LAKE COUNTY, IL

2014 SUMMARY REPORT LAKE MATTHEWS

PREPARED BY

LAKE COUNTY HEALTH DEPARTMENT

POPULATION HEALTH – ECOLOGICAL SERVICES

Lake Matthews, 2014

Lake Matthews is a 9 acre lake in Grant Township of unincorporated Lake County. It is primarily in a residential setting and part of the larger Chain O'Lakes waterway system. It has a channel with direct access to Pistakee Lake, which is used by many homeowners to gain access with their motorboats to the larger lakes within the Fox Chain. The Pistaqua Heights Improvement Association owns lake bottom and has a beach, boat launch, boat slips, and a park for their members. The lake was constructed by dredging in 1922. The current maximum water depth of Lake Matthews is 5 ft. with an average water depth of 2.5 ft.

In 2014, the Lake County Health Department– Ecological Services (LCHD-ES) selected Lake Matthews to be monitored along with 12 other lakes in the Fox Chain O'Lakes. Water samples were taken once a month at the deepest location in the lake from May to September (Appendix A, Figure 1). Due to the shallow nature of Lake Matthews, water samples were only collected near the surface instead of multiple depths. The shallow depth means that Lake Matthews does not thermally stratify. Rather than dividing into a warm upper water layer (epiliminion) and cool lower water layer (hypoliminion) Lake Matthews instead stays well mixed throughout the ice free season. This report summarizes the water quality sampling results and the aquatic plant survey on Lake Matthews by the LCHD-ES.

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LAKE FACTS

MAJOR WATERSHED:
FOX RIVER

SUB-WATERSHED:
UPPER FOX RIVER

SURFACE AREA:
8.76 ACRES

SHORELINE LENGTH:
0.71 MILES

MAXIMUM DEPTH:
5 FEET

AVERAGE DEPTH:
2.5 FEET

LAKE VOLUME:
21.9 ACRE-FEET

LAKE TYPE:
MAN-MADE

CURRENT USES:
FISHING, SWIMMING, BOATING, AESTHETICS

LAKE MATTHEWS SUMMARY

Lake Matthews, along with the Fox Chain O'Lakes, is designated as public waters by the Illinois Department of Natural Resources. This means the Fox Chain O'Lakes is a navigable waterbody and open or dedicated to the public use. The area is one of the busiest inland recreational waterways per acre in the United States with weekend usage around 60,000 people, and up to 100,000 people on weekends. The Chain O'Lakes, and all navigable channels directly connected to these lakes, are under jurisdiction of the Fox Waterway Agency, a regional body of government that was created by the State of Illinois in 1984 to manage the Fox Chain. A permit is required for aquatic herbicide treatment or for other lake alterations.

Due to the shallow nature of Lake Matthews, the water clarity is poor, clouded by suspended sediment and algae. Following are highlights of the water quality and aquatic macrophyte surveys from the 2014 monitoring season. The complete data sets for water quality and aquatic plant sampling conducted on Lake Matthews can be found in Appendix A of this report, and discussed in further detail in the following sections.

- In 2014, the average water clarity of Lake Matthews was 1.48 ft., which is a 5% increase since 2002 but remains below the Lake County median Secchi depth of 2.95 ft. by almost half.
- Water clarity is influenced by the amount of particles in the water column; this is measured by total suspended solids (TSS). The average TSS concentration on Lake Matthews was 25 mg/L in 2014 which is also above the Lake County median of 8.2 mg/L.
- The 2014 average total phosphorus concentration was 0.118 mg/L for Matthews Lake, which exceeds the Illinois Environmental Protection Agency (IEPA) impairment level of 0.05 mg/L. Algae is able to thrive in Lake Matthews due to phosphorus concentrations in the water that are more than twice as high as the median phosphorus concentration of other lakes throughout Lake County.
- Phosphorus can also be used as an indicator for trophic states by using the trophic state index (TSIp). The TSIp for Lake Matthews was 73. This TSIp value indicates that Lake Matthews is hypereutrophic states and it is ranked 130 out of 173 lakes in Lake County for TSIp values.
- Dissolved oxygen (DO) concentrations remained above 5 mg/L throughout the water column from surface to lake bottom throughout the entire season
- Dissolved oxygen concentrations never reached anoxic conditions (<1 mg/L).
- Results from the aquatic plant survey conducted in July 2014 showed 95% of the sampling sites had plant coverage. To maintain a healthy fishery, the Illinois Department of Natural Resources suggests plant coverage of 20% to 40%.
- Eurasian Watermilfoil (EWM), exotic invasive species, was found at 73% of the sampling sites. It was a dominant species in Lake Matthews.
- A total of 5 plant species were present with the most common being Coontail.
- Lake Matthews has one official state licensed swimming beach at Pistaqua Heights. From 2004 to 2014 there were four samples with high E.coli that issued a beach closure at Pistaqua Heights, occurring 2010 and 2012. During the 2014 monitoring season, there were no beach closures.

Lake Matthews is part of the Fox River Watershed, which spans both Wisconsin and Illinois.

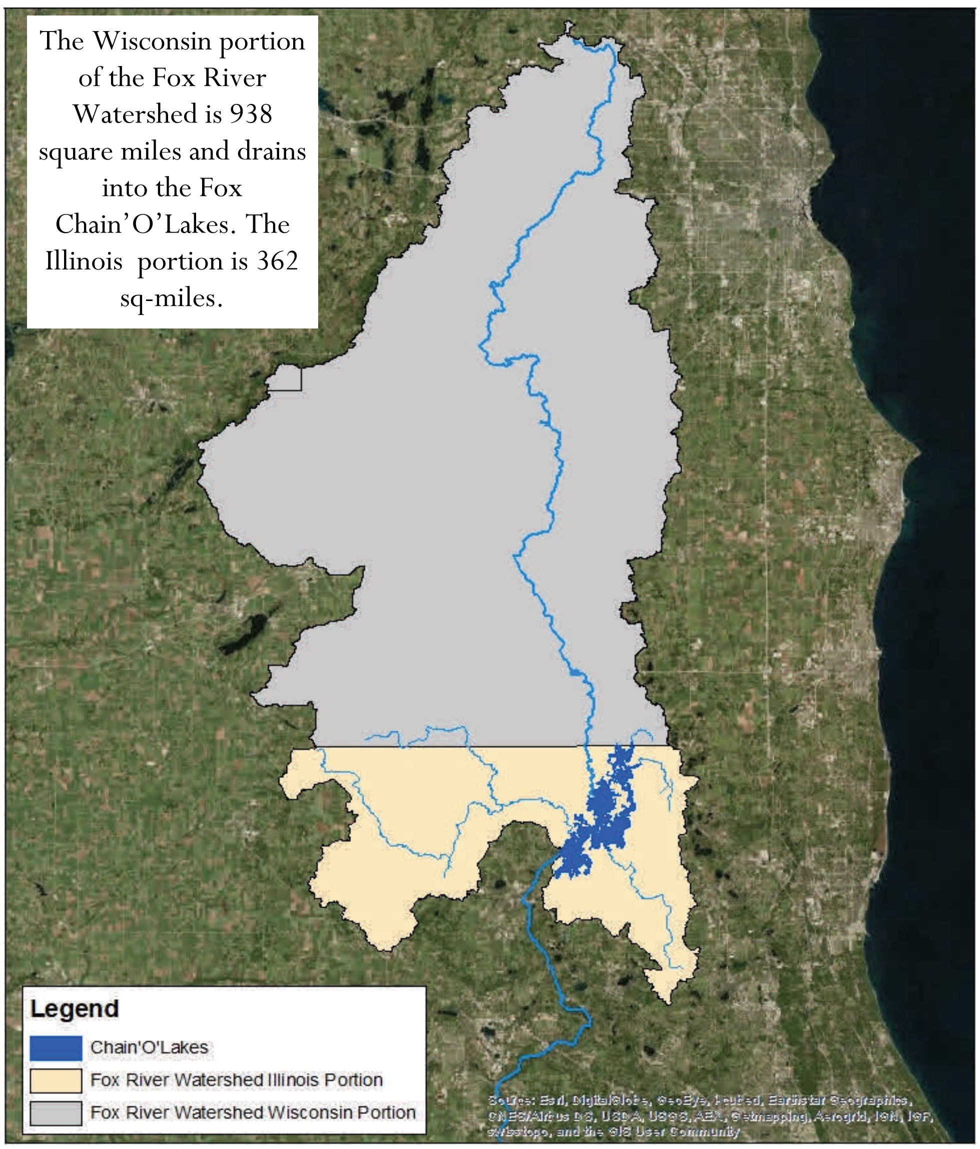
LAKES SAMPLED IN 2014

BANGS LAKE
BLUFF LAKE
CEDAR LAKE
CHANNEL LAKE
CRANBERRY LAKE
COUNTRYSIDE LAKE
DUNNS LAKE
FOX LAKE
GRASS LAKE
LAKE CATHERINE
LAKE MARIE
LONG LAKE
MATTHEWS LAKE
NIPPERSINK LAKE
PETITE LAKE
PISTAKEE LAKE
REDHEAD LAKE
SPRING LAKE
THIRD LAKE
WOOSTER LAKE

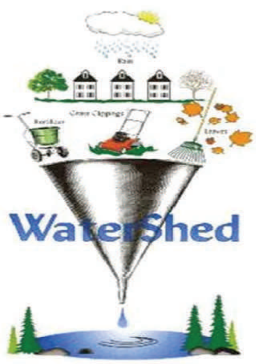
WATERSHED

Lake Matthews is part of the Chain O' Lakes drainage basin of the Fox River Watershed. The Fox River Watershed is a large watershed that spans both Illinois and Wisconsin. The Fox River Watershed has its headwaters in Wisconsin and flows south into Illinois and eventually discharges into the Illinois River. The Fox Chain'O'Lakes are a result of the last episode of glaciation, that left depressions filled with meltwater, forming the current lakes. The Chain'O'Lakes is composed of ten lakes connected by the Fox River and another five lakes that are connected by small canals and channels that can have limited access.

The Wisconsin portion of the Fox River Watershed is approximately 600,000 acres (938 sq-miles). The Illinois portion of the Upper Fox River Watershed drains land from McHenry and Lake counties and is approximately 2.5 times smaller than the Wisconsin portion of the watershed at about 230,000 acres (362 sq-miles). Land use upstream in Wisconsin plays a significant role in the water quality of the Chain O'Lakes. Since the Fox Chain O'Lakes have such a large drainage basin and a significant source of water flow from the Fox River and its tributaries, the inflow of water can carry more nutrients and sediments into the lakes. The large watershed makes it difficult to identify possible pollution sources, especially for nonpoint source pollution.



Everyone lives in a watershed! A watershed is an area of land where surface water from rain and melting snow meet at a point, such as a lake or stream.

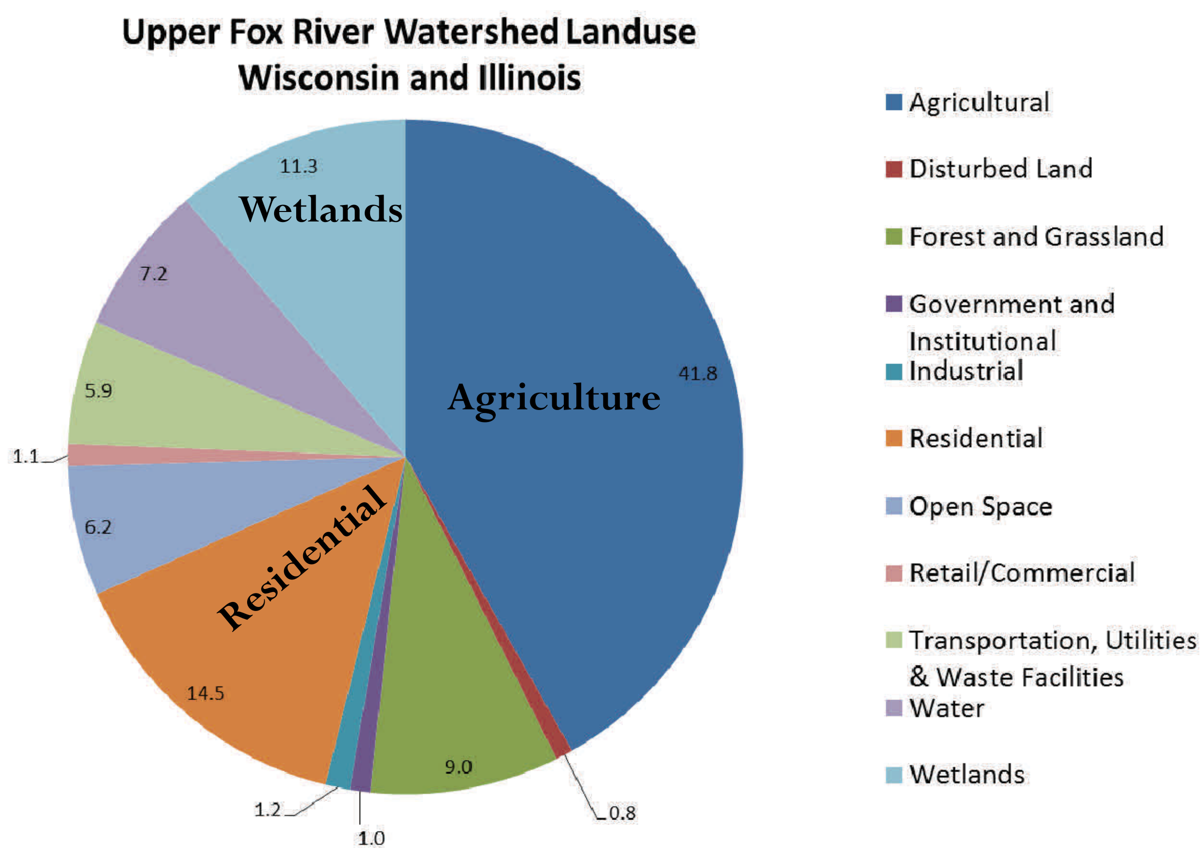


WATERSHED

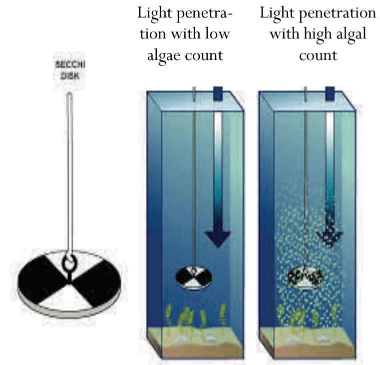
A general definition of a watershed is an area of land where all surface water from rain, melting snow and ice, converge at a lower elevation, usually a lake, river, or other body of water. Lake Matthews and the land surrounding it drains into Pistakee Lake. The majority of the landowners around the lake belong to the Pistaqua Heights Improvement Association. Pistaqua Heights Improvement Association also owns the lake bottom of Matthews. Lake Matthews has a heavily developed shoreline within a residential setting, and mostly armored with riprap with mowed lawn to the waters edge. Residents around Lake Matthews mostly use the lake for access to the larger lakes in the Fox chain, fishing from shore, and swimming.

The dominant land use for the entire watershed that drains to the Fox Chain O'Lakes, including Illinois and Wisconsin, is agriculture (42%) followed by residential (14.5%), wetlands (11.3%), and woodlands (9%) (Figure 1). While agricultural land is the most dominant in the watershed, there has been a progression of land use change from agriculture to residential uses over time in the region. The large portion of the watershed that is agriculture likely plays a significant role in the high concentrations of sediment and nutrients in the Fox Chain O'Lakes. Agricultural land use in Wisconsin is 48.4% of the watershed compared to 28.6% agricultural in Illinois. Near shore land use in the Fox Chain is primarily residential and wetlands/water – with municipalities also located near the lakes. Impervious surfaces (parking lots, roads, buildings, compacted soil) do not allow rain to infiltrate into the ground; a greater amount of runoff is generated than in more natural areas that allow water to infiltrate. Urbanized and built up areas account for approximately 24.5% of the watershed. Understanding dominant land uses can aid in the choosing appropriate management techniques for the watershed and individual lakes and help with targeting educational material.

Figure 1



WATER CLARITY



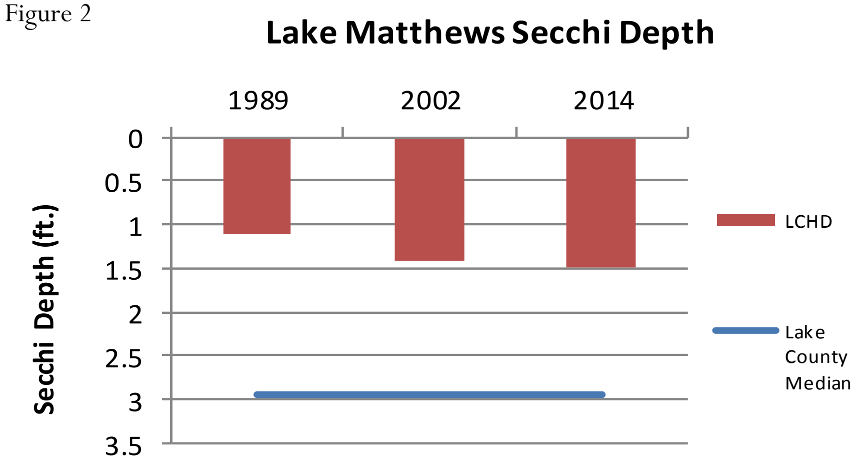
Water clarity, or water transparency, is an indicator of water quality related to chemical and physical properties.

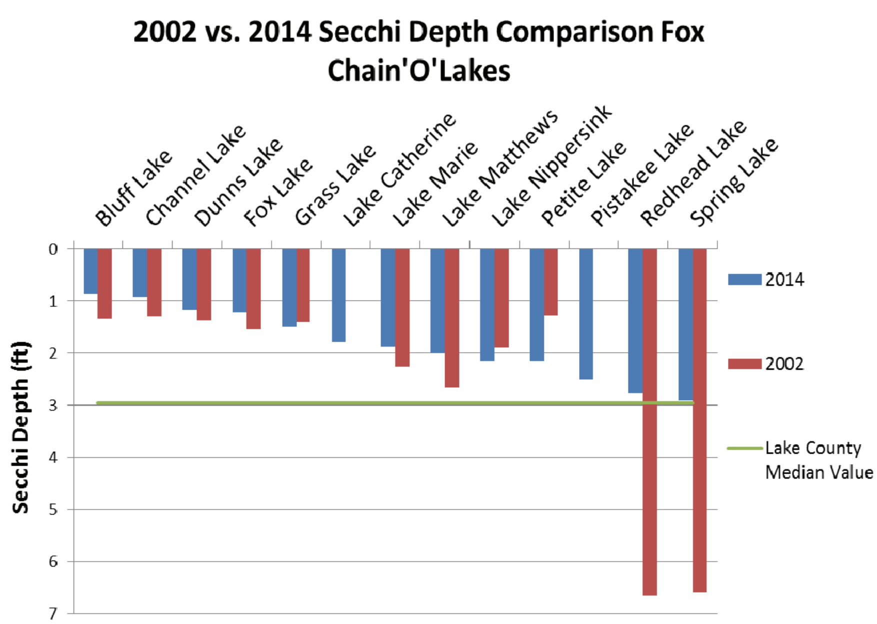
Water clarity is typically measured with a Secchi disk and indicates the amount of light penetration into a body of water. It can also provide an indirect measurement of the amount of suspended material in water (see the total suspended solids sections) A number of factors can interfere with light penetration and reduce water transparency. This includes: algae, water color, re-suspended bottom sediments, and eroded soil.

