LAKE COUNTY, IL

2017 WATERFORD LAKE SUMMARY REPORT

LAKE COUNTY HEALTH DEPARTMENT

ECOLOGICAL SERVICES

Waterford Lake, 2017

Waterford Lake is located in the Village of Lindenhurst in Lake Villa, Township and was created in 1969. The lake has a surface area of 67.5 acres and an average depth of 6.64 feet. It is located entirely within the village limits of Lindenhurst and is almost completely private, with the exception of two access points open to Lindenhurst residents. The lake is managed by the Lindenhurst Lakes Commission and is used for non-gas motor boating and fishing. The lake has no public beach; however several residents on the lake have private beaches on their property.

In 2017, the Lake County Health Department - Ecological Services (LCHD-ES) monitored Waterford Lake as part of routine water quality sampling. Two water samples were collected once a month from May through September. Water chemistry can be significantly different between the epilimnion (warm upper layer) and hypolimnion (cool bottom layer) within the lake. Therefore, two water samples were collected at the deepest point in the lake; three feet below the surface and 3 feet above the bottom (Appendix A). Samples were analyzed for nutrients, solid concentrations and other chemical parameters. Additionally, LCHD-ES conducted an aquatic plant survey was conducted in July 2017 and a shoreline assessment in August 2017.

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LAKE FACTS

MAJOR WATERSHED:

Des Plaines

SUB-WATERSHED:

North Mill Creek

SURFACE AREA:

67.5 Acres

SHORELINE LENGTH:

1.82 Miles

MAXIMUM DEPTH:

11.09 Feet

AVERAGE DEPTH:

6.35 Feet

LAKE VOLUME:

432.78 Acre-Feet

WATERSHED AREA:

241.2 Acres

LAKE TYPE:

Impoundment

CURRENT USES:

Swimming, Fishing, and non-gas powered boating.

ACCESS:

Access for Lindenhurst residents and two access areas.

WATERFORD LAKE SUMMARY

Following is a summary of the water quality sampling, shoreline survey and aquatic macrophyte survey from the 2017 monitoring season on Waterford Lake. The complete data sets can be found in Appendix A & B of this report, and discussed in further detail in the following sections. Included in the Appendix is an "Understanding Your Lake Data" guide that will help with additional questions about water chemistry results.

- Average water clarity as measured by Secchi depth in 2017 was 6.11 feet. This is a 30% increase since 2010 (4.70 ft.) and is above the Lake County median Secchi depth of 3.00 ft.
- Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS) concentration. The average epilimnion TSS concentrations on Waterford Lake was 3.8 mg/L in 2017, which is below the Lake County median of 8.2 mg/L. TSS have slightly decreased since 2010 from 3.9 mg/L to 3.8 mg/L.
- Nutrient availability indicated that Waterford Lake was phosphorus limited with an average TN:TP ratio of 26:1.
- In 2017, the average total epilimnion phosphorus concentration was 0.047 mg/L. This is slightly below the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.050 mg/L. However, TP concentrations have increased by 17.5% since the 2010 sampling.
- Trophic State Index based on 2017 total phosphorus concentrations (TSIp) for Waterford Lake is 59.7, meaning Waterford Lake is considered a eutrophic lake.
- A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support fisheries. DO concentrations dropped below 5.0 mg/L at depths greater than 9 feet in June, 10 feet in July, 6 feet in August, and 5 feet in September. Waterford Lake had anoxic conditions occur in June, August and September.
- The aquatic macrophyte survey showed that 48.6% of all sampling sites had plant coverage on Waterford Lake.
- In 2017, a total of 6 plant species and 1 macro-algae (Chara) were present in Waterford Lake. This was a decrease in plant diversity since the 2010 sampling where 9 species were observed. This is an increase in aquatic plants since 2010 when only two native species were observed.
- The most dominant aquatic plants in Waterford Lake were Chara (36%) and Sago Pondweed (22%).
- Curlyleaf Pondweed is an aquatic invasive species observed in Waterford Lake.
- Based on the shoreline assessment, only 15% of Waterford Lake had some degree of erosion along the shoreline. Of the 15% with erosion, 12% was considered slight, 2% moderate, and 1% severe.
- Based on the shoreline assessment, 86% of Waterford's Lake shoreline had poor buffer. Waterford Lake could benefit from shoreline native plantings.

WATERSHED & LANDUSE

Waterford Lake is in the North Mill Creek Watershed of the greater Des Plaines River Watershed. Waterford Lake receives water from Potomac Lake and it's watershed of approximately 241 acres. Waterford Lake drains into Spring Ledge Lake under Teal Road from the South outlet. The primary land use within the watershed is single family homes (47.2%) followed by water (33.5%).

Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. Because impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground, more runoff is generated than in the undeveloped condition. The major sources of runoff for Waterford Lake were water (56%), single family homes (23.7%) and transportation (15.6%). Runoff is referring to the amount of water making its way to the lake, however, each land use contributes different amount of pollutant loads associated with it's runoff. The water land use does not have high pollutants associated with it since it refers to the rainfall falling directly on the lake. Pollutants in rainfall are mostly related to atmospheric deposition and while contribute pollutants do so at a lower quantity than other land uses in urbanized areas. For example, the transportation land use, and other impervious surfaces, contain higher pollutants that are carried to the lake by runoff. In Waterford Lake, most pollutants are likely a result of the single family home and transportation land uses.

The size of the watershed feeding the lake relative to the lake size is also important factor in determining the amount of pollutants in a lake. The watershed to lake ratio is small, 3.6:1. Small watersheds mean focusing on BMPs around the lake become increasingly more important. The retention time, the amount of time it takes for water entering a lake to flow out of it again, was calculated to be approximately 264 days.

Waterford Lake is in the North Mill Creek Sub-watershed of the Des Plaines River Watershed

Figure 1: *Waterford Lake 2017 Land Use and Watershed Boundary*

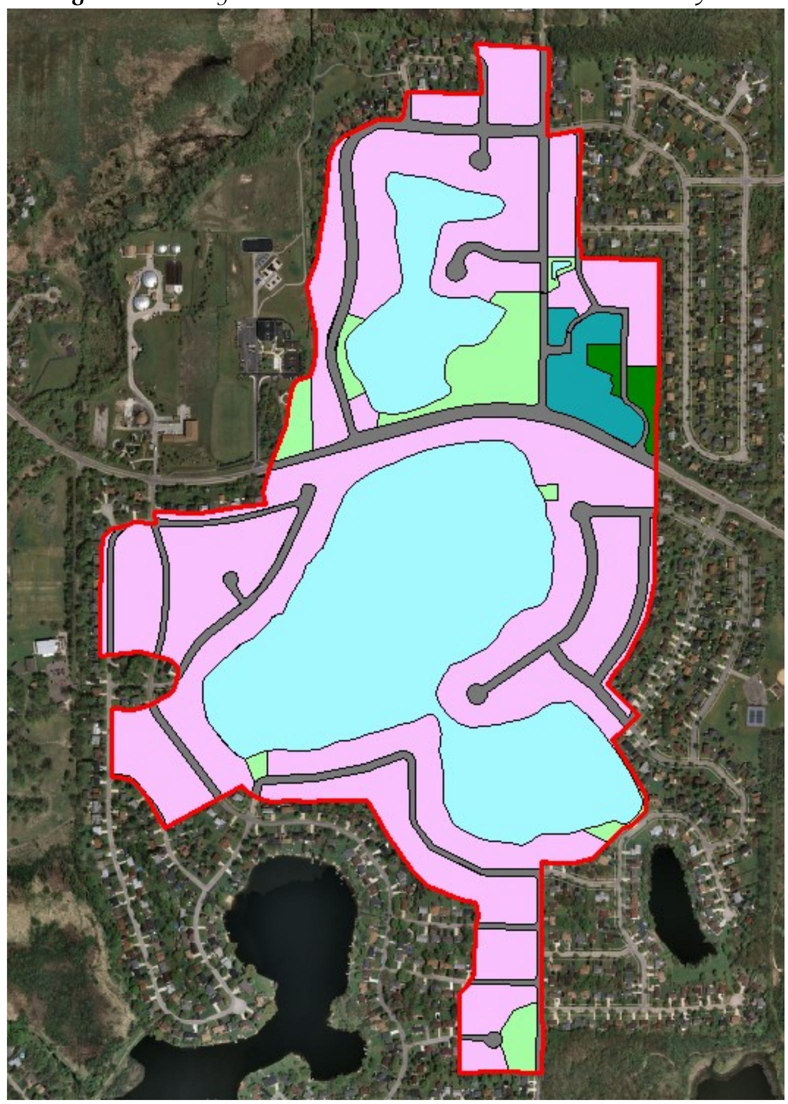


Table 1: *Waterford Lake 2017 Land Use and Estimated Runoff*

Land Use	Acreage	% of Total	% Total of Estimated Runoff
Forest and Grassland	2.11	0.9%	0.1%
Public and Private Open Space	11.87	4.9%	1.2%
Retail/Commercial	5.81	2.4%	3.4%
Single Family	113.94	47.2%	23.7%
Transportation	26.55	11.0%	15.6%
Water	80.90	33.5%	56.0%
Total Acres	**241.18**	**100.0%**	**100.0%**

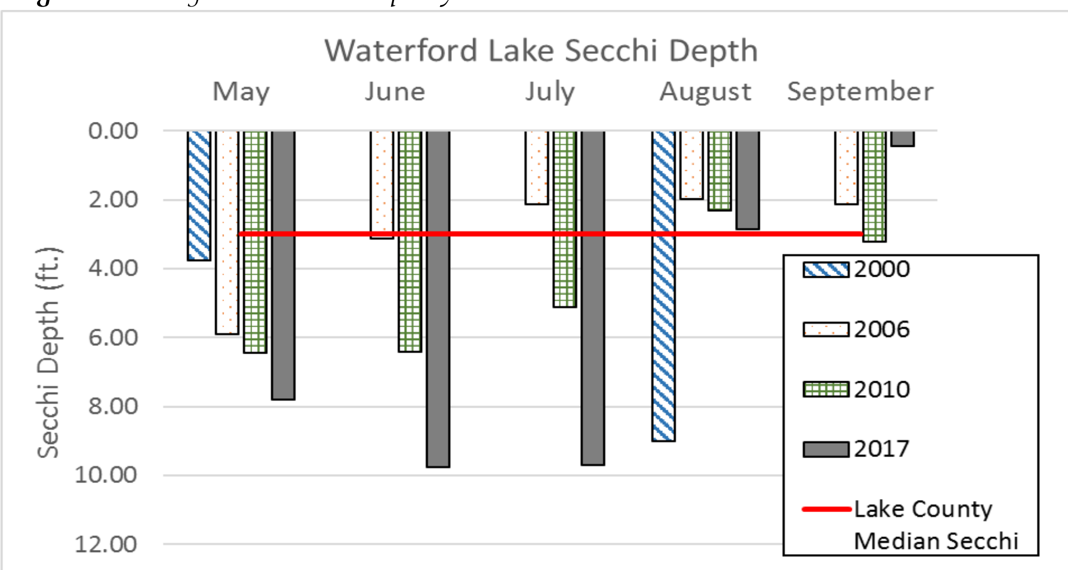
WATER CLARITY

Water Clarity is typically measured with a Secchi disk and is primarily used as an indicator of algal abundance and general lake productivity. Although it is only indicator, Secchi disk depth is the simplest and one of the most effective tools for estimating a lakes' productivity. It can also provide an indirect measurement of the amount of suspended materials in the water. A number of factors can interfere with light penetration and reduce water clarity. This includes: algae, water color, re-suspended bottom sediments, eroded soil, and invasive species.

The 2017 average water clarity for Waterford Lake based on Secchi depth was 6.11 feet. This is a 30% increase since the 2010 water quality sampling, which had a Secchi depth of 4.70 feet. As seen in Figure 2, Secchi depth on Waterford Lake starts out very clear from May—July, which the highest Secchi reading being 9.75 feet in June. In August and September water clarity shifts dramatically getting it's lowest Secchi reading in September of 0.45 feet. September noted a large blue-green algae bloom that covered most of the lake, reducing water clarity.

Waterford Lake average Secchi depth was 4.18 ft., which is above the Lake County median Secchi depth of 3.00 ft.

Figure 2: *Waterford Lake Secchi depth by Year*



VOLUNTEER LAKE MONITORING PROGRAM (VLMP)

The VLMP was established in 1981 by the Illinois Environmental Protection Agency (IEPA) to be able to collect information on Illinois inland lakes, and to provide an educational program for citizens. The volunteers are primarily lakeshore residents, lake owners/managers, members of environmental groups, and citizens with interest in a particular lake. The VLMP relies on volunteers to gather information on their chosen lake. The primary measurement by volunteers is Secchi depth (water clarity). The sampling season is May through October with measurements taken twice a month.

Waterford Lake is participating in the VLMP program, however more consistent readings are encouraged. Participating provides annual data that helps document water quality impacts and support lake management decisions.

TOTAL SUSPENDED SOLIDS

The Total Suspended Solids (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lakes water column, which includes both sediment and algal cells. Typical inorganic components of TSS are referred to as non-volatile suspended solids (NVSS) and originate from weathering and erosion of rocks and solids in the lakes watershed. The organic portion of TS are referred to as volatile suspended solids (TVS) and are mostly composed of algae and other organic matter such as decaying plants.

2017 TSS concentrations in the eplimnion of Waterford Lake averaged 3.8 mg/L, which is below the Lake County median of 8.3 mg/L. It is a slight decrease since the 2010 sampling (3.9 mg/L) but not notable. Algae blooms were noted in August and September and these are the months with the highest TSS concentrations and lowest Secchi readings. Secchi depth and TSS are inversely related. A lake can have a TSS impairment which is based on if the median surface NVSS is greater or equal to 12 mg/L for the monitoring season. In 2017, the median surface NVSS was 1.30 mg/L, therefor there is no TSS impairment on Waterford Lake.

The percentage of TSS that are NVSS gives insight into the source of the suspended solids. Lakes that have a higher percentage of NVSS to TSS represent more allochthonous (originating outside of the lake) input , or resuspended sediment indicative of more inorganic material. Lakes with lower percentage of NVSS to TSS may have more algae and organic material. The lowest percentage of NVSS:TSS were in August (less than 1%) and September (32%), which corresponds to the two months with notable algae blooms.

TSS

Total Suspended Solids

TSS are particles of algae or sediment suspended in the water column.

TVS

Total Volatile Solids

TVS represents the fraction of total solids that are organic in nature, such as algae cells.

NVSS

Non-Volatile Suspended Solids

NVSS represents the non-organic clay and sediments that are suspended in the water column.

TDS

Total Dissolved Solids

TDS are the amount of dissolved substance such as salts or minerals in the water after evaporation.

Figure 3: *Total Suspended Solid Concentrations vs. Secchi Depth in Waterford Lake, 2017*

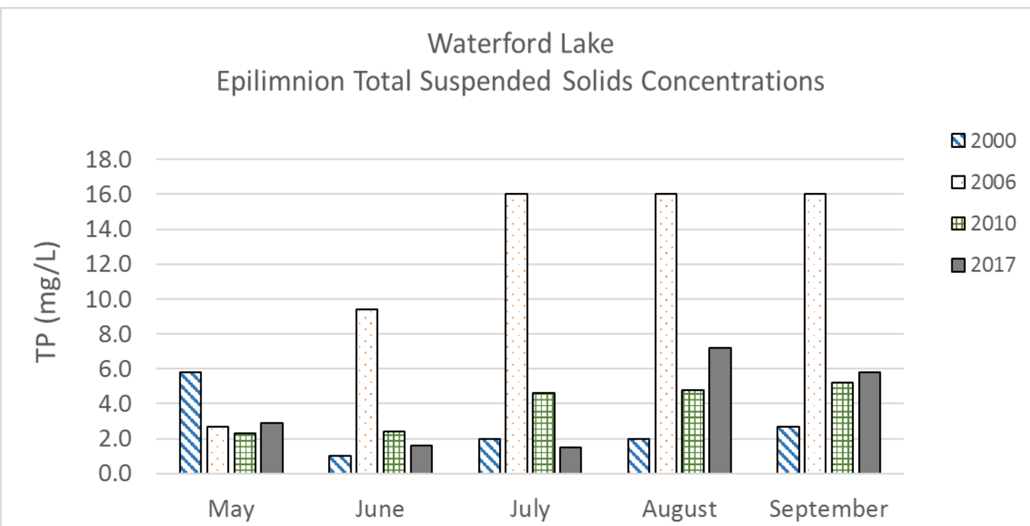


Table 2: *Solid concentrations on Waterford Lake, 2017*

2017 Epilimnion solid concentrations in mg/L on Waterford Lake

DATE	TSS	TS	TVS
16-May-17	2.9	508	71
13-Jun-17	1.6	546	96
11-Jul-17	1.5	466	73
15-Aug-17	7.2	378	58
12-Sep-17	5.8	425	102
Average	*3.8*	*465*	*80*

2017 Hypolimnion solid concentrations in mg/L on Waterford Lake

DATE	TSS	TS	TVS
16-May-17	43.3	548	109
13-Jun-17	2.4	536	89
11-Jul-17	1.8	457	65
15-Aug-17	8.9	379	54
12-Sep-17	5.3	420	78
Average	*12.3*	*468*	*79*

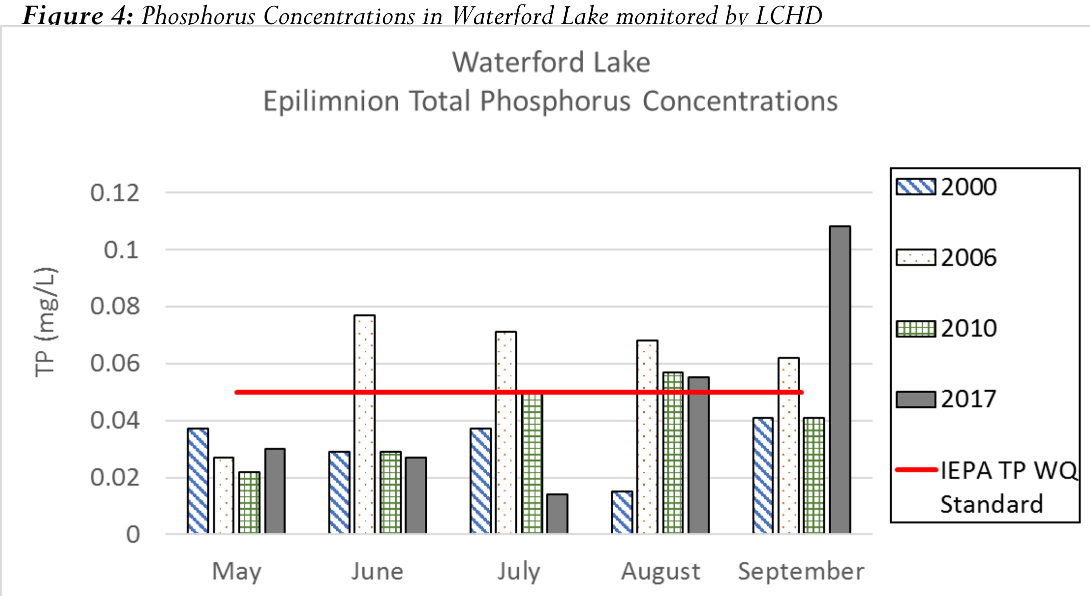
NUTRIENTS: PHOSPHORUS

In a lake, the primary nutrients needed for aquatic plant growth are phosphorus (P) and nitrogen (N). Sources of phosphorus can be external, internal, or both. External sources include: human and animal waste, soil erosion, detergents, sewage treatment plants, septic systems, and runoff from lawns. Internal sources of phosphorus originate with the lake and are typically linked to the lake sediment. When phosphorus is bound to sediments it is generally not available for use by algae, however, various chemical and biological processes can allow phosphorus to be released from the sediment, making it available in the water column.

