

**2006 SUMMARY REPORT
of
Lake Linden**

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Lake Linden was created in the early 1960's by developer, Mort Eagle, and construction of homes began immediately after the lake was created. The lake has a surface area of 31 acres and a mean depth of 4.8 feet. It is located entirely within the village limits of Lindenhurst and is used by Lindenhurst village residents for swimming, boating and fishing. There are two beaches, three parks and a boat launch on the lake.

The lake's water quality was assessed through many parameters from May-September, 2006. Water clarity in the lake was double the County median (3.27 feet), with an average Secchi depth of 6.54 feet, which was an increase since the 2002 sampling season (5.87 feet). The total suspended solids (TSS) concentration (2.9 mg/L) was similar to the 2002 average (2.3 mg/L). Conductivity is the measure of ions within water. The higher the conductivity, the more ions and the better the water can conduct electricity. In Lake Linden, average conductivity in 2006 was 1.203 mS/cm, which was an increase from the 2002 value of 0.9972 mS/cm. Almost all of the lakes in the county are experiencing similar increases in conductivity for the same reason. Road salts used in winter road management runoff into lakes and build up since aquatic organisms cannot use them. This leads to an increase in both conductivity and chloride ion (Cl-) concentrations, which are correlated. The median Cl- concentration in the county was 171.0 mg/L, but Lake Linden's concentration was higher at 270.0 mg/L.

Nitrogen and phosphorus are the two nutrients that can limit plant and algal growth. The 2006 average epilimnetic total phosphorus concentration in Lake Linden was 0.033 mg/L, which was almost half the county median (0.060 mg/L), and a decrease from the 2002 concentration (0.042 mg/L). The average total Kjeldahl nitrogen concentration in Lake Linden in 2006 (1.13 mg/L) was similar to the 2002 concentration (1.18 mg/L).

The aquatic plant community in the lake consisted of three species in July. *Chara* spp. was the most dominant species, with White Water Crowfoot and Water Stargrass also present. Plant diversity decreased between 2002 and 2006, with five species seen in 2002 that were not seen in 2006. The changes can probably be attributed to annual chemical plant treatments, as well as other factors such as natural annual variation and the timing of plant sampling.

Shoreline erosion increased on the lake from the initial 2002 assessment. Areas by the park on the southwest side are of specific concern. Exotic shoreline plant species such as Buckthorn and Purple Loosestrife were observed as well.

LAKE FACTS

Lake Name:	Lake Linden
Historical Name:	None
Nearest Municipality:	Lindenhurst
Location:	T46N, R21E, Section 35
Elevation:	772.7 feet
Major Tributaries:	None
Watershed:	Des Plaines River
Sub-watershed:	North Mill Creek
Receiving Water body:	Hastings Lake
Surface Area:	30.6 acres
Shoreline Length:	1.4 miles
Maximum Depth:	11 feet
Average Depth:	4.8 feet
Lake Volume:	146.4 acre-feet
Lake Type:	Human-made
Watershed Area:	354.1 acres
Major Watershed Land uses:	Single Family Homes and Transportation
Bottom Ownership:	Village of Lindenhurst
Management Entities:	Lindenhurst Lakes Management Association
Current and Historical uses:	Fishing, swimming and non-gas powered boating
Description of Access:	Private and Lindenhurst residents

SUMMARY OF WATER QUALITY

Lake Linden has a small watershed area (Figure 1) with single family homes covering the most area (62%). Transportation (roads) also covers a large portion of land (14%), as well as water and retail/commercial (4%) (Figure 2). The large amount of impervious surfaces associated with residential areas (rooftops, driveways, and roads) increase the amount of direct storm water runoff into a lake (Table 1).

Water samples were collected monthly from May through September at the deepest location in the lake (Figure 3) (Appendix B). One sample was taken from the upper water layer at three feet and analyzed for nutrients, solids concentration, and other physical parameters (Appendix A). During May and June, a second sample three feet from the bottom was taken because water level was higher than later in the season (Appendix C). Due to Lake Linden's shallow nature, wind and wave action kept the water well mixed.

The average epilimnetic dissolved oxygen (DO) concentration was 8.83 mg/L, which was an increase from 2002 (6.39 mg/L) (Table 2). The highest reading was in May (10.70 mg/L) and the lowest in July (7.28 mg/L). Adequate DO concentrations (>5.0 mg/L) were present throughout the sampling season, which is the concentration desired to support a healthy sunfish/bass fishery.

Total suspended solids (TSS) are made up of any type of solid particles in the water column, including algal cells and sediment. The average epilimnetic TSS concentration for Lake Linden in 2006 was 2.9 mg/L, which was similar to the concentration in 2002 (2.3 mg/L). The 2006 TSS concentration was below the county median of 7.9 mg/L (Appendix E). Water clarity and TSS concentrations are positively correlated. The Secchi depth (water clarity) average in Lake Linden was 6.54 feet, which was double the County median (3.27 feet) (Figure 4). Water clarity has increased since 2002 when the average Secchi depth was 5.87 feet. An accurate reading was unable to be taken in May since the Secchi disk reached the bottom and was still able to be seen. August had the lowest reading (5.57 feet), probably due to plant die-off. The Volunteer Lake Monitoring Program (VLMP) has been continuously active on the lake since 1993. This program has been very successful and should continue in the future in order to detect any changes in water clarity trends. The VLMP average Secchi depth for the 2006 season was 6.5 feet, which is very close to the average found by the LCHD. The differences between the VLMP data and LCHD-Lake Management Unit (LMU) data can be mostly attributed to discrepancies between samplers. Also, time of day and the number of readings the averages are compiled from have an affect (Figure 5).

Conductivity is the measure of dissolved ions within water. In Lake Linden, the average conductivity in 2006 was 1.2030 mS/cm, which was an increase from the 2002 value of 0.9972 mS/cm, and is above the County median (0.7948 mS/cm). Almost all of the lakes in the county are experiencing similar increases in conductivity for the same reason. Road salts used in winter road management runoff into lakes and build up since aquatic organisms cannot use them.

Figure 1. Approximate watershed delineation of Lake Linden, 2006.



Figure 2. Approximate land use within the Lake Linden watershed, 2006.

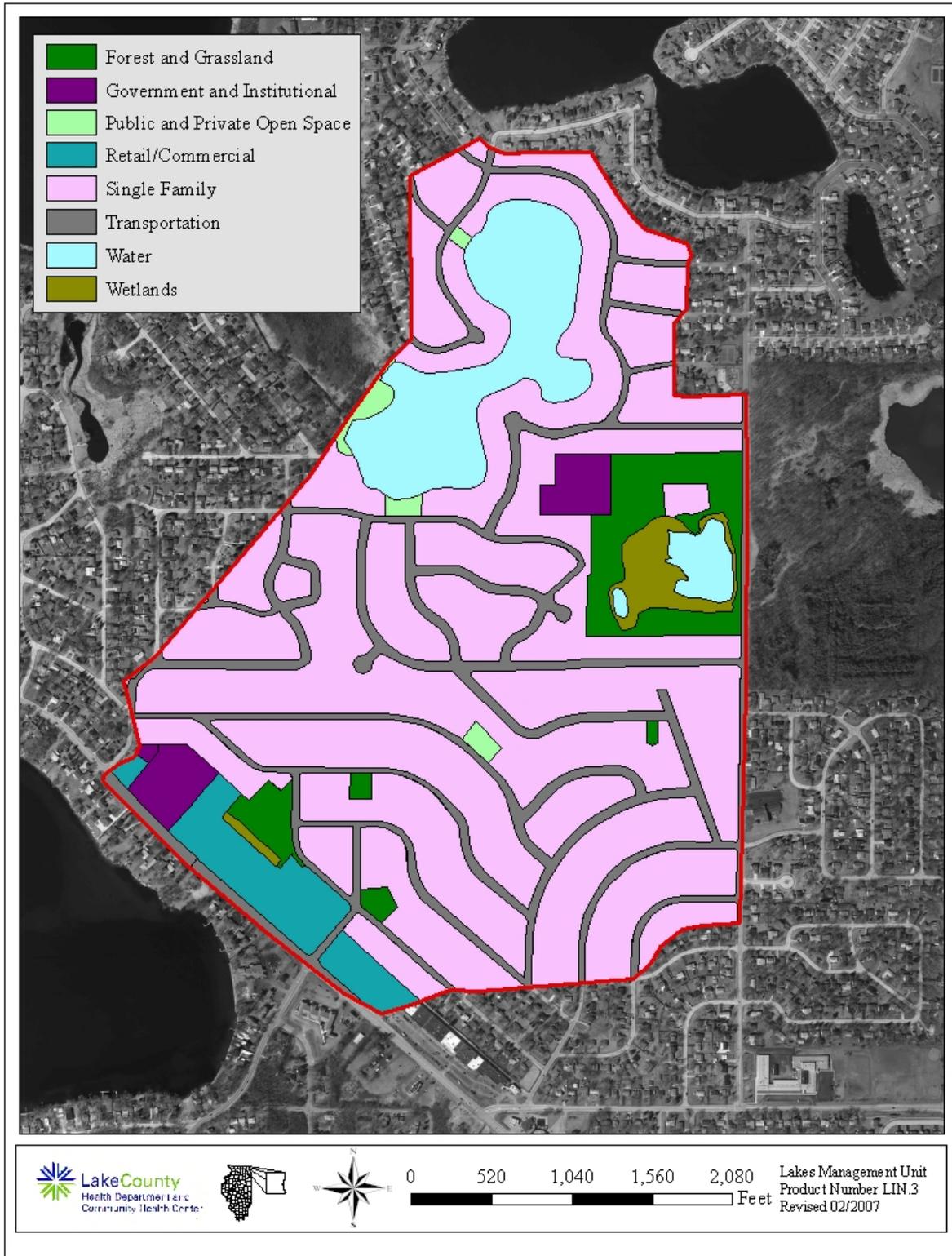


Figure 3. Water quality sampling point on Lake Linden, 2006.



Table 2. Water quality data for Lake Linden, 2002 and 2006.

