LAKE COUNTY, IL

2019 LAKE CHARLES SUMMARY REPORT

LAKE COUNTY HEALTH DEPARTMENT

ECOLOGICAL SERVICES

Lake Charles, 2019

Lake Charles is a man-made lake located within the Village of Vernon Hills. The lake has a surface area of 39.4 acres and a maximum depth of 10.0 feet. The Village of Vernon Hills actively manages the lake for non-motorized boating, fishing, irrigation and aesthetics. The western and southern shoreline are next to the White Deer Run Golf course and the eastern shore was deeded to the Vernon Hills Park District in 2003. By 2005, Lake Charles Park was completed with additional development funding from an Illinois Open Space and Land Acquisition Development Grant.

In 2019, the Lake County Health Department - Ecological Services (LCHD-ES) monitored Lake Charles as part of routine water quality sampling. Water samples were collected once a month from May through September at the deepest point in the lake; three feet below the surface (Appendix A). Samples were analyzed for nutrients, solid concentrations and other chemical parameters. Additionally, LCHD-ES conducted an aquatic plant survey in August 2019 and a shoreline assessment in October 2019. As part of the Des Plaines River Watershed Workgroup, inlets were also monitored on Lake Charles.

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LAKE FACTS

MAJOR WATERSHED:

Des Plaines

SUB-WATERSHED:

Indian Creek

SURFACE AREA:

39.41 Acres

SHORELINE LENGTH:

1.03 Miles

MAXIMUM DEPTH:

7.50 Feet

AVERAGE DEPTH:

3.84 Feet

LAKE VOLUME:

144.33 Acre-Feet

WATERSHED AREA:

3529.87.0 Acres

LAKE TYPE:

Impoundment

CURRENT USES:

Fishing, and non-motored boating and aesthetics

ACCESS:

Public Access through Lakes Charles Park

LAKE CHARLES SUMMARY

Following is a summary of the water quality sampling, shoreline survey and aquatic macrophyte survey from the 2019 monitoring season on Lake Charles. Overall water quality is good for Lake Charles and have improved slightly since previous years monitoring. Lake Charles water quality is above average compared to other lakes in Lake County based on water quality parameters. 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 2019 was 2.95 feet. This is a 34% increase since 2012. The 2019 Secchi is below the average Lake County median Secchi depth of 3.02 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 Lake Charles was 6.9 mg/L in 2019, which is below the Lake County median of 7.6 mg/L. TSS have decreased by 54.8% since 2012 from 15.1 mg/L to 6.9 mg/L.

♦ Nutrient availability indicated that Lake Charles is both nitrogen and phosphorus limited with an average TN:TP ratio of 14:1.

♦ In 2019, the average total epilimnion phosphorus concentration was 0.069 mg/L. This is above the Illinois Environmental Protection Agency (IEPA) water quality standard of 0.050 mg/L. While above the IEPA standard, TP concentrations have decreased by 25.8% since the 2012 sampling from 0.093 mg/L to 0.069 mg/L.

♦ Trophic State Index based on 2019 total phosphorus concentrations (TSIp) for Lake Charles is 65.2 meaning Lake Charles is considered eutrophic and nutrient enriched.

♦ The aquatic macrophyte survey showed that 97.9% of all sampling sites had plant coverage on Lake Charles. IDNR recommends 20-40% aquatic plant coverage for a healthy fish habitat.

♦ In 2019, a total of 16 plant species and 1 macro-algae (Chara) were present in Lake Charles. This is an increase in aquatic plant diversity since the 2012 sampling. The Floristic Quality Index (FQI) of Lake Charles went from 9.0 to 21.2

♦ The most dominant aquatic plants in Lake Charles was Coontail found at 85.1% of all sampling sites.

♦ Curlyleaf Pondweed, Eurasian Watermilfoil, and Brittle Naiad are all aquatic invasive plant species found in Lake Charles during the 2019 aquatic macrophyte survey.

♦ Based on the shoreline assessment, 34.2% of Lake Charles had some degree of erosion along the shoreline,.

♦ Based on the shoreline assessment, 27.4% of Lake Charles shoreline had poor buffer.

WATERSHED & LANDUSE

Charles Lake is in the Des Plaines River Watershed. Lake Charles receives water from the Seavey Ditch at the north end of the lake and exits the lake through a concrete spillway at the south end of the lake. Water leaving the Lake Charles flows to Little and Big Bear Lakes, then into Indian Creek and eventually the Des Plaines River. The approximately 3530 acre watershed is mostly large residential areas to the west and north of the lake.

The primary land use within the watershed is Single Family (43.6%) . The next primary land uses are transportation and public and private open space at 17.1% each. 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 Lake Charles are transportation (34.1%), single family (30.6%), and retail/commercial (9.6%)

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.   For example, the land use "water" 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 contribute pollutants at a lower quantity than other land uses in urbanized areas. On the other hand, landuses such as transportation and other impervious surfaces, contain higher pollutants that are carried to the lake by runoff. In Lake Charles, most pollutants are likely a result of the single family home and transportation land uses.

> Lake Charles is in the Indian Creek subwatershed of the Des Plaines River Watershed

Figure 1: *Lake Charles 2019 Land Use and Watershed Boundary*
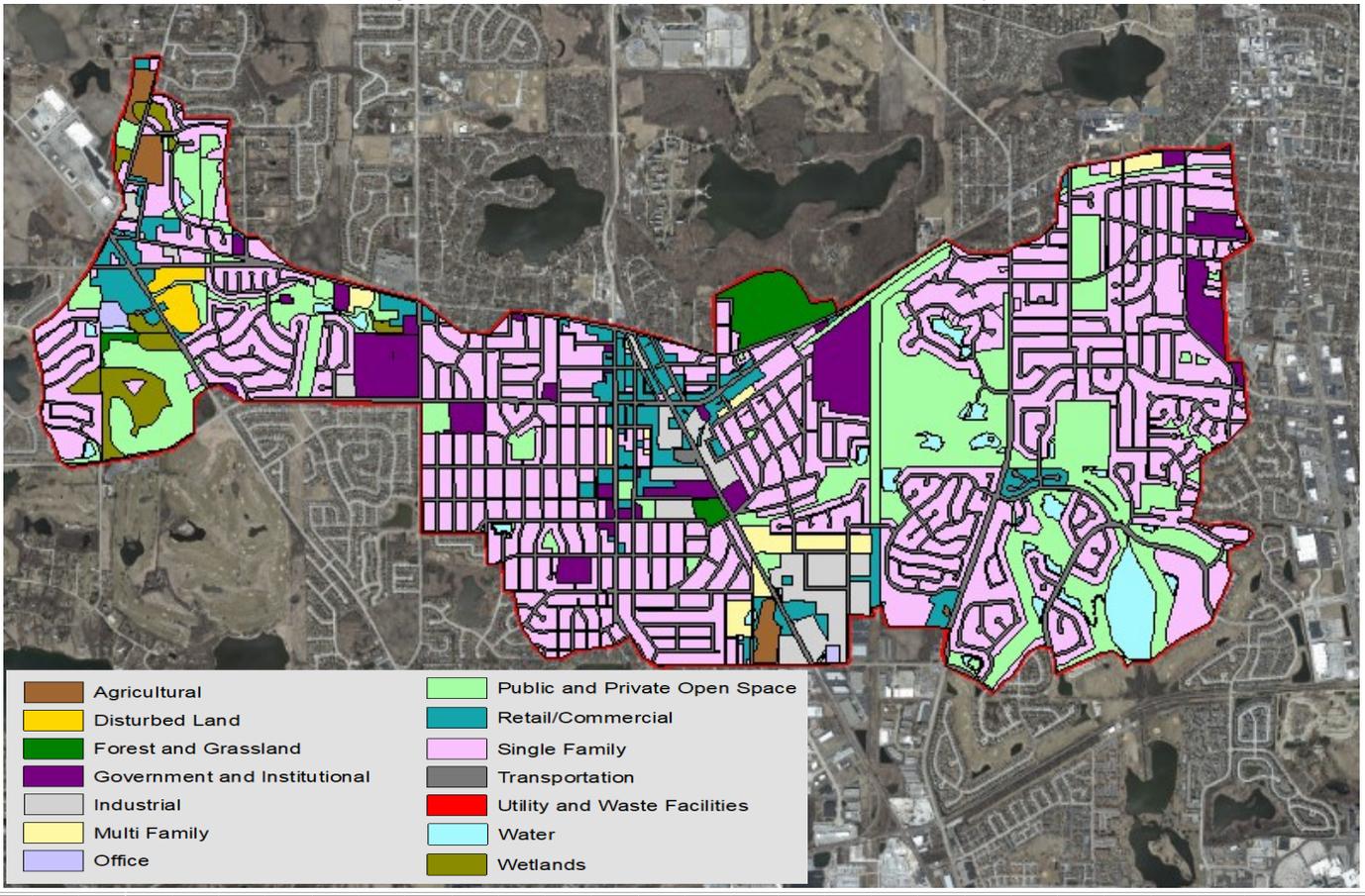
WATER CLARITY

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 2019 average water clarity for Lake Charles based on Secchi depth was 2.95 feet (Figure 2). This is a 34% increase since the 2012 water quality sampling, which had a Secchi depth of 2.20 feet. Water clarity is below the Lake County average (3.02 ft). July had the deepest Secchi depth rating at 4.00 feet and September was the least clear with a secchi depth of 2.31 feet.

Total Suspended solids also impacts water clarity and secchi depth and total suspended solids are inversely related (Figure 3).

Lake Charles average Secchi depth was 2.95 ft., which is above the Lake County median Secchi depth of 3.02 ft.

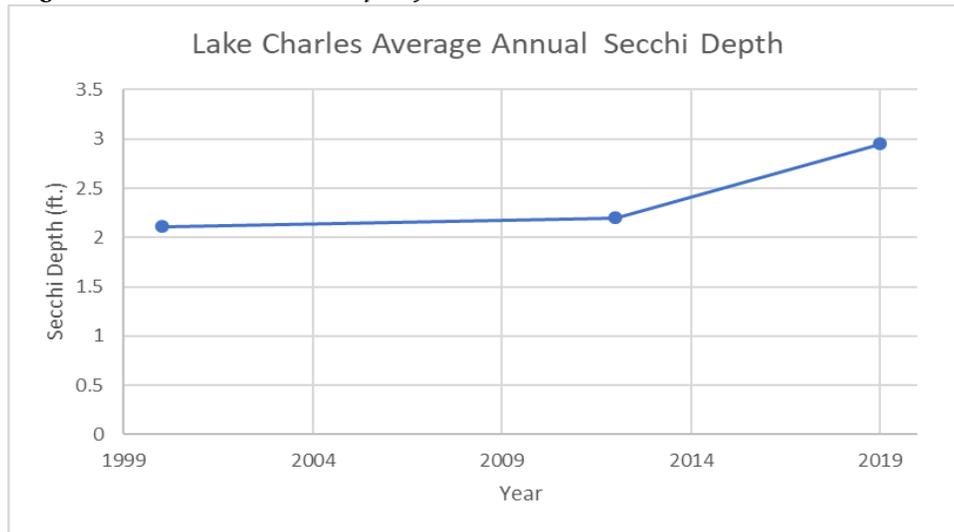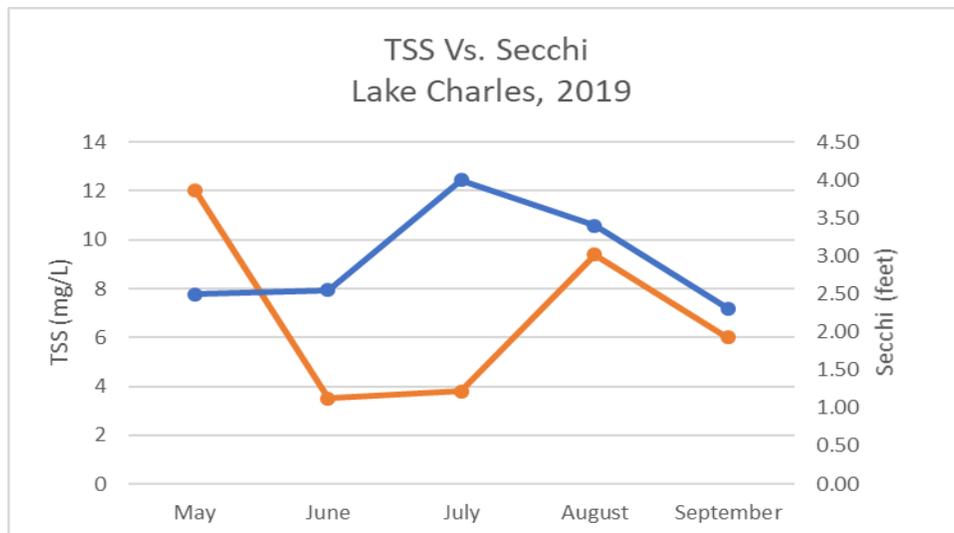**Figure 2:** *Lake Charles Secchi depth by Year*

Figure 3: *Total suspended solids (TSS) vs. Secchi Depth on Lake Charles for 2019*

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.

In 2019, TSS concentrations in the epilimnion of Lake Charles averaged 6.9 mg/L, which is below the Lake County median of 7.6 mg/L. It is a 54.8% decrease since the 2012 sampling (15.1 mg/L), see Figure 4. Decrease in TSS is likely a result of increased aquatic plant density around the lake. 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 2019, the median surface NVSS was 4.6 mg/L, therefor there is no TSS impairment on Lake Charles.

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. In general, Lake Charles seemed to have higher percentages of TSS, which makes sense since it is a flow through system. During heavy rains the inlet on north side of the lake carried high TSS and was visibly murky in color. For a list of TSS, TS, and TVS for Lake Charles, refer to Table 2.

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.

Figure 4: *Total Suspended Solid Concentrations by Year, Lake Charles*
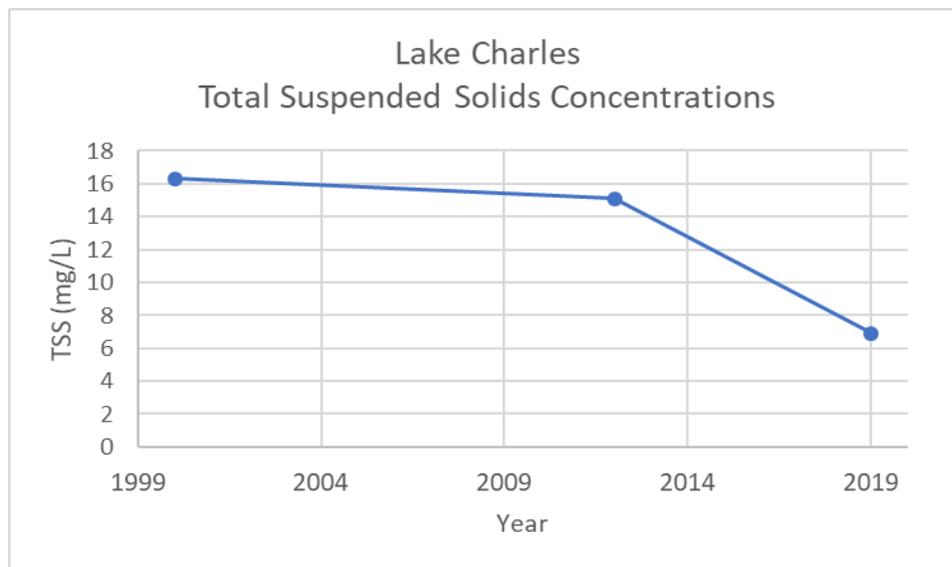
Table 2: 2019 Epilimnion solid concentrations in mg/L on Lake Charles

DATE	TSS	TS	TVS
5/14/2019	12.0	511	89
6/11/2019	3.5	565	114
7/16/2019	3.8	488	107
8/13/2019	9.4	464	121
9/17/2019	6.0	291	52
Average	*6.9*	*464*	*97*

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 within 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 Lake Charles was 0.069 mg/L for 2019 which is a 25.8% decrease since the 2012 sampling (0.093 mg/L). Total phosphorus concentrations are above the Illinois EPA water quality standard making Lake Charles impaired for phosphorus. August had the highest total phosphorus concentration of 0.112 mg/L .