The 2014 average water clarity in Lake Matthews was 1.48ft, only a slight increase of 5% since the 2002 sampling (1.41ft) (Figure 1). Compared to other lakes in Lake County, Lake Matthews is below the median Lake County Secchi depth of 2.95 ft. (Figure 3). The Secchi disk depth remained fairly constant throughout the season with the greatest depth occurring in August (1.8 ft) and the shallowest depth occurring in September at 1.1 ft.

LAKE MATTHEWS AVERAGE SECCHI WAS 1.48 FT.,WHICH IS BELOW THE LAKE COUNTY MEDIAN

Figure 2





WHAT YOU CAN DO TO IMPROVE WATER QUALITY IN

- Do not throw leaves, grass clippings, pet waste, and other organic debris into the street or driveway. Runoff carries these through storm sewers, directly into Lake Matthews.
- Build a rain garden to filter run-off from roofs, driveways, and streets. This allows the phosphorus to be bound to the soil so it does not reach surface waters
- Sweep up fertilizer that is spilled or inadvertently applied to hard surface areas, do not hose it away.

VOLUNTEER LAKE MONITORING PROGRAM (VLMP)

The VLMP was established in 1981 by the Illinois Environmental Protection Agency (IEPA) to be able to collect information on Illinois inland lakes, and to provide an educational program for citizens. The volunteers are primarily lakeshore residents, lake owners/managers, members of environmental groups, and citizens with interest in a particular lake.

The VLMP relies on volunteers to gather information on their chosen lake. The primary measurement by volunteers is Secchi depth (water clarity). Water clarity can provide an indication of the general water quality of the lake. Other observations such as water color, suspended algae and sediment, aquatic plants and odor are also recorded. The sampling season is May through October with measurements taken twice a month. In 2014, there were 59 lakes participating in Lake county.

Currently Lake Matthews is in need of a volunteer lake monitor. It is recommended that Lake Matthews participates in VLMP. Participating provides annual data that helps document water quality impacts and support lake management decisions.

LAKE MONITORING
VOLUNTEER PROGRAM
ILLINOIS

For more information visit:

www.epa.state.il.us/water/vlmp/index.html

PLEASE CONSIDER PARTICIPATING IN THE VOLUNTEER LAKE MONITORING PROGRAM ON LAKE MATTHEWS.

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TOTAL SUSPENDED SOLIDS

Another measure of water clarity is turbidity. Suspended particles dissipate light, which affects the depth at which plants can grow. The total suspended solid (TSS) parameter represents the concentration of all organic and inorganic materials suspended in the lake's water column. Typical inorganic components of TSS is referred to as non-volatile suspended solids (NVSS). NVSS originate from weathering and erosion of rocks and soils in the lake's watershed and re-suspension of lake sediments. The organic portion of TSS is called volatile suspended solids (TVS). TVS is mostly composed of algae and other organic matter such as decaying plant and animal matter.

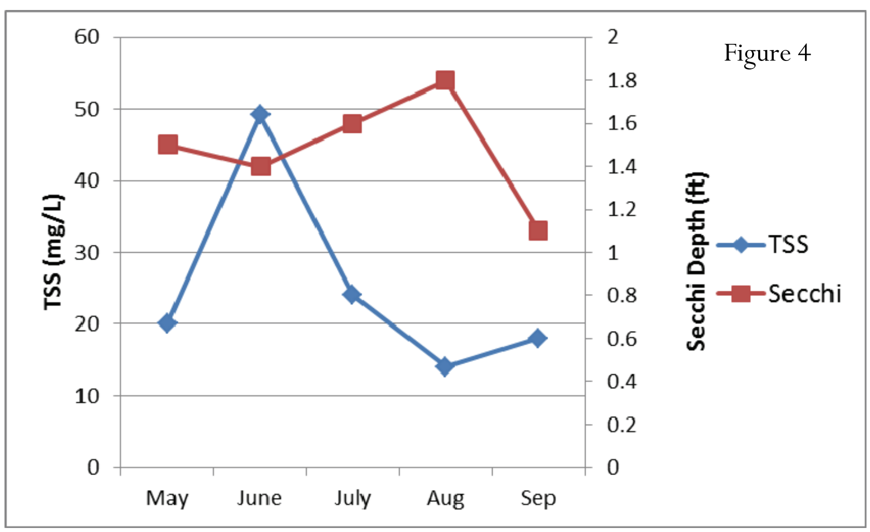


Figure 4: Secchi depth and TSS are inversely related, meaning when there are high TSS concentrations there are low Secchi

TOTAL SUSPENDED SOLIDS

2014 TSS concentrations in Lake Matthews averaged 25.0 mg/L which is 3 times greater than the Lake County median of 8.2 mg/L. TSS also showed an increase since the 2002 sampling by 18%. High TSS values typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of lake ecosystem including the plant and fish communities. Since Lake Matthews is shallow, it is easily impacted by wave, wind, boating, and carp action that can churn up the bottom sediments creating murky waters in the water column. TSS ranged from 14.0 mg/L (August) to 49.2 mg/L (June).

The calculated average nonvolatile suspended solids (NVSS) was 14.2 mg/L. Almost half of the TSS concentration in 2014 can be contributed to sediment particles. The June TSS concentration was 49.2 mg/L with a calculated NVSS of 29.4 mg/L. This means that 59% of the suspended solids in the water can be attributed to sediment in June. The increase in turbidity could have been caused by heavy rainfall events occurring in June(6.93 inches of precipitation), washing in sediments that became suspended in the water column. In addition, Lake Matthew's high TSS can be attributed to wind and wave action, enhanced by boating and the presence of carp and algae.

There was also algae and organic matter in the water column. The average TVS for the monitoring season was 132.2 mg/L which is above the county median of 121.0 mg/L. Algae also increase TSS concentrations in the water.

TSS

Total Suspended Solids

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

TVS

Total Volatile Solids

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

NVSS

Non-Volatile Suspended Solids

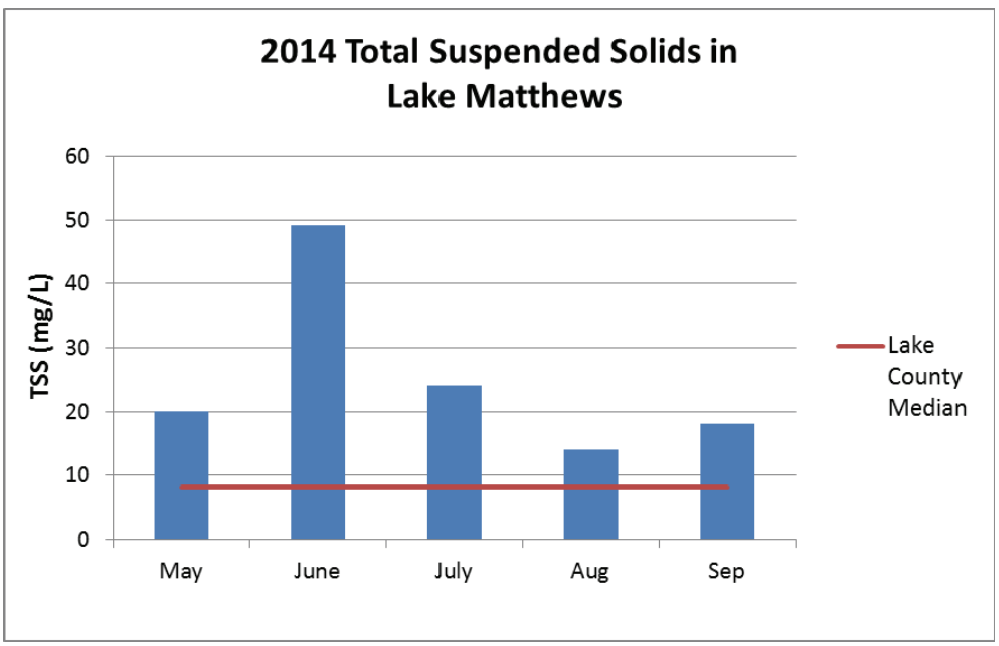
NVSS represents the non-organic clay and sediments that are suspended in the water column.

TDS

Total Dissolved Solids

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

There was a an 18% increase in TSS on Lake Matthews since 2002 sampling.



Month	2014 TSS (mg/L)	2002 TSS (mg/L)
May	20.0	17.0
June	49.2	9.9
July	24.0	28.0
August	14.0	31.1
September	18.0	20.0
Average	*25.0*	*21.2*

NUTRIENTS: PHOSPHORUS

Organisms take nutrients in from their environment. In a lake, the primary nutrients needed for aquatic plant and algal growth are phosphorus (P) and nitrogen (N). Phosphorus is a vital nutrient for converting sunlight into usable energy and essential for cellular growth and reproduction. Phosphorus occurs in dissolved organic and inorganic forms. Phosphates, the inorganic form, are preferred for plant growth but other forms can be used. Phosphorus also easily attaches to sediment particles, meaning phosphorus can build up in the sediments of a lake. When it remains in the 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 and be available in the water column. For instance, carp can churn up the bottom of lake re-suspending sediment and phosphorus into the water column. During anoxic conditions, P can be released from sediment, and then mixed in the water column when the lake de-stratifies. This is known as "internal phosphorus loading" and can be a source of algae blooms.

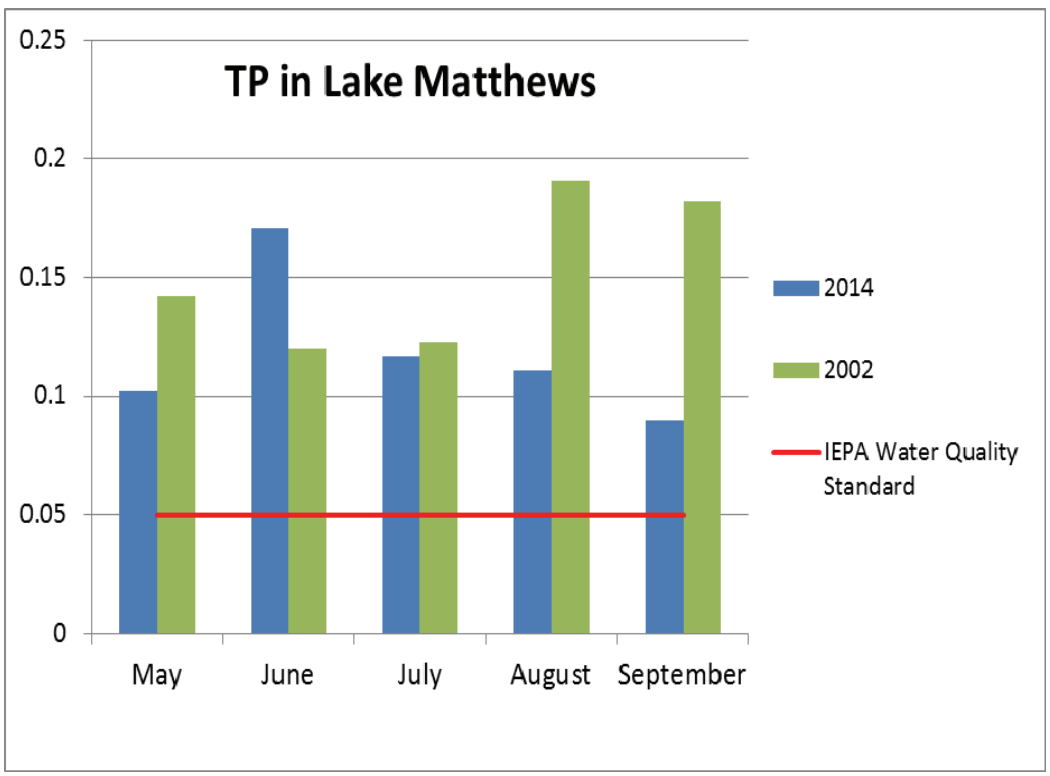
2014 phosphorus concentrations in Lake Matthews averaged 0.118 mg/L. Average TP values are above the Lake County median (.068 mg/L), but there was a decrease in P concentrations since 2002 from 0.152 mg/L (2002) to 0.118 mg/L (2014). Surface total phosphorus in Lake Matthews exceeded 0.05mg/L and is considered impaired by the IEPA. High levels of phosphorus may support high densities of algae and aquatic plants, which can reduce water clarity and dissolved oxygen. Lake Matthews exceeded the .05 mg/L value in all sampling months and has one of the highest average TP values on the Fox Chain. June had the highest TP concentration of 0.171 mg/L and September had the lowest at 0.090 mg/L.

WHAT HAS BEEN DONE TO REDUCE PHOSPHORUS LEVELS IN ILLINOIS?

2007- The Village of Antioch passed an ordinance banning the use of fertilizers containing phosphorus and fertilizer restriction within 10 feet of waterways.

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.



Month	TP (mg/L)
May	0.102
June	0.171
July	0.117
August	0.111
September	0.090
Average	*0.118*

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. Inorganic nitrogen did not exceed these levels in Lake Matthews during the sampling season. NO3 was below the detection limit for all samples during the season.

Total Kjeldahl nitrogen is a measure of organic nitrogen, and is typically bound up in algal and plant cells. Average total Kjeldahl nitrogen (TKN), an organically (algae) associated form of nitrogen, in Lake Matthews was 1.91 mg/L, which is higher than the Lake County median of 1.170 mg/L.

The TN:TP ratio looks at TKN + NO3 to total phosphorus. This ratio can indicate whether plant and algae growth in a lake is limited by nitrogen of phosphorus. Typically ratios of less than 10:1 suggest the lake is limited by nitrogen, while ratios greater than 20:1 are limited by phosphorus. Lake Matthews has a TN:TP ratio of 16:1, meaning the lake is not necessarily limited by either

TN:TP Ratio

<10:1 = nitrogen limited

>20:1= phosphorus limited

TN:TP Ratio on Matthew's:

16:1

Lake Matthews is influenced by both nutrients

WAYS TO REDUCE NUTRIENTS IN YOUR LAKE

Phosphorus and nitrogen originates from a variety of sources, many of which are related to human activities. Some sources include: human and animal waste, soil erosion, detergents, septic systems, common carp, and runoff from lawns and fields, fertilizers, manure and atmospheric deposition. Installing best management practices, such as buffer strips, planting more native plants, rain gardens, and using minimal amount of fertilizer are ways to help reduce nutrient runoff from your own property.

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! Avoid fertilizing before heavy precipitation events.
- 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.

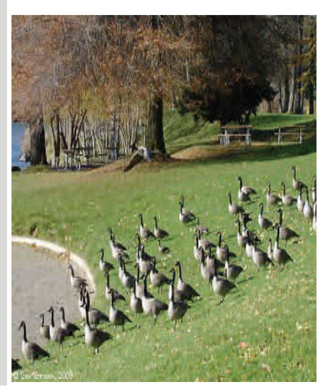
Landscaping Practices

- 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.

Regularly inspect septic systems



TROPHIC STATE INDEX

Trophic states are another indicator of water quality and can describe lake productivity. The Trophic State Index (TSI) value is based on phosphorus (TSIp) and secchi (TSIsd) and are calculated from the monitoring data. Lakes are classified into four main categories of trophic states that reflect nutrient levels and productivity. The 4 categories are: oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic. These range from nutrient poor and least productive to most nutrient rich and most productive.

A lake's response to additional phosphorus is an accelerated rate of eutrophication. Eutrophication is a natural process where lakes become increasingly enriched with nutrients. Lakes start out with clear water and few aquatic plants and over time become more enriched with nutrients and vegetation until the lake becomes a wetland. This process takes thousands of years. However, human activities that supply lakes with additional phosphorus and nitrogen (such as fertilizer, household products, waste by-products, etc.) are accelerating the eutrophication process.

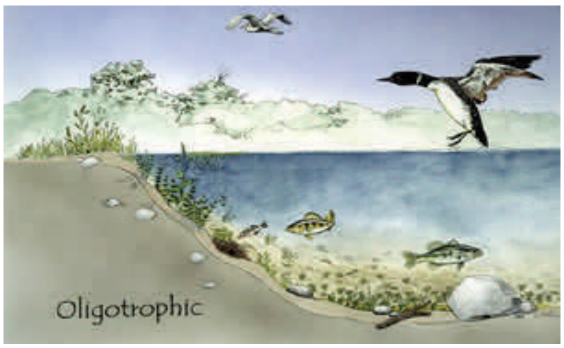
In 2014, Lake Matthews was considered hypereutrophic with a TSIp value of 73. Based on the TSIp, Lake Matthews ranked 130 out of 173 lakes studied by the LCHD-ES from 2000 –2014.

TN:TP RATIO:
16:1

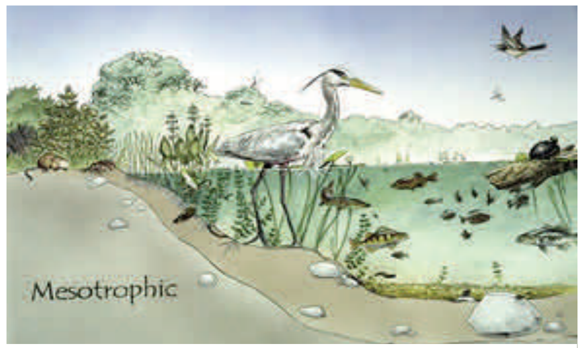
LAKE COUNTY AVERAGE
TSIP = 67.7

LAKE MATTHEWS
TSIP = 73

RANK
130/173

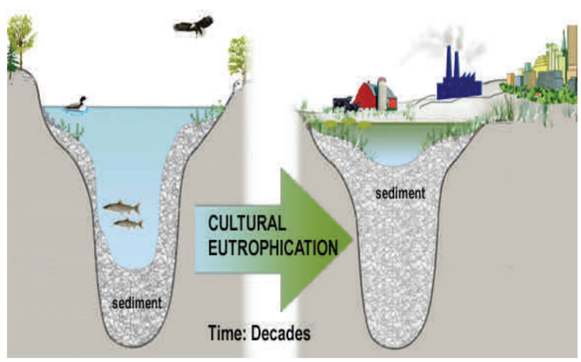


OLIGOTROPHIC
Lakes have low nutrients and are generally deep and free of weeds or large algae blooms. They do not support large fish populations.