The average total phosphorus concentrations in the epilimnion of Waterford's Lake was 0.047 mg/L for 2017. The highest TP concentration occurred in September at 0.108 mg/L and the lowest concentration was in July at 0.014 mg/L. The 2017 TP concentration is a 17.5% increase since the 2010 sampling (Figure 4).

While TP concentrations are a better overall indicator of a lake's nutrient status because it's concentration remains more stable than other forms of phosphorus, soluble reactive phosphorus (SRP) is another parameter included in the water chemistry analysis. SRP is a dissolved form of phosphorus that is readily available for plant and algae growth. Typically SRP values are non-detect as it is used up quickly when available. However, during anoxic conditions there is typically a spike in SRP. In the bottom samples collected on Waterford Lake, there are elevated SRP concentrations in August and September. August and September were the only months on Waterford when anoxic conditions occurred which can explain the SRP concentrations above the detection limit.

Figure 4: *Phosphorus Concentrations in Waterford Lake monitored by LCHD*



WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

2005-2008: *common carp removal by IDNR*

January 2009: *Lindenhurst passed an ordinance prohibiting the use of lawn fertilizers containing phosphorus.*

July 2010**—***The state of Illinois passed a law to reduce the amount of phosphorus content in dishwashing and laundry detergent*

July 2010: *The state of Illinois passed another law restricting the use of lawn fertilizers containing phosphorus by commercial applicators.*

TROPHIC STATE INDEX

Total phosphorus is also used to calculate the Trophic State Index (TSI) value. Trophic states describe the overall productivity of a lake and refers to the amount of nutrient enrichment. This has implications for the biological, chemical and physical conditions of the lake. Lakes are classified into four main categories: oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic. These range from nutrient poor and least productive (oligotrophic) to most nutrient rich and most productive (eutrophic). In 2017, Waterford Lake had a TSIp value of 59.7 which categorizes it as eutrophic. Based on the TSIp, Waterford's Lake is ranked 54 out of 175 lakes studied by the LCHD-ES from 2000 –2017 (Appendix B).

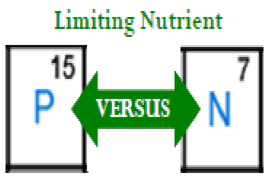
LAKE COUNTY AVERAGE TSIP = 65.7

WATERFORD LAKE TSIP = 59.7

TROPHIC STATE: EUTROPHIC

RANK= 54/175

NUTRIENTS: NITROGEN



Nitrogen in the form of nitrate (NO3-), nitrite (NO2-), or ammonium (NH4+) is a nutrient needed for plant and algal growth. Sources of nitrogen include septic systems, animal feed lots, agricultural fertilizers, manure, industrial wastewaters, sanitary landfills and atmospheric deposition. Nitrate/Nitrite concentrations in the epilimnion of Waterford Lake were below detectable concentrations for the entire monitoring season. Total Kjeldahl Nitrogen (TKN), an organically associated form of nitrogen averaged 1.12 mg/L, less than the Lake County median. There are no nitrogen impairments on Waterford Lake.

Typically lakes are either phosphorus or nitrogen limited. This means that one of the nutrients is in shorter supply and any addition of that nutrient to the lake will result in an increase of plant/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Waterford Lake had an average TN:TP of 26:1, and is a phosphorus limited system. Any additional inputs of phosphorus can increase algae/aquatic plant growth.

TN:TP Ratio

<10:1 = nitrogen limited

>20:1= phosphorus limited

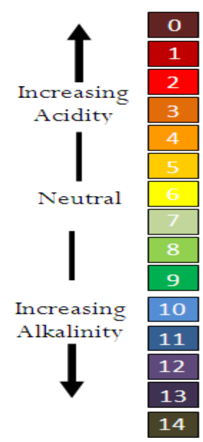
TN:TP Ratio on Waterford Lake is 26:1

Waterford Lake is Phosphorus

PH

pH is a measure of the hydrogen ion concentration of water. As the hydrogen ions are removed, pH increases. A well buffered lake also means that daily fluctuations of CO2 concentrations result in only minor changes in pH throughout the day. Aquatic organisms benefit from stable pH. Each organism has an ideal pH threshold, but most aquatic organisms prefer pH of 6.5—8.0. pH values <6.5 or >9.0 cause a water quality impairment.

Waterford Lake had an average pH in 2017 was 8.76. In August and September, the pH was 9.24 and 9.09, respectively, causing a water quality impairment. High pH values are often occur in the presence of blue-green algae blooms. In September, blue-green algae blooms were noted on Waterford Lake and this corresponds with the higher pH concentration. The formation of blooms can have effects on the chemistry of water, especially on its pH and dissolved oxygen. During photosynthesis, algae remove carbon dioxide from the water, which increases the hydroxide (OH−) levels, resulting in an increase in pH.



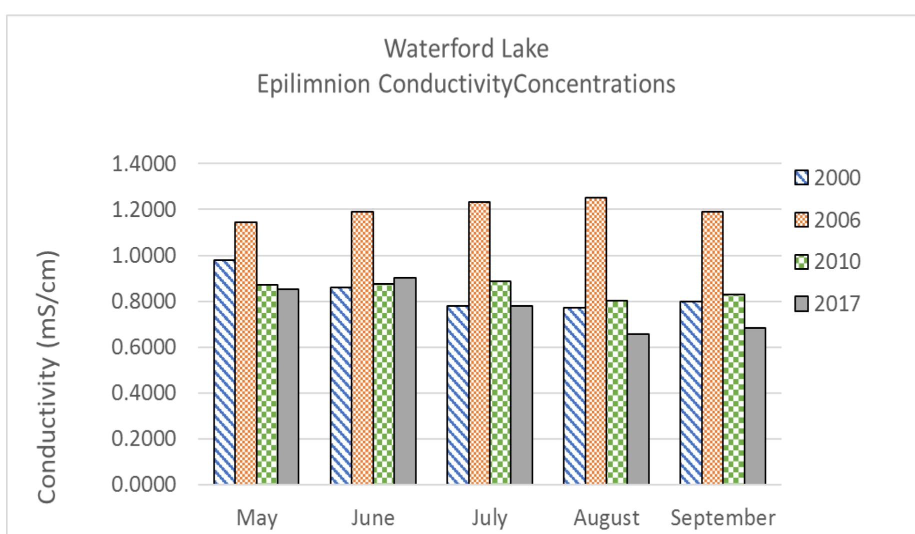
The pH scale ranges from 0 to 14. A pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7 are basic.

CONDUCTIVITY

Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, size of the watershed flowing into the lake, land use, evaporation, and bacterial activity.

In 2017, Waterford Lake average conductivity was 0.7750 mS/cm. This is below the Lake County median conductivity of 0.8491 mS/cm. This value is a 9% decrease since the 2010 concentrations (Figure 5).

Figure 5: *Conductivity Concentrations in Waterford Lake*

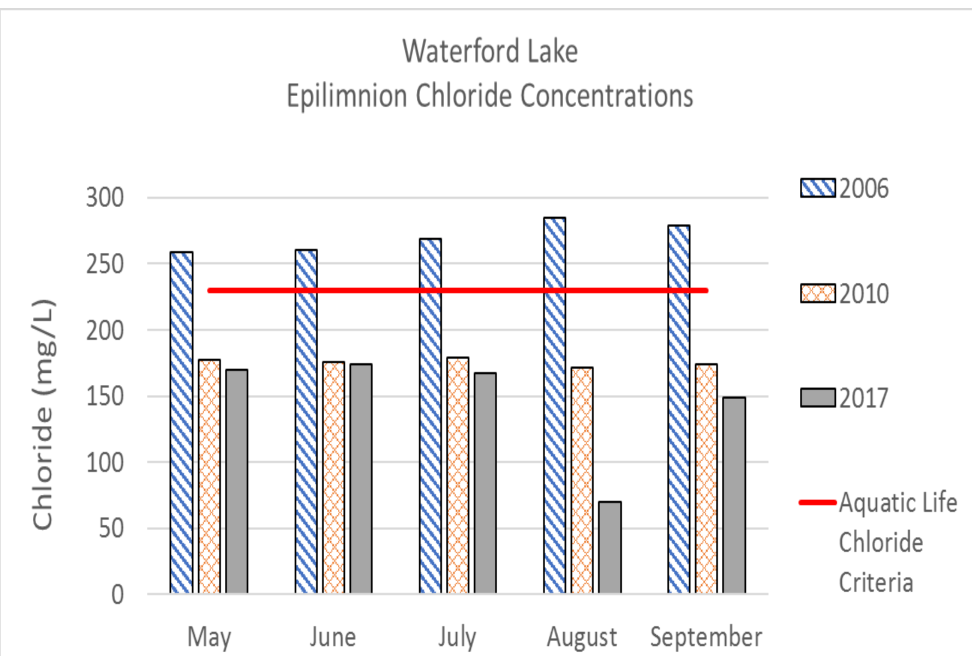


CHLORIDES

One of the most common dissolved solids is road salt used in winter road deicing. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocynaide salts. Waterford Lake's chloride concentration averaged 146 mg/L which is above the Lake County median of 160 mg/L (Figure 6). The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. While Waterford's Lake chloride concentration is below the aquatic life criteria, recent research has indicated organisms can get stressed at values much llower than 230 mg/L. Chloride ions do not break down and accumulate within a watershed. High chloride concentrations may make it difficult for many of our native plant species to survive while many of our invasive species such as Eurasian Watermilfoil, Cattail, and Common Reed are tolerant to high chloride levels.

The LCHD-ES and Lake County Stormwater Management Commission (LCSMC) have been holding annual trainings targeting deicing maintenance personnel for both public and private entities to hopefully reduce the amount of chloride being introduced into our environment while maintaining safe passageways. Almost all deicing products contain chloride so it is important to read an follow product labels for proper application. For instance, at 10°F Fahrenheit, rock salt is not at all effective in melting ice and will blow away before it melts anything. Additionally calling your local township office to ask them if they are taking actions to minimize deicers on their properties or supporting changes in their deicing policy to minimize salt usage is encouraged. Since a majority of pollutant-carrying runoff in Waterford Lake's watershed is single family homes and transportation, efforts should be made in the watershed for efficient de-icing practices, both for homeowners and streets.

Figure 6: *Waterford Lake Chloride Concentrations*



THE CRITICAL VALUE FOR CHLORIDES IN AQUATIC SYSTEMS IS 230 MG/L.

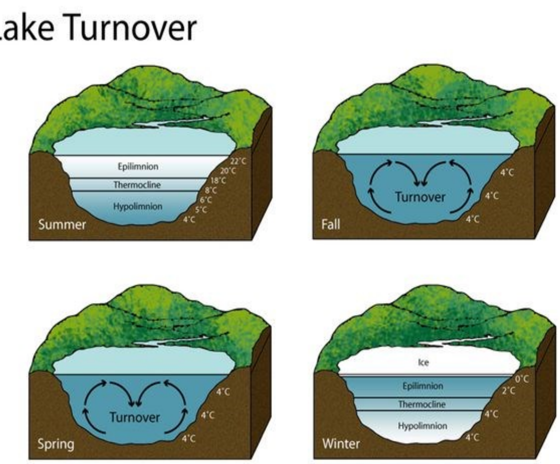
230 mg/L = 1 teaspoon of salt added to 5 gallons of water.

ICE FACTS

- Deicers melt snow and ice. They provide no traction on top of snow and ice.
- Anti-icing prevents the bond from forming between pavement and ice.
- De-icing works best if you plow/shovel before applying material.
- Pick the right material for the pavement temperatures.
- Sand only works on top of snow as traction. It provides no melting.
- Anti-icing chemicals must be applied prior to snow fall.
- NaCl (Road Salt) does not work on cold days, less than 15° F.
- NaCl is more effective at warmer temperatures—when it is warmer out, you do not need to put as much road salt down to melt ice efficiently.

STRATIFICATION

Figure 7: Lake Turnover/Stratification diagram

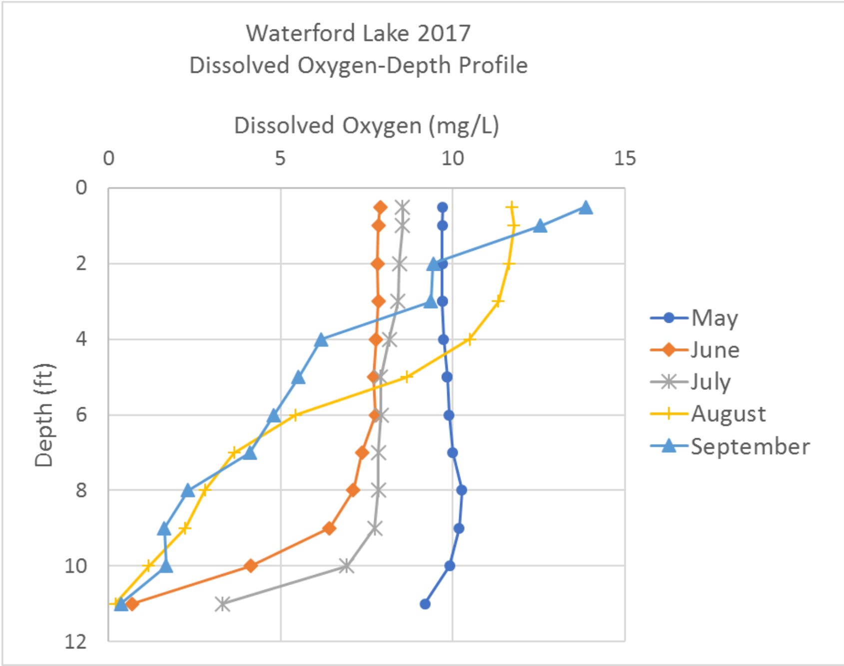


Lake stratification is a result of variations in density caused by temperature (or salinity) and can prevent warm and cold water from mixing. A lake's water quality and ability to support fish are affected by the extent to which the water mixes. Lakes that experience stratification have the water column divided in three zones: epilimnion (warm surface layer), thermocline (transition zone between warm and cold water) and hypolimnion (cold bottom water) (Figure 7). Stratification traps nutrients released from bottom sediments in the hypolimnion and prevents mixing. Lakes in lake county are either dimictic or polymictic. Dimictic means there are only two lake turnovers (spring and fall), whereas polymictic means that the thermocline is never that strong so the lake can go mix multiple times throughout the season.

Monthly depth profiles of water temperature, dissolved oxygen, conductivity, and pH were taken every foot from the lake surface to the lake bottom on Waterford Lake. The relative thermal resistance to mixing (RTRM) value can be calculated from this data and indicates if a lake stratifies, how strong the stratification is, and at what depth the thermocline occurs. In Waterford Lake, the did not stratify, meaning water was able to mix throughout the entire water column all season.

DISSOLVED OXYGEN

Figure 8: Waterford Lake 2017 DO Profile



A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a fishery since fish can suffer oxygen stress below this concentration. DO concentrations dropped below 5 mg/L towards the bottom the lake, which is not uncommon. In August and September, DO drops below 5 mg/L at depths greater than 6 ft. and 5 ft., respectively (Figure 8). This amounts to 22.1% of the lake volume below 5 mg/L in August and 15.2% of the lake volume in September.

Anoxic conditions, where DO concentrations are <1 mg/L, occurred June - September . Typically, oxygen production is greatest in the epilimnion, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Waterford experienced anoxic conditions only in August and September only at the deepest portion of the lake that is less than 1% of the lake volume.

Harmful Algal Blooms

Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and are often associated with increased concentrations of nutrients such as nitrogen and phosphorus. Harmful algal blooms (HABs), also known as blue-green algae or cyanobacteria, are a type of algae that can bloom and produce toxins. They are called harmful algal blooms because exposure to these blooms can result in adverse health effects to human and animals. Certain environmental conditions such as elevated levels of nutrients, warmer temperatures, still water, and plentiful sunlight can promote the growth of cyanbacteria to higher densities. However, their presence does not mean that toxins are present. It is still unclear what triggers HABs to produce the toxins. HABs tend to occur in late summer and early fall. Due to the potential presence of toxins, the IEPA and the LCHD have initiated a program to collect HABs from beaches and test for presence of microcystin, a common toxin produced by HABs. Table 3 shows guidelines for microcystin toxins based on the World Health Organization. EPA is in the process of releasing microcystin toxin criteria for recreational waters.

In 2017, filamentous and blue-green algae blooms were noted on Waterford Lake. Filamentous algae was noted early in the season (May) and blue-green algae blooms were noted later in the season (September). This is typical timing of these blooms in high-nutrient lakes.

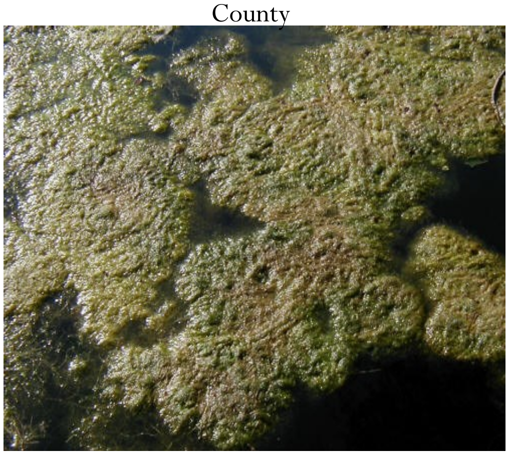
While Waterford Lake does not have a public swimming beach many homeowners have private beaches. The Lindenhurst Lakes Commission should educate themselves and homeowners on how to identify and report HABs. It is recommended to report any potential blue-green algae blooms by calling the LCHD so that the bloom can be tested. Blue-green algae blooms can be toxic to pets who drink from the water as well as to human health. Also, there should be a clear communication protocol amongst the LCFPD to disseminate information regarding the presence of blue-green algae.

