8	1.9	0.86
	9	2.1	0.82
	10	2.0	0.65
	11	2.1	0.82
	12	2.1	0.63
	13	2.1	0.63
	14	2.1	0.57
	15	1.9	0.41
	16	1.8	0.32
	17	1.8	0.26
	18	1.7	0.18
	19	1.3	0.19
	20	1.4	0.16
	21	1.0	0.14
	22	0.3	0.07
	23	0.2	0.00
	24	0.1	0.00
5/22/14	0	0.5	0.11
	1	0.5	0.12
	2	1.0	0.09
	3	1.2	0.15
	4	1.2	0.19
	5	1.3	0.66
	6	1.5	1.18
	7	1.5	2.15
	8	1.6	2.70
	9	1.6	2.95
	10	1.5	2.85
	11	1.9	2.77
	12	2.0	1.01
	13	1.9	2.83
	14	1.9	2.88
	15	1.8	2.10
	16	1.5	1.04
	17	0.4	0.54
	18	0.6	0.20
	19	0.4	0.15
	20	0.3	0.01
5/28/14	0	0.1	0.04
	1	0.1	0.00
	2	0.3	0.05
	3	0.2	0.31
	4	0.8	0.11
	5	0.9	0.78
	6	1.5	0.84
	7	1.7	2.35
	8	1.9	2.27
	9	1.9	2.86
	10	1.9	2.87
	11	1.8	3.01
	12	1.5	2.96
	13	1.7	2.40
	14	1.6	1.10
	15	1.4	0.59
	16	1.2	0.32
	17	1.1	0.04
	18	1.0	0.02
	19	0.5	0.07
	20	0.4	0.09
6/9/14	0	0.2	0.11
	1	0.2	0.03
	2	0.4	0.20
	3	0.5	0.35
	4	0.7	0.79
	5	1.2	1.18
	6	1.8	1.87
	7	1.8	2.43

	8	1.9	2.83
	9	2.1	2.41
	10	2.1	2.52
	11	2.1	3.02
	12	1.7	3.59
	13	2.0	2.28
	14	1.8	3.05
	15	1.8	2.28
	16	1.6	1.97
	17	1.4	0.99
	18	1.4	0.67
	19	1.0	0.18
	20	1.0	0.03
	21	0.9	0.10
	22	0.5	0.11
	23	0.1	0.00
6/24/14	0	0.3	0.09
	1	0.4	0.05
	2	0.6	0.09
	3	0.5	0.18
	4	0.0	0.00
	5	1.6	0.40
	6	1.8	0.43
	7	1.8	1.52
	8	1.9	2.59
	9	2.0	2.06
	10	2.1	2.12
	11	2.1	2.42
	12	2.1	2.38
	13	2.1	1.96
	14	2.1	2.53
	15	2.0	2.12
	16	1.5	2.29
	17	1.5	1.68
	18	1.5	1.22
	19	1.2	0.80
	20	1.2	0.43
	21	1.2	0.18
	22	0.7	0.05
	23	0.4	0.10
	24	0.1	0.00
7/9/14	0	0.1	0.00
	1	0.1	0.00
	2	0.2	0.01
	3	0.2	0.10
	4	0.6	0.12
	5	1.4	0.17
	6	1.1	0.63
	7	1.6	1.15
	8	1.8	1.81
	9	2.0	2.12
	10	2.0	1.60
	11	1.9	1.85
	12	1.9	2.03
	13	1.8	2.35
	14	1.9	2.04
	15	1.6	1.81
	16	1.5	1.47
	17	1.2	1.27
	18	1.2	0.97
	19	0.9	0.50
	20	1.0	0.22
	21	1.0	0.02
	22	0.5	0.11
	23	0.0	0.00
7/21/14	0	0.2	0.07
	1	0.8	0.92
	2	0.6	0.22
	3	1.0	0.24
	4	1.4	0.75
	5	1.5	1.07
	6	1.7	1.36
	7	1.7	1.73
	8	1.7	1.35
	9	1.7	1.81
	10	1.6	2.05
	11	1.5	1.87
	12	1.5	1.69
	13	1.4	1.23
	14	1.3	0.90
	15	1.2	0.63
	16	1.2	0.37
	17	1.0	0.14
	18	0.9	0.06
	19	0.5	0.13
	20	0.4	0.06
	21	0.2	0.03
8/5/14	0	0.1	0.00
	1	0.1	0.00
	2	0.4	0.11
	3	0.5	0.15
	4	0.6	0.14
	5	1.0	0.36
	6	1.6	0.38
	7	1.8	0.62
	8	1.8	0.70
	9	1.9	1.11
	10	2.0	1.18
	11	1.9	1.32
	12	1.5	1.41
	13	1.9	1.12
	14	1.8	1.11
	15	1.6	0.95
	16	1.7	0.83
	17	1.3	0.54
	18	1.3	0.47
	19	0.9	0.26
	20	1.0	0.09
	21	0.6	0.10
	22	0.4	0.04
	23	0.1	0.00
8/19/14	0	0.2	0.12
	1	0.05	0.00
	2	0.5	0.08
	3	0.5	0.24
	4	0.0	0.00
	5	1.5	0.46
	6	1.2	0.50
	7	1.7	0.70
	8	1.9	1.16
	9	2.0	0.99
	10	2.0	0.96
	11	2.0	1.04
	12	2.1	1.19
	13	1.6	1.15
	14	1.7	1.12
	15	1.8	1.02
	16	1.7	0.69
	17	1.4	0.46
	18	1.4	0.26
	19	1.3	0.25
	20	1.1	0.08
	21	1.1	0.06
	22	0.4	0.07
	23	0.05	0.00
9/6/14	0	0.4	0.03
	1	0.2	0.01
	2	0.8	0.10

	3	0.9	0.37
	4	1.4	1.20
	5	1.9	1.48
	6	2.0	1.85
	7	2.1	2.13
	8	2.2	1.58
	9	2.2	1.84
	10	2.2	2.08
	11	2.1	2.32
	12	2.2	1.83
	13	2.1	1.47
	14	2.0	1.53
	15	2.0	1.32
	16	1.6	1.19
	17	1.6	0.80
	18	1.6	0.34
	19	1.4	0.02
	20	0.9	0.12
	21	0.7	0.03
	22	0.2	0.00
9/17/14	0	0.05	0.00
	1	0.05	0.00
	2	0.1	0.01
	3	0.1	0.02
	4	0.8	0.09
	5	0.8	0.19
	6	1.0	0.30
	7	1.3	0.60
	8	1.8	0.73
	9	1.8	0.90
	10	1.8	1.06
	11	1.9	1.04
	12	1.7	1.35
	13	1.8	0.87
	14	1.6	0.91
	15	1.6	0.65
	16	1.2	0.71
	17	1.2	0.29
	18	1.0	0.10
	19	0.6	0.07
	20	0.6	0.07
	21	0.05	0.00
5/27/15	0	0.02	0.07
	1	0.3	0.12
	2	0.3	0.15
	3	0.4	0.35
	4	0.5	0.16
	5	0.2	0.76
	6	1.5	1.08
	7	1.6	1.50
	8	1.8	1.61
	9	1.8	1.55
	10	1.9	0.99
	11	1.8	1.55
	12	1.9	1.74
	13	1.5	1.35
	14	1.7	1.44
	15	1.7	1.16
	16	1.5	0.82
	17	1.3	0.50
	18	1.3	0.28
	19	1.3	0.09
	20	1.0	0.07
	21	0.9	0.05
	22	0.5	0.05
	23	0.1	0.00
6/9/15	0	0.1	0.00
	1	0.1	0.00
	2	0.2	0.05
	3	0.3	0.20
	4	0.8	0.28
	5	1.1	0.46
	6	1.7	1.16
	7	1.9	1.53
	8	1.9	1.44
	9	1.9	1.59
	10	2.0	1.60
	11	1.8	1.66
	12	1.8	1.57
	13	1.9	1.41
	14	1.7	1.27
	15	1.6	0.99
	16	1.5	0.81
	17	1.4	0.37
	18	1.4	0.20
	19	1.4	0.06
	20	0.6	0.04
	21	0.3	0.03
	22	0.0	0.00
6/25/15	0	0.1	0.01
	1	0.2	0.01
	2	0.7	0.02
	3	1.2	0.08
	4	1.3	0.34
	5	1.4	0.63
	6	1.4	0.55
	7	1.6	0.47
	8	1.8	1.28
	9	1.8	1.29
	10	1.8	1.35
	11	1.9	1.46
	12	1.9	1.38
	13	2.0	1.57
	14	1.7	1.27
	15	1.9	1.12
	16	1.7	0.99
	17	1.5	0.46
	18	0.8	0.17
	19	0.6	0.11
	20	0.3	0.11
	21	0.2	0.00
	22	0.5	0.06
7/7/15	0	0.6	0.10
	1	0.3	0.06
	2	0.4	0.10
	3	0.7	0.18
	4	0.9	0.17
	5	1.5	0.72
	6	1.6	1.43
	7	1.9	1.26
	8	2.0	1.54
	9	2.0	1.50
	10	2.1	1.89
	11	2.1	1.56
	12	1.9	1.86
	13	1.9	1.88
	14	1.9	1.57
	15	1.8	1.48
	16	1.6	1.36
	17	1.5	0.77
	18	1.5	0.35
	19	1.4	0.28
	20	1.2	0.01
	21	0.3	0.03
	22	0.5	0.03
	23	0.1	0.00
7/20/15	0	0.1	0.00
	1	0.5	0.00