MESOTROPHIC
Lakes have medium nutrients and intermediate level of productivity. Mesotrophic lakes typically have clear water with beds of submerged aquatic plants. Mesotrophic lakes can have a diverse fish population.

EUTROPHIC
Lakes are high in nutrients, and are usually weedy or subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are also susceptible to oxygen depletion. Increased sedimentation also is typical of eutrophic lakes



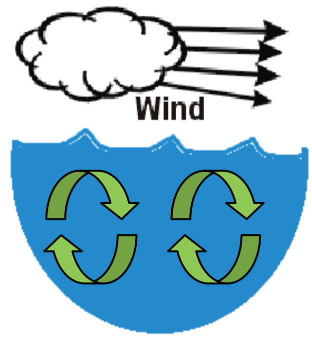
CULTURAL EUTROPHICATION
An enrichment and accumulation of a lake with nutrients, sediments, and organic matter from the surrounding watershed. It can be a natural process in lakes, occurring as they age through geologic time. Human activity occuring in the watershed can accelerate eutrophication, known as cultural eutrophication. This can lead to increased algal growth, increased rooted plant growth, and lower dissolved oxygen concentrations.

STRATIFICATION

A lake's water quality and ability to support fish are affected by the extent to which the water mixes. The depth, size, and shape of a lake are the most important factors influencing mixing, but climate, lakeshore topopgraphy, inflow from streams and vegetation also play a role. Variations in density caused by different temperatures can prevent warm and cold water from mixing, forming layers of different temperatures and densities called stratification.

Thermal stratification is when a lake divides into an upper, warm water layer (epiliminion) and a lower, cold water layer (hypoliminion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically experiences anoxic conditions, where dissolved oxygen (DO) concentrations drop below 1mg/L.

Lake Matthews is a shallow lake and did not thermally stratify during the summer months. Lake temperatures remained fairly constant throughout the depth of the lake. Lake Matthews is considered a polymictic lake, a lake that does not stratify and can continually mix during the ice free season.



Shallow lakes, like Lake Matthews, are more prone to mixing from wind and wave action. Redhead Lake is considered polymictic—which means it does not stratify and can mix throughout the ice free season.

DISSOLVED OXYGEN

Dissolved oxygen (DO) concentrations in Lake Matthews were adequate (>5.0 mg/L) throughout the monitoring season. This is due to the lake's shallow morphometry, which helps keep Lake Matthews well mixed. Average DO concentrations ranged from 8.6 mg/L (August) to 12.3 mg/L (September). Hypoxic conditions (DO<1.0 mg/L) never occurred. When DO concentration drop below 1.0 mg/L, biological and chemical processes release nutrients into the water, which are sequestered in the hypolimnion due to stratification and can be released into the surface waters. However, since stratification and anoxic conditions did not form in Lake Matthews this type of nutrient release is not an issue on the lake. Shallow lakes can experience increases algae productivity due to excess nutrients. When the algae die and decompose, the lake could experience low DO concentrations. It is important for home-owners to install BMPS to reduce nutrient runoff into Lake Matthews.

ALKALINITY AND PH

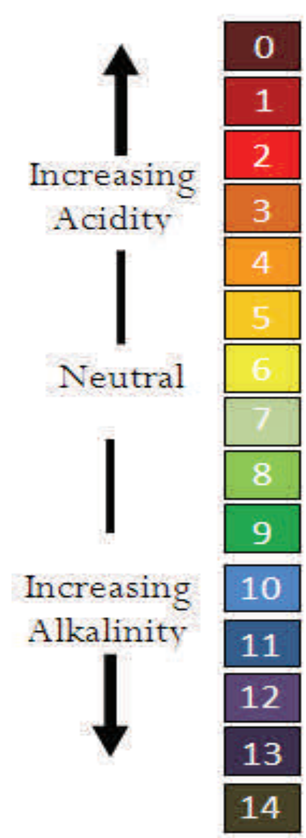
Alkalinity is the buffering capacity of a water body. It measures the ability of water bodies to neutralize acids and bases to maintain a stable pH. In a lake, alkalinity acts to buffer lakes from the effects of acid rain. Alkalinity comes from rocks, soils, salts, and certain plant activities. If a lakes watershed contains large quantities of calcium carbonate ($CaCO_3$, limestone), the surface waters tend to be more alkaline.; while granite bedrock does not have high amounts of $CaCO_3$ and therefore lacks alkaline materials to buffer acidic inputs.

In 2014, the average alkalinity ($CaCO_3$) concentration in Lake Matthews was 202 mg/L which is 35% greater than the Lake County median of 161 mg/L. The USEPA considers lakes with $CaCO_3$ 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 goes up or halts its decline. A well buffered lake also means that daily fluctuations of CO_2 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 Matthews average pH in 2014 was 8.25 which is in the normal range for Lake County waters.

The pH scale



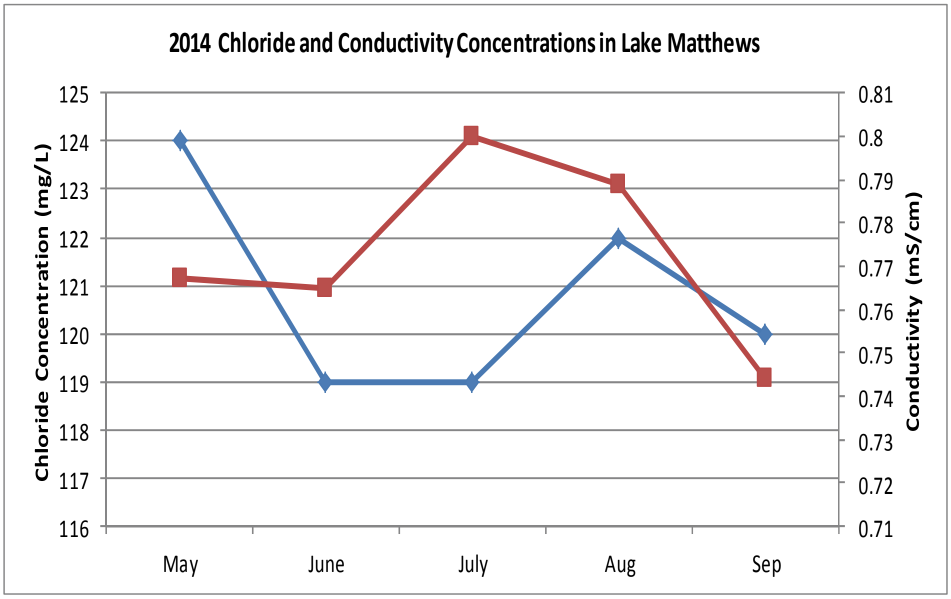
CONDUCTIVITY AND CHLORIDES

Another parameter measured during the 2014 is conductivity. Conductivity is the measure of different chemical ions in solution and is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate and phosphotate anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron, and aluminum cations (ions that carry a positive charge). As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the watershed geology, size of the watershed flowing into the lake, the 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 2014, Lake Matthews average conductivity was 0.7730 mS/cm. This is below the county median of 0.7900 mS/cm. This parameter increased since the 2002 sampling by 8% increase.

One of the most common dissolved solids is road salt used in winter road deicing. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocynaide salts. Lake Matthews 2014 average chloride concentration was 121 mg/L which is also below the Lake County median of 139 mg/L. The United States Environmental Protection agency has determined that chloride concentrations higher than 230 mg/L can disrupt aquatic systems. 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. Educating residents and townships about proper salting and de-icing methods can help protect water quality.

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

- De-icers 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.

Pavement Temp (F)	One Pound of Salt (NaCl) melts	Melt times
30	46.3 lbs of ice	5 min.
25	14.4 lbs of ice	10 min.
20	8.6 lbs of ice	20 min.
15	6.3 lbs of ice	1 hour
10	4.9 lbs of ice	Dry salt is ineffective and will blow away before it melts anything

BEACHES

Kerry McCaughey LCHD Lab staff uses black light technology to report E. coli beach data.

There is one official state licensed swimming beach on Lake Matthews at Pistaqua Heights. This sites have been monitored every two weeks from mid May to the end of August by LCHD-ES since 2004. The water samples are tested for E. coli bacteria, which are found in the intestines of warm-blooded animals. While not all strains of E. coli are the same, certain strains can make humans sick if ingested in high enough concentrations. If water samples come back high for E. coli (>235 E. coli/100 ml), the management body for the bathing beach is notified and a sign is posted indicating the swim ban. E. coli is used as an indicator organism, meaning that high concentrations of E. coli might suggest the presence of harmful pathogens such as, Salmonella, Giardia, etc.

From 2004 to 2014 there were four samples with high E.coli that issued a beach closure at Pistaqua Heights. Two of these were in 2010 and the other two were in 2012.

There are many ways E.coli can end up in a swimming beach. Heavy rainfall and strong wind associated with storms can cause the water to become cloudy with sediment from the lake bottom. Stormwater from rain can also wash in other particles from lawns, streets, and buildings. This sediment and stormwater may contain high concentrations of E. coli. Another source of E. coli contamination is the feces of gulls, geese, and other wildlife.

LAKE MATTHEWS HAD ONLY 4 BEACH CLOSURES RELATED TO BACTERIA LEVELS BETWEEN 2004– 2014. THERE WERE ZERO CLOSURES IN 2014.

YEAR	# OF CLOSURES
2010	2
2012	2

How to prevent illness and beach closure

Practicing common sense and good hygiene will go a long way in preventing illness from swimming beaches.

- If you are sick or have diarrhea, do NOT swim.
- Do NOT drink the water while swimming.
- Avoid swimming during heavy algae blooms.
- Keep pets, ducks, and geese out of the beach area
- Children who are not toilet trained should wear tight-fitting rubber or plastic pants.
- Take a shower before entering the water, and have kids take frequent bathroom breaks.
- Wash your hands after exiting the lake.
- Avoid swimming during algae blooms
- Identify sources of pollution (ex: failing septic systems, stagnant standing water near the

BLUE-GREEN ALGAE

Algae are important to freshwater ecosystems and most species of algae are not harmful. Algae can grow quickly in water and is often associated with increased concentrations of nutrients such as nitrogen and phosphorus. Blue-green algae, or "cyanobacteria" are a type of algae that can bloom and produce toxins, which are similar to bacteria in structure but utilize photosynthesis to grow. They have no nucleus and lack the photosynthetic pigments found in algae. They usually are too small to be seen individually, but can form visible colonies that can cover large areas of lakes. Certain species of blue-green algae can produce toxins that could pose a health risk to people and animals when they are exposed to them in large enough quantities.

Blooms can last for an extended period of time and can deplete the oxygen and block sunlight in the water that other organisms needs to live. The water can appear blue-green, bright green, brown, or red and may look like paint floating on the water. Not all blue-green algae produce harmful toxins. The three types of cyanobacteria that are often associated with Harmful Algal Bloom (HAB) are the Anabaena, Aphanizomenon, and Microcystis. The presence of these cyanobacteria does not generally mean that the toxins are present in the water. The presence of toxins can only be verified through a sample analyzed in the lab.

Six samples were collected at Pistaqua Heights Beach on Lake Matthews during 2013. All samples were above the detectable limit but zero samples had microcystin concentrations greater than 20 ug/L. Samples over 20 ug/L have potential health risks associated with recreational exposure to elevated concentrations of microcystin and the EPA recommends not to swim in the lake. The average on Lake Matthews was 1.24 ug/L.

Poisoning has caused the death of cows, dogs, and other animals. Most human cases occurred when people swim or ski in affected recreational water bodies during a bloom.

If you suspect that you are experiencing symptoms related to exposure to blue-green algae such as stomach cramps, diarrhea, vomiting, headache, fever, muscle weakness, or difficulty breathing contact your doctor or the poison control center.

Blue-green algae bloom are frequent in backwater areas and are becoming more common occurrences on various areas in the Fox Chain.

For more information or to report a blue-green algae bloom, contact the Lake County Health Department Environmental Services (847) 377-8030.

Lake Matthews	Value
# HAB Samples Collected	6
# of Non-Detect Samples	0
Average of Detectable samples (ug/L)	1.24
Median of samples (ug/L)	0.43
samples >20 ug/L	0

Photo: Summer blue-green algal bloom in the Fox Chain in 2014

FOR MORE INFORMATION ON BLUE-GREEN ALGAE:
www.epa.state.il.us/water/surface-water/blue-green-algae.html

TO REPORT BLUE-GREEN ALGAE BLOOM:
Lake County Health Department
847-377-8030

Anabaena Sp.

Microcystis Sp.

Aphanizomenon Sp.

Bathymetric maps

Bathymetric maps, also known as depth contour maps, 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 how much of the lake loses dissolved oxygen in the summer, 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.

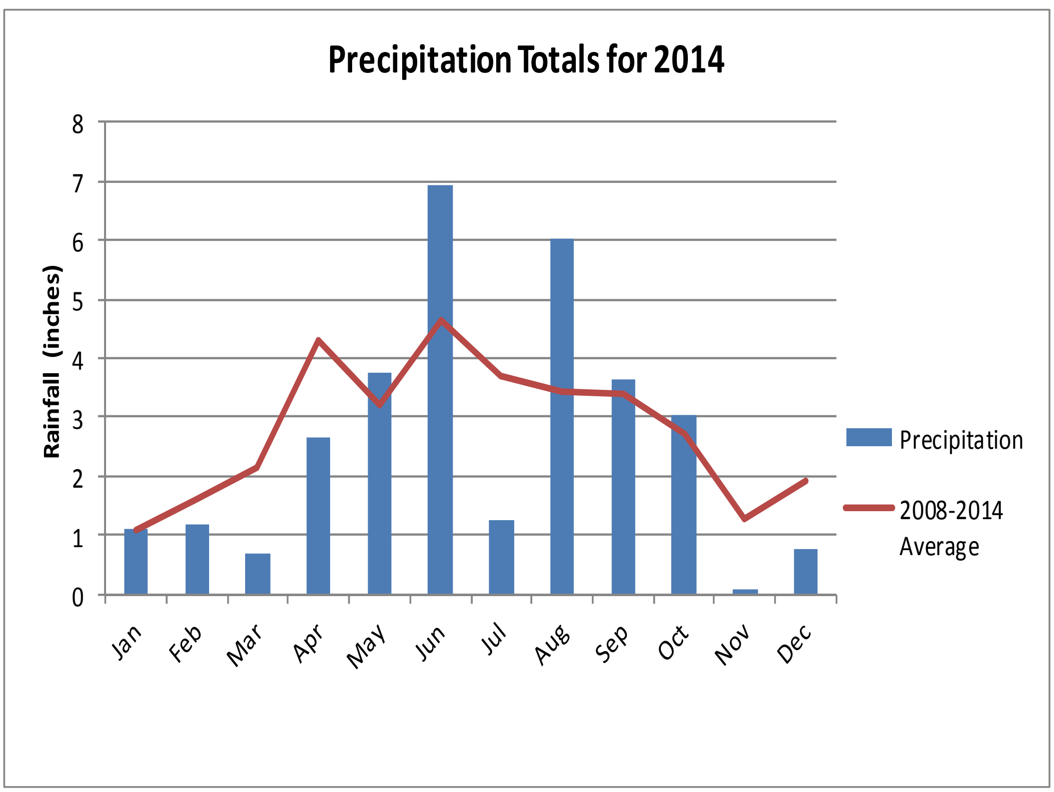
The LCHD-ES collects field data using Biosonics equipment along with a Trimble GPS unit with sub-foot accuracy. Once collected, the data will be analyzed and imported into ArcGIS for further analysis. In ArcGIS, the contours are drawn and the lake volume is calculated. The Lake County-ES has created bathymetric maps for many of the larger lakes in the county.

The LCHD-ES recommends the creation of an updated bathymetric map for all lakes larger than six acres and can provide the names of several companies that can be hired to do the work. If you are interested in the creation of a bathymetric map of your lake, please contact the LCHD-ES at (847) 377-8030.

Bathymetric maps provide Lake managers with an accurate Lake volume that can be used for herbicide application and help anglers find potential fishing spots.

Precipitation

Precipitation data was obtained from the Lake County Stormwater Management Commission that has several climate monitoring stations. Long Lake, just south-east of the Fox Chain was used to determine monthly precipitation totals. In 2014, May, June, and August were wet months, with rainfall for June and August being greater than 6 inches in precipitation. Heavy precipitation events can be a significant contributor to sediment and nutrients to the overall lake system.

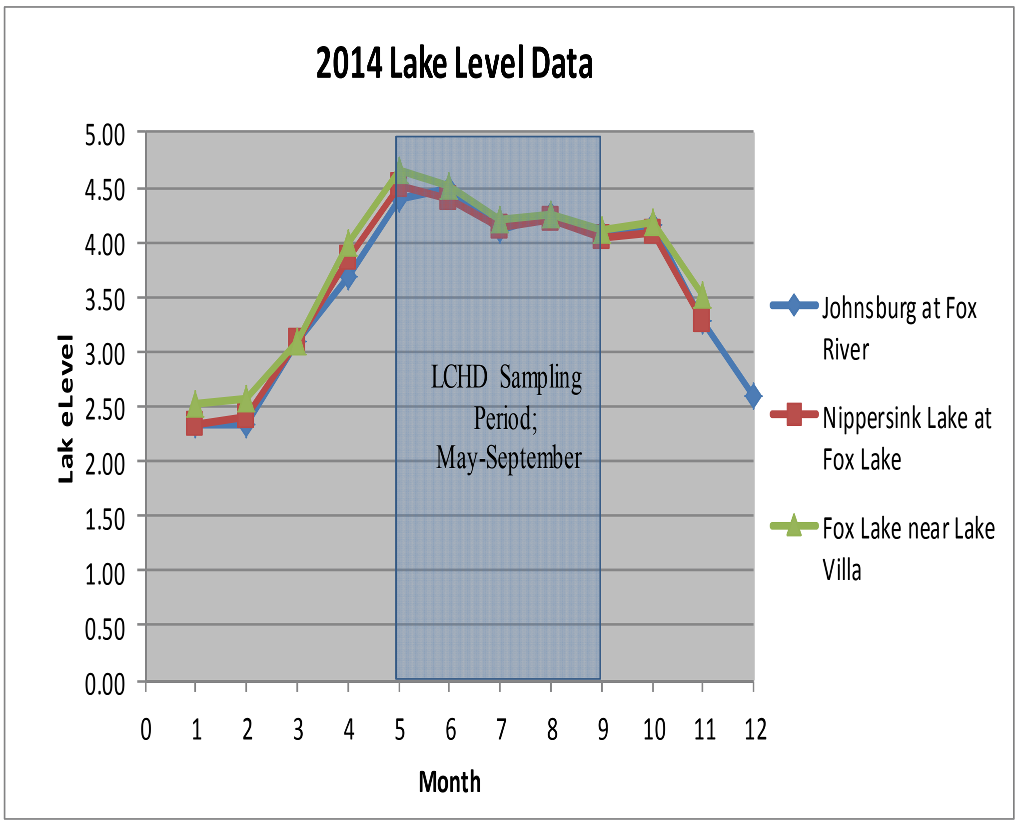


Left: Precipitation totals from Long Lake Station in Lake County

Lake levels

Lakes with stable water levels potentially have less shoreline erosion problems. The Chain O'Lakes water levels are affected by the McHenry Dam, where water levels are required to remain between 3.8-4.2 ft. Climate (rain, snow, and drought events) also play a role in lake level fluctuations.

