# 2009 SUMMARY REPORT
# of
# Ozaukee Lake

# Lake County, Illinois

*Prepared by the*

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# EXECUTIVE SUMMARY

Ozaukee Lake is an impoundment lake located in unincorporated Lake County and Fremont Township. The lake has a surface area of 20.37 acres and an average depth of 1.64 feet. The Lake County Forest Preserve District manages the undeveloped property within the lakes entire watershed. The public can utilize the lake for aesthetics and fishing.

Ozaukee Lake is listed as an ADID (advanced identification) wetland by the U.S. Environmental Protection Agency. This indicates that the lake and surrounding natural environments have potential to have high quality aquatic resources based on water quality and hydrology values.

Ozaukee Lake receives water from its 101.83 acre watershed and drains west under Fairfield Road into Lake Napa Suwe that is connected to a tributary to Mutton Creek and eventually flows into the Fox River. The primary land use within the Ozaukee Lake watershed was public and private open space (92%); which is a unique and valuable characteristic as Lake County only has 13% of land preserved as public and private open space.

The 2009 water quality in Ozaukee Lake was poor with many parameters above the county medians. Total phosphorus (TP) in Ozaukee Lake averaged 0.220 mg/L and the median for the county was 0.063 mg/L. Ozaukee Lake had the highest level of phosphorus in the entire Mutton Creek watershed in 2009. The abundance of algae and nonvolatile suspended solids (NVSS) led to a decrease in water clarity and an increase in Total Suspended Solids (TSS) over the course of the summer. TSS concentrations averaged 80.1 mg/L which was more than ten times the county median of 7.9 mg/L. A total nitrogen to total phosphorus ratio of 13:1 indicated that there was a surplus of nitrogen and phosphorus in the lake; the majority of lakes in Lake County and the Midwest are phosphorus limiting. Also using phosphorus as an indicator, the trophic state index (TSIp) ranked Ozaukee Lake as hypereutrophic with a TSIp value of 82.0. The average conductivity reading for Ozaukee Lake was 0.4956 mS/cm and average Cl- concentrations were 58 mg/L. Conductivity is positively correlated with chloride (Cl-) concentrations. These parameters were below the county median of 0.7910 mS/cm and 145 mg/L.

Presence of aquatic plants in Ozaukee Lake was sparse; only 5.5% of the lake surface area exhibited aquatic plants and the species documented were mostly considered nuisance species indicating poor water quality. There were two exotic species present in the lake, Curlyleaf Pondweed and Eurasian Watermilfoil**.** Although these exotic species possess many advantages over native aquatic plants Ozaukee Lake could not support an increase in aquatic plant populations due to the low light availability and the competition from blue-green algae. Blue-green algae are a concern due to the threat they pose through the potential release of cyanotoxins that may harm invertebrates, fish, and mammals.

Based on the 2009 assessment, there was an increase in shoreline erosion since the 2002 assessment with approximately 85% of the shoreline having some degree of erosion. Overall, 15% of the shoreline had no erosion, 9% had slight erosion, 36% had moderate, and 40% had severe erosion. The areas of moderate and severe erosion should be addressed soon. It is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion.

# LAKE FACTS

| | |
|---|---|
| **Lake Name:** | Ozaukee Lake |
| **Historical Name:** | Drummond Lake, ADID 117 |
| **Nearest Municipality:** | Wauconda |
| **Location:** | T44N, R10E, Section 19, NE 1/4 |
| **Elevation:** | 804.0 feet mean sea level |
| **Major Tributaries:** | None |
| **Watershed:** | Fox River |
| **Sub-watershed:** | Mutton Creek |
| **Receiving Waterbody:** | Napa Suwe Lake |
| **Surface Area:** | 20.4 acres |
| **Shoreline Length:** | 0.9 miles |
| **Maximum Depth:** | 3.0 feet |
| **Average Depth:** | 1.6 feet |
| **Lake Volume:** | 33.4 acre-feet |
| **Lake Type:** | Impoundment |
| **Watershed Area:** | 101.8 acres |
| **Major Watershed Land Uses:** | Public and private open space, transportation, and water |
| **Bottom Ownership:** | Lake County Forest Preserve District |
| **Management Entities:** | Lake County Forest Preserve District |
| **Current and Historical Uses:** | Aesthetics and fishing |
| **Description of Access:** | Public |

# SUMMARY OF WATER QUALITY

Water samples were collected monthly from May through September at the deepest point located on the west side of the lake (Figure 1, Appendix A). Samples were collected at the surface and analyzed for various water quality parameters (Appendix C). The Lakes Management Unit (LMU) also sampled Ozaukee Lake in 2002. Ozaukee Lake is located in the Mutton Creek watershed and is completely owned and managed by the Lake County Forest Preserve District (LCFPD). The LMU sampled one other lake within the Mutton Creek watershed in 2009, Lake Napa Suwe. Ozaukee Lake drains west under Fairfield Road into Lake Napa Suwe that is connected to a tributary to Mutton Creek and eventually flows into the Fox River. Other lakes in the Mutton Creek watershed include Lake Fairfield and Island Lake.

The Illinois Environmental Protection Agency's applicable standard for dissolved oxygen is 5.0 mg/L. This concentration is required to maintain a healthy fishery. Ozaukee maintained dissolved oxygen levels above 5.0 mg/L throughout the entire sampling season (Appendix B). Due to the shallow nature of the lake, wind and wave activity contributed enough disturbances to maintain oxygenated conditions within the entire water column (Figure 2). However it is important to keep in mind that dissolved oxygen was recorded during the day and aquatic plants and algae populations can cause fluctuations in dissolved oxygen levels from day to night.

In 2002 Ozaukee Lake had poor water quality; the impounded lake had frequent planktonic algal blooms, low water clarity and high nutrient levels. Many water quality parameters remained above county medians in 2009. The total suspended solid (TSS) parameter (turbidity) is composed of nonvolatile suspended solids (NVSS), non-organic clay or sediment materials, and volatile suspended solids (TVS) (algae and other organic matter). TSS concentrations averaged 80.1 mg/L (Table 2), which was ten times higher than the county median of 7.9 mg/L (Appendix E). Since 2002 the TSS value of 50.1 mg/L has increased by 35%. High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of the lake ecosystem including the plant and fish communities. Calculated nonvolatile suspended solids (NVSS) was 57.3 mg/L. This means that 71% of the TSS concentration is related to suspended inorganic particles. The other 29% can be attributed to organic particles. The 2002 NVSS value of 32.2 mg/L was 68% of the TSS. The 2002 and 2009 NVSS values indicate that the major impairment for water clarity was from inorganic suspended particles such as soil. However at these high concentrations the 32% of organic particles was significant. Ozaukee Lake experienced algal blooms the entire sampling season, covering 100% of the lake. TVS concentrations, were correlated with peaks in TSS concentrations (Figure 3). In July Ozaukee Lake had the highest level of TSS (110.0 mg/L) and TVS (138 mg/L) this sampling event was visually noted as having the highest density of algae during the sampling season.

Secchi disk transparency is an indicator overall water quality. In general, the greater the Secchi disk depth, the clearer the water and better the water quality. The median for Lake County lakes was 3.15 feet. Based on Secchi depth, Ozaukee Lake has very poor water quality. The 2009 Secchi disk depth was 0.51 feet which was a 37% decrease from the 2002 average of 0.81 feet. The monthly readings varied from 1.08 feet in May to 0.25 feet in September. The September Secchi disk reading was the worst reading taken by the LMU based on sampling efforts from 2000 to 2009. Within the Mutton Creek Watershed, Ozaukee Lake had the lowest average

**Figure 1. Water quality sampling site on Ozaukee Lake, 2009.**

**Figure 2. Bathymetric map of Ozaukee Lake, 2009.**

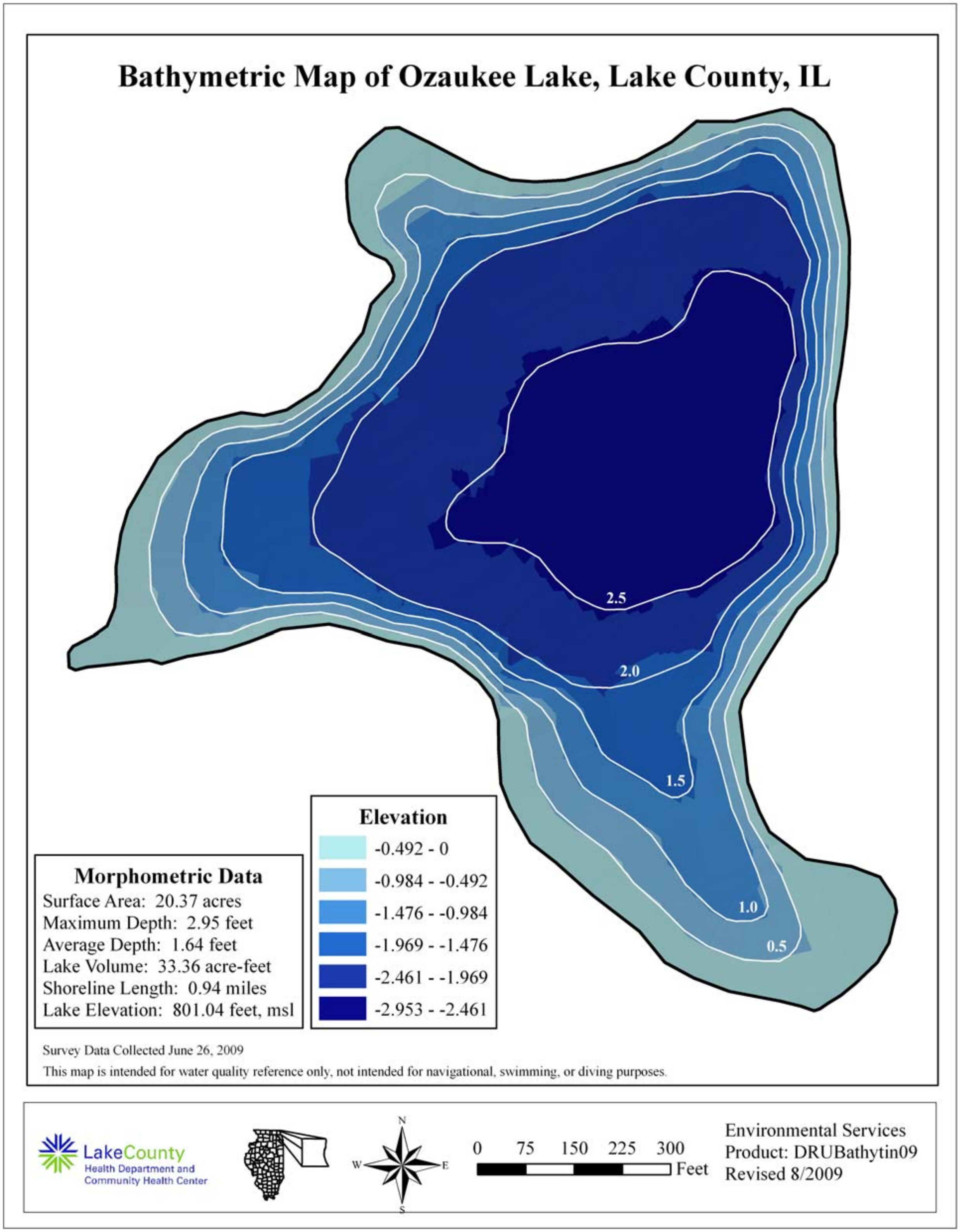

**Table 1. Morphometric features of Ozaukee Lake, 2009.**

Morphometric Features of Ozaukee Lake ~
Data From the June 26, 2009 Bathymetric Survey, LCHD Environmental Services

| Contour (Feet) | Area Enclosed (Acres) | Percent of Total Acres | Volume (Acre-Feet) | Depth Zone (Feet) | Area (Acres) | Percent Depth Zone To Total Acres | Percent Acre-Feet To Total Volume |
|---|---|---|---|---|---|---|---|
| 0 | 20.37 | 100.0% | 17.41 | 0 - 1 | 5.76 | 28.3% | 52.2% |
| 1 | 14.61 | 71.7% | 11.84 | 1 - 2 | 5.34 | 26.2% | 35.5% |
| 2 | 9.27 | 45.5% | 4.11 | 2 + | 9.27 | 45.5% | 12.3% |
| | | | 33.36 | | 20.37 | 100% | 100% |

Maximum Depth of Lake: 2.95 Feet
Average Depth of Lake: 1.64 Feet
Volume of Lake: 33.36 Acre-Feet

Area of Lake: 20.37 Acres
Shoreline Length: 0.94 Miles
Water Elevation at 801.04 Feet Above Mean Sea Level

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# Table 2. Water quality data for Ozaukee Lake, 2002 and 2009.

| 2009 | Epilimnion | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | DEPTH | ALK | TKN | $NH_3$-N | $NO_2$+$NO_3$-N | TP | SRP | TDS | Cl- | TSS | TS | TVS | SECCHI | COND | pH | DO |
| 12-May | 0 | 172 | 1.42 | 0.183 | 0.54 | 0.108 | 0.013 | NA | 50 | 47.6 | 340 | 90 | 1.08 | 0.5090 | 9.03 | 7.67 |
| 9-Jun | 0 | 170 | 2.66 | 0.452 | 0.10 | 0.202 | 0.035 | NA | 54 | 87.0 | 397 | 126 | 0.26 | 0.5060 | 8.75 | 10.15 |
| 14-Jul | 0 | 140 | 3.01 | <0.1 | <0.05 | 0.283 | 0.032 | NA | 58 | 110.0 | 413 | 138 | 0.66 | 0.4790 | 8.85 | 7.82 |
| 11-Aug | 0 | 145 | 3.26 | 0.214 | <0.05 | 0.286 | <0.005 | NA | 62 | 90.0 | 406 | 134 | 0.30 | 0.5120 | 8.43 | 6.44 |
| 15-Sep | 0 | 118 | 3.38 | <0.1 | <0.05 | 0.223 | 0.014 | NA | 66 | 66.0 | 370 | 132 | 0.25 | 0.4720 | 9.07 | 8.81 |
| | **Average** | 149 | 2.75 | 0.283[k] | 0.316[k] | 0.220 | 0.024[k] | NA | 58 | 80.1 | 385 | 124 | 0.51 | 0.4956 | 8.83 | 8.18 |