Table 3: *World Health Organization Microcystin Toxin Guidelines*

Relative Probability of Acute Health Effects	Cyanobacteria (cells/mL)	Microcystin-LR (µg/L)	Chlorophyll-a (µg/L)
Low	< 20,000	<10	<10
Moderate	20,000-100,000	10-20	10-50
High	100,000-10,000,000	20-2,000	50-5,000
Very High	> 10,000,000	>2,000	>5,000

Example of Blue-Green Algae Bloom in Lake County

Example of Filamentous algae bloom in Lake County

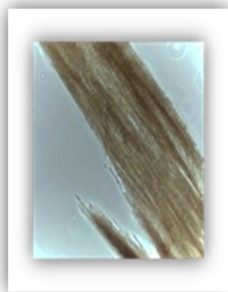


For More Information On Blue-green algae:
www.epa.state.il.us/water/surface-water/blue-green-algae.html

To report blue-green algae bloom:
Lake County Health Department
847-377-8030

Anabaena Sp.

Microcystis Sp.



Aphanizomenon Sp.

Bathymetric maps

Bathymetric maps are also known as depth contour maps and display the shape and depth of a lake. They are valuable tools for lake managers because they provide information about the surface area and volume of the lake at certain depths. This information can then be used to determine the volume of lake that goes anoxic, how much of the lake bottom can be inhabited by plants, and is essential in the application of whole-lake herbicide treatments, harvesting activities and alum treatments of your lake. Other common uses for the map include sedimentation control, fish stocking, and habitat management.

Figure 9: *Bathymetric Map of Waterford Lake*

The LCHD-ES collects field data for bathymetrics using a Lowrance HDS-5 Gen2; Lowrance cites accuracy measures of approximately 5m however actual accuracy is typically better than this conservative estimate and has been discovered to be sub-meter (CIBiobase,2013). Once collected, the data was analyzed and imported into ArcGiS 10.2 for further analysis. In ArcGIS 10.2, the contours and volumes were generated from the triangular irregular network (TIN).

Water level & July 2017 floods

On July 11-12th, Lake County was inundated with very heavy rain. Lake county experienced rainfall amounts between 3.4 - 7.2 inches of rain in a 24-hour period. The rainfall resulted in several different kinds of flooding countywide. Flash flooding and sewer backups began as the heavy rain overwhelmed storm-water infrastructure. River flooding began in the Fox, Des Plaines, and Skokie rivers and established record crest levels (Figure 10). Many lakes experienced high lake levels and increased nutrient levels. Waterford Lake's water level rose approximately 5 inches between June and July. In terms of water chemistry, the lowest TP, TSS and chloride concentrations were observed in July. While rainfall events can carry in pollutants, large flooding events can dilute and flush out pollutants, causing lower concentrations to occur.

Figure 10: *River crests as a result of the July Flooding in Lake County, Lake County Stormwater Management Commission*

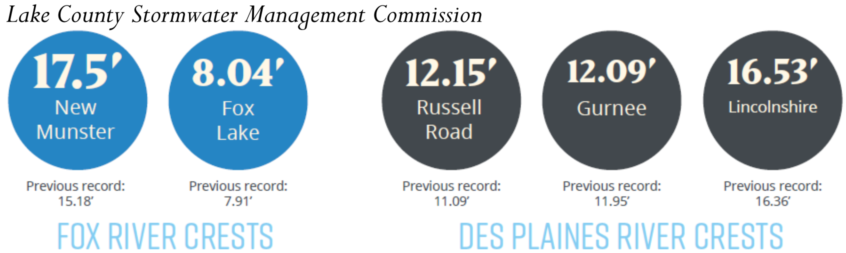


Table 3. 2017 Lake Levels on Waterford Lake

2017	Level (in)	Seasonal Change (in)	Monthly Change (in)
May	37.20		
June	35.40	1.80	1.80
July	32.28	4.92	3.12
August	35.40	1.80	-3.12
September	39.48	-2.28	-4.08

SHORELINE EROSION

Erosion is the natural process of weathering and transport of solids (sediment, soil, rock and other particles) in the environment. In lakes, shorelines are impacted by waves and ice movement which displaces soil particles. Disturbed shorelines caused by human activity such as replacing native plants with turfgrass, increasing impervious pavement which increases runoff will accelerate erosion. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth and once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

A shoreline erosion assessment was conducted on Waterford Lake 2017 (Figure 11). Waterford Lake was divided into reaches, and the shoreline evaluated for none, slight, moderate and severe erosion based on exposed soil and tree/plant roots, failing infrastructure and undercut banks. Based on the 2017 data, 85% of Waterford's Lake shoreline has no erosion. Out of the 15% that had erosion, 12% were slight, 2% moderate, and 1% severe. Figures 12-13 represent the some typical shoreline conditions on Waterford Lake. Many homeowners have created artificial shorelines to minimize erosion including riprap and seawalls.

For a complete dataset of shoreline erosion broken down by reach, refer to the shoreline condition assessment tables in Appendix B.

Figure 11: *Shoreline Erosion Condition Waterford Lake, 2017*

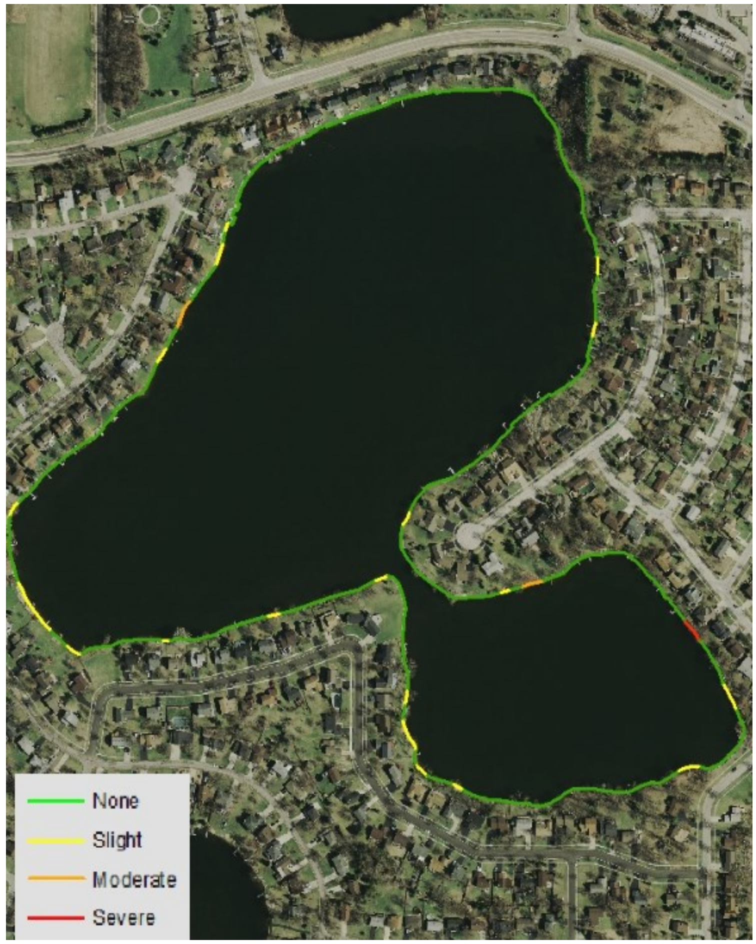


Figure 12: example of shoreline erosion on Waterford Lake

Figure 13: Example of riprap located along shoreline to minimize erosion

SHORELAND BUFFERS

A shoreland buffer helps stabilize the sediment near the lakes edge which prevents soil erosion. The buffer will also filter out pollutants and unwanted nutrients from entering the lake. Buffer strips should be at least 25 feet wide and can include native wildflowers, native grasses, and native wetland plants. Wider buffers may be needed for areas with a greater slope or additional runoff issues. Areas that are already severely or moderately eroding, a buffer strip of native plants may need to be bolstered for additional stability.

A shoreland buffer condition of Waterford Lake was assessed by looking at the land within 25 feet of the lake's edge on aerial images in ArcGIS. Shoreland buffer's were classified into three categories; poor, fair or good based on the amount of unmowed grasses, forbs, tree trunks and shrubs, and impervious surfaces within that 25 foot range. In 2017, Waterford Lake had 86% of the shoreline with poor buffer, 9% with fair, and only 5% with good buffer (Figure 14). Waterford Lake could benefit from homeowners increasing buffer strip along their shorelines. Figures 15-16 represent the typical buffer conditions around Waterford Lake. For a complete list of buffer condition by reach, refer to Appendix B.

Figure 14: *Shoreline Buffer Condition on Waterford Lake*

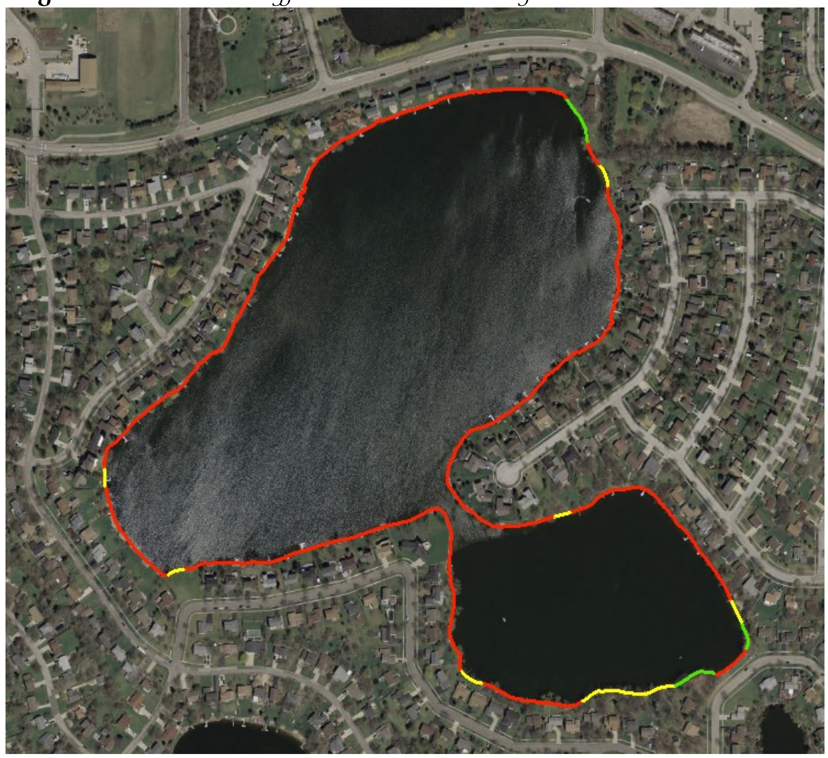


Figure 15: *Example of some native plants acting as buffer along lake shoreline*

Figure 16: *Has rock structures to stabilize bank but no buffer*

AQUATIC PLANTS

Aquatic plants are a critical component of a lakes ecosystem as they compete against algae for nutrients, improve water quality and provide fish habitat. **Their presence is natural and normal in lakes.** An aquatic macrophyte survey was conducted on Waterford Lake in August 2017. Sampling sites were based on a grid system created by mapping software, with each site located 60 meters apart for a total of 74 sites. At each site, overall plant abundance was ranked and plant species were identified and ranked. In addition to the plant rake survey, the lake was mapped using Sonar and CIBiobase as more accurate measure for overall aquatic plant biovolume. Based on the aquatic plant rake survey, plants occurred at 36 of the 74 sites (49% total lake coverage) with plants found at depths up to 9.6 feet (Figure 17).

There were a total of 6 aquatic plant species and one macro-algae found in Waterford Lake. Chara, a macro-algae, was the most dominant species found at 36% of the sampling sites. The next most abundant plant was Sago Pondweed observed at 22% of the sampling sites. Vallisneria was not collected in the rake sampling, however was observed in the water. The number of plant species (diversity) is an increase in the 2010 sampling where only 2 plant species and Chara were observed . In 2010, Water Stargrass was the most dominant species. For a complete list of aquatic plant species and density found in Waterford Lake, refer to the aquatic plant table found in Appendix B.

Figure 17: *Waterford Lake 2017 Plant Rake Density*

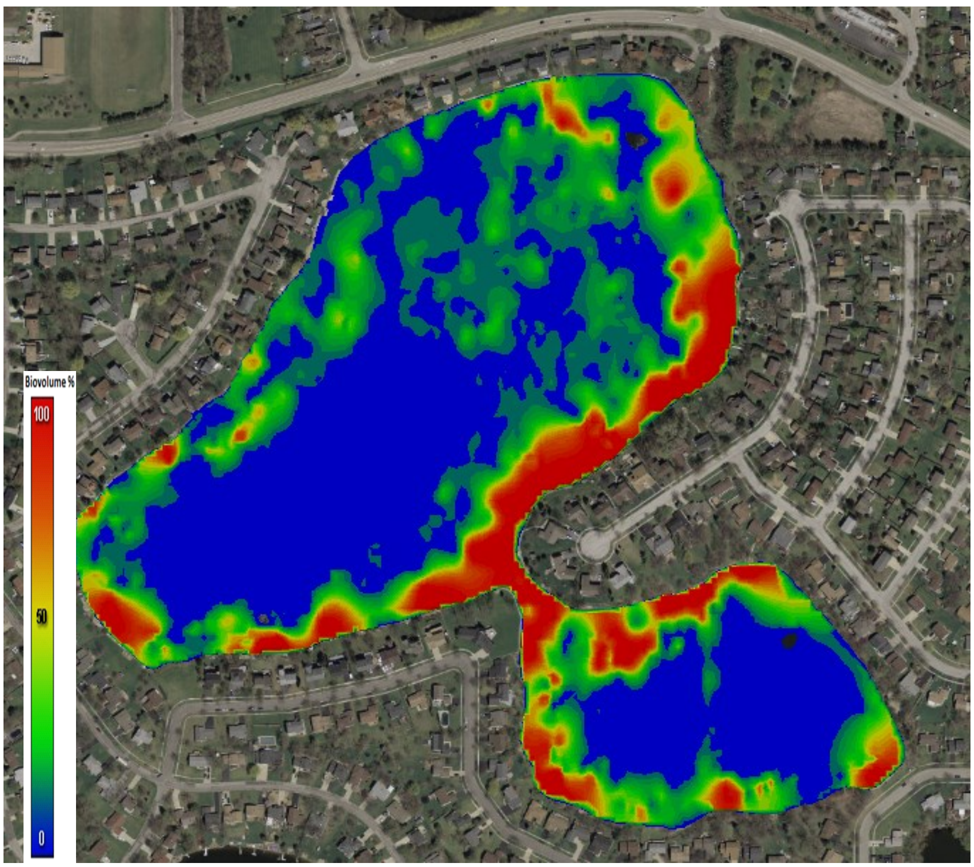


Table 4: 2017 Aquatic Plant Rake Density by Species

Plant Density	Chara	Curlyleaf Pondweed	Duckweed	Sago Pondweed	Watermeal	Water Stargrass
Absent	47	73	74	58	73	71
Present	7	1	0	7	0	2
Common	9	0	0	7	1	1
Abundant	11	0	0	1	0	0
Dominant	0	0	0	1	0	0
% Plant Occurrence	36%	1%	0%	22%	1%	4%

AQUATIC PLANTS —DOMINANT PLANTS

The most dominant plants found in Waterford Lake were: Chara (36%), Sago Pondweed (22%), and Water Stargrass at only 4%. The diversity and extent of plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow. When the light level in the water column falls below 1% of surface light level, plants can no longer grow. The 1% surface light level is roughly at 2 times the average Secchi depth or can be measured with a photosynthetically active radiation (PAR) sensor. For Waterford Lake, the 1% light level based on average Secchi values was approximately would be 12 feet . This would mean plants could be observed at the entire depth of the lake. However, water clarity varied substantially from month to month which limits plant growth. Plants were found up to 9.4 feet in Waterford Lake. Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates.

Common Plants in Waterford Lake in 2017

Chara
(*Chara sp.*)

Description

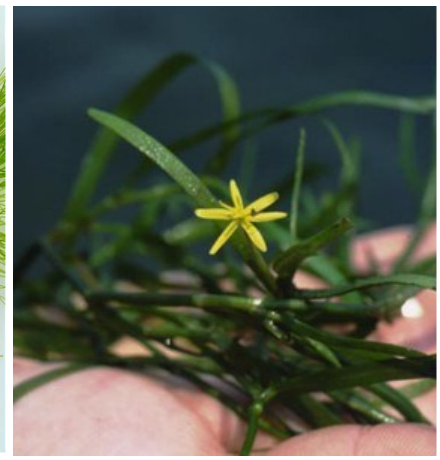
Chara is often called muskgrass or skunkweed because of its foul, musty odor. Chara is a gray-green branched multicellular algae that is often confused with submerged flowering plants. However, Chara has no flower, will not extend above the water surface, and has a "grainy" texture. Chara has cylindrical whorled branches.

Sago Pondweed
(*Potamogeton pectinatus*)

Description

Sago Pondweed is a perennial plant that has no floating leaves. The stems are thin, long, and highly branching with leaves very thin and filament-like—about 1/16 inch wide and 2 to over 12 inches long tapering to a point.

Water Stargrass
(*Heteranthera dubia*)



Description

Water Stargrass is grass-like with thin branching dark green stems and alternating leaves with no prominent midvein. Water Stargrass can grow up to 6 feet long and can form floating colonies. Flowers rise above the surface and are bright yellow and star shaped. Water Stargrass reproduces from seeds and through fragmentation.

AQUATIC PLANTS: WHERE DO THEY GROW?

Littoral Zone– the area that aquatic plants grow in a lake.

Algae– have no true roots, stems, or leaves and range in size from tiny, one- celled organisms to large, multicelled plant -like organisms.

