2008 SUMMARY REPORT
of
Zurich Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Kathleen Paap
Michael Adam
Leonard Dane
Kelly Deem

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Lake Zurich is a glacial lake encompassing approximately 232 acres and a shoreline length of 2.75 miles. Lake Zurich is part of the Flint Lake drainage of the Fox River watershed. Water clarity, as measured by Secchi disk transparency readings, averaged 10.40 feet for the 2008 season, which was significantly above the county median (where 50% of the lakes are above and below this value) of 3.12 feet. The 2008 average increased 88% from the 2002 average of 5.53 feet. The May reading of 14.11 feet is the deepest Secchi reading on the lake since the Lake County Health Department-Lakes Management Unit (LMU) has monitoring Lake Zurich. This increase in clarity is most likely due to the presence of Zebra Mussels in the lake.

Average epilimnetic total phosphorus (TP) concentration decreased 43% from the concentration recorded in 2002 (0.023 mg/L), however, the TP concentrations have fluctuated since the LMU has monitored TP in Lake Zurich. Lake Zurich is located at the top of the watershed and as expected had the lowest average epilimnetic TP concentration of all lakes within the Flint Creek watershed.

In 2008, both the average epilimnetic and hypolimnetic conductivity concentrations measured in Lake Zurich had increased since 2002. The 2008 epilimnetic average for conductivity was 0.9573 milliSiemens/cm (mS/cm). This is 26% higher than the 2002 average (0.7593 mS/cm), however still below the county epilimnetic median of 0.8195 mS/cm. The conductivity concentration in the anoxic zone of the lake averaged 0.9823 mS/cm. This was above the county hypolimnetic median of 0.8695 mS/cm. The most likely cause for the increase in conductivity readings was the increase in impermeable surface (roads) which were delivering dissolved solids such as chlorides into the lake from storm events.

In July 2008 a large Common Carp die off occurred on the lake. Fish exhibiting signs of infection were collected by the Illinois Department of Natural Resources (IDNR) and tested. The results of that testing were that the bacterium, *Aeromonas hydrophila*, was responsible for the fish kill. Due to the number of dead Common Carp counted during the IDNR sampling on July 10 it is estimated that greater than 1000 to 1500 were likely impacted. Fish species such as Bluegill, Black Crappie and Largemouth Bass should benefit from the reduced carp population.

In 2008, Water Stargrass and Chara co-dominated the lakes vegetation. There were two invasive non-native species present, Curlyleaf Pondweed and Eurasian Milfoil, however, they made up a small percentage of the vegetation and were present at 1.4% and 0.5% of the points sampled, respectively.

In 2008, LMU reassessed the shoreline erosion and found some eroded areas had been remediated, but identified new areas of erosion around the lake. These eroded areas should be remediated to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation rather than riprap or seawalls.

LAKE FACTS

Lake Name:	Lake Zurich
Historical Name:	None
Nearest Municipality:	Village of Lake Zurich
Location:	T43N, R10E, Sections 17, 18, 19 and 20
Elevation:	841.1 feet above mean sea level
Major Tributaries:	None
Watershed:	Fox River
Sub-watershed:	Flint Creek Drain
Receiving Waterbody:	Echo Lake
Surface Area:	232.3 acres
Shoreline Length:	2.8 miles
Maximum Depth:	33.0 feet
Average Depth (Estimated):	7.0 feet
Lake Volume (estimated):	1,635.5 acre-feet
Lake Type:	Glacial
Watershed Area:	605.0 acres
Major Watershed Land Uses:	Single Family and Transportation
Bottom Ownership:	Private, Public (Village of Lake Zurich)
Management Entities:	Village of Lake Zurich
Current and Historical Uses:	Swimming, fishing, motorized and non-motorized boating.
Description of Access:	All access locations are private, open to the public (with a permit sticker).

SUMMARY OF WATER QUALITY

Lake Zurich has been previously studied by the Lake County Health Department-Lakes Management Unit (LMU) in 1991, 1998 and 2002. A thorough review of these studies and the history of the lake were given in the 2002 report. Similar reports have been written on the data collected in 1991, 1998, and 2002; these reports are available online from the LMU (http://www.lakecountyil.gov/Health/want/LakeReports.htm).

Water quality data was collected at the deep hole from May through September in (Figure 1, Appendix A). In 2008, samples were collected at a depth of 3 feet and between 20-27 feet, depending on water level. Table 1 presents the water quality data collected from Lake Zurich in 2002 and 2008. Appendix C explains the various water quality parameters measured and how these parameters relate to each other, and why the measurement of each parameter is important.

In 2008, water clarity, as measured by Secchi disk transparency readings, averaged 10.40 feet for the season, which is above the county median (where 50% of the lakes are above and below this value) of 3.12 feet. Water clarity increased by 88% from 2002 when the seasonal average was 5.53 feet. Water clarity in 2008 was highest in May (14.11 feet) and poorest in July (3.94 feet). The May reading was the deepest recorded reading since LMU has been monitoring Lake Zurich, the overall increase in clarity is most likely the result of the presence of Zebra Mussels. These exotic mussels were first documented in Lake Zurich in 2002 and their population has exploded. They were found in large numbers frequently found attached to plants during 2008. While improved clarity is often viewed as a positive aspect, the filter feeding Zebra Mussel have negative long-term impacts on the food chain, as they feed on primary producers such as zooplankton, diatoms, and algae. The Secchi disk results from the Volunteer Lake Monitoring Program (VLMP) were similar with a 2008 seasonal average of 10.39 feet (Figure 2).

Lake Zurich is at the top of the Flint Creek Watershed. A watershed is the land and water around a lake that drains to that lake. This means that any management of the land within the watershed can directly affect the lake. Other lakes within the north branch of the Flint Creek Watershed had much worse water clarity readings in 2008 (Table 2). Echo Lake, which receives water from Lake Zurich and whose watershed is much larger than Lake Zurich's, had an average Secchi depth of 2.11 feet, which was below the county median. Echo, like the other lakes in the watershed is shallower, less vegetated and infested by Common Carp. Honey Lake would be the exception, as it too is at the top of its watershed. In 1998, both Honey Lake and Lake Zurich were sampled, at that time both had an average Secchi depth of 5.70 feet. Honey Lake's Secchi depth has increased as well over the ten year time period, without the assistance of Zebra Mussels, this is likely due to coverage of vegetation, as Honey Lake had over 50% of the sites sampled for plants with a rake density of greater than 90% plants.

Correlated with the good clarity readings from 2008 were low concentrations of total suspended solids (TSS). Lake Zurich's 2008 epilimnetic average of 2.7 mg/L for TSS decreased by 82% from the concentration recorded in 2002 (4.9 mg/L). Prior to 2002, and the arrival of Zebra Mussels, the TSS concentrations were relatively similar, ranging from 4.2 mg/L in 1998 to 4.9 mg/L in 1998. TSS concentrations were well below the county median of 8.2 mg/L. While low TSS values are considered a positive for water quality, it should be noted that the amount of total

Figure 1. Water quality sampling site on Lake Zurich, 2008.

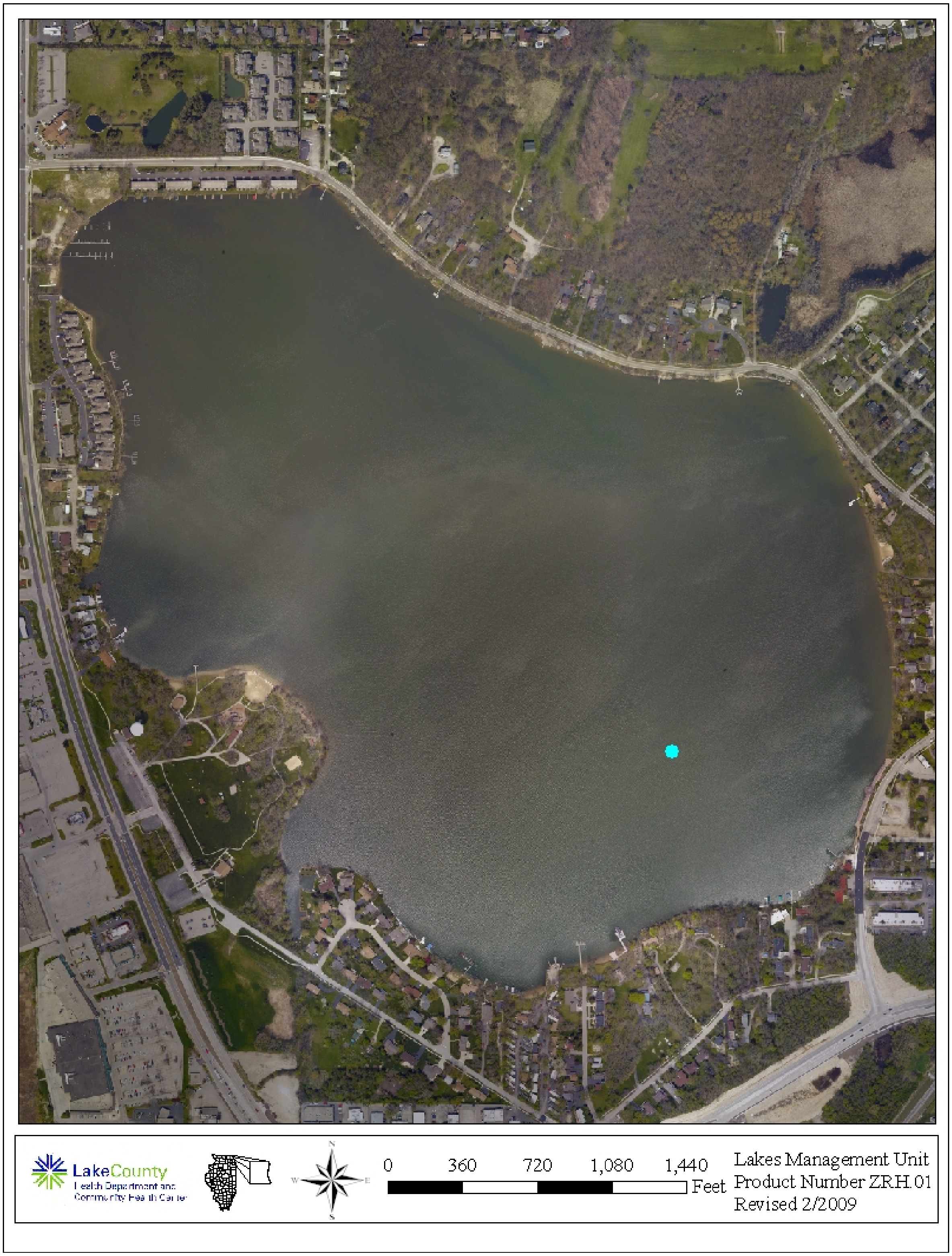


Table 1. Water quality data for Lake Zurich, 2002 and 2008.