The main inflow into the Fox Chain lakes is the Fox River with Sequiot, Nippersink, and Squaw creek being other significant tributaries. There is a minimal change in the stream gradient of the Fox River from where it enters Illinois at 732 feet of elevation to when it leaves the Chain O'Lakes at approximately 732 feet elevation. The Stratton Dam in McHenry also helps artificially maintain water these levels and there are three USGS gage stations in the Chain O'Lakes that measure real-time data of water levels . There is minimal lake level fluctuation between these gages and the lakes themselves. During the monitoring season (May - September), lake levels only fluctuated approximately 0.5 ft from 4.51 to 4.04. The lowest lake level occurred in September (4.04) with July also being low (4.13).



Left: Lake level data from the three USGS gage states located in the Fox Chain O'Lakes. LCHD-ES sampling occurred during the months of May-September.

Station	May	June	July	August	September
Johnsburg at Fox River	4.40 ft.	4.48 ft.	4.12 ft.	4.25 ft.	4.09 ft.
Nippersink Lake at Fox Lake	4.51 ft.	4.40 ft.	4.13 ft.	4.20 ft.	4.04 ft.
Fox Lake near Lake Villa	4.65 ft.	4.51 ft.	4.20 ft.	4.26 ft.	4.12 ft.

Shoreline erosion

Erosion is a natural process primarily caused by water resulting in the loss of material from the shoreline. Disturbed shorelines caused by human activity such as clearing of vegetation and beach rocks, and increasing runoff will accelerate erosion. Eroded materials cause turbidity, sedimentation, nutrients, and pollutants to enter a lake. Excess nutrients are the primary cause of algal blooms and increased aquatic plant growth and once in the lake, sediments, nutrients and pollutants are harder and more expensive to remove.

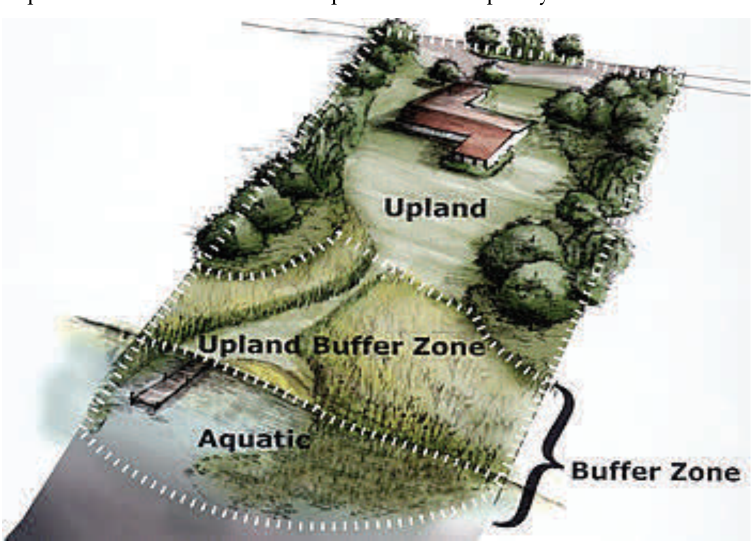
An in depth shoreline erosion study was not assessed in 2014 for Lake Matthews. Within the Fox Chain O' Lakes, shorelines typically have vertical seawalls that reflect wave energy. This can also cause scouring of the lake bottom, preventing aquatic plants from establishing near shore. Re-facing a vertical seawall with stone or native plants planted in front of the seawall can absorb wave energy and stabilize lake sediment, minimizing erosion. This will allow aquatic plants to grow in front of the seawall providing habitat for fish and wildlife. Many of the vertical seawalls are failing, and are recommended to be replaced. Permits may be requires for any alterations to shoreline in public waters, which includes Lake Matthews; contact the Illinois DNR.

Additionally, many properties along the lake have manicured lawn and turf up to the lakes edge. Replacing lawn and turf grass at the shoreline with a buffer strip containing native deep-rooted plants will help with erosion and add wildlife habitat. 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. If these areas are already severely or moderately eroding, a buffer strip of native plants may need to be bolstered with the addition of willow posts, biologs or A-Jacks. Buffer strips should be at least 10-20 feet wide and can include native wildflowers, native grasses, and native wetland plants. Wider buffers may be needed to areas with a greater slope or additional runoff issues. A concern with shoreland buffers is that it may limit access to the lakefront. A smaller mowed path to the shoreline can still allow access to the lake while not interrupting the integrity of the buffer strip. The mowed path for lake access should be kept at least 6 inches tall and not more than 6 feet wide. Buffers do not have to block the view of the lake as there are many colorful, low-growing plants that can be incorporated in the buffer strop and will provide all the benefits of improved water quality.

Seawall

Rip rap with a native plant buffer

Buffer strip between upland area and lake edge



"Vegetative buffer zones can play a key role in limiting negative water quality impacts from developed shoreland property"

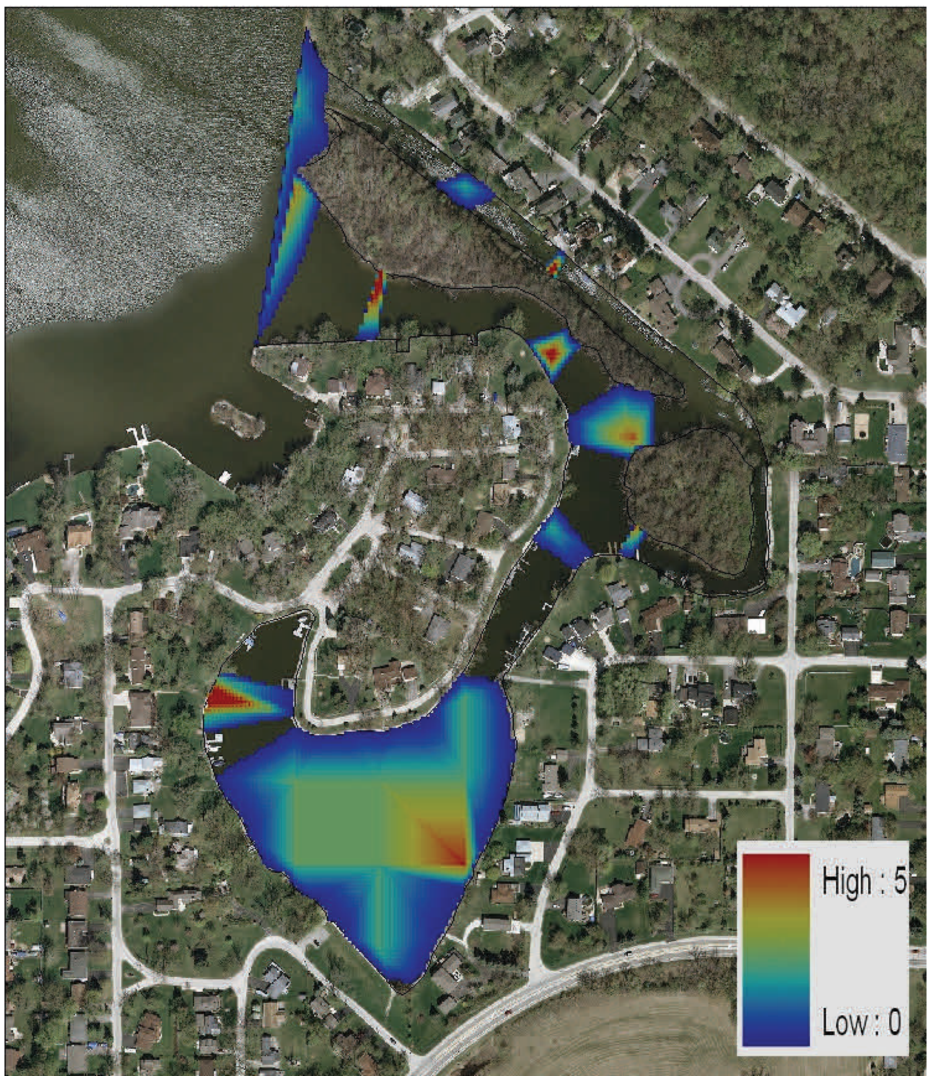
Aquatic plants

Plants growing in our lakes, ponds, and streams are called macrophytes. These aquatic plants appear in many shapes and sizes. Some have leaves that float on the water surface, while others grow completely underwater. In moderation, aquatic plants are aesthetically pleasing and desirable environmentally. **Their presence is natural and normal in lakes.**

Aquatic plant sampling was conducted on Lake Matthews in July 2014. There were 19 points generated based on a computer grid system with points 60 meters apart that were sampled. Aquatic plants occurred at 18 of the sites (94.7% total lake coverage) with plants found at a maximum depth of 5.0 feet. There were a total of only 5 aquatic plant species found. To maintain a healthy fishery, the Illinois Department of Natural Resources suggests plant coverage of 20% to 40%.

The most dominant species were Eurasian Watermilfoil, an exotic invasive species, found at 74% of the sites followed by Bladderwort found at 53% of the sampling sites of the sampling sites. The other three species found were duckweed, lotus, and flatstem pondweed. Lake Matthews has a low number of aquatic plant species and EWM is prevalent. Management of EWM and encouraging native plant species to grow in Matthews can be beneficial.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	1	5.3
>0-10%	10	52.6
10-40%	4	21.1
40-60%	1	5.3
60-90%	3	15.8
>90%	0	0.0
Total Sites with Plants	18	94.7
Total # of Sites	19	100.0



Above: Overall plant rank density for all species on Lake Matthews for July 2014.

AQUATIC PLANTS (CONTINUED)

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 maximum the maximum depth at which aquatic plants will grow. Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. 1% light level typically occurs at two times the secchi depth value. For Lake Matthews, the secchi depth was 1.48 ft, so you could expect plants to go at 3.96 ft depth. Plants were found at a maximum depth of 5.0ft. in Matthews Lake.

Aquatic plants provide many water quality benefits and play an important role in the lakes ecosystem by providing habitat for fish and shelter for aquatic organism. Plants provide oxygen, reduce nutrients such as phosphorus to prevent algae bloom, and help stabilize sediment. A native plant community tends to be diverse and usually does not impede lake activities such as boating, swimming and fishing.

AQUATIC PLANTS: WHERE DO THEY

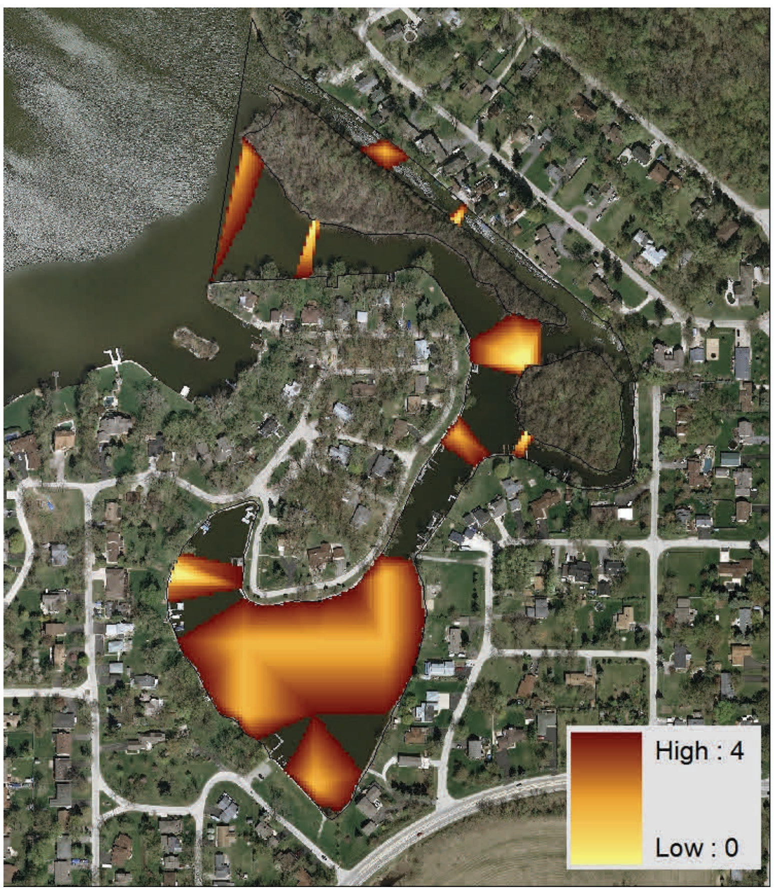
Littoral Zone– the area that aquatic plants grow in a lake.

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

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

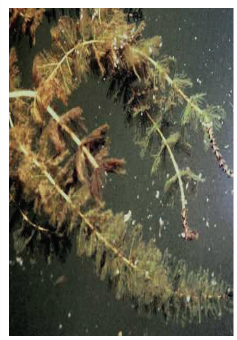
Floating-leaf Plants– are often rooted in the lake bottom, but their leaves and flowers lay flat on the water surface.

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



EURASIAN WATERMILFOIL

Myriophyllum spicatum



EXOTIC INVASIVE SPECIES, CAN FORM THICK UNDERWATER STANDS OF MATTED VEGETATION, OUTCOMPETES NATIVE PLANTS

Above: Map of Eurasian Watermilfoil plant rake density in Matthews Lakes surveyed in July 2014. EWM was found at 73.7% of the sampling sites.

Plant Species	% of Sampling Sites
Bladderwort	52.6
Duckweed	10.5
Eurasian Watermilfoil	73.7
Flatstem Pondweed	5.3
Lotus	10.5

Left: Table of the different plant species found in Lake Matthews in the 2014 plant survey

FLORISTIC QUALITY INDEX

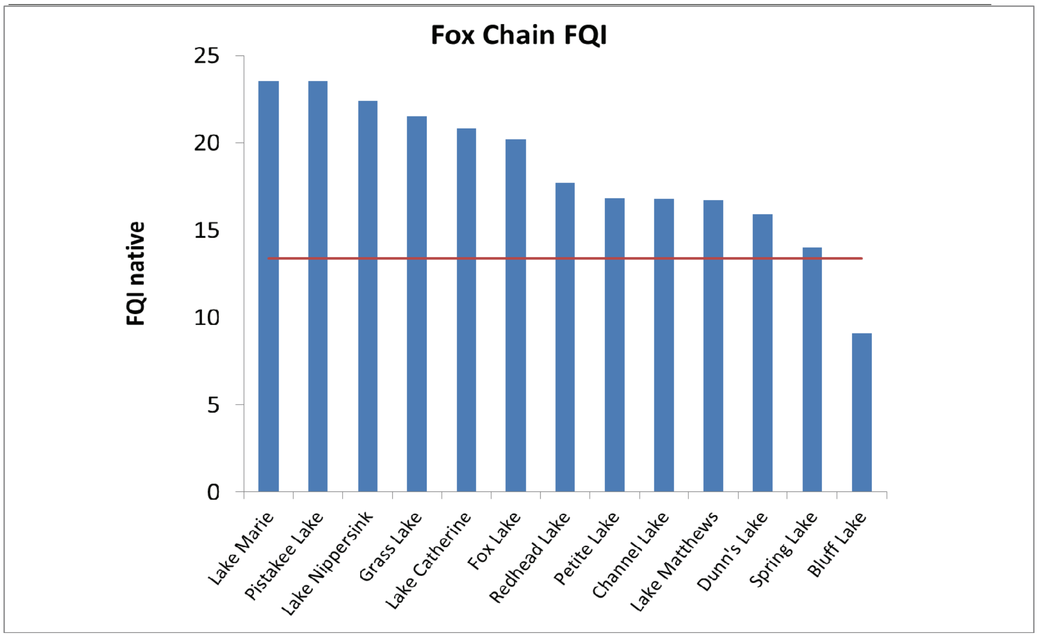
Floristic quality index (FQI) is an assessment tool designed to evaluate how close the flora of an area is that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site 3) monitor long-term floristic trends and 4) monitor habitat restoration efforts. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submerged plant species found in the lake. The FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that a large number of sensitive, high quality plant species are present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The median FQI for Lake County lakes from 2000-2014 was 13.4. Lake Matthews had an FQI value of 13.9 ranking it 83 out of 173 lakes in Lake County and 5 plant species were observed.

LAKE COUNTY AVERAGE FQI = 13.4

LAKE MATTHEWS FQI = 13.9

RANK = 83/173

AQUATIC PLANTS SPECIES OBSERVED = 5



MATTHEWS HAD AN FQI OF 13.9

IN MANY LAKES MACROPHYTES CONTRIBUTE TO THE AESTHETICALLY PLEASING APPEARANCE OF THE SETTING AND ARE ENJOYABLE IN THEIR OWN RIGHT. BUT EVEN MORE IMPORTANT, THEY ARE AN ESSENTIAL ELEMENT IN THE LIFE SYSTEMS OF MOST LAKES.

- Macrophyte leaves and stems provide a habitat or home for small attached plants and animals. Some are microscopic in size and some are larger. These attached organisms are valuable as food for animals higher in the food chain, such as fish and birds.
- Many types of small organisms live in the sediment. There are insects that spend the immature stages of life in the sediments, leaving when they become adults. Decomposing plant life provides part of the food supply for these sediment-dwelling organisms and the emerging insects, in turn, are food for fish.
- The submerged portions of macrophytes provide shelter and cover for small or young fish from larger fish that would feed on them.
- Types of plants that extend above the water can provide cover for waterfowl and their young, and many plants can serve directly as food for certain types of waterfowl.
- Aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available nutrients.

Aquatic pesticides and aquatic plant management

Herbicides are chemical pesticides used to disrupt the growth cycle of plants, and typically work by inhibiting photosynthesis from occurring within the plant. Diquat was used by property owners to control Eurasian watermilfoil and Curlyleaf pondweed in 2013 in Redhead Lake. Diquat is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis. It is non-selective herbicide and will kill a wide variety of plants on contact. It does not move throughout the plants, so it will only kill parts of the plants that it contacts. Following treatment, plants will die within a week. Diquat is not effective in lakes with muddy water because it is so strongly attracted to silt and clay particles in water. Therefore, bottom sediments must not be disturbed during treatments. There are no swimming restrictions for water bodies with Diquat; however water should not be consumed by pets for 1 day following treatment. For more information on Diquat and other chemical treatments, please reference the WIDNR Chemical Fact Sheet attached in the report Appendix D.