	2	0.7	0.07
	3	1.0	0.19
	4	1.4	0.42
	5	1.3	0.62
	6	1.4	0.95
	7	1.6	1.22
	8	1.7	1.47
	9	1.9	1.74
	10	1.9	1.96
	11	1.9	1.66
	12	2.0	1.87
	13	1.8	1.61
	14	2.1	1.40
	15	1.8	1.28
	16	1.8	1.49
	17	1.7	1.75
	18	1.4	0.21
	19	0.8	0.11
	20	0.9	0.06
	21	0.1	0.00
	22	0.2	0.00
	23	0.1	0.00
8/6/15	0	0.3	0.03
	1	0.1	0.00
	2	0.0	0.00
	3	0.2	0.00
	4	0.7	0.05
	5	0.9	0.32
	6	1.5	0.59
	7	1.5	1.08
	8	1.5	0.96
	9	1.5	0.95
	10	1.8	1.16
	11	1.7	1.13
	12	1.6	1.25
	13	1.6	1.15
	14	1.6	0.86
	15	1.5	0.81
	16	1.2	0.47
	17	1.1	0.40
	18	1.1	0.22
	19	1.1	0.08
	20	0.9	0.08
	21	0.6	0.05
	22	0.4	0.06
8/17/15	0	0.5	0.08
	1	3.0	0.02
	2	0.0	0.00
	3	0.1	0.00
	4	0.7	0.24
	5	1.0	0.26
	6	1.7	0.55
	7	1.7	0.90
	8	1.7	0.74
	9	1.7	1.15
	10	1.9	1.01
	11	1.8	1.06
	12	1.7	1.04
	13	1.7	1.06
	14	1.7	0.90
	15	1.6	0.48
	16	1.4	0.58
	17	1.3	0.30
	18	1.2	0.15
	19	1.2	0.11
	20	0.7	0.14
	21	0.2	0.00
	22	0.2	0.02
	23	0.1	0.00
8/31/15	0	0.1	0.00
	1	0.4	0.05
	2	0.3	0.00
	3	0.3	0.01
	4	0.8	0.10
	5	1.4	0.32
	6	1.7	0.66
	7	1.8	1.04
	8	1.9	1.64
	9	1.9	1.31
	10	2.1	1.34
	11	2.0	1.64
	12	1.9	1.36
	13	1.8	1.73
	14	1.8	1.44
	15	1.7	1.29
	16	1.5	0.71
	17	1.4	0.60
	18	1.3	0.61
	19	1.4	0.26
	20	1.3	0.15
	21	0.7	0.08
	22	0.5	0.00
	23	0.1	0.00
9/14/15	0	0.1	0.00
	1	0.3	0.04
	2	0.0	0.00
	3	0.2	0.07
	4	0.2	0.00
	5	1.3	0.12
	6	1.4	0.57
	7	1.6	0.90
	8	1.8	1.09
	9	1.7	0.96
	10	1.9	1.11
	11	1.8	1.29
	12	1.8	1.32
	13	1.6	1.60
	14	1.7	1.36
	15	1.6	1.08
	16	1.5	1.03
	17	1.3	0.68
	18	1.3	0.34
	19	1.2	0.12
	20	1.2	0.04
	21	0.5	0.02
	22	0.3	0.00
	23	0.1	0.00

Lost Creek

Date	Foot	Depth (ft)	Flow (m/s)
5/28/13	0	2.0	0.03
	1	2.5	0.00
	2	3.0	0.03
	3	2.9	0.03
	4	3.4	0.01
	5	3.5	0.03
	6	3.0	0.03
	7	3.0	0.02
	8	2.8	0.03
	9	2.5	0.01
	10	2.4	0.03
	11	2.2	0.01
	12	2.2	0.01
	13	2.2	0.01
	14	2.1	0.01
	15	2.5	0.01
	16	2.7	0.01

	17	2.2	0.01
6/19/13	0	2.2	0.04
	1	1.3	0.06
	2	1.0	0.06
	3	0.7	0.02
	4	0.8	0.10
	5	0.9	0.04
	6	1.0	0.05
	7	1.2	0.06
	8	1.5	0.08
	9	1.3	0.06
	10	1.2	0.02
	11	1.2	0.08
6/26/13	0	2.9	0.02
	1	1.6	0.03
	2	1.0	0.07
	3	0.6	0.03
	4	0.7	0.04
	5	0.7	0.03
	6	0.9	0.04
	7	1.0	0.04
	8	1.7	0.03
	9	1.7	0.04
	10	2.9	0.01
	11	1.4	0.02
	12	1.0	0.02
	13	0.8	0.02
7/18/13	0	1.5	0.02
	1	1.0	0.04
	2	0.7	0.03
	3	0.5	0.01
	4	0.6	0.01
	5	1.0	0.00
	6	0.9	0.02
	7	1.2	0.02
	8	1.3	0.03
	9	1.9	0.02
	10	1.2	0.03
	11	1.3	0.03
	12	1.0	0.02
7/24/13	0	2.7	0.06
	1	1.5	0.06
	2	1.1	0.06
	3	0.9	0.03
	4	0.8	0.03
	5	0.6	0.04
	6	0.6	0.00
	7	0.7	0.03
	8	0.9	0.02
	9	1.5	0.04
	10	1.5	0.03
	11	2.0	0.02
	12	1.4	0.06
	13	0.6	0.03
	14	2.1	0.06
8/9/13	0	3.3	0.09
	1	1.1	0.07
	2	0.9	0.07
	3	0.7	0.06
	4	0.9	0.06
	5	0.7	0.05
	6	0.9	0.07
	7	0.8	0.12
	8	1.1	0.08
	9	1.1	0.10
	10	1.0	0.10
	11	1.2	0.09
	12	1.2	0.09
	13	3.5	0.10
	14	1.0	0.09
8/19/13	0	2.8	0.07
	1	2.6	0.12
	2	1.2	0.09
	3	0.7	0.11
	4	0.6	0.11
	5	0.8	0.09
	6	1.1	0.10
	7	1.0	0.11
	8	1.2	0.11
	9	1.8	0.09
	10	1.8	0.09
	11	1.5	0.09
	12	1.0	0.11
	13	1.4	0.09
	14	2.0	0.10
9/10/13	0	2.8	0.07
	1	1.7	0.08
	2	1.0	0.10
	3	0.6	0.08
	4	0.6	0.07
	5	0.7	0.09
	6	1.0	0.09
	7	1.2	0.10
	8	1.3	0.10
	9	1.5	0.07
	10	1.3	0.11
	11	1.3	0.09
	12	1.0	0.10
	13	1.0	0.12
9/26/13	0	2.6	0.14
	1	1.2	0.12
	2	0.7	0.11
	3	0.8	0.12
	4	1.0	0.13
	5	0.8	0.12
	6	0.9	0.13
	7	1.0	0.11
	8	1.3	0.14
	9	1.3	0.11
	10	1.2	0.13
	11	1.4	0.14
	12	0.7	0.12
	13	1.0	0.10
5/22/14	0	0.5	0.05
	1	0.9	0.24
	2	1.1	0.60
	3	1.2	0.65
	4	1.3	0.47
	5	1.3	0.74
	6	1.4	0.75
	7	1.5	0.56
	8	1.2	0.41
	9	1.1	0.33
	10	1.1	0.27
	11	0.8	0.22
	12	0.3	0.11
	13	0.3	0.14
	14	0.3	0.01
5/28/14	0	1.4	0.21
	1	1.6	0.22
	2	2.0	0.26
	3	2.0	0.34
	4	2.1	0.31
	5	2.6	0.35
	6	2.2	0.13
	7	2.3	0.22
	8	2.5	0.44
	9	2.7	0.75

	10	2.7	0.52
	11	2.2	0.16
	12	2.2	0.24
	13	0.9	0.18
	14	0.5	0.09
6/9/14	0	2.5	0.12
	1	2.6	0.13
	2	2.6	0.10
	3	2.2	0.14
	4	2.2	0.12
	5	1.5	0.11
	6	1.5	0.14
	7	1.5	0.14
	8	1.9	0.19
	9	2.0	0.17
	10	1.7	0.19
	11	1.5	0.17
	12	1.0	0.14
	13	0.8	0.13
	14	1.0	0.15
	15	1.0	0.13
6/24/14	0	1.4	1.03
	1	1.2	0.20
	2	1.7	0.16
	3	1.7	0.13
	4	2.0	0.12
	5	2.3	0.19
	6	2.3	0.16
	7	2.3	0.13
	8	2.3	0.18
	9	2.4	0.35
	10	2.1	0.19
	11	1.9	0.13
	12	1.0	0.28
	13	1.9	0.10
	14	0.7	0.09
	15	1.2	0.07
7/9/14	0	1.5	0.12
	1	2.5	0.12
	2	2.2	0.13
	3	2.2	0.13
	4	2.2	0.10
	5	2.1	0.12
	6	2.4	0.12
	7	2.3	0.18
	8	2.2	0.13