2008	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
21-May	3	120	0.72	<0.100	0.133	<0.010	<0.005	213	NA	2.0	547	80	14.11	0.9778	8.42	9.52
18-Jun	3	118	0.67	<0.100	<0.050	0.015	<0.005	213	NA	3.5	557	100	10.01	0.9828	8.41	8.17
16-Jul	3	114	0.75	<0.100	<0.050	0.016	<0.005	209	NA	3.8	560	103	3.94	0.9721	8.77	8.76
20-Aug	3	98.8	0.66	<0.100	<0.050	0.015	<0.005	217	NA	2.3	557	110	10.83	0.9659	8.88	9.47
17-Sep	3	89.4	0.63	<0.100	<0.050	0.018	<0.005	201	NA	2.1	518	106	13.10	0.8881	8.59	7.50
	Average	108	0.68	<0.100	0.133	0.016[k]	<0.005	210.600	NA	2.7	548	100	10.40	0.9573	8.61	8.68

2002	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	3	127	0.97	<0.100	<0.050	0.029	0.005	NA	436	4.4	449	98	5.55	0.7873	8.19	9.87
24-Jun	3	104	0.97	<0.100	<0.050	0.024	<0.005	NA	420	2.7	442	101	8.60	0.7559	8.73	8.84
29-Jul	3	98	1.15	<0.100	<0.050	0.029	0.008	NA	420	7.5	462	115	4.40	0.7755	8.82	7.48
26-Aug	3	93	1.09	<0.100	<0.050	0.030	0.006	NA	422	5.8	435	99	3.45	0.7316	8.74	8.50
23-Sep	3	93	1.27	<0.100	<0.050	0.029	<0.005	NA	416	4.0	439	101	5.64	0.7461	8.14	7.00
	Average	103	1.09	<0.100	<0.050	0.028	0.006[k]	NA	423	4.9	445	103	5.53	0.7593	8.52	8.34

Glossary

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

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

Table 1. Continued.

2008	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
21-May	25	119	0.706	<0.100	0.132	0.02	<0.005	212	NA	4.1	538	76	NA	0.9780	8.45	9.24
18-Jun	20	118	0.712	0.000	<0.05	0.011	<0.005	213	NA	3.6	564	98	NA	0.9850	8.36	7.48
16-Jul	27	135	1.680	0.723	<0.05	0.055	<0.005	214	NA	10.0	562	95	NA	1.0335	7.29	0.23
20-Aug	25	135	1.130	<0.100	<0.05	0.079	<0.005	213	NA	17.0	572	105	NA	1.0224	7.59	0.31
17-Sep	27	93.1	0.807	0.102	<0.05	0.014	<0.005	201	NA	3.9	519	106	NA	0.8928	8.42	7.54
	Average	120	1.01	0.275	0.132	0.036	<0.005	211	NA	7.7	551	96	NA	0.9823	8.02	4.96

2002	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
20-May	27	129	1.02	<0.100	<0.05	0.045	0.008	NA	454	12.0	458	105	NA	0.7892	7.89	7.48
24-Jun	27	136	1.35	0.444	<0.05	0.051	0.010	NA	424	3.9	463	111	NA	0.8113	7.33	0.06
29-Jul	26	127	1.33	0.215	<0.05	0.037	<0.005	NA	432	6.5	464	112	NA	0.8156	7.07	0.07
26-Aug	27	178	2.68	1.530	<0.05	0.059	0.016	NA	448	5.0	481	109	NA	0.8320	6.92	0.10
23-Sep	27	180	3.99	2.790	<0.05	0.110	<0.005	NA	468	5.0	487	113	NA	0.8641	6.77	0.10
	Average	150	2.07	1.245	<0.05	0.060	0.011	NA	445	6.5	471	110	NA	0.8224	7.20	1.56

Glossary

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

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 2. Secchi disk averages from VLMP and LCHD records for Lake Zurich.

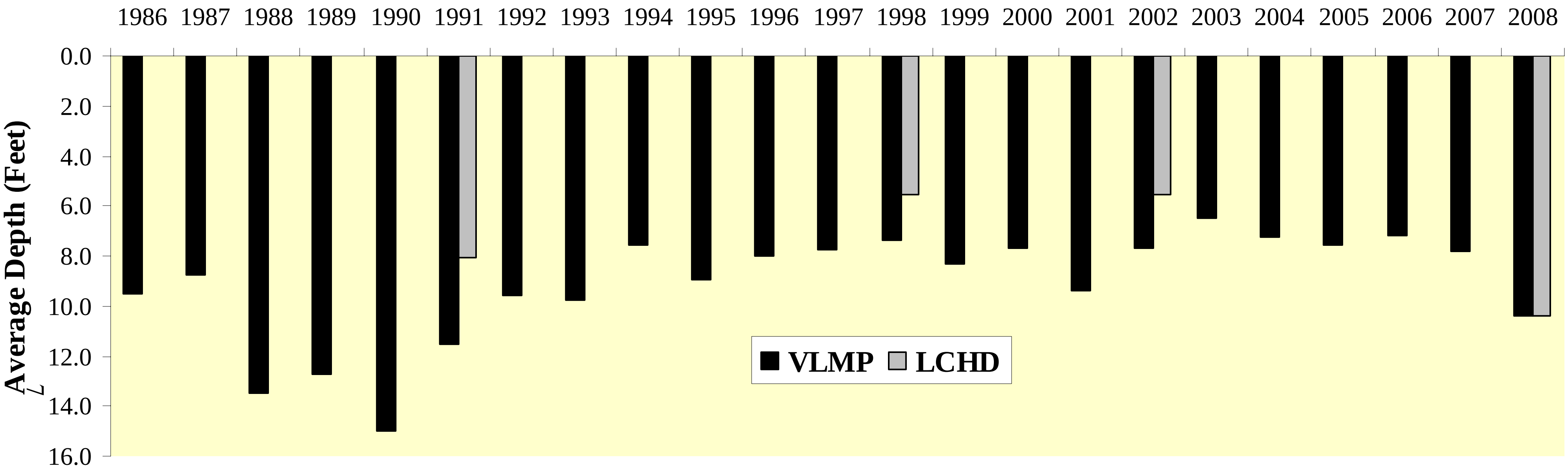


Table 2. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity readings in the Flint Creek watershed (Lake Zurich, Echo Lake, Honey Lake, Grassy Lake, Flint Lake, and Lake Louise)

	Lake Zurich	Lake Zurich	Lake Zurich	Lake Zurich	Echo Lake	Echo Lake	Honey Lake	Honey Lake	Honey Lake	Grassy Lake	Grassy Lake	Flint Lake	Flint Lake
Year	**1991**	**1998**	**2002**	**2008**	**2000**	**2008**	**1998**	**2001**	**2008**	**2000**	**2008**	**2003**	**2008**
Secchi (feet)	8.09	5.70	5.53	10.40	3.66	2.11	5.70	8.40	7.17	1.44	1.71	NA	NA
TSS (mg/L)	4.4	4.2	4.9	2.7	9.7	13.5	3.4	1.8	3.4	27.1	20.7	18.1	22.9
TP (mg/L)	0.023	0.017	0.028	0.016	0.079	0.125	0.040	0.038	0.034	0.195	0.161	0.564	0.293
Conductivity (milliSiemens/cm)	0.5400	0.7980	0.7593	0.9573	0.8872	1.2284	0.9370	1.1126	1.3174	0.9301	1.1608	1.5818	1.5188

	Lake Louise	Lake Louise	Flint Lake	Flint Lake
Year	**2003**	**2008**	**2003**	**2008**
Secchi (feet)	1.86	1.68	NA	NA
TSS (mg/L)	20.7	23.3	18.1	22.9
TP (mg/L)	0.194	0.156	0.564	0.293
Conductivity (milliSiemens/cm)	0.9354	0.9660	1.5818	1.5188

Direction of Watershed Flow

volatile solids (TVS) decreased in the lake during the same time period. TVS are made up of the primary producers, such as plant material, diatoms and algae, etc., for which larger organisms depend on for either food or habitat. Grassy Lake and Flint Lake, like Echo Lake had TSS concentrations well above the county median, this might be explained by larger watershed inputs, wave/wind action on shallower lake bottoms and infestation by Common Carp.

Since 2002, total phosphorus (TP) concentrations in Lake Zurich decreased by 75%. The 2008 epilimnetic average concentration was 0.016 mg/L. While Zebra Mussels may be the reason for the decline in TP, watershed contribution of phosphorus still poses a threat to the water quality of the lake. One source of phosphorus in the watershed is lawn fertilizer. Other sources can be stormwater and waste from pets and geese.

The primary land use within the 604.97 acre Lake Zurich watershed (Figure 3) was water (38.2%) followed by single family housing (19.8%) (Figure 4). Transportation which only represented 14.8% of the watersheds land use contributes the highest percentage of estimated runoff at 39.7% (Table 3). Retail and commercial property follow similar trends; they represent only 7.8% of the land use and contribute 21.0% of the estimated runoff within the watershed. Other notable contributors to the estimated runoff are single (18.9%) and multi family properties (12.6%). Hence, categories that represent a small percentage of land use can have a big impact on the percentage of runoff that they contribute. It is recommended that all homeowners and commercial properties in the watershed use phosphorus free fertilizers on their properties unless it is determined through a soil test that additional phosphorus is needed. Alternatives to applying road salt to roadways should be explored, as at this time, transportation contributes the highest percentage estimated runoff.

High nutrient concentrations are usually indicative of water quality problems. Plants and Algae need light and nutrients, most importantly carbon, nitrogen (N) and phosphorus (P), to grow. Light and carbon are not normally in short supply (limiting). This means that nutrients (N&P) are usually the limiting factors in plant and algal growth. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) that are more difficult to control than sources of phosphorus. To compare the availability of these nutrients, a ratio of total nitrogen to total phosphorus is used (TN: TP). Ratios < 10:1 indicates nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate there is enough of both nutrients for excessive algal growth. The TN: TP for Lake Zurich in 2008 was 56:1, indicating a strongly phosphorus-limited system. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon. Homeowners and commercial businesses are encouraged to use phosphorus-free fertilizers.

Based on data collected in 2008, standard classification indices compiled by the Illinois Environmental Protection Agency (IEPA) were used to determine the current condition of Lake Zurich. A general overall index that is commonly used is called a trophic state index or TSI. 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 productive). This index can be calculated using total phosphorus values obtained at or near the

Figure 3. Approximate watershed delineation for Lake Zurich, 2008.