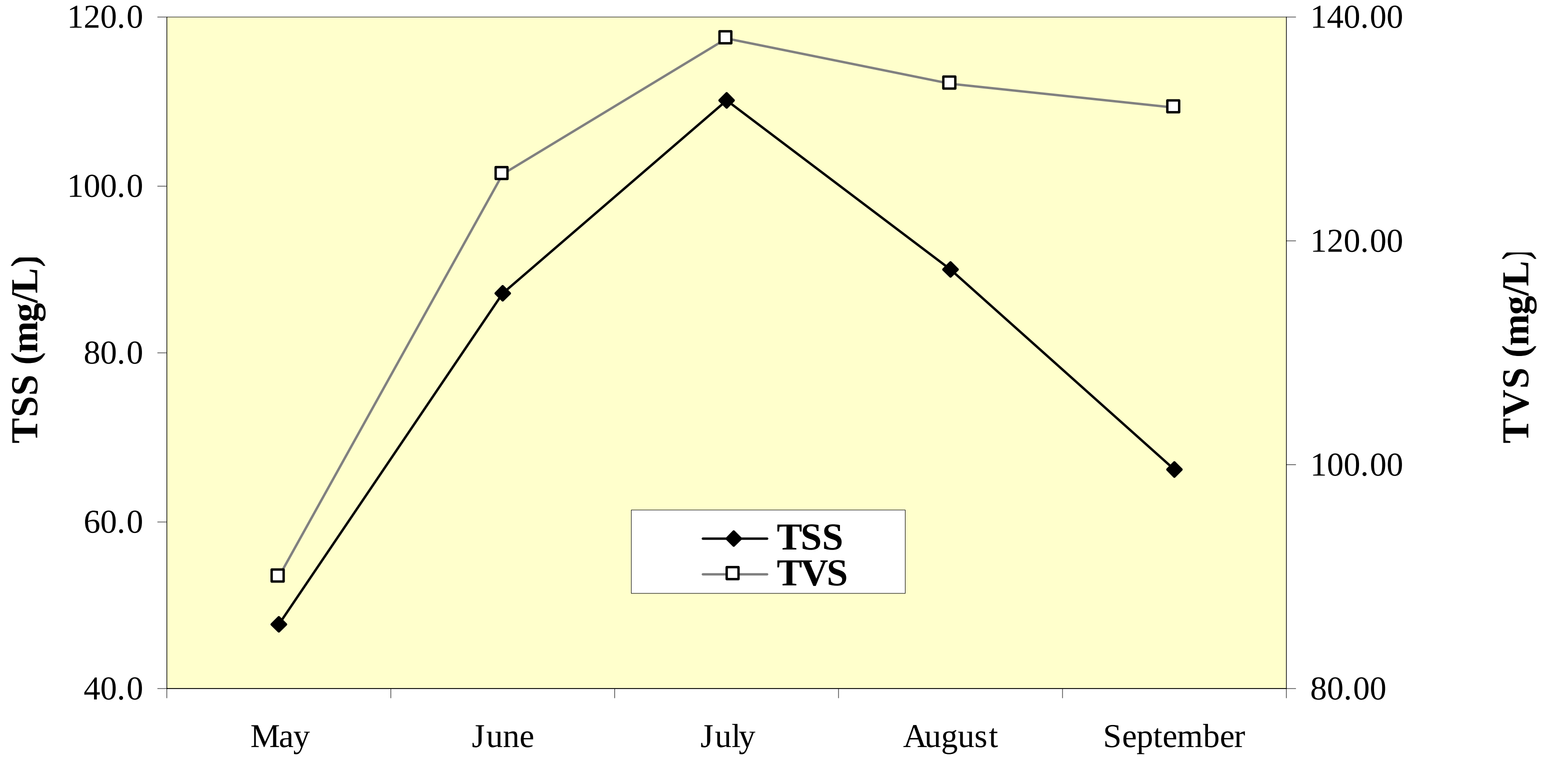
| 2002 | Epilimnion | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | DEPTH | ALK | TKN | NH3-N | NO3-N | TP | SRP | TDS | Cl- | TSS | TS | TVS | SECCHI | COND | pH | DO |
| 30-Apr | 3 | 193 | 1.97 | <0.1 | <0.05 | 0.120 | 0.005 | 338 | NA | 27.0 | 407 | 169 | 1.25 | 0.5962 | 8.55 | 10.6 |
| 5-Jun | 3 | 186 | 1.79 | 0.374 | 0.630 | 0.112 | 0.010 | 334 | NA | 34.4 | 396 | 132 | 1.02 | 0.5905 | 7.93 | 6.11 |
| 9-Jul | 0 | 160 | 2.42 | <0.1 | <0.05 | 0.168 | 0.060 | 382 | NA | 63.0 | 439 | 165 | 0.60 | 0.5862 | 8.30 | 5.44 |
| 6-Aug | 0 | 174 | 3.00 | <0.1 | <0.05 | 0.203 | 0.011 | 391 | NA | 93.1 | 497 | 180 | 0.53 | 0.6280 | 8.33 | 6.04 |
| 4-Sep | 0 | 121 | 1.89 | <0.1 | <0.05 | 0.152 | 0.005 | 290 | NA | 43.0 | 392 | 169 | 0.64 | 0.4998 | 8.25 | 5.98 |
| | **Average** | 167 | 2.21 | 0.374[k] | 0.630[k] | 0.151 | 0.018 | 347 | NA | 52.1 | 426 | 163 | 0.81 | 0.5801 | 8.27 | 6.83 |

**Glossary**

| | |
|---|---|
| ALK = Alkalinity, mg/L $CaCO_3$ | TDS = Total dissolved solids, mg/L |
| TKN = Total Kjeldahl nitrogen, mg/L | TSS = Total suspended solids, mg/L |
| $NH_3$-N = Ammonia nitrogen, mg/L | TS = Total solids, mg/L |
| $NO_2$+$NO_3$-N = Nitrate + Nitrite nitrogen, mg/L | TVS = Total volatile solids, mg/L |
| $NO_3$-N = Nitrate + Nitrite nitrogen, mg/L | SECCHI = Secchi disk depth, ft. |
| TP = Total phosphorus, mg/L | COND = Conductivity, milliSiemens/cm |
| SRP = Soluble reactive phosphorus, mg/L | DO = Dissolved oxygen, mg/L |
| $Cl^-$ = Chloride, mg/L | |

k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable
* = Prior to 2006 only Nitrate - nitrogen was analyzed

**Figure 3. Total suspended solid (TSS) concentrations vs. total volatile solids (TVS) for Ozaukee Lake, 2009.**



secchi depth (0.51 feet) and the highest average TSS (80.1 mg/L, Table 3). The lake's shallow nature, lack of aquatic plants, and abundance of Common Carp contribute to the elevated concentrations of these parameters. In contrast, Lake Fairfield had the greatest average Secchi depth (5.89 feet) and the lowest average TSS (5.1 mg/L). Lake Fairfield is located near the top of the watershed and is the deepest lake with in the watershed. Approximately 63% of the lake bottom was cover with the macro algae Chara that competes with algae and stabilizes sediments within the lake.

Another factor affecting water clarity was the amount of nutrients in the water. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting, ratios greater than or equal to 15:1 indicate phosphorus is limiting, and ratios greater than 10:1, but less than 15:1 indicate there is enough of both nutrients to facilitate excess algae or plant growth. In 2002 Ozaukee Lake was phosphorus limited (TN:TP ratio of 19:1) and in 2009 the TN:TP ratio was 13:1 indicating there was a surplus of nitrogen and phosphorus in the lake. The low abundance of plants in Ozaukee Lake also influences nutrient levels in a lake since aquatic plants are not using available phosphorus. This will lead to more algae blooms. Due to the low TN:TP ratios in July and August (11:1) Ozaukee Lake was susceptible to blue-green algae blooms. Blue green algae can fix nitrogen from the atmosphere when nitrogen supplies are low. Blue green algae may release cyanotoxins under certain conditions as they die that can poison mammals, fish, and invertebrates that directly ingest the algae or the infected water.

Nitrogen sources vary from fertilizer to human waste and sewage treatment plants, to groundwater, air, and rainfall. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Ozaukee Lake was 2.75 mg/L in 2009, which was twice the county median (1.18 mg/L) and a 20% increase from the 2002 average (2.21 mg/L). Ozaukee Lake also exhibited high values of Ammonia nitrogen, ($NH_3$-N) after heavy rain events in June (0.91 inches) and August (3.14 inches)

Total phosphorus (TP) in Ozaukee Lake averaged 0.220 mg/L which was three times the county median of 0.063 mg/L and a 31% increase from the 2002 value of 0.151 mg/L. The same watershed trend of TSS and Secchi disk occurred with TP. Ozaukee Lake had the highest TP concentration in the entire Mutton Creek watershed and Fairfield Lake had the lowest TP concentration (0.030 mg/L). Lakes with phosphorus levels greater than 0.050 mg/L are considered impaired as they may support nuisance algae and/or abundant aquatic plant growth. Phosphorus can enter a lake either internally (typically linked to sediment) or externally (point or non-point sources). Point source pollution can be from storm pipes or wastewater discharge and non-point source pollution is from groundwater runoff, which picks up phosphorus from agricultural fields, septic systems, lawns, or impervious surfaces. Internal sources within Ozaukee Lake were the decomposition of large densities of algae that continued to recycle phosphorus and sediments that are stirred up by carp and wind. Also, historically this was drained and farmed. The external sources of TP affecting Ozaukee Lake included stormwater from the 101.83 acres within its watershed (Figure 4). Public and private open space (92%),

**Table 3. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity within the Mutton Creek watershed.**

| | Ozaukee Lake | Ozaukee Lake | Lake Napa SuWe Inlet | Lake Napa SuWe Outlet | Lake Napa SuWe Inlet | Lake Napa SuWe Outlet |
|---|---|---|---|---|---|---|
| **Year** | **2002** | **2009** | **2002** | **2002** | **2009** | **2009** |
| **Secchi (feet)** | 0.81 | 0.51 | 0.98 | 0.81 | 2.66 | NA |
| **TSS (mg/L)** | 52.1 | 80.1 | 43.4 | 60.4 | 12.1 | 26.4 |
| **TP (mg/L)** | 0.15 | 0.22 | 0.2 | 0.23 | 0.07 | 0.06 |
| **Conductivity (milliSiemens/cm)** | 0.5801 | 0.4956 | 0.975 | 0.9609 | 0.6644 | 0.6390 |

| | Fairfield Lake | Island Lake |
|---|---|---|
| **Year** | **2000** | **2003** |
| **Secchi (feet)** | 5.89 | 2.9 |
| **TSS (mg/L)** | 5.1 | 14.9 |
| **TP (mg/L)** | 0.03 | 0.1 |
| **Conductivity (milliSiemens/cm)** | 0.6267 | 0.8376 |

**Direction of Watershed Flow**

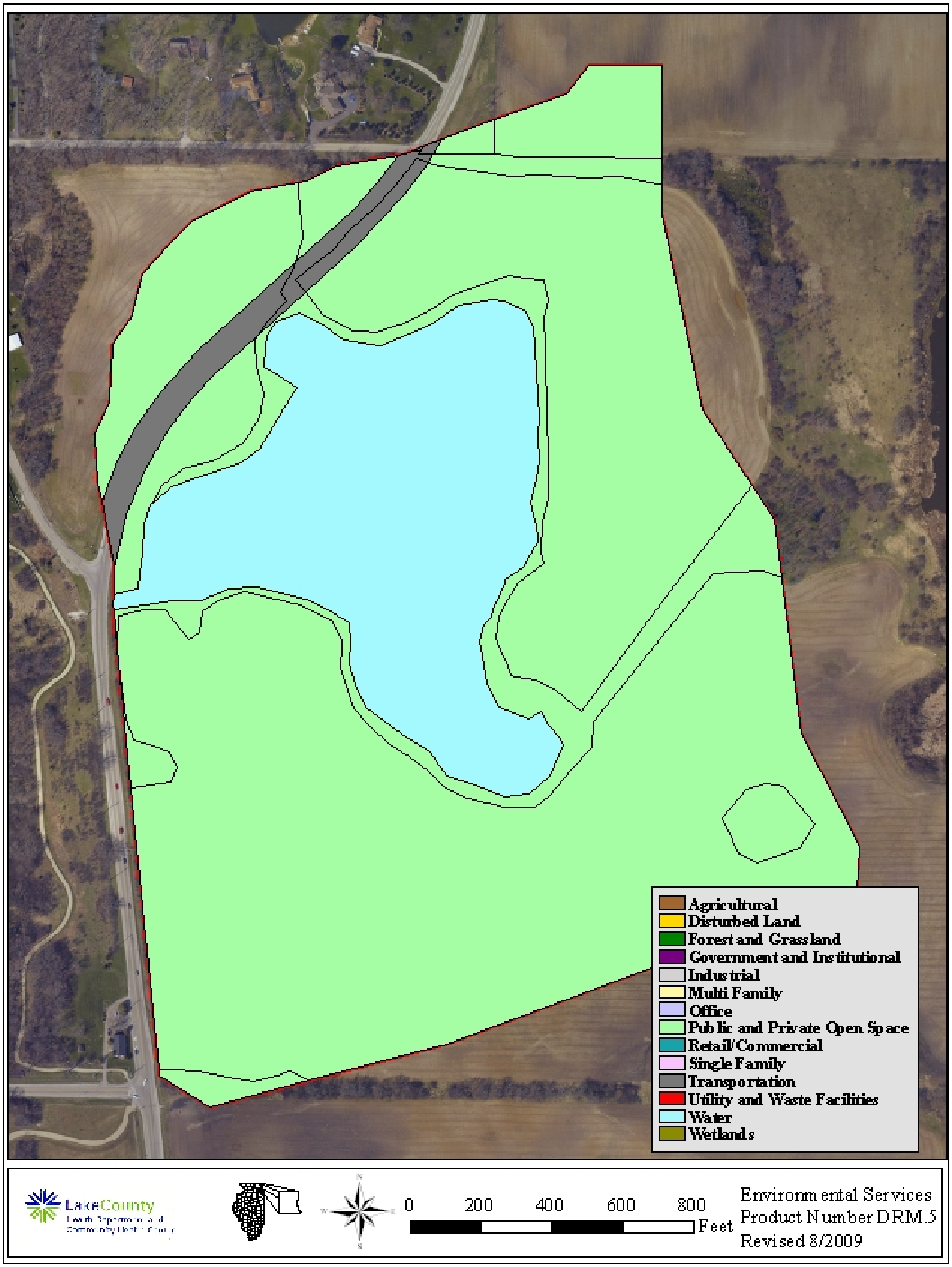
Figure 4. Approximate watershed delineation for Ozaukee Lake, 2009.

transportation (2%) and water (6%) were the only land uses within the watershed (Figure 5). The public and private space land use was a unique and valuable characteristic within a watershed as Lake County only has 13% of land preserved as open space. Based on the amount of impervious surfaces each land use contributes varied amounts of runoff. The two sources of runoff for Ozaukee Lake were public and private open space (88%) and transportation (12%, Table 4). Watershed characteristics are important lake management tools when considering options to reduce nutrient loads. The retention time (the amount of time it takes for water entering a lake to flow out of it again) was calculated to be approximately 85 days. A watershed is an area of land that drains into a body of water and the land management directly affects the water quality. Historically Ozaukee Lake's main external source of TP was from agricultural runoff entering the lake and farming within the current lake boundary. Currently the Lake County Forest Preserve is restoring the public and private open space into a savannah oak prairie and the external nutrient runoff should be minimal. This may indicate that a majority of Ozaukee Lake's TP was from internal sources. The Lake County Forest Preserve active management in 2009 included: winter cutting of exotic terrestrial plants and shrubs including Buckthorn and Honeysuckle and early summer herbicide treatments for those species and native prairie seed planting in the historical agricultural fields. Future restoration efforts will include planting a large quantity of oak trees within the prairie and wetland plant species around Ozaukee Lake.