	9	1.9	0.17
	10	1.3	0.12
	11	0.7	0.13
	12	0.5	0.15
	13	0.4	0.11
	14	0.2	0.00
7/21/14	0	1.2	0.13
	1	1.4	0.11
	2	1.3	0.16
	3	1.2	0.18
	4	1.3	0.12
	5	1.2	0.12
	6	1.5	0.29
	7	1.3	0.13
	8	1.7	0.14
	9	2.0	0.14
	10	1.8	0.13
	11	1.8	0.14
	12	1.3	0.11
	13	0.5	0.10
8/5/14	0	1.6	0.13
	1	1.3	0.11
	2	1.5	0.09
	3	1.3	0.11
	4	1.7	0.15
	5	1.9	0.12
	6	2.0	0.12
	7	2.3	0.12
	8	2.4	0.11
	9	2.3	0.13
	10	2.0	0.10
	11	1.7	0.12
	12	0.5	0.13
	13	0.7	0.12
	14	0.9	0.11
	15	0.1	0.00
8/19/14	0	1.9	0.11
	1	2.0	0.11
	2	1.8	0.10
	3	1.9	0.14
	4	1.7	0.13
	5	2.0	0.13
	6	2.8	0.11
	7	2.5	0.11
	8	2.8	0.12
	9	2.9	0.10

	10	2.5	0.11
	11	1.9	0.12
	12	0.8	0.11
	13	0.8	0.08
	14	0.8	0.09
	15	0.8	0.07
9/6/14	0	2.3	0.12
	1	1.3	0.07
	2	1.5	0.09
	3	2.1	0.10
	4	2.2	0.10
	5	2.5	0.08
	6	2.6	0.15
	7	2.6	0.13
	8	2.9	0.12
	9	2.5	0.12
	10	2.4	0.12
	11	1.1	0.08
	12	1.0	0.09
	13	0.9	0.05
	14	1.2	0.12
	15	0.2	0.00
9/17/14	0	3.0	0.10
	1	1.0	0.11
	2	1.4	0.10
	3	1.6	0.08
	4	1.8	0.09
	5	1.8	0.08
	6	1.7	0.11
	7	2.2	0.12
	8	2.5	0.11
	9	2.0	0.13
	10	2.0	0.16
	11	1.6	0.12
	12	1.0	0.10
	13	0.6	0.10
	14	0.8	0.11
5/27/15	0	1.8	0.12
	1	1.6	0.12
	2	1.6	0.08
	3	1.4	0.12
	4	1.2	0.10
	5	1.3	0.12
	6	1.3	0.11
	7	0.2	0.04
	8	1.0	0.04

	9	1.3	0.10
	10	1.1	0.09
	11	1.6	0.11
	12	1.6	0.09
	13	1.3	0.04
	14	1.0	0.11
6/9/15	0	1.9	0.14
	1	2.5	0.17
	2	1.3	0.15
	3	1.3	0.04
	4	2.0	0.06
	5	2.2	0.11
	6	2.4	0.10
	7	2.4	0.12
	8	2.5	0.10
	9	2.8	0.10
	10	2.1	0.08
	11	1.3	0.13
	12	1.1	0.13
	13	1.0	0.11
	14	1.0	0.11
	15	1.0	0.10
6/25/15	0	2.4	0.13
	1	2.2	0.13
	2	1.2	0.10
	3	1.5	0.12
	4	1.6	0.09
	5	2.2	0.11
	6	2.4	0.11
	7	2.4	0.13
	8	2.5	0.11
	9	2.4	0.13
	10	2.4	0.12
	11	2.4	0.12
	12	2.0	0.19
	13	1.2	0.13
	14	0.8	0.10
	15	0.8	0.13
	16	1.0	0.14
	17	1.1	0.13
	18	1.1	0.13
7/7/15	0	3.0	0.08
	1	1.5	0.09
	2	1.5	0.13
	3	1.7	0.10
	4	1.7	0.08
	5	2.4	0.11
	6	2.4	0.12
	7	2.4	0.15
	8	2.7	0.08
	9	2.4	0.09
	10	2.4	0.06
	11	2.3	0.11
	12	1.9	0.10
	13	1.1	0.09
	14	0.8	0.11
	15	0.9	0.11
	16	0.8	0.12
	17	0.9	0.09
	18	0.9	0.02
	19	0.5	0.08
7/20/15	0	2.5	0.08
	1	1.0	0.09
	2	1.6	0.10
	3	1.3	0.08
	4	1.6	0.09
	5	2.0	0.09
	6	2.1	0.09
	7	2.4	0.09
	8	2.1	0.10
	9	1.9	0.08
	10	1.9	0.10
	11	1.0	0.07
	12	0.7	0.08
	13	0.6	0.10
	14	0.8	0.10
	15	1.0	0.07
	16	0.1	0.09
	17	0.6	0.08
8/6/15	0	3.0	0.10
	1	2.3	0.11
	2	2.0	0.07
	3	2.3	0.08
	4	1.8	0.06
	5	1.9	0.10
	6	2.2	0.07
	7	2.3	0.08
	8	2.1	0.03
	9	1.9	0.09
	10	1.9	0.09
	11	1.9	0.08
	12	1.6	0.09
	13	0.8	0.08
	14	0.8	0.08
	15	0.8	0.10
8/17/15	0	2.8	0.06
	1	0.6	0.14
	2	1.7	0.06
	3	1.8	0.08
	4	1.8	0.08
	5	2.0	0.04
	6	2.0	0.07
	7	2.2	0.08
	8	2.2	0.07
	9	2.0	0.03
	10	2.0	0.09
	11	2.0	0.10
	12	1.0	0.08
	13	1.0	0.09
	14	1.3	0.09
	15	1.0	0.08
8/31/15	0	0.8	0.10
	1	1.9	0.08
	2	1.8	0.11
	3	2.0	0.07
	4	2.0	0.09
	5	2.4	0.09
	6	2.4	0.09
	7	2.5	0.10
	8	2.4	0.08
	9	2.4	0.07
	10	2.2	0.09
	11	2.0	0.07
	12	1.7	0.06
	13	1.7	0.11
	14	2.5	0.10
9/14/15	0	1.8	0.07
	1	1.8	0.09
	2	1.9	0.06
	3	1.8	0.07
	4	1.8	0.06
	5	2.2	0.04
	6	2.3	0.09
	7	2.3	0.07
	8	2.4	0.04
	9	2.0	0.06
	10	2.0	0.05
	11	1.4	0.05

	12	1.7	0.06
	13	1.7	0.03
	14	1.7	0.07

Fox Creek

Date	Foot	Depth (ft)	Flow (m/s)
5/28/13	0	0.2	0.04
	1	0.4	0.06
	2	0.5	0.10
	3	0.4	0.15
	4	0.3	0.46
	5	0.3	0.56
	6	0.4	0.87
	7	0.3	0.77
	8	0.3	0.57
	9	0.3	0.80
	10	0.3	0.70
	11	0.3	0.56
	12	0.3	0.45
	13	0.6	0.69
	14	0.6	0.48
	15	0.6	0.63
	16	0.6	0.73
	17	0.7	0.85
	18	0.8	0.84
	19	0.8	0.80
	20	0.9	0.86
	21	0.8	0.74
	22	0.9	0.63
	23	0.9	0.54
	24	0.6	0.39
	25	0.8	0.48
	26	0.8	0.74
	27	0.7	0.65
	28	0.7	0.49
6/19/13	0	0.7	2.13
	1	0.8	2.30
	2	0.9	2.59
	3	0.6	1.97
	4	0.7	1.25
	5	0.8	1.99
	6	0.9	2.16
	7	0.9	1.82
	8	0.9	2.83
	9	0.8	2.91
	10	0.6	3.06
	11	0.8	2.68
	12	0.7	2.13
	13	0.6	1.49
	14	0.6	2.54
	15	0.5	1.42
	16	0.4	2.23
	17	0.3	2.70
	18	0.3	2.57
	19	0.5	2.45
	20	0.5	2.55
	21	0.4	2.25
	22	0.4	2.50
	23	0.5	1.62
	24	0.5	1.25
	25	0.5	0.88
	26	0.4	0.22
6/26/13	0	0.3	0.45
	1	0.5	0.44
	2	0.5	0.83
	3	0.5	2.01
	4	0.5	2.15
	5	0.5	2.04
	6	0.4	1.75
	7	0.4	2.29
	8	0.3	2.00
	9	0.3	1.29
	10	0.3	0.95
	11	0.5	1.80
	12	0.6	2.39
	13	0.6	1.59
	14	0.6	2.36
	15	0.7	2.29
	16	0.7	3.01
	17	0.7	3.00
	18	0.6	3.32
	19	0.7	2.76
	20	0.8	2.51
	21	0.8	1.29
	22	0.7	1.47
	23	0.8	2.05
	24	0.9	3.05
	25	0.7	2.48
	26	0.6	0.52
7/18/13	0	0.4	1.48
	1	0.4	2.43
	2	0.6	1.57
	3	0.3	1.39
	4	0.4	1.35
	5	0.4	1.43
	6	0.6	1.32
	7	0.5	2.53
	8	0.5	2.43
	9	0.4	1.32
	10	0.4	2.07
	11	0.3	1.88
	12	0.2	1.22
	13	0.2	0.53
	14	0.2	0.17
	15	0.2	0.05
	16	0	0.00
	17	0	0.00
	18	0.2	0.90
	19	0.2	1.52
	20	0.2	0.91
	21	0.3	0.78
	22	0.2	0.32
	23	0.3	0.89
	24	0.2	0.95
	25	0.3	0.91
	26	0.2	0.79
7/24/13	0	0.3	0.97
	1	0.4	0.87
	2	0.4	2.15
	3	0.4	0.65
	4	0.3	0.85
	5	0.4	1.73
	6	0.4	1.52
	7	0.3	1.48
	8	0.3	1.45
	9	0.4	1.55
	10	0.3	1.52
	11	0.3	0.12
	12	0.2	1.30
	13	0.2	1.06
	14	0.2	0.54
	15	0.2	0.40
	16	0.0	0.00
	17	0.0	0.00
	18	0.0	0.00
	19	0.2	1.03
	20	0.2	1.07