2006	Epilimnion	ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ *	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
17-May	3	177	0.96	<0.1	0.084	0.029	<0.005	NA	260	1.7	664	99	0 ^a	1.209	8.08	10.70
21-Jun	3	156	1.00	<0.1	<0.05	0.034	<0.005	NA	258	2.9	669	127	7.46	1.191	8.25	8.74
19-Jul	3	135	1.10	<0.1	<0.05	0.034	<0.005	NA	264	3.1	647	104	6.88	1.194	8.42	7.28
16-Aug	3	136	1.31	<0.1	<0.05	0.037	<0.005	NA	292	3.5	674	113	5.57	1.220	9.22	8.53
20-Sep	3	156	1.30	<0.1	<0.05	0.029	<0.005	NA	277	3.5	649	103	6.23	1.200	8.43	8.89
Average		152	1.13	<0.1	0.084 ^k	0.033	<0.005	NA	270	2.9	661	109	6.54 ^k	1.203	8.48	8.83

2002	Epilimnion	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH	DO
29-Apr	3	155	0.91	<0.1	<0.05	0.019	<0.005	526	NA	2.2	520	88	5.74	0.952	8.34	8.38
3-Jun	3	150	1.02	<0.1	<0.05	0.032	<0.005	528	NA	1.1	523	88	0 ^a	0.949	8.51	7.57
8-Jul	3	137	1.04	<0.1	<0.05	0.041	<0.005	462	NA	1.6	513	98	7.42	0.918	8.71	7.69
5-Aug	3	169	1.22	<0.1	<0.05	0.052	<0.005	552	NA	3.7	575	108	4.82	1.029	8.41	6.16
3-Sep	3	191	1.72	0.36	<0.05	0.066	0.005	562	NA	3.0	593	109	5.51	1.037	7.71	2.17
Average		160	1.18	0.36 ^k	<0.05	0.042	0.005 ^k	526	NA	2.3	545	98	5.87 ^b	0.977	8.34	6.39

Glossary

ALK = Alkalinity, mg/L CaCO₃
 TKN = Total Kjeldahl nitrogen, mg/L
 NH₃-N = Ammonia nitrogen, mg/L
 NO₃-N = Nitrate + Nitrite nitrogen, mg/L
 NO₂+NO₃ = Nitrite and Nitrate nitrogen, mg/L
 TP = Total phosphorus, mg/L
 SRP = Soluble reactive phosphorus, mg/L
 Cl⁻ = Chlorides, mg/L
 TSS = Total suspended solids, mg/L
 TS = Total solids, mg/L
 TVS = Total volatile solids, mg/L
 SECCHI = Secchi disk depth, ft.
 COND = Conductivity, milliSiemens/cm
 DO = Dissolved oxygen, mg/L

k = Denotes that the actual value is known to be less than the value presented.

NA= Not applicable

* = Prior to 2006 only Nitrate was analyzed

Table 2. Continued.

2006 Hypolimnion		ALK	TKN	NH ₃ -N	NO ₂ +NO ₃ *	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH
DATE	DEPTH														
17-May	6	178	0.96	<0.1	0.074	0.023	<0.005	NA	260	1.1	656	89	NA	1.211	8.04
21-Jun	6	155	0.94	<0.1	<0.05	0.027	<0.005	NA	257	2.0	668	129	NA	1.191	8.30
Average		167	0.95	<0.1	0.074 ^k	0.025	<0.005	NA	259	1.6	662	109	NA	1.201	8.17

2002 Hypolimnion		ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	Cl ⁻	TSS	TS	TVS	SECCHI	COND	pH
DATE	DEPTH														
04/29/02	6	154	0.91	<0.1	<0.05	0.018	<0.005	520	NA	3.0	521	103	NA	0.9521	8.35
06/03/02	6	150	1.05	<0.1	<0.05	0.038	<0.005	520	NA	1.7	526	85	NA	0.9463	8.51
07/08/02	6	137	1.08	<0.1	<0.05	0.052	<0.005	452	NA	2.8	507	84	NA	0.9193	8.43
08/05/02	6	164	1.36	<0.1	<0.05	0.065	<0.005	548	NA	3.6	571	97	NA	1.0340	7.83
09/03/02	6	191	1.77	0.38	<0.05	0.093	0.006	562	NA	4.2	582	110	NA	1.0370	7.69
Average		159	1.23	0.38 ^k	<0.05	0.053	0.006 ^k	520	NA	3.1	541	96	NA	0.9777	8.16

Glossary

ALK = Alkalinity, mg/L CaCO₃
TKN = Total Kjeldahl nitrogen, mg/L
NH₃-N = Ammonia nitrogen, mg/L
NO₃-N = Nitrate + Nitrite nitrogen, mg/L
NO₂+NO₃ = Nitrite and Nitrate nitrogen, mg/L
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
Cl⁻ = Chlorides, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

k = Denotes that the actual value is known to be less than the value presented.

NA= Not applicable

* = Prior to 2006 only Nitrate was analyzed

Figure 4. Total suspended solids (TSS) concentration vs. Secchi depth for Lake Linden, 2006.

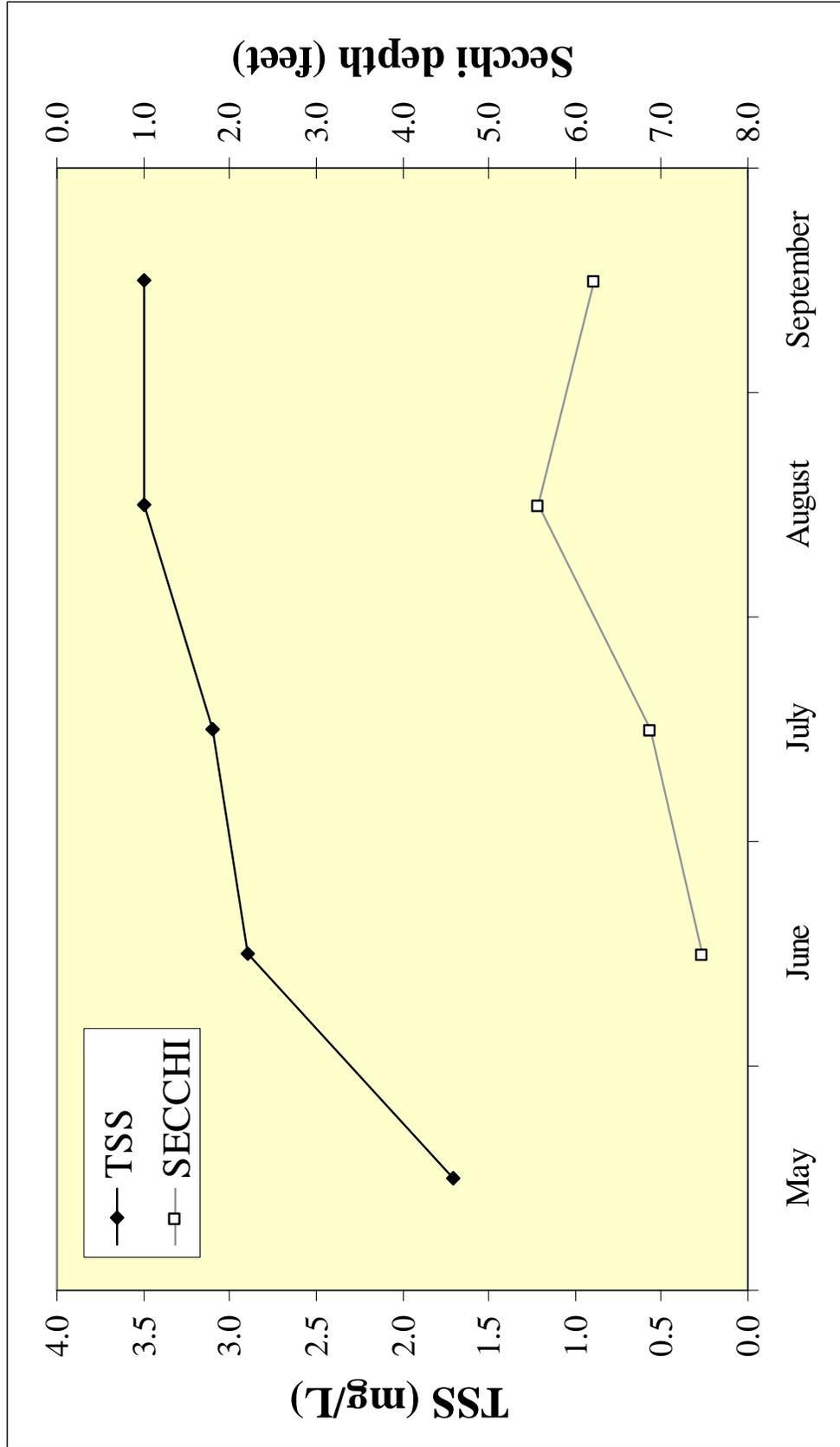
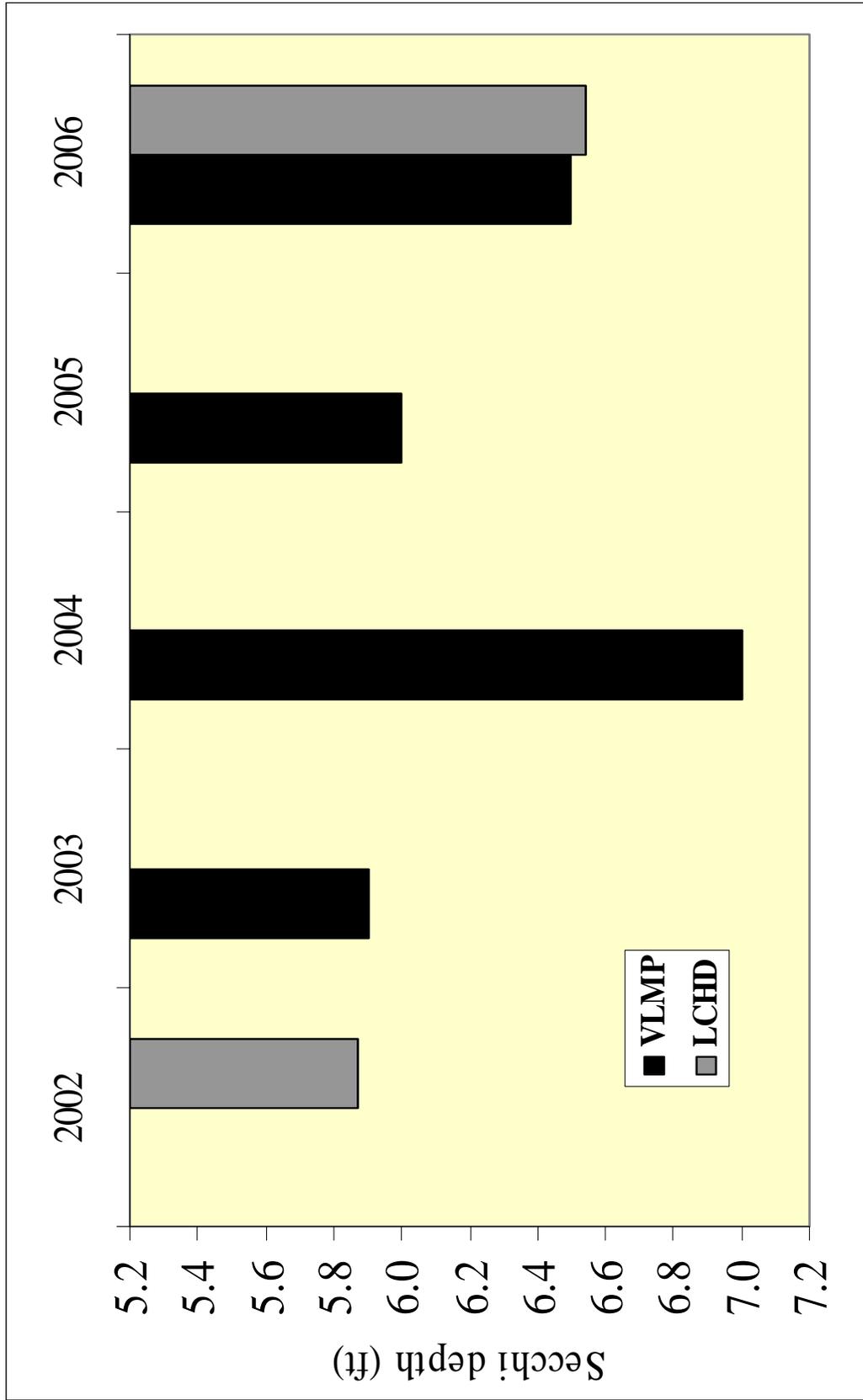


Figure 5. Comparison of Secchi depths between VLMP records and LCHD records for Lake Linden, 2002-2006.