While TP concentrations are a better overall indicator of a lake's nutrient status because it's concentrations remains more stable than other forms of phosphorus in the water column, soluble reactive phosphorus (SRP) is another parameter included in the water chemistry analysis. 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 Lake Charles, there are elevated SRP concentrations July—September.

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

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.

Figure 5: *Phosphorus Concentrations in Lake Charles monitored by LCHD*
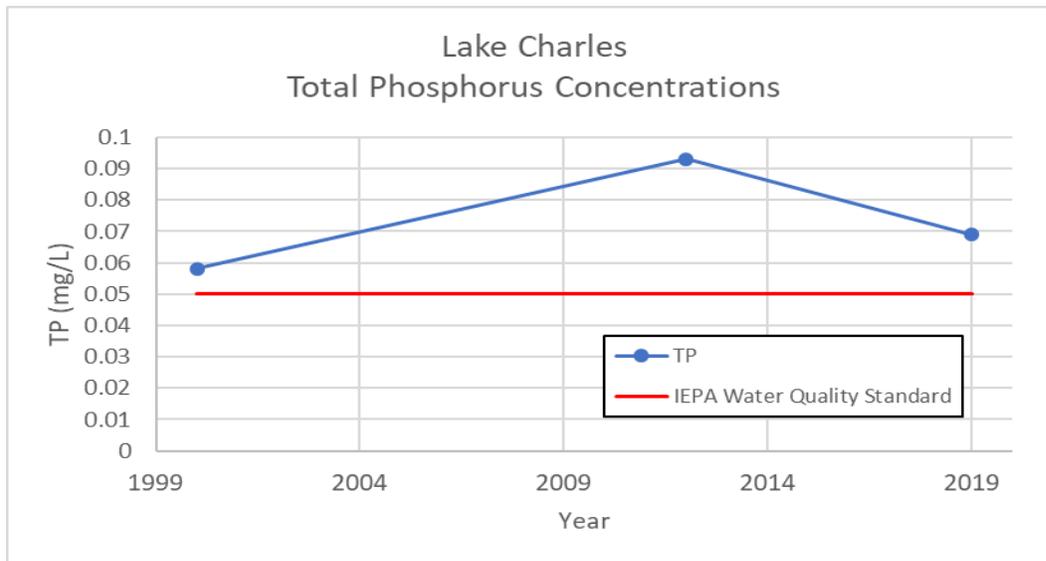
TROPHIC STATE INDEX

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 nutri-ent rich and most productive (eutrophic).

In 2019, Lake Charles had a TSIp value of 63.6 which categorizes it as eutrophic. Based on the TSIp, Lake Charles is ranked 75 out of 177 lakes studied by the LCHD-ES from 2000 – 2019 (Appendix B) and is considered eutrophic.

LAKE COUNTY AVERAGE TSIP = 65.0

**LAKE CHARLES TSIP = 63.6**

TROPHIC STATE: EUTROHPIC

RANK= 75/177

NUTRIENTS: NITROGEN

Nitrogen, in the forms of nitrate (NO_3^-), nitrite (NO_2^-), or ammonium (NH_4^+) is a nutrient needed for plant and algal growth. Nitrogen enters the ecosystem in a several chemical forms and a lake's nitrogen source can vary widely. Sources of nitrogen include septic systems, animal feed lots, agricultural fertilizers, manure, industrial waste waters, and sanitary landfills, and atmospheric deposition. All inorganic forms of nitrogen (NO3-, NO2-, and NH4+) can be used by aquatic plants and algae. If these inorganic forms exceed 0.3 mg/L, there is sufficient nitrogen to support summer algae blooms. If the surface median total nitrogen as N (TKN + NO2/NO3-N) exceeds 3.6 mg/L for the monitoring season, there is a nitrogen impairment for Lake Charles.

Nitrogen concentrations (NO3-N and NH3-N) in the epilimnion of Lake Charles were detectable in May (0.424 mg/L), June (0.137 mg/L) and September (0.407 mg/L). There were no nitrogen impairments for Lake Charles. Total Kjeldahl nitrogen (TKN), an organically (algae) associated form of nitrogen, in Lake Charles averaged 0.870 mg/L, which is significantly lower than the Lake County median of 1.170 mg/L. Total Kjeldahl nitrogen is a measure of organic nitrogen, and is typically bound up in algal and plant cells.

Typically lakes are either phosphorus or nitrogen limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/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. Ratios less than 10:1 suggest the lake is limited by nitrogen, while ratios greater than 20:1 are limited by phosphorus. Lake Charles has a TN:TP ratio of 14:1, meaning the lake is both phosphorus and nitrogen limited. The July TN:TP was 9:1 (nitrogen limited) and the May N:P was 27:1 (phosphorus limited). The 2012 TN:TP was 11:1

Limiting Nutrient
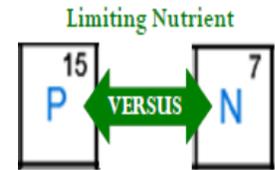
TN:TP Ratio

<10:1 = nitrogen limited

>20:1= phosphorus limited

TN:TP Ratio on Lake Charles:
14:1

Lake Charles is both Phosphorus and Nitrogen Limited

WAYS TO REDUCE NUTRIENTS IN YOUR LAKE

Waterfowl management (ducks and geese)

- Do not feed or encourage others to feed waterfowl

- Use good landscaping practices to discourage waterfowl. Landscapes with taller plants and shrubbery can discourage geese.

Fertilizer use:

- If you apply fertilizers to lawns and gardens, have your soil tested to determine how much fertilizer to apply.

- Check the weather before applying fertilizer—avoid applying before heavy rainfalls.

- Sweep up any fertilizer which is spilled on impervious surfaces such as walks and driveways.

- Do not spread fertilizer within 75 feet of surface waters or wetlands

Pet Waste Disposal

- Regularly scoop up and dispose of pest waste.

Landscaping Practices

- Consider native vegetation as a quality alternative to lawns. Native vegetation provides a more diverse plant community, and can filter out nutrients and also provides habitat for important pollinators.

- Plant a buffer strip of native plants (at least 20 feet) between the lake's edge and your property.

Keep fall leaves out of the storm drains

- Never rake leaves into or near storm drains, ditches, creeks, or on lakeshore.

ALKALINITY AND PH

Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases to maintain a stable pH. In a lake, alkalinity acts to buffer lakes from the effects of acid rain. Alkalinity comes from rocks, soils, salts, and certain plant activities. If a lakes watershed contains large quantities of calcium carbonate (CaCO3, limestone), the surface waters tend to be more alkaline; while granite bedrock does not have high amounts of CaCO3 and therefore lacks alkaline materials to buffer acidic inputs. In 2019, the average alkalinity (CaCO3) concentration in Lake Charles was 186 mg/L which is above the Lake County median alkalinity concentration of 163 mg/L. The USEPA considers lakes with CaCO3 concentrations greater than 20 mg/L to not be sensitive to acidification.

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.

Lake Charles average pH in 2019 was 7.67. There were no pH impairments for Lake Charles for the 2019 season.
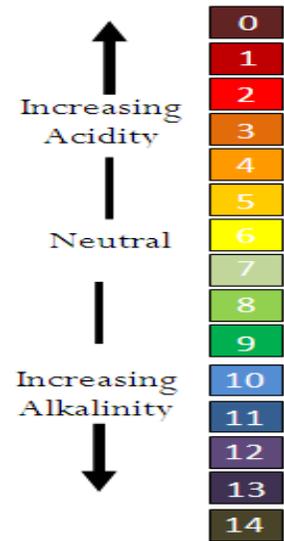
The pH scale ranges from 0 to 14. A pH of 7 is considered neutral. Substances with a pH of less than 7 are acidic, and greater than 7

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. Conductivity in urban areas has been shown to be highly correlated with chloride ions found in road salt mixes.

In 2019, Lake Charles average conductivity was 0.6993 mS/cm. This is below the Lake County median conductivity of 0.8569 mS/cm and a 10.8% decrease since the 2012 monitoring, but not as low as the 2000 sampling.

Figure 6: *Conductivity Concentrations in Lake Charles*
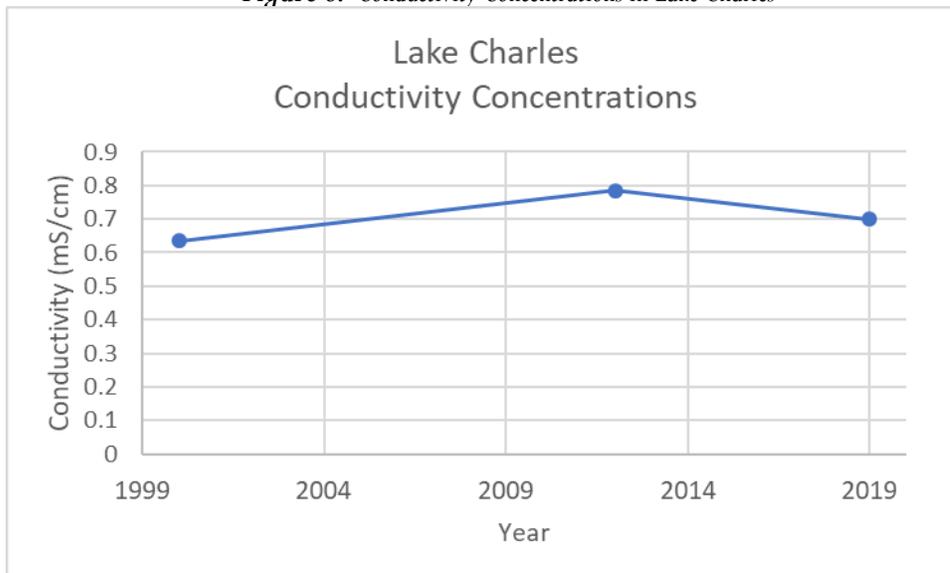
CHLORIDES

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 ferrocyanide salts. Lake Charles chloride concentration averaged 109 mg/L which is below the Lake County median of 170 mg/L (Figure 7). The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. While Lake Charles chloride concentration is below the aquatic life criteria, recent research has indicated organisms can get stressed at values much lower 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. Chloride concentrations decreased since 2012.

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 Lake Charles 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 7: *Lake Charles Chloride Concentrations*
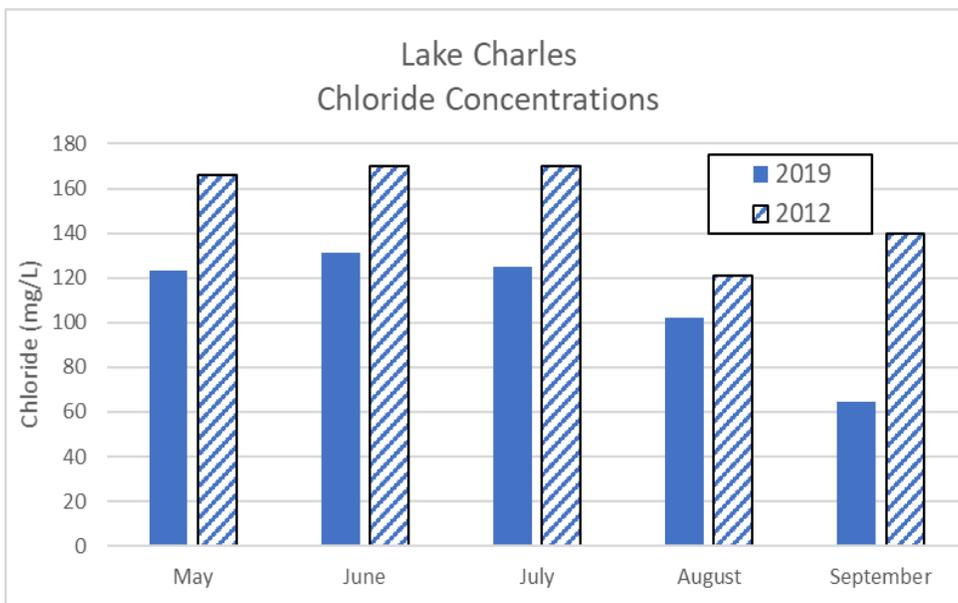
THE CRITICAL VALUE FOR CHLORIDES IN AQUATIC SYSTEMS IS 230 MG/L.

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.
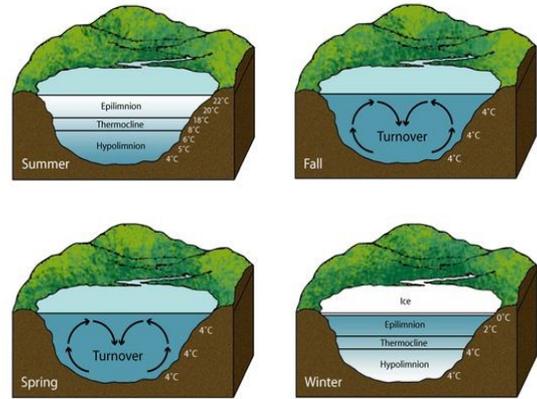
STRATIFICATION

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 8). 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.

Figure 8: Lake Turnover/Stratification diagram

Monthly depth profiles of water temperature, dissolved oxygen, conductivity, and pH were taken every two feet from the lake surface to the lake bottom on Lake Charles. 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. Lake Charles was stratified May-August. From the data, Lake Charles was not stratified in September. It is typical to see a spike in phosphorus concentrations after a lake turnover and mixes and there is a spike in TP in September (refer to Water Quality table in Appendix A)

DISSOLVED OXYGEN

Figure 9: Lake Charles 2019 DO Profile

A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a fishery as fish can suffer oxygen stress below 5 mg/L. DO concentrations dropped below 5 mg/L towards the bottom the lake, in all months. In July, DO was less than 5 mg/L starting at the surface of the water. This means 100% of the lake volume was below 5 mg/L in July.