	21	0.3	0.51
	22	0.3	0.99
	23	0.2	1.21
	24	0.3	0.70
	25	0.3	0.96
	26	0.2	0.81
8/9/13	0	0.5	0.08
	1	0.4	0.05
	2	0.6	0.10
	3	0.5	0.24
	4	1.2	0.27
	5	1.2	0.28
	6	2.0	0.36
	7	2.1	0.53
	8	2.2	0.56
	9	2.3	0.45
	10	2.4	0.53
	11	2.2	0.60
	12	2.1	0.55
	13	1.6	0.54
	14	2.1	0.33
	15	2.0	0.47
	16	1.9	0.41
	17	1.7	0.37
	18	1.7	0.22
	19	1.6	0.23
	20	1.4	0.22
	21	1.2	0.15
	22	0.9	0.06
	23	0.3	0.08
	24	0.1	0.00
8/19/13	0	0.2	0.83
	1	0.3	0.76
	2	0.3	1.05
	3	0.3	1.02
	4	0.3	1.07
	5	0.2	1.22
	6	0.2	1.42
	7	0.0	0.00
	8	0.1	0.12
	9	0.2	0.28
	10	0.2	0.82
	11	0.3	0.70
	12	0.4	1.78
	13	0.4	2.45
	14	0.4	1.84
	15	0.5	2.77
	16	0.5	1.98
	17	0.5	2.71
	18	0.5	1.73
	19	0.5	1.86
	20	0.6	1.91
	21	0.5	0.80
	22	0.6	1.11
	23	0.6	2.43
	24	0.5	1.51
	25	0.3	1.21
9/10/13	0	0.2	0.92
	1	0.3	1.17
	2	0.2	1.02
	3	0.2	0.45
	4	0.2	0.40
	5	0.2	1.10
	6	0.1	0.92
	7	0.0	0.00
	8	0.2	0.22
	9	0.1	0.22
	10	0.2	0.46
	11	0.2	0.71
	12	0.3	0.64
	13	0.3	1.53
	14	0.3	1.89
	15	0.4	2.15
	16	0.3	2.79
	17	0.3	1.89
	18	0.4	1.36
	19	0.5	1.62
	20	0.5	1.85
	21	0.4	0.66
	22	0.5	1.31
	23	0.5	2.47
	24	0.4	1.93
	25	0.3	1.68
9/26/13	0	0.2	0.58
	1	0.3	0.76
	2	0.3	0.80
	3	0.3	0.50
	4	0.2	0.66
	5	0.2	0.76
	6	0.2	1.42
	7	0.2	0.95
	8	0.1	0.00
	9	0.2	0.92
	10	0.2	0.04
	11	0.3	0.70
	12	0.3	1.15
	13	0.3	1.06
	14	0.4	2.24
	15	0.4	0.61
	16	0.4	1.83
	17	0.4	3.30
	18	0.4	2.00
	19	0.5	1.96
	20	0.6	1.71
	21	0.5	1.39
	22	0.5	0.65
	23	0.6	1.96
	24	0.6	2.35
	25	0.5	1.64
	26	0.4	1.66
5/22/14	0	1.4	2.65
	1	1.3	3.27
	2	1.4	3.27
	3	1.2	2.70
	4	1.1	1.68
	5	1.0	2.36
	6	1.1	1.95
	7	1.1	2.81
	8	1.1	3.20
	9	1.0	3.02
	10	1.0	3.77
	11	0.9	3.16
	12	0.8	3.42
	13	0.6	2.58
	14	0.8	2.97
	15	0.8	1.82
	16	0.8	2.26
	17	0.6	2.54
	18	0.6	2.38
	19	0.6	1.94
	20	0.6	2.38
	21	0.5	2.00
	22	0.5	1.82
	23	0.5	1.98
	24	0.6	2.19
	25	0.5	2.15
	26	0.2	1.80
	27	0.4	1.30

	28	0.4	1.16
	29	0.3	0.42
5/28/14	0	0.3	0.20
	1	0.3	0.52
	2	0.5	0.73
	3	0.6	1.29
	4	0.5	2.00
	5	0.6	1.95
	6	0.5	2.14
	7	0.5	1.71
	8	0.5	2.03
	9	0.5	2.78
	10	0.6	2.10
	11	0.6	1.94
	12	0.5	2.47
	13	0.3	2.66
	14	0.8	2.02
	15	0.5	2.37
	16	0.5	3.17
	17	0.7	3.09
	18	1.0	2.60
	19	1.0	2.36
	20	1.0	3.12
	21	1.0	3.41
	22	1.0	2.85
	23	1.0	2.76
	24	0.6	4.07
	25	1.1	2.92
	26	1.2	0.87
	27	1.3	2.46
	28	1.4	2.89
	29	1.4	2.45
6/9/14	0	1.4	2.68
	1	1.4	2.66
	2	1.4	2.97
	3	1.2	2.35
	4	1.1	2.32
	5	1.1	1.73
	6	1.1	2.33
	7	1.0	2.71
	8	1.0	3.07
	9	1.0	3.51
	10	0.9	2.74
	11	0.6	2.63
	12	0.9	3.51
	13	0.7	2.98
	14	0.7	2.74
	15	0.5	2.39
	16	0.5	2.28
	17	0.6	2.18
	18	0.5	2.25
	19	0.6	2.85
	20	0.5	2.36
	21	0.5	2.29
	22	0.6	2.24
	23	0.5	2.23
	24	0.5	2.60
	25	0.5	0.86
	26	0.4	1.02
	27	0.3	0.82
6/24/14	0	1.3	1.33
	1	1.3	2.66
	2	1.4	3.59
	3	1.1	2.08
	4	1.2	2.56
	5	1.1	2.56
	6	1.1	2.34
	7	1.0	3.59
	8	1.1	3.56
	9	1.1	3.31
	10	1.0	2.92
	11	1.0	3.41
	12	0.9	2.77
	13	0.8	2.67
	14	0.8	2.69
	15	0.6	2.72
	16	0.8	2.49
	17	0.7	1.91
	18	0.7	2.34
	19	0.6	1.78
	20	0.6	1.72
	21	0.6	1.74
	22	0.7	1.76
	23	0.7	1.53
	24	0.7	1.56
	25	0.6	1.76
	26	0.6	0.81
	27	0.6	0.87
	28	0.4	0.48
	29	0.2	0.31
7/9/14	0	1.1	1.13
	1	1.2	1.66
	2	1.2	2.24
	3	1.2	2.35
	4	1.1	1.45
	5	1.1	2.08
	6	1.0	0.81
	7	1.0	2.31
	8	1.0	2.85
	9	1.0	2.93
	10	0.8	3.06
	11	0.8	2.31
	12	0.8	2.20
	13	0.7	1.91
	14	0.7	2.08
	15	0.7	1.98
	16	0.7	1.74
	17	0.6	0.79
	18	0.6	1.66
	19	0.5	1.54
	20	0.5	1.54
	21	0.5	1.33
	22	0.4	1.28
	23	0.5	1.23
	24	0.5	1.41
	25	0.5	1.30
	26	0.5	1.50
	27	0.5	0.97
	28	0.4	1.03
	29	0.3	0.64
	30	0.3	0.32
7/21/14	0	1.0	1.20
	1	1.0	1.95
	2	0.8	2.29
	3	1.0	2.15
	4	0.8	1.02
	5	0.8	2.63
	6	0.8	0.47
	7	0.8	2.25
	8	0.6	2.44
	9	0.5	3.13
	10	0.8	2.64
	11	0.7	2.22
	12	0.6	1.78
	13	0.5	2.05
	14	0.4	1.22
	15	0.5	1.05
	16	0.5	0.80