This leads to an increase in both conductivity and chloride ion (Cl⁻) concentrations, which are correlated (Figure 6). The median Cl⁻ concentration in the county is 171.0 mg/L, but Lake Linden's concentration was higher at 270.0 mg/L. Conductivity and Cl⁻ concentrations stayed consistent from May to September. A study done in Canada reported 10% of aquatic species are harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations in lakes were associated with chloride concentrations as low as 12 mg/l. At the current levels in Lake Linden, chloride concentrations may negatively impact aquatic life.

Another aspect of water quality is the nutrients within a water body, especially nitrogen (N) and phosphorus (P). These are the two nutrients that can limit plant and algal growth. Carbon and light are the other factors that control plant and algal growth, but these are not normally limiting. In 2006, the average epilimnetic total phosphorus (TP) concentration in Lake Linden was 0.033 mg/L, which is lower than the county median (0.060 mg/L). TP conditions have decreased since sampling was performed in 2002 (0.042 mg/L). The average total Kjeldahl nitrogen (TKN) concentration in Lake Linden in 2006 (1.13 mg/L) was similar to 2002 (1.18 mg/L). Another form of nitrogen is nitrate and nitrite. The only nitrate+nitrite concentration found above the detection limit (<0.05 mg/L) in May (0.084 mg/L).

Another way to look at phosphorus levels and how they affect productivity of the lake is to use a Trophic State Index (TSI) based on phosphorus (TSIp). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). The higher the phosphorus levels the greater the amount of algal biomass, which leads to a higher TSIp and corresponding trophic state. Based on a TSIp value of 54.4, Lake Linden was classified as eutrophic (≥ 50 , <70 TSI). A eutrophic lake is defined as a productive system that has above average nutrient levels and high algal biomass (growth). This was an improvement from the 2002 TSIp value of 58.1. Based on a Secchi TSI of 49.1, Lake Linden was classified as mesotrophic (≥ 40 , <50). Based on the TSIp, Lake Linden ranked 41st out of 162 lakes studied by the Lakes Management Unit from 2000-2006 (Table 3). This was a slight increase since 2002 when it was ranked 40th.

TSI values along with other water quality parameters can be used to make other analyses based on use impairment indexes established by the Illinois Environmental Protection Agency (IEPA). Most water quality standard impairment assessments were listed as *None*. Furthermore, based on IEPA indices, Lake Linden has *Partial* support for recreational use and *Full* support of swimming and aquatic life use. Based on these indices, this lake is listed as providing *Full* overall use support.

There are two swimming beaches on Lake Linden at Linden's Landing and Meyer's Beach. They were sampled for bacteria (*E. coli*) levels every two weeks, from the beginning of May to the end of August, by the LCHD in 2006. No beach closings were reported that related to bacteria levels at Meyer's Beach, and only one closing was reported at Linden's Landing. This was the first closing on Linden's Landing since 2003 when there was also one closing, and in 2002 when there were four closings. Overall, this beach has been safe to swim on.

Table 3. Lake County average TSI phosphorus (TSIp) ranking, 2000-2006.

RANK	LAKE NAME	TP AVE	TSIp
1	Cedar Lake	0.0154	43.61
2	Windward Lake	0.0158	43.95
3	Sterling Lake	0.0162	44.31
4	Lake Minear	0.0165	44.57
5	Pulaski Pond	0.0180	45.83
6	Timber Lake	0.0180	45.83
7	Fourth Lake	0.0182	45.99
8	West Loon Lake	0.0182	45.99
9	Lake Carina	0.0193	46.86
10	Independence Grove	0.0194	46.91
11	Lake Kathryn	0.0200	47.35
12	Lake of the Hollow	0.0200	47.35
13	Banana Pond	0.0202	47.49
14	Bangs Lake	0.0220	48.72
15	Cross Lake	0.0220	48.72
16	Third Lake	0.0221	48.82
17	Dog Pond	0.0222	48.85
18	Sand Pond	0.0230	49.36
19	Stone Quarry Lake	0.0230	49.36
20	Cranberry Lake	0.0240	49.98
21	Deep Lake	0.0240	49.98
22	Druce Lake	0.0244	50.22
23	Little Silver Lake	0.0246	50.33
24	Round Lake	0.0254	50.80
25	Lake Leo	0.0256	50.91
26	Dugdale Lake	0.0274	51.89
27	Peterson Pond	0.0274	51.89
28	Lake Miltmore	0.0276	51.99
29	Ames Pit	0.0278	52.10
30	East Loon Lake	0.0280	52.20
31	Lake Zurich	0.0282	52.30
32	Lake Fairfield	0.0296	53.00
33	Gray's Lake	0.0302	53.29
34	Highland Lake	0.0302	53.29
35	Hook Lake	0.0302	53.29
36	Lake Catherine (Site 1)	0.0308	53.57
37	Lambs Farm Lake	0.0312	53.76
38	Old School Lake	0.0312	53.76
39	Sand Lake	0.0316	53.94
40	Sullivan Lake	0.0320	54.13
41	Lake Linden	0.0326	54.39
42	Gages Lake	0.0338	54.92
43	Hendrick Lake	0.0344	55.17
44	Diamond Lake	0.0372	56.30

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
45	Channel Lake (Site 1)	0.0380	56.60
46	White Lake	0.0408	57.63
47	Sun Lake	0.0410	57.70
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Wooster Lake	0.0433	58.48
52	Deer Lake	0.0434	58.52
53	Schreiber Lake	0.0434	58.52
54	Nielsen Pond	0.0448	58.98
55	Turner Lake	0.0458	59.30
56	Seven Acre Lake	0.0460	59.36
57	Willow Lake	0.0464	59.48
58	Lucky Lake	0.0476	59.85
59	Davis Lake	0.0476	59.85
60	East Meadow Lake	0.0478	59.91
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	Werhane Lake	0.0630	63.89
75	Liberty Lake	0.0632	63.94
76	Countryside Glen Lake	0.0642	64.17
77	Leisure Lake	0.0648	64.30
78	St. Mary's Lake	0.0666	64.70
79	Long Lake	0.0680	65.00
80	Mary Lee Lake	0.0682	65.04
81	Hastings Lake	0.0684	65.08
82	Honey Lake	0.0690	65.21
83	North Tower Lake	0.0718	65.78
84	Lake Fairview	0.0724	65.90
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

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
89	Broberg Marsh	0.0782	67.01
90	Countryside Lake	0.0788	67.12
91	Echo Lake	0.0792	67.19
92	Sylvan Lake	0.0794	67.23
93	Big Bear Lake	0.0806	67.45
94	Petite Lake	0.0834	67.94
95	Lake Marie (Site 1)	0.0850	68.21
96	North Churchill Lake	0.0872	68.58
97	Grandwood Park, Site II, Outflow	0.0876	68.65
98	South Churchill Lake	0.0896	68.97
99	Rivershire Pond 2	0.0900	69.04
100	McGreal Lake	0.0914	69.26
101	International Mine and Chemical Lake	0.0948	69.79
102	Eagle Lake (Site I)	0.0950	69.82
103	Dunns Lake	0.0952	69.85
104	Fish Lake	0.0956	69.91
105	Lake Barrington	0.0956	69.91
106	Lochanora Lake	0.0960	69.97
107	Owens Lake	0.0978	70.23
108	Woodland Lake	0.0986	70.35
109	Island Lake	0.0990	70.41
110	McDonald Lake 1	0.0996	70.50
111	Tower Lake	0.1000	70.56
112	Longview Meadow Lake	0.1024	70.90
113	Redwing Slough, Site II, Outflow	0.1072	71.56
114	Lake Forest Pond	0.1074	71.59
115	Bittersweet Golf Course #13	0.1096	71.88
116	Fox Lake (Site 1)	0.1098	71.90
117	Bresen Lake	0.1126	72.27
118	Round Lake Marsh North	0.1126	72.27
119	Timber Lake S	0.1128	72.29
120	Deer Lake Meadow Lake	0.1158	72.67
121	Taylor Lake	0.1184	72.99
122	Grand Avenue Marsh	0.1194	73.11
123	Columbus Park Lake	0.1226	73.49
124	Nippersink Lake (Site 1)	0.1240	73.66
125	Grass Lake (Site 1)	0.1288	74.21
126	Lake Holloway	0.1322	74.58
127	Lakewood Marsh	0.1330	74.67
128	Summerhill Estates Lake	0.1384	75.24
129	Redhead Lake	0.1412	75.53
130	Forest Lake	0.1422	75.63
131	Antioch Lake	0.1448	75.89
132	Valley Lake	0.1470	76.11

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
133	Slocum Lake	0.1496	76.36
134	Drummond Lake	0.1510	76.50
135	Pond-a-Rudy	0.1514	76.54
136	Lake Matthews	0.1516	76.56
137	Buffalo Creek Reservoir	0.1550	76.88
138	Pistakee Lake (Site 1)	0.1592	77.26
139	Salem Lake	0.1650	77.78
140	Half Day Pit	0.1690	78.12
141	Lake Eleanor Site II, Outflow	0.1812	79.13
142	Lake Farmington	0.1848	79.41
143	ADID 127	0.1886	79.71
144	Lake Louise Inlet	0.1938	80.10
145	Grassy Lake	0.1952	80.20
146	Dog Bone Lake	0.1990	80.48
147	Redwing Marsh	0.2072	81.06
148	Stockholm Lake	0.2082	81.13
149	Bishop Lake	0.2156	81.63
150	Hidden Lake	0.2236	82.16
151	Fischer Lake	0.2278	82.43
152	Lake Napa Suwe (Outlet)	0.2304	82.59
153	Patski Pond (outlet)	0.2512	83.84
154	Oak Hills Lake	0.2792	85.36
155	Loch Lomond	0.2954	86.18
156	McDonald Lake 2	0.3254	87.57
157	Fairfield Marsh	0.3264	87.61
158	ADID 182	0.3280	87.69
159	Slough Lake	0.4134	91.02
160	Flint Lake Outlet	0.4996	93.75
161	Rasmussen Lake	0.5025	93.84
162	Albert Lake, Site II, outflow	1.1894	106.26

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in July of 2006. In previous years, the sampler, with the goal of covering most of the lake and finding all species present, chose sampling sites randomly. While this method worked well, a new sampling technique was implemented in 2005. Sampling sites were based on a grid system created by mapping software (ArcGIS), with each site located 60 meters (200 feet) apart. On Lake Linden, there were 34 sampling sites in 2006 (Figure 6). Overall, there were three species found, with *Chara* spp. (a macroalgae) having the highest density (found at 85% of the sites). White Water Crowfoot and Water Stargrass were also present and found at 6% and 3% of the sites, respectively (Table 4a). Plants need at least 1% of surface light levels in order to survive. Plants were found down to a depth of 6.7 feet, which relates to the 1% light level depth of approximately 7.0 feet. Out of the 34 sample sites, plants were found at 32 of them (94%) (Table 4b).