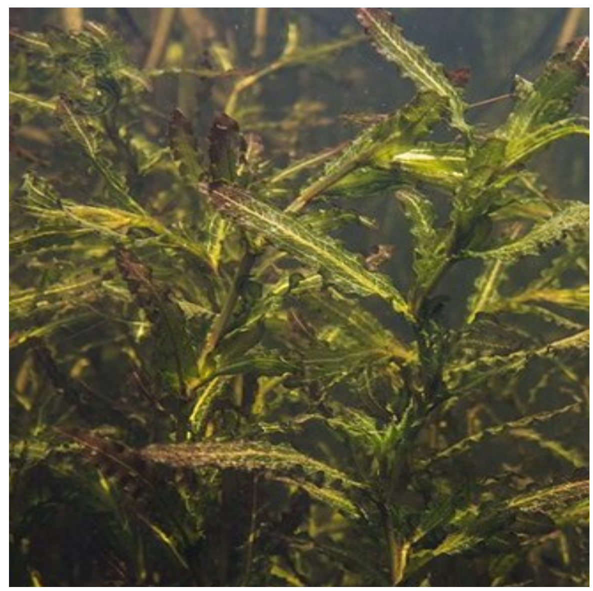
Submerged Plants– have stems and leaves that grow entirely underwater, although some may also have floating leaves.

Floating-leaf Plants– are often rooted in the lake bottom, but their leaves and flowers lay flat on the water surface.

Emergent Plants– are rooted in the lake bottom, but their leaves and stems extend out of the water.

Invasive Species: Culyleaf pondweed

Figure 18: *Curlyleaf Pondweed*



Curlyleaf Pondweed is a non-native invasive pondweed. Like the native pondweeds, it is a perennial monocot. This has management consequences as the native pondweeds and other native species are equally sensitive to herbicides that are effective on this invasive. Curlyleaf Pondweed, however, does have a life cycle that is different from native pondweeds. Curlyleaf Pondweed is one of the first plants to emerge in early spring. The turions (which are the main source of reproduction for Curlyleaf pondweed) sprout in fall and are rapidly able to elongate in spring after ice melts as temperatures reach 5°C. This means that Curlyleaf Pondweed's peak growth is occurring as most of our native plants are just beginning to emerge. The vegetative part of the plant dies back completely in early summer and only seeds and turions oversummer. Because of its earlier life cycle, Curlyleaf Pondweed herbicide treatments can be effective early in the season without impacting native plants. Algal blooms have been associated with large stands of senescing or dying plants of CLP as it releases nutrients back into the water.

In 2017, Curlyleaf Pondweed was only noted at 1% of the sampling sites, however, the LCHD aquatic macrophyte survey is conducted in late July/early August to capture the timing of most aquatic plants. Since Curlyleaf Pondweed has an earlier cycle it is often under represented in the aquatic macrophyte survey. It is likely that abundance of Curlyleaf Pondweed is more than what is recorded during our august sampling on Waterford Lake.

An aquatic plant management plan is critical to maintaining the health of the lake and a balanced aquatic plant community. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. The primary focus of the plan must include the removal of invasive species such as CWP. Follow up is critical to achieve long-term success.

FLORISTIC QUALITY INDEX

Floristic Quality Index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions . It can be used to (1) identity natural areas, (2) compare the quality of different sites, (3) monitor long term floristic trends and (4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a value based on the species sensitivity. A high FQI number indicates that a large number of sensitive, high quality plants species are present in the lake. The average FQI for Lake County lakes from 2000-2017 was 13.7 Waterford Lake has an FQI of 13.1 ranking it 85/171 lakes in the county.

Lake county Average
FQI = 13.8

Waterford Lake
FQI = 13.1

Rank =85/171

Aquatic Plants Species: 6

Native plant species: 5

Aquatic Herbicides

Herbicide treatments are one of the many tools available to lake managers. When used alone, they provide a quick fix, that does not address the source of the problem, high nutrient levels.

The Lindenhurst Lakes Commission contracts with Integrated Lakes Management (ILM) for algae and plant control. ILM monitored the lake roughly every two weeks to assess if treatments were needed. Between April—September a total of 9 treatments were done on Waterford Lake addressing issues such as: Curlyleaf Pondweed, filamentous algae, and Sago Pondweed (Table 4). On Waterford Lake, an early season Sonar treatment was conducted to treat for Curlyleaf Pondweed. Following treatments consisted of trying to reduce filamentous algae with mixtures of Cutrine Plus and Cygnet Plus as well as reducing the abundance of Sago Pondweed. LCHD recommends chemical treatments to only treat invasive species and nuisance algae conditions. Native Pondweeds should remain to provide a the benefits of aquatic plants to the lake. If areas of the lake become excessive with a certain native plants that prohibit user access, spot treating areas to create pathways for navigation can be done. However, native plants provide many beneficial uses to the lake including: outcompeting algae for nutrients, stabilizing bottom sediments, and providing suitable fish habitat.

Table 5: Waterford Lakes Herbicide Treatments, 2017

Date	Product	Amount	Target
4/7/2017	Sonar AS	132 oz	Curlyleaf
4/20/2017	Sonar AS	87 oz	Curlyleaf, E. Watermilfoil
5/12/2017	Cutrine Plus	5 gallons	Filamentous
5/18/2017	Cutrine Plus, Cygnet Plus	1 gallon, 2 oz	Filamentous
5/25/2017	SeClear, Cygnet Plus	7 gallons, 14 oz	Filamentous
6/1/2017	CuSO4, Cygnet Plus	5 gal, 20 oz	Filamentous
7/27/2017	Reward, Cygnet Plus	30 gal, 32 oz	Sago Pondweed
8/10/2017	Reward, Cygnet Plus	22.5 gal, 90 oz	Sago Pondweed
8/24/2017	Reward, Cygnet Plus, Cutrine Plus	5.0 gal, 20 oz, 0.25 gal	Sago Pondweed

Chemic algae is solution multipl treated bottom oxygen) that th rebound

Aquatic herbicides (Copper Salts)

Copper salts is one of the earliest known herbicides for terrestrial and aquatic weed control. The use of copper sulfate is appealing because it has little or no effect on flowering plants at normal rates and there are no restriction on the use of water following treatment. The efficiency of copper sulfate is greatly affected by the carbonate alkalinity ($CaCO_3$) concentrations in the water. The copper will combine with the carbonates and precipitate out preventing the copper from entering the algal cells. Waterford Lake average alkalinity in 2017 was 129 mg/L. Alkalinity concentrations between 50 to 250 mg/L provide effective treatment and protect fish from lethal doses of copper. Copper sulfate is a contact herbicide, therefore, direct exposure of the algae to the compound is required. Copper sulfate has a fairly short active period and is quickly absorbed into the sediment. Over time a build up of copper can occur in the sediment. Copper is toxic to invertebrates, which are aquatic bugs that live in the sediment. This can cause a disruption in the food chain from the bottom up resulting in a reduction in growth rates in the fish community.

Herbicide Terms You Should Know

Non-selective: A herbicide that controls many different types of plant species.

Selective: A herbicide that is effective at controlling some species but not the others

Contact: Herbicides that affect only the tissues that come into contact with.

Systemic: Herbicides that are translocated, or moved, throughout the plant.

Aquatic herbicides (Fluoridone/Sonar)

Sonar™ is a broad spectrum herbicide used to reduce the populations of a variety of submerged, emergent , and floating plants. Sonar is absorbed through the leaves and shoots and from the soil through the roots. Sonar is a photosynthetic inhibitor, the application blocks the light reactions of photosynthesis where plants convert the energy from sunlight into food. Depending on conditions symptoms of the treatment can be observed 7-10 days after treatment. Leaves will appear pale green, yellow, or yellow-white in color. Sonar was applied in the early season on Wateford Lake to treat Curlyleaf Pondweed. An early season plant survey should be conducted to determine the need for a whole lake sonar treatment, or if spot treatment could be applicable.

AQUATIC PLANT MANAGEMENT OPTIONS

Aquatic plants are essential for maintaining a balanced, healthy lake, but sometimes plants can create a nuisance for recreation, lake aesthetics, and invasive plant species can outcompete native plant species. Aquatic plant management is both controlling undesirable species while encouraging desirable species in important habitat areas. For Waterford Lake there has been heavy chemical control for plants and algae. The main types of plant control include: mechanical harvesting, manual harvesting, and herbicides. Mechanical harvesting involves the use of specially designed machines that cut and remove plant material from a lake. Harvesting only reduces the height of aquatic plants in the water column. Manual or hand harvesting is the most environmentally friendly is best for small scale operations. The most common control tool in aquatic plant management is the use of herbicides registered by the U.S. environmental Protection Agency. Below is a table that briefly summarizes some pros and cons of the different aquatic plant management techniques. This is not a comprehensive list and should only be used as a guide to understanding different management options available.

Management Options	Pros	Cons
Mechanical	Cost competitive with chemical controls	Undesirable plants may fragment, spread and colonize new areas
	Removes nutrients from the lake but may be minimal compared	Desirable plants such as pondweeds may be suppressed
	Removes organic material from the lake	Limited operation in shallow water and around docks and rafts
	May provide some selective con-	Machine breakdowns can disrupt
		Drifting plant fragments may accu-mulate at nuisance levels in quiet
Hand Harvesting	Low Cost	Lab intensive
	Excellent control in small areas	Not suitable for large areas
	Low environmental impact	
Herbicides	Costs are reasonable in many situa-tions	Involves the introduction of pesti-cides into shared water resources
	Range of products and combina-tions available provides flexibility	Potential for misuse
	Some products are highly selective for nuisance species	May contribute to the buildup of organic material
	Can provide complete control of plants for swimming beaches	Algal blooms are possible following large herbicide treatments
		Fish kills may occur with misuse of certain products
		Large treatments may encourage shifts in plant communities
		Water use restrictions may be need to be imposed
		Does not address the cause of cultural eutrophication

AQUATIC PLANT RESTORATION

The Village of Lindenhurst owns and manages Waterford Lake making restoration activities more feasible. Aquatic plant restoration is a relatively inexpensive restoration activity that can increase aquatic plant diversity, stabilize bottom sediments, and outcompete with algae for nutrients. Some aquatic plants are more easily transplanted than others. In Lake County, there has been success with transplanting American Pondweed, Vallisneria, and White Water Lily. Potential location for restoration activities could be the Highpoint Drive shoreline. Previous shoreline restoration work as taken place and extending this for aquatic plants can provide a good demonstration site. Minimizing the treatment of native pondweeds is also crucial to allow native plants to grow.

Figure 18: *Example of transplanted plant enclosure*

FISHERIES/FISHING

Waterford Lake is located entirely within the village limits of Lindenhurst and is almost completely private, with the exception of two access points open to Lindenhurst residents. The lake is used for non-gas motor boating and fishing and managed by the Lindenhurst Lakes Commission (LLC). The village of Lindenhurst has passed several ordinances to protect the Waterford Lake fishery. The two ordinances that further restrict Illinois anglers are the use of live bait fish and the catch and release of game fish species. The village encourages the use of barbless hooks to promote release of the fish with minimal hook damage. The Village of Lindenhurst supplements the fish populations in Waterford Lake based on IDNR and LLC recommendations to maintain a balanced fish community. IDNR conducted a fish survey in 2013 on Waterford. Since 2010, a few stocking efforts have continued including muskie stocking in 2013, channel catfish stocking in 2015 and channel catfish stocking in October of 2017. In 2017, Channel Catfish stocking occurred in all the Lindenhurst Lakes totaling about 400 lbs between the lakes. Waterford had approximately 228 lbs of catfish added. Channel catfish are catch and release only.

Figure 19: *2013 Muskie stocking*

Figure 19: *2017 Channel Catfish stocking*

COARSE WOODY DEBRIS

Fish depend on aquatic plants to provide habitat and forage for food and most freshwater fish rely on aquatic plants at some point during their life stage. The plant composition and density can play an important role in the nesting, growth, and foraging success of these fish. While many fish require some aquatic vegetation for growth, excessive amounts of aquatic vegetation can negatively impact growth by reducing foraging success. The parameters of an ideal fish habitat change base on the size and species of fish, the type of lake, structures present in the lake and many other factors. An example of in-lake fish habitat that would be beneficial in Waterford Lake is coarse woody habitat (CWH) or large woody debris (LWD). CWH often happens naturally as trees or large branches fall into the lake and this creates food, shelter, and breeding areas for aquatic insects, fish, turtles, and waterfowl.

Bluegills and young of the year game fish often seek shelter in and around CWH. Larger logs with branching limbs provide shade and protection for the smaller fish. Black Bass species (smallmouth and largemouth) often build spawning nests in proximity to CWH, particularly large logs.

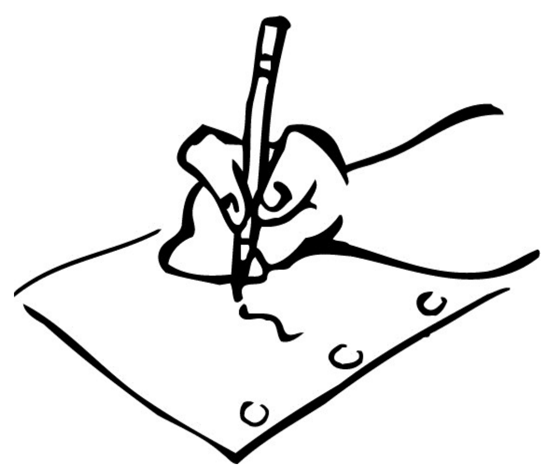
LAKE MANAGEMENT PLANS

It is recommended that a long term Lake Management Plans be developed to effectively manage lake issues. Lindenhurst Lakes Commission can have a lake management plan for all lakes within their jurisdiction. All stakeholders should participate in the development of the plan and include homeowners, recreational users, lake management associations, park districts, townships or any other entity involved in managing Waterford Lake. Lake Management plans should educate the public about specific lake issues, provide a concise assessment of the problem, outline methods and techniques that will be employed to control the problems and clearly define the goals of the program. Mechanisms for monitoring and evaluation should be developed as well and information gathered during these efforts should be used to implement management efforts (Biology and Control of Aquatic Plants, Gettys et al., 2009).

What are the steps in creating a Lake Management Plan?

1. **Getting Started**: Identify lake stakeholders and communication pathways
2. **Setting Goals:** Getting the effort organized, identifying problems to be addressed, and agreeing on the goals
3. **Problem Assessment & Analysis**: collecting baseline information to define the past and existing conditions. Synthesize the information, quantifying and comparing the current conditions to desired conditions, researching opportunities and constraints and setting direction to achieve goals.
4. **Alternatives:** List all possible management alternatives and evaluate their strengths, weakness, and general feasibility.
5. **Recommendations:** Prioritize management options, setting objectives and drafting the plan
6. **Project Management:** Management of assets, detailed records of expenses and time
7. **Implementation:** adopting the plan, lining up funding, and scheduling activities for taking action to achieve goals.
8. **Monitor & Modify:** Develop a mechanism for tracking activities and adjusting the plan as it evolves.

Follow these steps when getting started with writing Lake Management Plans. While each step is necessary, the level of effort and detail for each step will vary depending on the project's goals, size of the lake, and number of stakeholders.



LAKE RECOMMENDATIONS

Waterford Lake's management is administered by the Village of Lindenhurst's Lakes Commission. To improve overall quality of Waterford Lake, the LCHD-ES has the following recommendations:

- Develop a Lake Management Plan for the Waterford Lake and the other lakes within the Village of Lindenhurst. A key component to this plan should focus on aquatic plant management.
- Focus on restoration of beneficial native aquatic plants. Restoration can include Vallisneria and Water Stargrass as they are already present in Waterford Lake. Introducing American Pondweed or White Water Lily's can increase the plant diversity in Waterford Lake.
- Have an early season Curlyleaf Pondweed aquatic plant survey to determine it's density and population. This will help guide treatment early treatment management decisions.
- It is recommended to not treat native pondweeds. If native pondweeds become significant and restrict boating, for instance in the channel, pathways can be cleared to allow recreational use.
- Increase fish habitat with coarse woody debris or fish structures.
- Establish a designated Volunteer Lake Monitors for Waterford Lake that can commit to twice a month Secchi disk readings.
- Encourage homeowners to incorporate native plants in their landscaping through rain gardens or shoreline buffers.

LakeCounty
Health Department and
Community Health Center

ECOLOGICAL SERVICES

Senior Biologist: Mike Adam

madam@lakecountyil.gov

Population Health Services
500 W. Winchester Road
Libertyville, Illinois 60048-1331

Phone: 847-377-8030
Fax: 847-984-5622

For more information visit us at:

http://www.lakecountyil.gov/Health/want/BeachLakeInfo.htm

Protecting the quality of our lakes is an increasing concern of Lake County residents. Each lake is a valuable resource that must be properly managed if it is to be enjoyed by future generations. To assist with this endeavor, Population Health Environmental Services provides technical expertise essential to the management and protection of Lake County surface waters.