	17	0.4	0.06
	18	0.3	1.87
	19	0.3	1.45
	20	0.3	1.45
	21	0.3	1.04
	22	0.2	0.74
	23	0.3	0.92
	24	0.3	1.00
	25	0.2	1.04
	26	0.3	1.27
	27	0.2	1.07
	28	0.2	0.61
	29	0.1	0.51
	30	0.1	0.12
8/5/14	0	0.9	1.35
	1	1.0	1.53
	2	0.9	1.81
	3	0.9	1.91
	4	0.8	1.34
	5	0.7	1.64
	6	0.7	0.14
	7	0.5	2.15
	8	0.6	2.52
	9	0.4	2.52
	10	0.5	2.25
	11	0.5	2.04
	12	0.5	2.01
	13	0.4	1.63
	14	0.4	1.35
	15	0.4	1.15
	16	0.4	0.91
	17	0.3	1.27
	18	0.2	1.49
	19	0.2	1.21
	20	0.2	1.14
	21	0.2	0.94
	22	0.2	0.97
	23	0.3	0.87
	24	0.3	0.87
	25	0.3	1.09
	26	0.3	0.86
	27	0.2	0.42
	28	0.1	0.47
	29	0.05	0.00
8/19/14	0	1.0	1.54
	1	1.0	2.02
	2	1.0	2.14
	3	0.9	1.87
	4	0.8	0.84
	5	0.7	1.86
	6	0.7	0.02
	7	0.7	2.02
	8	0.5	2.34
	9	0.4	2.74
	10	0.6	2.18
	11	0.6	2.43
	12	0.5	2.19
	13	0.4	2.11
	14	0.4	1.75
	15	0.4	1.51
	16	0.4	1.01
	17	0.1	0.23
	18	0.3	2.07
	19	0.2	1.20
	20	0.2	1.13
	21	0.2	0.90
	22	0.2	0.87
	23	0.3	0.81
	24	0.3	1.09
	25	0.3	1.32
	26	0.3	1.26
	27	0.2	0.29
	28	0.1	0.51
	29	0.05	0.00
9/6/14	0	1.3	2.12
	1	1.3	2.68
	2	1.3	3.05
	3	1.2	2.75
	4	1.1	3.48
	5	0.9	3.39
	6	1.0	3.54
	7	1.0	2.77
	8	0.9	2.94
	9	0.8	4.03
	10	0.9	2.40
	11	0.9	3.32
	12	0.7	2.48
	13	0.6	3.53
	14	0.5	2.62
	15	0.7	2.69
	16	0.7	2.36
	17	0.5	1.80
	18	0.5	2.07
	19	0.5	1.98
	20	0.5	1.24
	21	0.5	1.31
	22	0.5	1.49
	23	0.5	1.78
	24	0.5	1.77
	25	0.5	1.72
	26	0.5	1.50
	27	0.5	1.10
	28	0.3	0.60
	29	0.3	0.70
9/17/14	0	0.9	1.17
	1	0.7	2.14
	2	1.0	1.68
	3	0.7	1.90
	4	0.8	1.29
	5	0.7	1.67
	6	0.6	0.74
	7	0.7	2.28
	8	0.7	2.70
	9	0.5	2.93
	10	0.6	2.11
	11	0.5	1.94
	12	0.4	1.86
	13	0.4	1.40
	14	0.4	1.33
	15	0.3	1.27
	16	0.4	1.19
	17	0.2	0.89
	18	0.2	0.89
	19	0.2	1.84
	20	0.2	0.72
	21	0.1	0.84
	22	0.2	0.69
	23	0.2	0.59
	24	0.3	0.99
	25	0.2	1.03
	26	0.2	0.88
	27	0.2	0.56
	28	0.1	0.19
5/27/15	0	0.7	1.40
	1	0.8	1.19
	2	0.9	3.30
	3	0.9	2.93
	4	0.8	1.44

	5	0.8	3.04
	6	0.8	1.13
	7	0.7	2.76
	8	0.6	3.02
	9	0.6	3.31
	10	0.8	3.00
	11	0.6	2.34
	12	0.6	1.96
	13	0.4	1.54
	14	0.4	0.87
	15	0.4	0.87
	16	0.3	0.53
	17	0.1	2.23
	18	0.3	1.13
	19	0.3	1.37
	20	0.2	1.02
	21	0.2	0.94
	22	0.2	0.06
	23	0.3	0.99
	24	0.3	1.12
	25	0.2	1.06
	26	0.2	0.78
	27	0.2	0.99
	28	0.2	0.28
6/9/15	0	0.8	0.92
	1	1.0	3.12
	2	1.0	3.06
	3	1.0	2.72
	4	0.9	2.94
	5	0.8	3.14
	6	0.8	2.66
	7	0.6	3.67
	8	0.8	4.25
	9	0.7	2.25
	10	0.7	3.30
	11	0.8	2.84
	12	0.7	2.54
	13	0.5	2.62
	14	0.5	1.52
	15	0.4	1.12
	16	0.4	1.69
	17	0.3	0.90
	18	0.3	1.34
	19	0.3	1.04
	20	0.3	1.14
	21	0.3	1.14
	22	0.3	1.11
	23	0.3	1.39
	24	0.3	1.23
	25	0.3	1.29
	26	0.3	1.67
	27	0.3	1.12
	28	0.2	0.44
6/25/15	0	0.8	1.18
	1	0.9	2.54
	2	0.9	2.69
	3	0.9	2.68
	4	0.6	1.55
	5	0.6	3.05
	6	0.6	1.68
	7	0.7	2.58
	8	0.7	3.82
	9	0.5	3.67
	10	0.6	3.43
	11	0.5	2.48
	12	0.6	2.03
	13	0.4	1.91
	14	0.4	1.69
	15	0.3	1.38
	16	0.3	1.54
	17	0.3	0.59
	18	0.3	1.90
	19	0.2	0.75
	20	0.3	0.93
	21	0.2	1.11
	22	0.2	0.90
	23	0.2	0.66
	24	0.3	1.18
	25	0.3	1.45
	26	0.3	1.21
	27	0.3	1.06
	28	0.2	0.30
7/7/15	0	0.9	1.85
	1	0.9	2.55
	2	1.0	2.50
	3	0.9	1.49
	4	0.9	2.51
	5	0.9	0.85
	6	0.8	3.11
	7	0.8	3.48
	8	0.8	3.71
	9	0.8	3.51
	10	0.7	2.97
	11	0.7	3.03
	12	0.7	2.35
	13	0.6	2.58
	14	0.5	2.41
	15	0.6	2.53
	16	0.5	2.65
	17	0.5	1.89
	18	0.5	2.10
	19	0.4	1.67
	20	0.4	1.53
	21	0.4	1.52
	22	0.4	1.84
	23	0.4	1.79
	24	0.4	1.92
	25	0.4	1.81
	26	0.4	1.80
	27	0.3	1.09
	28	0.2	0.12
	29	0.1	0.08
7/20/15	0	0.9	0.42
	1	1.0	2.51
	2	1.0	2.90
	3	0.9	2.84
	4	0.7	0.35
	5	0.8	2.35
	6	0.7	2.32
	7	0.6	4.11
	8	0.7	3.93
	9	0.7	2.50
	10	0.7	2.80
	11	0.7	2.49
	12	0.7	2.48
	13	0.6	2.06
	14	0.5	3.22
	15	0.5	2.58
	16	0.4	1.74
	17	0.4	1.50
	18	0.3	0.02
	19	0.4	1.41
	20	0.3	0.58
	21	0.3	0.91
	22	0.4	2.02
	23	0.4	1.60
	24	0.4	1.77
	25	0.4	1.94