The Illinois EPA has indices used for assessing lakes for aquatic life and recreational use impairment. The indices are calculated using the mean trophic state index (TSI), percent macrophyte coverage, and the median nonvolatile suspended solids concentration. The TSI index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), and eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich and productive). This index can be calculated using TP values obtained at or near the surface. In 2002 Ozaukee Lake was hypereutrophic with a TSIp value of 76.5 with aquatic life having full support and recreational use scoring partial support. In 2009 Ozaukee Lake was again hypereutrophic with a TSIp value of 82.0 ranking the lake 154$^{th}$ out of 165 in the county (Table 5). The impairment indices determined that Ozaukee Lake had partial support for aquatic life and non-support for recreational use do to high nutrient levels and substantial NVSS concentrations. (The IEPA discontinued calculating the Swimming Use Index in 2007).

Conductivity readings, which are influenced by chloride concentrations, have been increasing throughout the past few years in the county. Road salts used in winter road maintenance consist of sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanides which are detected when chlorides are analyzed. The 2009 average conductivity reading for Ozaukee Lake was 0.4956 mS/cm. This was one of the few parameters lower than the county median of 0.7910 mS/cm and was a slight decrease from 2002 (0.5801 mS/cm). Chloride concentrations averaged 58 mg/L for the season and were almost a third less than the county median of 145 mg/L. A study done in Canada reported 10% of aquatic species were harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations were associated with chloride concentrations as low as 12 mg/l. It appears that road salt is compounding in many lakes in the county. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years particularly lakes within watersheds that

**Figure 5. Approximate land use within the Ozaukee Lake watershed, 2009.**



## Table 4. Approximate land uses and retention time for Ozaukee Lake, 2009.

| Land Use | Acreage | % of Total |
|---|---|---|
| Public and Private Open Space | 304.59 | 91.5% |
| Transportation | 7.30 | 2.2% |
| Water | 20.83 | 6.3% |
| **Total Acres** | **332.72** | **100.0%** |

| Land Use | Acreage | Runoff Coeff. | Estimated Runoff, acft. | % Total of Estimated Runoff |
|---|---|---|---|---|
| Public and Private Open Space | 304.59 | 0.15 | 125.6 | 88.0% |
| Transportation | 7.30 | 0.85 | 17.1 | 12.0% |
| Water | 20.83 | 0.00 | 0.0 | 0.0% |
| **TOTAL** | **332.72** | | **142.7** | 100.0% |

| | | |
|---|---|---|
| **Lake volume** | **33.36** | **acre-feet** |
| **Retention Time (years)= lake volume/runoff** | **0.23** | **years** |
| | **85.32** | **days** |

# Table 5. Lake County average TSI phosphorous (TSIp) ranking 2000-2009.

| RANK | LAKE NAME | TP AVE | TSIp |
|---|---|---|---|
| 1 | Lake Carina | 0.0100 | 37.35 |
| 2 | Sterling Lake | 0.0100 | 37.35 |
| 3 | Independence Grove | 0.0135 | 39.24 |
| 4 | Lake Zurich | 0.0130 | 41.14 |
| 5 | Sand Pond (IDNR) | 0.0165 | 41.36 |
| 6 | West Loon Lake | 0.0140 | 42.21 |
| 7 | Windward Lake | 0.0158 | 43.95 |
| 8 | Cedar Lake | 0.0170 | 45.00 |
| 9 | Pulaski Pond | 0.0180 | 45.83 |
| 10 | Timber Lake | 0.0180 | 45.83 |
| 11 | Fourth Lake | 0.0182 | 45.99 |
| 12 | Lake Kathryn | 0.0200 | 47.35 |
| 13 | Highland Lake | 0.0200 | 47.35 |
| 14 | Banana Pond | 0.0202 | 47.49 |
| 15 | Lake Minear | 0.0204 | 47.63 |
| 16 | Cross Lake | 0.0220 | 48.72 |
| 17 | Sun Lake | 0.0220 | 48.72 |
| 18 | Dog Pond | 0.0222 | 48.85 |
| 19 | Lake of the Hollow | 0.0230 | 49.36 |
| 20 | Stone Quarry Lake | 0.0230 | 49.36 |
| 21 | Round Lake | 0.0230 | 49.36 |
| 22 | Deep Lake | 0.0234 | 49.61 |
| 23 | Bangs Lake | 0.0240 | 49.98 |
| 24 | Druce Lake | 0.0244 | 50.22 |
| 25 | Little Silver | 0.0250 | 50.57 |
| 26 | Lake Leo | 0.0256 | 50.91 |
| 27 | Dugdale Lake | 0.0274 | 51.89 |
| 28 | Peterson Pond | 0.0274 | 51.89 |
| 29 | Lake Miltmore | 0.0276 | 51.99 |
| 30 | Lake Fairfield | 0.0296 | 53.00 |
| 31 | Third Lake | 0.0300 | 53.20 |
| 32 | Gray's Lake | 0.0302 | 53.29 |
| 33 | Lake Catherine (Site 1) | 0.0308 | 53.57 |
| 34 | Lambs Farm Lake | 0.0312 | 53.76 |
| 35 | Old School Lake | 0.0312 | 53.76 |
| 36 | Sand Lake | 0.0316 | 53.94 |
| 37 | Lake Linden | 0.0326 | 54.39 |
| 38 | Gages Lake | 0.0338 | 54.92 |
| 39 | Honey Lake | 0.0340 | 55.00 |
| 40 | Hendrick Lake | 0.0344 | 55.17 |
| 41 | Cranberry Lake | 0.0360 | 55.82 |
| 42 | Sullivan Lake | 0.0370 | 56.22 |
| 43 | Diamond Lake | 0.0372 | 56.30 |
| 44 | Channel Lake (Site 1) | 0.0380 | 56.60 |
| 45 | Ames Pit | 0.0390 | 56.98 |
| 46 | Schreiber Lake | 0.0400 | 57.34 |

# Table 5. Continued.

| RANK | LAKE NAME | TP AVE | TSIp |
|---|---|---|---|
| 47 | White Lake | 0.0408 | 57.63 |
| 48 | Hook Lake | 0.0410 | 57.70 |
| 49 | Potomac Lake | 0.0424 | 58.18 |
| 50 | Duck Lake | 0.0426 | 58.25 |
| 51 | Deer Lake | 0.0434 | 58.52 |
| 52 | Nielsen Pond | 0.0448 | 58.98 |
| 53 | Turner Lake | 0.0458 | 59.30 |
| 54 | Seven Acre Lake | 0.0460 | 59.36 |
| 55 | Willow Lake | 0.0464 | 59.48 |
| 56 | Lucky Lake | 0.0476 | 59.85 |
| 57 | East Meadow Lake | 0.0478 | 59.91 |
| 58 | Old Oak Lake | 0.0490 | 60.27 |
| 59 | East Loon Lake | 0.0490 | 60.27 |
| 60 | Countryside Lake | 0.0490 | 60.27 |
| 61 | College Trail Lake | 0.0496 | 60.45 |
| 62 | Lake Lakeland Estates | 0.0524 | 61.24 |
| 63 | Butler Lake | 0.0528 | 61.35 |
| 64 | West Meadow Lake | 0.0530 | 61.40 |
| 65 | Heron Pond | 0.0545 | 61.80 |
| 66 | Little Bear Lake | 0.0550 | 61.94 |
| 67 | Lucy Lake | 0.0552 | 61.99 |
| 68 | Lake Napa Suwe (Outlet) | 0.0570 | 62.45 |
| 69 | Lake Christa | 0.0576 | 62.60 |
| 70 | Lake Charles | 0.0580 | 62.70 |
| 71 | Owens Lake | 0.0580 | 62.70 |
| 72 | Crooked Lake | 0.0608 | 63.38 |
| 73 | Waterford Lake | 0.0610 | 63.43 |
| 74 | Wooster Lake | 0.0610 | 63.43 |
| 75 | Lake Naomi | 0.0616 | 63.57 |
| 76 | Lake Tranquility S1 | 0.0618 | 63.62 |
| 77 | Werhane Lake | 0.0630 | 63.89 |
| 78 | Liberty Lake | 0.0632 | 63.94 |
| 79 | Countryside Glen Lake | 0.0642 | 64.17 |
| 80 | Lake Fairview | 0.0648 | 64.30 |
| 81 | Leisure Lake | 0.0648 | 64.30 |
| 82 | Davis Lake | 0.0650 | 64.34 |
| 83 | Tower Lake | 0.0662 | 64.61 |
| 84 | St. Mary's Lake | 0.0666 | 64.70 |
| 85 | Mary Lee Lake | 0.0682 | 65.04 |
| 86 | Hastings Lake | 0.0684 | 65.08 |
| 87 | Lake Helen | 0.0720 | 65.82 |
| 88 | Spring Lake | 0.0726 | 65.94 |
| 89 | ADID 203 | 0.0730 | 66.02 |
| 90 | Bluff Lake | 0.0734 | 66.10 |
| 91 | Harvey Lake | 0.0766 | 66.71 |
| 92 | Broberg Marsh | 0.0782 | 67.01 |

# Table 5. Continued.

| RANK | LAKE NAME | TP AVE | TSIp |
|---|---|---|---|
| 93 | Sylvan Lake | 0.0794 | 67.23 |
| 94 | Big Bear Lake | 0.0806 | 67.45 |
| 95 | Petite Lake | 0.0834 | 67.94 |
| 96 | Timber Lake (South) | 0.0848 | 68.18 |
| 97 | Lake Marie (Site 1) | 0.0850 | 68.21 |
| 98 | North Churchill Lake | 0.0872 | 68.58 |
| 99 | Grand Avenue Marsh | 0.0874 | 68.61 |
| 100 | Grandwood Park, Site II, Outflow | 0.0876 | 68.65 |
| 101 | North Tower Lake | 0.0878 | 68.68 |
| 102 | South Churchill Lake | 0.0896 | 68.97 |
| 103 | Rivershire Pond 2 | 0.0900 | 69.04 |
| 104 | McGreal Lake | 0.0914 | 69.26 |
| 105 | Long Lake | 0.0920 | 69.35 |
| 106 | International Mine and Chemical Lake | 0.0948 | 69.79 |
| 107 | Eagle Lake (Site I) | 0.0950 | 69.82 |
| 108 | Valley Lake | 0.0950 | 69.82 |
| 109 | Dunns Lake | 0.0952 | 69.85 |
| 110 | Fish Lake | 0.0956 | 69.91 |
| 111 | Lochanora Lake | 0.0960 | 69.97 |
| 112 | Woodland Lake | 0.0986 | 70.35 |
| 113 | Island Lake | 0.0990 | 70.41 |
| 114 | McDonald Lake 1 | 0.0996 | 70.50 |
| 115 | Nippersink Lake | 0.1000 | 70.56 |
| 116 | Longview Meadow Lake | 0.1024 | 70.90 |
| 117 | Lake Barrington | 0.1053 | 71.30 |
| 118 | Redwing Slough, Site II, Outflow | 0.1072 | 71.56 |
| 119 | Lake Forest Pond | 0.1074 | 71.59 |
| 120 | Bittersweet Golf Course #13 | 0.1096 | 71.88 |
| 121 | Fox Lake (Site 1) | 0.1098 | 71.90 |
| 122 | Osprey Lake | 0.1108 | 72.04 |
| 123 | Bresen Lake | 0.1126 | 72.27 |
| 124 | Round Lake Marsh North | 0.1126 | 72.27 |
| 125 | Deer Lake Meadow Lake | 0.1158 | 72.67 |
| 126 | Taylor Lake | 0.1184 | 72.99 |
| 127 | Columbus Park Lake | 0.1226 | 73.49 |
| 128 | Nippersink Lake (Site 1) | 0.1240 | 73.66 |
| 129 | Echo Lake | 0.1250 | 73.77 |
| 130 | Grass Lake (Site 1) | 0.1288 | 74.21 |
| 131 | Lake Holloway | 0.1322 | 74.58 |
| 132 | Lakewood Marsh | 0.1330 | 74.67 |
| 133 | Redhead Lake | 0.1412 | 75.53 |
| 134 | Forest Lake | 0.1422 | 75.63 |
| 135 | Antioch Lake | 0.1448 | 75.89 |
| 136 | Slocum Lake | 0.1496 | 76.36 |
| 137 | Pond-a-Rudy | 0.1514 | 76.54 |
| 138 | Lake Matthews | 0.1516 | 76.56 |