The plant sampling sites covered the entire lake and therefore the lake has approximately 94% plant coverage, with none of the area topped out (plants reaching and crowding the surface of the lake). *Chara* spp. was the dominant species and covered approximately 85% of the lake, and is not a good species for fish habitat. Ideally, a lake should have 30-40% plant coverage for a healthy game fishery, according to the Illinois Department of Natural Resources. Because *Chara* spp. is a macroalgae, Lake Linden has a lower than recommended plant community. The high-density macroalgae community helps utilize the nutrient load that Lake Linden experiences from fertilizers and stormwater runoff, and helps to keep the water clarity at a decent level. If macroalgae were reduced, microscopic algal populations may increase and cloud the water.

Plant diversity decreased between 2002 and 2006 (Table 5). Curlyleaf Pondweed, Horned Pondweed, Small Pondweed, Eel Grass and Sago Pondweed were the species found in 2002, but not in 2006. The changes can probably be attributed to annual chemical plant treatments, as well as other factors such as natural annual variation, and the timing of sampling. Curlyleaf Pondweed, which is an invasive species, was not found in 2006, however, it may have been present earlier in the year, and died-off by the time we conducted our sampling.

To the Lakes Management Unit's knowledge, Lake Linden implemented the following plant management techniques. In late March and early April, 2006, a 10/10 ppb split Sonar[®] treatment was applied to the lake. The lake was also treated with copper sulfate when needed to control algae from late April until the middle of August. Past years have seen similar treatments. In 2003, a 10/10 ppb split Sonar[®] treatment was done in May and copper sulfate was applied from early May to early July. In 2004, a 10/10 ppb split Sonar[®] treatment was done in late April/early May and copper sulfate was applied from early May to mid-September. In 2005, a 10/10 ppb split Sonar[®] treatment was done in April and copper sulfate was applied from mid-May to early September. This was according to the VLMP records.

Figure 6. Aquatic plant sampling grid that illustrates plant density in July on Lake Linden, 2006.

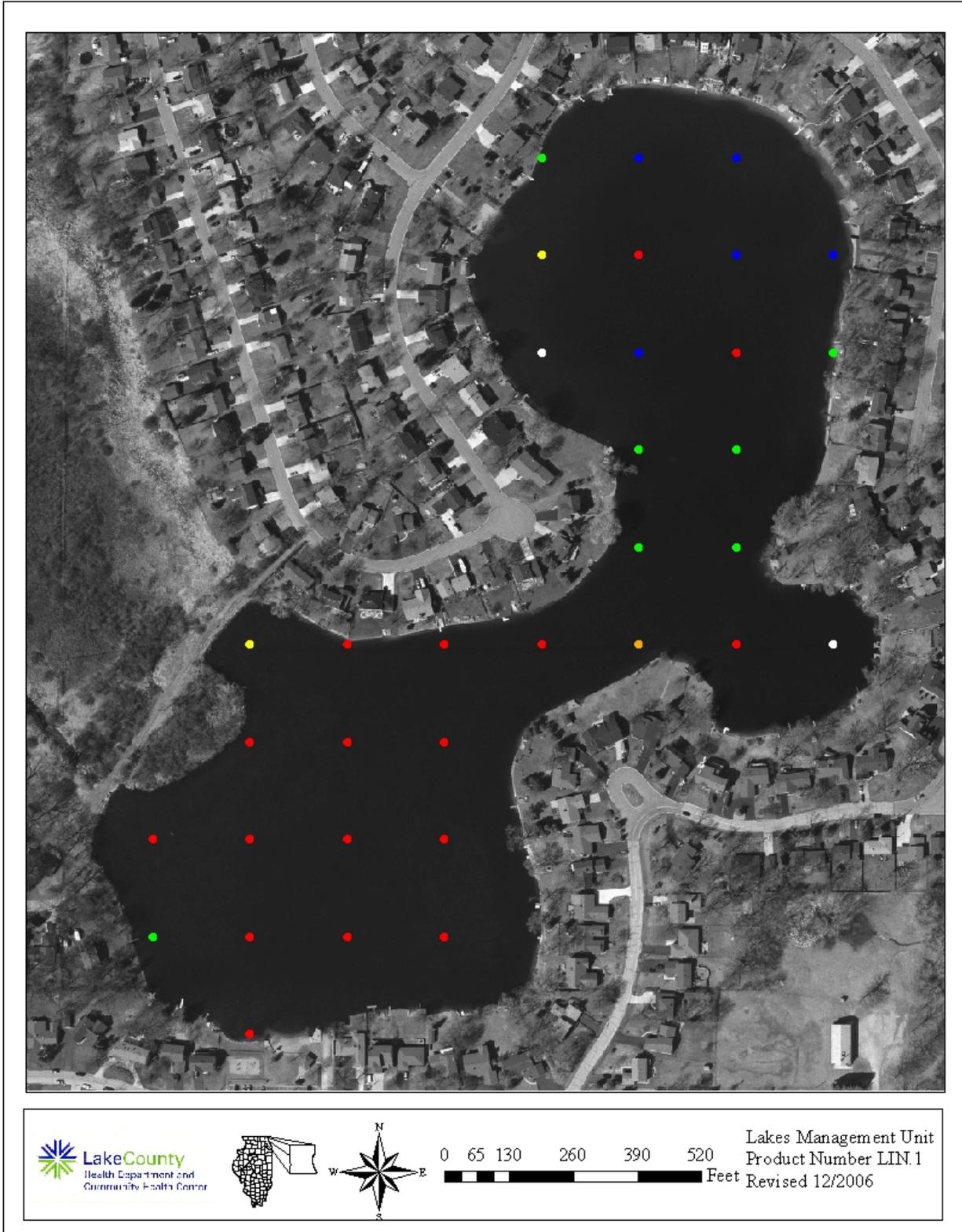


Table 4a. Aquatic plant species found at the sampling sites on Lake Linden, 2006. Maximum depth that plants were found was 6.7 feet.

Plant Density	Chara	White Crowfoot	Water Stargrass
Absent	5	32	33
Present	5	1	1
Common	4	1	0
Abundant	1	0	0
Dominant	19	0	0
% Plant Occurrence	85%	6%	3%

Table 4b. Distribution of rake density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	2	6%
>0-10%	7	21%
10-40%	5	15%
40-60%	1	3%
60-90%	2	6%
>90%	17	50%
Total Sites with Plants	32	94%
Total # of Sites	34	100%

Table 5. Aquatic plant species found in Lake Linden, 2006.

Chara (Macro algae)
Water Stargrass
White Water Crowfoot

Chara spp.
Heteranthia dubia
Ranunculus longirostris

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 (Nichols, 1999). Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates there are a large number of sensitive, high quality plants species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2006 Lake County lakes was 13.6. Lake Linden had a FQI of 11.3 in 2006, which ranked it 92nd out of 151 lakes sampled (Table 6). This was a decrease from 2002 when the FQI was 15.1, which is due to the decrease in plant diversity.

Plankton are microscopic plants and animals that are free-floating within the water column. Samples were collected during water quality testing and analyzed for phytoplankton and zooplankton species content (Appendix A). No algal blooms were noted throughout the sampling season in Lake Linden, and each month there was very little algae counted in our samples. This was probably due to the high amounts of copper sulfate used to treat algae in the lake. In May, there was very little phytoplankton at all, while in June and July the community was dominated by flagellate species (species motored by a flagella). In August, the community was dominated by blue-green algae, and in September diatoms (silica encased species) were dominant.

SUMMARY OF SHORELINE CONDITION

In 2002, a complete shoreline assessment was performed in July. This assessment found 100% of Lake Linden's shoreline was developed, with rip rap and seawall being the most common land use (29.3 % and 28.6%, respectively). Other shoreline types found were beach, shrub, buffer and lawn. In 2002, approximately 8% of the shoreline was eroded to some degree. A reassessment of shoreline erosion in 2006 found areas of slightly and moderately eroded shoreline at the park on the southwest side (Figure 7). The remaining shoreline had small sections of slightly eroded shoreline scattered throughout.

While some residents have installed buffer strips along their lakefront, many areas of manicured lawn remain. The roots of lawn grass do not provide the stabilization needed to hold sediment in place. The Lakes Management Unit recommends that more buffer strips be installed to prevent further erosion, especially at the noted sites at the park. A possible cause of erosion can be improperly installed seawall and rip rap. Rip rap needs to consist of large rocks with a liner underneath that holds the rock to the shoreline and also prevents erosion between the rocks. Otherwise, rock can be carried out into the lake by wave action. If seawall was installed improperly, undercutting can occur and can be costly to repair. The low amount of water level fluctuation was one reason that further erosion did not occur, as the water level in 2006 did not fluctuate by more than three inches from month to month.

Table 6. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/A) and with native species only (native).