It is recommended that a long term Aquatic Plant Management Plan (APMP) be developed for the Fox Chain 'O' Lakes to promote native plant diversity and control exotic invasive species. This would provide parties interested in aquatic plant management with a template to follow and allow decisions on aquatic plant management to be consistent throughout the lakes'. 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 managing aquatic plants on the Fox Chain 'O' Lakes. All aquatic plant management strategies should be investigated and prioritized by the stakeholders. To accomplish this, the plan should address lake usage, sensitive areas and any areas that herbicides are not allowed to come into contact with plants, such as on property owned by landowners who do not wish to have chemicals used on their property. Considerations for herbicide applications include the timing of application. Many pesticides are more effective in cooler water temperatures. Additionally, native plants tend to begin their growth later than some of the invasives. This suggests earlier herbicide applications are recommended.

Systemic herbicides: *absorbed and transported throughout the plant, killing the entire plant including the roots.*

Contact herbicides: *only kill the portions of the plant in which the chemical comes into contact with.*

Non-selective: *will kill or injure a wide variety of plant species*

Selective: *effective on only certain plant species*

PERMIT REQUIREMENTS FOR APPLYING PESTICIDES

Lake Matthews is part of the Fox Chain O'Lakes which are designated as public waters in the state of Illinois. As per the Illinois Department of Natural Resources' Administrative Rule 895, any person, company, or organization that is sponsoring or conducting chemical or non-chemical treatment for the management of aquatic plants in the Fox Chain O'Lakes needs to obtain a Letter of Permission (LOP) from the IDNR. An application for a letter of permission for treatment of plants must be completed—including a map of the proposed area—and submitted to IDNR. The IDNR will then either issue or deny the request within 45 days after the receipt of the complete application. You can find links to the permit application at the Fox Waterway Agency website at www.foxwaterway.com.

New regulations in Illinois require a National Pollutant Discharge Elimination System (NPDES) to apply any type of pesticides over or into waters of the State. Who has to get a permit? According to the language in the permit, anyone who qualifies as an "operator", which is defined as: "any person, persons, group, or entity in control over the financing for, or over the decision to perform pest control activities, or applying pesticides that will result in a discharge to waters of the State". Homeowner associations or even individuals may need to get a permit. Regardless of the size of treatment, a permit will be needed. If the treatment area or total annual area exceeds certain thresholds then additional requirements will be required such as a Pesticide Discharge Management Plan and an annual report. Anyone or any group planning to treat Lake Matthews this year should take into account both of these requirements. Applicators should be aware of this requirement.

FOR FULL DETAILS OF THE RULE SEE:

HTTP: / / WWW.EPA.STATE.IL.US /WATER/ PERMITS/ PESTICIDE/ INDEX.HTML

AQUATIC INVASIVE SPECIES

Aquatic invasive species (AIS) are species that cause economic or environmental harm, or harm to human health. Illinois has a number of invasive species with the most common including: common carp, grass carp, and zebra mussels. The most common aquatic exotic plants include Curlyleaf Pondweed and Eurasian Watermilfoil. Water recreation is a main transport of AIS, as these species can get transported from boats or trailers and then introduced into the water. Invasive species usually outcompete habitat of native species and are more tolerant to variations in water quality giving them an advantage to thrive.

ZEBRA MUSSELS (*Dreissena polymorpha)*

Zebra mussels are small, fingernail-sized mollusks originally native to eastern Europe and western Asia. Zebra mussels were most likely introduced to North America in 1985 or 1986 by ballast water of ships that traveled across the Atlantic and emptied their ballast in the Great Lakes ports. Zebra mussels spread by attaching to boats, nets, docks, swim platforms, boat lifts, and can be moved on any of these objects. They also can attach to aquatic plants which are often transported accidently when plant material gets stuck on boats and boat parts. Microscopic larvae (called veligers) can also be carried in water contained in bait buckets, bilges, or any other water removed from an infested lake.

Female zebra mussels can lay up to a million eggs each summer, typically when waters reach around 50°F and spawning peaks at water temperatures around 68°F. A fertilized egg develops into a tiny, free-swimming larvae called a veliger. Veligers are suspended in the water column for 1 to 5 weeks and then begin to sink and search for a stable surface to live, grow and reproduce. This is a unique characteristic of zebra mussels because typically freshwater mussels do not attach to surfaces. Currently, 35 inland lakes in Lake County are known to be infested with the zebra mussel including the Fox Chain O'Lakes, which first documented zebra mussels in 1998. There has appeared to be a die off of Zebra Mussels in the Fox Chain the most recent years, with less being observed.

Zebra mussels are filter feeders feeding on algae/phytoplankton and zooplankton that they obtain by filtering water. One zebra mussel can filter about one quart of water per day, and large colonies can filter a significant amount of water that can remove food resources for other aquatic organisms. Zebra mussels can increase competition for these food sources affecting fish population. Since zebra mussels are plankton feeders, there is often an increase in water clarity and decrease in TP concentrations after an infestation. There is also a concern that zebra mussels may increase blue-green algae as they selectively filter out other plankton species, leaving blue-greens more abundant. Zebra mussels impact recreational lake users by attaching to boat hulls and motors—causing inconvenience for boaters. They are also very sharp and can cut bare feet, as well as dead mussels can have an unpleasant odor effecting swimming and beach areas.

You can monitor for zebra mussels by immersing a hard substrate (such as a concrete block) in several different places in the lake including boat launches. It is important to monitor several different locations because zebra mussel population may be concentrated in one area of the lake before spreading to the rest. Check the blocks throughout the summer and fall for attached adult mussels. You can also check submerged equipment such as docks and buoys when you remove them for winter storage.

WHAT CAN YOU DO TO HELP PREVENT AIS?

- Clean all visible aquatic plants, zebra mussels, and other invasive species from watercraft, trailers, and water-related equipment before leaving any water access or shoreland.
- Drain water-related equipment (boat, ballast, tanks, portable bait containers, motors) and drain bilge, livewell and baitwell by removing drain plugs before leaving a water access or shoreline property. Keep drain plugs out and water draining devices open while transporting watercraft.
- Dispose of unwanted (including minnows, leeches, and worms) in the trash.
- Educate yourself and others on exotic species. Learn to identify invasive exotic species and report new species if you come across them.

AQUATIC INVASIVE SPECIES (CONTINUED)

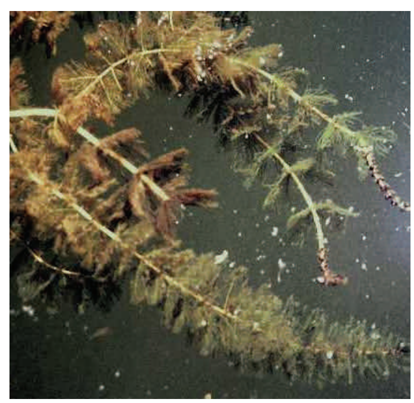
CURLYLEAF PONDWEED (*Potamogeton crispus)*

Curlyleaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidently introduced to the United States water in the mid-1880's by hobbyists who use it as an aquarium plant.

CLP is a submersed aquatic plant. Curlyleaf pondweed is identifiable by its entire leaves with prominent midvein and curly toothed edge which alternate along the stem of the plant. CLP has a unique life cycle. Unlike our native pondweeds, it begins growing in the early spring. The vegetative part of the plant dies back completely in early summer and only seeds and turions remain over summer. The turions (which are the main source of reproduction in CLP) sprout in fall, and are rapidly able to elongate in spring after ice melts as temperatures reach 5°C. CLP becomes invasive in some areas because of its adaptations for low light tolerance and low water temperatures which allow the plant to get a head start and outcompete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen.

Large populations of CLP also can cause changes in nutrient availability. In midsummer, CLP plants usually die back which is typically followed by an increase in phosphorus availability that may fuel nuisance algal blooms. CLP can form dense mats that may interfere with boating and other recreational uses. It can also displace native aquatic plants. The most important action that you can take to limit the spread of curlyleaf and other non-native aquatic plants is remove all vegetation from your watercraft before you move it from one body of water to another. Curlyleaf pondweed was not detected in Lake Matthews in our 2014 sample, but its occurrence and may be an underestimate due to the timing of the survey in July, after most CLP has died off.

EURASIAN WATERMILFOIL (*MYRIOPHYLLUM SPICATUM)*



Eurasian Watermilfoil (EWM) is an invasive, submersed aquatic plant accidently introduced in the 1940s to North America from Europe from the aquarium trade. EWM can form thick underwater stands of tangled stems and mats of vegetation at the waters surface, which can interfere with water recreation including boating, fishing, and swimming. The plant's floating canopy can also crowd out native plant species. EWM can reproduce through stem fragmentation and runners meaning a single segment of stem and leaves can take root and form an entire new colony. Removing native vegetation allows for EWM to overtake a lake. EWM can have a difficult time becoming established in lakes with well established populations of native plants. EWM can be controlled using aquatically approved herbicides, mechanical (i.e. harvester or cutter) methods, or biological controls (i.e. weevil). In the Fox Chain O'Lakes, a Letter Of Permission (LOP) from the IDNR is required for any aquatic plant management (see Pesticides section). Aquatic management methods for EWM that cause as little damage to native aquatic plants as possible are encouraged and early season treatments will have the least impact on native populations. EWM was detected in Lake Matthews in 2014 at 74% of the sampling sites. In the Fox Chain O'Lakes, 5 lakes were determined to have a EWM as a dominant member based on the 2014 plant surveys and those lakes include: Bluff, Matthews, Marie, Petite, and Pistakee. EWM abundance seems to fluctuate from year to year which can be attributed to a number of factors including weather patterns and herbicide applications.

Aquatic invasive species (continued)

Carp (Cyprinus carpio)

Carp are considered to be one of the most damaging invasive fish species. Originally introduced to the Midwest waters in the 1800's as a food fish, carp can now be found in 48 States. In the U.S., the common carp is more abundant in manmade impoundments, lakes, and turbid sluggish streams and less abundant in clear waters or streams with a high gradient. They are also highly tolerant of poor water quality.

The common carp has a dark copper-gold back with sides that are lighter, a yellowish belly and olive fins. They have 2 pairs of short barbells on their upper lip and their dorsal and anal fins have a leading spine that are serrated. They spawn from early spring to late summer in water ranging from 15 – 28 C and prefer freshly flooded vegetation as spawning substrate. They prefer to spawn in shallow weedy areas in groups consisting of one female and several males. A single female can produce up to 100,000-500,000 which hatch in 5-8 days. The spawning ritual involves a lot of thrashing in shallow water contributing to turbidity problems. Many eggs succumb to predation, fungus, and bacteria.

Carp are omnivorous and feed over soft bottom substrate where they suck up silt and filter out crustaceans, insect larvae and other desirable food items. Carp are very active when feeding and can be observed around shallow areas where they uproot plants which increases turbidity and nutrient concentrations. Increase in nutrients causes algal blooms and reduction in light penetration that impacts aquatic plants. This can be particularly a problem in shallow lakes, such as Redhead where nutrients can easily cycle throughout the water column.

The carp population on the Fox Chain O' Lakes is made up of 2-3 year classes. The average size of the carp in 2013 for all the lakes was 23.4 inches and weighing 6.25 lbs. The Chain has a healthy population of predator fish such as bass, walleye, catfish and musky that feed on the juvenile carp.

Carp spawning and feeding can both cause increase in turbidity, especially in shallow waters where they uproot plants, and re-suspend bottom sediments

Actions you take as a responsible boater are critical in preventing the spread of invasive species in Lake County. Remember, before leaving a lake or river:

- INSPECT and REMOVE all aquatic plants and animals
- DRAIN water from motors, live wells, and bait containers
- DISPOSE of unwanted live bait on land
- RINSE your boat and equipment with hot (04°F) high pressure tap water or
- DRY your boat and equipment for at least 5 days

Aquatic invasive species (continued)

American Gizzard shad (*Dorosoma cepedianum, native*)

Gizzard shad are native to central and eastern United States mainly in warm low gradient rivers and streams as well as reservoirs, lakes and ponds. Shad are filter feeders; they prefer warm nutrient rich waters. Their range is temperature limited. Die offs usually occur when the water temperature drops below 37°F. The Illinois DNR collected its first sample of gizzard shad in the Fox Chain O' Lakes in 2007. These shad migrated up the Fox River over fish ladders and dams in order to make it to the Chain. Lakes that receive flood waters from the Des Plaines river can also have them.

While most shad live for 3-5 years, some have been documented to live past 10 years. They reach maturity in 2-3 years and females can produce 40,000 to 450,000 eggs. Spawning takes place during the middle of spring to early summer and usually occurs in the evening. The preferred spawning temperature is between 60oF and 70oF. Male and female shad congregate along the shallow sandy or gravel areas where eggs are released and fertilized. Once the eggs hatch they are on their own since there is no parental care from the parents. The success of the shad fry correlates with the abundance of zooplankton along with stable water level and warmer temperatures. Drastic changes in water level and temperature can decrease the survival rate of the fry. Once they reach the juvenile stage, they grow rapidly. Gizzard shad feed on organic detritus associate with sediments by and also on phytoplankton and zooplankton. At this stage they develop a gizzard and begin filter feeding for food. Sediment and sand are also ingested by the gizzard shad that helps it to digest food in its muscular gizzard; this is where the fish got its name.

Fishermen on the Fox Chain O' Lakes have been seeing large schools of shad swimming in the shallow weedy bays. Gizzard shad provide an abundant food source for bass and walleye, but they may compete with bluegill, crappies and other young of the year game-fish for food. Shad have rapid growth rates, often growing to 5.5 inches in length during their first year. This provides a smaller window of opportunity for bass and walleyes which are gape limited and can only feed effectively on shad up to 6". Fortunately, the Chain has a healthy population of muskies, which are capable of feeding on adult shad. Muskies have benefited from this new food source which is not only abundant but it's easier for them to catch than bluegills and perch.

Gizzard shad can alter the size and density structure of a fishery. They may stunt the bluegill population through common food competition or by reducing the predation pressure. Bass may grow larger due to having more food available for them to eat but their fry may have to compete for food. Gizzard shad also can affect water quality of a lake. Since they are filter feeders, gizzard shad can bring an increase in water clarity in lakes, but they can also impact nutrient dynamics. Gizzard shad have been shown to transfer large quantities of nutrients from benthic (bottom-lake) habitats via sediment feeding and subsequent excretion. At this point it is hard to predict what the overall outcome of the gizzard shad will be on the fishery in the Fox Chain O'Lakes.

LakeCounty
Health Department and
Community Health Center

ENVIRONMENTAL SERVICES

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For more information visit us at:

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

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

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

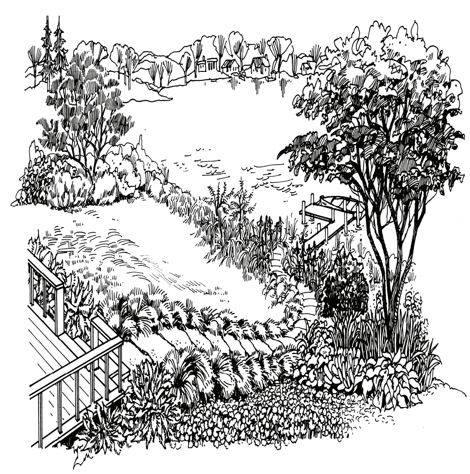
- Maintain or improve water quality and alleviate nuisance conditions
- Promote healthy and safe lake conditions
- Protect and improve ecological diversity

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

LAKE RECOMMENDATIONS

Lake Matthews is a shallow lake with poor water quality and high amount of nutrients, especially phosphorus. To improve the overall quality of Lake Matthews; the ES (Ecological Services) has the following recommendations:

- Participate in the Volunteer Lake Monitoring Program to give baseline and yearly data on water clarity for Lake Matthews
- Consider installing Best Management Practices (BMPs) to minimize phosphorus and sediment runoff into Lake Matthews This can include: rain gardens, native buffers between shoreline and homeowner property, and increasing native plantings around the lake.
- Consider use of shoreline buffers to reduce erosion and minimize nutrient runoff.
- Develop an aquatic plant management plan that targets the reduction of invasive species such as the abundance of EWM on Lake Matthews and promotes native plant diversity.
- Install a permanent staff gage to monitor lake level fluctuations.
- Install a signs to educate on AIS species and steps to prevent aquatic hitchhiking.
- Regularly inspect septic systems.
- The LCHD-ES recommends the creation of an updated bathymetric map. Bathymetric maps provide lake managers with an accurate lake volume that can be used for herbicide application and help anglers find potential fishing spots.