	26	0.4	2.12
	27	0.3	0.85
	28	0.1	0.03
8/6/15	0	0.6	0.62
	1	0.8	2.39
	2	0.9	2.63
	3	0.5	1.76
	4	0.6	2.23
	5	0.6	0.06
	6	0.5	2.31
	7	0.5	2.16
	8	0.5	3.52
	9	0.5	2.99
	10	0.4	2.38
	11	0.5	1.72
	12	0.4	1.99
	13	0.3	1.18
	14	0.1	1.07
	15	0.3	0.24
	16	0.2	1.27
	17	0.1	1.70
	18	0.1	0.58
	19	0.2	0.67
	20	0.1	0.61
	21	0.1	0.02
	22	0.2	0.44
	23	0.2	0.90
	24	0.2	0.74
	25	0.1	0.72
	26	0.1	0.96
	27	0.1	0.27
	28	0.1	0.13
8/17/15	0	0.6	0.24
	1	0.6	2.63
	2	0.8	2.73
	3	0.6	1.92
	4	0.6	1.98
	5	0.6	0.68
	6	0.5	0.10
	7	0.3	2.77
	8	0.5	3.23
	9	0.3	3.20
	10	0.5	2.29
	11	0.5	2.32
	12	0.4	2.07
	13	0.4	1.44
	14	0.2	0.91
	15	0.3	0.96
	16	0.2	1.39
	17	0.2	0.55
	18	0.2	0.18
	19	0.2	0.69
	20	0.1	0.61
	21	0.1	0.00
	22	0.1	0.53
	23	0.2	0.97
	24	0.1	0.76
	25	0.2	0.24
	26	0.2	1.21
	27	0.1	0.59
	28	0.1	0.22
8/31/15	0	1.1	1.48
	1	1.0	2.31
	2	1.0	2.34
	3	0.7	1.06
	4	0.7	2.04
	5	0.6	2.34
	6	0.7	2.20
	7	0.6	3.36
	8	0.6	3.17
	9	0.7	2.57
	10	0.7	2.25
	11	0.6	2.33
	12	0.5	2.59
	13	0.5	1.94
	14	0.5	1.05
	15	0.5	2.68
	16	0.2	0.50
	17	0.3	1.81
	18	0.3	1.55
	19	0.3	2.02
	20	0.3	1.84
	21	0.3	1.61
	22	0.3	1.26
	23	0.3	1.31
	24	0.3	1.11
	25	0.3	1.56
	26	0.3	1.87
	27	0.2	1.74
9/14/15	0	0.8	0.29
	1	0.8	2.47
	2	1.0	2.81
	3	0.7	0.32
	4	0.7	2.94
	5	0.6	0.14
	6	0.6	2.73
	7	0.6	2.97
	8	0.6	3.28
	9	0.7	2.70
	10	0.6	2.11
	11	0.7	2.15
	12	0.6	2.60
	13	0.5	1.52
	14	0.3	1.23
	15	0.3	1.86
	16	0.4	1.39
	17	0.3	1.08
	18	0.2	1.88
	19	0.2	1.32
	20	0.2	1.06
	21	0.1	1.00
	22	0.3	1.22
	23	0.2	1.15
	24	0.2	0.67
	25	0.3	1.55
	26	0.2	1.02
	27	0.2	0.83
	28	0.1	0.38

Appendix E

Algae Data and Report

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FY000225

POLK COUNTY LAND & WATER RESOU
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

ID#:   493144
Waterbody/Outfall ID: 2627000
Point/Well:
Account #:   PP001
Project No:
Date Received: 02/19/2014 08:28:00
Date Reported: 03/10/2014
Sample Reason:

Field #:
Collection Start: 05/28/2013
Collection End:
Collected By: JEREMY WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: ; COMPOSITE SAMPLER
Sample Location: BIG BLAKE LAKE
Sample Description: MID LAKE
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
ASTERIONELLA FORMOSA	BACILLARIOPHYTA	131.	CELLS/ML	1.4 %
AULACOSEIRA SP.	BACILLARIOPHYTA	341.	CELLS/ML	3.7 %
FRAGILARIA CROTONENSIS	BACILLARIOPHYTA	2804.	CELLS/ML	30.6 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	26.	CELLS/ML	0.3 %
STAURASTRUM SP.	CHLOROPHYTA	26.	CELLS/ML	0.3 %
DINOBRYON SP.	CHRYSOPHYTA	1598.	CELLS/ML	17.4 %
CRYPTOMONAS SP.	CRYPTOPHYTA	970.	CELLS/ML	10.6 %
KOMMA CAUDATA	CRYPTOPHYTA	3275.	CELLS/ML	35.7 %

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Madison, WI 53707-7996
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FY000225

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9567392

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FY000226

POLK COUNTY LAND & WATER RESOU
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

ID#: 493144
Waterbody/Outfall ID: 2627000
Point/Well:
Account #: PP001
Project No:
Date Received: 02/19/2014 08:28:00
Date Reported: 03/10/2014
Sample Reason:

Field #:
Collection Start: 06/26/2013
Collection End:
Collected By: JEREMY WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: ; COMPOSITE SAMPLER
Sample Location: BIG BLAKE LAKE
Sample Description: MID LAKE
Analyses and Results:

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	454.	CELLS/ML	9.6 %
CAVINULA SP.	BACILLARIOPHYTA	14.	CELLS/ML	0.3 %
FRAGILARIA CROTONENSIS	BACILLARIOPHYTA	1306.	CELLS/ML	27.7 %
SCHROEDERIA SP.	CHLOROPHYTA	695.	CELLS/ML	14.7 %
DINOBRYON SP.	CHRYSOPHYTA	284.	CELLS/ML	6.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	199.	CELLS/ML	4.2 %
KOMMA CAUDATA	CRYPTOPHYTA	1717.	CELLS/ML	36.4 %
CERATIUM HIRUNDINELLA	PYRRHOPHYTA	43.	CELLS/ML	0.9 %

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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FY000226

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit
LOD = Level of detection
LOQ = Level of quantification
ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

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Report #: 9567393

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FY000227

POLK COUNTY LAND & WATER RESOU
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

ID#: 493144
Waterbody/Outfall ID: 2627000
Point/Well:
Account #: PP001
Project No:
Date Received: 02/19/2014 08:28:00
Date Reported: 03/10/2014
Sample Reason:

Field #:
Collection Start: 07/24/2013
Collection End:
Collected By: JEREMY WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: ; COMPOSITE SAMPLER
Sample Location: BIG BLAKE LAKE
Sample Description: MID LAKE
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB   WI00007   WI DATCP ID: 105-415

WSLH Sample: FY000227

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	30.	CELLS/ML	0.7 %
CAVINULA SP.	BACILLARIOPHYTA	30.	CELLS/ML	0.7 %
FRAGILARIA CROTONENSIS	BACILLARIOPHYTA	180.	CELLS/ML	4.3 %
SYNEDRA SP.	BACILLARIOPHYTA	20.	CELLS/ML	0.5 %
DICTYOSPHAERIUM SP.	CHLOROPHYTA	220.	CELLS/ML	5.2 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	30.	CELLS/ML	0.7 %
MICRACTINIUM SP.	CHLOROPHYTA	220.	CELLS/ML	5.2 %
OOCYSTIS SP.	CHLOROPHYTA	40.	CELLS/ML	1.0 %
PEDIASTRUM SP.	CHLOROPHYTA	10.	CELLS/ML	0.2 %
SCENEDESMUS SP.	CHLOROPHYTA	40.	CELLS/ML	1.0 %
SCHROEDERIA SP.	CHLOROPHYTA	80.	CELLS/ML	1.9 %
SPHAEROCYSTIS SP.	CHLOROPHYTA	210.	CELLS/ML	5.0 %
STAURASTRUM SP.	CHLOROPHYTA	20.	CELLS/ML	0.5 %
TETRAEDRON SP.	CHLOROPHYTA	20.	CELLS/ML	0.5 %
TETRASELMIS SP.	CHLOROPHYTA	40.	CELLS/ML	1.0 %
CRYPTOMONAS SP.	CRYPTOPHYTA	391.	CELLS/ML	9.3 %
KOMMA CAUDATA	CRYPTOPHYTA	1723.	CELLS/ML	41.1 %
ANABAENA SP.	CYANOPHYTA	491.	CELLS/ML	11.7 %
TRACHELOMONAS SP.	EUGLENOPHYTA	100.	CELLS/ML	2.4 %
CERATIUM HIRUNDINELLA	PYRRHOPHYTA	281.	CELLS/ML	6.7 %
PERIDINIUM SP.	PYRRHOPHYTA	20.	CELLS/ML	0.5 %

Test results for NELAP accredited tests are certified to meet the requirements of the NELAC standards. For a list of accredited analytes see http://www.slh.wisc.edu/nelap/

List of Abbreviations:

Natural Unit = Unicell, Colony or Filament Equals 1 Unit

LOD = Level of detection

LOQ = Level of quantification

ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

If there are questions about this report, please contact Dawn Perkins at 608-224-6230.

The results in this report apply only to the sample specifically listed above. This report is not to be reproduced except in full.