# Table 5. Continued.

| RANK | LAKE NAME | TP AVE | TSIp |
|---|---|---|---|
| 139 | Buffalo Creek Reservoir | 0.1550 | 76.88 |
| 140 | Pistakee Lake (Site 1) | 0.1592 | 77.26 |
| 141 | Grassy Lake | 0.1610 | 77.42 |
| 142 | Salem Lake | 0.1650 | 77.78 |
| 143 | Half Day Pit | 0.1690 | 78.12 |
| 144 | Lake Eleanor Site II, Outflow | 0.1812 | 79.13 |
| 145 | Lake Farmington | 0.1848 | 79.41 |
| 146 | Lake Louise | 0.1850 | 79.43 |
| 147 | ADID 127 | 0.1886 | 79.71 |
| 148 | Patski Pond (outlet) | 0.1970 | 80.33 |
| 149 | Summerhill Estates Lake | 0.1990 | 80.48 |
| 150 | Dog Bone Lake | 0.1990 | 80.48 |
| 151 | Redwing Marsh | 0.2072 | 81.06 |
| 152 | Stockholm Lake | 0.2082 | 81.13 |
| 153 | Bishop Lake | 0.2156 | 81.63 |
| **154** | **Ozaukee Lake** | **0.2200** | **81.93** |
| 155 | Hidden Lake | 0.2236 | 82.16 |
| 156 | Fischer Lake | 0.2278 | 82.43 |
| 157 | Oak Hills Lake | 0.2792 | 85.36 |
| 158 | Loch Lomond | 0.2954 | 86.18 |
| 159 | McDonald Lake 2 | 0.3254 | 87.57 |
| 160 | Fairfield Marsh | 0.3264 | 87.61 |
| 161 | ADID 182 | 0.3280 | 87.69 |
| 162 | Slough Lake | 0.4134 | 91.02 |
| 163 | Flint Lake Outlet | 0.4996 | 93.75 |
| 164 | Rasmussen Lake | 0.5025 | 93.84 |
| 165 | Albert Lake, Site II, outflow | 1.1894 | 106.26 |

have transportation as a primary land use. Compared to lakes in undeveloped areas, lakes with residential and/or urban land uses in their watershed often have higher conductivity readings and higher $Cl^-$ concentrations because of the use of road salts. Ozaukee Lake had the lowest conductivity readings in the Mutton Creek watershed and Island Lake had the highest reading (0.8376 mS/cm). Island Lake is the most downstream lake within the Mutton Creek watershed. Chlorides tend to accumulate within a watershed as these ions do not break down and are not utilized by plants or animals.

## SUMMARY OF AQUATIC MACROPHYTES

Plant sampling was conducted on Ozaukee Lake in July. There were 91 points sampled based on a computed generated grid system with points 30 meters apart (Figure 6). Aquatic plants were only found at four of the sites (Figure 7). In an effort to eliminate sampling bias and to document any existing aquatic plant populations a perimeter assessment and meandering survey within the entire lake was also conducted. The meander method was random and covered areas that could have small amounts of vegetation while the perimeter survey consisted of the areas near the shorelines. During these combined sampling procedures no additional aquatic plants were found. In 2002 Ozaukee Lake had approximately 10% aquatic plant surface coverage in 2009 that percentage was nearly halved at 5.5% (Table 5b). The diversity and health of aquatic plant populations can be influenced by a variety of factors. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow. When the light level in the water column falls below 1% of the surface light level, plants can no longer photosynthesize. The 1% light level in Ozaukee Lake reached the 3 foot depth (bottom) for the entire sampling season. Plants were only found at a maximum depth of 0.5 feet. The morphology of Ozaukee Lake is particularly shallow with the average depth being 1.64 feet. The shallow nature, availability of light and high nutrients makes Ozaukee Lake likely to experience 100% aquatic plant cover. A healthy lake has an aquatic plant community that covers 30-40% of the lake; however only 5.5% of Ozaukee Lake experienced aquatic plants and the species documented were mostly considered nuisance species indicating poor water quality. There were two exotic species present in the lake, Curlyleaf Pondweed and Eurasian Watermilfoil. While the aquatic plant community was sparse the two species found at 3% of the sites were Coontail and Eurasian Watermilfoil (Table 5a). Curlyleaf Pondweed was only found at 2 sites. This exotic plant has a tolerance for low light and low water temperatures that allow it to get a head start and out-compete native plants in the spring. Curlyleaf Pondweed in Lake County is known for forming dense mats that interfere with boating and other recreational uses. An example of this was Summerhill Lake sampled in 2009 by the LMU. However due to the degraded water quality of Ozaukee Lake even an exotic with advantages that other native plants do not have could not establish a population in the lake due to the exceptionally high TSS levels. Duckweed was only found at one site in Ozaukee Lake. Duckweed is an aquatic floating plant that is not limited by light availability or substrate, this species typically appears in highly nutrient enriched lakes and reproduces at an alarming rate. However this situation did not occur on Ozaukee Lake as the Duckweed population has not increased as the 2002 inventory also documented a 1% occurrence. Blue-green algae dominated the surface of Ozaukee Lake during the entire sampling season. Blue green algae are often described as “nuisance” or “noxious” because some can grow to enormous populations that discolor lakes and form floating scums. This was the situation on

**Figure 6. Aquatic plant sampling grid on Ozaukee Lake, July 2009.**

**Figure 7. Aquatic plant sampling grid that illustrates plant density on Ozaukee Lake, July 2009.**

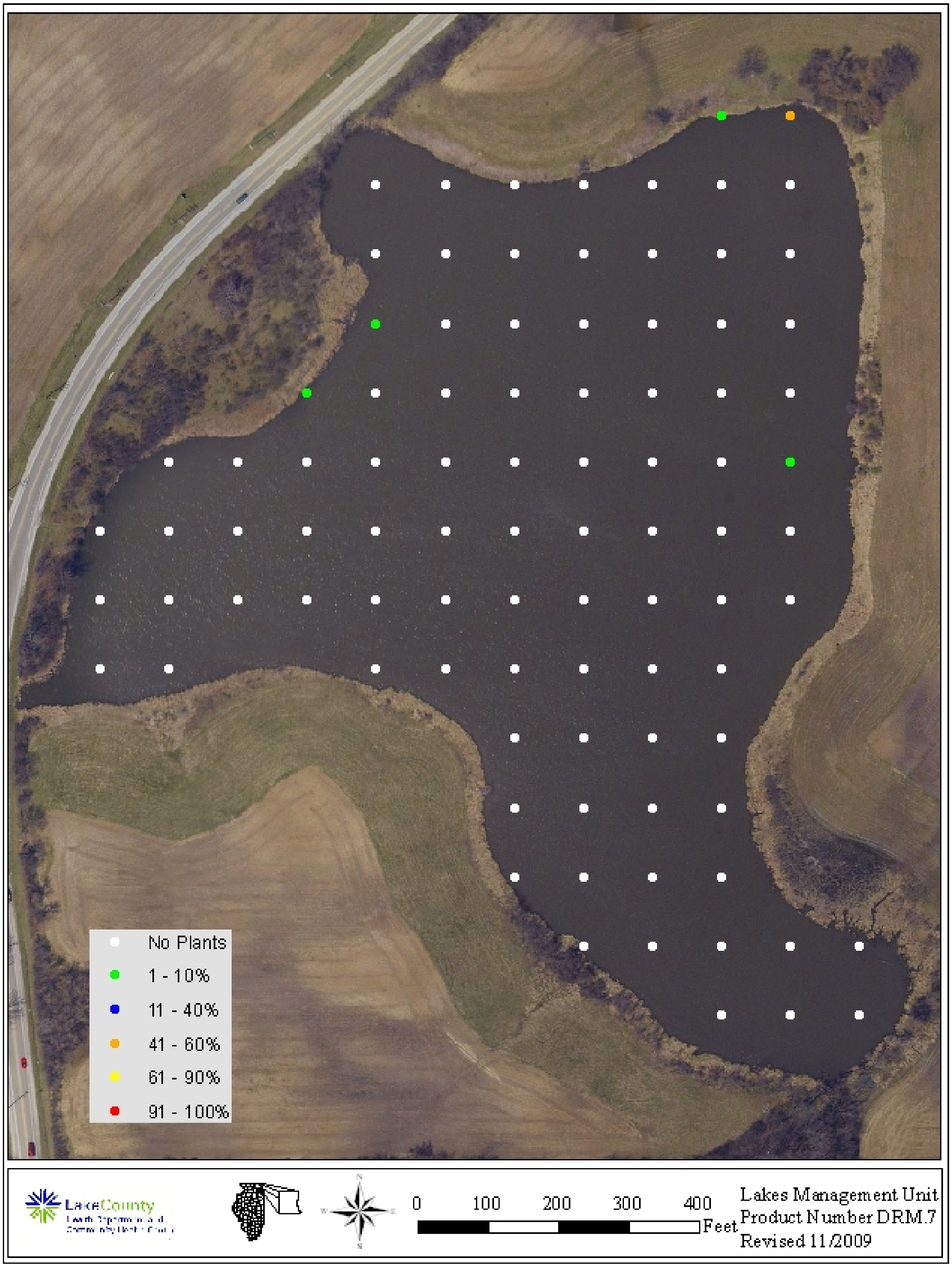


**Table 6a. Aquatic plant species found at the 91 sampling sites on Ozaukee Lake, July 2009.**
**Maximum depth that plants were found was 0.5 feet.**

| Plant Density | Coontail | Curlyleaf Pondweed | Duckweed | Eurasian Watermilfoil | Sago Pondweed |
|---|---|---|---|---|---|
| Present | 3 | 2 | 1 | 2 | 1 |
| Common | 0 | 0 | 0 | 1 | 0 |
| Abundant | 0 | 0 | 0 | 0 | 1 |
| Dominant | 0 | 0 | 0 | 0 | 0 |
| % Plant Occurrence | 3.3 | 2.2 | 1.1 | 3.3 | 2.2 |

**Table 6b. Distribution of rake density across all sampled sites.**

| Rake Density (coverage) | # of Sites | % of Sites |
|---|---|---|
| No Plants | 86 | 94.5 |
| >0-10% | 4 | 4.4 |
| 10-40% | 0 | 0.0 |
| 40-60% | 1 | 1.1 |
| 60-90% | 0 | 0.0 |
| >90% | 0 | 0.0 |
| Total Sites with Plants | 5 | 5.5 |
| Total # of Sites | 91 | 100.0 |

**Table 7. Aquatic plant species found in Ozaukee Lake in 2009.**

| | |
|---|---|
| Coontail | *Ceratophyllum demersum* |
| Duckweed | *Lemna* spp. |
| Eurasian Watermilfoil^ | *Myriophyllum spicatum* |
| Curlyleaf Pondweed^ | *Potamogeton crispus*^ |
| Sago Pondweed | *Potamogeton pectinatus* |

**^ Exotic plant**

Ozaukee Lake from the first site visit in May to the last in September; the whole lake surface was neon green and appeared as though a paint spill had occurred. The smell matched the devastating site as the odor of the lake could be described as having origins in chemical and sewage waste. Blue-green algae are not true algae but are actually more closely related to bacteria and are referred to as cyanobacteria. Not all cyanobacteria produce nuisance/noxious conditions the three genera that are responsible are *Anabaena, Aphanizomenon, and Microcystis*. The dominant genus found in Ozaukee Lake was *Aphanizomenon; Anabaena and Microcystis* were also abundant. The growth requirements of cyanobacteria and other true algae and aquatic plants are essentially the same. In addition to the ability to fix nitrogen from the atmosphere cyanobacteria's adaptation of positive buoyancy, which is regulated by gas vesicles, allows them to out-compete true algae and aquatic plants. The primary concern of blue green algae blooms is the release of cyanotoxins. *Aphanizomenon*, *Anabaena*, and *Microcystis* are capable of producing cyanotoxins. The reasons why a toxic population is produced is unknown. Mammals, birds, reptiles, amphibians, and fish are susceptible to the toxins produced by cyanobacteria when ingested. To establish a healthy aquatic plant population, the cyanobacteria population on Ozaukee Lake will have to be actively managed. Aquatic vegetation is critical to good lake health and provides important wildlife habitat and food sources. Additionally, aquatic plants provide many water quality benefits such as sediment stabilization and competition with algae for available resources.

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. It can be used to: 1) 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 floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An 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 indicate that there were large numbers of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for Lake County lakes from 2000-2009 was 13.7. Ozaukee Lake was ranked 139$^{th}$ out of 154 lakes with a FQI score of 6.7 (Table 8).

## SUMARY OF SHORELINE CONDITION

Lakes with stable water levels potentially have less shoreline erosion problems. The water level fluctuations on the lake were considerably unstable with a seasonal change from May to September of a decreased water level by 9.0 inches. The highest water level occurred in May with the lowest level in July. The most significant water level fluctuation occurred from July to August with an increase in lake level of 10.0 inches after a storm event that produced 3.14 inches of rain. Ozaukee Lake appears to be significantly influenced by rain events; even though the watershed is small (101.83 acres). The morphological features of the lake including the shallow depth (1.64 feet) and surface area (20.37 acres) make the lake more susceptible to storm water runoff. These types of water level fluctuations can have detrimental effects on shorelines. In order to accurately monitor water levels it is recommended that a staff gauge be installed and levels measured and recorded frequently (daily or weekly).