Appendix A:

Tables & Figures

Figure 1: Matthew's Water Quality Sampling Location

Figure 2:

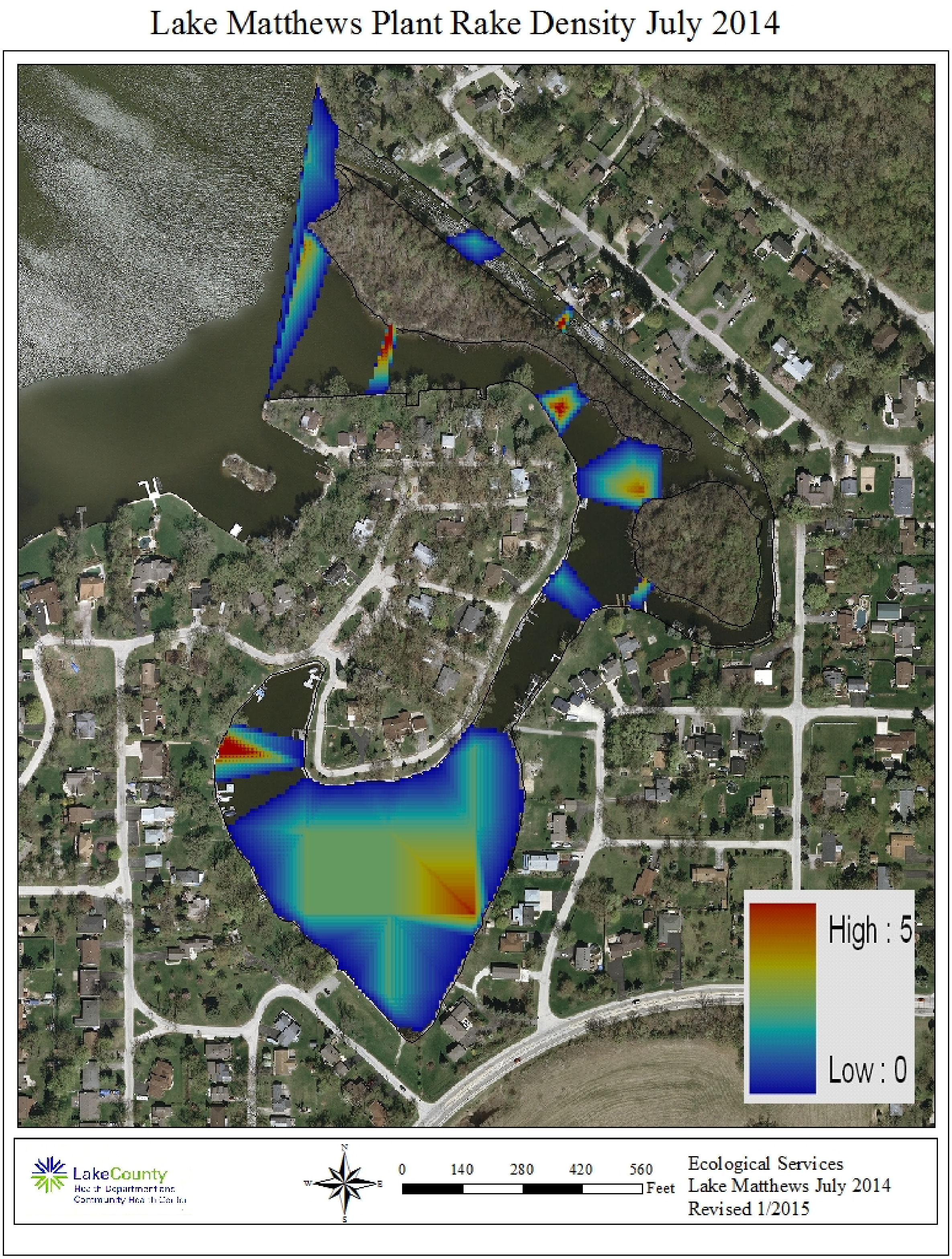

Lake Matthews Plant Rake Density July 2014
High : 5
Low : 0
LakeCounty
Health Department and
Community Health Center
N
W
E
S
0
140
280
420
560
Feet
Ecological Services
Lake Matthews July 2014
Revised 1/2015

Figure 3:

Lake Matthews Plant Species Diversity, July 2014

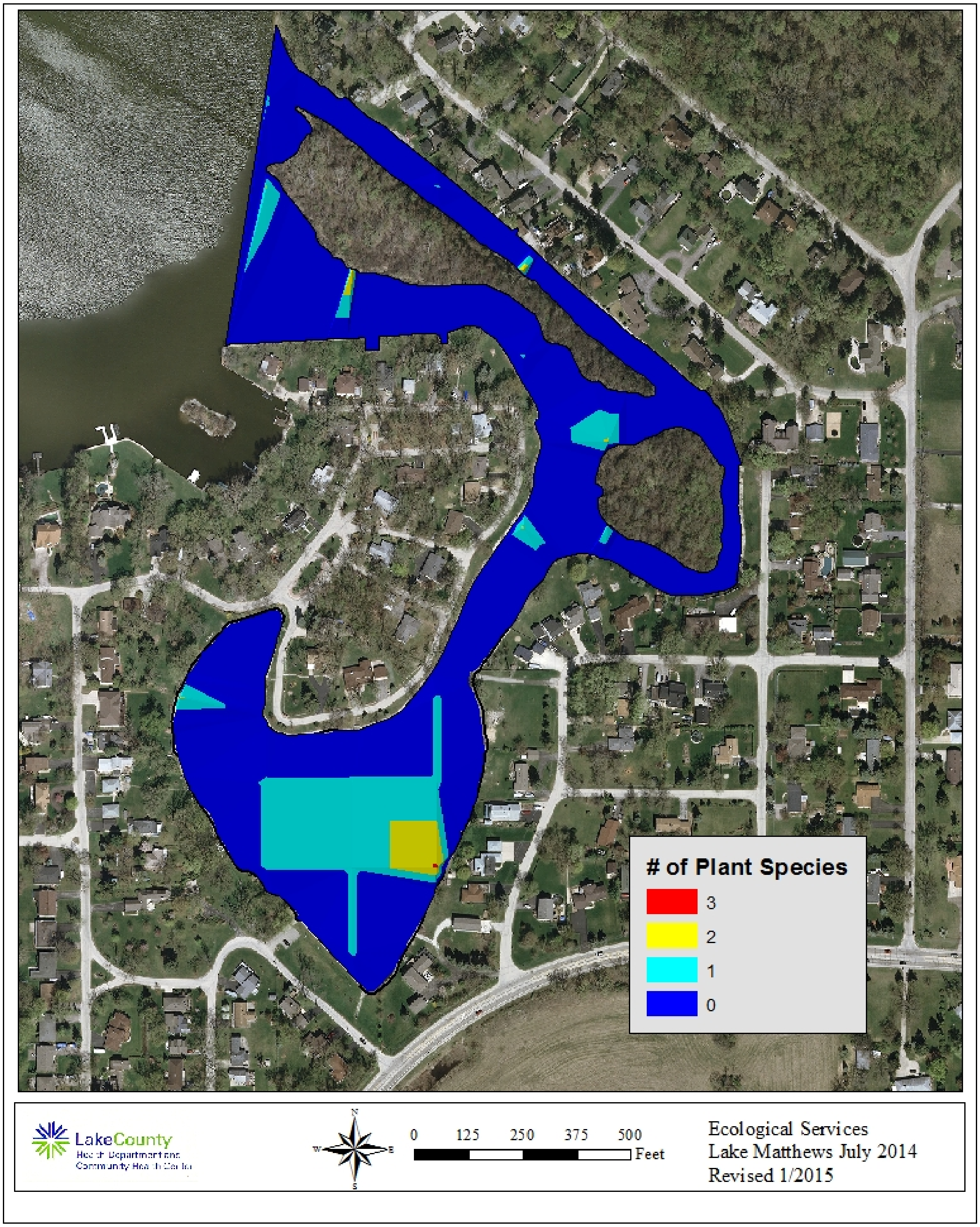


Figure 4:

Lake Matthews
Eurasian Watermilfoil Plant Rake Density July 2014

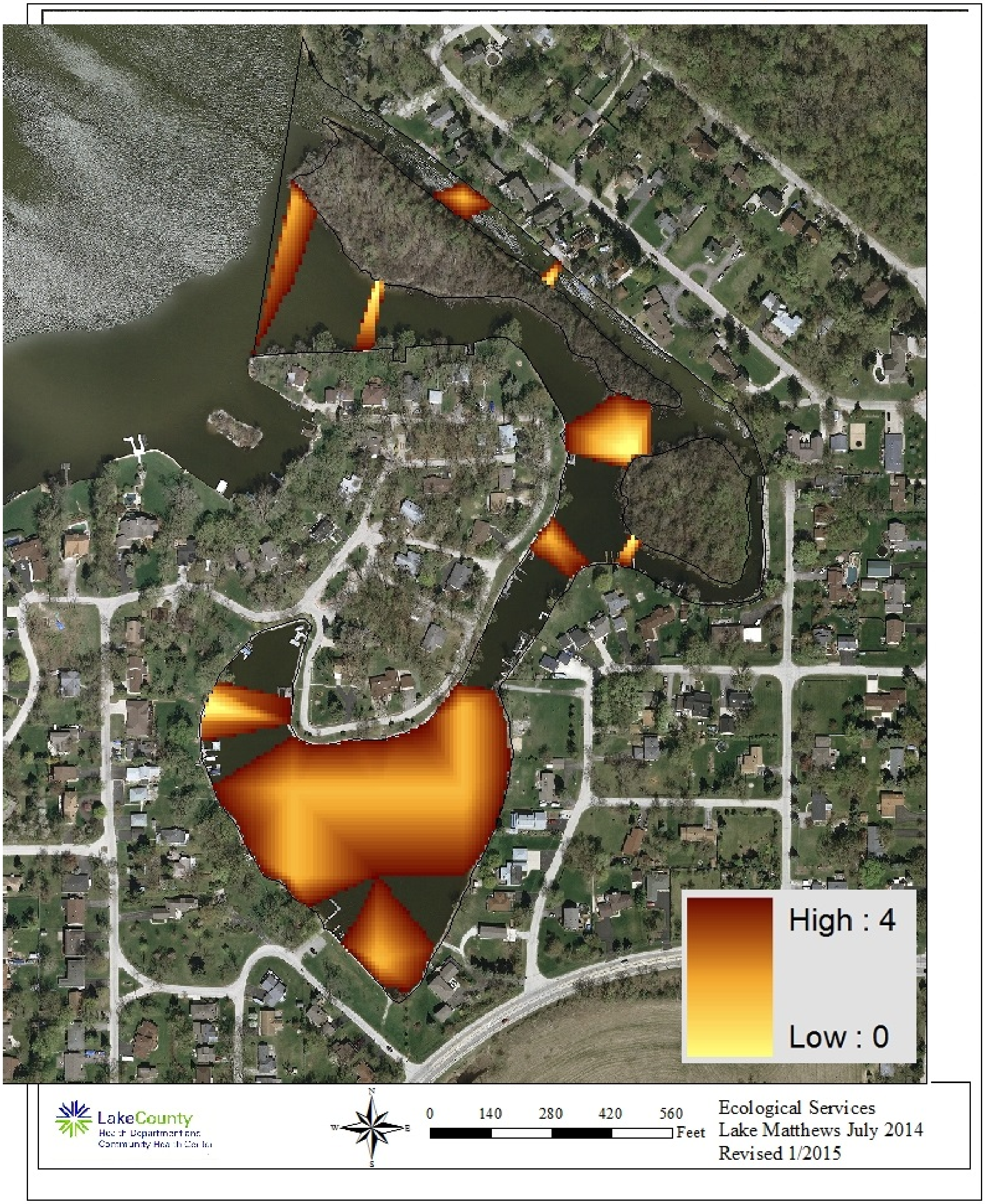


Table 1. 2014 and 2002 Water Quality Data for Lake Matthews

2014	Epilimnion															
DATE	DEPTH	ALK	TKN	NH3	NO3	TP	SRP	TDS	Cl-	TSS	TS	TVS	SECCHI	COND	pH	DO
5/7/2014	1	186	1.66	<0.1	<0.05	0.102	<0.005	433	124	20.0	514	128	1.50	0.7670	8.44	11.84
6/11/2014	1	190	2.84	0.107	<0.05	0.171	<0.005	432	119	49.2	521	149	1.40	0.7650	8.08	9.28
7/9/2014	1	219	1.73	<0.1	<0.05	0.117	<0.005	450	119	24.0	511	129	1.60	0.8000	8.24	9.20
8/13/2014	1	207	1.67	<0.1	<0.05	0.111	<0.005	444	122	14.0	515	141	1.80	0.7890	8.03	8.58
9/17/2014	1	210	1.63	<0.1	<0.05	0.090	<0.005	422	120	18.0	490	114	1.10	0.7440	8.48	12.25
	Average	202	1.91	0.101^{k}	.05k	0.118	0.005^{k}	436	121	25.0	510	132	1.48	0.7730	8.25	10.23

2002	Epilimnion															
DATE	DEPTH	ALK	TKN	NH3	NO3	TP	SRP	TDS	Cl-	TSS	TS	TVS	SECCHI	COND	pH	DO
5/7/2002	0	223	1.98	0.107	0.125	0.142	0.009	442	NA	17.0	467	131	1.77	0.7667	8.21	7.62
6/11/2002	0	218	2.10	<0.1	<0.05	0.120	0.006	444	NA	9.9	470	137	2.43	0.7510	8.52	12.06
7/16/2002	0	171	2.92	<0.1	<0.05	0.123	<0.005	354	NA	28.0	471	179	0.95	0.6700	8.90	13.82
8/13/2002	0	162	4.62	<0.1	<0.05	0.191	<0.005	408	NA	31.0	461	163	0.79	0.6703	8.92	8.01
9/10/2002	0	188	3.27	<0.1	<0.05	0.182	<0.005	412	NA	20.0	464	148	1.10	0.7095	8.78	10.05
	Average	192	2.98	0.107^{k}	0.125^{k}	0.152	0.008^{k}	412	NA	21.2	467	152	1.41	0.7135	8.67	10.3

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_3-N = Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
NVSS = Nonvolatile suspended solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.
Values below the detection limit are calculated at the detection limit value to calculate averages for the season.
NA = Not Applicable

Lake Matthew's 2014 Multiparameter Data

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	BGA-PC	Depth of PAR æE/s/mý	Light Meter feet	% Light Transmissior Average	Extinction Coefficient
5/7/2014	0.25	0.52	13.92	11.52	111.8	0.766	8.38	8447	NR	Surface		
5/7/2014	1	1.04	13.91	11.84	114.9	0.767	8.44	6921	NR	Surface		
5/7/2014	2	2.08	13.82	11.92	115.5	0.767	8.44	11601	NR	0.33		
5/7/2014	3	3.01	13.78	11.91	115.3	0.768	8.46	11229	NR	1.26		
5/7/2014	4	3.89	13.81	10.49	101.6	0.768	8.45	31222	NR	2.14		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	BGA-PC	Light Meter feet	Depth of % Light Transmission	Extinction Coefficient Average
6/11/2014											
6/11/2014	0.25		19.91	9.49	104.4	0.765	8.03	10801	NR	Surface	
6/11/2014	1		19.94	9.28	102.1	0.765	8.08	12015	NR	Surface	
6/11/2014	2		19.88	9.19	101.1	0.762	8.03	13259	NR	0.24	
6/11/2014	3		19.86	9.15	100.6	0.761	8.02	9841	NR	1.27	
6/11/2014	4		19.84	9.03	99.3	0.76	8.01	14193	NR		

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	BGA-PC	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmissior Average	Extinction Coefficient
7/9/2014	0.25	0.54	21.73	9.1	111.200	0.800	6.92	2040	NR	Surface		
7/9/2014	1	0.99	25.32	9.2	111.700	0.800	8.24	15916	NR	Surface		
7/9/2014	2	2.01	25.29	9.1	111.200	0.800	8.11	11422	NR	0.28		
7/9/2014	3	3.01	25.15	8.6	105.100	0.800	8.10	15309	NR	1.29		
7/9/2014	4	3.94	24.79	7.1	85.900	0.800	8.02	39965	NR			

Lake Matthew's 2014 Multiparameter Data

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	BGA-PC	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
8/13/2014	0.25	0.501	23.01	8.69	101.5	0.788	8.10	14627	NR	Surface		
8/13/2014	1	1.023	22.63	8.58	99.5	0.789	8.03	18264	NR	Surface		
8/13/2014	2	2.065	22.61	8.43	97.8	0.788	8.02	16687	NR	0.22		
8/13/2014	3	3.034	22.26	7.81	90.0	0.790	7.98	17056	NR	1.24		
8/13/2014	4	3.971	21.98	7.83	89.7	0.791	7.96	18731	NR			

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	BGA-PC	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
9/17/2014	0.25	0.25	16.78	12.25	126.5	0.744	8.48	NR	NR	Surface		
9/17/2014	1	1	16.33	11.81	120.8	0.747	8.47	NR	NR	Surface		
9/17/2014	2	2	16.16	13.12	133.7	0.743	8.47	NR	NR	0.22		
9/17/2014	3	3	16.05	13.03	132.5	0.744	8.46	NR	NR	1.22		
9/17/2014	4	4	16.06	10.63	108.1	0.745	8.00	NR	NR	2.22		

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Cedar Lake	0.0130	41.14
4	Indpendence Grove	0.0130	41.14
5	Lake Zurich	0.0135	41.68
6	Druce Lake	0.0140	42.00
7	Windward Lake	0.0160	44.13
8	Sand Pond (IDNR)	0.0165	44.57
9	West Loon	0.0170	45.00
10	Pulaski Pond	0.0180	45.83
11	Banana Pond	0.0200	47.35
12	Gages Lake	0.0200	47.35
13	Lake Kathryn	0.0200	47.35
14	Lake Minear	0.0200	47.35
15	Highland Lake	0.0202	47.49
16	Lake Miltmore	0.0210	48.00
17	Timber Lake (North)	0.0210	48.05
18	Cross Lake	0.0220	48.72
19	Dog Training Pond	0.0220	48.72
20	Sun Lake	0.0220	48.72
21	Deep Lake	0.0230	49.36
22	Lake of the Hollow	0.0230	49.36
23	Round Lake	0.0230	49.36
24	Stone Quarry Lake	0.0230	49.36
25	Little Silver Lake	0.0250	50.57
26	Bangs Lake	0.0260	51.13
27	Lake Leo	0.0260	51.13
28	Cranberry Lake	0.0270	51.68
29	Dugdale Lake	0.0270	51.68
30	Peterson Pond	0.0270	51.68
31	Fourth Lake	0.0360	53.00
32	Lambs Farm Lake	0.0310	53.67
33	Old School Lake	0.0310	53.67
34	Grays Lake	0.0310	54.00
35	Harvey Lake	0.0320	54.50
36	Hendrick Lake	0.0340	55.00
37	Honey Lake	0.0340	55.00
38	Sand Lake	0.0380	56.00
39	Third Lake	0.0384	56.00
40	Sullivan Lake	0.0370	56.22
41	Ames Pit	0.0390	56.98
42	Diamond Lake	0.0390	56.98
43	East Loon	0.0400	57.34
44	Schreiber Lake	0.0400	57.34
45	Waterford Lake	0.0400	57.34
46	Hook Lake	0.0410	57.70

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
47	Nielsen Pond	0.0450	59.04
48	Seven Acre Lake	0.0460	59.36
49	Turner Lake	0.0460	59.36
50	Willow Lake	0.0460	59.36
51	East Meadow Lake	0.0480	59.97
52	Lucky Lake	0.0480	59.97
53	Old Oak Lake	0.0490	60.27
54	College Trail Lake	0.0500	60.56
55	Hastings Lake	0.0520	61.13
56	Butler Lake	0.0530	61.40
57	West Meadow Lake	0.0530	61.40
58	Wooster Lake	0.0530	61.40
59	Lucy Lake	0.0550	61.94
60	Lake Linden	0.0570	62.45
61	Lake Christa	0.0580	62.70
62	Owens Lake	0.0580	62.70
63	Briarcrest Pond	0.0580	63.00
64	Lake Barrington	0.0600	63.10
65	Redhead Lake	0.0608	63.20
66	Lake Lakeland Estates	0.0620	63.66
67	Lake Naomi	0.0620	63.66
68	Lake Tranquility (S1)	0.0620	63.66
69	Lake Catherine	0.0620	63.76
70	Liberty Lake	0.0630	63.89
71	North Tower Lake	0.0630	63.89
72	Werhane Lake	0.0630	63.89
73	Countryside Glen Lake	0.0640	64.12
74	Davis Lake	0.0650	64.34
75	Leisure Lake	0.0650	64.34
76	St. Mary's Lake	0.0670	64.78
77	Channel Lake	0.0680	64.91
78	Buffalo Creek Reservoir 1	0.0680	65.00
79	Mary Lee Lake	0.0680	65.00
80	Little Bear Lake	0.0680	65.00
81	Timber Lake (South)	0.0720	65.82
82	Lake Helen	0.0720	65.82
83	Grandwood Park Lake	0.0720	65.82
84	Crooked Lake	0.0710	66.00
85	ADID 203	0.0730	66.02
86	Broberg Marsh	0.0780	66.97
87	Redwing Slough	0.0822	67.73
88	Tower Lake	0.0830	67.87
89	Countryside Lake	0.0800	68.00
90	Lake Nippersink	0.0800	68.00
91	Woodland Lake	0.0800	68.00

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
92	Lake Fairview	0.0890	68.00
93	Potomac Lake	0.0850	68.21
94	White Lake	0.0862	68.42
95	Grand Ave Marsh	0.0870	68.55
96	North Churchill Lake	0.0870	68.55
97	McDonald Lake 1	0.0880	68.71
98	Pistakee Lake	0.0880	68.71
99	Rivershire Pond 2	0.0900	69.04
100	South Churchill Lake	0.0900	69.04
101	McGreal Lake	0.0910	69.20
102	Lake Charles	0.0930	69.40
103	Deer Lake	0.0940	69.66
104	Eagle Lake (S1)	0.0950	69.82
105	International Mine and Chemical Lake	0.0950	69.82
106	Valley Lake	0.0950	69.82
107	Buffalo Creek Reservoir 2	0.0960	69.97
108	Fish Lake	0.0960	69.97
109	Lochanora Lake	0.0960	69.97
110	Big Bear Lake	0.0960	69.97
111	Fox Lake	0.1000	70.52
112	Nippersink Lake - LCFP	0.1000	70.56
113	Sylvan Lake	0.1000	70.56
114	Petite Lake	0.1020	70.84
115	Longview Meadow Lake	0.1020	70.84
116	Lake Marie	0.1030	71.00
117	Dunn's Lake	0.1070	71.53
118	Lake Forest Pond	0.1070	71.53
119	Long Lake	0.1070	71.53
120	Grass Lake	0.1090	71.77
121	Spring Lake	0.1100	71.93
122	Kemper 2	0.1100	71.93
123	Bittersweet Golf Course #13	0.1100	71.93
124	Bluff Lake	0.1120	72.00
125	Middlefork Savannah Outlet 1	0.1120	72.00
126	Osprey Lake	0.1110	72.06
127	Bresen Lake	0.1130	72.32
128	Round Lake Marsh North	0.1130	72.32
129	Deer Lake Meadow Lake	0.1160	72.70
130	Lake Matthews	0.1180	72.94
131	Taylor Lake	0.1180	72.94
132	Island Lake	0.1210	73.00

Lake County average TSI phosphorus (TSIp) ranking 2000-2014.