Anoxic conditions, where DO concentrations are <1 mg/L, occurred May - 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. Lake Charles experienced it's greatest volume of anoxic conditions in August where oxygen levels dropped below 1 mg/L at depths greater than 4 ft (14.7% lake volume).
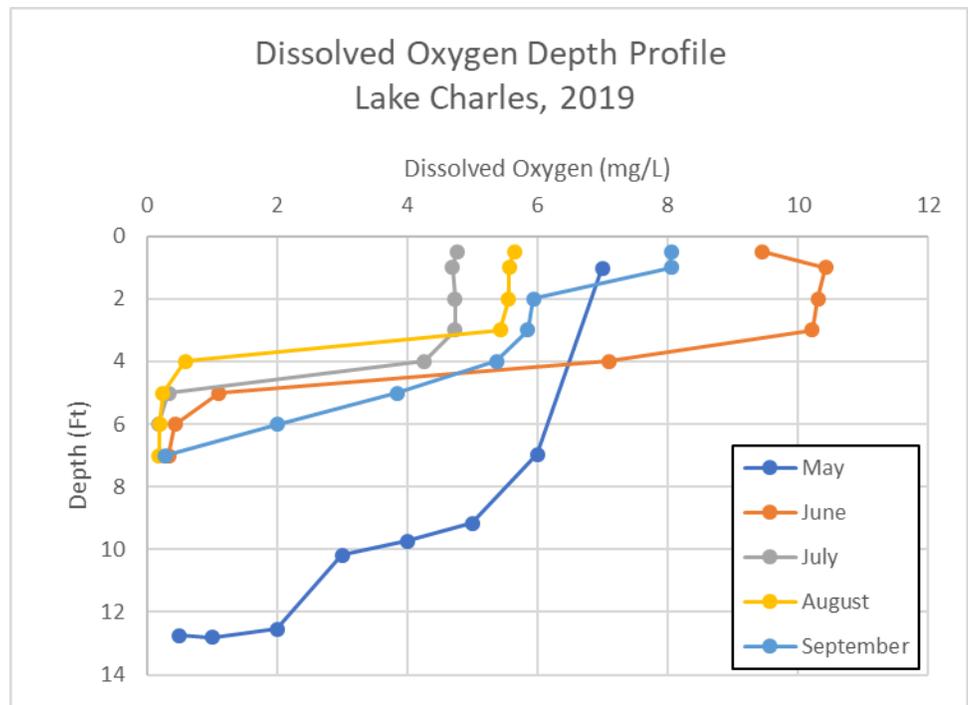
BATHYMETRIC MAPS

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.

Lake Charles had a bathymetric survey conducted in 2009 by LCHD (Figure 10). The maximum depth was 7.50 ft. and average depth was 3.84 ft. Lake volume was estimated 144.33 acre-feet. LCHD recommends updating bathymetric map every 10 years. For a complete list of the morphometric table for Lake Charles refer to Appendix B.

Figure 10: *Bathymetric Map of Lake Charles*

Morphometric Data
Surface Area: 37.55
Max Depth: 7.50 feet
Ave Depth: 3.84 feet
Lake Volume: 144.33 acre-feet
Shoreline Length: 1.03miles
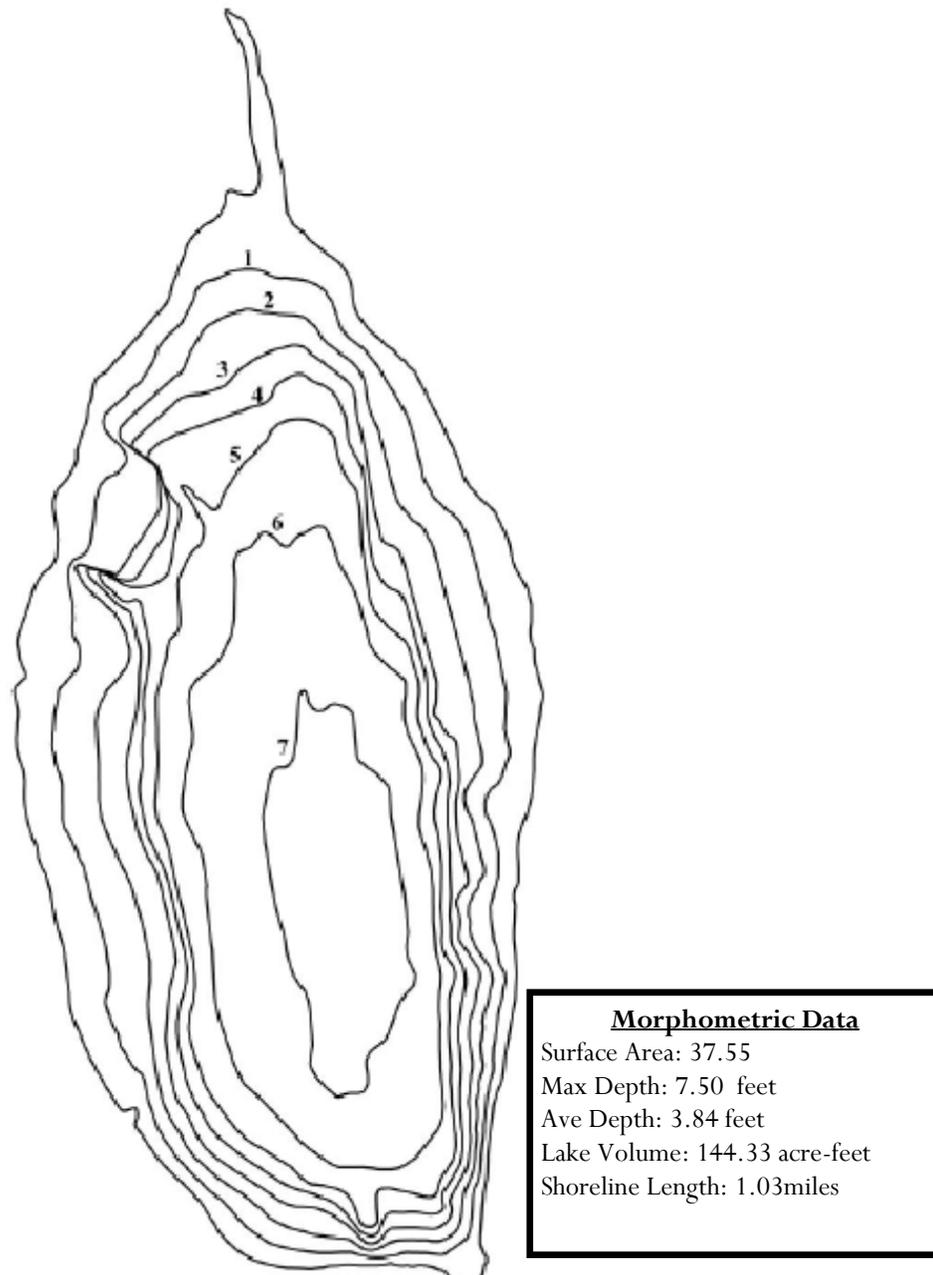
SHORELINE EROSION

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 can also be caused by human activity such as replacing native plants with turfgrass. Increasing impervious pavement increases runoff and 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 Lake Charles in 2019 (Figure 13). Lake Charles was evaluated for none, slight, moderate and severe erosion based on exposed soil and tree/plant roots, failing infrastructure and undercut banks. Based on the 2019 data, 34.2% of Lake Charles shoreline is eroding with 24.1% being slight erosion and 10.1% being moderate. Figure 14 represent the typical shoreline conditions on Lake Charles. Many homeowners have created artificial shorelines to minimize erosion including riprap and seawalls.

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

Figure 13: Shoreline Erosion Condition Lake Charles, 2019
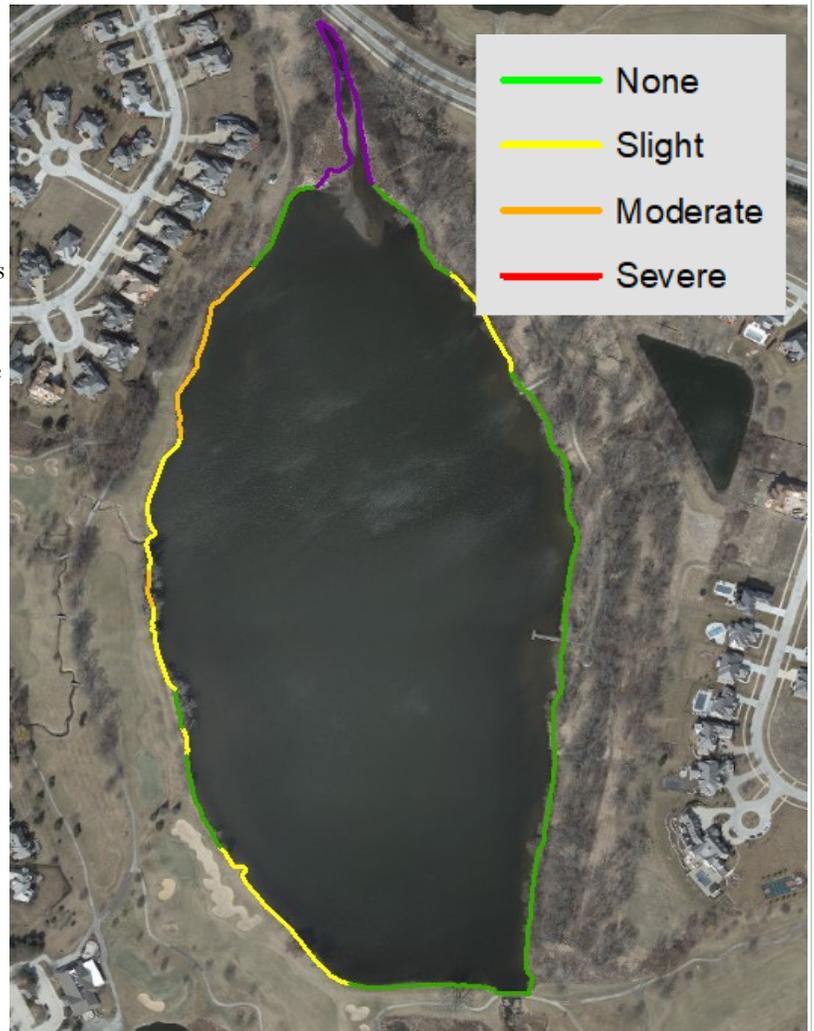
Figure 14: Example of erosion along Lake Charles shoreline

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 Lake Charles 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 2019, Lake Charles 21.5% with good buffer, 51.1% with fair, and 27.4% with poor buffer.

Lake Charles could benefit from improved buffer on the west side of the lake. Village of Vernon Hills should continue maintenance on the buffer on the east side of the lake. Since Lake Charles has a small watershed, buffer strips along the shoreline can help capture pollutants and sediment from entering the lake. Figures 16 represent the typical buffer conditions around Lake Charles, which is mowed turf grass up to the lakes edge.

Figure 15: Shoreline Buffer Condition on Lake Charles
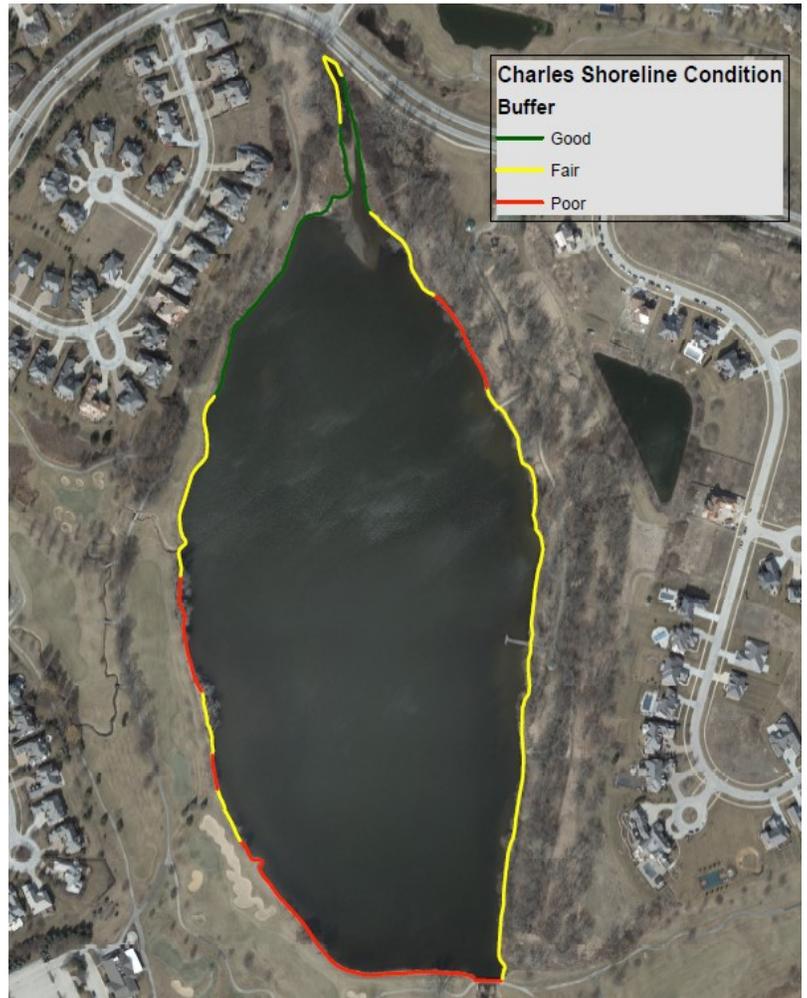
Figure 16: Typical of Lake Charles is mowed grass up to edge of lake

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 Lake Charles in August 2019. Sampling sites were based on a grid system created by mapping software, with each site located 60 meters apart for a total of 46 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 46 of the 47sites (97.9% total lake coverage) with plants found at depths up to 6.5 feet (Figure 17). Density of the plants was very high with 51% of the sampling sites having >90% plant rake density.

There were a total of 16 aquatic plant species and one macro-algae found in Lake Charles. Coontail was the most dominant species found at 85.1% of the sampling sites. The next most abundant plants were watermeal (70.2%), duckweed (66.0%), and white water lily (66.0%). The number of plant species (diversity) has increased since the 2012 sampling where only 6 plant species and Chara were observed . In 2012, Eurasian watermilfoil was the most dominant plant found at 51% of the sampling sites. For a complete list of aquatic plant species and density found in Lake Charles, refer to the aquatic plant table found in Appendix B.