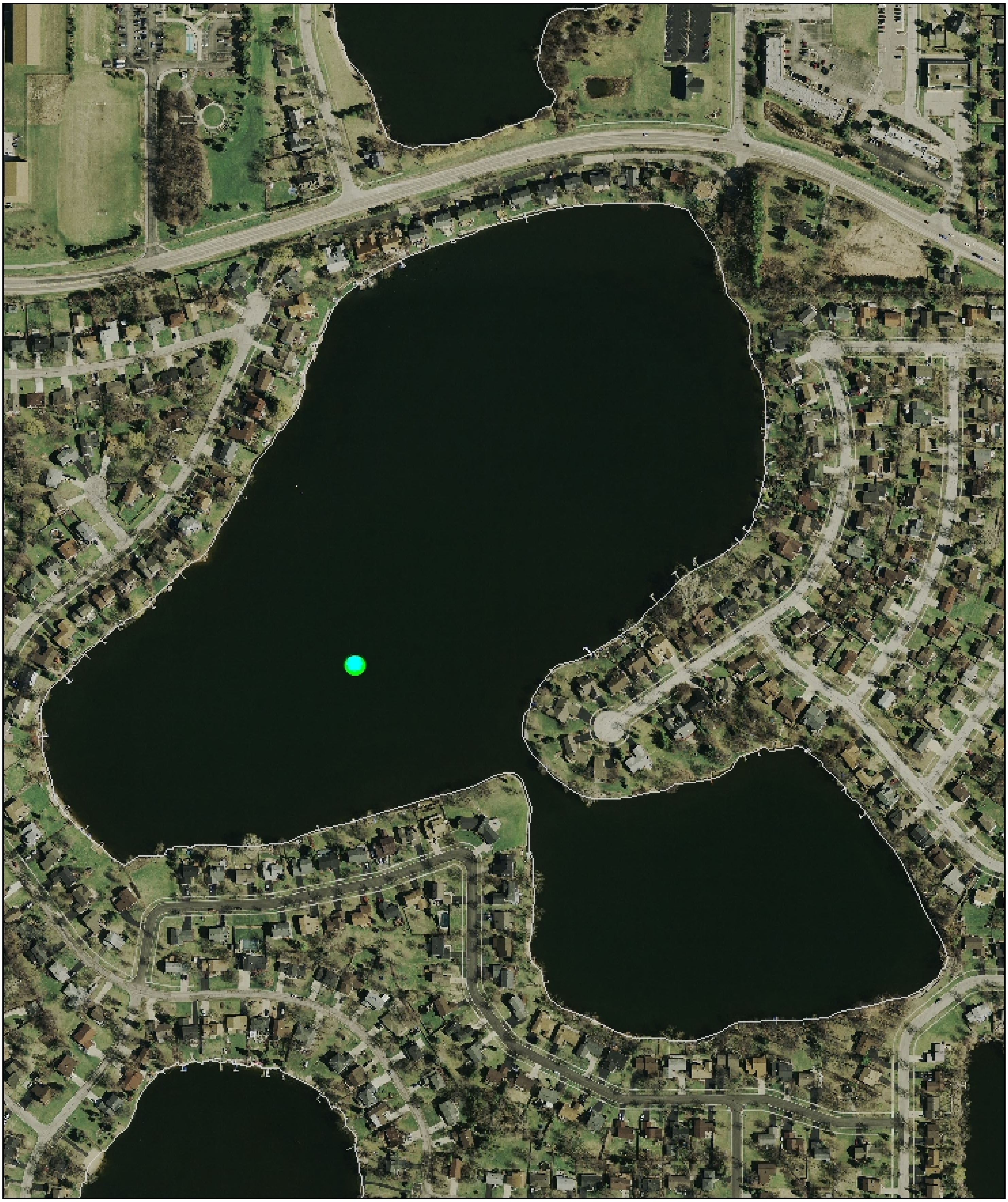
Environmental Service's goal is to monitor the quality of the county's surface water in order to:

- Maintain or improve water quality and alleviate nuisance conditions
- Promote healthy and safe lake conditions
- Protect and improve ecological diversity

Services provided are either of a technical or educational nature and are provided by a professional staff of scientists to government agencies (county, township and municipal), lake property owners' associations and private individuals on all bodies of water within Lake County.

Appendix A:
Figures

Waterford Water Quality Sampling Location



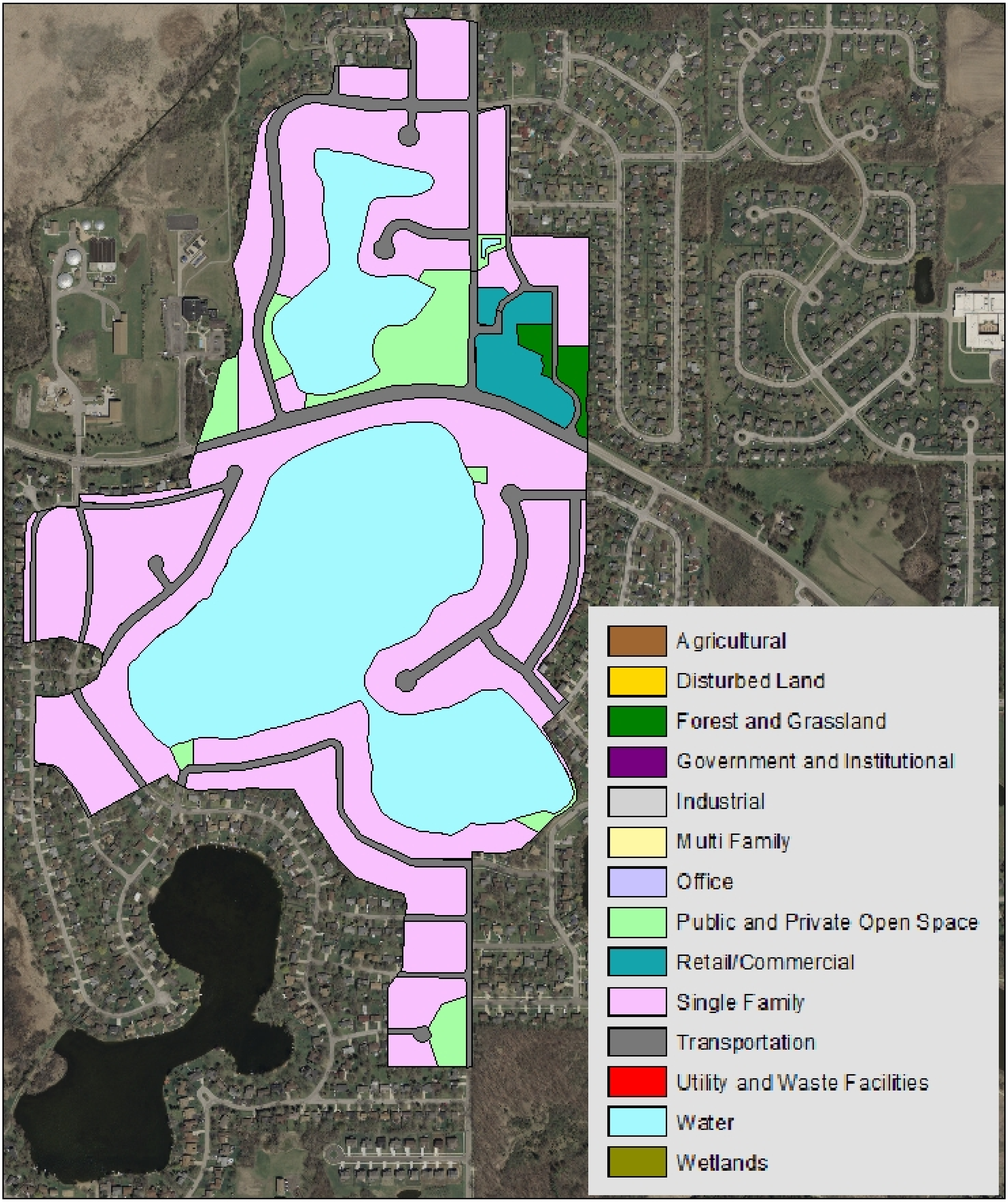
LakeCounty Health Department and Community Health Center

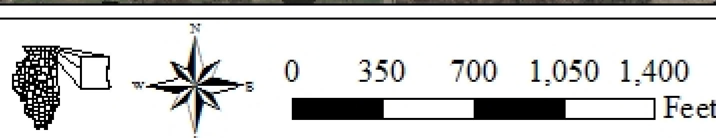
0 170 340 510 680 Feet

Ecological Services
Product Number WTF17
Revised 05/2017

Waterford Lake Watershed Boundary

Waterford Lake Landuse 2017

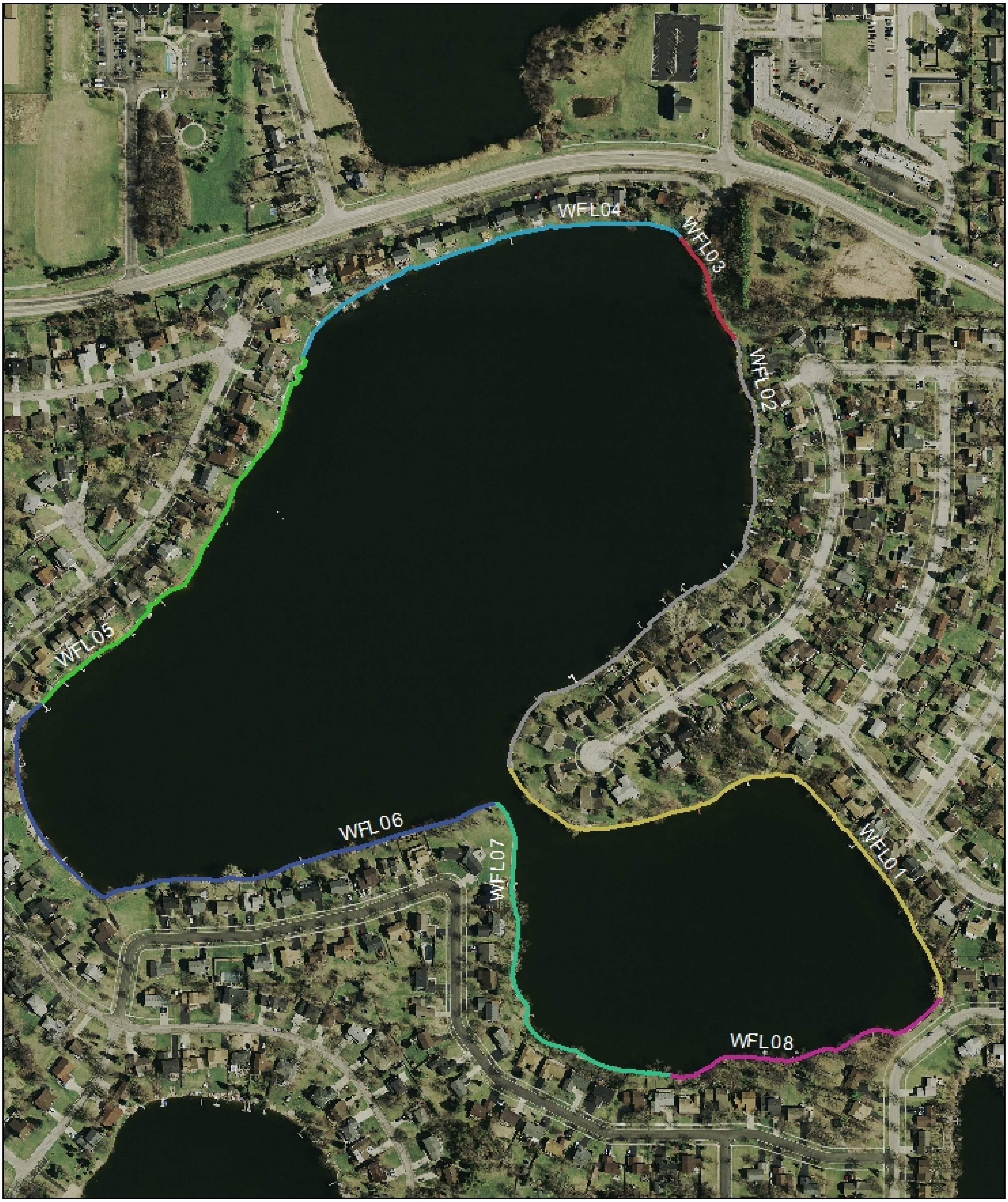




LakeCounty
Health Department and Community Health Center

Ecological Services
Product Number WFL17
Revised 11/2017

Waterford Shoreline Reaches 2017



Ecological Services
Product Number W17
Revised 05/2017

Waterford Shoreline Erosion, 2017

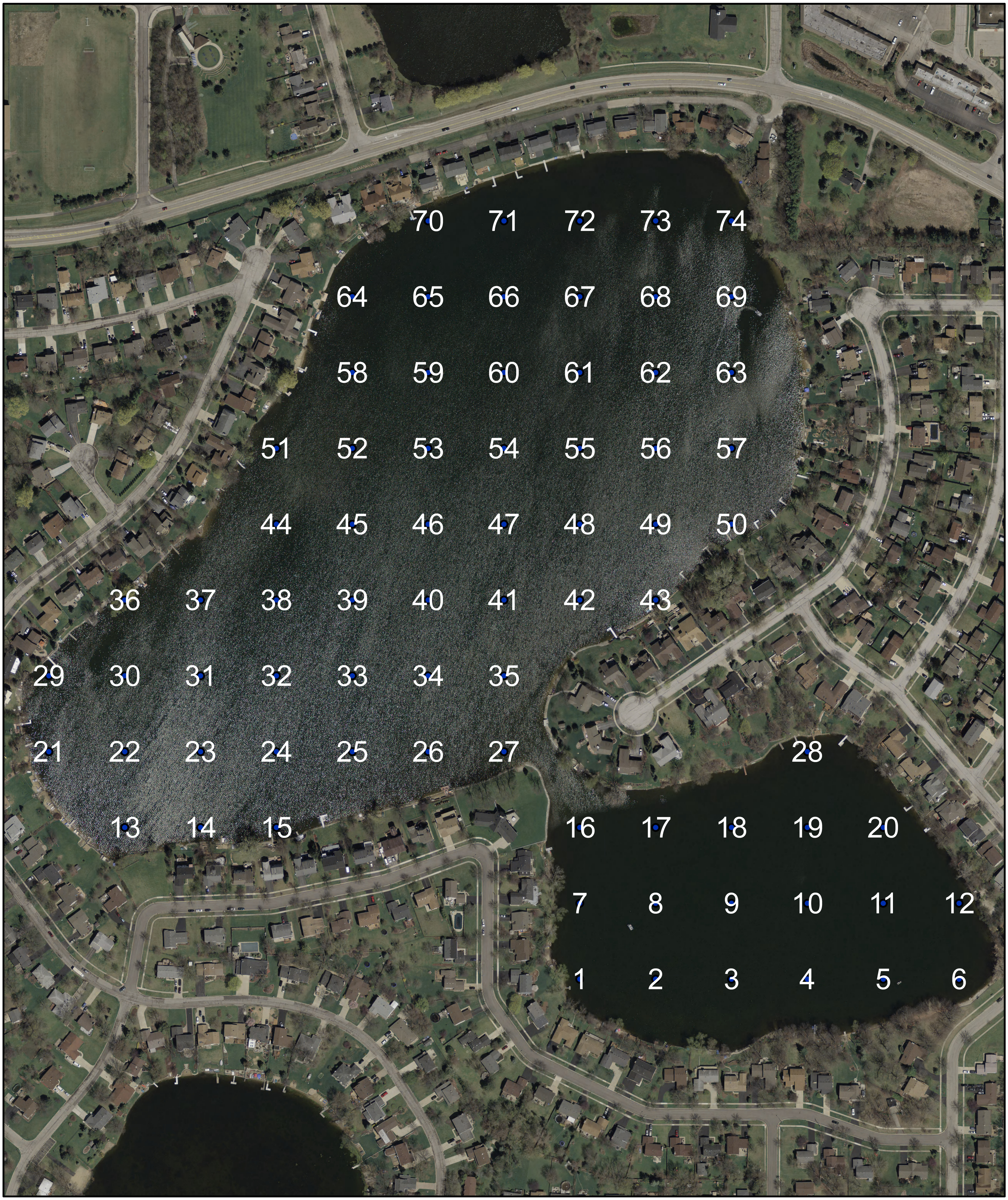
LakeCounty Health Department and Community Health Center

0 200 400 600 800 Feet

Ecological Services
Product Number WFD17
Revised 10/2017

Waterford Shoreline Buffer, 2017

Waterford Plant Grid 2017



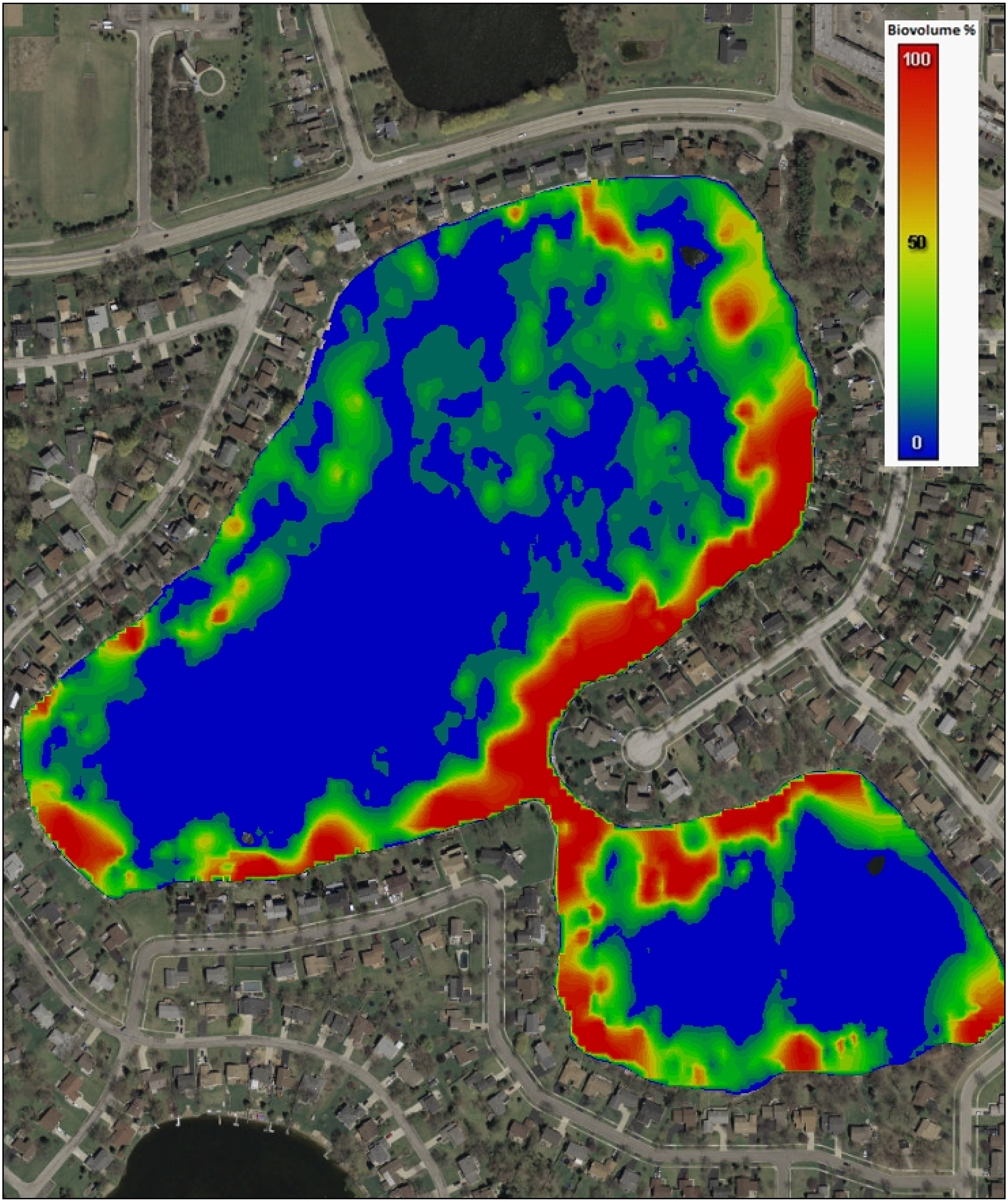
LakeCounty
Health Department and
Community Health Center