RANK	LAKE NAME	TP AVE	TSIp
133	Columbus Park Lake	0.1230	73.54
134	Echo Lake	0.1250	73.77
135	Lake Holloway	0.1320	74.56
136	Antioch Lake	0.1450	75.91
137	Lakewood Marsh	0.1510	76.50
138	Pond-A-Rudy	0.1510	76.50
139	Forest Lake	0.1540	76.78
140	Slocum Lake	0.1500	77.00
141	Middlefork Savannah Outlet 2	0.1590	77.00
142	Grassy Lake	0.1610	77.42
143	Salem Lake	0.1650	77.78
144	Half Day Pit	0.1690	78.12
145	Lake Eleanor	0.1810	79.11
146	Lake Farmington	0.1850	79.43
147	Lake Louise	0.1850	79.43
148	ADID 127	0.1890	79.74
149	Lake Napa Suwe	0.1940	80.00
150	Patski Pond	0.1970	80.33
151	Dog Bone Lake	0.1990	80.48
152	Summerhill Estates Lake	0.1990	80.48
153	Redwing Marsh	0.2070	81.05
154	Stockholm Lake	0.2082	81.13
155	Bishop Lake	0.2160	81.66
156	Ozaukee Lake	0.2200	81.93
157	Kemper 1	0.2220	82.08
158	Hidden Lake	0.2240	82.19
159	McDonald Lake 2	0.2250	82.28
160	Fischer Lake	0.2280	82.44
161	Oak Hills Lake	0.2790	85.35
162	Loch Lomond	0.2950	86.16
163	Heron Pond	0.2990	86.35
164	Rollins Savannah 1	0.3070	87.00
165	Fairfield Marsh	0.3260	87.60
166	ADID 182	0.3280	87.69
167	Slough Lake	0.3860	90.03
168	Manning's Slough	0.3820	90.22
169	Rasmussen Lake	0.4860	93.36
170	Albert Lake, Site II, outflow	0.4950	93.67
171	Flint Lake Outlet	0.5000	93.76
172	Rollins Savannah 2	0.5870	96.00
173	Almond Marsh	1.9510	113.00

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	37.4	38.9
2	East Loon Lake	34.7	36.1
3	Cranberry Lake	29.7	29.7
4	Deep Lake	29.7	31.2
5	Little Silver Lake	29.6	31.6
6	Round Lake Marsh North	29.1	29.9
7	West Loon Lake	27.1	29.5
8	Sullivan Lake	26.9	28.5
9	Bangs Lake	26.2	27.8
10	Third Lake	25.1	22.5
11	Fourth Lake	24.7	27.1
12	Indpendence Grove	24.6	27.5
13	Sterling Lake	24.5	26.9
14	Sun Lake	24.3	26.1
15	Lake Zurich	24.3	27.1
16	Redwing Slough	24.0	25.8
17	Schreiber Lake	23.9	24.8
18	Lakewood Marsh	23.8	24.7
19	Deer Lake	23.5	24.4
20	Round Lake	23.5	25.9
21	Pistakee Lake	23.5	25.2
22	Lake Marie	23.5	25.2
23	Honey Lake	23.3	25.1
24	Lake of the Hollow	23.0	24.8
25	Cross Lake	22.4	24.2
26	Nippersink Lake (Fox Chain)	22.4	23.2
27	Countryside Glen Lake	21.9	22.8
28	Grass Lake	21.5	22.2
29	Davis Lake	21.4	21.4
30	Butler Lake	21.4	23.1
31	Lake Barrington	21.2	21.2
32	Duck Lake	21.1	22.9
33	Timber Lake (North)	20.9	23.4
34	Lake Catherine	20.8	21.8
35	ADID 203	20.5	20.5
36	Broberg Marsh	20.5	21.4
37	McGreal Lake	20.2	22.1
38	Fox Lake	20.2	21.2
39	Lake Kathryn	19.6	20.7
40	Fish Lake	19.3	21.2
41	Druce Lake	19.1	21.8
42	Turner Lake	18.6	21.2
43	Wooster Lake	18.5	20.2
44	Salem Lake	18.5	20.2
45	Lake Helen	18.0	18.0
46	Old Oak Lake	18.0	19.1
47	Potomac Lake	17.8	17.8
48	Redhead Lake	17.7	18.7
49	Long Lake	17.7	15.8
50	Hendrick Lake	17.7	17.7
51	Rollins Savannah 2	17.7	17.7
52	Grandwood Park Lake	17.2	19.0
53	Seven Acre Lake	17.0	15.5
54	Lake Miltmore	16.8	18.7
55	Petite Lake	16.8	18.7
56	Channel Lake	16.8	18.7
57	McDonald Lake 1	16.7	17.7

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
58	Highland Lake	16.7	18.9
59	Bresen Lake	16.6	17.8
60	Almond Marsh	16.3	17.3
61	Owens Lake	16.3	17.3
62	Windward Lake	16.3	17.6
63	Grays Lake	16.1	16.1
64	White Lake	16.0	17.0
65	Dunns Lake	15.9	17.0
66	Dog Bone Lake	15.7	15.7
67	Osprey Lake	15.5	17.3
68	Heron Pond	15.1	15.1
69	North Churchill Lake	15.0	15.0
70	Hastings Lake	15.0	17.0
71	Lake Tranquility (S1)	15.0	17.0
72	Forest Lake	14.8	15.9
73	Dog Training Pond	14.7	15.9
74	Grand Ave Marsh	14.3	16.3
75	Nippersink Lake	14.3	16.3
76	Taylor Lake	14.3	16.3
77	Manning's Slough	14.1	16.3
78	Tower Lake	14.0	14.0
79	Dugdale Lake	14.0	15.1
80	Eagle Lake (S1)	14.0	15.1
81	Crooked Lake	14.0	16.0
82	Spring Lake	14.0	15.2
83	Lake Matthews	13.9	15.5
84	Longview Meadow Lake	13.9	13.9
85	Bishop Lake	13.4	15.0
86	Ames Pit	13.4	15.5
87	Mary Lee Lake	13.1	15.1
88	Old School Lake	13.1	15.1
89	Summerhill Estates Lake	12.7	13.9
90	Buffalo Creek Reservoir 1	12.5	11.4
91	Buffalo Creek Reservoir 2	12.5	11.4
92	McDonald Lake 2	12.5	12.5
93	Rollins Savannah 1	12.5	12.5
94	Stone Quarry Lake	12.5	12.5
95	Kemper Lake 1	12.2	13.4
96	Pond-A-Rudy	12.1	12.1
97	Stockholm Lake	12.1	13.5
98	Lake Carina	12.1	14.3
99	Lake Leo	12.1	14.3
100	Lambs Farm Lake	12.1	14.3
101	Grassy Lake	12.0	12.0
102	Flint Lake Oulet	11.8	13.0
103	Albert Lake	11.5	10.3
104	Rivershire Pond 2	11.5	13.3
105	Antioch Lake	11.3	13.4
106	Hook Lake	11.3	13.4
107	Briarcrest Pond	11.2	12.5
108	Lake Naomi	11.2	12.5
109	Pulaski Pond	11.2	12.5
110	Lake Napa Suwe	11.0	11.0
111	Redwing Marsh	11.0	11.0
112	West Meadow Lake	11.0	11.0
113	Lake Minear	11.0	13.9
114	Nielsen Pond	10.7	12.0
115	Lake Holloway	10.6	10.6

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

RANK	LAKE NAME	FQI (w/A)	FQI (native)
116	Sylvan Lake	10.6	10.6
117	Gages Lake	10.2	12.5
118	College Trail Lake	10.0	10.0
119	Valley Lake	9.9	9.9
120	Werhane Lake	9.8	12.0
121	Loch Lomond	9.4	12.1
122	Columbus Park Lake	9.2	9.2
123	Lake Lakeland Estates	9.2	9.2
124	Waterford Lake	9.2	9.2
125	Bluff Lake	9.1	11.0
126	Lake Fairfield	9.0	10.4
127	Lake Louise	9.0	10.4
128	Fischer Lake	9.0	11.0
129	Lake Fairview	8.5	6.9
130	Timber Lake (South)	8.5	6.9
131	East Meadow Lake	8.5	8.5
132	South Churchill Lake	8.5	8.5
133	Kemper Lake 2	8.5	9.8
134	Lake Christa	8.5	9.8
135	Lake Farmington	8.5	9.8
136	Lucy Lake	8.5	9.8
137	Bittersweet Golf Course #13	8.1	8.1
138	Lake Linden	8.0	8.0
139	Sand Lake	8.0	10.4
140	Countryside Lake	7.7	11.5
141	Fairfield Marsh	7.5	8.7
142	Lake Eleanor	7.5	8.7
143	Banana Pond	7.5	9.2
144	Slocum Lake	7.1	5.8
145	Lucky Lake	7.0	7.0
146	North Tower Lake	7.0	7.0
147	Lake Forest Pond	6.9	8.5
148	Ozaukee Lake	6.7	8.7
149	Leisure Lake	6.4	9.0
150	Peterson Pond	6.0	8.5
151	Little Bear Lake	5.8	7.5
152	Deer Lake Meadow Lake	5.2	6.4
153	ADID 127	5.0	5.0
154	Island Lake	5.0	5.0
155	Liberty Lake	5.0	5.0
156	Oak Hills Lake	5.0	5.0
157	Slough Lake	5.0	5.0
158	International Mining and Chemical Lake	5.0	7.1
159	Diamond Lake	3.7	5.5
160	Lake Charles	3.7	5.5
161	Big Bear Lake	3.5	5.0
162	Sand Pond (IDNR)	3.5	5.0
163	Harvey Lake	3.3	5.0
164	Half Day Pit	2.9	5.0
165	Lochanora Lake	2.5	5.0
166	Echo Lake	0.0	0.0
167	Hidden Lake	0.0	0.0
168	St. Mary's Lake	0.0	0.0
169	Willow Lake	0.0	0.0
170	Woodland Lake	0.0	0.0
	Mean	**14.1**	**15.2**
	Median	**13.4**	**15.0**

Lake County average Floristic Quality Index (FQI) ranking 2000-2014.

APPENDIX B. 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.

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 C. 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

Appendix D:

Chemical Fact Sheets of Common Aquatic Pesticides
from the
Wisconsin Department of Natural Resources

Wisconsin Department of Natural Resources

January 2012

Diquat Chemical Fact Sheet

Formulations

Diquat, or diquat dibromide, is the common name of the chemical 6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazinediium dibromide. Originally registered by the EPA in 1986, diquat was reregistered in 1995 and is currently being reviewed again. It is sold for agricultural and household uses as well as for use on certain floating-leaf and submersed aquatic plants and some algae. The aquatic formulations are liquids: two of the more commonly used in Wisconsin are Reward™ and Weedtrine-D™ (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Diquat is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis. It is a non-selective herbicide and will kill a wide variety of plants on contact. It does not move throughout the plants, so will only kill parts of the plants that it contacts. Following treatment, plants will die within a week.

Diquat will not be effective in lakes or ponds with muddy water or where plants are covered with silt because it is strongly attracted to silt and clay particles in the water. Therefore, bottom sediments must not be disturbed during treatment, such as may occur with an outboard motor. Only partial treatments of ponds or bays should be conducted (1/2 to 1/3 of the water body). If the entire pond were to be treated, the decomposing vegetation may result in very low oxygen levels in the water. This can be lethal to fish and other aquatic organisms. Untreated areas can be treated 10-14 days after the first treatment.

Diquat is used to treat duckweed (*Lemna* spp.), which are tiny native plants. They are a food source for waterfowl but can grow thickly and become a nuisance. Navigation lanes through cattails (*Typha* spp.) are also maintained with diquat. Diquat is labeled for use on the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) but in practice is not frequently used to control it because other herbicide options are more selective.

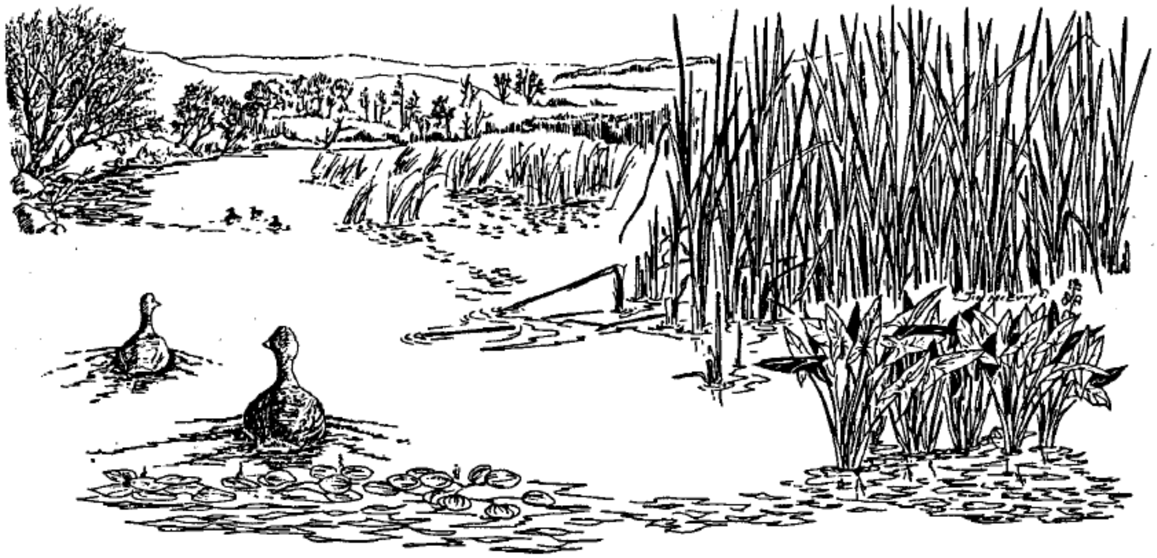
Post-Treatment Water Use Restrictions

There are no restrictions on swimming or eating fish from water bodies treated with diquat. Treated water should not be used for drinking water for one to three days, depending on the concentration used in the treatment. Do not use treated water for pet or livestock drinking water for one day following treatment. The irrigation restriction for food crops is five days, and for ornamental plants or lawn/turf, it varies from one to three days depending on the concentration used.

Herbicide Degradation, Persistence and Trace Contaminants

Diquat is not degraded by microbes. When applied to a waterbody, diquat binds with the organic matter in the sediment indefinitely. It does not degrade and will accumulate in the sediments. Diquat is usually detectable in the water column for less than a day to ~35 days after treatment. Diquat will remain in the water column longer when treating a waterbody with sandy soils due to the low organic matter and clay content. Because of its persistence and very high affinity for the soil, diquat does not leach into groundwater.

Ethylene dibromide (EDB) is a trace contaminant in diquat products. It originates from the manufacturing process. EDB is a carcinogen, and the EPA has evaluated the health risk of its presence in formulated diquat products. The maximum level of EDB in diquat dibromide is 10 ppb (parts per billion), it degrades over time, and it does not persist as an impurity.



Impacts on Fish and Other Aquatic Organisms

At application rates, diquat does not have any apparent short-term effects on most of the aquatic organisms that have been tested. However, certain species of important aquatic food chain organisms such as amphipods and Daphnia (water fleas) can be adversely affected at label application rates. Direct toxicity and loss of habitat are believed to be the causes. Tests on snails have shown that reproductive success may be affected, as well. These organisms only recolonize the treated area as vegetation becomes re-established.

Laboratory tests indicate walleye are the fish most sensitive to diquat, displaying toxic symptoms when confined in water treated with diquat at label application rates. Other game and panfish (e.g. northern pike, bass, and bluegills) are apparently not affected at these application rates. Limited field studies to date have not identified significant short or long-term impacts on fish and other aquatic organisms in lakes or ponds treated with diquat.

The bioconcentration factors measured for diquat in fish tissues is low. Therefore, bioconcentration is not expected to be a concern with diquat.

Human Health

The risk of acute exposure to diquat would be primarily to chemical applicators. Diquat causes severe skin and eye irritation and is toxic or fatal if absorbed through the skin, inhaled or swallowed. Wearing skin and eye protection (e.g. rubber gloves, apron, and goggles) to minimize eye and skin irritation is required when applying diquat.