**Table 8. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native)**

| RANK | LAKE NAME | FQI (w/A) | FQI (native) |
|---|---|---|---|
| 1 | Cedar Lake | 38.2 | 40.2 |
| 2 | Cranberry Lake | 32.5 | 33.3 |
| 3 | East Loon Lake | 30.6 | 32.7 |
| 4 | Deep Lake | 29.7 | 31.2 |
| 5 | Little Silver | 29.6 | 31.6 |
| 6 | Bangs Lake | 29.5 | 31.0 |
| 7 | Round Lake Marsh North | 29.1 | 29.9 |
| 8 | Deer Lake | 28.2 | 29.7 |
| 9 | Sullivan Lake | 26.9 | 28.5 |
| 10 | West Loon Lake | 25.7 | 27.3 |
| 11 | Cross Lake | 25.2 | 27.8 |
| 12 | Wooster Lake | 25.0 | 26.6 |
| 13 | Independence Grove | 24.6 | 27.5 |
| 14 | Sterling Lake | 24.5 | 26.9 |
| 15 | Lake Zurich | 24.3 | 27.1 |
| 16 | Sun Lake | 24.3 | 26.1 |
| 17 | Schreiber Lake | 23.9 | 24.8 |
| 18 | Lakewood Marsh | 23.8 | 24.7 |
| 19 | Round Lake | 23.5 | 25.9 |
| 20 | Honey Lake | 23.3 | 25.1 |
| 21 | Fourth Lake | 23.0 | 24.8 |
| 22 | Lake of the Hollow | 23.0 | 24.8 |
| 23 | Druce Lake | 22.8 | 25.2 |
| 24 | Countryside Glen Lake | 21.9 | 22.8 |
| 25 | Butler Lake | 21.4 | 23.1 |
| 26 | Davis Lake | 21.4 | 21.4 |
| 27 | Duck Lake | 21.1 | 22.9 |
| 28 | Timber Lake (North) | 20.8 | 22.8 |
| 29 | ADID 203 | 20.5 | 20.5 |
| 30 | Broberg Marsh | 20.5 | 21.4 |
| 31 | McGreal Lake | 20.2 | 22.1 |
| 32 | Lake Kathryn | 19.6 | 20.7 |
| 33 | Fish Lake | 19.3 | 21.2 |
| 34 | Redhead Lake | 19.3 | 21.2 |
| 35 | Turner Lake | 18.6 | 21.2 |
| 36 | Salem Lake | 18.5 | 20.2 |
| 37 | Lake Miltmore | 18.4 | 20.3 |
| 38 | Lake Helen | 18.0 | 18.0 |
| 39 | Old Oak Lake | 18.0 | 19.1 |
| 40 | Hendrick Lake | 17.7 | 17.7 |
| 41 | Long Lake | 17.2 | 19.0 |
| 42 | Seven Acre Lake | 17.0 | 15.5 |
| 43 | Gray's Lake | 16.9 | 19.8 |
| 44 | Owens Lake | 16.3 | 17.3 |

# Table 8. Continued

| Rank | LAKE NAME | FQI (w/A) | FQI (native) |
|---|---|---|---|
| 45 | Countryside Lake | 16.7 | 17.7 |
| 46 | Highland Lake | 16.7 | 18.9 |
| 47 | Lake Barrington | 16.7 | 17.7 |
| 48 | Bresen Lake | 16.6 | 17.8 |
| 49 | Diamond Lake | 16.3 | 17.4 |
| 50 | Windward Lake | 16.3 | 17.6 |
| 51 | Dog Bone Lake | 15.7 | 15.7 |
| 52 | Redwing Slough | 15.6 | 16.6 |
| 53 | Osprey Lake | 15.5 | 17.3 |
| 54 | Lake Fairview | 15.2 | 16.3 |
| 55 | Heron Pond | 15.1 | 15.1 |
| 56 | Lake Tranquility (S1) | 15.0 | 17.0 |
| 57 | North Churchill Lake | 15.0 | 15.0 |
| 58 | Dog Training Pond | 14.7 | 15.9 |
| 59 | Island Lake | 14.7 | 16.6 |
| 60 | Grand Avenue Marsh | 14.3 | 16.3 |
| 61 | Lake Nippersink | 14.3 | 16.3 |
| 62 | Taylor Lake | 14.3 | 16.3 |
| 63 | Dugdale Lake | 14.0 | 15.1 |
| 64 | Eagle Lake (S1) | 14.0 | 15.1 |
| 65 | Longview Meadow Lake | 13.9 | 13.9 |
| 66 | Third Lake | 13.9 | 16.6 |
| 67 | Ames Pit | 13.4 | 15.5 |
| 68 | Bishop Lake | 13.4 | 15.0 |
| 69 | Buffalo Creek Reservoir | 13.1 | 14.3 |
| 70 | Mary Lee Lake | 13.1 | 15.1 |
| 71 | McDonald Lake 2 | 13.1 | 14.3 |
| 72 | Old School Lake | 13.1 | 15.1 |
| 73 | Dunn's Lake | 12.7 | 13.9 |
| 74 | Summerhill Estates Lake | 12.7 | 13.9 |
| 75 | Timber Lake (South) | 12.7 | 14.7 |
| 76 | White Lake | 12.7 | 14.7 |
| 77 | Hastings Lake | 12.5 | 14.8 |
| 78 | Sand Lake | 12.5 | 14.8 |
| 79 | Stone Quarry Lake | 12.5 | 12.5 |
| 80 | Lake Carina | 12.1 | 14.3 |
| 81 | Lake Leo | 12.1 | 14.3 |
| 82 | Lambs Farm Lake | 12.1 | 14.3 |
| 83 | Pond-A-Rudy | 12.1 | 12.1 |
| 84 | Stockholm Lake | 12.1 | 13.5 |
| 85 | Grassy Lake | 12.0 | 12.0 |
| 86 | Lake Matthews | 12.0 | 12.0 |
| 87 | Flint Lake | 11.8 | 13.0 |
| 88 | Harvey Lake | 11.8 | 13.0 |
| 89 | Lake Napa Suwe | 11.7 | 13.9 |
| 90 | Rivershire Pond 2 | 11.5 | 13.3 |

# Table 8.  Continued

| Rank | LAKE NAME | FQI (w/A) | FQI (native) |
|---|---|---|---|
| 91 | Antioch Lake | 11.3 | 13.4 |
| 92 | Hook Lake | 11.3 | 13.4 |
| 93 | Lake Charles | 11.3 | 13.4 |
| 94 | Lake Linden | 11.3 | 11.3 |
| 95 | Lake Naomi | 11.2 | 12.5 |
| 96 | Pulaski Pond | 11.2 | 12.5 |
| 97 | Lake Minear | 11.0 | 13.9 |
| 98 | Redwing Marsh | 11.0 | 11.0 |
| 99 | Tower Lake | 11.0 | 11.0 |
| 100 | West Meadow Lake | 11.0 | 11.0 |
| 101 | Nielsen Pond | 10.7 | 12.0 |
| 102 | Lake Holloway | 10.6 | 10.6 |
| 103 | Crooked Lake | 10.2 | 12.5 |
| 104 | College Trail Lake | 10.0 | 10.0 |
| 105 | Lake Lakeland Estates | 10.0 | 11.5 |
| 106 | Valley Lake | 9.9 | 9.9 |
| 107 | Werhane Lake | 9.8 | 12.0 |
| 108 | Big Bear Lake | 9.5 | 11.0 |
| 109 | Little Bear Lake | 9.5 | 11.0 |
| 110 | Loch Lomond | 9.4 | 12.1 |
| 111 | Columbus Park Lake | 9.2 | 9.2 |
| 112 | Sylvan Lake | 9.2 | 9.2 |
| 113 | Fischer Lake | 9.0 | 11.0 |
| 114 | Grandwood Park Lake | 9.0 | 11.0 |
| 115 | Lake Fairfield | 9.0 | 10.4 |
| 116 | Lake Louise | 9 | 10.4 |
| 117 | McDonald Lake 1 | 8.9 | 10.0 |
| 118 | East Meadow Lake | 8.5 | 8.5 |
| 119 | Lake Christa | 8.5 | 9.8 |
| 120 | Lake Farmington | 8.5 | 9.8 |
| 121 | Lucy Lake | 8.5 | 9.8 |
| 122 | South Churchill Lake | 8.5 | 8.5 |
| 123 | Bittersweet Golf Course #13 | 8.1 | 8.1 |
| 124 | Woodland Lake | 8.1 | 9.9 |
| 125 | Albert Lake | 7.5 | 8.7 |
| 126 | Banana Pond | 7.5 | 9.2 |
| 127 | Fairfield Marsh | 7.5 | 8.7 |
| 128 | Lake Eleanor | 7.5 | 8.7 |
| 129 | Patski Pond | 7.1 | 7.1 |
| 130 | Rasmussen Lake | 7.1 | 7.1 |
| 131 | Slough Lake | 7.1 | 7.1 |
| 132 | Lucky Lake | 7.0 | 7.0 |
| 133 | Lake Forest Pond | 6.9 | 8.5 |
| **134** | **Ozaukee Lake** | **6.7** | **8.7** |
| 135 | Leisure Lake | 6.4 | 9.0 |
| 136 | Peterson Pond | 6.0 | 8.5 |

# Table 8. Continued

| Rank | LAKE NAME | FQI (w/A) | FQI (native) |
|---|---|---|---|
| 137 | Gages Lake | 5.8 | 10.0 |
| 138 | Slocum Lake | 5.8 | 7.1 |
| 139 | Deer Lake Meadow Lake | 5.2 | 6.4 |
| 140 | ADID 127 | 5.0 | 5.0 |
| 141 | IMC Lake | 5.0 | 7.1 |
| 142 | Liberty Lake | 5.0 | 5.0 |
| 143 | Oak Hills Lake | 5.0 | 5.0 |
| 144 | Forest Lake | 3.5 | 5.0 |
| 145 | Sand Pond (IDNR) | 3.5 | 5.0 |
| 146 | Half Day Pit | 2.9 | 5.0 |
| 147 | Lochanora Lake | 2.5 | 5.0 |
| 148 | Echo Lake | 0.0 | 0.0 |
| 149 | Hidden Lake | 0.0 | 0.0 |
| 150 | North Tower Lake | 0.0 | 0.0 |
| 151 | Potomac Lake | 0.0 | 0.0 |
| 152 | St. Mary's Lake | 0.0 | 0.0 |
| 153 | Waterford Lake | 0.0 | 0.0 |
| 154 | Willow Lake | 0.0 | 0.0 |
| | ***Mean*** | **13.7** | **15.0** |
| | ***Median*** | **12.5** | **14.3** |

A shoreline assessment was conducted in July 2002 to determine the condition of the lake shoreline. Of particular interest was the condition of the shoreline at the water/land interface. Shorelines were assessed for a variety of criteria. All of Ozaukee Lake's shoreline was undeveloped. This undeveloped shoreline was made up of three main types: shrub (15%), wetland (10%), and buffer (75%). The dominance of these three types of shoreline was encouraging as they normally contain plants with deep root systems that are less prone to erosion and provide good wildlife habitat. However, a majority of the shoreline of Ozaukee Lake was plagued by nuisance weed species such Reed Canary Grass, Common Buckthorn, Common Reed, and Purple Loosestrife.

The shoreline was reassessed in 2009 for significant changes in erosion since 2002. Based on the 2009 assessment, there was an increase in shoreline erosion with 85% of the shoreline having some degree of erosion (Figure 8). This was higher than the 2002 assessment of 77% and the most notable change was the 40% increase in severe erosion. Overall, 9% of the shoreline had slight erosion, 36% had moderate erosion, and 40% had severe erosion. The severe and moderately eroded areas should be remediated immediately to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. It is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. The most affected shoreline type was buffer; these areas that have experienced erosion were found to be moderately to steeply sloped. Additionally, these buffer areas, which normally have less erosion, were found to be overrun with the invasive species that have poor (shallow) root systems and offer little stabilization benefit.

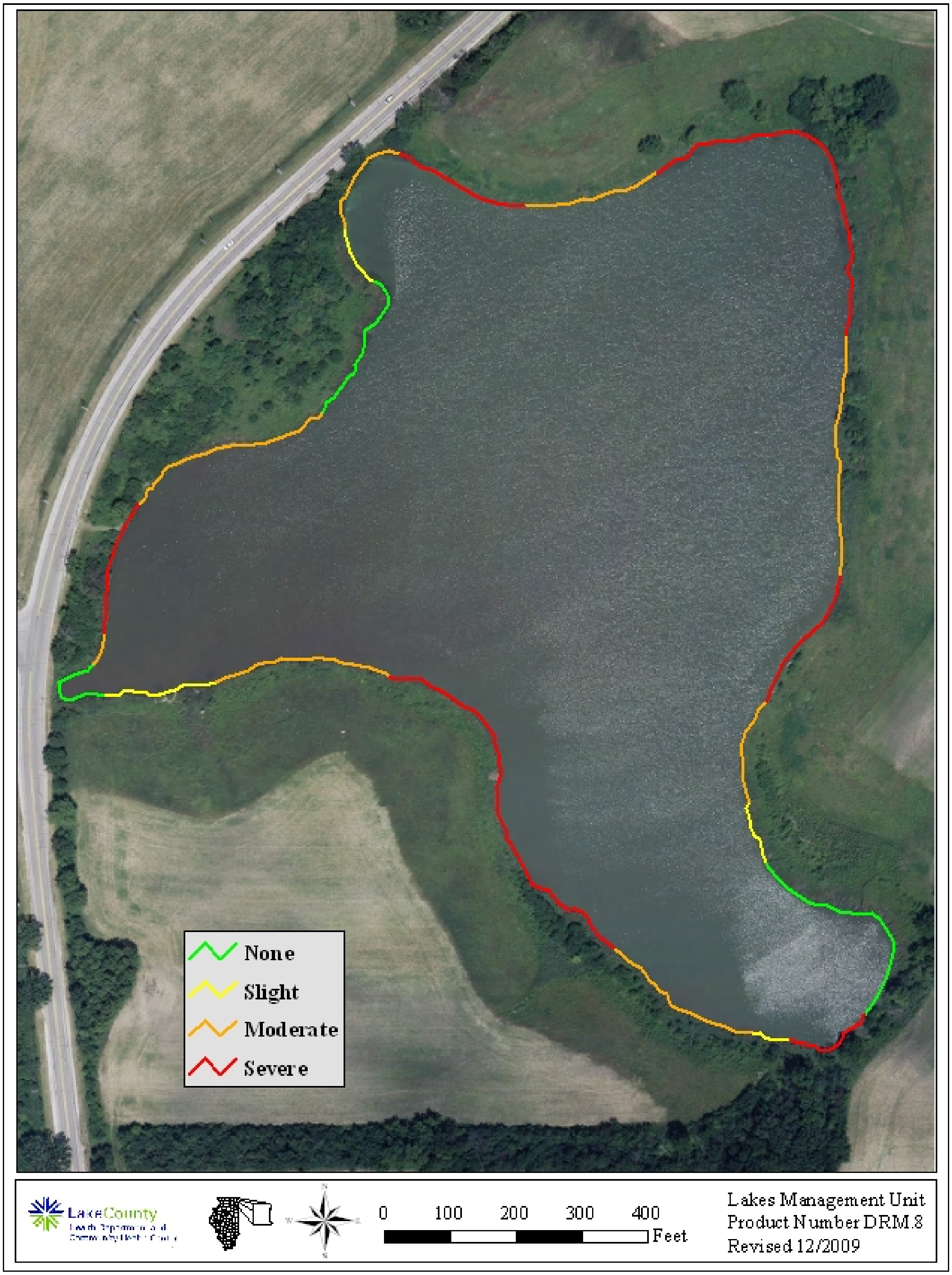
Another factor degrading the aesthetic value of Ozaukee Lake shorelines was the amount of litter; especially around the west side of the lake near Fairfield Road. There were excessive amounts of bottles and trash from the road and fisherman. Litter was not confined to the shorelines; within Ozaukee Lake were tires and old electoral boxes which is evidence of an historical unauthorized dumping site (Figure 9).