Report #: 9567394

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
http://www.slh.wisc.edu

Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division   Environmental Toxicology

WDNR LAB ID: 113133790   NELAP LAB ID: E37658   EPA LAB WI00007   WI DATCP ID: 105-415

WSLH Sample: FY000228

POLK COUNTY LAND & WATER RESOU
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

Bill To

Customer ID: 336949
POLK COUNTY LAND & WATER RESOURCES DEPARTMENT
100 POLK CO. PLAZA, STE 120
BALSAM LAKE WI 54810

ID#: 493144
Waterbody/Outfall ID: 2627000
Point/Well:
Account #: PP001
Project No:
Date Received: 02/19/2014 08:28:00
Date Reported: 03/10/2014
Sample Reason:

Field #:
Collection Start: 08/19/2013
Collection End:
Collected By: JEREMY WILLIAMSON
County:
Sample Source: SURFACE WATER
Sample Depth: 2 Meters
Sample Information: ; COMPOSITE SAMPLER
Sample Location: BIG BLAKE LAKE
Sample Description: MID LAKE
Analyses and Results:

Wisconsin State Laboratory of Hygiene
2601 Agriculture Drive, PO Box 7996
Madison, WI 53707-7996
(800)442-4618 • FAX (608)224-6213
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FY000228

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	136.	CELLS/ML	0.9 %
CAVINULA SP.	BACILLARIOPHYTA	27.	CELLS/ML	0.2 %
CHODATELLA SP.	CHLOROPHYTA	82.	CELLS/ML	0.5 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	164.	CELLS/ML	1.1 %
EUDORINA SP.	CHLOROPHYTA	409.	CELLS/ML	2.7 %
OOCYSTIS SP.	CHLOROPHYTA	164.	CELLS/ML	1.1 %
PEDIASTRUM SP.	CHLOROPHYTA	27.	CELLS/ML	0.2 %
SCHROEDERIA SP.	CHLOROPHYTA	27.	CELLS/ML	0.2 %
TETRASELMIS SP.	CHLOROPHYTA	27.	CELLS/ML	0.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	2889.	CELLS/ML	18.9 %
KOMMA CAUDATA	CRYPTOPHYTA	4006.	CELLS/ML	26.2 %
ANABAENA SP.	CYANOPHYTA	1744.	CELLS/ML	11.4 %
APHANIZOMENON FLOS-AQUAE	CYANOPHYTA	2861.	CELLS/ML	18.7 %
COELOSPHAERIUM SP.	CYANOPHYTA	1690.	CELLS/ML	11.1 %
MICROCYSTIS AERUGINOSA	CYANOPHYTA	491.	CELLS/ML	3.2 %
CERATIUM HIRUNDINELLA	PYRRHOPHYTA	545.	CELLS/ML	3.6 %

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ND = None detected. Results are less than the LOD

Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

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WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

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POLK COUNTY LAND & WATER RESOU
100 POLK CO. PLAZA, STE 120
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Laboratory Report

D.F. Kurtycz, M.D., Medical Director • Charles D. Brokopp, Dr.P.H., Director

Environmental Health Division — Environmental Toxicology

WDNR LAB ID: 113133790 NELAP LAB ID: E37658 EPA LAB WI00007 WI DATCP ID: 105-415

WSLH Sample: FY000229

Taxa	Division	Result	Unit	Percentage
AULACOSEIRA SP.	BACILLARIOPHYTA	40.	CELLS/ML	0.2 %
CAVINULA SP.	BACILLARIOPHYTA	140.	CELLS/ML	0.6 %
CLOSTERIUM SP.	CHLOROPHYTA	20.	CELLS/ML	0.1 %
DYSMORPHOCOCCUS SP.	CHLOROPHYTA	60.	CELLS/ML	0.3 %
OOCYSTIS SP.	CHLOROPHYTA	301.	CELLS/ML	1.3 %
SCENEDESMUS SP.	CHLOROPHYTA	160.	CELLS/ML	0.7 %
SCHROEDERIA SP.	CHLOROPHYTA	341.	CELLS/ML	1.5 %
SPHAEROCYSTIS SP.	CHLOROPHYTA	1242.	CELLS/ML	5.5 %
STAURASTRUM SP.	CHLOROPHYTA	20.	CELLS/ML	0.1 %
TETRAEDRON SP.	CHLOROPHYTA	40.	CELLS/ML	0.2 %
TETRASELMIS SP.	CHLOROPHYTA	40.	CELLS/ML	0.2 %
CRYPTOMONAS SP.	CRYPTOPHYTA	2645.	CELLS/ML	11.8 %
KOMMA CAUDATA	CRYPTOPHYTA	1643.	CELLS/ML	7.3 %
ANABAENA SP.	CYANOPHYTA	260.	CELLS/ML	1.2 %
APHANIZOMENON FLOS-AQUAE	CYANOPHYTA	561.	CELLS/ML	2.5 %
COELOSPHAERIUM SP.	CYANOPHYTA	9518.	CELLS/ML	42.4 %
MICROCYSTIS AERUGINOSA	CYANOPHYTA	1703.	CELLS/ML	7.6 %
PSEUDANABAENA SP.	CYANOPHYTA	3707.	CELLS/ML	16.5 %

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Responsible Party: Steve Geis Steve Geis, Chemist Supervisor

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Report #: 9567396

Lake		Big Blake	Big Blake	Big Blake
Date		**6/24/14**	**7/21/14**	**8/19/14**
Division	**Taxa**	**cells/ml**	**cells/ml**	**cells/ml**
Bacillariiophyta	Aulacoseira	186.39	0.00	0.00
Bacillariiophyta	centric sm	0.00	0.00	0.00
Bacillariiophyta	Cocconeis	11.65	22.02	0.00
Bacillariiophyta	Fragilaria crotonensis	2912.39	352.24	1033.26
Bacillariiophyta	Gomhonema	23.30	0.00	0.00
Bacillariiophyta	Naviculoid	11.65	0.00	0.00
Bacillariiophyta	Stephanodiscus	0.00	88.06	32.29
Bacillariiophyta	Synedra	34.95	22.02	0.00
Chlorophyta	Ankistrodesmus	11.65	44.03	0.00
Chlorophyta	Chlamydomonas	104.85	44.03	0.00
Chlorophyta	Coccoid greens	139.79	110.08	581.21
Chlorophyta	Cosmarion	0.00	0.00	0.00
Chlorophyta	Dictyosphaerium	1071.76	3148.18	161.45
Chlorophyta	Eudorina	0.00	154.11	0.00
Chlorophyta	Franceia	0.00	0.00	0.00
Chlorophyta	Gloeocystis	0.00	88.06	129.16
Chlorophyta	Lagerheimia	0.00	0.00	32.29
Chlorophyta	Mougeotia	0.00	0.00	32.29
Chlorophyta	Nephrocytium	93.20	0.00	0.00
Chlorophyta	Oedogonium	0.00	0.00	193.74
Chlorophyta	Oocystis	46.60	66.05	742.65
Chlorophyta	Pandorina	93.20	0.00	0.00
Chlorophyta	Pediastrum	0.00	88.06	32.29
Chlorophyta	Scenedesmus	0.00	352.24	0.00
Chlorophyta	Schroederia	0.00	0.00	0.00
Chlorophyta	Staurastrum	0.00	44.03	32.29
Chlorophyta	Tetraedron	0.00	0.00	0.00
Chrysophyta	Dinobryon	34.95	0.00	0.00
Chrysophyta	Komma Caudata	34.95	132.09	0.00
Chrysophyta	Mallomonas	0.00	286.20	0.00
Chrysophyta	Synura	0.00	5569.87	32.29
Cryptophyta	Cryptomonas	0.00	132.09	64.58
Cyanophyta	Anabaena	349.49	1871.30	5650.63
Cyanophyta	Aphanizomenon flos-aquae	0.00	0.00	30416.53
Cyanophyta	Aphanocapsa	0.00	0.00	0.00
Cyanophyta	Aphanothece	0.00	0.00	0.00
Cyanophyta	Chroococcus	69.90	0.00	1162.42
Cyanophyta	Coelospharium	151.44	0.00	0.00
Cyanophyta	Gloeocystis	0.00	0.00	0.00

Cyanophyta	Gomphosphaeria	151.44	0.00	2098.81
Cyanophyta	Microcystis	0.00	0.00	10849.21
Cyanophyta	Planktolyngbya	0.00	0.00	0.00
Cyanophyta	Schizothrix	0.00	0.00	0.00
Euglenophyta	Euglena	0.00	44.03	0.00
Euglenophyta	Trachelomonas	11.65	0.00	0.00
Pyrrhophyta	Ceritum	0.00	0.00	0.00
Pyrrhophyta	Peridinium	0.00	0.00	0.00

From:
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Date: Dec 10, 2015

To:
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100 Polk County Plaza, Suite 120
Balsam Lake, WI 54810

Project Overview

Wisconsin Lakes Report: Analysis of phytoplankton samples from Big Blake Lake and Lotus Lake during June-August 2014.

Methods

This set of lake samples was received in the spring of 2015.
Lake samples were concentrated when necessary in glass funnels. Samples were then enumerated using a Palmer-Maloney nanoplankton counting chamber and a Olympus BX40 research microscope at 400x magnification. This allows for the calculations of cell densities (cells/ml) At least 400 cells were counted and identified to genus using Prescot (1952), Taft and Taft (1971) Wehr and Sheath (2003) as the main taxonomic guides. All samples were counted within 5 weeks of receiving them.

Results

Cell densities for each sample are reported in Table 1. The data is grouped by lake and algal division. An electronic version will be included.

-The taxa labeled “centric sm” refers to small (<8 um) centric diatoms which most likely belong to the genus *Cyclotella* but distinguishing details important to taxonomic resolution could not be resolved.

-The Taxa labeled “Naviculoid” represents diatoms that resembled the genus *Navicula* but lack any taxonomic features resolvable at 400x with uncleaned samples.