Figure 17: Plant Biovolume Lake Charles, August 2019
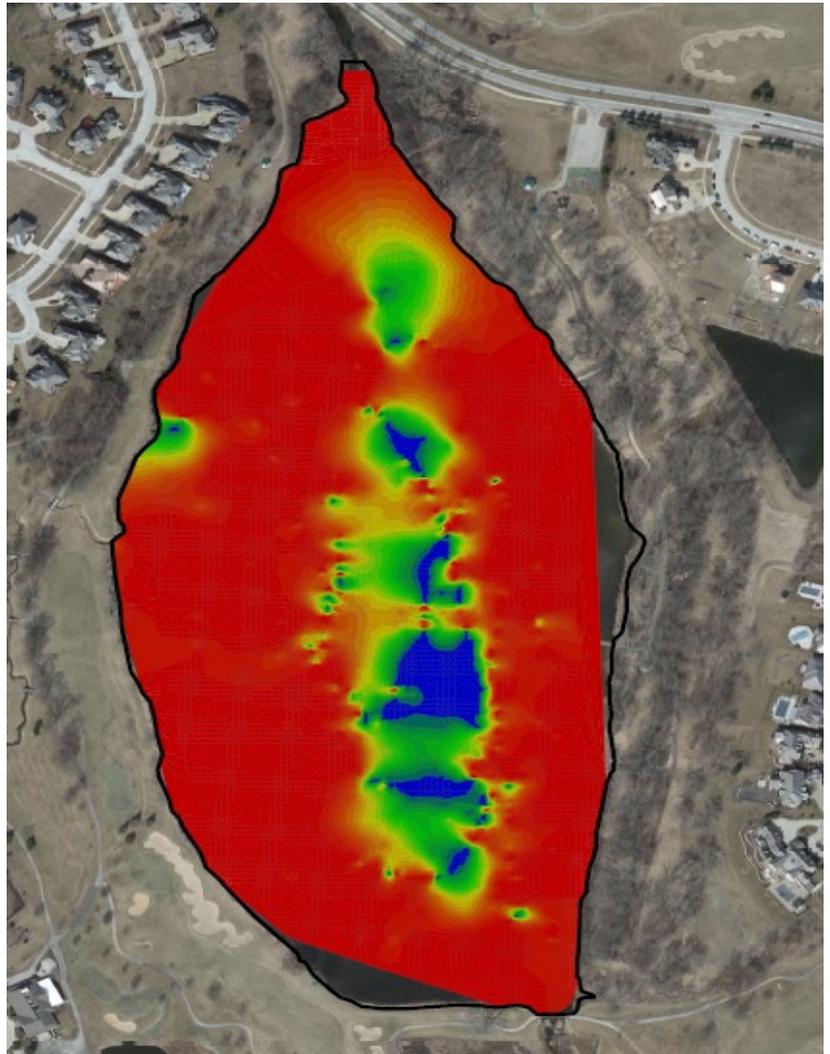
Table 3: Lake Charles Aquatic Plant Species by Year

2019 Plant List

American Pondweed	Sago Pondweed
Brittle Naiad	Southern Naiad
Chara	Spatterdock
Coontail	Vallisneria
Curlyleaf Pondweed	Watermeal
Common Duckweed	White Water Lily
Elodea	Floating Leaved Pondweed
Eurasian Watermilfoil	Small Pondweed
Giant Duckweed	

2012 Plant List

Eurasian Watermilfoil

Chara

Common Duckweed

Coontail

Curlyleaf Pondweed

White Water Lily

Sago Pondweed

AQUATIC PLANTS –DOMINANT PLANTS

The most dominant plants found in Lake Charles were: Coontail (85.1%), Watermeal (70.2%), and White Water Lily (66.0%). 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 Lake Charles, the 1% light level based on average Secchi values was approximately would be 14 feet , however, water clarity varied substantially from month to month which limits plant growth. Plants were found up to 6.5 feet in Lake Charles. Submerged portions of all aquatic plants provide habitats for many micro and macro invertebrates.

Common Plants in Lake Charles in 2019

Coontail	**Watermeal**	**White Water Lily**
(*Ceratophyllum demersum*	**(*Wolfia Columbiana)***	**(*Nymphaea tuberosa)***

Description

Coontail grows underwater with no roots and may reach the surface. Plants are often bushy near the tip giving the plant a "coontail or "christmas" tree" look. It can provide food and shelter for many aquatic life however, when growing densely commonly causes nuisance conditions

Description

Watermeal is the smallest flowering plant in the world. It is usually between 1-4 mm long, floating, without roots. It is often growing with duckweeds.

Description

A floating plant. Lily pad leaf has slit in it and typically a white flower when in bloom..

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 2000-2019 was 14.0. Lake Charles has an FQI of 21.3 ranking it 24/173 lakes in the county. It's important to promote native aquatic plant diversity in Lake Charles.

LAKE COUNTY AVERAGE FQI = 14.0

LAKE CHARLES FQI = 21.3

RANK =24/173

AQUATIC PLANTS SPECIES: 12

NATIVE PLANT SPECIES: 9

INVASIVE SPECIES: EURASIAN WATERMILFOIL

Eurasian Watermilfoil (EWM) is a feathery submerged aquatic plant (Figure 18) that can quickly form thick mats in shallow areas of lakes and rivers in North America. These mats can interfere with swimming and entangle propellers, which hinders boating fishing, and waterfowl hunting. Matted milfoil can displace native aquatic plants, impacting fish and wildlife. Since it was discovered in North America in the 1940's, EWM has invaded nearly every US state and at least three Canadian Provinces. Milfoil spreads when plant pieces break off and float on water currents. It can cross land to new waters by clinging to sailboats, personal watercraft, powerboats, motors, trailers, and fishing gear.

In 2019, Lake Charles had 48.9% of the sampling sites with Eurasian Watermilfoil.

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 control of exotic aquatic species including EWM and Curlyleaf Pondweed. Lake Charles should continue to monitor the presence of EWM in order to make effective herbicide treatment decisions.

Figure 19: Difference between 2016 and 2019 Plant biovolume and presence of Eurasian Watermilfoil
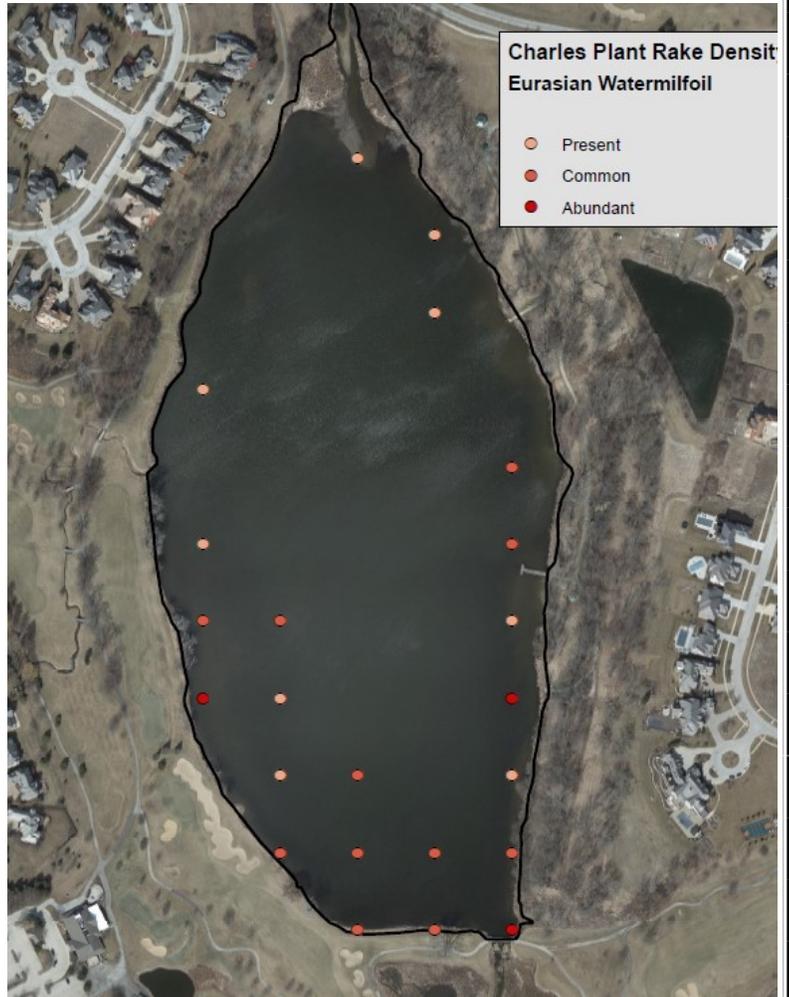
Figure 18: Eurasian Watermilfoil

INVASIVE SPECIES: CURYLEAF PONDWEED

Curlyleaf Pondweed (CLP) is an invasive aquatic plant that is native to Eurasia, Africa and Australia. It was accidently introduced to the Unted States waers in the mid-1880's by hobbyists who use it as an aquarium plant. The leaves are reddish-green, and about 3 inches long with distinct wavy edges.

Unlike native pondweeds, Curlyleaf Pondweed begins growing in the early spring. CLP has even been documented growing under the ice in lakes. The plant then reaches maturity in mid summer, typically June. This is when are natives are starting to emerge, so in general CLP has an earlier life cycle than our common natives. CLP becomes invasive in some areas because of its adaptations for low light , low temperatures, and higher turbidity. Plants die off usually in mid summer when most native plants are growing. If large quantities of CLP are present, plant die-offs may result in critical loss of dissolved oxygen. Large populations of CLP can also cause changes in nutrient availability. In mid-summer, CLP die back which can be followed by an increase in phosphorus availability that may fuel nuisance algal blooms.

The August 2019 plant survey showed Curlyleaf Pond found at 19.1% of the sampling sites. Since LCHD conducts aquatic plant surveys in August and CLP is typically an earlier season plant, these concentrations can be skewed as an august plant survey is typically missing peak CLP growth (June-early July). To get an accurate sense of density of CLP, an early season Curlyleaf Pondweed plant survey would be recommended.

Figure 20: Curlyleaf Pondweed Plant Rake Density on Lake Charles
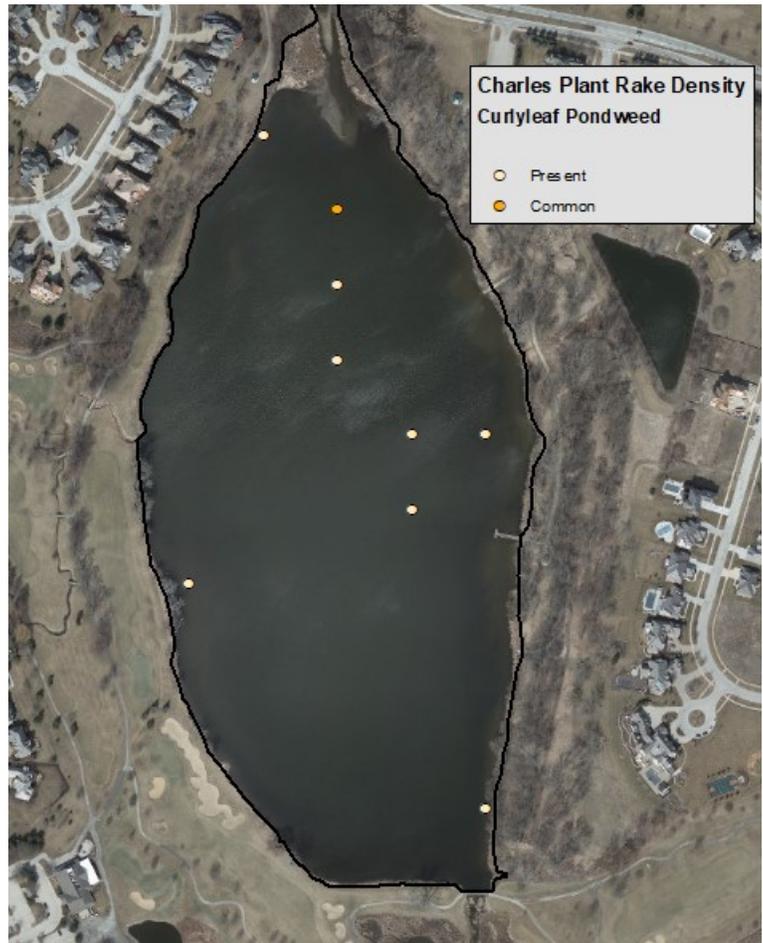
STOP THE SPREAD OF AQUATIC INVASIVE SPECIES
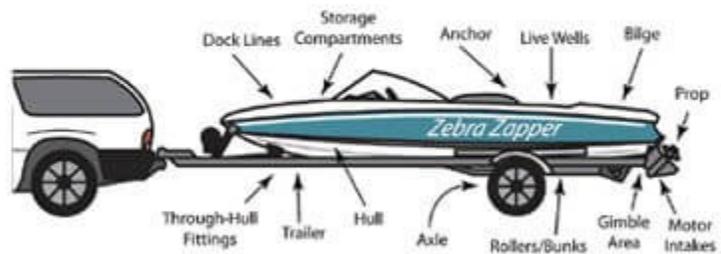
AQUATIC HERBICIDES

Herbicide treatments are one of the many tools available to lake managers. Herbicide treatments can be an affective means of managing aquatic invasive plants, however, when used alone they provide a quick fix that does not address the source of the problem, high nutrient levels.

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. LCHD recommends that Lake Charles continues to assess annually if treatments are needed.

> **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 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.

Lake Charles has seen improvements in the aquatic plant diversity and water quality and it's important to maintain this healthy ecosystem. The main types of plant control include: mechanical harvesting, manual harvesting, and herbicides. The most common control tool in aquatic plant management is the use of herbicides registered by the U.S. Environmental Protection Agency.

Table 5 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	Undesirable plants may fragment, spread and colonize new areas
	Removes nutrients from the lake but may be minimal compared with other methods	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 control	Machine breakdowns can disrupt operations
Hand Harvesting	Low Cost, low environmental impact	Time intensive
	Excellent control in small areas	Not suitable for large areas
Herbicides	Costs are reasonable	introduction of pesticides
	Range of products and combinations available provides flexibility in management options	Algal blooms and fish kills are possible following large herbicide treatments (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	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

NATIVE MUSSELS: GIANT FLOATER

Figure 21a-c: Giant Floater native mussels Lake

Lake Charles had a healthy native mussel population of Giant Floaters spread throughout the lake. Native mussels can be a great indicator for lake and water quality health. While typically freshwater mussels are more common and have a biodiversity in streams they are also found in lakes. The two more common mussels typically found in lakes are the Giant Floater and the White Heelsplitter. Both of these mussels can use a variety of fish hosts making them a more common species. In Lake Charles, only the giant floater was found during a brief mussel survey.

Despite their small size, mussels provide a number of benefits as they act as a living filter. When mussels feed, they take in large amounts of water and during that process they filter out bacteria, algae, nutrients and more before releasing clean water back out. One freshwater mussel can filter up to 6 gallons of water a day.

Mussels have a unique life cycle and they have to lure fish close to them so that the female can eject glochidia (parasitic larval stage of mussels/ offspring) onto the fish host.The glochidia then attach to the fish's gills, fins, and skin mostly using the fish as a safe place to transition into a juvenile mussel. After a few weeks or months (depending on species) the glochidia fall off the fish to the sediment below for their next growing stage. Mussels can be pretty clever in trying to lure fish to get close enough where they can infect them with their glochidia. They can mimic worms, crayfish, and lures that draw fish close.

Freshwater mussels also make up the most endangered groups in North America. Out of the 300 known species of native freshwater mussels in the United States, 213 are listed as endangered, threatened or species of special concern at the federal or state levels. In Illinois, once home to 80+ species- more than half are considered extirpated or extinct, state or federally listed or species at risk.

The Giant Floater is easily distinguished by its large size and has a distinct beak (umbo) compared to similar species. This mussel also has no teeth. Giant floaters may be the most adaptable and common mussel in the Midwest because of it's tolerance for turbidity and silty substrates. It can have approximately 35 different fish species as hosts and it is widespread and common throughout the region.

LAKE LEVEL

Fluctuations of lake levels are important to document as they can give insight to floods, droughts, and normal water year conditions. Lakeshore properties can often be impacted by lake level fluctuations which can cause flooding and shoreline erosion damage.