Figure 4. Approximate land use within the Lake Zurich watershed, 2008.

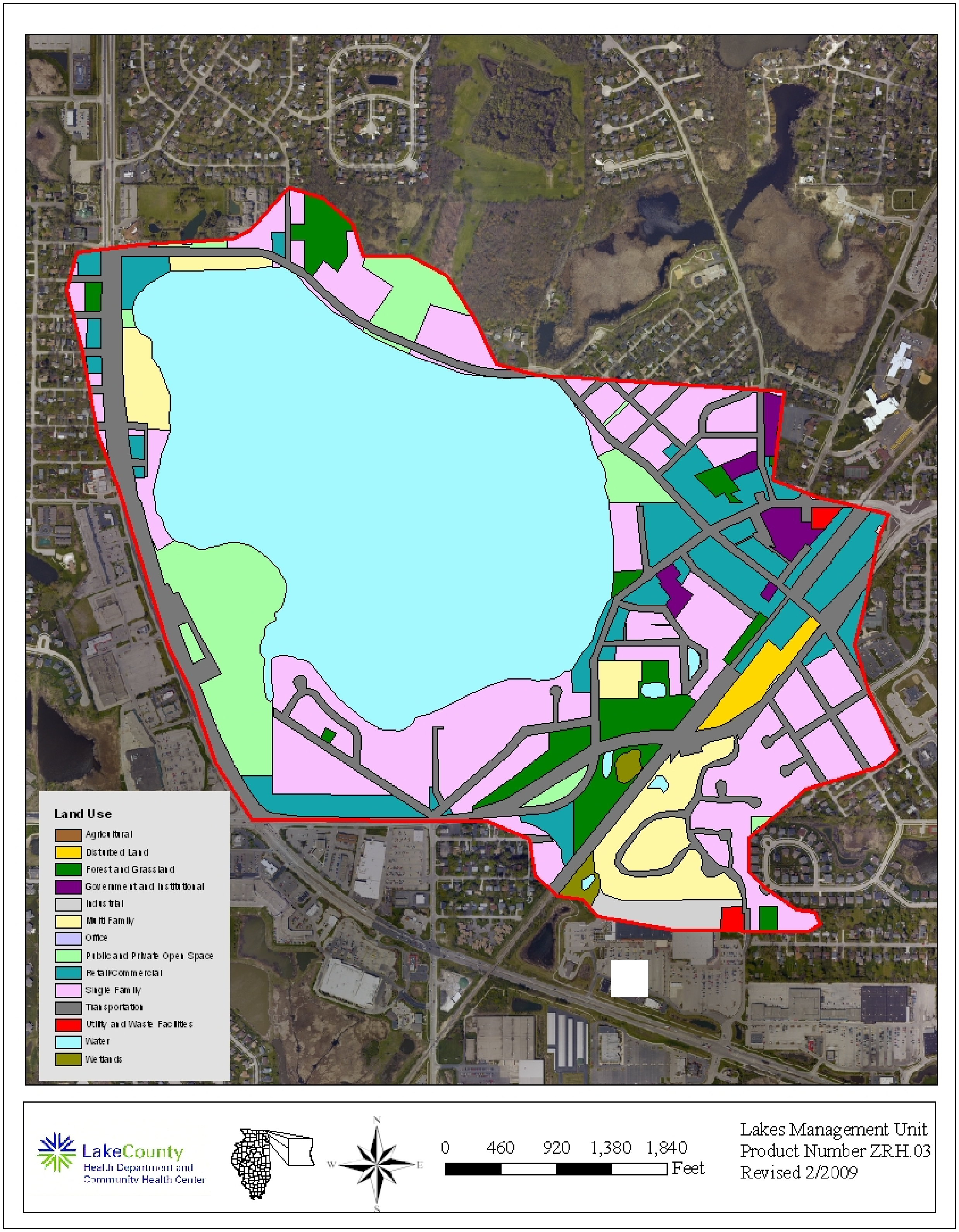


Table 3. Approximate land uses and retention time for the Lake Zurich watershed, 2008.

Land Use	Acreage	% of Total
Disturbed Land	5.60	0.9%
Forest and Grassland	24.29	4.0%
Government and Institutional	7.26	1.2%
Industrial	5.82	1.0%
Multi Family	28.37	4.7%
Public and Private Open Space	41.97	6.9%
Retail/Commercial	47.10	7.8%
Single Family	120.07	19.8%
Transportation	89.34	14.8%
Utility and Waste Facilities	1.65	0.3%
Water	230.86	38.2%
Wetlands	2.63	0.4%
Total Acres	**604.97**	**100.0%**

Land Use	Acreage	Runoff Coefficient	Estimated Runoff, acre-feet.	% Total of Estimated Runoff
Disturbed Land	5.60	0.05	0.8	0.1%
Forest and Grassland	24.29	0.05	3.3	0.6%
Government and Institutional	7.26	0.50	10.0	1.9%
Industrial	5.82	0.50	8.0	1.5%
Multi Family	28.37	0.85	66.3	12.6%
Public and Private Open Space	41.97	0.15	17.3	3.3%
Retail/Commercial	47.10	0.85	110.1	21.0%
Single Family	120.07	0.30	99.1	18.9%
Transportation	89.34	0.85	208.8	39.7%
Utility and Waste Facilities	1.65	0.30	1.4	0.3%
Water	230.86	0.00	0.0	0.0%
Wetlands	2.63	0.05	0.4	0.1%
TOTAL	**604.97**		**525.4**	100.0%

Lake volume	**1635.47**	**acre-feet**
Retention Time (years)= lake volume/runoff	**3.11**	**years**
	1136.10	**days**

surface. The TSIp for Lake Zurich in 2008 classified it as a mesotrophic lake (TSIp = 41.1). Eutrophic lakes are the most common types of lakes throughout the lower Midwest, and they are particularly common among manmade lakes. Lake Zurich ranked 4th of 163 lakes monitored between 2000 and 2008, based on average TP concentrations (Table 4). The current rank of a lake is dependent upon many factors including lake origin, water source, nutrient loads, and morphometric features (volume, depth, substrate, etc.). Lake Zurich had low indices for both aquatic life and recreational use, indicating a full degree of support for these uses within the lake. The overall use index was classified as full use.

Lake Zurich nutrient concentrations were much higher in the hypolimnion than in the epilimnion, which is expected in a stratified lake. The lake did not stratify until July, it was weakly stratified at 14 feet with strong stratification occurring at approximately 24 feet. It remained strongly stratified at 24 feet through August. By September the lake had turned over. The hypolimnion became anoxic, dissolved oxygen (DO) concentrations below 1.0 mg/L during July and August. Based on the bathymetric map created by the LMU in 1991, the maximum volume experiencing anoxia was approximately 5.4% (below 20 feet), thus there are no apparent DO problems in Lake Zurich.

Conductivity readings in Lake Zurich have increased 26% from 2002 (0.7593 mS/cm). The 2008 epilimnetic average for conductivity was 0.9573 mS/cm, which was above the county median of 0.8195 mS/cm. The hypolimnetic average for 2008 was 0.9823 mS/cm, which was also above the county median of 0.8695 mS/cm. The most likely cause for these increases in conductivity readings was input from dissolved solids washed into the lake from storm events. One of the most common dissolved solids is road salt used in winter road maintenance. Because of many of our lakes are experiencing increases and high conductivity readings, one additional parameter, chlorides, was collected by the LMU beginning in 2005. The seasonal average for chlorides in Lake Zurich in 2008 was 211 mg/L in both the epilimnion and the hypolimnion. The IEPA standard for chloride is 500 mg/L. Once values exceed this standard the water body is deemed to be impaired, thus impacting aquatic life. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years. In a study by Environment Canada (equivalent to our USEPA), it was estimated that 5% of aquatic species such as fish, zooplankton and benthic invertebrates would be affected at chloride concentrations of about 210 mg/L. Additionally, shifts in algae populations in lakes were associated with chloride concentrations as low as 12 mg/L. The current concentrations of chlorides in Lake Zurich may be adversely affecting aquatic life in the lake.

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in July of 2008. Sampling sites were based on a grid system created by mapping software (ArcMap), with each site located 60 meters apart for a total of 257 sites, 219 of the 257 sites were sampled (Figure 5). Fifteen aquatic submersed and floating plant species and one macro algae (*Chara* spp.) were found (Table 5)

The number of species increased by two species in 2008 when evaluating all plants found during the multiple sampling events that occurred in 2002. Species composition changed slightly as well. Coontail and Leafy Pondweed were found in 2002 but not in 2008. Spiny Naiad and

Table 4. Lake County average TSI phosphorous (TSIp) ranking 2000-2008

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	Bangs 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	Lake of the Hollow	0.0200	47.35
14	Banana Pond	0.0202	47.49
15	Lake Minear	0.0204	47.63
16	Cedar Lake	0.0220	48.72
17	Cross Lake	0.0220	48.72
18	Sun Lake	0.0220	48.72
19	Dog Pond	0.0222	48.85
20	Stone Quarry Lake	0.0230	49.36
21	Deep Lake	0.0234	49.61
22	Druce Lake	0.0244	50.22
23	Little Silver	0.0250	50.57
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Cranberry Lake	0.0270	51.68
27	Dugdale Lake	0.0274	51.89
28	Peterson Pond	0.0274	51.89
29	Lake Miltmore	0.0276	51.99
30	Third Lake	0.0280	52.20
31	Lake Fairfield	0.0296	53.00
32	Gray's Lake	0.0302	53.29
33	Highland Lake	0.0302	53.29
34	Hook Lake	0.0302	53.29
35	Lake Catherine (Site 1)	0.0308	53.57
36	Lambs Farm Lake	0.0312	53.76
37	Old School Lake	0.0312	53.76
38	Sand Lake	0.0316	53.94
39	Sullivan Lake	0.0320	54.13
40	Lake Linden	0.0326	54.39
41	Gages Lake	0.0338	54.92
42	Honey Lake	0.0340	55.00
43	Hendrick Lake	0.0344	55.17
44	Diamond Lake	0.0372	56.30
45	Channel Lake (Site 1)	0.0380	56.60
46	Ames Pit	0.0390	56.98