## OBSERVATIONS OF WILDLIFE AND HABITAT

Wildlife observations were made on a monthly basis during water quality and plant sampling activities. Ozaukee Lake offers uncommon opportunities for Lake County due to the fact that the lake and its watershed is completely owned by the Lake County Forest Preserve District and contains a variety of habitats that can support a diversity of wildlife including fish, reptiles, mammals and birds. Wildlife habitat in the form of open space and prairie was abundant around Ozaukee Lake. However only a few types of waterfowl, songbirds, mammals and fish were observed over the course of the study, therefore it's very important that this natural area not only be maintained but improved to provide the appropriate habitat for all wildlife species in the future.

To LMU's knowledge there has not been a fish survey conducted on Ozaukee Lake. During sampling events fishermen were documented utilizing the lake for recreational fishing. The only fish observed during the 2009 sampling season were Common Carp. This nuisance species is

**Figure 8. Shoreline erosion on Ozaukee Lake, 2009.**



exotic and invasive, disrupting aquatic plant growth that stabilize sediment and compete with algae for available resources which improve water clarity/quality. This species is tolerant of low dissolved oxygen levels which may be present at night. The frequency and abundance of blue-green algae (cyanobacteria) blooms may be influencing dissolved oxygen levels, thus selecting for a low dissolved oxygen tolerant species. Algae produce oxygen during the day as they photosynthesize however during the night the production of oxygen stops and the consumption of oxygen begins as the process of respiration continues. A fish survey is typically used to document the fish community and further address the management options needed to support a diverse healthy fishery. However, unless the nutrients and sediment issues that are degrading water quality can be addressed a fish survey maybe unnecessary and an alternative of turning the lake into a wetland marsh could be considered.

# LAKE MANAGEMENT RECOMMENDATIONS

Historically Ozaukee Lake had poor water quality for Lake County lakes; the impounded lake had frequent planktonic algal blooms, low water clarity and high nutrient levels. Ozaukee Lake offers uncommon opportunities for Lake County due to the fact that the lake and its watershed is completely owned by the Lake County Forest Preserve District and contains a variety of habitats that can support a diversity of wildlife including fish, reptiles, mammals and birds with an active management plan with the goal to improve water quality.

## Increasing Lake Depth

Ozaukee Lake has substantial amounts of nutrients driving a variety of water quality parameters. The majority the nutrients in the lake were from internal sources. Increasing the lake depth may be effective in removing nutrient rich sediment, which can reduces nuisance algal growth. Additionally, due to the shallow nature of Ozaukee Lake the increased depth may also provide protection against the resuspension of sediment from wind and wave action (Appendix D1).

## Lakes with Shoreline Erosion

Based on the 2009 assessment, there was an increase in shoreline erosion with 85% of the shoreline having some degree of erosion. This was higher than the 2002 assessment of 77% and the most notable change was the 40% increase in severe erosion. The erosion should be addressed soon. All of the eroded areas should be remediated to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. Buffered areas around the lake also exhibited erosion especially areas with steep slopes remediation of shoreline slopes may be necessary to implement successful shoreline restoration **(**Appendix D2).

## Options for Nuisance Algae Management

Algae blooms were frequent and abundant in Ozaukee Lake. Algae are free floating and buoyant which enables the plant to take advantage of the excessive nutrients resulting in over abundance. Without a healthy and diverse aquatic plant community to compete for nutrients the frequency and abundance of algal blooms will likely continue (Appendix D3).

## Low Dissolved Oxygen Concentrations

Ozaukee Lake maintained dissolved oxygen levels to support a healthy fishery throughout the entire sampling season during the day. However dissolved oxygen levels vary from day to night and can be significantly influenced by algae production. Ozaukee Lake's abundance of blue-green (cyanobacteria) blooms may be causing low-dissolved oxygen levels during the night, as oxygen was not being produced from photosynthesis but being consumed during respiration (Appendix D4).

- **Lakes with a High Carp Population**

  During the 2009 assessment of Ozaukee Lake, Common Carp were documented throughout the season and in high abundance during plant sampling and bathymetric mapping. An active management strategy should be developed to address this nuisance species and its disturbance to water quality (Appendix D5).

- **Participate in the volunteer lake monitoring program (VLMP)**

  To track future water quality trends, it is recommended the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October (Appendix D6). In addition to the VMLP, a staff gauge should be installed to monitor the lake level each month. The establishment of a VLMP on Ozaukee Lake would provide valuable historical data and enable lake managers to create baseline information to evaluate the improvement or decline of lake water quality over time.

- **Lake Clean Up**

  Ozaukee Lake had excessive amounts of litter on the shorelines and within the lake. Large litter within the lake should be removed from July to September when lake levels are low and the litter is exposed. Trash cans should be placed on the west side of the lake near the access point off of Fairfield Road to encourage lake users and fisherman to dispose of litter properly.

- **Grant program opportunities**

  There are opportunities to receive grants to help accomplish some of the management recommendations listed above (Appendix F).

# APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

## Water Sampling and Laboratory Analyses

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

## Plant Sampling

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

## Shoreline Assessment

In previous years a complete assessment of the shoreline was done. However, this year we did a visual estimate to determine changes in the shoreline. The degree of shoreline erosion was categorically defined as none, slight, moderate, or severe. Below are brief descriptions of each category.

> None – Includes man-made erosion control such as beach, rip-rap and sea wall.
>
> Slight – Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as “slight”.

Moderate – Recession is characterized by past or recently eroded banks; area may exhibit some exposed roots, fallen vegetation or minor slumping of soil material; erosion control practices may be recommended although the section is not deemed to warrant immediate remedial action.

Severe – Recession is characterized by eroding of exposed soil on nearly vertical banks, exposed roots, fallen vegetation or extensive slumping of bank material, undercutting, washouts or fence posts exhibiting realignment; erosion control practices are recommended and immediate remedial action may be warranted.

## 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<br>EPA-600/R-93/100<br>Detection Limit = 0.05 mg/L |
| Ammonia nitrogen | SM 18th ed. Electrode method, #4500 $NH_3$-F<br>Detection Limit = 0.1 mg/L |
| Total Kjeldahl nitrogen | SM 18th ed, 4500-$N_{org}$ C<br>Semi-Micro Kjeldahl, plus 4500 $NH_3$-F<br>Detection Limit = 0.5 mg/L |
| pH | Hydrolab DataSonde® 4a, or YSI 6600 Sonde®<br>Electrometric method |
| Total solids | SM 18th ed, Method #2540B |
| Total suspended solids | SM 18th ed, Method #2540D<br>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<br>Detection Limit = 0.01 mg/L |
| Soluble reactive phosphorus | SM 18th ed, Methods #4500-P B 1 and #4500-P E<br>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 |

**Ozaukee Lake 2009 Multiparameter data**

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 2.50 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/12/2009 | 0 | 0.51 | 15.66 | 8.02 | 80.7 | 0.5090 | 9.03 | 3565 | Surface | | |
| 5/12/2009 | 1 | 1.00 | 15.66 | 7.88 | 79.4 | 0.5090 | 8.93 | 3365 | Surface | 100% | |
| 5/12/2009 | 2 | 2.01 | 15.63 | 7.80 | 78.5 | 0.5090 | 8.90 | 1058 | 0.255 | 30% | 4.539 |
| 5/12/2009 | 3 | 3.00 | 15.61 | 7.67 | 77.2 | 0.5090 | 8.87 | 94 | 1.249 | 3% | 1.940 |
| 5/12/2009 | 4 | 4.00 | 15.57 | 7.48 | 75.3 | 0.5090 | 8.85 | 10 | 2.247 | 0% | 1.019 |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 7.04 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/9/2009 | 0 | 0.50 | 19.87 | 10.11 | 111.1 | 0.5060 | 8.75 | 507 | Surface | | |
| 6/9/2009 | 1 | 1.01 | 19.88 | 10.22 | 112.2 | 0.5060 | 8.76 | 1200 | Surface | 100% | |
| 6/9/2009 | 2 | 2.02 | 19.73 | 9.95 | 109.0 | 0.5070 | 8.73 | 56 | 0.267 | 5% | 11.458 |
| 6/9/2009 | 3 | 3.01 | 19.60 | 10.15 | 110.9 | 0.5060 | 8.75 | 2 | 1.255 | 0.2% | 2.621 |
| 6/9/2009 | 4 | 3.90 | 19.42 | 8.70 | 94.7 | 0.5080 | 8.61 | 0 | 2.146 | | |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 13.21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/14/2009 | 0 | 0.51 | 23.70 | 7.93 | 93.8 | 0.4790 | 8.85 | 2596 | Surface | | |
| 7/14/2009 | 1 | 0.99 | 23.69 | 7.85 | 92.8 | 0.4780 | 8.82 | 2475 | Surface | 100% | |
| 7/14/2009 | 2 | 1.98 | 23.67 | 7.82 | 92.4 | 0.4780 | 8.84 | 125 | 0.226 | 5% | 13.207 |
| 7/14/2009 | 3 | 3.00 | 23.63 | 7.61 | 89.9 | 0.4780 | 8.83 | 0 | 1.248 | | |

| Date MMDDYY | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient 6.36 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/11/2009 | 0 | 0.50 | 26.63 | 9.59 | 119.7 | 0.5120 | 8.43 | 3506 | Surface | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/11/2009 | 1 | 0.99 | 26.56 | 9.02 | 112.4 | 0.5120 | 8.38 | 3505 | Surface | 100% | |
| 8/11/2009 | 2 | 2.00 | 26.32 | 8.20 | 101.7 | 0.5140 | 8.28 | 386 | 0.245 | 11% | 9.004 |
| 8/11/2009 | 3 | 3.01 | 25.93 | 6.44 | 79.3 | 0.5170 | 8.09 | 4 | 1.259 | 0.1% | 3.713 |

| Date **MMDDYY** | Text Depth feet | Dep25 feet | Temp øC | DO mg/l | DO% Sat | SpCond mS/cm | pH Units | PAR æE/s/mý | Depth of Light Meter feet | % Light Transmission Average | Extinction Coefficient NA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 40071 | 0 | 0.493 | 23.53 | 9.15 | 107.9 | 0.472 | 9.07 | NA | Surface | | |
| 40071 | 1 | 0.992 | 23.36 | 9.45 | 111.1 | 0.473 | 8.98 | NA | Surface | NA | |
| 40071 | 2 | 2.04 | 23.06 | 8.7 | 101.6 | 0.4730 | 8.71 | NA | 0.291 | NA | NA |
| 40071 | 3 | 3.08 | 22.93 | 8.81 | 102.7 | 0.4740 | 8.48 | NA | 1.33 | NA | NA |

# 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 2000-2009 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. When 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 2000-2009 was 0.063 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2009 was 0.167 mg/L and ranged from a minimum of 0.012 mg/L in Independence Grove Lake to a maximum of 3.880 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 7.9 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 132.8 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, but was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations.

**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 the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. 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 average Secchi depth for Lake County lakes is 3.12 feet. From 2000-2009, Ozaukee Lake had the lowest Secchi depths (0.25 feet) and West Loon Lake had the highest (24.77 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.

*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 but 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 8.34, with a minimum 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.  LAKE MANAGEMENT OPTIONS.

# *D1. Options for Increasing Lake Depth*

**Option 1.  Mechanical Dredging**

Mechanical dredging employs the use of heavy equipment such as draglines, bulldozers, scrapers or backhoes.  If the use of bulldozers or scrapers were desired, partial drawdown of the lake would be necessary.  The exposed sediment is then allowed to dry or freeze before equipment is brought in to push out the sediment.  The use of a backhoe or dragline would not require lake drawdown.  These machines work from shore, scooping out the sediment.  In either case, the sediment is stockpiled onshore until trucked away, or loaded directly into trucks to be taken to the disposal site. Dredging can improve navigation, however it is very expensive.  It also may be effective in removing nutrient rich sediment, which can reduce nuisance plant and algal growth. But at the same time causes very turbid water, limiting plant growth and fish predator prey relationships.  Overall, a deeper lake may have less sediment resuspension from wind and wave action and boating activity.

**Option 2. Hydraulic Dredging**

Hydraulic dredging does not need lake drawdown since the equipment used floats and works directly in the water.  However, in very shallow water, this unit may not be able to operate. Sediment can be removed faster with hydraulic dredging and it causes less turbidity in the water. A cutter with steel blades loosens the sediment, and a pump "vacuums" up the loose sediment and water slurry.  This mixture is piped to a site nearby with a de-watering basin, where the water drains away, and the sediment dries.  A horizontal auger dredge has a corkscrew-like unit (auger) that loosens the sediment as it rotates.  The dredge moves across the lake by a winch with a cable, and can cut while moving forward and backward.  Navigation and recreational access can be improved, however is an expensive process.  Nutrient rich sediment may be removed, in turn reducing the amount available for plant and algal growth but it can also be dredged to shallow and too many nutrients are added to the lake or can be dredged below the limit of light penetration, and future plant growth may be inhibited.