Lake Charles has a lake level gauge at the spillway on the north end of the lake. However, over time, this gauge as degraded and the numbers cannot be read. It is recommended to re-install a new gauge to replace the degraded one.

Lake Charles had the largest fluctuation in water level from August to September. Heavy rains in August/September resulted in this water level increase. Through the season, there was a 17" change in water level.

Figure 22: Example of a lake level gauge

AQUATIC PLANTS AND FISH

Fish depend on aquatic plants to provide habitat, forage for food and most fish rely on aquatic plants at some point during their lifecycle stage. The plant composition and density can play an important role in the nesting, growth, and foraging success of these fish (Table 4). 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.

Table 4: Fish and their affinity for aquatic plants

Fish	Plant Affinity	Life Stage				Relationship	
		Larvae	Juvenile	Adult	Spawn	Forage	Predator avoidance
Bluegill sunfish	High	X	X	X	X	X	X
Common carp	High	X	X	X	X	X	X
Largemouth bass	High	X	X	X	X	X	X
Musky	High	X	X	X	X	X	X
Northern Pike	High	X	X	X	X	X	X
Black crappie	Moderate		X	X	X	X	X
Smallmouth bass	Moderate		X	X		X	X
Yellow perch	Moderate	X	X			X	X
White crappie	Low		X			X	
Salmon, trout	Low		X				X
Shad	Low	X					
Walleye	Low			X		X	

2019 INLET SAMPLING

In 2019, the Des Plaines River Watershed Workgroup Lakes Committee contracted with the Lake County Health Department to monitor inlets on Big Bear, Little Bear, and Lake Charles to get a better understanding of pollutant loads entering the lake, specifically looking at total suspended solids (TSS), total phosphorus (TP), and chlorides. LCHD monitored 2 main inlets on Charles (Inlet 1 and Inlet 2 in Figure 23) as well as the outlet structure.

Inlets were monitored once a month and during 3 storm events. Inlet 1 on the north side of the lake had the highest concentration for total suspended solids averaging 40.2 mg/L for the season (Table 5). This was evident visually as after heavy rainfall events this inlet would be a murky brown entering the lake. Carp also hung out in this inlet, stirring up bottom sediments. This inlet also had the highest loads to Lake Charles as the creek had the most amount of water flowing through. Total Suspended Solids for Inlet 1 had a larger range as well , with the highest TSS concentration being 150 mg/L in August 2019.

Inlet 2 had the highest total phosphorus concentration at 0.091 mg/L. Inlet 2 is an intermittent flashy stream that runs through golf course property.

Table 5: Average concentrations for the monitoring season for Inlets on Lake Charles

Figure 23: Inlet Monitoring Locations on Lake Charles

Figure 23: Inlet Monitoring Concentrations on Lake Charles

Site	TP (mg/L)	TSS (mg/L)	Chloride (mg/L)
Inlet 1	0.068	40.2	71.7
Inlet 2	0.091	12.5	83.0
Inlet 3	0.036	2.9	62.2
Outlet	0.067	9.0	100.0
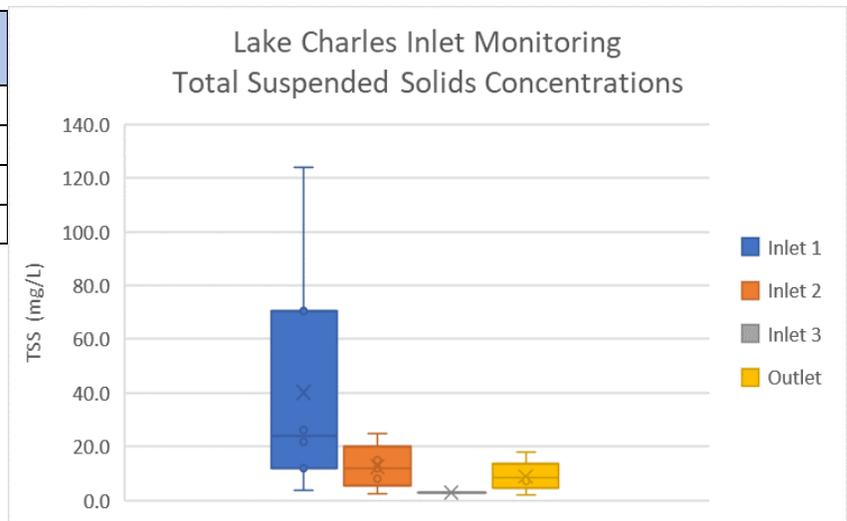
LAKE MANAGEMENT PLANS

It is recommended that a long term Lake Management Plan be developed to effectively manage lake issues. 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 Lake Charles. 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). The Lake County Health Department has created tools for homeowners to develop these plans. All materials can be found on the website at: https://www.lakecountyil.gov/4084/Lake-Management-Planning-Guide.

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.
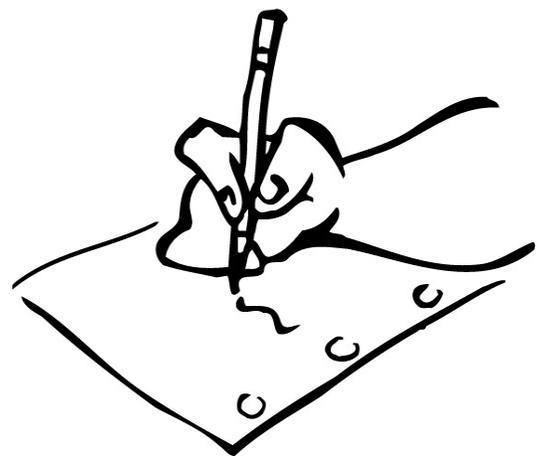
LAKE RECOMMENDATIONS

Lake Charles water quality is good and a combination of managing aquatic plant diversity and watershed improvements can help improve and maintain it's water quality. . To improve overall quality of Lake Charles, the LCHD-ES has the following recommendations:

♦ Develop a Lake Management Plan for Lake Charles. A key component to this plan should focus on maintaining aquatic plant diversity while reducing aquatic invasive species. For more information on lake management plans, check out the tools and worksheets available on the website: http://lakecountyil.gov/4084/Lake-Management-Planning-Guide

♦ It is recommended to not treat native plants. If native pondweeds become significant a pathway can be created for recreational access.

♦ Reinstall lake gauge near dam.

♦ Keep accurate records of management activities and lake observations.

♦ Updated fisheries survey and fish stocking recommendations.

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:

https://www.lakecountyil.gov/2381/Lakes-Management-Unit

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

Lake Charles Inlet and Outlet Sampling Locations

Inlet 1
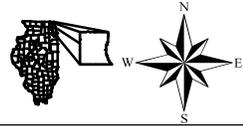
Inlet 3

Inlet 2

Outlet

△ Inlet and Outlet Sampling Location

LakeCounty
Health Department and
Community Health Center

N
W   E
S

0   200   400   600   800
Feet

Ecological Services
Product Number CHL19
Revised 12/2019

Lake Charles Watershed & Landuse, 2019

Legend

- Single Family
- Multi Family
- Office
- Wetlands
- Industrial
- Agricultural
- Disturbed Land
- Forest and Grassland
- Government and Institutional
- Water
- Public and Private Open Space
- Retail/Commercial
- Utility and Waste Facilities
- Transportation

N
W E
S

0   0.5   1   1.5   2
Miles

Lake Charles Shoreline Erosion Condition, 2019

Charles Shoreline Condition

Erosion

— None
— Slight
— Moderate
— Not Assessed

LakeCounty
Health Department and
Community Health Center

0   140   280   420   560
Feet

Ecological Services
Product Number CHA19
Revised 12/2019

Lake Charles Shoreline Erosion Condition, 2019

Charles Shoreline Condition
Buffer

— Good
— Fair
— Poor

LakeCounty
Health Department and
Community Health Center

N
W   E
S

0   150   300   450   600
Feet

Ecological Services
Product Number CHA19
Revised 11/2019

Charles Lake Plant Grid, 2019

LakeCounty
Health Department and
Community Health Center

0   150   300   450   600
Feet

Ecological Services
Product Number CHA19
Revised 7/2019
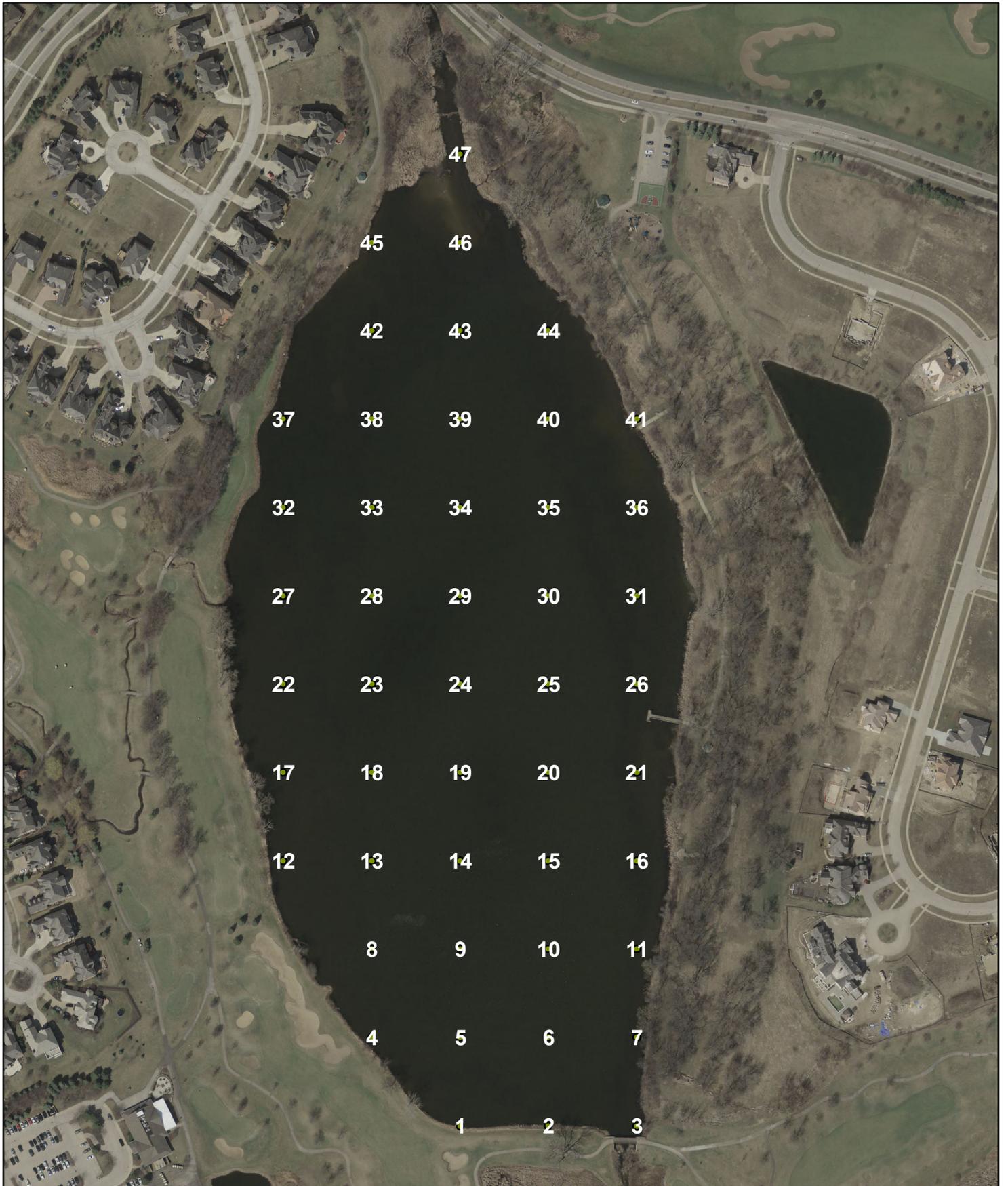
Lake Charles Plant Biovolume, 2019