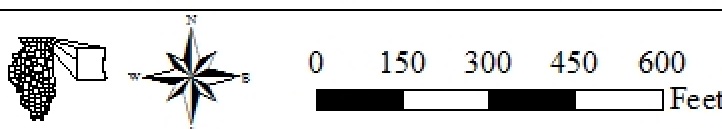
N W E S

0 160 320 480 640 Feet

Ecological Services
Product Number SGH16
Revised 05/2017

Waterford Plant Biovolume, August 2017

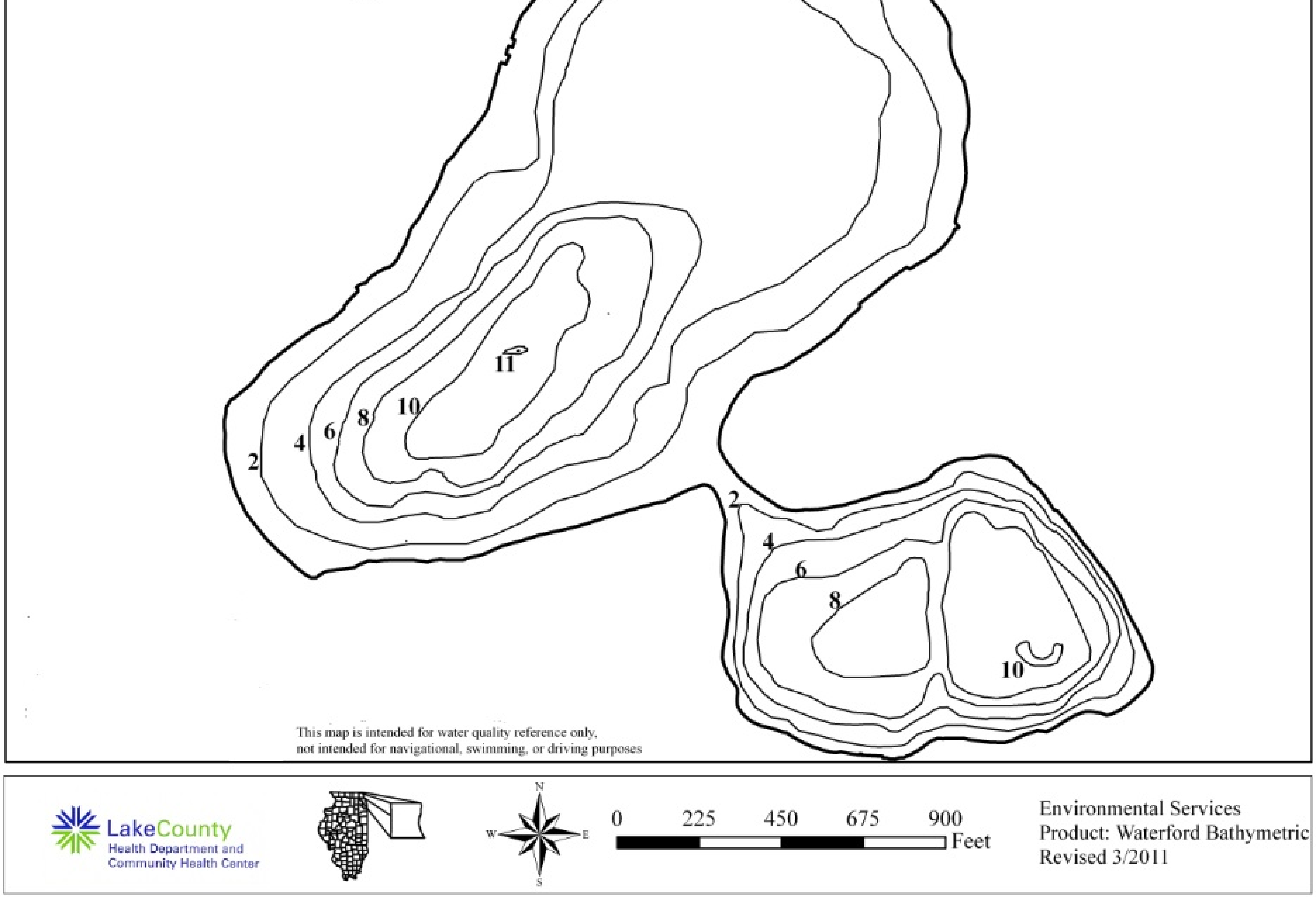




LakeCounty
Health Department and Community Health Center

Ecological Services
Product Number WTD17
Revised 01/2018

Bathymetric Map of Waterford Lake, Lake County, IL



Appendix B:
Tables

Waterford Lake Water Quality Summary Data
2000, 2006, 2010, 2017

2017	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	3	148	0.58	<0.1	<0.05	0.030	<0.005	170	477	2.9	508	71	7.80	0.8540	8.40	9.70
13-Jun	3	156	0.65	<0.1	<0.05	0.027	<0.005	174	501	1.6	546	96	9.75	0.9020	8.28	7.84
11-Jul	3	124	0.72	NA	<0.05	0.014	<0.005	167	439	1.5	466	73	9.70	0.7786	8.79	8.42
15-Aug	3	104	1.39	<0.1	<0.05	0.055	0.011	140	378	7.2	378	58	2.85	0.6564	9.24	11.33
12-Sep	3	114	2.28	<0.1	<0.05	0.108	<0.005	149	391	5.8	425	102	0.45	0.6840	9.09	9.37
	Average	129	1.12	<0.1	<0.05	0.047	0.006[k]	160	437	3.8	465	80	6.11	0.7750	8.76	9.33

2010	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
18-May	3	153	0.68	<0.1	<0.05	0.022	<0.005	177	NA	2.3	496	86	6.45	0.8730	8.53	11.63
15-Jun	3	150	0.80	<0.1	0.24	0.029	<0.005	176	NA	2.4	486	72	6.40	0.8750	8.32	6.87
20-Jul	3	143	0.98	<0.1	0.06	0.050	<0.005	179	NA	4.6	500	84	5.12	0.8880	8.38	5.58
17-Aug	3	128	0.92	<0.1	<0.05	0.057	<0.005	171	NA	4.8	452	75	2.30	0.8020	8.34	5.33
20-Sep	3	138	0.89	<0.1	<0.05	0.041	<0.005	174	NA	5.2	465	81	3.22	0.8300	8.02	7.16
	Average	142	0.85	<0.1[k]	0.09[k]	0.040	<0.005[k]	175	NA	3.9	480	80	4.70	0.8536	8.32	7.31

2006	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	168	1.07	0.1	0.05	0.027	<0.005	259	NA	2.7	626	85	5.90	1.1460	8.23	10.88
21-Jun	3	166	1.33	0.1	<0.05	0.077	<0.005	260	NA	9.4	650	110	3.11	1.1890	8.13	6.77
19-Jul	3	169	1.98	<0.1	<0.05	0.071	<0.005	269	NA	16.0	688	113	2.13	1.2330	7.79	6.43
16-Aug	3	169	1.58	<0.1	<0.05	0.068	<0.005	285	NA	16.0	704	110	1.97	1.2520	8.64	7.80
20-Sep	3	157	1.65	<0.1	<0.05	0.062	<0.005	279	NA	16.0	659	107	2.13	1.1910	8.65	9.22
	Average	166	1.52	0.1[k]	0.05[k]	0.061	<0.005	270	NA	12.0	665	105	3.05	1.2022	8.29	8.22

2000	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
1-May	3	136	1.77	<0.1	<0.05	0.037	<0.005	NA	550	5.8	580	110	3.77	0.9778	8.96	12.28
5-Jun	3	105	1.20	<0.1	0.09	0.029	<0.005	NA	476	1.0	508	101	0[a]	0.8618	9.05	7.54
10-Jul	3	97.2	0.79	<0.1	0.06	0.037	0.005	NA	430	2.0	465	88	0[a]	0.7784	8.89	8.66
7-Aug	3	93.5	1.20	<0.1	<0.05	0.015	<0.005	NA	422	2.0	439	81	9.00	0.7715	8.92	8.06
5-Sep	3	98.2	1.03	<0.1	<0.05	0.041	0.007	NA	438	2.7	474	93	0[a]	0.7978	9.17	7.44
	Average	106	1.20	<0.1[k]	0.08[k]	0.032	0.006[k]	NA	463	2.7	493	95	6.4[b]	0.8375	9.00	8.80

Waterford Lake Water Quality Summary Data
2000, 2006, 2010, 2017

2017	**Hypolimnion**																
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	8.5	149	0.59	<0.1	<0.05	0.041	<0.005	167	477	43.3	548	109	NA	0.8550	8.37	10.23
13-Jun	8.5	156	0.726	<0.1	<0.06	0.033	<0.005	176	502	2.4	536	89	NA	0.9030	8.17	6.77
11-Jul	8	124	0.699	NA	<0.07	0.028	0.0057	165	442	1.8	457	65	NA	0.7849	8.73	7.84
15-Aug	8	105	1.07	<0.1	<0.08	0.049	0.0092	144	381	8.9	379	54	NA	0.6635	8.55	2.80
12-Sep	8	113	NA	<0.1	<0.09	0.137	<0.005	148	393	5.3	420	78	NA	0.6865	8.55	2.31
	Average	129	0.77	<0.1	<0.10	0.058	0.006[k]	160	439	12	468	79	NA	0.7786	8.47	5.99

2010	**Hypolimnion**																
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
18-May	10	153	0.73	<0.1	<0.05	0.031	<0.005	173	NA	2.3	496	86	NA	0.8730	8.54	11.56
15-Jun	9	151	1.64	0.1	0.05	0.027	<0.005	176	NA	3.4	497	81	NA	0.8780	8.26	6.01
20-Jul	10	148	1.12	0.3	0.14	0.136	0.038	178	NA	6.6	498	83	NA	0.8880	8.29	4.09
17-Aug	10	129	0.87	<0.1	<0.05	0.053	0.009	170	NA	2.8	457	79	NA	0.7990	8.19	4.17
20-Sep	10	135	0.97	0.0	0.00	0.039	<0.005	172	NA	4.8	472	83	NA	0.8300	8.12	6.79
	Average	143	1.07	0.2[k]	0.08[k]	0.057	<0.014	173.8	NA	4.0	484	82	NA	0.8536	8.28	6.52

2006	**Hypolimnion**																
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	8	169	1.22	0.1	0.05	0.040	<0.005	257	NA	3.8	626	83	NA	1.1490	8.10	9.38
21-Jun	8	167	1.32	0.1	<0.05	0.065	<0.005	261	NA	9.6	656	113	NA	1.1900	8.13	6.32
19-Jul	7	167	2.00	0.2	<0.05	0.098	<0.005	267	NA	19.0	672	104	NA	1.2370	7.89	4.15
16-Aug	7	169	1.67	<0.1	<0.05	0.068	<0.005	286	NA	17.0	707	121	NA	1.2540	8.20	4.38
20-Sep	8	157	1.50	<0.1	<0.05	0.060	<0.005	279	NA	16.0	667	112	NA	1.1910	8.68	9.21
	Average	166	1.54	0.1	0.05[k]	0.066	<0.005	270	NA	13.1	666	107	NA	1.2042	8.20	6.69

2000	**Hypolimnion**																
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
1-May	8	136	1.52	<0.1	<0.05	0.041	<0.005	NA	566	6.4	542	154	NA	0.9811	8.96	2.69
5-Jun	9	105	1.18	<0.1	0.06	0.026	<0.005	NA	481	1.1	507	110	NA	0.8622	9.05	7.19
10-Jul	9	97.3	0.99	<0.1	0.05	0.032	<0.005	NA	447	1.7	461	104	NA	0.7791	8.89	5.41
7-Aug	9	94.9	1.10	<0.1	<0.05	0.029	0.01	NA	434	3.3	440	79	NA	0.7760	8.70	0.40
5-Sep	8	98.7	1.00	<0.1	<0.05	0.041	<0.005	NA	444	1.8	481	120	NA	0.7987	9.12	7.43
	Average	106	1.16	<0.1[k]	0.05[k]	0.034	0.01[k]	NA	474	2.9	486	113	NA	0.8394	8.94	4.62

Waterford Lake Water Quality Summary Data
2000, 2006, 2010, 2017

Glossary	
ALK = Alkalinity, mg/L $CaCO_3$	k = Denotes that the actual value is known to be less than the value presented.
TKN = Total Kjeldahl nitrogen, mg/L	NA= Not applicable
NH_3-N = Ammonia nitrogen, mg/L	* = Prior to 2006 only Nitrate was analyzed
NO_3-N = Nitrate + Nitrite nitrogen, mg/L	
NO2+NO3 = Nitrite and Nitrate nitrogen, mg/L	
TP = Total phosphorus, mg/L	
SRP = Soluble reactive phosphorus, mg/L	
Cl^- = Chlorides, mg/L	
TSS = Total suspended solids, mg/L	
TS = Total solids, mg/L	
TVS = Total volatile solids, mg/L	
SECCHI = Secchi disk depth, ft.	
COND = Conductivity, milliSiemens/cm	
DO = Dissolved oxygen, mg/L	

Waterford Lake Multiparameter Data, 2017

Date	Depth	Depth Text	Temp	spCond	DO mg/l	DO Sat	pH	BGA
MM/DD/YYYY	Feet	Feet	°C	mS/cm	mg/L	%	Units	RFU
5/16/2017	0.89	0.5	20.06	0.8557	9.71	110.7	8.55	0.05
5/16/2017	1.05	1.0	20.00	0.8553	9.70	110.5	8.46	0.05
5/16/2017	2.09	2.0	19.95	0.8550	9.70	110.4	8.44	0.05
5/16/2017	3.03	3.0	19.80	0.8554	9.70	110.0	8.41	0.07
5/16/2017	3.02	3.0	19.86	0.8546	9.70	110.2	8.40	0.03
5/16/2017	3.97	4.0	19.68	0.8544	9.74	110.3	8.40	0.03
5/16/2017	5.06	5.0	19.43	0.8532	9.84	110.9	8.39	0.06
5/16/2017	5.04	5.0	19.44	0.8532	9.84	110.8	8.39	0.08
5/16/2017	6.02	6.0	19.35	0.8525	9.90	111.4	8.38	0.09
5/16/2017	7.08	7.0	19.24	0.8529	10.01	112.3	8.36	0.15
5/16/2017	8.00	8.0	19.00	0.8546	10.27	114.7	8.37	0.26
5/16/2017	9.01	9.0	18.49	0.8564	10.19	112.6	8.37	0.18
5/16/2017	10.09	10.0	18.18	0.8570	9.91	108.8	8.36	1.10
5/16/2017	10.98	11.0	18.08	0.8586	9.20	100.8	8.26	0.25

Date	Depth	Depth Text	Temp	spCond	DO mg/l	DO Sat	pH	BGA
MM/DD/YYYY	Feet	Feet	°C	mS/cm	mg/L	%	Units	RFU
6/13/2017	0.41	0.5	26.34	0.9025	7.90	100.8	8.28	-0.02
6/13/2017	1.24	1.0	26.12	0.9026	7.85	99.8	8.31	0.00
6/13/2017	2.23	2.0	26.07	0.9025	7.82	99.3	8.30	-0.01
6/13/2017	3.03	3.0	26.05	0.9023	7.84	99.4	8.28	-0.02
6/13/2017	4.19	4.0	25.91	0.9027	7.78	98.4	8.27	0.00
6/13/2017	4.90	5.0	25.81	0.9022	7.71	97.4	8.26	-0.01
6/13/2017	6.07	6.0	25.68	0.9023	7.77	97.9	8.25	0.00
6/13/2017	7.09	7.0	25.52	0.9033	7.37	92.6	8.23	0.02
6/13/2017	8.18	8.0	25.36	0.9026	7.11	89.1	8.19	-0.02
6/13/2017	9.04	9.0	25.22	0.9033	6.43	80.3	8.16	0.02
6/13/2017	10.05	10.0	24.74	0.9063	4.13	51.2	8.02	0.24
6/13/2017	10.96	11.0	24.55	0.9075	0.70	8.6	7.91	1.40

Waterford Lake Multiparameter Data, 2017

Date	Depth	Depth Text	Temp	spCond	DO mg/l	DO Sat	pH	BGA
MM/DD/YYYY	Feet	Feet	°C	mS/cm	mg/L	%	Units	RFU
7/11/2017	0.40	0.5	26.37	0.7908	8.55	106.3	8.80	0.01
7/11/2017	1.08	1.0	26.35	0.7902	8.54	106.1	8.79	0.01
7/11/2017	2.02	2.0	26.12	0.7894	8.46	104.7	8.79	-0.01
7/11/2017	3.07	3.0	26.07	0.7886	8.42	104.1	8.79	0.00
7/11/2017	4.03	4.0	26.01	0.7881	8.16	100.8	8.76	0.03
7/11/2017	5.01	5.0	25.97	0.7852	7.91	97.7	8.74	0.04
7/11/2017	6.01	6.0	25.94	0.7841	7.92	97.7	8.74	0.04
7/11/2017	7.10	7.0	25.89	0.7838	7.84	96.6	8.73	0.07
7/11/2017	8.11	8.0	25.85	0.7849	7.84	96.5	8.73	0.12
7/11/2017	9.08	9.0	25.83	0.7849	7.74	95.2	8.72	0.07
7/11/2017	10.06	10.0	25.79	0.7838	6.93	85.2	8.64	0.11
7/11/2017	10.99	11.0	25.63	0.7843	3.32	40.8	8.16	0.28

Date	Depth	Depth Text	Temp	spCond	DO mg/l	DO Sat	pH	BGA
	Feet	Feet	°C	mS/cm	mg/L	%	Units	RFU
8/15/2017	0.46	0.5	24.94	0.6565	11.72	141.9	9.27	1.78
8/15/2017	1.11	1.0	24.97	0.6566	11.78	142.8	9.28	1.8
8/15/2017	2.00	2.0	24.71	0.6570	11.64	140.4	9.26	1.89
8/15/2017	3.04	3.0	24.56	0.6564	11.33	136.2	9.24	1.75
8/15/2017	4.11	4.0	24.36	0.6570	10.50	125.8	9.19	1.71
8/15/2017	5.06	5.0	24.19	0.6558	8.66	103.4	9.07	1.54
8/15/2017	6.13	6.0	23.78	0.6581	5.44	64.5	8.82	0.9
8/15/2017	7.09	7.0	23.35	0.6637	3.65	42.9	8.64	0.44
8/15/2017	8.21	8.0	23.20	0.6635	2.80	32.9	8.55	0.34
8/15/2017	9.00	9.0	23.15	0.6642	2.23	26.1	8.47	0.26
8/15/2017	10.00	10.0	23.09	0.6655	1.17	13.6	8.33	0.22
8/15/2017	11.02	11.0	22.95	0.6710	0.21	2.5	8.21	0.34