**Option 4.  Small Scale Manual Sediment Removal - Pumps**

Small-scale pumping systems are a form of hydraulic dredging.  The necessary components are: an intake, a suction hose, a pump, a discharge hose and a disposal area.  The basic idea is similar to using a vacuum.  When using these systems, the pumping efficiency is reduced if the discharge pipe is higher than the intake pipe at the lake.  This is because of the extra effort required for the pump to push the water and sediment "uphill." Different types of pumps include a diaphragm pump, and a centrifugal pump, which can be rented.  Diaphragm pumps can be easily moved around the lakeshore and often discharge less water not allowing sediment to be pumped more than 50 feet away.  Because of low water pressure clay sediment is difficult to remove.  Centrifugal pumps are easily moved around the lakeshore as well, however they tend to pump more water than sediment.

**Option 5.  Small Area Manual Removal – Heavy Equipment**

For small projects, such as clearing sediment from a stormwater outlet, or around piers or beaches, some people have simply scooped out the sediment with buckets, bobcats, or small backhoes.  Bobcats, which can be rented, would work best after lake draw-down. They remove firm sediment from shallow water, but they can get stuck in softer sediments.  A backhoe can be used for small areas if lake draw-down is not possible.  This piece of equipment can only be used from shore.  Bobcats can be more effective at removing large amounts of solids and low water content so a de-watering area is not needed.  Lake drawdown is necessary for this equipment to work best and it can take weeks for the sediment to dry out enough to use this equipment.  A backhoe does not require a lake drawdown but can only be used from shore, so the area is limited to within an arms reach.  Unless fabric screens are set up around the dredging area, the disturbance from digging increases the turbidity in the water.  Not only is clarity diminished, but the disturbed silt can cover fish eggs and aquatic plants.

**Option 6. Manual Removal with Buckets**

Sediment removal with buckets is extremely labor intensive, and work is slow – about two or three people may remove four cubic yards in one day.  Some have employed the use of a small johnboat to float several filled buckets back to shore for disposal.  Permits are still necessary for this type of sediment removal.  However, it is the least expensive and no heavy equipment is needed.

**Option 7. Removal of Organic Sediment via Bacterial Products in a Small Area.**

Some bacterial products may have the ability to reduce the amount of organic sediment.  These products contain several species of beneficial, non-pathogenic bacteria.  In order for the bacteria to work, the sediment would need to be composed of organic materials such as decaying plant matter.  Although bacteria are normally present in a lake or pond situation, the premise here would be to add a highly concentrated solution of similar bacteria to decompose the organic materials more quickly.  Multiple applications are necessary throughout the season, with an initial dosage higher than the weekly or bi-weekly recommended maintenance dosages. Turbidity and disposal of sediment are not an issue in this option.  However, the bacteria need dissolved oxygen concentrations of at least 3 mg/L at the bottom to do their job and there is no guarantee of the amount of sediment that will be removed.

## *D2. Options for Lakes with Shoreline Erosion*

**Option 1:  Install a Seawall**

Seawalls are designed to prevent shoreline erosion on lakes in a similar manner they are used along coastlines to prevent beach erosion or harbor siltation. Today, seawalls are generally constructed of steel, although in the past seawalls were made of concrete or wood (frequently old railroad ties). A new type of construction material being used is vinyl or PVC. Vinyl seawalls will not rust over time.

If installed properly and in the appropriate areas (i.e., shorelines with severe erosion) seawalls provide effective erosion control. Seawalls are made to last many years and have relatively low maintenance. However, seawalls are disadvantageous for several reasons. One of the main disadvantages is that they are expensive, since a professional contractor and heavy equipment are needed for installation. Also, if any fill material is placed in the floodplain along the shoreline, compensatory storage may also be needed. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling of another portion. Permits and surveys are needed whether replacing old seawall or installing a new one. Seawalls also provide little habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls. In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e., bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e., stunted fish populations).

**Option 2: Install Rock Rip-Rap or Gabions**

Rip-rap is the procedure of using rocks to stabilize shorelines. Size of the rock depends on the severity of the erosion, distance to rock source, and aesthetic preferences. Generally, four to eight inch diameter rocks are used. Gabions are wire cages or baskets filled with rock. They provide similar protection as rip-rap, but are less prone to displacement. They can be stacked, like blocks, to provide erosion control for extremely steep slopes.

Rip-rap and gabions can provide good shoreline erosion control. Rocks can absorb some of the wave energy while providing a more aesthetically pleasing appearance than seawalls. If installed properly, rip-rap and gabions will last for many years. Maintenance is relatively low, however, undercutting of the bank can cause sloughing of the rip-rap and subsequent shoreline. Fish and wildlife habitat can also be provided if large (not small) boulders are used. A major disadvantage of rip-rap is the initial expense of installation and associated permits. Installation is expensive since a licensed contractor and heavy equipment are generally needed to conduct the work. Permits are required if replacing existing or installing new rip-rap or gabions and must be acquired prior to work beginning.

**Option 3: Create a Buffer Strip**

Another effective, more natural method of controlling shoreline erosion is to create a buffer strip with existing or native vegetation. Native plants have deeper root systems than turfgrass and thus hold soil more effectively. Native plants also provide positive aesthetics and good wildlife habitat. Allowing vegetation to naturally propagate the shoreline would be the most cost effective, depending on the severity of erosion and the composition of the current vegetation. Stabilizing the shoreline with vegetation is most effective on slopes less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems.

Buffer strips can be one of the least expensive means to stabilize shorelines. If no permits or heavy equipment are needed (i.e., no significant earthmoving or filling is planned), the property owner can complete the work without the need of professional contractors. Once established (typically within 3 years), a buffer strip of native vegetation will require little maintenance and may actually reduce the overall maintenance of the property, since the buffer strip will not have to be continuously mowed, watered, or fertilized. Buffer strips may slow the velocity of floodwaters, thus preventing shoreline erosion. Native plants also can withstand fluctuating water levels more effectively than commercial turfgrass. In addition, many wildlife species prefer the native shoreline vegetation habitat and various species are even dependent on native shoreline vegetation for their existence. In addition to the benefits of increased wildlife use, a buffer strip planted with a variety of native plants may provide a season long show of colors from flowers, leaves, seeds, and stems. This is not only aesthetically pleasing to people, but also benefits wildlife and the overall health of the lake's ecosystem.

There are few disadvantages to native shoreline vegetation. Certain species (i.e., cattails) can be aggressive and may need to be controlled occasionally. If stands of shoreline vegetation become dense enough, access and visibility to the lake may be compromised to some degree. However, small paths could be cleared to provide lake access or smaller plants could be planted in these areas.

**<u>Option 4: Install Biolog, Fiber Roll, or Straw Blanket with Plantings</u>**

These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Biologs, fiber rolls, and straw blankets provide erosion control that secure the shoreline in the short-term and allow native plants to establish which will eventually provide long-term shoreline stabilization. They are most often made of bio-degradable materials, which break down by the time the natural vegetation becomes established (generally within 3 years). They provide additional strength to the shoreline, absorb wave energy, and effectively filter run-off from watershed sources. They are most effective in areas where plantings alone are not effective due to existing erosion.

**<u>Option 5: Install A-Jacks®</u>**

A-Jacks® are made of two pieces of pre-cast concrete when fitted together resemble a playing jacks. These structures are installed along the shoreline and covered with soil and/or an erosion control product. Native vegetation is then planted on the backfilled area. They can be used in areas where severe erosion does not justify a buffer strip alone.
The advantage to A-Jacks® is that they are quite strong and require low maintenance once installed. In addition, once native vegetation becomes established the A-Jacks® cannot be seen. A disadvantage is that installation cost can be high since labor is intensive and requires some heavy equipment. A-Jacks® need to be pre-made and hauled in from the manufacturing site.

**Option 6: Establish a "No Wake" Zone or No Motor Area**

Establishing a "no wake" zone or no motor area will not solve erosion problems by itself. However, since shoreline erosion is generally not caused by one specific factor, these techniques can be effective if used in combination with one or more of the techniques described above. Limiting boat activity, particularly near shorelines or in shallow areas, may also have an additional benefit by improving water quality since less sediment may be disturbed and resuspended in the water column. Less motorboat disturbance will also benefit wildlife and may encourage many species to use the lake both during spring and fall migration and for summer residence. This may add to the lake's aesthetics and increasing recreational opportunities for some lake users.

Enforcement and public education are the primary obstacles with the "no wake" techniques. Public resistance to any regulation change may be strong, particularly if the lake is open to the public and has had no similar regulations in the past. Depending on the regulations implemented, there may be some loss of recreational use for some users, particularly powerboating. However, if the lake is large enough, certain parts of the lake (i.e., the middle or deepest) may be used for this activity without negatively influencing other uses.

## *D3. Options for Nuisance Algae Management*

**Option 1: Algaecides**

Algaecides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ($CuSO_4$) and chelated copper products are the two main algaecides in use. There is also a non-copper based algaecide on the market called GreenClean™ from BIOsafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, all forms act as contact killers. This means that the product has to come into contact with the algae to be effective. Algaecides come in two forms: granular and liquid. Granular algaecides are mainly used on filamentous algae where they are spread over their mats. Liquid algaecides are mixed with a known amount of water to achieve a known concentration and sprayed onto/into the water. Liquid forms are used on both filamentous and planktonic algae. When applying an algaecide it is important that the label is completely read and followed. If too much of the lake is treated, an oxygen crash caused by the decomposition of treated algae may cause fish kills. Additionally, treatments should never be applied when blooms/mats are at their fullest extent. It is best to divide the lake into at least two sections depending on the size of the lake, (larger lakes will need to be divided into more sections), and then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algaecides should never be done in extremely hot weather (>90$^{o}$F) or when dissolved oxygen concentrations are low. It is best to treat in spring or when the blooms/mats start to appear.

A properly implemented plan can often provide season long control with minimal applications. The fishery and waterfowl populations of the lake would also benefit due to a decrease in nuisance algal blooms, which would increase water clarity. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would improve spawning habitat and food source availability for fish. Waterfowl population would also benefit from increases in quality food sources. By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae.

The most obvious drawback of using algaecides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. As the algae are continuously exposed to copper, some species are becoming more and more tolerant. This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are showing up. These species can often be more difficult to control due to an inherent resistance to copper products. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

## Option 2: Alum Treatment

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom making it unavailable, thus reducing algal growth. This flocculent layer can then prevent sediment bound phosphorus from entering the water column. Alum treatments typically last 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ratio (thermally stratified lakes) will see more longevity from an alum application due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited.

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lakes ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food/habitat sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations.

There are also several drawbacks to alum. In order for alum to provide long-term effectiveness, external nutrient inputs must also be reduced or eliminated. With larger watersheds this could prove to be physically and financially difficult. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied, toxicity problems may occur. Due to these concerns, it is recommended that a lake management professional plans and administers the alum treatment.

**Option 3: Revegetation With Native Aquatic Plants**

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a sparse to non-existent plant population. This is due to reduction in light penetration by excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Planting depth light levels must be greater than 1-5% of the surface light levels for plant growth. If aquatic herbicides are being used to control existing vegetation, their use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake should be allowed to naturally expand into adjacent areas filling the niche left by the nuisance algae. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with each other to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire should be erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. A list can be obtained from the Lake Management Unit that lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants (pondweeds, *Vallisneria*, etc).

By revegetating opened areas, the lake will benefit in several ways. Once established, native plant populations will help to control growth of nuisance algae by shading and competition for resources. This provides a more natural approach as compared to other management options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also improve due to the improvement in water quality and the suppression of weedy species.

One drawback is the possibility of new vegetation expanding to nuisance levels and needing control. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

## *D4. Options for Low Dissolved Oxygen Concentrations*

### Option 1: Aeration via Artificial Circulation

The principal effect of artificial circulation is to raise the DO content throughout the lake. This is accomplished by circulating the entire water column to the surface, where atmospheric oxygen can diffuse into surface waters. While the vertical movement of water is usually achieved by releasing compressed air at some depth, little oxygen increase is actually achieved through direct diffusion from bubbles (King, 1970; Smith et al. 1975).

These systems can improve DO concentrations in the water column to help prevent fish kills and increase habitat for aquatic life. Algal blooms may be controlled through aeration and internal loading of phosphorus can theoretically be decreased through increased circulation. Artificial circulation in winter can help alleviate low oxygen conditions when the systems are able to keep about 2-3% of the lake's surface free from snow and ice cover (Wirth, 1988).

Aeration systems should be started just after spring/fall turnover to avoid mixing anoxic water from the hypolimnion with surface waters that can cause DO concentrations in the entire water column to fall below the amount needed for fish survival. Internal phosphorus loading from the sediment may actually increase as temperature at the sediment-water interface is raised in the circulation process. If nutrient-rich waters are brought to the surface by the circulating water, algae and plant growth can become a greater nuisance. For shallow lakes where light is not a limiting factor, algae populations may not decrease. Depending on the size and type of the compressor(s), seasonal or annual electrical costs may run in the hundreds or thousands of dollars.

### Option 2. Reduce Lake Phosphorus Concentrations

If a lake has an overabundance of plants and algae, severe oxygen losses can occur when they die and decompose. Reducing phosphorus concentrations can decrease algal populations and (possibly) plant populations. Phosphorus entering lakes from the watershed is more difficult to control. Watershed controls may not reduce phosphorus in the lake for years, and if the lake receives high concentrations of phosphorus from the watershed, treatments could be short-lived.

**Option 3. Snow Removal from Ice-Covered Lakes**

Although aquatic plants do die back in the fall, a lake's primary source of oxygen in the winter is from submersed aquatic plants and algae as they photosynthesize. A layer of snow over ice prevents sunlight from penetrating through the ice and reaching the plants, slowing or even stopping this process. Snow five or more inches deep will block virtually all light from passing through. If the photosynthetic process is halted for too long, the demand for oxygen may deplete the supply. To help increase the oxygen supply, snow should be removed from the ice. This seems to work better in lakes dominated by plants rather than algal blooms in the summer, as plant dominated lakes seem to have more oxygen than lakes dominated by algae. In cases where snow removal helped, about 30% or more of the lake's surface area was cleared. Plowing was done in alternating strips rather than clearing large areas, which cut down on the need to stockpile the snow.