Table 4. Continued

RANK	LAKE NAME	TP AVE	TSIp
47	White Lake	0.0408	57.63
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Deer Lake	0.0434	58.52
52	Schreiber Lake	0.0434	58.52
53	Nielsen Pond	0.0448	58.98
54	Turner Lake	0.0458	59.30
55	Seven Acre Lake	0.0460	59.36
56	Willow Lake	0.0464	59.48
57	Lucky Lake	0.0476	59.85
58	Davis Lake	0.0476	59.85
59	East Meadow Lake	0.0478	59.91
60	East Loon 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 Christa	0.0576	62.60
69	Lake Charles	0.0580	62.70
70	Crooked Lake	0.0608	63.38
71	Waterford Lake	0.0610	63.43
72	Lake Naomi	0.0616	63.57
73	Lake Tranquility S1	0.0618	63.62
74	Wooster Lake	0.0620	63.66
75	Countryside Lake	0.0620	63.66
76	Werhane Lake	0.0630	63.89
77	Liberty Lake	0.0632	63.94
78	Countryside Glen Lake	0.0642	64.17
79	Lake Fairview	0.0648	64.30
80	Leisure Lake	0.0648	64.30
81	Tower Lake	0.0662	64.61
82	St. Mary's Lake	0.0666	64.70
83	Mary Lee Lake	0.0682	65.04
84	Hastings Lake	0.0684	65.08
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
89	Broberg Marsh	0.0782	67.01
90	Sylvan Lake	0.0794	67.23
91	Big Bear Lake	0.0806	67.45
92	Petite Lake	0.0834	67.94

Table 4. Continued

RANK	LAKE NAME	TP AVE	TSIp
93	Timber Lake (South)	0.0848	68.18
94	Lake Marie (Site 1)	0.0850	68.21
95	North Churchill Lake	0.0872	68.58
96	Grand Avenue Marsh	0.0874	68.61
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	North Tower Lake	0.0878	68.68
99	South Churchill Lake	0.0896	68.97
100	Rivershire Pond 2	0.0900	69.04
101	McGreal Lake	0.0914	69.26
102	International Mine and Chemical Lake	0.0948	69.79
103	Eagle Lake (Site I)	0.0950	69.82
104	Valley Lake	0.0950	69.82
105	Dunns Lake	0.0952	69.85
106	Fish Lake	0.0956	69.91
107	Lochanora Lake	0.0960	69.97
108	Owens Lake	0.0978	70.23
109	Woodland Lake	0.0986	70.35
110	Island Lake	0.0990	70.41
111	McDonald Lake 1	0.0996	70.50
112	Longview Meadow Lake	0.1024	70.90
113	Lake Barrington	0.1053	71.31
114	Redwing Slough, Site II, Outflow	0.1072	71.56
115	Lake Forest Pond	0.1074	71.59
116	Bittersweet Golf Course #13	0.1096	71.88
117	Fox Lake (Site 1)	0.1098	71.90
118	Osprey Lake	0.1108	72.04
119	Bresen Lake	0.1126	72.27
120	Round Lake Marsh North	0.1126	72.27
121	Deer Lake Meadow Lake	0.1158	72.67
122	Long Lake	0.1170	72.82
123	Taylor Lake	0.1184	72.99
124	Columbus Park Lake	0.1226	73.49
125	Nippersink Lake (Site 1)	0.1240	73.66
126	Echo Lake	0.1250	73.77
127	Grass Lake (Site 1)	0.1288	74.21
128	Lake Holloway	0.1322	74.58
129	Lakewood Marsh	0.1330	74.67
130	Summerhill Estates Lake	0.1384	75.24
131	Redhead Lake	0.1412	75.53
132	Forest Lake	0.1422	75.63
133	Antioch Lake	0.1448	75.89
134	Slocum Lake	0.1496	76.36
135	Drummond Lake	0.1510	76.50
136	Pond-a-Rudy	0.1514	76.54
137	Lake Matthews	0.1516	76.56
138	Buffalo Creek Reservoir	0.1550	76.88

Table 4. Continued

RANK	LAKE NAME	TP AVE	TSIp
139	Pistakee Lake (Site 1)	0.1592	77.26
140	Grassy Lake	0.1610	77.42
141	Salem Lake	0.1650	77.78
142	Half Day Pit	0.1690	78.12
143	Lake Eleanor Site II, Outflow	0.1812	79.13
144	Lake Farmington	0.1848	79.41
145	Lake Louise	0.1850	79.43
146	ADID 127	0.1886	79.71
147	Dog Bone Lake	0.1990	80.48
148	Redwing Marsh	0.2072	81.06
149	Stockholm Lake	0.2082	81.13
150	Bishop Lake	0.2156	81.63
151	Hidden Lake	0.2236	82.16
152	Fischer Lake	0.2278	82.43
153	Lake Napa Suwe (Outlet)	0.2304	82.59
154	Patski Pond (outlet)	0.2512	83.84
155	Oak Hills Lake	0.2792	85.36
156	Loch Lomond	0.2954	86.18
157	McDonald Lake 2	0.3254	87.57
158	Fairfield Marsh	0.3264	87.61
159	ADID 182	0.3280	87.69
160	Slough Lake	0.4134	91.02
161	Flint Lake Outlet	0.4996	93.75
162	Rasmussen Lake	0.5025	93.84
163	Albert Lake, Site II, outflow	1.1894	106.26

Figure 5. Aquatic plant grid illustrating plant on Lake Zurich, July 2008

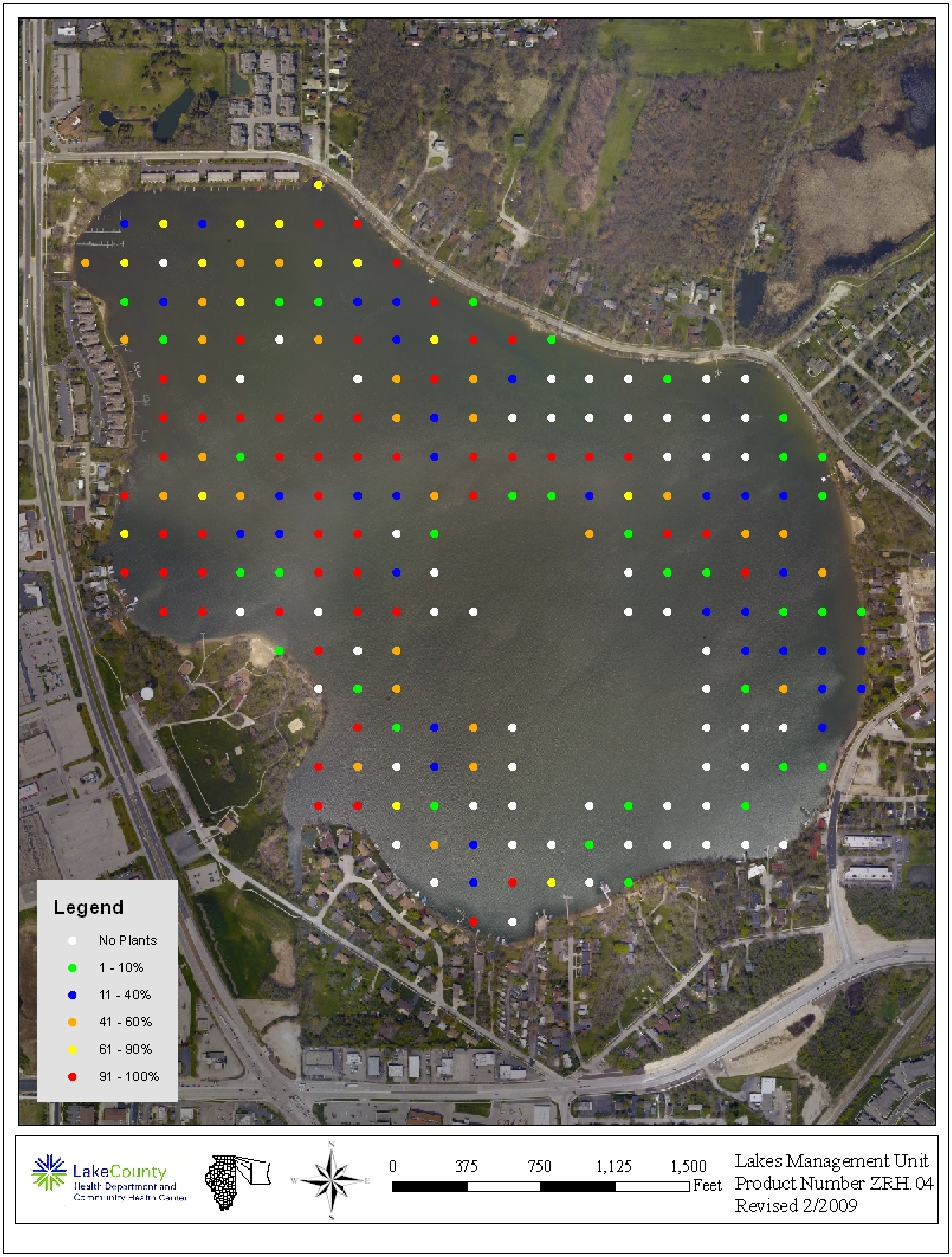


Table 5. Aquatic plant species found in Lake Zurich in 2008.

Chara (Macro algae)	*Chara* spp.
Water Stargrass	*Heteranthera dubia*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Slender Naiad	*Najas flexilis*
Spiny Naiad	*Najas marina*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Curlyleaf Pondweed^	*Potamogeton crispus*^
American Pondweed	*Potamogeton nodosus*
Sago Pondweed	*Potamogeton pectinatus*
Small Pondweed	*Potamogeton pusillus*
Wigeon Grass	*Ruppia maritime*
Common Bladderwort	*Utricularia vulgaris*
Eel Grass	*Vallisneria americana*
Horned Pondweed	*Zanichellia palustris*

^ Exotic plant

American Pondweed were identified in 2008 but were not present in 2002. American Pondweed has been detected in past surveys. The composition of the vegetation has degraded slightly since 2002 as Spiny Naiad is exotic to the Chicago region.

In 2008, Water Stargrass and *Chara* spp. co-dominated the lake. They were found at 48.4% and 31.1% of the sites sampled, respectively (Table 5a). Slender Naiad 12.8%, Large-leaf Pondweed 12.3% and Sago Pondweed 9.1% were other frequently found species during the July, 2008 sampling.

Current plant management records show that in 2008 there were two occasions when herbicide applications occurred. In May, approximately 17 acres along the northwestern shoreline was treated with one hundred and twenty-three gallons of a Reward and Aquathol K (28/72) mix targeting Largeleaf Pondweed. An additional 15acres within the ski lanes was treated with 30 gallons of Reward, the target species was Wigeon Grass, and although algae was not targeted, 5 gallons of chelated copper was included in the treatment to improve results due to the presence of algae on the vegetation. In May 2007, seven specific locations encompassing 33 acres of Lake Zurich were treated using 71.5 gallons of an herbicide mix of Reward and Cygnet Plus to control excessive pondweed growth; the target species were Curlyleaf Pondweed, Longleaf Pondweed and Wigeon Grass. The management of vegetation has been successful in the past few years as EWM and Curlyleaf Pondweed were minor components of the lakes vegetation assemblage. The LMU cautions the treatment of the native pondweeds however, due to the absence of natives providing openings for the re-establishment of undesirable, non native species. A diverse balanced plant assemblage such as is present in Lake Zurich provides a diverse array of habitats for other aquatic organisms such as macro invertebrates and fish.