Waterford Lake Multiparameter Data, 2017

Date	Depth	Depth Text	Temp	spCond	DO mg/l	DO Sat	pH	BGA
MM/DD/YYYY	Feet	Feet	°C	mS/cm	mg/L	%	Units	RFU
9/12/2017	0.40	0.5	20.01	0.6818	13.87	152.8	9.34	19.24
9/12/2017	1.02	1.0	19.54	0.6815	12.55	137.0	9.28	12.74
9/12/2017	2.08	2.0	18.83	0.6843	9.43	101.5	9.12	8.26
9/12/2017	2.97	3.0	18.76	0.6840	9.37	100.8	9.09	6.04
9/12/2017	4.10	4.0	18.57	0.6850	6.18	66.2	8.89	1.91
9/12/2017	5.06	5.0	18.49	0.6849	5.52	59.0	8.82	1.45
9/12/2017	6.18	6.0	18.41	0.6850	4.81	51.4	8.78	1.10
9/12/2017	7.00	7.0	18.35	0.6850	4.10	43.7	8.73	0.83
9/12/2017	8.19	8.0	18.34	0.6865	2.31	24.6	8.55	0.64
9/12/2017	8.98	9.0	18.34	0.6876	1.63	17.4	8.44	0.56
9/12/2017	10.18	10.0	18.34	0.6874	1.68	17.9	8.44	0.69
9/12/2017	10.94	11.0	18.35	0.6766	0.36	3.9	8.08	1.52

2017 Waterford Land Use

Land Use	Acreage	% of Total
Forest and Grassland	2.11	0.9%
Public and Private Open Space	11.87	4.9%
Retail/Commercial	5.81	2.4%
Single Family	113.94	47.2%
Transportation	26.55	11.0%
Water	80.90	33.5%
Total Acres	**241.18**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Forest and Grassland	2.11	0.05	0.3	0.1%
Public and Private Open Space	11.87	0.15	4.9	1.2%
Retail/Commercial	5.81	0.85	13.6	3.4%
Single Family	113.94	0.30	94.0	23.7%
Transportation	26.55	0.85	62.1	15.6%
Water	80.90	1.00	222.5	56.0%
TOTAL	**241.18**		**397.3**	100.0%

Lake volume	**287.26**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.72**	**years**
	263.90	**days**

Waterford Lake Shoreline Erosion Condition, 2017

Reach	No Erosion		Slight Erosion		Moderate Erosion		Severe Erosion		Total	Lateral Recession Rate
	ft.	%	ft.	%	ft.	%	ft.	%	ft	ft/yr
WFL01	1360.8	83%	124.6	8%	72.6	4%	76.1	5%	1634.1	0.03
WFL02	1384.0	90%	153.3	10%	0.0	0%	0.0	0%	1537.3	0.01
WFL03	326.6	100%	0.0	0%	0.0	0%	0.0	0%	326.6	0.01
WFL04	1183.6	100%	0.0	0%	0.0	0%	0.0	0%	1183.6	0.01
WFL05	1017.8	79%	166.2	13%	102.1	8%	0.0	0%	1286.1	0.02
WFL06	1333.2	76%	428.0	24%	0.0	0%	0.0	0%	1761.2	0.01
WFL07	846.4	78%	238.6	22%	0.0	0%	0.0	0%	1085.0	0.01
WFL08	739.4	91%	73.8	9%	0.0	0%	0.0	0%	813.2	0.01
Total	8191.8	85%	1184.5	12%	174.7	2%	76.1	1%	9627.1	0.02

Wateford Lake Shoreline Buffer Condition, 2017

Reach	Good		Fair		Poor		Total
	ft.	%	ft.	%	ft.	%	ft
WFL01	108.8	7%	168.0	10%	1357.3	83%	1634.1
WFL02	0.0	0%	51.4	3%	1485.9	97%	1537.3
WFL03	196.8	60%	38.4	12%	91.4	28%	326.6
WFL04	0.0	0%	0.0	0%	1183.6	100%	1183.6
WFL05	0.0	0%	0.0	0%	1286.1	100%	1286.1
WFL06	0.0	0%	131.2	7%	1630.0	93%	1761.2
WFL07	0.0	0%	94.5	9%	990.5	91%	1085.0
WFL08	178.8	22%	382.2	47%	252.2	31%	813.2
Total	484.4	5%	865.7	9%	8277.0	86%	9627.1

Aquatic plants found at 36 sampling sites on Waterford Lake in August 2016.
The maximum depth that plants were found was 9.6 ft.

Plant Density	Chara	Curlyleaf Pondweed	Duckweed	Sago Pondweed	Watermeal	Water Stargrass
Absent	47	73	74	58	73	71
Present	7	1	0	7	0	2
Common	9	0	0	7	1	1
Abundant	11	0	0	1	0	0
Dominant	0	0	0	1	0	0
% Plant Occurance	36%	1%	0%	22%	1%	4%
Total Sites	74	74	74	74	74	74

* Vallisneria was present although not captured in rakes.

Distribution of Rake Density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	38	51.4%
>0-10%	13	17.6%
10-40%	10	13.5%
40-60%	12	16.2%
60-90%	1	1.4%
>90%	0	0.0%
Total Sites with Plants	36	48.6%
Total # Sites	74	100.0%

Morphometric Features of Waterford Lake ~
Data From the June 7, 2011 Bathymetric Survey, LCHD Environmental Services

Contour (feet)	Area enclosed (acres)	Percent of total acres	Volume (acre-feet)	Depth zone (feet)	Area (acres)	Percent (depth zone to total acres)
0	67.54	100%	65.94	0 - 1	3.20	4.7%
1	64.34	95%	62.68	1 - 2	3.31	4.9%
2	61.04	90%	59.18	2 - 3	3.70	5.5%
3	57.34	85%	54.72	3 - 4	5.20	7.7%
4	52.15	77%	48.28	4 - 5	7.63	11.3%
5	44.51	66%	39.89	5 - 6	9.08	13.4%
6	35.44	52%	29.33	6 - 7	11.81	17.5%
7	23.62	35%	21.36	7 - 8	4.45	6.6%
8	19.17	28%	17.55	8 - 9	3.19	4.7%
9	15.98	24%	13.92	9 - 10	4.01	5.9%
10	11.97	18%	8.31	10 - 11	6.85	10.1%
11	5.1196	8%	2.61	11 - 12	4.36	6.5%
12	0.7550	1%	0.541	12+	0.76	1.1%
			424.32		67.54	100%

Maximum Depth of Lake: 12.86 feet
Average Depth of Lake: 6.35 feet
Volume of Lake: 423.78 acre-feet

Area of Lake: 67.54 acres
Shoreline Length: 1.82 miles
Water Elevation at 767.25 feet above mean s
Water Elevation of Outlet: 767.29 feet abov

LakeCounty
Health Department and
Community Health Center

Percent (acre-feet to total volume)
15.5%
14.8%
13.9%
12.9%
11.4%
9.4%
6.9%
5.0%
4.1%
3.3%
2.0%
0.6%
0.1%
100%

sea level
e mean sea level

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	37.4	38.9
2	East Loon Lake	34.7	36.1
3	Cranberry Lake	29.7	29.7
4	Deep Lake	29.7	31.2
5	Round Lake Marsh North	29.1	29.9
6	West Loon Lake	27.1	29.5
7	Sullivan Lake	26.9	28.5
8	Bangs Lake	26.2	27.8
9	Little Silver Lake	25.2	26.7
10	Third Lake	25.1	22.5
11	Fourth Lake	24.7	27.1
12	Indpendence Grove	24.4	26.8
13	Sun Lake	24.3	26.1
14	Redwing Slough	24.0	25.8
15	Schreiber Lake	23.9	24.8
16	Lakewood Marsh	23.8	24.7
17	Sterling Lake	23.6	25.4
18	Deer Lake	23.5	24.4
19	Round Lake	23.5	25.9
20	Pistakee Lake	23.5	25.2
21	Lake Marie	23.5	25.2
22	Timber Lake (North)	23.2	24.9
23	Lake of the Hollow	23.0	24.8
24	Nippersink Lake (Fox Chain)	22.4	23.2
25	Countryside Glen Lake	21.9	22.8
26	Grass Lake	21.5	22.2
27	Davis Lake	21.4	21.4
28	Lake Catherine	20.8	21.8
29	Cross Lake	20.7	18.7
30	ADID 203	20.5	20.5
31	Broberg Marsh	20.5	21.4
32	McGreal Lake	20.2	22.1
33	Fox Lake	20.2	21.2
34	Honey Lake	20.0	20.0
35	Lake Barrington	19.9	21.8
36	Lake Kathryn	19.6	20.7
37	Druce Lake	19.1	21.8
38	Turner Lake	18.6	21.2
39	Salem Lake	18.5	20.2
40	Duck Lake	18.3	19.2
41	Wooster Lake	18.0	20.1
42	Lake Helen	18.0	18.0
43	Old Oak Lake	18.0	19.1
44	Lake Minear	18.0	20.1
45	Lake Zurich	17.7	18.9
46	Redhead Lake	17.7	18.7
47	Long Lake	17.7	15.8
48	Hendrick Lake	17.7	17.7
49	Rollins Savannah 2	17.7	17.7
50	Grandwood Park Lake	17.2	19.0
51	Seven Acre Lake	17.0	15.5
52	Lake Miltmore	16.8	18.7
53	Petite Lake	16.8	18.7
54	Channel Lake	16.8	18.7
55	Highland Lake	16.7	18.9
56	Almond Marsh	16.3	17.3
57	Owens Lake	16.3	17.3
58	Windward Lake	16.3	17.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
59	Butler Lake	16.1	18.1
60	Grays Lake	16.1	16.1
61	Dunns Lake	15.9	17.0
62	Dog Bone Lake	15.7	15.7
63	Osprey Lake	15.5	17.3
64	Heron Pond	15.1	15.1
65	Ames Pit	15.1	17.6
66	North Churchill Lake	15.0	15.0
67	Forest Lake	14.8	15.9
68	Dog Training Pond	14.7	15.9
69	Summerhill Estates Lake	14.5	15.5
70	Grand Ave Marsh	14.3	16.3
71	Nippersink Lake	14.3	16.3
72	Taylor Lake	14.3	16.3
73	Manning's Slough	14.1	16.3
74	Tower Lake	14.0	14.0
75	Dugdale Lake	14.0	15.1
76	Eagle Lake (S1)	14.0	15.1
77	Spring Lake	14.0	15.2
78	Hastings Lake	14.0	15.1
79	Lake Matthews	13.9	15.5
80	Longview Meadow Lake	13.9	13.9
81	Fischer Lake	13.6	14.7
82	Bishop Lake	13.4	15.0
83	Mary Lee Lake	13.1	15.1
84	Old School Lake	13.1	15.1
85	Waterford Lake	13.1	14.3
86	Crooked Lake	13.0	14.3
87	Lake Tranquility (S1)	12.6	12.6
88	Potomac Lake	12.5	12.5
89	Buffalo Creek Reservoir 1	12.5	11.4
90	Buffalo Creek Reservoir 2	12.5	11.4
91	Rollins Savannah 1	12.5	12.5
92	Stone Quarry Lake	12.5	12.5
93	Kemper Lake 1	12.2	13.4
94	McDonald Lake 1	12.1	12.1
95	Pond-A-Rudy	12.1	12.1
96	Stockholm Lake	12.1	13.5
97	Lake Leo	12.1	14.3
98	Lambs Farm Lake	12.1	14.3
99	Bresen Lake	12.0	13.9
100	Grassy Lake	12.0	12.0
101	Flint Lake Oulet	11.8	13.0
102	Albert Lake	11.5	10.3
103	Rivershire Pond 2	11.5	13.3
104	Hook Lake	11.3	13.4
105	Briarcrest Pond	11.2	12.5
106	Lake Naomi	11.2	12.5
107	Pulaski Pond	11.2	12.5
108	Lake Napa Suwe	11.0	11.0
109	Redwing Marsh	11.0	11.0
110	West Meadow Lake	11.0	11.0
111	Nielsen Pond	10.7	12.0
112	Lake Holloway	10.6	10.6
113	Sylvan Lake	10.6	10.6
114	Echo Lake	10.4	10.4
115	Gages Lake	10.2	12.5
116	College Trail Lake	10.0	10.0

Lake County average Floristic Quality Index (FQI) ranking 2000-2017.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
117	Valley Lake	9.9	9.9
118	Werhane Lake	9.8	12.0
119	Fish Lake	9.6	10.6
120	Lake Carina	9.5	12.5
121	Columbus Park Lake	9.2	9.2
122	Lake Lakeland Estates	9.2	9.2
123	Lake Linden	9.2	9.2
124	Bluff Lake	9.1	11.0
125	Lake Fairfield	9.0	10.4
126	Des Plaines Lake	8.6	9.9
127	Antioch Lake	8.5	8.5
128	Loch Lomond	8.5	8.5
129	Lake Fairview	8.5	6.9
130	Timber Lake (South)	8.5	6.9
131	East Meadow Lake	8.5	8.5
132	South Churchill Lake	8.5	8.5
133	Kemper Lake 2	8.5	9.8
134	Lake Christa	8.5	9.8
135	Lake Farmington	8.5	9.8
136	Lucy Lake	8.5	9.8
137	Lake Louise	8.4	8.4
138	Bittersweet Golf Course #13	8.1	8.1
139	Sand Lake	8.0	10.4
140	Countryside Lake	7.7	11.5
141	Fairfield Marsh	7.5	8.7
142	Lake Eleanor	7.5	8.7
143	Banana Pond	7.5	9.2
144	Slocum Lake	7.1	5.8
145	Lucky Lake	7.0	7.0
146	North Tower Lake	7.0	7.0
147	Lake Forest Pond	6.9	8.5
148	Ozaukee Lake	6.7	8.7
149	Leisure Lake	6.4	9.0
150	Peterson Pond	6.0	8.5
151	Little Bear Lake	5.8	7.5
152	Deer Lake Meadow Lake	5.2	6.4
153	ADID 127	5.0	5.0
154	Island Lake	5.0	5.0
155	Liberty Lake	5.0	5.0
156	Oak Hills Lake	5.0	5.0
157	Slough Lake	5.0	5.0
158	International Mining and Chemical Lake	5.0	7.1
159	Lochanora Lake	5.0	5.0
160	Diamond Lake	3.7	5.5
161	Lake Charles	3.7	5.5
162	Big Bear Lake	3.5	5.0
163	Sand Pond (IDNR)	3.5	5.0
164	Harvey Lake	3.3	5.0
165	Half Day Pit	2.9	5.0
166	White Lake	0.0	0.0
167	McDonald Lake 2	0.0	0.0
168	Hidden Lake	0.0	0.0
169	St. Mary's Lake	0.0	0.0
170	Willow Lake	0.0	0.0
171	Woodland Lake	0.0	0.0
	Mean	**13.7**	**14.7**
	Median	**13.0**	**14.2**

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

RANK	LAKE NAME	TP AVE	TSIp
1	Sterling Lake	0.0110	38.73
2	Lake Carina	0.0110	38.73
3	Indpendence Grove	0.0130	40.38
4	Cedar Lake	0.0130	41.14
5	Druce Lake	0.0140	42.21
6	Windward Lake	0.0160	44.13
7	Lake Minear	0.0164	44.49
8	Sand Pond (IDNR)	0.0165	44.57
9	West Loon	0.0170	45.00
10	Pulaski Pond	0.0180	45.83
11	Ames Pit	0.0190	46.61
12	Banana Pond	0.0200	47.35
13	Gages Lake	0.0200	47.35
14	Lake Kathryn	0.0200	47.35
15	Highland Lake	0.0202	47.49
16	Lake Miltmore	0.0210	48.05
17	Lake Zurich	0.0210	48.05
18	Cross Lake	0.0216	48.46
19	Dog Training Pond	0.0220	48.72
20	Sun Lake	0.0220	48.72
21	Deep Lake	0.0230	49.36
22	Lake of the Hollow	0.0230	49.36
23	Round Lake	0.0230	49.36
24	Stone Quarry Lake	0.0230	49.36
25	Timber Lake (North)	0.0232	49.49
26	Bangs Lake	0.0260	51.13
27	Lake Leo	0.0260	51.13
28	Lake Barrington	0.0270	51.68
29	Cranberry Lake	0.0270	51.68
30	Dugdale Lake	0.0270	51.68
31	Peterson Pond	0.0270	51.68
32	Little Silver Lake	0.0280	52.20
33	Wooster Lake	0.0290	52.71
34	Lambs Farm Lake	0.0310	53.67
35	Old School Lake	0.0310	53.67
36	Grays Lake	0.0310	53.67
37	Harvey Lake	0.0320	54.13
38	Butler Lake	0.0324	54.31
39	Hendrick Lake	0.0340	55.00
40	Fourth Lake	0.0360	55.82
41	Sullivan Lake	0.0370	56.22
42	Sand Lake	0.0380	56.60
43	Third Lake	0.0384	56.77
44	Diamond Lake	0.0390	56.98
45	East Loon	0.0400	57.34
46	Schreiber Lake	0.0400	57.34
47	Hook Lake	0.0410	57.70
48	Lake Tranquility (S1)	0.0412	57.77
49	Lake Linden	0.0420	58.05
50	Nielsen Pond	0.0450	59.04
51	Seven Acre Lake	0.0460	59.36
52	Turner Lake	0.0460	59.36