Biovolume %

100

50

0

LakeCounty
Health Department and
Community Health Center

N
W E
S

0   200   400   600   800
Feet

Ecological Services
Product Number CHL19
Revised 12/2019

Lake Charles Eurasian Watermilfoil Plant Rake Density, 2019

Charles Plant Rake Density
Eurasian Watermilfoil

- Present
- Common
- Abundant

LakeCounty
Health Department and
Community Health Center

N
W E
S

0   200   400   600   800
Feet
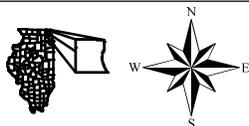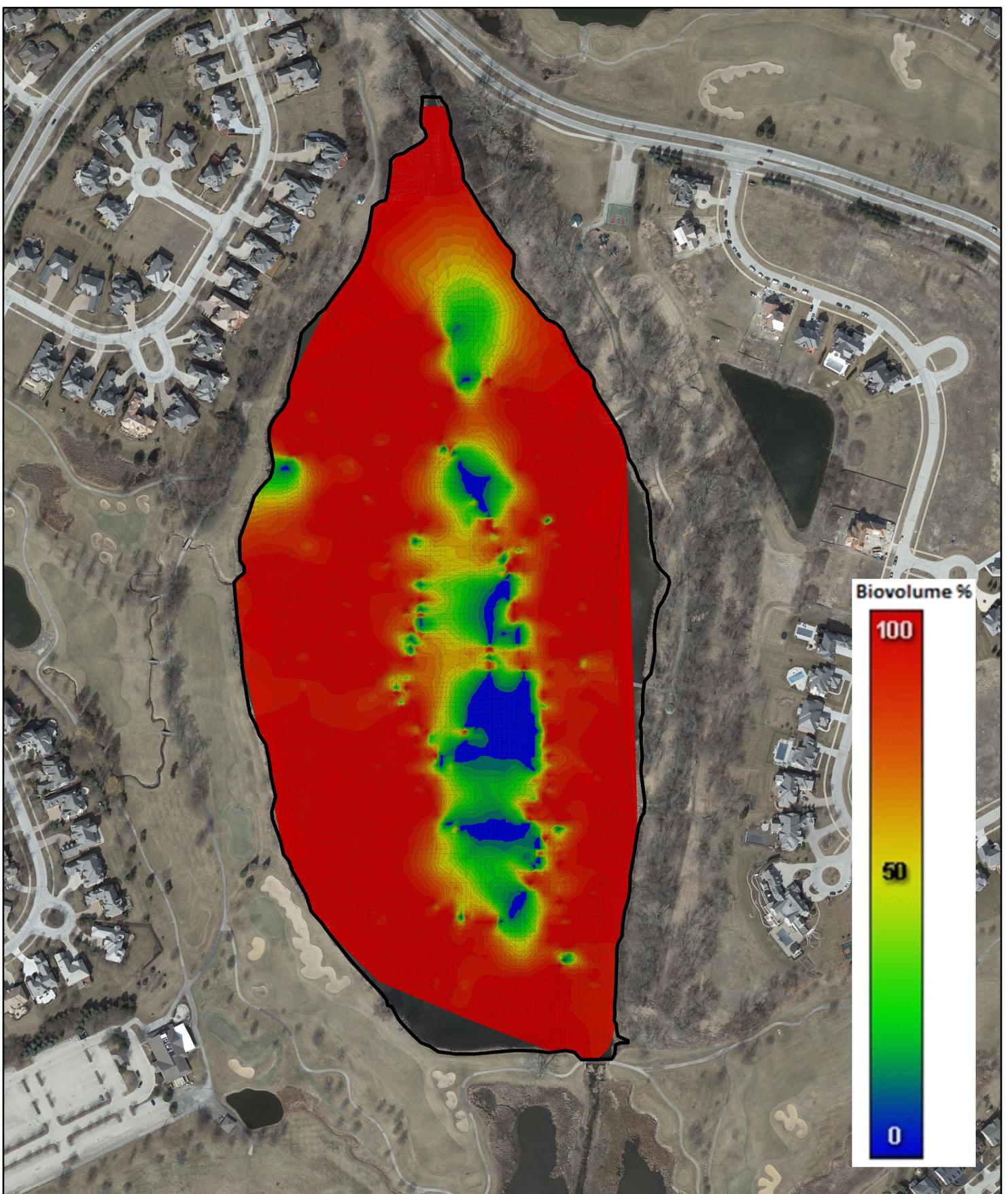
Ecological Services
Product Number CHL19
Revised 12/2019
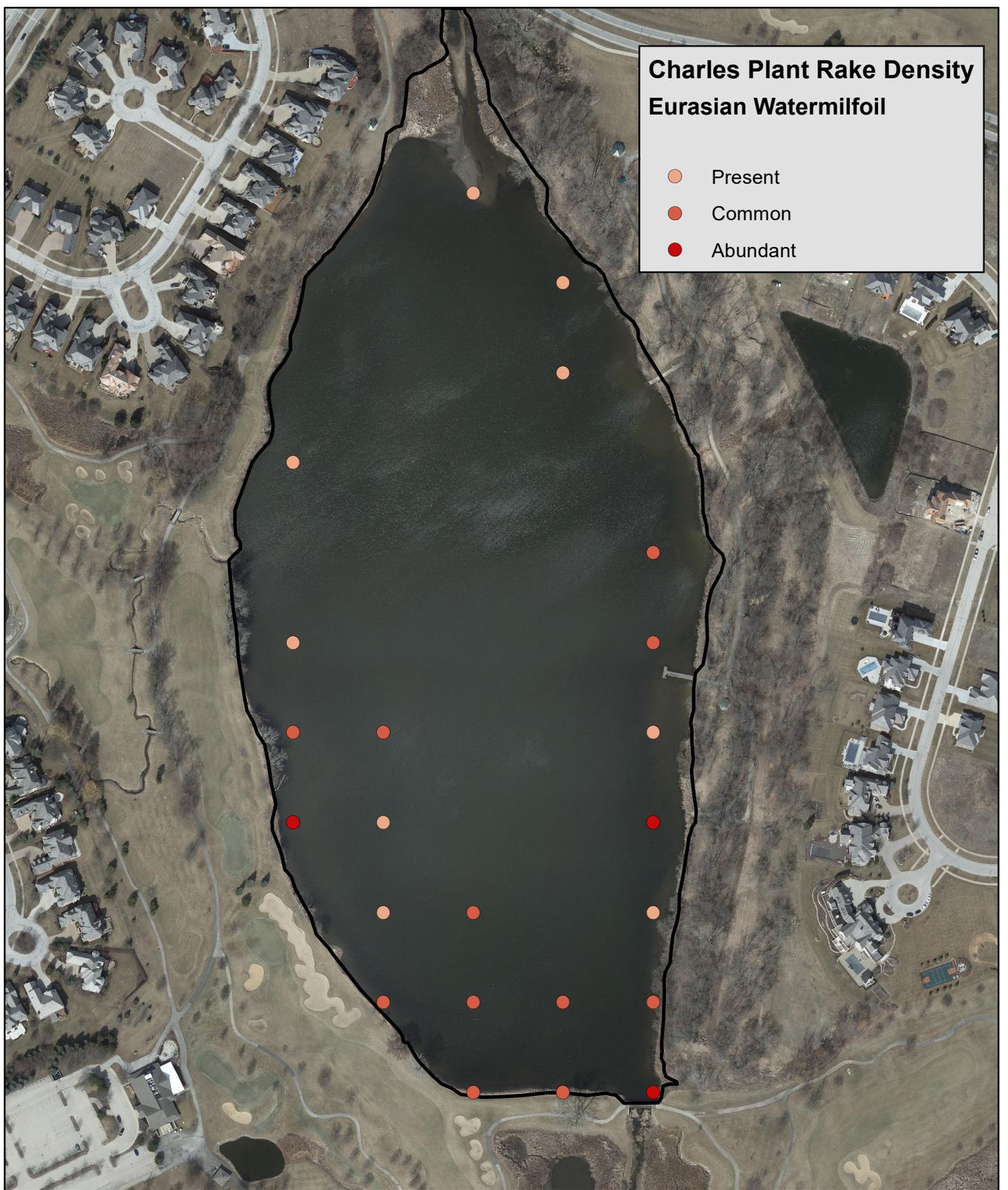
Lake Charles Curlyleaf Pondweed Plant Rake Density, 2019

Charles Plant Rake Density
Curlyleaf Pondweed

○ Present
● Common

LakeCounty
Health Department and
Community Health Center

N
W E
S

0   200   400   600   800
Feet

Ecological Services
Product Number CHL19
Revised 12/2019
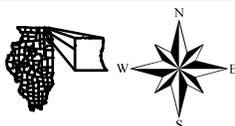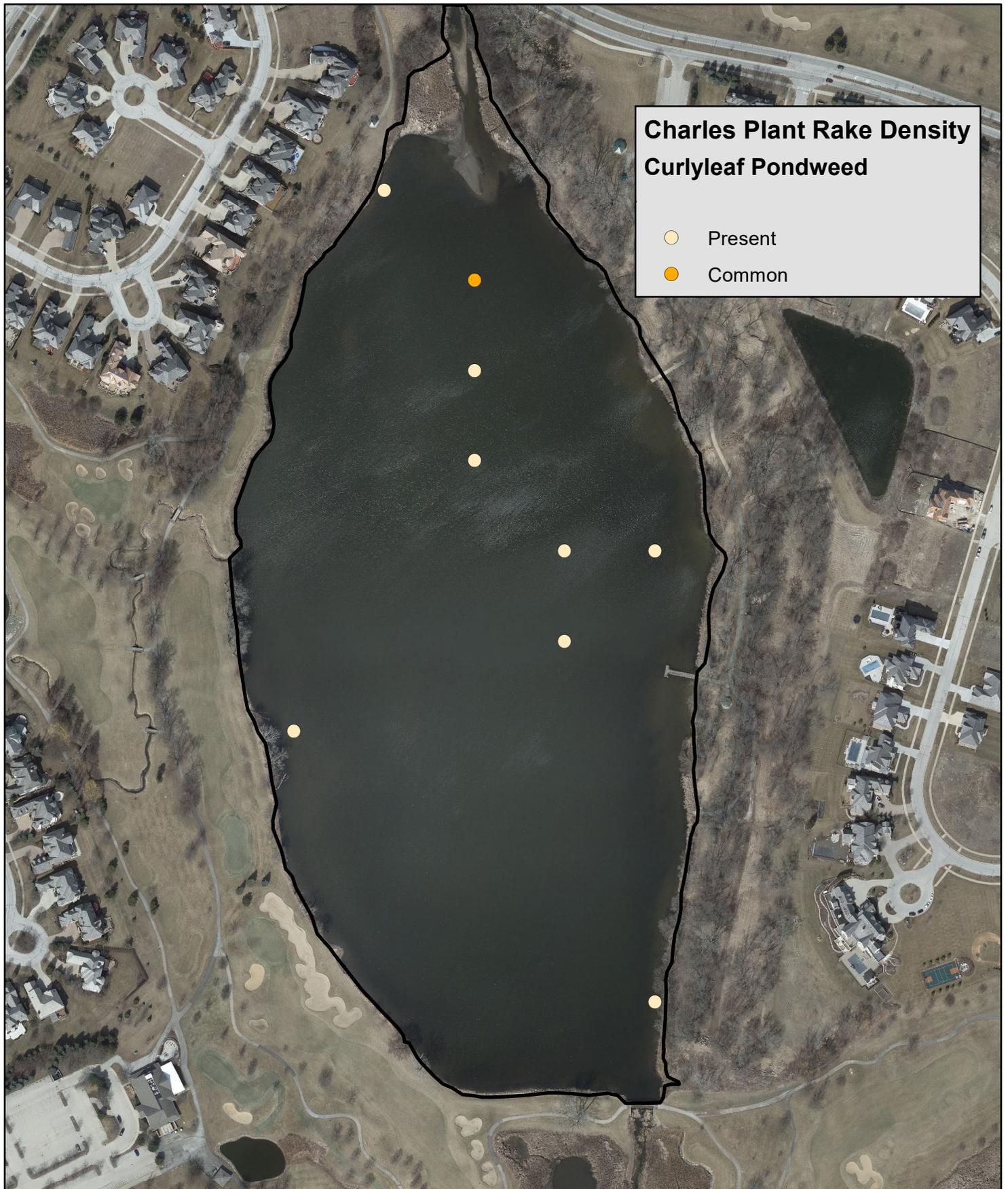
Lake Charles Eurasian Watermilfoil Plant Rake Density, 2019
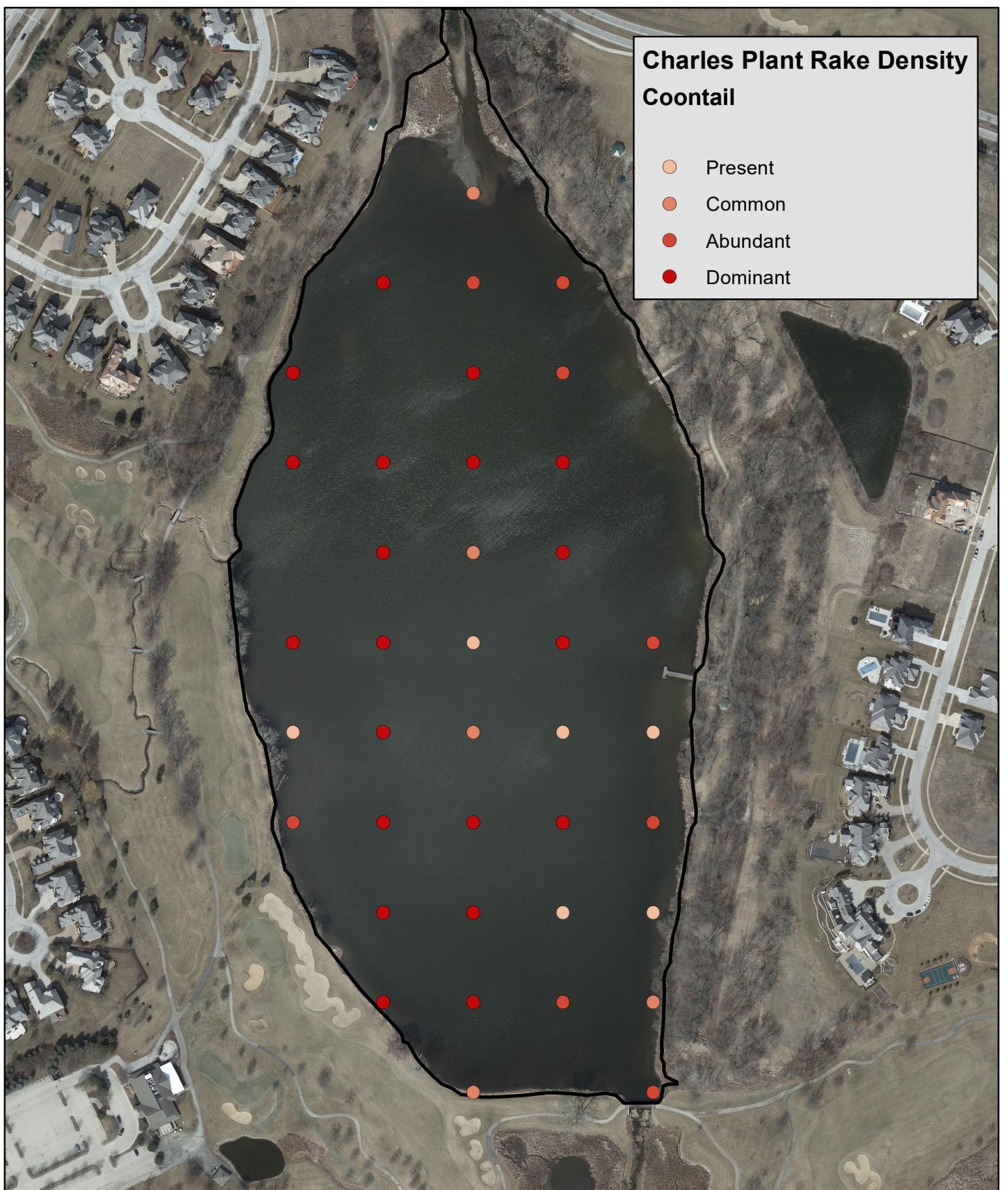
Charles Plant Rake Density
Coontail

- Present
- Common
- Abundant
- Dominant

LakeCounty
Health Department and
Community Health Center

N
W   E
S

0   200   400   600   800
Feet

Ecological Services
Product Number CHL19
Revised 12/2019

Appendix B:

Tables

Lake Charle

Lake Charles Multiparameter Data, 2019

MAY

Date	Depth (Ft.)	Depth Text (Ft.)	Temp (°C)	SpCond (ms/cm)	DO (mg/L)	DO Sat	pH	BGA RFU
5/14/2019	0.70	0.50	14.05	0.78	12.74	124.00	8.01	0.36
5/14/2019	1.09	1.00	14.03	0.78	12.80	124.60	8.03	0.43
5/14/2019	2.08	2.00	13.89	0.79	12.55	121.80	8.02	0.61
5/14/2019	3.11	3.00	13.43	0.83	10.19	97.90	7.90	0.40
5/14/2019	4.08	4.00	12.62	0.83	9.74	91.90	7.80	0.41
5/14/2019	5.02	5.00	11.66	0.83	9.17	84.70	7.75	0.76
5/14/2019	5.99	6.00	11.04	0.85	6.97	63.50	7.68	0.42
5/14/2019	6.98	7.00	11.00	0.98	1.02	9.20	7.58	0.60

JUNE

Date	Depth (Ft.)	Depth Text (Ft.)	Temp (°C)	SpCond (ms/cm)	DO (mg/L)	DO Sat	pH	BGA RFU
6/11/2019	0.41	0.50	17.50	0.00	9.45	98.80	6.01	0.42
6/11/2019	1.34	1.00	20.13	0.75	10.43	115.20	7.98	0.25
6/11/2019	2.12	2.00	20.13	0.76	10.31	114.00	8.01	0.33
6/11/2019	3.08	3.00	20.11	0.76	10.22	113.00	8.04	0.30
6/11/2019	4.18	4.00	19.58	0.82	7.09	77.60	7.90	0.23
6/11/2019	5.00	5.00	17.22	0.92	1.11	10.10	7.77	0.99
6/11/2019	6.25	6.00	16.25	0.77	0.43	4.40	7.68	0.98
6/11/2019	6.88	7.00	15.47	0.77	0.33	3.40	7.56	1.36