To maintain a healthy sunfish/bass fishery, the optimal aquatic plant (macrophyte) coverage is 30% to 40% across the lake bottom. Approximately 63% of the lake bottom was vegetated (Table 5b). The maximum depth that plants were found in Lake Zurich was 17.0 feet. Small Pondweed was the only species present at this site. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize at water depths with less than 1% of the available sunlight at the surface. During 2008, the depth of the 1% light level ranged from 25 feet in May to 19 feet recorded in June. The poor light penetration in September was due to the algae bloom occurring at that time.

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area 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 plant species found in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. Lake Zurich had a FQI of 24.3 in 2008, which was a slight increase from 2002 (24.0), however, annual variation and the implementation of a new plant sampling technique may account for the difference. The median FQI for 2000-2008 Lake County lakes is 13.6 (Table 6).

Table 5a. Aquatic plant species found at the 219 sampling sites on Lake Zurich, July 2008. Maximum depth that plants were found was 17.0 feet

Plant Density	American Pondweed	Bladderwort	Chara	Curlyleaf Pondweed	Eurasian Watermilfoil	Horned Pondweed	Largeleaf Pondweed	Sago Pondweed	Slender Naiad	Small Pondweed	Spatterdock	Spiny Naiad	Vallisneria	Widgeon Grass	Water Stargrass	White Water Lily
Absent	218	212	151	216	218	218	192	199	191	205	217	218	218	211	113	217
Present	0	3	21	3	1	1	11	14	21	13	2	0	1	5	30	2
Common	1	1	22	0	0	0	7	4	4	1	0	1	0	2	17	0
Abundant	0	2	11	0	0	0	5	2	2	0	0	0	0	1	22	0
Dominant	0	1	14	0	0	0	4	0	1	0	0	0	0	0	37	0
% Plant Occurrence	0.5%	3.2%	31.1%	1.4%	0.5%	0.5%	12.3%	9.1%	12.8%	6.4%	0.9%	0.5%	0.5%	3.7%	48.4%	0.9%

Table 5b. Distribution of rake density across all sampling sites.

Rake Density (Coverage)	# of Sites	%
No plants	56	34.4
>0 to 10%	34	20.9
>10 to 40%	33	20.2
>40 to 60%	28	17.2
>60 to 90%	15	9.2
>90%	53	32.5
Total Sites with Plants	163	74.4
Total # of Sites	219	100.0

Table 6. 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	36.3	38.4
2	East Loon Lake	30.6	32.7
3	Cranberry Lake	30.1	31.6
4	Deep Lake	29.7	31.2
5	Little Silver	29.6	31.6
6	Round Lake Marsh North	29.1	29.9
7	Deer Lake	28.2	29.7
8	Sullivan Lake	28.2	29.7
9	Schreiber Lake	26.8	27.6
10	Bangs Lake	25.7	27.4
11	West Loon Lake	25.7	27.3
12	Cross Lake	25.2	27.8
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	Lake of the Hollow	23.8	26.2
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	Druce Lake	22.8	25.2
23	Countryside Glen Lake	21.9	22.8
24	Butler Lake	21.4	23.1
25	Duck Lake	21.1	22.9
26	Timber Lake (North)	20.8	22.8
27	Broberg Marsh	20.5	21.4
28	Davis Lake	20.5	21.4
29	ADID 203	20.5	20.5
30	McGreal Lake	20.2	22.1
31	Lake Kathryn	19.6	20.7
32	Fish Lake	19.3	21.2
33	Owens Lake	19.3	20.2
34	Redhead Lake	19.3	21.2
35	Turner Lake	18.6	21.2
36	Wooster Lake	18.5	20.2
37	Salem Lake	18.5	20.2
38	Lake Miltmore	18.4	20.3
39	Hendrick Lake	17.7	17.7
40	Summerhill Estates Lake	17.1	18.0
41	Seven Acre Lake	17.0	15.5
42	Gray's Lake	16.9	19.8
43	Lake Barrington	16.7	17.7
44	Bresen Lake	16.6	17.8

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
45	Diamond Lake	16.3	17.4
46	Lake Napa Suwe	16.3	17.4
47	Windward Lake	16.3	17.6
48	Dog Bone Lake	15.7	15.7
49	Redwing Slough	15.6	16.6
50	Osprey Lake	15.5	17.3
51	Lake Fairview	15.2	16.3
52	Heron Pond	15.1	15.1
53	Lake Tranquility (S1)	15.0	17.0
54	North Churchill Lake	15.0	15.0
55	Dog Training Pond	14.7	15.9
56	Island Lake	14.7	16.6
57	Highland Lake	14.5	16.7
58	Grand Avenue Marsh	14.3	16.3
59	Taylor Lake	14.3	16.3
60	Dugdale Lake	14.0	15.1
61	Eagle Lake (S1)	14.0	15.1
62	Longview Meadow Lake	13.9	13.9
63	Ames Pit	13.4	15.5
64	Bishop Lake	13.4	15.0
65	Hook Lake	13.4	15.5
66	Long Lake	13.1	15.1
67	Buffalo Creek Reservoir	13.1	14.3
68	Mary Lee Lake	13.1	15.1
69	McDonald Lake 2	13.1	14.3
70	Old School Lake	13.1	15.1
71	Dunn's Lake	12.7	13.9
72	Old Oak Lake	12.7	14.7
73	Timber Lake (South)	12.7	14.7
74	White Lake	12.7	14.7
75	Hastings Lake	12.5	14.8
76	Sand Lake	12.5	14.8
77	Stone Quarry Lake	12.5	12.5
78	Lake Carina	12.1	14.3
79	Lake Leo	12.1	14.3
80	Lambs Farm Lake	12.1	14.3
81	Pond-A-Rudy	12.1	12.1
82	Stockholm Lake	12.1	13.5
83	Grassy Lake	12.0	12.0
84	Lake Matthews	12.0	12.0
85	Flint Lake	11.8	13.0
86	Harvey Lake	11.8	13.0
87	Rivershire Pond 2	11.5	13.3
88	Antioch Lake	11.3	13.4
89	Lake Charles	11.3	13.4
90	Lake Linden	11.3	11.3

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
91	Lake Naomi	11.2	12.5
92	Pulaski Pond	11.2	12.5
93	Lake Minear	11.0	13.9
94	Redwing Marsh	11.0	11.0
95	Tower Lake	11.0	11.0
96	West Meadow Lake	11.0	11.0
97	Nielsen Pond	10.7	12.0
98	Lake Holloway	10.6	10.6
99	Third Lake	10.2	12.5
100	Crooked Lake	10.2	12.5
101	College Trail Lake	10.0	10.0
102	Lake Lakeland Estates	10.0	11.5
103	Valley Lake	9.9	9.9
104	Werhane Lake	9.8	12.0
105	Big Bear Lake	9.5	11.0
106	Little Bear Lake	9.5	11.0
107	Loch Lomond	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Lake Louise	9	10.4
111	Fischer Lake	9.0	11.0
112	Grandwood Park Lake	9.0	11.0
113	Lake Fairfield	9.0	10.4
114	McDonald Lake 1	8.9	10.0
115	Countryside Lake	8.7	10.6
116	East Meadow Lake	8.5	8.5
117	Lake Christa	8.5	9.8
118	Lake Farmington	8.5	9.8
119	Lucy Lake	8.5	9.8
120	South Churchill Lake	8.5	8.5
121	Bittersweet Golf Course #13	8.1	8.1
122	Woodland Lake	8.1	9.9
123	Albert Lake	7.5	8.7
124	Banana Pond	7.5	9.2
125	Fairfield Marsh	7.5	8.7
126	Lake Eleanor	7.5	8.7
127	Patski Pond	7.1	7.1
128	Rasmussen Lake	7.1	7.1
129	Slough Lake	7.1	7.1
130	Lucky Lake	7.0	7.0
131	Lake Forest Pond	6.9	8.5
132	Leisure Lake	6.4	9.0
133	Peterson Pond	6.0	8.5
134	Gages Lake	5.8	10.0
135	Slocum Lake	5.8	7.1
136	Deer Lake Meadow Lake	5.2	6.4

Table 6. Continued

Rank	LAKE NAME	FQI (w/A)	FQI (native)
137	ADID 127	5.0	5.0
138	Drummond Lake	5.0	7.1
139	IMC Lake	5.0	7.1
140	Liberty Lake	5.0	5.0
141	Oak Hills Lake	5.0	5.0
142	Forest Lake	3.5	5.0
143	Sand Pond (IDNR)	3.5	5.0
144	Half Day Pit	2.9	5.0
145	Lochanora Lake	2.5	5.0
146	Echo Lake	0.0	0.0
147	Hidden Lake	0.0	0.0
148	North Tower Lake	0.0	0.0
149	Potomac Lake	0.0	0.0
150	St. Mary's Lake	0.0	0.0
151	Waterford Lake	0.0	0.0
152	Willow Lake	0.0	0.0
	Mean	**13.6**	**14.9**
	Median	**12.5**	**14.3**

SUMMARY OF SHORELINE CONDITION

In 2008, the shoreline was reassessed for erosion. Approximately 40% of Lake Zurich's shoreline had some degree of erosion (Figure 6). Severe erosion was noted on 1% of the shoreline. Moderate erosion was classified on an additional 8% of the shoreline. Areas of severe and moderate erosion should be remediated immediately to prevent additional shoreline degradation and input of sediment into the lake. When possible, areas with slight erosion should be addressed as soon as possible, as it is more cost efficient to do so. It is also recommended that buffer strip plantings be implemented versus riprap as this practice improves water quality by trapping nutrients and sediment and also provides some wildlife habitat.