-The taxa labeled “Coccoid greens” represent small (3-6um), coccoid, green algae (phylum Chlorophyta) cells that lack characteristics to distinguish among several genera from the order Chlorococcales.

Discussion

In both Big Blake and Lotus lakes, there is a general increase in blue-green taxa (Cyanobacteria) from June to August which is typical of many mesotrophic and eutrophic lakes. For each month, Big Blake Lake has high cell densities compared to Lotus Lake.

In general there seems to be a good agreement with both the cell densities and taxonomic composition when these samples are compared with past analyses conducted by the Wisconsin State laboratory of Hygiene from these same lakes. Those reports noted the presence of the diatom genus *Cavinula* was recently split off from the genus *Navicula*. In the cells counts presented in this report those cells would have been labeled as “Naviculoid”. At the magnification used for this report, I did not believe that I could consistently and accurately keep that two taxa separate.

References:

Prescott, G.W. 1952. Algae of the western great lakes area. Otto Koeltz Science Publishers. Koenigstein. Germany.

Taft, C.E., and Taft, C.W. 1971. The algae of western Lake Erie. Bulletin of Ohio Biological survey. 4(1). College of Biological sciences, Ohio State University. Columbus, OH.

Wehr, J.E., and Sheath, R.G. (eds) 2003. Freshwater algae of North America. Ecology and Classification. Academic Press. New York, NY.

Lake	Big Blake	Big Blake	Big Blake
Date	**6/25/15**	**7/20/15**	**8/17/15**
units	**cells/ml**	**cells/ml**	**cells/ml**
Taxa			
Amphora	6	0	0
Asterionella	0	442	0
Aulacoseira granulata	0	1567	0
centric sm	11	241	136
Cocconeis	0	0	0
Cymbella	0	40	34
Fragilaria crotonensis	841	4621	0
Gomhonema	0	0	0
Naviculoid	0	40	102
Nitzschia	0	0	0
Stephanodiscus	0	0	0
Synedra	17	161	136
Tabellaria	0	0	0
Actinastrum	0	0	816
Ankistrodesmus	0	40	0
Arthrodesmus	0	0	0
Characium	0	0	0
Chlamydomonas	105	80	714
Closterium	0	0	0
Coccoid greens	0	0	0
Coelastrum	44	0	0
Cosmarion	0	0	0
Crucigenia	0	0	0
Cylindrocapsa	0	0	0
Dictyosphaerium	144	2049	68
Elactothrix	11	0	0
Euastrum	0	0	0
Eudorina	160	0	0
Franceia	0	80	0
Gloeocystis	33	241	0
Kirchneriella	0	0	0
Lagerheimia	0	40	0
Mougeotia	0	0	0
Nephrocytium	0	0	0
Oedogonium	0	0	0
Oocystis	183	643	136
Pandorina	44	0	0
Pediastrum	0	0	34
Quadrigula	0	0	0

Scenedesmus	0	321	136
Schroederia	17	0	34
Sphaerocystis	0	0	0
Spondylosium	0	0	0
Staurastrum	0	40	0
Tetraedron	0	0	0
Dinobryon	6	0	0
Mallomonas	55	0	136
Synura	0	0	0
Uroglenopsis	0	0	0
Cryptomonas	71	362	714
Komma Caudata	94	241	238
Anabaena	0	6028	40311
Aphanizomenon flos-aquae	0	5063	7348
Aphanocapsa	1681	3215	0
Aphanothece	0	0	0
Chroococcus	44	723	0
Coelospharium	0	0	0
Gloeocystis	0	0	102
Gomphosphaeria	72	1567	0
Merismopedia	0	0	0
Microcystis	0	0	442
Planktolyngbya	548	362	4899
Planktothrix	354	0	2721
Schizothrix	0	0	0
Euglena	0	0	0
Trachelomonas	6	80	0
Ceratium	0	0	0
Euglena	0	0	0
Peridinium	0	0	34
total	4546	28290	59293

From: **Date: Oct 10, 2016**

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Balsam Lake, WI 54810

Project Overview

Wisconsin Lakes Report: Analysis of phytoplankton samples from:
Big Blake Lake – June to August 2015 (3 samples)
Bone Lake –April to September 2015 (5 samples
Lotus Lake - June to August 2015 (3 samples)
North Pipe Lake- June to August 2015 (4 samples)
Pipe Lake- June to September 2015 (5 samples)

Methods

This set of lake samples was received in the spring of 2016.
Lake samples were concentrated when necessary in glass funnels to increase cell densities. Samples were then enumerated using a Palmer-Maloney nanoplankton counting chamber and a Olympus BX40 research microscope at 400x magnification. This allows for the calculations of cell densities (cells/ml, back-calculating to the original cell densities). At least 400 cells were counted and identified to genus using Prescot (1952), Taft and Taft (1971), Wehr et al. (2015) as the main taxonomic guides. All samples were counted within 5 weeks of receiving them.

Results

Cell densities for each sample are reported in Table 1. The data is grouped by lake and algal division and presented both as cells/ml and % of total cells counted. An electronic version will be included.

-The taxa labeled "centric sm" refers to small (<8 um) centric diatoms which most likely belong to the genus *Cyclotella* but distinguishing details important to taxonomic resolution could not be resolved. Larger centric diatoms, where it was possible to note genus distinctions, were identified to genera.

-The Taxa labeled “Naviculoid” represents diatoms that resembled the genus *Navicula* but lack any taxonomic features resolvable at 400x with uncleaned samples.

-The taxa labeled “Coccoid greens” represent small (3-6um), coccoid, green algae (phylum Chlorophyta) cells that lack characteristics to distinguish among several genera from the order Chlorococcales.

Discussion

Since I also counted the 2014 for both Big Blake Lake and Lotus Lake, we can compare the phytoplankton samples from these lakes from 2014 and 2015. The cell densities, largely driven by Cyanobacteria, are comparable between 2014 and 2015 with Lotus lake, at any given time, having a higher densities. In 2014, both lakes had their highest sampled densities in August. But in 2015, while Big Blake Lake still peaked in August, Lotus had peak cell densities in July which was also the highest cell densities of the 2015 sampled (over 272,000 cells/ml). This high density sample consisted mostly (71%) of *Planktolyngbia*. This genus is a Cyanobacteria that grows in filaments composed of very small cells. Therefore, even with high cell densities, other lakes may have had more turbid conditions. The second most common taxa (9%) from this sample as *Planktothrix*, a slightly larger filamentous Cyanobacteria. It is interesting to note that while Planktothrix is fairly distinct and was present in all sampled lakes in 2015, it was absent from the 2014 samples.

Bone Lake was sampled across the largest range of months (April to September) and seems to show a spring algal bloom in April which is gone by June. This vernal peak was mostly driven by small-celled Cyanobacteria (*Planktolyngbia* and *Aphanocapsa*). A late summer/fall peak was also observed (mainly caused by a bloom of *Aphanizomenon*) which significantly diminished by late September.

North Pipe Lake exhibited high densities of blue-green algae (*Anabaena* and *Aphanizomenon*) in August. Both of these taxa are “nitrogen fixers” so their dominance might indicate the system was Nitrogen limited during this time. Pipe Lake, however, had relatively low algal densities throughout the sampling season (June to September). This lack of a summer plankton bloom suggests that Pipe Lake might be considered oligotrophic compared to the other sampled lakes which seemed more typical of mesotrophic to eutrophic conditions. Pipe Lake exhibited a spring (June) flora consisting of the diatom *Asterionella*, the green alga *Gloeosystis*, and the flagellated chrysophyte Dinobryon. For the rest of the sampling period (July to September) the algal community was dominated by *Aphanizomenon* and *Anabaena*, which may indicate that the system is also limited by Nitrogen.

References:

Prescott, G.W. 1952. Algae of the western great lakes area. Otto Koeltz Science Publishers. Koenigstein. Germany.

Taft, C.E., and Taft, C.W. 1971. The algae of western Lake Erie. Bulletin of Ohio Biological survey. 4(1). College of Biological sciences, Ohio State University. Columbus, OH.

Wehr, J.E., Sheath, R.G. and Kociolek, J.P. (eds) 2015. Freshwater algae of North America. Ecology and Classification (Second Edition). Academic Press. New York, NY.

Appendix F

Zooplankton Data and Report

Big Blake Lake Zooplankton (number per liter)

Month	Year	Rotifera	Copepoda	Cladodocera	testate protista	*Chaoborus sp.*
June	2013	11.0	4.7	1.3	0.0	*0.0*
July	2013	14.7	15.9	5.4	0.0	*0.0*
Aug	2013	4.2	3.3	3.8	0.8	*0.4*
June	2014	13.4	3.8	0.4	0.0	*0.0*
July	2014	4.7	5.7	1.3	0.0	*0.0*
Aug	2014	16.3	9.2	2.5	0.4	*0.0*
June	2015	26.1	8.2	4.4	0.0	*0.0*
July	2015	21.8	16.7	1.7	1.3	*0.0*
Aug	2015	11.0	22.0	0.6	0.0	*0.0*