JULY

Date	Depth (Ft.)	Depth Text (Ft.)	Temp (°C)	SpCond (ms/cm)	DO (mg/L)	DO Sat	pH	BGA RFU
7/16/2019	0.57	0.50	25.31	0.79	4.76	58.10	7.58	0.49
7/16/2019	1.13	1.00	25.31	0.79	4.69	57.30	7.59	0.50
7/16/2019	2.11	2.00	25.32	0.79	4.73	57.60	7.59	0.47
7/16/2019	3.07	3.00	25.31	0.79	4.73	57.70	7.59	0.53
7/16/2019	4.08	4.00	25.29	0.79	4.26	51.90	7.56	0.57
7/16/2019	5.06	5.00	24.29	0.81	0.33	3.90	7.18	2.64
7/16/2019	6.06	6.00	22.35	0.82	0.17	1.90	6.99	0.55

AUGUST

Date	Depth (Ft.)	Depth Text (Ft.)	Temp (°C)	SpCond (ms/cm)	DO (mg/L)	DO Sat	pH	BGA RFU
8/13/2019	0.50	0.50	24.33	0.63	5.64	67.50	7.51	0.85
8/14/2019	1.00	1.00	24.33	0.63	5.56	66.50	7.50	0.88
8/15/2019	2.00	2.00	24.34	0.63	5.55	66.60	7.50	0.84
8/16/2019	3.00	3.00	24.30	0.63	5.43	65.10	7.48	0.63
8/17/2019	4.00	4.00	23.66	0.64	0.59	7.80	7.11	2.01
8/18/2019	5.00	5.00	22.54	0.64	0.24	2.80	6.94	2.76
8/19/2019	6.00	6.00	21.89	0.63	0.19	2.10	9.78	0.94
8/19/2019	7.00	7.00	21.28	0.67	0.18	2.00	6.66	1.14

Lake Charles Multiparameter Data, 2019

SEPTEMBER

Date	Depth (Ft.)	Depth Text (Ft.)	Temp (°C)	SpCond (ms/cm)	DO (mg/L)	DO Sat	pH	BGA RFU
9/17/2019	0.54	0.50	21.45	0.39	8.05	91.20	7.65	0.63
9/17/2019	1.01	1.00	21.45	0.39	8.05	91.20	7.67	0.72
9/17/2019	2.07	2.00	21.09	0.48	5.94	66.80	7.40	0.50
9/17/2019	3.09	3.00	20.70	0.49	5.85	65.30	7.36	0.35
9/17/2019	4.09	4.00	20.43	0.49	5.37	59.60	7.30	0.16
9/17/2019	5.08	5.00	20.21	0.50	3.84	42.50	7.23	0.16
9/17/2019	6.06	6.00	20.02	0.50	2.00	22.00	7.13	0.12
9/17/2019	7.18	7.00	19.74	0.49	0.28	3.10	7.03	0.21

Approximate Land Use Within the Lake Charles Watershed, 2019.

Land Use	Acreage	% of Total
Agricultural	32.04	0.9%
Disturbed Land	22.40	0.6%
Forest and Grassland	59.15	1.7%
Government and Institutional	184.18	5.2%
Industrial	110.84	3.1%
Multi Family	53.13	1.5%
Office	8.46	0.2%
Public and Private Open Space	602.98	17.1%
Retail/Commercial	170.16	4.8%
Single Family	1538.25	43.6%
Transportation	603.86	17.1%
Utility and Waste Facilities	0.00	0.0%
Water	84.44	2.4%
Wetlands	57.39	1.6%
Total Acres	**3527.27**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	32.04	0.05	4.4	0.1%
Disturbed Land	22.40	0.05	3.1	0.1%
Forest and Grassland	59.15	0.05	8.1	0.2%
Government and Institutional	184.18	0.50	253.3	6.1%
Industrial	110.84	0.80	243.8	5.9%
Multi Family	53.13	0.30	43.8	1.1%
Office	8.46	0.85	19.8	0.5%
Public and Private Open Space	602.98	0.15	248.7	6.0%
Retail/Commercial	170.16	0.85	397.7	9.6%
Single Family	1538.25	0.30	1269.1	30.6%
Transportation	603.86	0.85	1411.5	34.1%
Utility and Waste Facilities	0.00	0.30	0.0	0.0%
Water	84.44	1.00	232.2	5.6%
Wetlands	57.39	0.05	7.9	0.2%
TOTAL	**3527.27**		**4143.5**	**100.0%**

Lake volume	214.20	**acre-feet**
Retention Time (years)= lake volume/runoff	0.05	**years**
	18.87	**days**

Lake Charles Shoreline Erosion Condition, 2019

Erosion Category	Shoreline length (ft.)	Shoreline %
None	3102.0	50.2%
Slight	1490.6	24.1%
Moderate	621.0	10.1%
Severe	0.0	0.0%
Not Assessed	965.1	15.6%
Total	6178.8	100.0%

Lake Charles Shoreland Buffer Condition, 2019

Buffer Condition	Length of Shoreline (ft)	% of Shoreline
Good	1325.7	21.5%
Fair	3159.6	51.1%
Poor	1693.5	27.4%
Total	6178.8	100.0%

Lake Charles 2019 Aquatic Macrophyte Survey

Aquatic Plants found at 46 sampling sites on Lake Charles

The maximum depth plants were found at was 8 feet.

	American Pondweed	Brittle Naiad	Chara	Coontail	Curlyleaf Pondweed	Common Duckweed	Elodea	Eurasian Water Milfoil	Giant Duckweed
Absent	38	37	46	7	38	16	42	24	19
Present	2	1	0	6	8	24	3	9	16
Common	2	2	0	5	1	7	2	11	10
Abundant	4	7	1	8	0	0	0	3	2
Dominant	1	0	0	21	0	0	0	0	0
% Plant Occurrence	19.1%	21.3%	2.1%	85.1%	19.1%	66.0%	10.6%	48.9%	59.6%

	Sago Pondweed	Southern Naiad	Spatterdock	Vallisneria	Watermeal	White Water Lily	Floating Leaved Pondweed	Small Pondweed
Absent	40	46	46	46	14	16	46	41
Present	3	0	0	0	16	2	0	2
Common	4	0	0	0	16	13	1	4
Abundant	0	1	0	0	1	5	0	0
Dominant	0	0	1	1	0	11	0	0
% Plant Occurrence	14.9%	2.1%	2.1%	2.1%	70.2%	66.0%	2.1%	12.8%

Overall Rake Density

Rake Density	# of Sites	% of Sites
No Plants	1	2.1%
>0-10%	3	6.4%
10-40%	3	6.4%
40-60%	8	17.0%
60-90%	8	17.0%
>90%	24	51.1%
Total Sites with Plants	46	97.9%
Total	47	100.0%

Lake County Secchi Disk Clarity Ranking, 2000-2019.

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	Round Lake	12.97	40.18
5	Cedar Lake	12.55	40.66
6	Druce Lake	11.86	41.47
7	Pulaski Pond	11.69	41.68
8	West Loon Lake	11.55	41.85
9	Gages Lake	10.42	43.33
10	Lake Zurich	10.40	43.37
11	Indpendence Grove	10.31	43.49
12	Ames Pit	9.97	43.97
13	Davis Lake	9.65	44.44
14	Harvey Lake	9.47	44.72
15	Little Silver Lake	9.42	44.79
16	Old School Lake	9.40	44.82
17	Lake Kathryn	9.39	44.84
18	Lake Miltmore	9.28	45.01
19	Dugdale Lake	9.22	45.10
20	Dog Training Pond	9.04	45.39
21	Banana Pond	8.85	45.69
22	Sand Lake	8.83	45.72
23	Deep Lake	8.83	45.72
24	Stone Quarry Lake	8.81	45.76
25	Wooster Lake	8.74	45.87
26	Lake of the Hollow	8.74	45.87
27	Cross Lake	8.18	46.83
28	Bangs Lake	8.02	47.11
29	Briarcrest Pond	8.00	47.15
30	Heron Pond	7.87	47.39
31	Sand Pond (IDNR)	7.42	48.23
32	Highland Lake	7.42	48.23
33	Lake Leo	7.31	48.45
34	Schreiber Lake	7.25	48.57
35	Nielsen Pond	7.23	48.61
36	Honey Lake	7.17	48.73
37	Lake Minear	7.13	48.81
38	Lake Helen	6.43	50.30
39	Sun Lake	6.33	50.52
40	Lake Barrington	6.12	51.01
41	Waterford Lake	6.11	51.03
42	Timber Lake (North)	6.03	51.22
43	Cranberry Lake	5.94	51.44
44	Lake Fairfield	5.89	51.56
45	Third Lake	5.78	51.83
46	Owens Lake	5.30	53.08
47	Lake Linden	5.28	53.14
48	Valley Lake	5.05	53.78
49	McGreal Lake	5.04	53.81
50	Old Oak Lake	4.85	54.36

51	Grays Lake	4.59	55.16
52	Peterson Pond	4.51	55.41
53	Timber Lake (South)	4.46	55.57
54	Crooked Lake	4.39	55.79
55	Mary Lee Lake	4.35	55.93
56	Butler Lake	4.35	55.93
57	Little Bear Lake	4.35	55.93
58	Deer Lake	4.20	56.45
59	Seven Acre Lake	4.18	56.51
60	Hastings Lake	4.18	56.51
61	Lambs Farm Lake	4.17	56.54
62	Lake Naomi	4.05	56.96
63	Hook Lake	3.95	57.32
64	Turner Lake	3.92	57.43
65	North Tower Lake	3.89	57.54
66	Leisure Lake	3.85	57.69
67	Summerhill Estates Lake	3.84	57.73
68	Acorn Lake	3.84	57.73
69	Salem Lake	3.77	58.00
70	Lake Fariview	3.75	58.07
71	Duck Lake	3.71	58.23
72	Countryside Glen Lake	3.64	58.50
73	Beaver Lake	3.64	58.50
74	Fish Lake	3.57	58.78
75	Taylor Lake	3.52	58.99
76	Lochanora	3.52	58.99
77	Bishop Lake	3.47	59.19
78	Lake Lakeland Estates	3.41	59.44
79	Lake Holloway	3.40	59.49
80	Stockholm Lake	3.38	59.57
81	Crooked Lake	3.35	59.70
82	East Loon Lake	3.30	59.92
83	Lucky Lake	3.22	60.27
84	Diamond Lake	3.17	60.50
85	Liberty Lake	3.16	60.54
86	International Mining and Chemical Lake	3.08	60.91
87	Long Lake	3.05	61.05
88	Lake Christa	3.01	61.24
89	Lucy Lake	2.99	61.34
90	Lake Charles	2.95	61.53
91	Lake Catherine	2.9	61.78
92	St. Mary's Lake	2.79	62.34
93	Channel Lake	2.77	62.44
94	Werhane Lake	2.71	62.76
95	Fischer Lake	2.70	62.81
96	Bresen Lake	2.69	62.86
97	East Meadow Lake	2.61	63.30
98	Buffalo Creek Reservoir 1	2.60	63.35
99	Countryside Lake	2.58	63.46
100	Big Bear Lake	2.58	63.46
101	Kemper Lake 1	2.56	63.58

Lake County Secchi Disk Clarity Ranking, 2000-2019.

102	Bluff Lake	2.51	63.86
103	Broberg Marsh	2.50	63.92
104	Antioch Lake	2.48	64.03
105	Island Lake	2.32	65.00
106	Tower Lake	2.31	65.06
107	Buffalo Creek Reservoir 2	2.30	65.12
108	Woodland Lake	2.28	65.25
109	Rivershire Pond 2	2.23	65.57
110	College Trail Lake	2.18	65.89
111	Loch Lomond	2.17	65.96
112	Redhead Lake	2.16	66.03
113	Pistakee Lake	2.15	66.09
114	Des Plaines Lake	2.14	66.16
115	Echo Lake	2.11	66.36
116	Eagle Lake (S1)	2.10	66.43
117	West Meadow Lake	2.07	66.64
118	Forest Lake	2.04	66.85
119	Grand Ave Marsh	2.03	66.92
120	Columbus Park Lake	2.03	66.92
121	Grassy Lake	2.00	67.14
122	Petite Lake	2.00	67.14
123	Sylvan Lake	1.98	67.28
124	Bittersweet Golf Course #13	1.98	67.28
125	Deer Lake Meadow Lake	1.83	68.42
126	Spring Lake	1.78	68.82
127	Kemper Lake 2	1.77	68.90
128	Fourth Lake	1.77	68.90
129	Nippersink Lake	1.73	69.23
130	Lake Louise	1.68	69.65
131	Willow Lake	1.63	70.09
132	Slough Lake	1.63	70.09
133	Rasmussen Lake	1.62	70.17
134	Lake Farmington	1.62	70.17
135	Half Day Pit	1.60	70.35
136	Lake Marie	1.56	70.72
137	White Lake	1.53	71.00
138	Longview Meadow Lake	1.51	71.19
139	Lake Matthews	1.48	71.48
140	Rollins Savannah 1	1.38	72.51
141	Fox Lake	1.28	73.57
142	Dunn's Lake	1.22	74.26
143	Lake Eleanor	1.16	74.99
144	Lake Napa Suwe	1.06	76.29
145	Osprey Lake	1.03	76.70
146	Manning's Slough	1.00	77.13
147	Dog Bone Lake	0.94	78.02
148	Redwing Marsh	0.88	78.97
149	Flint Lake Oulet	0.83	79.82
150	Fairfield Marsh	0.81	80.17
151	Slocum Lake	0.81	80.17
152	Oak Hills Lake	0.79	80.53

Lake County Secchi Disk Clarity Ranking, 2000-2019.

153	McDonald Lake 1	0.79	80.53
154	Grass Lake	0.78	80.71
155	Lake Nippersink	0.77	80.90
156	South Churchill Lake	0.73	81.67
157	Lake Forest Pond	0.71	82.07
158	Rollins Savannah 2	0.66	83.03
159	ADID 127	0.66	83.12
160	North Churchill Lake	0.61	84.26
161	Hidden Lake	0.56	85.54
162	McDonald Lake 2	0.53	86.28
163	Ozaukee Lake	0.51	86.84
	average	*4.35*	*60.37*

Lake County Average TSI phosphorus (TSIp) ranking 2000-2019.