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	35.7	37.9
2	Deep Lake	33.9	35.4
3	Round Lake Marsh North	29.1	29.9
4	East Loon Lake	28.4	29.9
5	Deer Lake	28.2	29.7
6	Sullivan Lake	28.2	29.7
7	Little Silver Lake	27.9	30.0
8	Schreiber Lake	26.8	27.6
9	Cranberry Lake	26.6	28.6
10	Bangs Lake	26.4	28.0
11	West Loon Lake	26.0	27.6
12	Cross Lake	25.2	27.8
13	Lake Zurich	24.0	26.0
14	Lake of the Hollow	23.8	26.2
15	Lakewood Marsh	23.8	24.7
16	Round Lake	23.5	25.9
17	Fourth Lake	23.0	24.8
18	Druce Lake	22.8	25.2
19	Sun Lake	22.7	24.5
20	Countryside Glen Lake	21.9	22.8
21	Sterling Lake	21.8	24.1
22	Butler Lake	21.4	23.1
23	Duck Lake	21.1	22.9
24	Timber Lake (North)	20.8	22.8
25	Broberg Marsh	20.5	21.4
26	Davis Lake	20.5	21.4
27	ADID 203	20.5	20.5
28	McGreal Lake	20.2	22.1
29	Wooster Lake	19.8	22.3
30	Lake Kathryn	19.6	20.7
31	Fish Lake	19.3	21.2
32	Redhead Lake	19.3	21.2
33	Owens Lake	19.3	20.2
34	Lake Minear	18.8	20.6
35	Turner Lake	18.6	21.2
36	Salem Lake	18.5	20.2
37	Lake Miltmore	18.4	20.3
38	Hendrick Lake	17.7	17.7
39	Summerhill Estates Lake	17.1	18.0
40	Ames Pit	17.0	18.0
41	Seven Acre Lake	17.0	15.5
42	Gray's Lake	16.9	19.8

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
43	Grand Avenue Marsh	16.9	18.7
44	Long Lake	16.9	18.7
45	Bresen Lake	16.6	17.8
46	Windward Lake	16.3	17.6
47	Lake Barrington	16.3	17.4
48	Diamond Lake	16.3	17.4
49	Lake Napa Suwe	16.3	17.4
50	Dog Bone Lake	15.7	15.7
51	Redwing Slough	15.6	16.6
52	Independence Grove	15.5	16.7
53	Tower Lake	15.2	17.6
54	Heron Pond	15.1	15.1
55	Lake Tranquility (S1)	15.0	17.0
56	North Churchill Lake	15.0	15.0
57	Island Lake	14.7	16.6
58	Dog Training Pond	14.7	15.9
59	Highland Lake	14.5	16.7
60	Lake Fairview	14.3	16.3
61	Taylor Lake	14.3	16.3
62	Third Lake	14.1	16.3
63	Dugdale Lake	14.0	15.1
64	Eagle Lake (S1)	14.0	15.1
65	Longview Meadow Lake	13.9	13.9
66	Hook Lake	13.4	15.5
67	Timber Lake (South)	13.4	15.5
68	Bishop Lake	13.4	15.0
69	Mary Lee Lake	13.1	15.1
70	Old School Lake	13.1	15.1
71	Buffalo Creek Reservoir	13.1	14.3
72	McDonald Lake 2	13.1	14.3
73	Old Oak Lake	12.7	14.7
74	White Lake	12.7	14.7
75	Dunn's Lake	12.7	13.9
76	Echo Lake	12.5	14.8
77	Hastings Lake	12.5	14.8
78	Sand Lake	12.5	14.8
79	Countryside Lake	12.5	14.0
80	Stone Quarry Lake	12.5	12.5
81	Honey Lake	12.1	14.3
82	Lake Leo	12.1	14.3
83	Lambs Farm Lake	12.1	14.3
84	Stockholm Lake	12.1	13.5
85	Pond-A-Rudy	12.1	12.1

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
86	Lake Matthews	12.0	12.0
87	Flint Lake	11.8	13.0
88	Harvey Lake	11.8	13.0
89	Rivershire Pond 2	11.5	13.3
90	Antioch Lake	11.3	13.4
91	Lake Charles	11.3	13.4
92	Lake Linden	11.3	11.3
93	Lake Naomi	11.2	12.5
94	Pulaski Pond	11.2	12.5
95	Redwing Marsh	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	Lake Carina	10.2	12.5
100	Crooked Lake	10.2	12.5
101	Lake Lakeland Estates	10.0	11.5
102	College Trail Lake	10.0	10.0
103	Werhane Lake	9.8	12.0
104	Big Bear Lake	9.5	11.0
105	Little Bear Lake	9.5	11.0
106	Loch Lomond	9.4	12.1
107	Sand Pond (IDNR)	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Fischer Lake	9.0	11.0
111	Grandwood Park Lake	9.0	11.0
112	Lake Fairfield	9.0	10.4
113	McDonald Lake 1	8.9	10.0
114	East Meadow Lake	8.5	8.5
115	South Churchill Lake	8.5	8.5
116	Lake Christa	8.5	9.8
117	Lake Farmington	8.5	9.8
118	Lucy Lake	8.5	9.8
119	Bittersweet Golf Course #13	8.1	8.1
120	Woodland Lake	8.1	9.9
121	Albert Lake	7.5	8.7
122	Lake Eleanor	7.5	8.7
123	Fairfield Marsh	7.5	8.7
124	Lake Louise	7.5	8.7
125	Banana Pond	7.5	9.2
126	Patski Pond	7.1	7.1
127	Rasmussen Lake	7.1	7.1
128	Slough Lake	7.1	7.1
129	Lucky Lake	7.0	7.0

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
130	Lake Forest Pond	6.9	8.5
131	Leisure Lake	6.4	9.0
132	Peterson Pond	6.0	8.5
133	Grassy Lake	5.8	7.1
134	Slocum Lake	5.8	7.1
135	Gages Lake	5.8	10.0
136	Deer Lake Meadow Lake	5.2	6.4
137	ADID 127	5.0	5.0
138	Liberty Lake	5.0	5.0
139	Oak Hills Lake	5.0	5.0
140	Drummond Lake	5.0	7.1
141	IMC Lake	5.0	7.1
142	North Tower Lake	4.9	7.0
143	Forest Lake	3.5	5.0
144	Half Day Pit	2.9	5.0
145	Lochanora Lake	2.5	5.0
146	Hidden Lake	0.0	0.0
147	St. Mary's Lake	0.0	0.0
148	Valley Lake	0.0	0.0
149	Waterford Lake	0.0	0.0
150	Potomac Lake	0.0	0.0
151	Willow Lake	0.0	0.0
	<i>Mean</i>	13.6	14.9
	<i>Median</i>	12.5	14.3

Figure 7. Approximate shoreline erosion on Lake Linden, 2006.



Invasive plant species, including Reed Canary Grass, Buckthorn and Purple Loosestrife were present along 26% of the shoreline in 2002, and were observed again in 2006. These plants are extremely invasive and exclude native plants from the areas they inhabit. Buckthorn provides very poor shoreline stabilization and may lead to increasing erosion problems in the future. Reed Canary Grass and Purple Loosestrife inhabit mostly wet areas and can easily out-compete native plants. Additionally, they do not provide the quality habitat or shoreline stabilization that native plants provide. Since the relative density of the invasive species found around Lake Linden was not high (Purple Loosestrife was observed on only one lot), steps to eliminate these plants should be carried out before they become a nuisance.

SUMMARY OF WILDLIFE AND HABITAT CONDITIONS

Habitat conditions around Lake Linden are fair, with the three parks located along the shoreline offering limited habitat. Improvement of other areas around the lake should be seriously considered.

In the early 1970's, fish surveys performed on Lake Linden by the Illinois Department of Natural Resources (IDNR) indicated that the lake was dominated by small Black Bullheads and Pumpkinseed Sunfish. By the 1990's carp and stunted panfish dominated the fish community. In 1991, a Rotenone treatment was conducted on Lake Linden, killing nearly all of the fish left in the lake (except large game fish which were removed prior to treatment). From 1992-1997, Largemouth Bass, Channel Catfish, Muskellunge and Tiger Muskellunge were stocked each year. Since 1998, Bluegill have been stocked annually and Muskellunge and Channel Catfish have been stocked supplementally. In 1997, 1998 and 2001, 32, 9-12 inch musky were stocked in the lake and in 2002, 40, 18-22 inch musky were stocked. A Muskellunge stocking program has been set-up on the lake so that a predetermined amount are stocked every other year (2002, 2004, 2006, etc.). There is a catch and release rule on both musky species and Largemouth Bass, as the Lindenhurst Lakes Commission is attempting to keep panfish in check with larger predators. No live bait is permitted on Lake Linden and protective overflow screens have been installed in various places to prevent European Carp from re-entering the lake.

While the fishery appears to be healthy and reports from anglers are positive, it is strongly recommended by the Lakes Management Unit that a new fishery assessment be conducted to determine the current status of the fish community. Of particular interest would be the status of the European Carp population, the possible presence of stunted panfish and the status of the large predator fish population and the forage base for the predator population. The suggested stocking rate for musky is one fish per acre, and Lake Linden is currently adhering to this suggested rate. However, at the size that these fish are being stocked, they are likely exerting heavy predation pressure on the current forage base. It is therefore important that the status of this forage base and the size eventually attained by the musky population be determined.

LAKE MANAGEMENT RECOMMENDATIONS

Lake Linden provides a good place for recreational opportunities to its residents and has many water quality parameters that are better than the county median. There are a few areas that could be improved to make this lake even better and to ensure it is in good condition for future generations to enjoy.

Enhance wildlife habitat conditions on a lake

Lake Linden has three parks around the lake that provide some good habitat area. Creating more habitats by installing buffer strips would help increase the amount of wildlife viewing on the lake by creating nesting areas and a natural food supply (See Appendix D1 for more details).

Lakes with shoreline erosion

Erosion around Lake Linden was not that extensive, but is still present and could pose a larger problem in the future. Of special concern was the shoreline at the park on the southwest side of the lake. This section of shoreline has increased in erosive severity over the past four years. In the long run, it is more cost efficient to prevent erosion than to fix it. Native planted buffer strips, rip-rap and seawall are all methods used to remediate and prevent erosion from occurring (See Appendix D2 for more details).

Aquatic plant management

The plant coverage on Lake Linden was very small (only 9%), while the macroalgae community covered 85% of the lake. This is due to the high amount of chemicals used to treat the growth of aquatic plants. While macroalgae helps utilize nutrients from storm water runoff, it does not provide a healthy fish habitat. Revitalization of native aquatic plants is recommended (See Appendix D3 for more details).

Assess your lake's fishery

The last known fishery assessment was performed by the IDNR in the 1970's. A current assessment would be beneficial in determining the size of the forage base (amount of small fish) that the Muskellunge being stocked are feeding off of. This would be especially beneficial since a fishery assessment has not been conducted since the Rotenone treatment in 1991 (See Appendix D4 for more details).

Reduce Conductivity and Chloride Concentrations

The current concentration of chloride in Lake Linden has the potential to negatively impact aquatic life, from plants to algae to fish. Road salt usage in the watershed is the major contributor to chloride and conductivity levels (See Appendix D5 for more details).

 **Watershed Nutrient Reduction**

While phosphorus levels have decreased since Lake Linden was last sampled in 2002, it is still recommended that phosphorus free fertilizer be looked into. (See Appendix D6 for more details).

**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 9.1) overlaid a grid pattern onto a 2006 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.