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

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RANK	LAKE NAME	TP AVE	TSIp
53	Willow Lake	0.0460	59.36
54	Waterford Lake	0.0470	59.67
55	East Meadow Lake	0.0480	59.97
56	Lucky Lake	0.0480	59.97
57	Old Oak Lake	0.0490	60.27
58	College Trail Lake	0.0500	60.56
59	Summerhill Estates Lake	0.0514	60.96
60	West Meadow Lake	0.0530	61.40
61	Lucy Lake	0.0550	61.94
62	Lake Christa	0.0580	62.70
63	Owens Lake	0.0580	62.70
64	Briarcrest Pond	0.0580	62.70
65	Honey Lake	0.0586	62.85
66	Crooked Lake	0.0604	63.29
67	Redhead Lake	0.0608	63.38
68	St. Mary's Lake	0.0608	63.38
69	Duck Lake	0.0610	63.43
70	Lake Lakeland Estates	0.0620	63.66
71	Lake Naomi	0.0620	63.66
72	Lake Catherine	0.0620	63.66
73	Liberty Lake	0.0630	63.89
74	North Tower Lake	0.0630	63.89
75	Werhane Lake	0.0630	63.89
76	Countryside Glen Lake	0.0640	64.12
77	Davis Lake	0.0650	64.34
78	Leisure Lake	0.0650	64.34
79	Channel Lake	0.0680	65.00
80	Buffalo Creek Reservoir 1	0.0680	65.00
81	Mary Lee Lake	0.0680	65.00
82	Little Bear Lake	0.0680	65.00
83	Potomac Lake	0.0714	65.70
84	Timber Lake (South)	0.0720	65.82
85	Lake Helen	0.0720	65.82
86	Grandwood Park Lake	0.0720	65.82
87	ADID 203	0.0730	66.02
88	Fish Lake	0.0730	66.02
89	Hastings Lake	0.0746	66.33
90	Broberg Marsh	0.0780	66.97
91	Echo Lake	0.0790	67.16
92	Countryside Lake	0.0800	67.34
93	Lake Nippersink	0.0800	67.34
94	Woodland Lake	0.0800	67.34
95	Redwing Slough	0.0822	67.73
96	Tower Lake	0.0830	67.87
97	Lake Antioch	0.0850	68.21
98	Grand Ave Marsh	0.0870	68.55
99	North Churchill Lake	0.0870	68.55
100	White Lake	0.0874	68.61
101	Pistakee Lake	0.0880	68.71
102	Lake Fairview	0.0890	68.88
103	Rivershire Pond 2	0.0900	69.04
104	South Churchill Lake	0.0900	69.04

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

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RANK	LAKE NAME	TP AVE	TSIp
105	McGreal Lake	0.0910	69.20
106	Lake Charles	0.0930	69.51
107	Deer Lake	0.0940	69.66
108	Eagle Lake (S1)	0.0950	69.82
109	International Mine and Chemical Lake	0.0950	69.82
110	Valley Lake	0.0950	69.82
111	McDonald Lake 1	0.0952	69.85
112	Buffalo Creek Reservoir 2	0.0960	69.97
113	Big Bear Lake	0.0960	69.97
114	Fox Lake	0.1000	70.56
115	Nippersink Lake - LCFP	0.1000	70.56
116	Sylvan Lake	0.1000	70.56
117	Petite Lake	0.1020	70.84
118	Longview Meadow Lake	0.1020	70.84
119	Lake Marie	0.1030	70.98
120	McDonald Lake 2	0.1050	71.26
121	Dunn's Lake	0.1070	71.53
122	Lake Forest Pond	0.1070	71.53
123	Long Lake	0.1070	71.53
124	Grass Lake	0.1090	71.80
125	Des Plaines Lake	0.1090	71.80
126	Spring Lake	0.1100	71.93
127	Kemper 2	0.1100	71.93
128	Bittersweet Golf Course #13	0.1100	71.93
129	Osprey Lake	0.1110	72.06
130	Bluff Lake	0.1120	72.19
131	Middlefork Savannah Outlet 1	0.1120	72.19
132	Lochanora Lake	0.1120	72.19
133	Round Lake Marsh North	0.1130	72.32
134	Deer Lake Meadow Lake	0.1160	72.70
135	Lake Matthews	0.1180	72.94
136	Taylor Lake	0.1180	72.94
137	Island Lake	0.1210	73.31
138	Columbus Park Lake	0.1230	73.54
139	Lake Holloway	0.1320	74.56
140	Fischer Lake	0.1380	75.20
141	Slocum Lake	0.1500	76.40
142	Lakewood Marsh	0.1510	76.50
143	Pond-A-Rudy	0.1510	76.50
144	Forest Lake	0.1540	76.78
145	Bresen Lake	0.1580	77.15
146	Middlefork Savannah Outlet 2	0.1590	77.24
147	Grassy Lake	0.1610	77.42
148	Salem Lake	0.1650	77.78
149	Half Day Pit	0.1690	78.12
150	Lake Louise	0.1810	79.11
151	Lake Eleanor	0.1810	79.11
152	Lake Farmington	0.1850	79.43
153	ADID 127	0.1890	79.74
154	Lake Napa Suwe	0.1940	80.11
155	Loch Lomond	0.1960	80.26

Lake County average TSI phosphorus (TSIp) ranking 2000-2017

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RANK	LAKE NAME	TP AVE	TSIp
156	Patski Pond	0.1970	80.33
157	Dog Bone Lake	0.1990	80.48
158	Redwing Marsh	0.2070	81.05
159	Stockholm Lake	0.2082	81.13
160	Bishop Lake	0.2160	81.66
161	Ozaukee Lake	0.2200	81.93
162	Kemper 1	0.2220	82.06
163	Hidden Lake	0.2240	82.19
164	Oak Hills Lake	0.2790	85.35
165	Heron Pond	0.2990	86.35
166	Rollins Savannah 1	0.3070	86.73
167	Fairfield Marsh	0.3260	87.60
168	ADID 182	0.3280	87.69
169	Manning's Slough	0.3820	89.88
170	Slough Lake	0.3860	90.03
171	Rasmussen Lake	0.4860	93.36
172	Albert Lake, Site II, outflow	0.4950	93.62
173	Flint Lake Outlet	0.5000	93.76
174	Rollins Savannah 2	0.5870	96.08
175	Almond Marsh	1.9510	113.40
	Average	***0.1107***	***65.7***

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
1	Lake Carina	16.96	36.31
2	Windward Lake	14.28	38.79
3	Sterling Lake	13.84	39.24
4	Cedar Lake	12.55	40.66
5	Druce Lake	12.25	41.00
6	Pulaski Pond	11.69	41.68
7	West Loon Lake	11.55	41.85
8	Lake Zurich	10.40	43.37
9	Indpendence Grove	10.31	43.49
10	Ames Pit	9.97	43.97
11	Third Lake	9.76	44.28
12	Davis Lake	9.65	44.44
13	Harvey Lake	9.47	44.72
14	Little Silver Lake	9.42	44.79
15	Old School Lake	9.40	44.82
16	Lake Kathryn	9.39	44.84
17	Dugdale Lake	9.22	45.10
18	Dog Training Pond	9.04	45.39
19	Banana Pond	8.85	45.69
20	Deep Lake	8.83	45.72
21	Stone Quarry Lake	8.81	45.76
22	Wooster Lake	8.74	45.87
23	Lake of the Hollow	8.74	45.87
24	Cross Lake	8.18	46.83
25	Bangs Lake	8.02	47.11
26	Briarcrest Pond	8.00	47.15
27	Sand Lake	7.48	48.12
28	Sand Pond (IDNR)	7.42	48.23
29	Lake Miltmore	7.35	48.37
30	Lake Leo	7.31	48.45
31	Schreiber Lake	7.25	48.57
32	Nielsen Pond	7.23	48.61
33	Honey Lake	7.17	48.73
34	Lake Minear	7.13	48.81
35	Round Lake	7.01	49.05
36	Highland Lake	6.97	49.14
37	Lake Helen	6.43	50.30
38	Sun Lake	6.33	50.52
39	Lake Barrington	6.12	51.01
40	Waterford Lake	6.11	51.03
41	Timber Lake (North)	6.03	51.22
42	Cranberry Lake	5.94	51.44
43	Lake Fairfield	5.89	51.56
44	Gages Lake	5.45	52.68
45	Owens Lake	5.30	53.08
46	Lake Linden	5.28	53.14
47	Valley Lake	5.05	53.78
48	McGreal Lake	5.04	53.81
49	Old Oak Lake	4.85	54.36
50	Peterson Pond	4.51	55.41
51	Timber Lake (South)	4.46	55.57

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
52	Crooked Lake	4.39	55.79
53	Mary Lee Lake	4.35	55.93
54	Butler Lake	4.35	55.93
55	Deer Lake	4.20	56.45
56	Seven Acre Lake	4.18	56.51
57	Hastings Lake	4.18	56.51
58	Lambs Farm Lake	4.17	56.54
59	Grays Lake	4.08	56.86
60	Lake Naomi	4.05	56.96
61	Hook Lake	3.95	57.32
62	Turner Lake	3.92	57.43
63	Leisure Lake	3.85	57.69
64	Summerhill Estates Lake	3.84	57.73
65	North Tower Lake	3.89	57.74
66	Salem Lake	3.77	58.00
67	Lake Fariview	3.75	58.07
68	Duck Lake	3.71	58.23
69	Countryside Glen Lake	3.64	58.50
70	Fish Lake	3.57	58.78
71	Taylor Lake	3.52	58.99
72	Lochanora	3.52	58.99
73	Bishop Lake	3.47	59.19
74	Lake Lakeland Estates	3.41	59.44
75	Lake Holloway	3.40	59.49
76	Stockholm Lake	3.38	59.57
77	Crooked Lake	3.35	59.70
78	East Loon Lake	3.30	59.92
79	Lucky Lake	3.22	60.27
80	Diamond Lake	3.17	60.50
81	Liberty Lake	3.16	60.54
82	International Mining and Chemical Lake	3.08	60.91
83	Long Lake	3.05	61.05
84	Lake Christa	3.01	61.24
85	Lucy Lake	2.99	61.34
86	Lake Catherine	2.9	61.78
87	St. Mary's Lake	2.79	62.34
88	Channel Lake	2.77	62.44
89	Werhane Lake	2.71	62.76
90	Fischer Lake	2.70	62.81
91	Bresen Lake	2.69	62.86
92	East Meadow Lake	2.61	63.30
93	Buffalo Creek Reservoir 1	2.60	63.35
94	Countryside Lake	2.58	63.46
95	Kemper Lake 1	2.56	63.58
96	Bluff Lake	2.51	63.86
97	Broberg Marsh	2.50	63.92
98	Antioch Lake	2.48	64.03
99	Little Bear Lake	2.38	64.63
100	Island Lake	2.32	65.00
101	Tower Lake	2.31	65.06

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
102	Buffalo Creek Reservoir 2	2.30	65.12
103	Woodland Lake	2.28	65.25
104	Rivershire Pond 2	2.23	65.57
105	Lake Charles	2.20	65.76
106	College Trail Lake	2.18	65.89
107	Loch Lomond	2.17	65.96
108	Redhead Lake	2.16	66.03
109	Pistakee Lake	2.15	66.09
110	Des Plaines Lake	2.14	66.16
111	Echo Lake	2.11	66.36
112	Eagle Lake (S1)	2.10	66.43
113	West Meadow Lake	2.07	66.64
114	Forest Lake	2.04	66.85
115	Grand Ave Marsh	2.03	66.92
116	Columbus Park Lake	2.03	66.92
117	Grassy Lake	2.00	67.14
118	Petite Lake	2	67.14
119	Sylvan Lake	1.98	67.28
120	Bittersweet Golf Course #13	1.98	67.28
121	Spring Lake	1.78	68.82
122	Kemper Lake 2	1.77	68.90
123	Fourth Lake	1.77	68.90
124	Nippersink Lake	1.73	69.23
125	Deer Lake Meadow Lake	1.73	69.23
126	Lake Louise	1.68	69.65
127	Willow Lake	1.63	70.09
128	Slough Lake	1.63	70.09
129	Rasmussen Lake	1.62	70.17
130	Lake Farmington	1.62	70.17
131	Half Day Pit	1.60	70.35
132	Lake Marie	1.56	70.72
133	White Lake	1.53	71.00
134	Longview Meadow Lake	1.51	71.19
135	Lake Matthews	1.48	71.48
136	Big Bear Lake	1.32	73.13
137	Fox Lake	1.28	73.57
138	Dunn's Lake	1.22	74.26
139	Lake Eleanor	1.16	74.99
140	Lake Napa Suwe	1.06	76.29
141	Rollins Savannah 1	1.05	76.43
142	Osprey Lake	1.03	76.70
143	Manning's Slough	1.00	77.13
144	Rollins Savannah 2	0.95	77.87
145	Dog Bone Lake	0.94	78.02
146	Redwing Marsh	0.88	78.97
147	Flint Lake Oulet	0.83	79.82
148	Fairfield Marsh	0.81	80.17
149	Slocum Lake	0.81	80.17
150	Oak Hills Lake	0.79	80.53
151	McDonald Lake 1	0.79	80.53
152	Grass Lake	0.78	80.71

Lake County Secchi Disk Clarity Ranking, 2000-2017.

RANK	LAKE NAME	SECCHI AVE	TSIsd
153	Lake Nippersink	0.77	80.90
154	South Churchill Lake	0.73	81.67
155	Lake Forest Pond	0.71	82.07
156	ADID 127	0.66	83.12
157	North Churchill Lake	0.61	84.26
158	Hidden Lake	0.56	85.54
159	McDonald Lake 2	0.53	86.28
160	Ozaukee Lake	0.51	86.84
	average	***4.22***	***60.74***

Appendix C:
Methods for Field Data Collection and Laboratory Analyses

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were at the deepest point in the lake (see sample site map), three feet below the surface, and 3 feet above the bottom. Samples were collected with a horizontal Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every two feet until reaching the bottom.

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.3) overlaid a grid pattern onto an aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Shoreline Assessment

Shoreline Assessment Protocol

Each lake was divided into reaches in ArcGIS based on nearshore landuse. For each reach, a shoreline assessment worksheet was filled out in the field focusing on shoreline conditions (land use, slope, erosion, buffer, etc) that describe the overall reach segment of the lake.

A GPS Trimble unit was used to collect the degree of shoreline erosion along the entire length of the lake. The degree of shoreline erosion was categorically defined as none, slight, moderate, or severe. Below are brief descriptions of each category.

Table 1: Degree of Shoreline Erosion

Category	Description
None	Includes man-made erosion control such as rip-rap and sea wall.
Slight	Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as "slight". Beaches have been included as "slight" erosion.
Moderate	Recession is characterized by past or recently eroded banks; area may exhibit some exposed roots, fallen vegetation or minor slumping of soil material; erosion control practices may be recommended although the section is not deemed to warrant immediate remedial action.
Severe	Recession is characterized by eroding of exposed soil on nearly vertical banks, exposed roots, fallen vegetation or extensive slumping of bank material, undercutting, washouts or fence posts exhibiting realignment; erosion control practices are recommended and immediate remedial action may be warranted.

Lateral recession rates were calculated on a per reach basis based on the IL EPA stream methodology, defining lateral recession into four main categories (slight, moderate, severe, and very severe). Descriptions of each category are defined in the Table 2.

Table 2: Lateral Recession Rate Categories

Lateral Recession Rate	Description	Description
0.01 – 0.05	Slight	Some bare bank but active erosion not readily apparent. Some rills but no vegetation overhanging. No exposed tree roots.
0.06 – 0.2	Moderate	Bank mostly bare with some rills and vegetation overhanging.
0.3 – 0.5	Severe	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross-section becomes more U-shaped as opposed to V-shaped.
0.5+	Very Severe	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains and culverts eroding out and changes in cultural features as above. Massive slips or washouts common. Channel cross-section is U-shaped and streamcourse or gully may be meandering.

Shoreline Buffer Condition

Lakeshore buffer condition was assessed using a qualitative methodology that considered an area up to 25 feet inland from the shoreline for each reach. The assessment was done by viewing high resolution 2014 aerial images in ArcGIS. A 25 foot buffer was chosen based on research that indicates a 25-foot vegetated buffer is the minimum effective width for in-lake habitat maintenance (a 15 foot buffer is the minimum effective width for bank stability). Criteria used for category assignment are shown in table below.

Table 3: Shoreline Buffer Condition Categories

Category	Criteria	Percentage
Good	Unmowed grasses & forbs + tree trunks + shrubs	≥70%
	and impervious surfaces	≤5%
Fair	Unmowed grasses & forbs + tree trunks + shrubs	≥50% and <70%
	and Impervious surface	≤10%
Poor	Unmowed grasses & forbs +tree trunks + shrubs	<50%
	and Impervious surface	≥50%

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal.
Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

Parameter	*Method*
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate and Nitrite nitrogen	USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L
Ammonia nitrogen	SM 18th ed. Electrode method, #4500 NH_3-F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18th ed, 4500-N_{org} C Semi-Micro Kjeldahl, plus 4500 NH_3-F Detection Limit = 0.5 mg/L
pH	Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method
Total solids	SM 18th ed, Method #2540B
Total suspended solids	SM 18th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18th ed, Method #4500C1-D
Total volatile solids	SM 18th ed, Method #2540E, from total solids
Alkalinity	SM 18th ed, Method #2320B, patentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor

Appendix D:
Interpreting Your Lake's Water Quality Data

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2010 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the ***epilimnion***, while the cold bottom water layer is called the ***hypolimnion***. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. Many of the plants or algae die at the end of the growing season. Their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:

For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2010 was 0.065 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on seven lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2010 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.800 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:

Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2 (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^-, NO_2^-, NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1

suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County was 8.1 mg/L, ranging from below the 0.1 mg/L detection limit to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 123.0 mg/L, ranging from 34.0 mg/L in Pulaski Pond to 298.0 mg/L in Fairfield Marsh.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004. This practice was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations. Since 2004, chloride concentrations data are collected..

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake’s overall water quality. It is affected by a lake’s water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact both plant and fish communities. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The median Secchi depth for Lake County lakes is 2.95 feet. From 2000-2010, both Ozaukee Lake and McDonald Lake #2 had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (23.50 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:
Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^-) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate ($CaCO_3$) or dolomite ($CaMgCO_3$), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.

Conductivity and Chloride:
Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

Since 2004 measurements taken in Lake County lakes have exhibited a trend of increasing salinity measured by chloride concentrations. The median near surface chloride concentration of Lake County Lakes was 142 mg/L. In 2009, Schreiber Lake had the lowest chloride concentration recorded at 2.7 mg/L. The maximum average chloride measurement was at 2760 mg/L at IMC. It is important to note that salt water is denser than fresh water and so it accumulates in the hypolimnion or near the bottom of the lake, this can impact mixing of bottom waters into surface waters in lakes that experience turnover. This phenomenon could have far reaching impacts to an entire ecosystem within a lake. Further, in studies conducted in

Minnesota, chloride concentrations as low as 12 mg/L have been found to impact some species of algae.

pH:

pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life they may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes was 8.37, with a minimum average of 7.07 in Bittersweet #13 Lake and a maximum of 10.40 in Summerhill Estates Lake.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning "well nourished." This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake's natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a "good to bad" categorization, as most lake residents rate their lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	≥40<50	>0.012 ≤ 0.024	≥6.56<13.12
Eutrophic	≥50<70	>0.024 ≤ 0.096	≥1.64<6.56
Hypereutrophic	≥70	>0.096	< 1.64