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	Highland 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	Gages Lake	0.0170	45.00
11	Pulaski Pond	0.0180	45.83
12	Ames Pit	0.0190	46.61
13	Round Lake	0.0190	46.61
14	Banana Pond	0.0200	47.35
15	Lake Kathryn	0.0200	47.35
16	Lake Zurich	0.0210	48.05
17	Lake Miltmore	0.0210	47.80
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	Stone Quarry Lake	0.0230	49.36
24	Timber Lake (North)	0.0232	49.49
25	Third Lake	0.0242	50.10
26	Bangs Lake	0.0260	51.13
27	Lake Leo	0.0260	51.13
28	Grays Lake	0.0260	51.13
29	Druce Lake	0.0270	51.68
30	Lake Barrington	0.0270	51.68
31	Cranberry Lake	0.0270	51.68
32	Dugdale Lake	0.0270	51.68
33	Peterson Pond	0.0270	51.68
34	Fourth Lake	0.0270	51.68
35	Sand Lake	0.0272	51.78
36	Little Silver Lake	0.0280	52.20
37	Wooster Lake	0.0290	52.71
38	Heron Pond	0.0298	53.10
39	Lambs Farm Lake	0.0310	53.67
40	Old School Lake	0.0310	53.67
41	Harvey Lake	0.0320	54.13
42	Butler Lake	0.0324	54.31
43	Hendrick Lake	0.0340	55.00
44	Little Bear Lake	0.0358	55.74
45	Sullivan Lake	0.0370	56.22
46	Diamond Lake	0.0390	56.98
47	East Loon	0.0400	57.34
48	Schreiber Lake	0.0400	57.34
49	Hook Lake	0.0410	57.70
50	Lake Tranquility (S1)	0.0412	57.77
51	Lake Linden	0.0420	58.05
52	Nielsen Pond	0.0450	59.04

Lake County Average TSI phosphorus (TSIp) ranking 2000-2019.

53	Seven Acre Lake	0.0460	59.36
54	Turner Lake	0.0460	59.36
55	Willow Lake	0.0460	59.36
56	Waterford Lake	0.0470	59.67
57	East Meadow Lake	0.0480	59.97
58	Lucky Lake	0.0480	59.97
59	Old Oak Lake	0.0490	60.27
60	College Trail Lake	0.0500	60.56
61	Summerhill Estates Lake	0.0514	60.96
62	Big Bear Lake	0.0514	60.96
63	West Meadow Lake	0.0530	61.40
64	Beaver Lake	0.0532	61.46
65	Lucy Lake	0.0550	61.94
66	Acorn Lake	0.0564	62.30
67	Lake Christa	0.0580	62.70
68	Owens Lake	0.0580	62.70
69	Briarcrest Pond	0.0580	62.70
70	Honey Lake	0.0586	62.85
71	Crooked Lake	0.0604	63.29
72	Redhead Lake	0.0608	63.38
73	St. Mary's Lake	0.0608	63.38
74	Duck Lake	0.0610	63.43
75	Lake Charles	0.0618	63.62
76	Lake Lakeland Estates	0.0620	63.66
77	Lake Naomi	0.0620	63.66
78	Lake Catherine	0.0620	63.66
79	Liberty Lake	0.0630	63.89
80	North Tower Lake	0.0630	63.89
81	Werhane Lake	0.0630	63.89
82	Countryside Glen Lake	0.0640	64.12
83	Davis Lake	0.0650	64.34
84	Leisure Lake	0.0650	64.34
85	Channel Lake	0.0680	65.00
86	Buffalo Creek Reservoir 1	0.0680	65.00
87	Mary Lee Lake	0.0680	65.00
88	Potomac Lake	0.0714	65.70
89	Timber Lake (South)	0.0720	65.82
90	Lake Helen	0.0720	65.82
91	Grandwood Park Lake	0.0720	65.82
92	ADID 203	0.0730	66.02
93	Fish Lake	0.0730	66.02
94	Hastings Lake	0.0746	66.33
95	Deer Lake Meadow Lake	0.0755	66.50
96	Broberg Marsh	0.0780	66.97
97	Echo Lake	0.0790	67.16
98	Countryside Lake	0.0800	67.34
99	Lake Nippersink	0.0800	67.34
100	Woodland Lake	0.0800	67.34
101	Redwing Slough	0.0822	67.73
102	Tower Lake	0.0830	67.87
103	Lake Antioch	0.0850	68.21
104	Grand Ave Marsh	0.0870	68.55
105	North Churchill Lake	0.0870	68.55

Lake County Average TSI phosphorus (TSIp) ranking 2000-2019.

106	White Lake	0.0874	68.61
107	Pistakee Lake	0.0880	68.71
108	Lake Fairview	0.0890	68.88
109	Rivershire Pond 2	0.0900	69.04
110	South Churchill Lake	0.0900	69.04
111	McGreal Lake	0.0910	69.20
112	Deer Lake	0.0940	69.66
113	Eagle Lake (S1)	0.0950	69.82
114	International Mine and Chemical Lake	0.0950	69.82
115	Valley Lake	0.0950	69.82
116	McDonald Lake 1	0.0952	69.85
117	Buffalo Creek Reservoir 2	0.0960	69.97
118	Fox Lake	0.1000	70.56
119	Nippersink Lake - LCFP	0.1000	70.56
120	Sylvan Lake	0.1000	70.56
121	Petite Lake	0.1020	70.84
122	Longview Meadow Lake	0.1020	70.84
123	Lake Marie	0.1030	70.98
124	McDonald Lake 2	0.1050	71.26
125	Dunn's Lake	0.1070	71.53
126	Lake Forest Pond	0.1070	71.53
127	Long Lake	0.1070	71.53
128	Grass Lake	0.1090	71.80
129	Des Plaines Lake	0.1090	71.80
130	Spring Lake	0.1100	71.93
131	Kemper 2	0.1100	71.93
132	Bittersweet Golf Course #13	0.1100	71.93
133	Osprey Lake	0.1110	72.06
134	Rollins Savannah 1	0.1116	72.14
135	Bluff Lake	0.1120	72.19
136	Middlefork Savannah Outlet 1	0.1120	72.19
137	Lochanora Lake	0.1120	72.19
138	Round Lake Marsh North	0.1130	72.32
139	Lake Matthews	0.1180	72.94
140	Taylor Lake	0.1180	72.94
141	Island Lake	0.1210	73.31
142	Columbus Park Lake	0.1230	73.54
143	Lake Holloway	0.1320	74.56
144	Fischer Lake	0.1380	75.20
145	Slocum Lake	0.1500	76.40
146	Lakewood Marsh	0.1510	76.50
147	Pond-A-Rudy	0.1510	76.50
148	Forest Lake	0.1540	76.78
149	Bresen Lake	0.1580	77.15
150	Middlefork Savannah Outlet 2	0.1590	77.24
151	Grassy Lake	0.1610	77.42
152	Salem Lake	0.1650	77.78
153	Half Day Pit	0.1690	78.12
154	Rollins Savannah 2	0.1746	78.59
155	Lake Louise	0.1810	79.11
156	Lake Eleanor	0.1810	79.11
157	Lake Farmington	0.1850	79.43

Lake County Average TSI phosphorus (TSIp) ranking 2000-2019.

158	ADID 127	0.1890	79.74
159	Lake Napa Suwe	0.1940	80.11
160	Loch Lomond	0.1960	80.26
161	Patski Pond	0.1970	80.33
162	Dog Bone Lake	0.1990	80.48
163	Redwing Marsh	0.2070	81.05
164	Stockholm Lake	0.2082	81.13
165	Bishop Lake	0.2160	81.66
166	Ozaukee Lake	0.2200	81.93
167	Kemper 1	0.2220	82.06
168	Hidden Lake	0.2240	82.19
169	Oak Hills Lake	0.2790	85.35
170	Fairfield Marsh	0.3260	87.60
171	ADID 182	0.3280	87.69
172	Manning's Slough	0.3820	89.88
173	Slough Lake	0.3860	90.03
174	Rasmussen Lake	0.4860	93.36
175	Albert Lake, Site II, outflow	0.4950	93.62
176	Flint Lake Outlet	0.5000	93.76
177	Almond Marsh	1.9510	113.40
	Average	*0.1040*	*65.0*

Lake County average Floristic Quality Index (FQI) ranking 2000-2019

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	37.4	38.9
2	East Loon Lake	34.7	36.1
3	Deep Lake	29.7	31.2
4	Cranberry Lake	29.7	29.7
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	Round Lake	24.9	27.7
11	Indpendence Grove	24.4	26.8
12	Sun Lake	24.3	26.1
13	Redwing Slough	24.0	25.8
14	Schreiber Lake	23.9	24.8
15	Lakewood Marsh	23.8	24.7
16	Sterling Lake	23.6	25.4
17	Lake Marie	23.5	25.2
18	Pistakee Lake	23.5	25.2
19	Deer Lake	23.5	24.4
20	Druce Lake	23.3	26.6
21	Timber Lake (North)	23.2	24.9
22	Lake of the Hollow	23.0	24.8
23	Third Lake	22.7	25.1
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 Charles	21.3	23.6
29	Fourth Lake	21.0	23.8
30	Lake Catherine	20.8	21.8
31	Cross Lake	20.7	18.7
32	Broberg Marsh	20.5	21.4
33	ADID 203	20.5	20.5
34	McGreal Lake	20.2	22.1
35	Fox Lake	20.2	21.2
36	Honey Lake	20.0	20.0
37	Lake Barrington	19.9	21.8
38	Lake Kathryn	19.6	20.7
39	Rollins Savannah 2	18.7	19.8
40	Turner Lake	18.6	21.2
41	Salem Lake	18.5	20.2
42	Duck Lake	18.3	19.2
43	Lake Minear	18.0	20.1
44	Wooster Lake	18.0	20.1
45	Old Oak Lake	18.0	19.1
46	Lake Helen	18.0	18.0
47	Lake Zurich	17.7	18.9
48	Redhead Lake	17.7	18.7
49	Hendrick Lake	17.7	17.7
50	Long Lake	17.7	15.8
51	Gages Lake	17.3	20.1
52	Highland Lake	17.3	20.0
53	Grandwood Park Lake	17.2	19.0
54	Seven Acre Lake	17.0	15.5
55	Petite Lake	16.8	18.7
56	Lake Miltmore	16.8	18.7
57	Grays Lake	16.8	18.7
58	Channel Lake	16.8	18.7
59	Windward Lake	16.3	17.6
60	Almond Marsh	16.3	17.3

Lake County average Floristic Quality Index (FQI) ranking 2000-2019

61	Owens Lake	16.3	17.3
62	Butler Lake	16.1	18.1
63	Dunns Lake	15.9	17.0
64	Dog Bone Lake	15.7	15.7
65	Osprey Lake	15.5	17.3
66	Ames Pit	15.1	17.6
67	North Churchill Lake	15.0	15.0
68	Forest Lake	14.8	15.9
69	Dog Training Pond	14.7	15.9
70	Summerhill Estates Lake	14.5	15.5
71	Grand Ave Marsh	14.3	16.3
72	Nippersink Lake	14.3	16.3
73	Taylor Lake	14.3	16.3
74	Manning's Slough	14.1	16.3
75	Spring Lake	14.0	15.2
76	Dugdale Lake	14.0	15.1
77	Eagle Lake (S1)	14.0	15.1
78	Tower Lake	14.0	14.0
79	Hastings Lake	14.0	15.1
80	Lake Matthews	13.9	15.5
81	Longview Meadow Lake	13.9	13.9
82	Fischer Lake	13.6	14.7
83	Sand Lake	13.6	15.4
84	Bishop Lake	13.4	15.0
85	Mary Lee Lake	13.1	15.1
86	Old School Lake	13.1	15.1
87	Waterford Lake	13.1	14.3
88	Crooked Lake	13.0	14.3
89	Acorn Lake	13.0	13.0
90	Lake Tranquility (S1)	12.6	12.6
91	Potomac Lake	12.5	12.5
92	Stone Quarry Lake	12.5	12.5
93	Buffalo Creek Reservoir 1	12.5	11.4
94	Buffalo Creek Reservoir 2	12.5	11.4
95	Kemper Lake 1	12.2	13.4
96	Lake Leo	12.1	14.3
97	Lambs Farm Lake	12.1	14.3
98	Stockholm Lake	12.1	13.5
99	McDonald Lake 1	12.1	12.1
100	Pond-A-Rudy	12.1	12.1
101	Bresen Lake	12.0	13.9
102	Grassy Lake	12.0	12.0
103	Flint Lake Oulet	11.8	13.0
104	Rivershire Pond 2	11.5	13.3
105	Albert Lake	11.5	10.3
106	Deer Lake Meadow Lake	11.4	12.5
107	Hook Lake	11.3	13.4
108	Briarcrest Pond	11.2	12.5
109	Lake Naomi	11.2	12.5
110	Pulaski Pond	11.2	12.5
111	Lake Napa Suwe	11.0	11.0
112	Redwing Marsh	11.0	11.0
113	West Meadow Lake	11.0	11.0
114	Nielsen Pond	10.7	12.0
115	Lake Holloway	10.6	10.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2019

116	Sylvan Lake	10.6	10.6
117	Echo Lake	10.4	10.4
118	College Trail Lake	10.0	10.0
119	Valley Lake	9.9	9.9
120	Beaver Lake	9.9	9.9
121	Werhane Lake	9.8	12.0
122	Fish Lake	9.6	10.6
123	Lake Carina	9.5	12.5
124	Columbus Park Lake	9.2	9.2
125	Lake Lakeland Estates	9.2	9.2
126	Lake Linden	9.2	9.2
127	Bluff Lake	9.1	11.0
128	Big Bear Lake	9.1	11.0
129	Lake Fairfield	9.0	10.4
130	Heron Pond	8.6	9.9
131	Des Plaines Lake	8.6	9.9
132	Kemper Lake 2	8.5	9.8
133	Lake Christa	8.5	9.8
134	Lake Farmington	8.5	9.8
135	Lucy Lake	8.5	9.8
136	Antioch Lake	8.5	8.5
137	East Meadow Lake	8.5	8.5
138	Loch Lomond	8.5	8.5
139	South Churchill Lake	8.5	8.5
140	Lake Fairview	8.5	6.9
141	Timber Lake (South)	8.5	6.9
142	Lake Louise	8.4	8.4
143	Bittersweet Golf Course #13	8.1	8.1
144	Rollins Savannah 1	8.0	8.0
145	Countryside Lake	7.7	11.5
146	Banana Pond	7.5	9.2
147	Fairfield Marsh	7.5	8.7
148	Lake Eleanor	7.5	8.7
149	Slocum Lake	7.1	5.8
150	Lucky Lake	7.0	7.0
151	North Tower Lake	7.0	7.0
152	Lake Forest Pond	6.9	8.5
153	Little Bear Lake	6.9	9.9
154	Ozaukee Lake	6.7	8.7
155	Leisure Lake	6.4	9.0
156	Peterson Pond	6.0	8.5
157	International Mining & Chemical Lake	5.0	7.1
158	ADID 127	5.0	5.0
159	Island Lake	5.0	5.0
160	Liberty Lake	5.0	5.0
161	Lochanora Lake	5.0	5.0
162	Oak Hills Lake	5.0	5.0
163	Slough Lake	5.0	5.0
164	Diamond Lake	3.7	5.5
165	Sand Pond (IDNR)	3.5	5.0
166	Harvey Lake	3.3	5.0
167	Half Day Pit	2.9	5.0
168	Hidden Lake	0.0	0.0
169	McDonald Lake 2	0.0	0.0
170	St. Mary's Lake	0.0	0.0
171	White Lake	0.0	0.0
172	Willow Lake	0.0	0.0
173	Woodland Lake	0.0	0.0
	Mean	**14.0**	**15.0**
	Median	**13.3**	**14.5**

Lake County average Floristic Quality Index (FQI) ranking 2000-2019

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.

<u>Shoreline Buffer Condition</u>

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