Plankton Sampling

Plankton were sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a or YSI 6600 Sonde® 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 63µm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton were collected within a small cup on the bottom of the tow. The collected sample was then emptied into a pre-labeled brown plastic bottle. The net was rinsed with deionized water into the bottle in order to ensure all the plankton were collected. The sample was then transferred to a graduated cylinder to measure the amount of milliliters (mL) that the sample was. The sample was then returned to the bottle and preserved with Lugol's iodine solution (5 drops/mL). The sample bottle was then closed and stored in a cooler until returning

to the lab, where it was transferred to the refrigerator until enumeration. Enumeration was performed within three months, but ideally within one month, under a microscope. Prior to sub-sample being removed for enumeration, the sample bottle was inverted several times to ensure proper homogenization. An automated pipette was used to retrieve 1 mL of sample, which was then placed in a Sedgewick Rafter slide. This is a microscope slide on which a rectangular chamber has been constructed, measuring 50 mm x 20 mm in area and 1 mm deep. The slide was then placed under the microscope and counted at a 20X magnification (phytoplankton) or 10X magnification (zooplankton). For phytoplankton, twenty fields of view were randomly counted with all species within each field counted. Due to their larger size, zooplankton were counted throughout the entire slide. Through calculations, it was determined how many of each species were in 1 mL of lake water.

Phytoplankton (algae) are free-floating and microscopic and are distinguished from plants because they lack roots, stems and leaves. There are four distinct groups of phytoplankton found in Lake County lakes: blue-greens, greens, diatoms, and dinoflagellates/chrysophytes. Blue-greens are also known as cyanobacteria because they are the only group of bacteria that obtain their energy from photosynthesis like plants. Some of these species can be toxic. Green algae are the closest ancestors of land plants and are the most common group. Diatoms are unique because they are encased in a cell wall made of silica that can be very ornate. Dinoflagellates and chrysophytes are almost always flagellated (able to move by flagella, a whip-like tail) and some can both photosynthesize and consume bacteria for food.

Zooplankton are made up of rotifers and two crustacean groups; the cladocerans and the copepods (broken down further into calanoids and cyclopoids). Rotifers are smaller and most have a crown of cilia (hair-like structure) used for movement and drawing in suspended particles to eat. Crustaceans have jointed appendages and are enclosed in an exoskeleton. Cladocerans, such as the “water flea” *Daphnia* species, are filter-feeding like rotifers, while the copepod group contains both filter-feeders (calanoids and cyclopoids) and raptorial species (cyclopoids).

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.

<i>Parameter</i>	<i>Method</i>
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 18 th ed. Electrode method, #4500 NH ₃ -F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18 th 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 18 th ed, Method #2540B
Total suspended solids	SM 18 th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18 th ed, Method #4500C1-D
Total volatile solids	SM 18 th ed, Method #2540E, from total solids
Alkalinity	SM 18 th ed, Method #2320B, potentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18 th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18 th 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 LINDEN, 2006.

Linden Lake 2006 Multiparameter data

Text											
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 Average	Extinction Coefficient 0.71
5/17/2006	0.5	0.494	14.99	10.89	108.4	1.106	8.28	2895.9	Surface		
5/17/2006	1	1.030	14.97	10.86	108.0	1.207	8.15	2858.5	Surface	100%	
5/17/2006	2	2.017	14.93	10.77	107.0	1.208	8.09	698.9	0.347	24%	4.06
5/17/2006	3	3.005	14.80	10.70	106.1	1.209	8.08	97.3	1.335	3%	1.48
5/17/2006	4	4.002	14.72	10.58	104.7	1.210	8.07	83.9	2.332	3%	0.06
5/17/2006	5	4.998	14.68	10.47	103.5	1.211	8.05	193.2	3.328	7%	-0.25
5/17/2006	6	6.017	14.57	10.62	104.7	1.211	8.04	147.4	4.347	5%	0.06
5/17/2006	7	7.002	14.15	10.65	104.1	1.211	8.05	112.6	5.332	4%	0.05
5/17/2006	8	8.024	14.09	10.47	102.1	1.211	8.03	98.9	6.354	3%	0.02
5/17/2006	9	8.960	14.06	9.46	92.3	1.211	8.01	21.3	7.290	0.7%	0.21

Text											
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 Average	Extinction Coefficient 0.70
6/21/2006	0.5	0.523	24.36	9.00	107.9	1.190	7.96	1503.3	Surface		
6/21/2006	1	1.009	24.40	8.90	106.8	1.190	8.11	1500.0	Surface	100%	
6/21/2006	2	1.998	24.36	8.83	106.0	1.190	8.19	380.5	0.328	25%	4.18
6/21/2006	3	3.061	24.26	8.74	104.7	1.191	8.25	249.4	1.391	17%	0.30
6/21/2006	4	4.038	24.23	8.65	103.5	1.191	8.27	184.3	2.368	12%	0.13
6/21/2006	5	5.028	24.23	8.56	102.4	1.191	8.29	103.2	3.358	7%	0.17
6/21/2006	6	6.015	24.20	8.47	101.3	1.191	8.29	107.3	4.345	7%	-0.01
6/21/2006	7	7.027	24.16	8.33	99.6	1.190	8.30	73.8	5.357	5%	0.07
6/21/2006	8	8.056	24.13	8.07	96.4	1.191	8.29	56.6	6.386	4%	0.04

Date	Text	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light	% Light	Extinction
MMDDYY		feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	Meter	Transmission	Coefficient
										feet	Average	0.44
7/19/2006		0.5	0.476	28.47	7.19	93.0	1.193	8.06	3013.7	Surface		
7/19/2006		1	1.019	28.43	7.21	93.1	1.193	8.28	2776.8	Surface	100%	
7/19/2006		2	2.125	28.12	7.19	92.3	1.193	8.33	1189.6	0.455	43%	1.86
7/19/2006		3	3.006	28.10	7.28	93.5	1.194	8.42	740.3	1.336	27%	0.36
7/19/2006		4	3.900	28.10	7.36	94.5	1.193	8.45	494.8	2.230	18%	0.18
7/19/2006		5	4.999	27.88	7.52	96.2	1.194	8.47	377.5	3.329	14%	0.08
7/19/2006		6	6.042	27.86	7.46	95.4	1.193	8.48	269.5	4.372	10%	0.08
7/19/2006		7	7.048	27.84	7.43	95.0	1.193	8.48	200.9	5.378	7%	0.05

Date	Text	Depth	Dep25	Temp	DO	DO%	SpCond	pH	PAR	Depth of Light	% Light	Extinction
MMDDYY		feet	feet	øC	mg/l	Sat	mS/cm	Units	æE/s/mý	Meter	Transmission	Coefficient
										feet	Average	
8/16/2006		0.5	0.489	25.83	8.71	107.4	1.219	9.22	NA	Surface		
8/16/2006		1	1.018	25.66	8.83	108.5	1.222	9.23	NA	Surface	NA	NA
8/16/2006		2	2.048	25.52	8.77	107.4	1.220	9.23	NA	0.378	NA	NA
8/16/2006		3	3.035	25.45	8.53	104.4	1.220	9.22	NA	1.365	NA	NA
8/16/2006		4	4.031	25.35	8.00	97.7	1.221	9.22	NA	2.361	NA	NA
8/16/2006		5	5.056	25.29	7.53	91.9	1.221	9.22	NA	3.386	NA	NA
8/16/2006		6	6.025	25.25	7.22	88.1	1.221	9.20	NA	4.355	NA	NA
8/16/2006		7	7.029	25.24	7.16	87.4	1.221	9.21	NA	5.359	NA	NA
8/16/2006		8	7.945	25.19	6.82	83.1	1.219	9.17	NA	6.275	NA	NA

Date MMDDYY	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient
9/20/2006	0.5	0.493	16.25	9.48	96.9	1.200	8.36	NA	Surface		
9/20/2006	1	1.033	16.26	8.87	90.6	1.199	8.41	NA	Surface	NA	NA
9/20/2006	2	1.997	16.24	8.91	91.1	1.200	8.43	NA	0.327	NA	NA
9/20/2006	3	3.076	16.17	8.89	90.7	1.200	8.43	NA	1.406	NA	NA
9/20/2006	4	4.010	16.14	8.92	91.0	1.200	8.43	NA	2.340	NA	NA
9/20/2006	5	4.977	16.00	8.91	90.5	1.215	8.43	NA	3.307	NA	NA
9/20/2006	6	5.993	15.96	8.86	90.0	1.202	8.42	NA	4.323	NA	NA
9/20/2006	7	6.986	15.87	8.80	89.3	1.202	8.42	NA	5.316	NA	NA
9/20/2006	8	7.992	15.83	8.66	87.7	1.203	8.42	NA	6.322	NA	NA

APPENDIX C. INTERPRETING YOUR LAKES 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 2000-2005 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 2000-2005 is 0.063 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2005 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in West Loon 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) were measured each month by the Lakes Management Staff, total suspended solids (TSS) 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 7.9 mg/L, ranging from below the 1 mg/L detection limit (10 lakes) 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 mg/L, ranging from 34 mg/L in Pulaski Pond to 298 mg/L in Fairfield Marsh.

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 3.17 feet. From 2000-2005, 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 ($\text{CO}_3^{=}$) 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 8.30, 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	$\geq 40 < 50$	$> 0.012 \leq 0.024$	$\geq 6.56 < 13.12$
Eutrophic	$\geq 50 < 70$	$> 0.024 \leq 0.096$	$\geq 1.64 < 6.56$
Hypereutrophic	≥ 70	> 0.096	< 1.64

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. 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 placed 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.

D2. Options for Lakes with Shoreline Erosion

Option 1: Install a Seawall

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

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

Option 2: Install Rock Rip-Rap or Gabions

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

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

Option 3: Create a Buffer Strip

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

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

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

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.

D3. Options for Aquatic Plant Management

Option 1: Aquatic Herbicides

Aquatic herbicides are the most common method to control nuisance vegetation/algae. When used properly, they can provide selective and reliable control. Products cannot be licensed for use in aquatic situations unless there is less than a 1 in 1,000,000 chance of any negative effects on human health, wildlife, and the environment. Prior to herbicide application, licensed applicators should evaluate the lake's vegetation and, along with the lake's management plan, choose the appropriate herbicide and treatment areas, and apply the herbicides during appropriate conditions (i.e., low wind speed, DO concentration, temperature).

When used properly, aquatic herbicides can be a powerful tool in management of excessive vegetation. Often, aquatic herbicide treatments can be more cost effective in the long run compared to other management techniques. The fisheries and waterfowl populations of the lake would benefit greatly due to an increase in quality habitat and food supply. Dense stands of plants would be thinned out and improve spawning habitat and food source availability for fish. By implementing a good management plan with aquatic herbicides, usage opportunities of the lake would increase.