WILDLIFE OBSERVATIONS

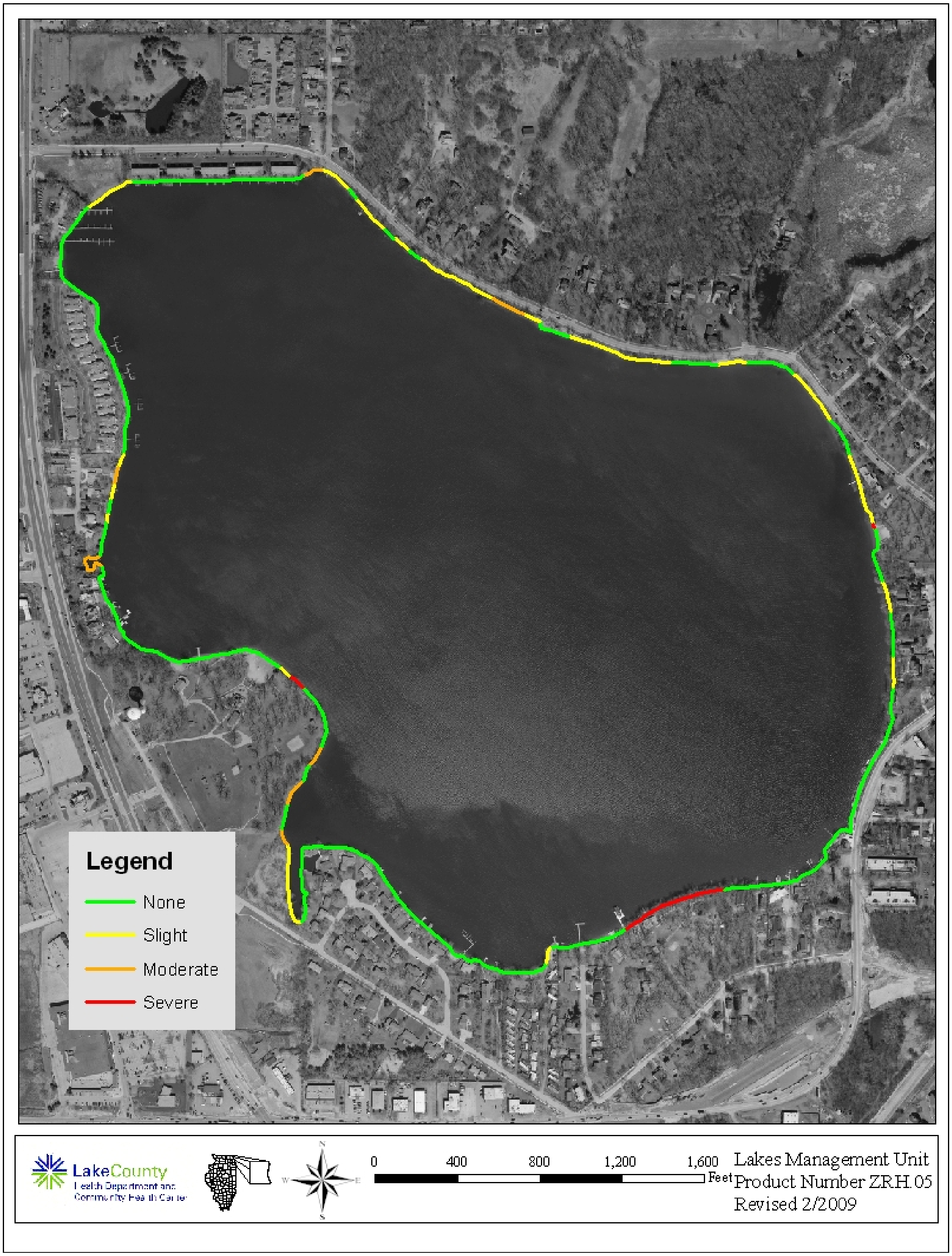
In July 2008 a large Common Carp die off occurred on the lake. Fish exhibiting signs of infection were collected by the Illinois Department of Natural Resources (IDNR) and sent to a lab for testing. The results showed that the bacterium, *Aeromonas hydrophila*, was responsible for the fish kill. Due to the number of dead Common Carp counted during the IDNR sampling on July 10, it is estimated that greater than 1000 to 1500 Common Carp were likely impacted. Fish species such as Bluegill, Black Crappie and Largemouth Bass should benefit from the reduced Common Carp population.

A standardized fish survey was conducted in September, 2005 by the IDNR. They collected 17 species during a 60 minute daylight electrofishing (D/C), a set of two trapnets and one 250 foot experimental mesh gill net. In total 2114 fish were collected. The number of fish collected increased substantially from the 2001 sampling where only 144 fish were caught (10 species). The IDNR cites that some of the differences in the number of fish collected were the amount of vegetation present and sampling gear. In 2005 species such as Grass Pickeral, Brown and Yellow Bullhead, Warmouth and some of the minnows and shiners were collected. Several surveys had gone by since these species were detected. There were no threatened or endangered (T & E) species collected via 60 minute electrofishing. Although conditions seemed favorable for Blackchin Shiners in the northwestern and western portions of the lake were vegetation was abundant. The IDNR had planned to seine for T & E species at a later date.

In 2005 the recommendation was that a stocking regime consisting of predatory fish species Walleye, Channel Catfish, and Northern Pike should be implemented. Muskie, another option, and depending on whether or not they were "pure" or "hybrid" populations could take anywhere from 5 to 15 years to develop the lake as a Muskie fishery. They also recommended continuing spot herbicide treatments to treat Eurasian Milfoil. This method of application tends to reduce algal blooms and provides for an overall healthier lake compared to other methods utilized in the past.

In response to the recommendations by the IDNR, it appears that 2000 Walleye were stocked in October, 2005.

Figure 6. Shoreline erosion on Lake Zurich, 2008.



LAKE MANAGEMENT RECOMMENDATIONS

Lake Zurich's water clarity has remained stable until recently, the increase in clarity is most likely due to the zebra mussels in the lake. Dissolved oxygen concentrations are good, however, algal blooms have persisted over time. The state of the lake's fishery appears well balanced. However, there are several of recommendations that will aid in improving the overall quality of Lake Zurich (see Appendix D for more details).

Lakes with Shoreline Erosion

There are still some areas around the lake with erosion, including areas not previously identified in 2002. These eroded areas should be remediated to prevent additional loss of shoreline and continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawalls (Appendix D1).

Reduce Conductivity and Chloride Concentrations

Conductivity readings in Lake Zurich have increased compared to past years. The 2008 epilimnetic average for conductivity was 0.9778 mS/cm, which is 25.% higher than the 2002 average of 0.7873 mS/cm, however still below the county median of 0.8195 mS/cm. The most likely cause for these increases in conductivity readings is input from dissolved solids washed into the lake from storm events (Appendix D2).

Lakes with Zebra Mussels

Zebra mussels were first documented in Lake Zurich in 2003 and were found in large numbers in the lake in 2008. Zebra mussels were frequently found attached to plants during the season. While improved clarity is often viewed as a positive aspect, the filter feeding zebra mussel may have negative long-term impacts on the food chain. Efforts should be made to prevent their spread to other area lakes (Appendix D3).

Enhance Wildlife Habitat Conditions on a Lake

With the lake being in a residential setting with the majority of the shoreline as riprap, seawall, or lawn, wildlife habitat is limited. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones, and are recommended as one aspect of shoreline protection (Appendix D4).

Creating a bathymetric map

Creating an updated bathymetric map can help with improvements to Lake Zurich. A bathymetric map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management (Appendix D5). Lake Zurich had a bathymetric map created in 1991. It is recommended that any map older than 15 years be updated.

- **<u>Grant program opportunities</u>**

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

APPENDIX B. MULTI-PARAMETER DATA FOR LAKE ZURICH IN 2008.

Lake Zurich 2008 Multiparameter data

Date MMDDYY	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	Extinction Coefficient
										Average	0.29
52108	0	0.48	15.50	9.63	100.6	0.9776	8.23	4555	Surface	100%	
52108	1	1.08	15.50	9.54	99.7	0.9778	8.35	4341	Surface	100%	
52108	2	1.92	15.50	9.54	99.6	0.9776	8.38	1644	0.250	38%	3.88
52108	3	3.03	15.49	9.52	99.5	0.9778	8.42	1489	1.360	34%	0.07
52108	4	4.03	15.49	9.50	99.3	0.9779	8.43	1141	2.360	26%	0.11
52108	6	6.00	15.48	9.50	99.2	0.9779	8.44	964	4.330	22%	0.04
52108	8	8.06	15.45	9.51	99.2	0.9777	8.47	537	6.390	12%	0.09
52108	10	10.07	15.33	9.54	99.3	0.9782	8.49	514	8.400	12%	0.01
52108	12	11.99	15.29	9.47	98.5	0.9781	8.49	376	10.320	9%	0.03
52108	14	13.97	15.29	9.47	98.5	0.9782	8.50	236	12.300	5%	0.04
52108	16	15.98	15.29	9.44	98.2	0.9781	8.47	162	14.310	4%	0.03
52108	18	18.03	15.29	9.42	98.0	0.9781	8.54	119	16.360	2.7%	0.02
52108	20	19.99	15.28	9.40	97.8	0.9785	8.42	92	18.320	2.1%	0.01
52108	22	22.22	15.25	9.36	97.2	0.9793	8.42	65	20.550	1.5%	0.02
52108	24	23.97	15.23	9.36	97.2	0.9779	8.49	50	22.300	1.2%	0.01
52108	26	26.13	14.98	9.11	94.1	0.9780	8.44	36	24.460	0.8%	0.01
52108	28	28.01	14.67	7.91	81.2	1.1190	7.71	24	26.340	0.6%	0.02

Date MMDDYY	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	Extinction Coefficient
										Average	0.28
61808	0	0.46	22.73	8.15	97.7	0.9838	8.31	4184	Surface	100%	
61808	1	1.03	22.72	8.12	97.3	0.9827	8.35	4198	Surface	100%	
61808	2	2.00	22.67	8.11	97.1	0.9832	8.37	1750	0.330	42%	2.65
61808	3	3.00	22.53	8.17	97.5	0.9828	8.41	1376	1.330	33%	0.18
61808	4	3.95	22.52	8.13	97.1	0.9835	8.42	1173	2.280	28%	0.07
61808	6	6.01	22.50	8.08	96.5	0.9842	8.44	768	4.340	18%	0.10
61808	8	8.01	22.45	7.93	94.6	0.9834	8.40	438	6.340	10%	0.09

61808	10	9.99	22.36	7.81	93.0	0.9842	8.41	314	8.320	7%	0.04
61808	12	11.95	22.33	7.79	92.7	0.9842	8.39	190	10.280	5%	0.05
61808	14	13.82	22.32	7.83	93.2	0.9845	8.41	86	12.150	2%	0.07
61808	16	16.13	22.29	7.90	93.9	0.9843	8.45	71	14.460	2%	0.01
61808	18	18.21	22.22	7.92	94.0	0.9840	8.43	52	16.540	1.2%	0.02
61808	20	20.18	22.07	7.48	88.6	0.9850	8.36	35	18.510	0.8%	0.02
61808	22	21.95	21.32	5.04	58.8	0.9862	8.11	26	20.280	0.6%	0.01