The risk to water users of serious health impacts (e.g. birth defects and cancer) is not believed to be significant according to the EPA. Some risk of allergic reactions or skin irritation is present for sensitive individuals.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
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January 2012

2,4-D Chemical Fact Sheet

Formulations

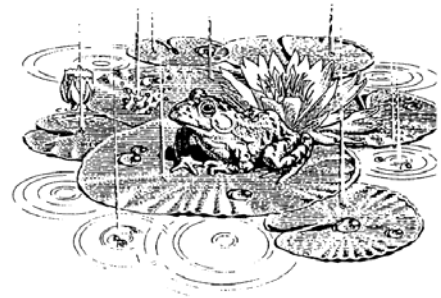
2,4-D is an herbicide that is widely used as a household weed-killer, agricultural herbicide, and aquatic herbicide. It has been in use since 1946, and was registered with the EPA in 1986 and re-reviewed in 2005. The active ingredient is 2,4-dichloro-phenoxyacetic acid. There are two types of 2,4-D used as aquatic herbicides: dimethyl amine salt and butoxyethyl ester. Both liquid and slow-release granular formulations are available. 2,4-D is sold under the trade names Aqua-Kleen, Weedar 64 and Navigate (product names are provided solely for your reference and should not be considered endorsements nor exhaustive).

Aquatic Use and Considerations

2,4-D is a widely-used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. When the treatment occurs, the 2,4-D is absorbed into the plant and moved to the roots, stems, and leaves. Plants begin to die in a few days to a week following treatment, but can take several weeks to decompose. Treatments should be made when plants are growing.

For many years, 2,4-D has been used primarily in small-scale spot treatments. Recently, some studies have found that 2,4-D moves quickly through the water and mixes throughout the waterbody, regardless of where it is applied. Accordingly, 2,4-D has been used in Wisconsin experimentally for whole-lake treatments.

2,4-D is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may be affected include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.



Post-Treatment Water Use Restrictions

There are no restrictions on eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Following the last registration review in 2005, the ester products require a 24-hour waiting period for swimming. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of 2,4-D (the time it takes for half of the active ingredient to degrade) ranges from 12.9 to 40 days depending on water conditions. In anaerobic lab conditions, the half-life has been measured up to 333 days. After treatment, the 2,4-D concentration in the water is reduced primarily through microbial activity, off-site movement by water, or adsorption to small particles in silty water. It is slower to degrade in cold or acidic water, and appears to be slower to degrade in lakes that have not been treated with 2,4-D previously.

There are several degradation products from 2,4-D: 1,2,4-benzenetriol, 2,4-dichlorophenol, 2,4-dichloroanisole, chlorohydroquinone (CHQ), 4-chlorophenol and volatile organics.

Impacts on Fish and Other Aquatic Organisms

Toxicity of aquatic 2,4-D products vary depending on whether the formulation is an amine or an ester 2,4-D. The ester formulations are toxic to fish and some important invertebrates such as water fleas (*Daphnia*) and midges at application rates; the amine formulations are not toxic to fish or invertebrates at application rates. Loss of habitat following treatment may cause reductions in populations of invertebrates with either formulation, as with any herbicide treatment. These organisms only recolonize the treated areas as vegetation becomes re-established.

Available data indicate 2,4-D does not accumulate at significant levels in the bodies of fish that have been tested. Although fish that are exposed to 2,4-D will take up some of the chemical, the small amounts that accumulate are eliminated after exposure to 2,4-D ceases.

On an acute basis, 2,4-D is considered moderately to practically nontoxic to birds. 2,4-D is not toxic to amphibians at application rates; effects on reptiles are unknown. Studies have shown some endocrine disruption in amphibians at rates used in lake applications, and DNR is currently funding a study to investigate endocrine disruption in fish at application rates.

As with all chemical herbicide applications it is very important to read and follow all label instructions to prevent adverse environmental impacts.

Human Health

Adverse health effects can be produced by acute and chronic exposure to 2,4-D. Those who mix or apply 2,4-D need to protect their skin and eyes from contact with 2,4-D products to minimize irritation, and avoid inhaling the spray. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with 2,4-D.

Concerns have been raised about exposure to 2,4-D and elevated cancer risk. Some (but not all) epidemiological studies have found 2,4-D associated with a slight increase in risk of non-Hodgkin's lymphoma in high exposure populations (farmers and herbicide applicators). The studies show only a possible association that may be caused by other factors, and do not show that 2,4-D causes cancer. The EPA determined in 2005 that there is not sufficient evidence to classify 2,4-D as a human carcinogen.

The other chronic health concern with 2,4-D is the potential for endocrine disruption. There is some evidence that 2,4-D may have estrogenic activities, and that two of the break-down products of 2,4-D (4-chlorophenol and 2,4-dichloroanisole) may affect male reproductive development. The extent and implications of this are not clear and it is an area of ongoing research.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
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http://dnr.wi.gov/lakes/plants/

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January 2012

Endothall Chemical Fact Sheet

Formulations

Endothall is the common name of the active ingredient endothal acid (7-oxabicyclo[2,2,1] heptane-2,3-dicarboxylic acid). Endothall products are used to control a wide range of terrestrial and aquatic plants. Both granular and liquid formulations of endothall are available for aquatic use in Wisconsin. Two types of endothall are available: dipotassium salt (such as Aquathol®) and monoamine salts (such as Hydrothol 191). Trade names are provided for your reference only and are neither exhaustive nor endorsements of one product over another.

Aquatic Use and Considerations

Endothall is a contact herbicide that prevents certain plants from making the proteins they need. Factors such as density and size of the plants present, water movement, and water temperature determine how quickly endothall works. Under favorable conditions, plants begin to weaken and die within a few days after application.

Endothall products vary somewhat in the target species they control, so it is important to always check the product label for the list of species that may be affected. Endothall products are effective on Eurasian watermilfoil (*Myriophyllum spicatum*) and also kill desirable native species such as pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum* spp.). In addition, Hydrothol 191 formulations can also kill wild celery (*Vallisneria americana*) and some species of algae (*Chara, Cladophora, Spirogyra, and Pithophora*).

Endothall will kill several high value species of aquatic plants (especially *Potamogeton* spp.) in addition to nuisance species. The plants that offer important values to aquatic ecosystems often resemble, and may be growing with those plants targeted for treatment. Careful identification of plants and application of endothall products is necessary to avoid unintended harm to valuable native species.

For effective control, endothall should be applied when plants are actively growing. Most submersed weeds are susceptible to Aquathol formulations. The choice of liquid or granular formulations depends on the size of the area requiring treatment. Granular is more suited to small areas or spot treatments, while liquid is more suitable for large areas.

If endothall is applied to a pond or enclosed bay with abundant vegetation, no more than 1/3 to ½ of the surface should be treated at one time because excessive decaying vegetation may deplete the oxygen content of the water and kill fish. Untreated areas should not be treated until the vegetation exposed to the initial application decomposes.

Post-Treatment Water Use Restrictions

Due to the many formulations of this chemical the post-treatment water use restrictions vary. Each product label must be followed. For all products there is a drinking water standard of 0.1 ppm and can not be applied within 600 feet of a potable water intake. Use restrictions for Hyrdtohol products have irrigation and animal water restrictions.

Herbicide Degradation, Persistence and Trace Contaminants

Endothall disperses with water movement and is broken down by microorganisms into carbon, hydrogen, and oxygen. Field studies show that low concentrations of endothall persist in water for several days to several weeks depending on environmental conditions. The half-life (the time it takes for half of the active ingredient to degrade) averages five to ten days. Complete degradation by microbial action is 30-60 days. The initial breakdown product of endothall is an amino acid, glutamic acid, which is rapidly consumed by bacteria.

Impacts on Fish and Other Aquatic Organisms

At recommended rates, the dipotassium salts (Aquathol and Aquathol K) do not have any apparent short-term effects on the fish species that have been tested. In addition, numerous studies have shown the dipotassium salts induce no significant adverse effects in aquatic invertebrates (such as snails, aquatic insects, and crayfish) when used at label application rates. However, as with other herbicide use, some plant-dwelling populations of aquatic organisms may be adversely affected by application of endothall formulations due to habitat loss.

In contrast to the low toxicity of the dipotassium salt formulations, laboratory studies have shown the monoamine salts (Hydrothol 191 formulations) are toxic to fish at dosages above 0.3 parts per million (ppm). In particular, the liquid formulation will readily kill fish present in a treatment site. By comparison, EPA approved label rates for plant control range from 0.05 to 2.5 ppm. In recognition of the extreme toxicity of the monoamine salt, product labels recommend no treatment with Hydrothol 191 where fish are an important resource.

Other aquatic organisms can also be adversely affected by Hydrothol 191 formulations depending upon the concentration used and duration of exposure. Tadpoles and freshwater scuds have demonstrated sensitivity to Hydrothol 191 at levels ranging from 0.5 to 1.8 ppm.

Findings from field and laboratory studies with bluegills suggest that bioaccumulation of dipotassium salt formulations by fish from water treated with the herbicide is unlikely. Tissue sampling has shown residue levels become undetectable a few days after treatment.

Human Health

Most concerns about adverse health effects revolve around applicator exposure. Liquid endothall formulations in concentrated form are highly toxic. Because endothall can cause eye damage and skin irritation, users should minimize exposure by wearing suitable eye and skin protection.

At this time, the EPA believes endothall poses no unacceptable risks to water users if water use restrictions are followed. EPA has determined that endothall is not a neurotoxicant or mutagen, nor is it likely to be a human carcinogen.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
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Wisconsin Department of Natural Resources

January 2012

Fluridone Chemical Fact Sheet

Formulations

Fluridone is an aquatic herbicide that was initially registered with the EPA in 1986. The active ingredient is 1-methyl-3-phenyl-5-3-(trifluoromethyl)phenyl|-41H|-pyridinone. Both liquid and slow-release granular formulations are available. Fluridone is sold under the brand names Avast!, Sonar, and Whitecap (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Fluridone is an herbicide that stops the plant from making a protective pigment that keeps chlorophyll from breaking down in the sun. Treated plants will turn white or pink at the growing tips after a week and will die in one to two months after treatment as it is unable to make food for itself. It is only effective if plants are growing at the time of treatment.

Fluridone is used at very low concentrations, but a very long contact time is required (45-90 days). If the fluridone is removed before the plants die, they will once again be able to produce chlorophyll and grow.

Fluridone moves rapidly through water, so it is usually applied as a whole-lake treatment to an entire waterbody or basin. There are pellet slow-release formulations that may be used as spot treatments, but the efficacy of this is undetermined. Fluridone has been applied to rivers through a drip system to maintain the concentration for the required contact time.

Plants vary in their susceptibility to fluridone, so typically some species will not be affected even though the entire waterbody is treated.

Plants have been shown to develop resistance to repeated fluridone use, so it is recommended to rotate herbicides with different modes of action when using fluridone as a control.

Fluridone is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). It also is commonly used for control of invasive hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*), neither of which are present in Wisconsin yet. Desirable native species that are usually affected at concentrations used to treat the invasives include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of fluridone (the time it takes for half of the active ingredient to degrade) ranges from 4 to 97 days depending on water conditions. After treatment, the fluridone concentration in the water is reduced through dilution due to water movement, uptake by plants, adsorption to the sediments, and break down from light and microbial action.

There are two major degradation products from fluridone: n-methyl formamide (NMF) and 3-trifluoromethyl benzoic acid. NMF has not been detected in studies of field conditions, including those at the maximum label rate.

Fluridone residues in sediments reach a maximum in one to four weeks after treatment and decline in four months to a year depending on environmental conditions. Fluridone adsorbs to clay and soils with high organic matter, especially in pellet form, and can reduce the concentration of fluridone in the water. Adsorption to the sediments is reversible; fluridone gradually dissipates back into the water where it is subject to chemical breakdown.

Impacts on Fish and Other Aquatic Organisms

Fluridone does not appear to have any apparent short-term or long-term effects on fish at application rates.

Fish exposed to water treated with fluridone absorb fluridone into their tissues. Residues of fluridone in fish decrease as the herbicide disappears from the water. The EPA has established a tolerance for fluridone residues in fish of 0.5 parts per million (ppm).

Studies on Fluridone's effects on aquatic invertebrates (i.e. midge and water flea) have shown increased mortality at label application rates.

Studies on birds indicate that fluridone would not pose an acute or chronic risk to birds. No studies have been conducted on amphibians or reptiles.

Human Health

The risk of acute exposure to fluridone would be primarily to chemical applicators. The acute toxicity risk from oral and inhalation routes is minimal. Concentrated fluridone may cause some eye or skin irritation. No personal protective equipment is required on the label to mix or apply fluridone.

Fluridone does not show evidence of causing birth defects, reproductive toxicity, or genetic mutations in mammals tested. It is not considered to be carcinogenic nor does it impair immune or endocrine function.

There is some evidence that the degradation product NMF causes birth defects. However, since NMF has only been detected in the lab and not following actual fluridone treatments, the manufacturer and EPA have indicated that fluridone use should not result in NMF concentrations that would adversely affect the health of water users. In the re-registration assessment that is currently underway for fluridone, the EPA has requested additional studies on both NMF and 3-trifluoromethyl benzoic acid.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
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http://npic.orst.edu/

Hamelink, J.L., D.R. Buckler, F.L. Mayer, D.U. Palawski, and H.O. Sanders. 1986. Toxicity of Fluridone to Aquatic Invertebrates and Fish. Environmental Toxicology and Chemistry 5:87-94.

Fluridone ecological risk assessment by the Bureau of Land Management, Reno Nevada: http://www.blm.gov/pgdata/etc/medialib/blm/wo/Planning_and_Renewable_Resources/veis.Par.91082.File.tmp/Fluridone%20Ecological%20Risk%20Assessment.pdf

January 2012

Triclopyr Chemical Fact Sheet

Formulations

Triclopyr was initially registered with the EPA in 1979 and was reregistered in 1997. Triclopyr acid has different formulations for aquatic and terrestrial use. The active ingredient triethylamine salt (3,5,6-trichloro-2-pyridinyloxyacetic acid), commonly called triclopyr, is the formulation registered for use in aquatic systems. It is sold both as a liquid (Renovate 3™) as well as a granular form (Renovate OTF™) for control of submerged, emergent and floating-leaf vegetation. There is also a liquid premixed formulation (Renovate Max G™) that contains triclopyr plus 2,4-D, another aquatic herbicide.

Aquatic Use and Considerations

Triclopyr is used to treat the invasive Eurasian watermilfoil (Myriophyllum spicatum). Desirable native species that may also be affected include native milfoils, water shield (*Brasenia schreberi*), pickerelweed (*Pontederia cordata*), and lilies (*Nymphaea* spp. and *Nuphar* spp.).

Triclopyr is a systemic herbicide that moves throughout the plant tissue and works by interfering with cell growth and division. Following treatment, plant growth will be abnormal and twisted, and then plants will die within two to three weeks after application. Plants will decompose over several weeks.

Triclopyr needs to be applied to plants that are actively growing. A water body should not be treated with triclopyr if there is an outlet, or in moving waters such as rivers or streams. If there is water movement at a treated site, higher concentrations or a repeated application may be required.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated water bodies, or pet/livestock drinking water use. Before treated water can be used for irrigation, the concentration must be below one part per billion (ppb), or at least 120 days must pass. Treated water should not be used for drinking water until concentrations of triclopyr are less than 400 ppb.

Herbicide Degradation, Persistence and Trace Contaminants

Triclopyr is broken down rapidly by light and microbes and has a half-life (the time it takes for half of the active ingredient to degrade) of about a day. Dissipation studies in lakes indicate that the half-life in natural systems ranges from 0.5 to 7.5 days. Lakes with more organic matter in the soil will have more rapid degradation.

The initial breakdown products of triclopyr are TCP (3,5,6-trichloro-2-pyridinol) and TMP (3,5,6-trichloro-2-methoxypridine). TCP and TMP appear to be slightly more toxic to aquatic organisms than triclopyr; however the peak concentration of these degradates is very low following treatment, so that they do not pose a concern to aquatic organisms. The half-lives for TCP and TMP are similar to those of triclopyr.

Triclopyr doesn't bind to soil, and limited leaching of triclopyr and its degradation products may occur. It likely is not mobile enough to contaminate groundwater, and EPA has determined that the evidence of possible leaching is not sufficient to require further study.

Impacts on Fish and Other Aquatic Organisms

Testing indicates that the aquatic formulation of triclopyr is practically non-toxic to fish and invertebrates. Species tested included catfish, trout, bluegill, minnows, crayfish and water fleas (*Daphnia* sp.). Triclopyr is slightly toxic to mallards, but at concentrations well above (400x) the highest allowed application rate. Water pH will affect toxicity because greater exposure to triclopyr will occur in low pH water. Tests have not been conducted in low pH water except for salmon species. However, the margin of safety in the toxicity tests that were conducted suggest that even in low pH water there would not be toxic effects on fish.

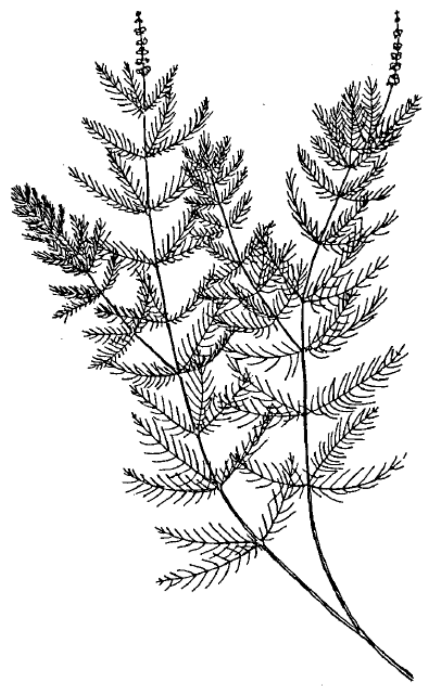
Tests on the degradation product TCP indicate that acute effects to bluegill and rainbow trout would not occur at label usage rates, although it is slightly more toxic than triclopyr. The degradation product TMP is moderately toxic to fish, but after treatment is found only in low proportions if it is detected at all. The EPA has requested additional data to evaluate the fate of the degradation product TCP in aquatic systems as well as its chronic toxicity to fish.

Triclopyr and TCP do not bioaccumulate and clear from fish and crayfish tissues at rates similar to that which occurs in the water. TMP does appear to bioaccumulate in fatty fish tissues, such as inedible and visceral tissues, but does not persist in fish following TMP disappearance from the water.

Human Health

The risk of acute exposure to triclopyr would be primarily to chemical applicators. Concentrated triclopyr does not pose an inhalation risk, but can cause skin irritation and eye corrosion. Persons who mix or apply triclopyr need to protect their skin and eyes from contact. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with triclopyr.

Triclopyr does not show evidence of birth defects, reproductive toxicity or genetic mutations in mammals tested. Triclopyr is not metabolized by humans and the majority is excreted intact. Some tumors of breast tissue occurred in tests on rodents; however there was no consistent pattern and insufficient evidence to list triclopyr as a carcinogen. Based on its low acute toxicity to mammals, and its rapid disappearance from the water column due to light and microbial degradation, triclopyr is not considered to pose a risk to water users.



For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/