The most obvious drawback of using aquatic herbicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error can make them unsafe and bring about undesired outcomes. If not properly used, aquatic herbicides can remove too much vegetation from the lake. Another problem associated with removing too much vegetation is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. After the initial removal, there is a possibility for regrowth of vegetation. Upon regrowth, weedy plants such as Eurasian Watermilfoil and Coontail quickly reestablish, form dense stands, and prevent the growth of desirable species. This causes a decrease in plant biodiversity. Over-removal, and possible regrowth of nuisance vegetation that may follow will drastically impair recreational use of the lake.

Option 2: Mechanical Harvesting

Mechanical harvesting involves the cutting and removal of nuisance aquatic vegetation by large specialized boats with underwater cutting bars. The total removal or over removal (neither of which should never be the plan of any management entity) of plants by mechanical harvesting should never be attempted. To avoid complete or over removal, the management entity should have a harvesting plan that determines where and how much vegetation is to be removed.

Mechanical harvesting can be a selective means to reduce stands of nuisance vegetation in a lake. Typically, plants cut low enough to restore recreational use and limit or prevent

regrowth. This practice normally improves habitat for fish and other aquatic organisms. High initial investment, extensive maintenance, and high operational costs have led to decreased use. Mechanical harvesters cannot be used in less than 2-4 feet of water (depending on draft of the harvester) and cannot maneuver well in tight places. The harvested plant material must be disposed of properly to a place that can accommodate large quantities of plants and prevent any from washing back into the lake. Fish, mussels, turtles and other aquatic organisms are commonly caught in the harvester and injured or even removed from the lake in the harvesting process. After the initial removal, there is a possibility for vegetation regrowth. If complete/over removal does occur several problems can result. One problem is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. Another problem with mechanical harvesting, even if properly done, is that it can be a nonselective process.

Option 3: Hand Removal

Hand removal of excessive aquatic vegetation is a commonly used management technique. Hand removal is normally used in small ponds/lakes and limited areas for selective vegetation removal. Areas surrounding piers and beaches are commonly targeted areas. Typically tools such as rakes and cutting bars are used to remove vegetation. Hand removal is a quick, inexpensive, and selective way to remove nuisance vegetation. There are few negative attributes to hand removal. One negative implication is labor. Depending on the extent of infestation, removal of a large amount of vegetation can be quite tiresome. Another drawback can be disposal. Finding a site for numerous residents to dispose of large quantities of harvested vegetation can sometimes be problematic.

Option 4: Water Milfoil Weevil

Euhrychiopsis lecontei (*E. lecontei*) is a biological control organism used to control Eurasian Watermilfoil (EWM). *E. lecontei* is a native weevil, which feeds exclusively on milfoil species. It is stocked as a biocontrol and is commonly referred to as the Eurasian Watermilfoil weevil. Currently, the LCHD-Lakes Management Unit has documented weevils in 35 Lake County lakes. Many of these lakes have seen declines in EWM densities in recent years. Weevils are stocked in known quantities to achieve a density of 1-4 weevils per stem. As weevil populations expand, EWM populations may decline. After EWM declines, weevil populations decline and do not feed on any other aquatic plants. Currently only one company, EnviroScience Inc., has a stocking program (called the MiddFoil® process). The program includes evaluation of EWM densities, of current weevil populations (if any), stocking, monitoring, and restocking as needed.

If control with milfoil weevils were successful, the quality of the lake would be improved. Native plants could start to recolonize, and the fishery of the lake would improve due to more balanced predation and higher quality habitat. Waterfowl would benefit due to increased food sources and availability of prey. Use of milfoil weevils does have some drawbacks. Control using the weevil has been inconsistent in many cases. Also, milfoil control using weevils may not work well on plants in deep water.

Furthermore, weevils do not work well in areas where plants are continuously disturbed by activities such as powerboats, swimming, harvesting or herbicide use. One of the most prohibitive aspects to weevil use is price. Typically weevils are stocked to achieve a density of 1-4 weevils per stem. This translates to 500-3000 weevils per acre.

Option 5: Reestablishing Native Aquatic Vegetation

Revegetation should only be done when existing nuisance vegetation, such as Eurasian Watermilfoil, are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. By revegetating newly opened areas that were once infested with nuisance species, the lake will benefit in several ways. There are few negative impacts to revegetating a lake. One possible drawback is the possibility of new vegetation expanding to nuisance levels and needing control. However, this is an unlikely outcome. Another drawback could be the high costs of extensive revegetation with imported plants.

D4. Options to Assess Your Lake's Fishery

Many lakes have a fish-stocking program in which fish are stocked every year or two to supplement fish species already occurring in the lake or to introduce additional fish species into the system. However, few lakes that participate in stocking check the progress or success of these programs with regular fish surveys. Lake managers should have information about whether or not funds delegated to fish stocking are being well spent, and it is difficult to determine how stocked fish species are surviving and reproducing or how they are affecting the rest of the fish community without a comprehensive fish assessment.

A simple, inexpensive way to collect information on the status of a fishery is to sample anglers actively involved in recreational fishing on the lake and evaluate the types, numbers and sizes of fish caught. Such information provides insight on the status of fish populations in the lake, as well as a direct measure of the quality of fishing and the fishing experience. However, the numbers and types of fish sampled by anglers are limited, focusing on game and catchable-sized fish. Thus, in order to obtain a comprehensive assessment of the fish community, including non-game fish species, more quantitative methods such as gill netting, trap netting, seining, trawling, angling (hook and line fishing) and electroshocking must be employed. Each method has its advantages and limitations, and frequently multiple gears are employed. The best gear and sampling methods depend on the target species and life stage, the types of information desired, and the environment to be sampled.

It is best to monitor fish populations annually. The best time of year depends on the sampling method, the target fish species, and the types of data to be collected. In many lakes and regions, the best time to sample fish is during the fall turnover period after thermal stratification breaks down and the lake is completely mixed because: (1) young-of-year (YOY) and age 1+ (one year or older) fish of most target species should be present and vulnerable to most standard collection gear, including seines, trap nets and electroshockers; (2) species that dwell in the hypolimnion during the summer may be more vulnerable to capture during fall overturn; and (3) lower water temperatures in the fall can help reduce sampling-related mortality. Sampling locations are also species, life stage, and gear dependent. As with sampling methods and time, locations should be selected to maximize capture efficiency for the target species of interest and provide the greatest gain in information for the least amount of sampling effort.

The Illinois Department of Natural Resources (IDNR) will perform a fish survey at no charge on most public and some private water bodies. In order to determine if your lake is eligible for a survey by the IDNR, contact Frank Jakubecik, Fisheries Biologist, at (815) 675-2319. If a lake is not eligible for an IDNR fish survey or if a more comprehensive survey is desired, contact the Lakes Management Unit for a list of consultants.

D5. 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 dolomitic 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.

D6. Options for Watershed Nutrient Reduction

The two key nutrients for plant and algae growth are nitrogen and phosphorus. Fertilizers used for lawn and garden care have significant amounts of both. The three numbers on the fertilizer bag identify the percent of nitrogen, phosphorus and potash in the fertilizer mixture. For example, a fertilizer with the numbers 5-10-5 has 5% nitrogen, 10% phosphorus and 5% potash. Fertilizers considered low in phosphorus (the second number) have a number of 5 or lower. A lower concentration of phosphorus applied to a lawn will result in a smaller concentration of phosphorus in stormwater runoff. An established lawn will not be negatively affected by a lower phosphorus rate. However, for areas with new seeding or new sod, the homeowner would still want to use a fertilizer formulated for encouraging growth until the lawn is established. A simple soil test can determine the correct type and amount of fertilizer needed for the soil. Knowing this, homeowners can avoid applying the wrong type or amount of fertilizer.

Option 1. Buffer Strips

Buffer strips of unmowed native vegetation at least 25 feet wide along the shoreline can slow nutrient laden runoff from entering a lake. It can help prevent shoreline erosion and provide habitat beneficial for wildlife. Different plant mixes can be chosen to allow for more aesthetically pleasing buffer strips and tall species can be used to deter waterfowl from congregating along the shore. Initially the cost of plants can be expensive, however, over time less maintenance is required for the upkeep of a buffer strip.

Option 2. Lake Friendly Lawn and Garden Care Practices – Phosphorus Reduction

- a. Compost yard waste instead of burning. Ashes from yard waste contain nutrients and are easily washed into a lake.
- b. Avoid dumping yard waste along or into a ditch, pond, lake, or stream. As yard waste decomposes, the nutrients are released directly into the water, or flushed to the lake via the ditch.
- c. Avoid applying fertilizer up to the water's edge. Leave a buffer strip of at least 25 feet of unfertilized yard before the shoreline.
- d. **Avoid applying fertilizers when heavy rains are expected, or over-watering the ground after applying fertilizer.**
- e. When landscaping, keep site disturbance to a minimum, especially the removal of vegetation and exposure of bare soil. Exposed soil can easily erode.
- f. When landscaping, seed or plant exposed soil and cover it with mulch as soon as possible to minimize erosion and runoff.
- g. Use lawn and garden chemicals sparingly, or do not use them at all.
- e. Most lawns in Lake County do not need additional phosphorus for sufficient plant

growth. Consider using a phosphorus-free fertilizer.

Option 3. Street Sweeping

Street sweeping has been used in communities to help prevent debris from clogging stormsewer drains, but it also benefits lakes by removing excess phosphorus, sand, silt and other pollutants. Leftover sand and salt applied to streets has been found to contain higher concentrations of silt, phosphorus and trace metals than new sand and salt mixes. If a municipality does not manage the lake, the lake management entity may be able to offer the village or city extra payment for sweeping streets closest to the lake.

Option 4: Reduce Stormwater Volume from Impervious Surfaces

The quality and quantity of runoff directly affects the lake's water quality. With continued growth and development in Lake County, more impervious surfaces such as parking lots and buildings contribute to the volume of stormwater runoff. Runoff picks up pollutants such as nutrients and sediment as it moves over land or down gutters. A faster flow rate and higher volume can result in erosion and scouring, adding sediment and nutrients to the runoff.

Roof downspouts should be pointed away from driveways and foundations and toward lawns or planting beds where water can soak into the soil. A splash block directly below downspouts helps prevent soil erosion. If erosion still occurs, a flexible perforated plastic tubing attached to the downspout can dissipate the water flow.

Option 5: Required Practices for Construction

Follow the requirements in the Watershed Development Ordinance (WDO) concerning buffer strips. Buffer strips can slow the velocity of runoff and trap sediment and attached nutrients. Setbacks, buffer strips and erosion control features, when done properly, will help protect the lake from excessive runoff and associated pollutants. Information about the contents of the ordinance can be obtained through Lake County Planning and Development, (847) 360-6330.

Option 6. Organize a Local Watershed Organization

A watershed organization can be instrumental in circulating educational information about watersheds and how to care for them. Often a galvanized organization can be a stronger working unit and a stronger voice than a few individuals. Watershed residents are the first to notice problems in the area, such as a lack of erosion control at construction sites. This organization would be an advocate for the watershed, and members could voice their concerns about future development impacts to local officials. This organization could educate the community about how phosphorus (and other pollutants) affect lakes and can help people implement watershed controls. Several types of educational outreaches can be used together for best results. These include:

community newsletters, newspaper articles, local cable and radio station announcements. In some cases fundraising may be utilized to secure more funding for a project.