Date MMDDYY	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	Extinction Coefficient
										Average	0.24
71608	0	0.39	25.79	8.67	109.7	0.9726	8.74	3890	Surface	100%	
71608	1	1.13	25.77	8.69	109.9	0.9723	8.74	3478	Surface	100%	
71608	2	2.11	25.70	8.72	110.1	0.9724	8.76	1464	0.440	42%	1.97
71608	3	3.01	25.59	8.76	110.4	0.9721	8.77	1275	1.340	37%	0.10
71608	4	4.07	25.56	8.77	110.4	0.9714	8.79	918	2.400	26%	0.14
71608	6	5.97	25.54	8.80	110.8	0.9718	8.81	625	4.300	18%	0.09
71608	8	7.96	25.50	8.77	110.4	0.9717	8.80	284	6.290	8%	0.13
71608	10	10.04	25.48	8.76	110.2	0.9717	8.76	160	8.370	5%	0.07
71608	12	12.11	24.87	8.37	104.1	0.9720	8.76	153	10.440	4%	0.00
71608	14	14.26	24.15	7.86	96.5	0.9695	8.70	100	12.590	3%	0.03
71608	16	16.02	23.74	6.95	84.7	0.9708	8.57	74	14.350	2.1%	0.02
71608	18	17.96	23.56	6.47	78.6	0.9714	8.50	53	16.290	1.5%	0.02
71608	20	19.88	23.41	5.62	68.0	0.9739	8.33	34	18.210	1.0%	0.02
71608	22	21.99	22.50	2.69	32.1	0.9820	7.97	21	20.320	0.6%	0.02
71608	24	24.00	20.76	0.45	5.2	0.9921	7.66	12	22.330	0.3%	0.03
71608	26	26.02	18.95	0.25	2.7	1.0150	7.52	5	24.350	0.1%	0.04
71608	28	27.97	17.87	0.21	2.3	1.0230	7.37	3	26.300	0.1%	0.02
71608	30	29.87	17.08	0.20	2.1	1.0440	7.21	3	28.200	0.1%	0.00

Date MMDDYY	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	Extinction Coefficient
										Average	0.23

82008	0	0.30	25.05	9.44	117.3	0.9662	8.85	3601	Surface	100%	
82008	1	0.97	25.03	9.48	117.7	0.9668	8.86	3496	Surface	100%	
82008	2	2.04	25.03	9.45	117.3	0.9660	8.87	1202	0.370	34%	2.89
82008	3	3.01	25.03	9.47	117.5	0.9659	8.88	1010	1.340	29%	0.13
82008	4	3.98	25.02	9.45	117.3	0.9656	8.88	701	2.310	20%	0.16
82008	6	6.00	25.02	9.43	117.0	0.9657	8.88	666	4.330	19%	0.01
82008	8	7.97	25.01	9.43	116.9	0.9656	8.89	459	6.300	13%	0.06
82008	10	10.04	24.99	9.36	116.0	0.9655	8.89	336	8.370	10%	0.04
82008	12	12.01	24.98	9.30	115.4	0.9650	8.84	242	10.340	7%	0.03
82008	14	13.98	24.79	8.78	108.5	0.9653	8.81	175	12.310	5%	0.03
82008	16	15.95	24.55	7.97	98.0	0.9658	8.73	133	14.280	3.8%	0.02
82008	18	17.99	24.25	7.14	87.3	0.9661	8.62	95	16.320	2.7%	0.02
82008	20	20.01	23.81	5.04	61.1	0.9696	8.31	70	18.340	2.0%	0.02
82008	22	22.02	23.39	3.32	40.0	0.9723	8.10	48	20.350	1.4%	0.02
82008	24	24.02	21.99	0.37	4.3	0.9828	7.79	33	22.350	0.9%	0.02
82008	26	26.01	19.27	0.24	2.7	1.0620	7.39	16	24.340	0.5%	0.03
82008	28	28.01	18.25	0.22	2.4	1.1010	7.11	3	26.340	0.1%	0.06

Date MMDDYY	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	Extinction Coefficient
										Average	0.20
91708	0	0.33	19.90	8.56	96.7	0.8880	8.59	4069	Surface	100%	
91708	1	0.98	19.90	8.56	96.7	0.8879	8.59	3948	Surface	100%	
91708	2	2.00	19.88	8.57	96.7	0.8890	8.59	1576	0.330	40%	2.78
91708	3	3.03	19.87	8.61	97.1	0.8881	8.59	1613	1.360	41%	-0.02
91708	4	3.98	19.84	8.59	96.9	0.8881	8.59	1319	2.310	33%	0.09
91708	6	6.02	19.80	8.65	97.5	0.8883	8.60	1157	4.350	29%	0.03
91708	8	8.01	19.80	8.69	97.9	0.8881	8.60	449	6.340	11%	0.15
91708	10	10.01	19.77	8.71	98.1	0.8884	8.60	351	8.340	8.9%	0.03
91708	12	11.98	19.75	8.76	98.6	0.8883	8.60	233	10.310	5.9%	0.04
91708	14	13.98	19.75	8.85	99.6	0.8885	8.61	179	12.310	4.5%	0.02
91708	16	16.08	19.73	8.84	99.5	0.8892	8.62	133	14.410	3.4%	0.02
91708	18	18.06	19.70	8.83	99.2	0.8884	8.62	92	16.390	2.3%	0.02
91708	20	20.00	19.68	8.55	96.1	0.8881	8.58	66	18.330	1.7%	0.02

91708	22	22.07	19.63	8.50	95.4	0.8887	8.57	47	20.400	1.2%	0.02
91708	24	24.02	19.59	8.36	93.8	0.8890	8.55	34	22.350	0.9%	0.01
91708	26	26.00	19.51	7.84	87.8	0.8902	8.48	26	24.330	0.7%	0.01
91708	28	27.96	19.45	7.23	80.8	0.8935	8.36	18	26.290	0.5%	0.01
91708	30	30.00	19.26	3.42	38.1	0.9074	7.96	13	28.330	0.3%	0.01

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 2000-2008 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 2000-2008 is 0.065 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 2000-2008 was 0.181 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 is 8.2 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 2000-2008, Fairfield Marsh and Patski Pond had the lowest Secchi depths (0.33 feet) and Bangs Lake had the highest (29.23 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 is 8.32, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

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

D1. 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.

Option 4: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

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.

Option 5: Install A-Jacks®

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.

D2. Options to Reduce Conductivity and Chloride Concentrations

Road salt (sodium chloride) is the most commonly used winter road de-icer. While recent advances in the technology of salt spreaders have increased the efficiency to allow more even distribution, the effect to the surrounding environment has come into question. Whether it is used on highways for public safety or on your sidewalk and driveway to ensure your own safety, the main reason for road salt's popularity is that it is a low cost option. However, it could end up costing you more in the long run from the damages that result from its application.

Excess salt can effect soil and in turn plant growth. This can lead to the die-off of beneficial native plant species that cannot tolerate high salt levels, and lead to the increase of non-native, and/or invasive species that can.

Road salts end up in waterways either directly or through groundwater percolation. The problem is that animals do not use chloride and therefore it builds up in a system. This can lead to decreases in dissolved oxygen, which can lead to a loss of biodiversity.

The Lakes Management Unit monitors the levels of salts in surface waters in the county by measuring conductivity and chloride concentrations (which are correlated to each other). There has been an overall increase in salt levels that has been occurring over the past couple of decades. These increases could have detrimental effects on plants, fish and animals living and using the water.

What can you do to help maintain or reduce chloride levels?

Option 1. Proper Use on Your Property

Ultimately, the less you use of any product, the better. Physically removing as much snow and ice as possible before applying a de-icing agent is the most important step. Adding more products before removing what has already melted can result in over application, meaning unnecessary chemicals ending up in run-off to near by streams and lakes.

Option 2. Examples of Alternatives

While alternatives may contain chloride, they tend to work faster at lower temperatures and therefore require less application to achieve the same result that common road salt would.
Calcium, Magnesium or Potassium Chloride

- Aided by the intense heat evolved during its dissolution, these are used as ice-melting compounds.

Calcium Magnesium Acetate (CMA)

- Mixture of dolomic lime and acetic acid; can also be made from cheese whey and may have even better ice penetration.
- Benefits: low corrosion rates, safe for concrete, low toxicity and biodegradable, stays on surfaces longer (fewer applications necessary).
- Multi-Purpose: use straight, mix with sodium chloride, sand or as a liquid
- Negatives: slow action at low temperatures, higher cost.

Agricultural Byproducts

- Usually mixed with calcium chloride to provide anti-corrosion properties.
- Lower the freezing point of the salt they are added to.
- as a pre-wetting (anti-ice) agent, it's like a Teflon treatment to which ice and snow will not stick.

Local hardware and home improvement stores should carry at least one salt alternative. Some names to look for: Zero Ice Melt Jug, Vaporizer, Ice Away, and many others. Check labels or ask a sales associate before you buy in order to ensure you are purchasing a salt alternative.

Option 3. Talk to Your Municipality About Using an Alternative

Many municipalities are testing or already using alternative products to keep the roads safe. Check with your municipality and encourage the use of these products.

D3.Options for Lakes with Zebra Mussels

Zebra Mussels get their name from the alternating black and white stripped pattern on their shells. They have spread extensively in the Great Lakes region in the past decade. They attach themselves to any solid underwater object such as boat hulls, piers, intake pipes, plants, other bivalves (mussels), and even other Zebra Mussels. Zebra Mussels originated from Eastern Europe, specifically the Black and Caspian Seas. By the mid 18^{th} and 19^{th} centuries they had spread to most of Europe. The mussels were believed to have been spread to this country in the mid 1980s by cargo ships that discharged their ballast water into the Great Lakes. They were first discovered in Lake St. Clair (the body of water that connects lakes Erie and Huron) in June of 1988. The mussels then spread to the rest of the Great Lakes. The first sighting in Lake Michigan was in June 1989. By 1990, Zebra Mussels had been found in all of the Great Lakes. By 1991 they had made their way into the adjacent waters of the Great Lakes such as the Illinois River, which eventually led to their spread into the Mississippi River and all the way down to the Gulf of Mexico. Other states in the Midwest have also experienced Zebra Mussel infestations of their inland lakes. Southeastern Wisconsin has about a dozen lakes infested and Michigan has about 100 infested lakes. Even though they are a fresh water mussel they have also been found in brackish (slightly saline) water and they can even live out of the water for up to 10 days at high humidity and cool temperatures. At average summer temperatures, Zebra Mussels can survive out of water for an average of five days.