Snowplowing with a vehicle can clear 30% of the surface area of the lake in less than a day. Villages, Park Districts and Association’s may already own the equipment and thus, the staff hourly rate costs could be minimal. In situations where no other oxygen sources will be made available for a prolonged period of time (such as weeks of heavy snow cover and continued cold weather), snow removal can be a quick and an effective option. Although snow removal has helped in cases where 30% or more of the surface area was cleared, it is difficult to be sure how much snow removal would be necessary. Safety issues and subsequent liability are of primary concern. The ice would need to be able to support someone with a snow blower (for small areas) or a truck with a snowplow. Also, piling snow on the ice can cause unstable ice conditions due to variations in weight distribution. If snowplowing companies were hired, the cost would increase dramatically.

**Option 4. Increasing Lake Depth**

As a general rule of thumb, at least 25% of the lake or pond should be 10 feet deep or deeper to minimize winter fish kills in the Lake County region. However, if the watershed delivers more than an eighth of an inch of sediment per year to the lake, this may not be a practical option. This option will not guarantee the prevention of winter fish kills as many factors control oxygen consumption. Prices are normally based on cubic yards of sediment removed, and can vary widely.

**Option 5. Aquatic Plant Management**

Plants use dissolved oxygen at night during respiration, a process necessary to produce food for plant growth. A lake with nuisance plant populations could suffer dissolved oxygen losses at night as the plants respire. Reducing the plant coverage to 30% - 40% of the lake’s surface area may help this situation.

**Option 6. Reduce Organic Matter**

Decomposition of organic matter by bacteria can consume large quantities of oxygen. The addition of bacteria products and enzymes may reduce the amount of organic matter in the sediment, which could lessen the oxygen demand.

## *D5. Option for Lakes with a High Carp Population*

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants, making it biodegradable. It kills fish by chemically inhibiting the use of oxygen in biochemical pathways, therefore adult fish are much more susceptible than fish eggs. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal.

Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and Green Sunfish, are high enough to kill more desirable species such as bass, Bluegill, crappie, Walleye, and Northern Pike. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are $<50^{o}$F. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois, as it is a restricted use pesticide.

Rotenone is one of the only ways to effectively remove undesirable fish species, however it can be expensive. It allows for rehabilitation of the lake's fishery, which will allow for improvement of the aquatic plant community, and overall water quality. There are some negative impacts that may also occur with the use of rotenone. In the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. The IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species.

As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and Green Sunfish), 2.022 gal/AF is required. In waters with high turbidity and/or planktonic algal blooms, the ppm may have to be higher. An IDNR fisheries biologist will be able to determine if higher concentrations will be needed.

## *D6. Participate in the Volunteer Lake Monitoring Program*

In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection Agency (Illinois EPA) to gather fundamental information on Illinois' inland lakes, and to provide an educational program for citizens. Approximately 165 lakes (of 3,041 lakes in Illinois) are sampled annually by approximately 300 volunteers. The volunteers are lakeshore residents, lake owners/managers, members of environmental groups, public water supply personnel, and/or citizens with interest in a particular lake.

The VLMP relies on volunteers to gather a variety of information on their chosen lake. The primary measurement is Secchi disk depth. Analysis of the Secchi disk measurement provides an indication of the general water quality condition of the lake, as well as the amount of usable habitat available for fish and other aquatic life.

Microscopic plants and animals, water color, and suspended sediments are factors that interfere with light penetration through the water column and lessen the Secchi disk depth. As a rule, one to three times the Secchi depth is considered the lighted zone of the lake. In this region of the lake there is enough light to allow plants to grow and produce oxygen. Water below the lighted zone can be expected to have little or no dissolved oxygen. 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 volunteer measurements taken twice a month. After volunteers have completed one year of the basic monitoring program, they are qualified to participate in the Expanded Monitoring Program. In the expanded program, volunteers are trained to collect water samples that are shipped to the Illinois EPA laboratory for analysis of total and volatile suspended solids, total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. Other parameters that are part of the expanded program include dissolved oxygen, temperature, and zebra mussel monitoring. Additionally, chlorophyll *a* monitoring has been added to the regiment for selected lakes.

For information, please contact:

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# APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES.

# 2000 - 2009 Water Quality Parameters, Statistics Summary

| | ALKoxic <=3ft00-2009 | |
|---|---|---|
| Average | **166** | |
| Median | **161** | |
| Minimum | **65** | **IMC** |
| Maximum | **330** | **Flint Lake** |
| STD | **42** | |
| n = | **819** | |

| | ALKanoxic 2000-2009 | |
|---|---|---|
| Average | **198** | |
| Median | **189** | |
| Minimum | **103** | **Heron Pond** |
| Maximum | **470** | **Lake Marie** |
| STD | **49** | |
| n = | **251** | |

| | Condoxic <=3ft00-2009 | |
|---|---|---|
| Average | **0.8846** | |
| Median | **0.7910** | |
| Minimum | **0.2260** | **Schreiber Lake** |
| Maximum | **6.8920** | **IMC** |
| STD | **0.5217** | |
| n = | **823** | |

| | Condanoxic 2000-2009 | |
|---|---|---|
| Average | **1.0121** | |
| Median | **0.8431** | |
| Minimum | **0.3210** | **Lake Kathyrn, Schreiber Lake** |
| Maximum | **7.4080** | **IMC** |
| STD | **0.7784** | |
| n = | **251** | |

| | NO3-N, Nitrate+Nitrite,oxic <=3ft00-2009 | |
|---|---|---|
| Average | **0.514** | |
| Median | **0.160** | |
| Minimum | **<0.05** | ***ND** |
| Maximum | **9.670** | **South Churchill Lake** |
| STD | **1.087** | |
| n = | **824** | |

*ND = Many lakes had non-detects (76.5%)
Only compare lakes with detectable
concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

| | NH3-Nanoxic 2000-2009 | |
|---|---|---|
| Average | **2.134** | |
| Median | **1.430** | |
| Minimum | **<0.1** | ***ND** |
| Maximum | **18.400** | **Taylor Lake** |
| STD | **2.325** | |
| n = | **251** | |

*ND = 20.3% Non-detects from 32 different lakes

| | pHoxic <=3ft00-2009 | |
|---|---|---|
| Average | **8.35** | |
| Median | **8.34** | |
| Minimum | **7.07** | **Bittersweet #13** |
| Maximum | **10.40** | **Summerhill Estates** |
| STD | **0.46** | |
| n = | **818** | |

| | pHanoxic 2000-2009 | |
|---|---|---|
| Average | **7.31** | |
| Median | **7.33** | |
| Minimum | **6.24** | **Banana Pond** |
| Maximum | **8.48** | **Heron Pond** |
| STD | **0.41** | |
| n = | **251** | |

| | All Secchi 2000-2009 | |
|---|---|---|
| Average | **4.56** | |
| Median | **3.15** | |
| Minimum | **0.25** | **Ozaukee Lake** |
| Maximum | **24.77** | **West Loon Lake** |
| STD | **3.80** | |
| n = | **763** | |

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# 2000 - 2009 Water Quality Parameters, Statistics Summary (continued)

| | TKNoxic<br><=3ft00-2009 | |
|---|---|---|
| Average | **1.418** | |
| Median | **1.180** | |
| Minimum | **<0.1** | ***ND** |
| Maximum | **10.300** | **Fairfield Marsh** |
| STD | **0.826** | |
| n = | **824** | |

*ND = 3.8% Non-detects from 15 different lakes

| | TKNanoxic<br>2000-2009 | |
|---|---|---|
| Average | **2.883** | |
| Median | **2.235** | |
| Minimum | **<0.5** | ***ND** |
| Maximum | **21.000** | **Taylor Lake** |
| STD | **2.300** | |
| n = | **251** | |

*ND = 2.9% Non-detects from 4 different lakes

| | TPoxic<br><=3ft00-2009 | |
|---|---|---|
| Average | **0.099** | |
| Median | **0.063** | |
| Minimum | **<0.01** | ***ND** |
| Maximum | **3.880** | **Albert Lake** |
| STD | **0.171** | |
| n = | **824** | |

*ND = 2.4% Non-detects from 8 different lakes

| | TPanoxic<br>2000-2009 | |
|---|---|---|
| Average | **0.311** | |
| Median | **0.167** | |
| Minimum | **0.012** | **Independ. Grove** |
| Maximum | **3.800** | **Taylor Lake** |
| STD | **0.417** | |
| n = | **251** | |

| | TSSall<br><=3ft00-2009 | |
|---|---|---|
| Average | **15.3** | |
| Median | **7.9** | |
| Minimum | **<0.1** | ***ND** |
| Maximum | **165.0** | **Fairfield Marsh** |
| STD | **20.3** | |
| n = | **830** | |

*ND = 1.3% Non-detects from 8 different lakes

| | TVSoxic<br><=3ft00-2009 | |
|---|---|---|
| Average | **129.7** | |
| Median | **125.5** | |
| Minimum | **34.0** | **Pulaski Pond** |
| Maximum | **298.0** | **Fairfield Marsh** |
| STD | **39.8** | |
| n = | **774** | |

No 2002 IEPA Chain Lakes

| | TDSoxic<br><=3ft00-2004 | |
|---|---|---|
| Average | **470** | |
| Median | **454** | |
| Minimum | **150** | **Lake Kathryn, White** |
| Maximum | **1340** | **IMC** |
| STD | **169** | |
| n = | **745** | |

No 2002 IEPA Chain Lakes.

| | CLanoxic<br><=3ft00-2009 | |
|---|---|---|
| Average | **198** | |
| Median | **117** | |
| Minimum | **3.5** | **Schreiber Lake** |
| Maximum | **2390** | **IMC** |
| STD | **327** | |
| n = | **159** | |

| | CLoxic<br><=3ft00-2009 | |
|---|---|---|
| Average | **191** | |
| Median | **145** | |
| Minimum | **2.7** | **Schreiber Lake** |
| Maximum | **2760** | **IMC** |
| STD | **220** | |
| n = | **561** | |

Anoxic conditions are defined <=1 mg/l D.O.
pH Units are equal to the -Log of [H] ion activity
Conductivity units are in MilliSiemens/cm
Secchi Disk depth units are in feet
All others are in mg/L

Minimums and maximums are based on data from all lakes from 2000-2009 (n=1378).

Average, median and STD are based on data from the most recent water quality sampling year for each lake.

LCHD Lakes Management Unit ~ 12/9/2009

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# APPENDIX F.  GRANT PROGRAM OPPORTUNITES

## Table F1.  Potential Grant Opportunities

| Grant Program Name | Funding Source | Contact Information | Funding Focus: Water Quality/ Wetland | Funding Focus: Habitat | Funding Focus: Erosion | Funding Focus: Flooding | Cost Share |
|---|---|---|---|---|---|---|---|
| Challenge Grant Program | USFWS | 847-381-2253 or 309-793-5800 | | X | X | | |
| Chicago Wilderness Small Grants | CW | 312-346-8166 ext. 30 | | | | | None |
| Partners in Conservation (formerly C2000) | IDNR | http://dnr.state.il.us/orep/c2000/ | | X | | | None |
| Conservation Reserve Program | NRCS | http://www.nrcs.usda.gov/programs/crp/ | | X | | | Land |
| Ecosystems Program | IDNR | http://dnr.state.il.us/orep/c2000/ecosystem/ | | X | | | None |
| Emergency Watershed Protection | NRCS | http://www.nrcs.usda.gov/programs/ewp/ | | | X | X | None |
| Five Star Challenge | NFWF | http://www.nfwf.org/AM/Template.cfm | | X | | | None |
| Illinois Flood Mitigation Assistance Program | IEMA | http://www.state.il.us/iema/construction.htm | | | | X | None |
| Great Lakes Basin Program | GLBP | http://www.glc.org/basin/stateproj.html?st=il | X | | X | | None |
| Illinois Clean Energy Community Foundation | ICECF | http://www.illinoiscleanenergy.org/ | | X | | | |
| Illinois Clean Lakes Program | IEPA | http://www.epa.state.il.us/water/financial-assistance/index.html | | | | | None |
| Lake Education Assistance Program (LEAP) | IEPA | http://www.epa.state.il.us/water/conservation-2000/leap/index.html | X | | | | $500 |

CW = Chicago Wilderness
ICECF = Illinois Clean Energy Community Foundation
IEMA = Illinois Emergency Management Agency
IEPA = Illinois Environmental Protection Agency
IDNR = Illinois Department of Natural Resources
IDOA = Illinois Department of Agriculture
LCSMC = Lake County Stormwater Management Commission
LCSWCD = Lake County Soil and Water Conservation District
NFWF = National Fish and Wildlife Foundation
NRCS = Natural Resources Conservation Service
USACE = United States Army Corps of Engineers
USFWS = United States Fish and Wildlife Service

**Table F1. Continued**

| Grant Program Name | Funding Source | Contact Information | Funding Focus: Water Quality/ Wetland | Habitat | Erosion | Flooding | Cost Share |
|---|---|---|---|---|---|---|---|
| Northeast Illinois Wetland Conservation Account | USFWF | 847-381-2253 | X | | | | |
| Partners for Fish and Wildlife | USFWS | http://ecos.fws.gov/partners/ | | X | | | > 50% |
| River Network's Watershed Assistance Grants Program | River Network | http://www.rivernetwork.org | X | X | X | | na |
| Section 206: Aquatic Ecosystems Restoration | USACE | 312-353-6400, 309-794-5590 or 314-331-8404 | | X | | | 35% |
| Section 319: Non-Point Source Management Program | IEPA | http://www.epa.state.il.us/water/financial-assistance/non point.html | X | X | | | >40% |
| Section 1135: Project Modifications for the Improvement of the Environment | USACE | 312-353-6400, 309-794-5590 or 314-331-8404 | | X | | | 25% |
| Stream Cleanup And Lakeshore Enhancement (SCALE) | IEPA | http://www.epa.state.il.us/water/watershed/scale.html | X | X | | | None |
| Streambank Stabilization & Restoration (SSRP) | IDOA/ LCSWCD | http://www.agr.state.il.us/Environment/conserv/ or call LCSWCD at (847) 223-1056 | | X | X | | 25% |
| Watershed Management Boards | LCSMC | http://www.co.lake.il.us/smc/projects/wmb/default.asp | X | | X | X | 50% |
| Wetlands Reserve Program | NRCS | http://www.nrcs.usda.gov/programs/wrp/ | X | X | | | Land |
| Wildlife Habitat Incentive Program | NRCS | http://www.nrcs.usda.gov/programs/whip/ | | X | | | Land |

CW = Chicago Wilderness
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