Option 7. Motor Boat Restrictions for Shallow Lakes

To reduce resuspension of phosphorus from the sediment, communities that have a shallow lake or large shallow areas in their lake may want to restrict motorized boating. The action of a spinning prop in shallow areas can disturb the sediment. Flocculent sediment particles can release loosely attached phosphorus into the water. Restrictions could include a ban of motorized traffic in certain areas or ban the use of motors entirely, however this could be hard to enforce without hiring law enforcement personnel. This would work best for lakes with shallow areas that have a large phosphorus source in the sediment.

Option 8. Discourage Waterfowl from Congregating

Waterfowl droppings (feces) can be a source of phosphorus (and bacteria) to the water, especially if they are congregating in large numbers along beaches and/or other nearshore areas. The annual nutrient load from two Canada Geese can be greater than the annual nutrient load from residential areas (Gremlin and Malone, 1986). These birds prefer habitat with short plants or no plants, such as lawns mowed to the water's edge and beaches. Waterfowl avoid areas with tall, dense vegetation through which they are unable to see predators. Tactics to discourage waterfowl from congregating in large groups include scare devices, a buffer strip of tall plants along the shoreline, and discouraging people from feeding geese and ducks. Signage could be erected at public parks/beaches discouraging people from feeding waterfowl. A template is available from Lakes Management Unit.

APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES

2000 - 2006 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2006		ALKanoxic 2000-2006		
Average	167.2		Average	201	
Median	162.0		Median	191	
Minimum	64.9	IMC	Minimum	103	Heron Pond
Maximum	330.0	Flint Lake	Maximum	470	Lake Marie
STD	41.8		STD	49	
n =	798		n =	247	

	Condoxic <=3ft00-2006		Condanoxic 2000-2006		
Average	0.8838		Average	0.9949	
Median	0.7954		Median	0.8276	
Minimum	0.2542	Broberg Marsh	Minimum	0.3210	Lake Kathryn
Maximum	6.8920	IMC	Maximum	7.4080	IMC
STD	0.5391		STD	0.7811	
n =	796		n =	247	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2006		NH3-Nanoxic 2000-2006		
Average	0.521		Average	2.103	
Median	0.153		Median	1.350	
Minimum	<0.05	*ND	Minimum	<0.1	*ND
Maximum	9.670	South Churchill Lake	Maximum	18.400	Taylor Lake
STD	1.060		STD	2.354	
n =	803		n =	247	

*ND = Many lakes had non-detects (71.5%)

*ND = 18.6% Non-detects from 27 different lakes

Only compare lakes with detectable concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

	pHoxic <=3ft00-2006		pHanoxic 2000-2006		
Average	8.30		Average	7.20	
Median	8.30		Median	7.18	
Minimum	5.21	Redwing Slough	Minimum	6.24	Banana Pond
Maximum	10.28	Round Lake Marsh North	Maximum	8.48	Heron Pond
STD	0.48		STD	0.39	
n =	796		n =	247	

	All Secchi 2000-2006		81 of 161 lakes had anoxic conditions 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
Average	4.48		
Median	3.27		
Minimum	0.33	Fairfield Marsh, Patski Pond	
Maximum	21.82	Bangs Lake	
STD	3.69		
n =	740		

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2000 - 2006 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic ≤3ft00-2006		TKNanoxic 2000-2006		
Average	1.481		Average	2.971	
Median	1.260		Median	2.270	
Minimum	<0.5	*ND	Minimum	<0.5	*ND
Maximum	10.300	Fairfield Marsh	Maximum	21.000	Taylor Lake
STD	0.828		STD	2.341	
n =	798		n =	247	
*ND = 3.6% Non-detects from 14 different lakes			*ND = 3.2% Non-detects from 5 different lakes		

	TPoxic ≤3ft00-2006		TPanoxic 2000-2006		
Average	0.101		Average	0.279	
Median	0.061		Median	0.162	
Minimum	<0.01	*ND	Minimum	0.012	West Loon Lake
Maximum	3.880	Albert Lake	Maximum	3.800	Taylor Lake
STD	0.179		STD	0.369	
n =	798		n =	247	
*ND = 0.1% Non-detects from 5 different lakes (Carina, Minear, & Stone Quarry)					

	TSSall ≤3ft00-2006		TVSoxic ≤3ft00-2006		
Average	15.4		Average	137.7	
Median	7.9		Median	134.0	
Minimum	<0.1	*ND	Minimum	34.0	Pulaski Pond
Maximum	165.0	Fairfield Marsh	Maximum	298.0	Fairfield Marsh
STD	20.5		STD	41.2	
n =	810		n =	752	
*ND = 1.3% Non-detects from 10 different lakes			No 2002 IEPA Chain Lakes		

	TDSoxic ≤3ft00-2004		CLanoxic ≤3ft00-2006		
Average	470		Average	261	
Median	454		Median	116	
Minimum	150	Lake Kathryn, White	Minimum	41	Timber Lake (N)
Maximum	1340	IMC	Maximum	2390	IMC
STD	169		STD	450	
n =	745		n =	79	
No 2002 IEPA Chain Lakes.					

	CLOxic ≤3ft00-2006	
Average	220	
Median	171	
Minimum	30	White Lake
Maximum	2760	IMC
STD	275	
n =	317	



APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. A list of potential grant opportunities

Grant Program Name	Funding Source	Funding Focus			Cost Share	Typical Award
		Water Quality	Flooding	Habitat		
Challenge Grant Program	USFWS			X	>50%	<\$10,000
Chicago Wilderness Small Grants Program	CW			X	None	\$15,000
Conservation 2000 (C2000)	IDNR			X	None	\$10,000 to \$500,000
Conservation Reserve Program	NRCS			X	Land	Variable
Five Star Challenge Grant	NFWF			X	None	\$5,000 to \$20,000
Flood Mitigation Assistance Program	IEMA		X		25%	\$200,000
Habitat Restoration Program for the Fox Watershed	LCSWCD			X	25%	<\$1,000K
Illinois Clean Lakes Program (ICLP)	IEPA	X			>50%	\$5,000 to \$30,000
Illinois Clean Energy Community Foundation	ICECF			X	None	Variable
Lakes Education Assistance Grant Program (LEAP)	IEPA	X			None	\$500
Northeast Illinois Wetland Conservation Account	USFWS	X		X	>50%	\$600 to \$200,000
Partners for Fish and Wildlife Program	USFWS			X	>50%	\$3,000
Section 206: Aquatic Ecosystem Restoration	USACE			X	35%	<\$1,000,000
Section 319: Non-Point Source Management Program	IEPA	X		X	>40%	Variable
STAG Grants	LCSMC	X			None	Variable
Stream Cleanup And Lakeshore Enhancement (SCALE)	IEPA	X			None	\$2,000
Streambank Stabilization and Restoration Program (SSRP)	LCSWCD	X		X	25%	Variable
Unincorporated Lake County Drainage Fund	LCPBD		X		>50%	\$5,000 to \$10,000
Wildlife Habitat Incentives Program	NRCS			X	Land	Variable
Watershed Management Board	LCSMC	X	X	X	>50%	\$5K to \$10K
Wetland Reserve Program	NRCS			X	Land	Variable

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
 LCPBD = Lake County Planning, Building, and Development Department
 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 F2. Grant Contacts

Chicago Wilderness (CW)

Elizabeth McCance, Director of Conservation Programs

Phone: (312) 580-2138

E-mail: emccance@chicagowilderness.org

<http://www.chicagowilderness.org/>

Illinois Clean Energy Community Foundation (ICECF)

2 N. LaSalle Street

Suite 950

Chicago, IL 60602

Phone: (312) 372-5191

Fax: (312) 372-5190

<http://www.illinoiscleanenergy.org/>

Illinois Department of Natural Resources (IDNR)

One Natural Resources Way

Springfield, IL 62702-1271

Phone: (217) 782-9740

<http://dnr.state.il.us/orep/C2000>

Illinois Emergency Management Agency (IEMA)

110 East Adams Street

Springfield, Illinois 62701

Phone: (217) 785-0229

<http://www.state.il.us/iema/index.htm>

Illinois Environmental Protection Agency (IEPA)

Bureau of Water - Surface Water Section

1021 North Grand Avenue East

P.O. Box 19276

Springfield, Illinois 62794-9276

Telephone: (217) 782-3362

Fax: (217) 785-1225

<http://www.epa.state.il.us/water/financial-assistance/non-point.html>

Lake County Planning, Building, and Development Department (LCPBD)

18 N. County Street
Waukegan, IL 60085
Phone: (847) 377-2875
Fax: (847) 782-3016

Lake County Soil and Water Conservation District (LCSWCD)

100 N. Atkinson Road
Suite 102A
Grayslake, IL 60030
Phone: (847)-223-1056
Fax: (847)-223-1127
<http://www.lakeswcd.org/>

Lake County Stormwater Management Commission (LCSMC)

333-B Peterson Road
Libertyville, IL 60048
Phone: (847) 918-5260
Fax: (847) 918-9826
<http://www.co.lake.il.us/smc>

National Fish and Wildlife Foundation (NFWF)

Attn: Five Star Restoration Program
1120 Connecticut Avenue N.W., Suite 900
Washington, DC 20036
Phone: (202) 857-0166
Fax: (202) 857-0162
<http://nfwf.org/programs/5star-rfp.htm>

Natural Resources Conservation Service (NRCS)

Wildlife Habitat Incentives Program Coordinator
USDA Natural Resources Conservation Service
1902 Fox Drive
Champaign, IL 61820
Phone: (217) 398-5267
<http://www.nrcs.usda.gov/programs/whip/>

United States Army Corps of Engineers (USACE)

111 N. Canal Street
Chicago, Illinois 60606-7206
Telephone: (312)-846-5333
Fax: (312)-353-2169
<http://www.lrc.usace.army.mil/>

United States Fish and Wildlife Service (USFWS)

Chicago Field Office
1250 South Grove Avenue, Suite 103
Barrington, IL 60010
Phone: (847)-381-2253
Fax: (847)-381-2285

Other Related Contacts

Catalog of Federal Funding Sources for Watershed Protection Web Site
<http://cfpub.epa.gov/fedfund/>

Fox River Ecosystem Partnership (FREP)
<http://foxriverecosystem.org/>

North American Wetlands Conservation Act Grants Program
<http://birdhabitat.fws.gov/NAWCA/grants.htm>

North American Wetland Conservation Act Programs
<http://birdhabitat.fws.gov/NAWCA/grants.htm>

U.S. Fish and Wildlife Foundation
<http://www.nfwf.org/>