The Zebra Mussels reproductive cycle allows for rapid expansion of the population. A mature female can produce up to 40,000 eggs in a cycle and up to one million in a season. Eggs hatch within a few days and young larvae (called veligers) are free floating for up to 33 days, carried along on water currents. This allows for the distribution of larvae to uninfected areas, which accelerates their spread. The larvae attach themselves by a filamentous organ (called a byssus) near their foot. Once attached to a solid surface, larvae develop into a double shelled adult within three weeks and are capable of reproduction in a year. Zebra Mussels can live as long as five years and have an average life span of about 3.5 years. The adults are typically about the size of a thumb nail but can grow as large as 2 inches in diameter. Colonies can reach densities of 30,000 - 70,000 mussels per square meter.

Due to their quick life cycle and explosive growth rate, Zebra Mussels can quickly edge out native mussel species. Negative impacts on native bivalve populations include interference with feeding, habitat, growth, movement, and reproduction. Some native species of bivalves have been found with 10,000 Zebra Mussels attached to them. Many of these native, rare, threatened and endangered bivalve species may not be able to survive if Zebra Mussels populations continue to expand. The impact that the mussels have on fish populations is not fully understood. However, they feed on phytoplankton (algae), which is also a major food source for planktivorous fish, such as Bluegill. These fish, in turn, are a food source for piscivorus fish (fish eating fish), such as Largemouth Bass and Northern Pike. Concern has also arisen over the concentration of pollutants found in Zebra Mussels. Mussels are filter feeders, taking up water and sediment containing pollutants, which then builds to high concentrations in their tissue (bioaccumulation). Due to the large number of mussels that are consumed by fish, concentrations of pollutants are even higher in the fish (biomagnification), which are potentially consumed by humans.

In addition to the ecological impacts, there are also many economical concerns. Zebra Mussels have caused major problems for industrial complexes located on the Great Lakes and associated bodies of water. Mussels can clog water intakes of power plants, public water supplies, and other industrial facilities. This can reduce water flow (by as much as two-thirds) to heat exchangers, condensers, fire fighting equipment, and air conditioning systems. Zebra Mussels can infest inboard motor intakes and can actually grow inside the motor, causing considerable damage. Navigational buoys have sunk due to the weight of attached mussels. Corrosion of concrete and steel, which can lead to loss of structural integrity, can occur from long-term mussel attachment. A Michigan-based paper company recently reported that it had spent 1.4 million dollars in removing only 400 cubic yards of Zebra Mussels. It has been estimated that billions of dollars have been incurred in removal efforts and in damage to factories, water supply companies, power plants, ships, and the fishing industry. There are several methods of control, which include both removal and eradication. Many are site specific, so control methods are often dictated by the situation. These control methods include chemical molluscicides, manual removal, thermal irritation, acoustical vibration, toxic and non-toxic coatings, CO_2 injection, and ultraviolet light. Additionally, several biological controls are being investigated. However, there is currently no widespread/whole lake control practice that would be effective without harming other wildlife.

Surprisingly, some positive impacts have been observed from Zebra Mussel infestations. They are capable of filtering one liter of water per day. This water often contains sediment and phytoplankton, which contribute to turbidity. As a result, large infestations have brought about significant improvements in water clarity in some lakes. Due to severe mussel infestations, Lake Erie water clarity has increased four to six times what it was before Zebra Mussels invaded the lake (in addition to improvements as a result of pollution control measures). This has resulted in deeper penetration of light and an expansion of aquatic plant populations, something that has not been seen for decades. In turn, the increased plant growth is providing better fish habitat and better fishing. Unfortunately, the negative ecological and economical impacts associated with Zebra Mussels far outweigh any positive benefits.

Here are some tips from the Great Lakes Sea Grant Network that can help prevent the spread of Zebra Mussels:

- Flush clean water (tap) through the cooling system of your motor to rinse out any larvae.

- Drain all bilge water, live wells, bait buckets, and engine compartments. Make sure water is not trapped in your trailer.

- Always inspect your boat and boat trailer carefully before transporting.

- In their earlier stages, attached Zebra Mussels may not be easily seen. Pass your hand across the bottom of the boat - if it feels grainy, ịtis probably covered with mussels. Don’t take a chance; clean them off by scraping or blasting.

- Full grown Zebra Mussels can be easily seen but cling stubbornly to surfaces. Carefully scrape the hull (or trailer), or use a high pressure spray (250 psi) to dislodge them. Or leave your boat out of the water for at least 10-14 days, preferably two weeks. The mussels will die and drop off.

- Dispose of the mussels in a trash barrel or other garbage container. Don’t leave them on the shore where they could be swept back into the lake or foul the area.

- Before you leave the boat launch site, remove from the boat trailer any plant debris where tiny Zebra Mussels may be entangled.

- Always use extra caution when transporting bait fish from one lake to another. You could be carrying microscopic veligers. To be safe, do not take water from one lake to another.

- Certain polymer waxes discourage Zebra Mussels from attaching. But check your hull periodically because the mussels cling to drain holes and speedometer brackets.

D4. Options to Enhance Wildlife Habitat Conditions on a Lake

Option 1: Increase Habitat Cover

One of the best ways to increase habitat cover is to leave a minimum 25-foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes. This will provide cover from predators and provide nesting structure for many wildlife species and their prey.

Brush piles also make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They should be place at least 10 feet away from the shoreline to prevent any debris from washing into the lake. Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets. Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife. Finally, by increasing habitat, wildlife is attracted to and uses the area as a place to raise their young. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline.

Option 2: Increase Natural Food Supply

This can be accomplished in conjunction with Option 1. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Beneficial aquatic plants are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration. Supplying natural foods artificially (i.e., birdfeeders, nectar feeders, corn cobs, etc.) will attract wildlife and in most cases does not harm the animals. However, “people food” such as bread should be avoided. Care should be given to maintain clean feeders and birdbaths to minimize disease outbreaks. Providing food for wildlife will increase the likelihood they will use the area. Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish.

Option 3: Limit Disturbance

Since most species of wildlife are susceptible to human disturbance, any action to curtail disturbances is beneficial. Limiting disturbance can include posting signs in areas of the lake where wildlife may live (e.g., nesting waterfowl), establish a "no wake" area, boat horsepower or speed limits, or establish restricted boating hours. These are examples of time and space zoning for lake usage. Enforcement and public education are needed if this option is to be successful. In some areas, off-duty law enforcement officers can be hired to patrol the lake.

Limiting disturbance will increase the chance that wildlife will use the lake, particularly for raising their young. Many wildlife species have suffered population declines due to loss of habitat and poor breeding success. This is due in part to their sensitivity to disturbance. Recreation activities such as canoeing and paddleboating may be enhanced by the limited disturbance.

One of the strongest opponents to this option would probably be the powerboat users and water skiers. However, this problem may be solved if a significant portion of the daylight hours and the use of the middle part of the lake (assuming the lake is deep enough) are allowed for powerboating. For example, powerboating could be allowed between 9 AM and 6 PM within the boundaries established by "no wake" restricted area buoys.

D5. Option for Creating a Bathymetric Map

A bathymetric (depth contour) map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Some bathymetric maps for lakes in Lake County do exist, but they are frequently old, outdated and do not accurately represent the current features of the lake. Maps can be created by the Lake County Health Department - Lakes Management Unit (LMU). LMU recently purchased a BioSonics DT-X™ Echosounder. With this equipment the creation of an accurate bathymetric map of almost any size lake in the county is possible. Costs vary, but can range from $2,000-5,000 depending on lake size.

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

2000 - 2008 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2008	
Average	**167**	
Median	**162**	
Minimum	**65**	**IMC**
Maximum	**330**	**Flint Lake**
STD	**42**	
n =	**802**	

	ALKanoxic 2000-2008	
Average	**202**	
Median	**194**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**50**	
n =	**243**	

	Condoxic <=3ft00-2008	
Average	**0.8934**	
Median	**0.8195**	
Minimum	**0.2542**	**Broberg Marsh**
Maximum	**6.8920**	**IMC**
STD	**0.5250**	
n =	**806**	

	Condanoxic 2000-2008	
Average	**1.0312**	
Median	**0.8695**	
Minimum	**0.3210**	**Lake Kathyrn**
Maximum	**7.4080**	**IMC**
STD	**0.7985**	
n =	**243**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2008	
Average	**0.508**	
Median	**0.156**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.073**	
n =	**807**	

*ND = Many lakes had non-detects (74.1%)
Only compare lakes with detectable concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

	NH3-Nanoxic 2000-2008	
Average	**2.192**	
Median	**1.630**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.343**	
n =	**243**	

*ND = 19.8% Non-detects from 28 different lakes

	pHoxic <=3ft00-2008	
Average	**8.32**	
Median	**8.32**	
Minimum	**7.07**	**Bittersweet #13**
Maximum	**10.28**	**Round Lake Marsh North**
STD	**0.44**	
n =	**801**	

	pHanoxic 2000-2008	
Average	**7.28**	
Median	**7.28**	
Minimum	**6.24**	**Banana Pond**
Maximum	**8.48**	**Heron Pond**
STD	**0.42**	
n =	**243**	

	All Secchi 2000-2008	
Average	**4.51**	
Median	**3.12**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pon**
Maximum	**24.77**	**West Loon Lake**
STD	**3.78**	
n =	**749**	

LakeCounty
Health Department and
Community Health Center

2000 - 2008 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2008	
Average	**1.450**	
Median	**1.200**	
Minimum	**<0.1**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.845**	
n =	**802**	

*ND = 3.9% Non-detects from 15 different lakes

	TKNanoxic 2000-2008	
Average	**2.973**	
Median	**2.330**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.324**	
n =	**243**	

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

	TPoxic <=3ft00-2008	
Average	**0.105**	
Median	**0.065**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.218**	
n =	**808**	

*ND = 2.6% Non-detects from 9 different lakes

	TPanoxic 2000-2008	
Average	**0.316**	
Median	**0.181**	
Minimum	**0.012**	**Independ. Grove**
Maximum	**3.800**	**Taylor Lake**
STD	**0.419**	
n =	**243**	

	TSSall <=3ft00-2008	
Average	**15.5**	
Median	**8.2**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**813**	

*ND = 1.5% Non-detects from 9 different lakes

	TVSoxic <=3ft00-2008	
Average	**132.8**	
Median	**129.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**39.8**	
n =	**757**	

No 2002 IEPA Chain Lakes

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

No 2002 IEPA Chain Lakes.

	CLanoxic <=3ft00-2008	
Average	**234**	
Median	**139**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**364**	
n =	**125**	

	CLoxic <=3ft00-2008	
Average	**210**	
Median	**166**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**233**	
n =	**470**	

Lake County Health Department and Community Health Center

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 2000-2008 (n=1351).

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

LCHD Lakes Management Unit ~ 12/1/2008

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
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