2006 SUMMARY REPORT
of
Timber Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

3010 Grand Avenue
Waukegan, Illinois 60085

Leonard Dane
Michael Adam
Shaina Keseley
Adrienne Orr

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EXECUTIVE SUMMARY

Timber Lake is a 33-acre glacial lake east of Antioch in northern Lake County. Timber Lake receives water from two small intermittent streams, one at the northwestern corner of the lake and the other along the southeastern shoreline. The outflow at the northeast corner of the lake flows into a small wetland complex, which drains to North Mill Creek and eventually to the Des Plaines River.

During 2006, the Lake County Forest Preserve District (LCFPD) was implementing a master plan of improvements to the land around Timber Lake. The improvements included wetland and woodland restoration and the installation of educational loops, fishing piers, overlooks, a picnic area, and trails for hiking, biking, and horseback riding with future trail access planned at the northwest, southwest, and southeast corners of the property.

Timber Lake was weakly stratified in May and strongly stratified by June (at approximately 8 – 10 feet). Turnover was beginning during the September sampling, although the thermocline was still present at approximately 19 – 20 feet. Dissolved oxygen concentrations in the epilimnion did not indicate any significant problems. However, anoxic conditions (< 1.0 mg/L) existed from May through September in the hypolimnion.

Secchi depth (water clarity) averaged 10.35 feet during 2006, which was above the Lake County median of 3.27 feet. This was an increase from the 2001 sampling when the Secchi depth averaged 7.12 feet. The concentrations of total suspended solids (TSS), which directly affect the water clarity, decreased from an average of 4.1 mg/L in 2001 to 2.4 mg/L in 2006. Both of these values were less than the Lake County epilimnetic median of 7.9 mg/L. Total phosphorus (TP) concentrations in Timber Lake averaged lower than the Lake County epilimnetic median of 0.060 mg/L and higher than the hypolimnetic median of 0.163 mg/L. The TP had decreased from 2001 when the epilimnetic TP averaged 0.027 mg/L and the hypolimnetic TP averaged 0.211 mg/L. The 2006 average TP concentration was 0.018 mg/L in the epilimnion and 0.172 mg/L in the hypolimnion.

Conductivity is a measurement of water's ability to conduct electricity and is correlated with chloride (Cl^-) concentrations. The Lake County epilimnetic median conductivity reading was 0.7948 milliSiemens/cm (mS/cm). During 2006, the Timber Lake average epilimnetic conductivity reading was lower, at 0.59996 mS/cm. This was a slight increase from the 2001 average of 0.5027 mS/cm. The Cl^- concentration in Timber Lake was also lower than the Lake County epilimnetic median of 171 mg/L during 2006, with a seasonal epilimnetic average of 43 mg/L. In addition, the hypolimnetic average was the lowest in the county at 41mg/L. The county hypolimnetic median was 116 mg/L.

There were a total of 12 plant species and one macro-algae found in Timber Lake. The most common species was Eurasian Watermilfoil (EWM) at 52% of the sampling sites, while White Water Lily was the second most abundant species at 50% of the sampling sites. In 2001 White Water Lily was the most common aquatic plant and EWM was found only in a small pocket on the southwestern portion of the lake.

LAKE FACTS

Lake Name:	Timber Lake (N)
Historical Name:	Huntley Lake, Old Huntley Lake, and Pollack Lake
Nearest Municipality:	Antioch
Location:	T46N, R10E, Section 23, NE 1/4
Elevation:	756.0 feet
Major Tributaries:	None
Watershed:	Des Plaines River
Sub-watershed:	North Mill Creek
Receiving Waterbody:	North Mill Creek
Surface Area:	33.4 acres
Shoreline Length:	1.1 miles
Maximum Depth:	36.0 feet
Average Depth:	18.0 feet (estimated)
Lake Volume:	600.5 acre-feet (estimated)
Lake Type:	Glacial
Watershed Area:	412.1 acres
Major Watershed Land Uses:	Agriculture, Forest and Grasslands, and Wetlands
Bottom Ownership:	LCFPD, Private
Management Entities:	LCFPD
Current and Historical Uses:	Fishing, aesthetics, swimming
Description of Access:	Access available through Raven Woods Forest Preserve

SUMMARY OF WATER QUALITY

Water samples were collected monthly from May through September at the deepest point in the lake (Figure 1, Appendix A). Timber Lake was sampled at depths of three feet and 30 to 31 feet depending on water level and the samples were analyzed for various water quality parameters (Appendix C). In addition, Timber Lake has participated in the Volunteer Lake Monitoring Program (VLMP) since 2005.

Timber Lake was thermally stratified from May through September. Thermal stratification is when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold-water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically experiences anoxic conditions (where DO concentrations drop below 1 mg/L) by mid-summer. In 2006, Timber Lake was weakly stratified in May and strongly stratified by June (at approximately the 8 – 10 feet). The thermocline (the transitional region between the epilimnion and the hypolimnion) remained strong through the season. Turnover was beginning during the September sampling, although the thermocline was still present at approximately 19 – 20 feet.

A dissolved oxygen (DO) concentration of 5.0 mg/L is considered adequate to support a sunfish/bass fishery, since these fish can suffer oxygen stress below this amount. DO concentrations in the epilimnion did not indicate any significant problems (Appendix B). Anoxic conditions existed from May through September in the hypolimnion. This is a normal phenomenon in large, deep lakes that stratify. The anoxic boundary was at 18 – 19 feet for the entire sampling season. Since an accurate bathymetric map with volumetric calculations does not exist for Timber Lake it was impossible to determine the volume of the lake that was anoxic during 2006.

Secchi disk depth (water clarity) averaged 10.35 feet during 2006 and 7.12 feet during 2001 (Table 1). Both of these readings were above the Lake County median of 3.27 feet (Appendix E). The VLMP average Secchi depth decreased from 13.58 feet in 2005 to 10.18 feet in 2006 (Figure 2). The increase in water clarity from 2001 was correlated with a decrease in total suspended solids (TSS) in the water column (Figure 3). TSS is composed of nonvolatile suspended solids, non-organic clay or sediment materials, and volatile suspended solids, algae and other organic matter. In 2006 the average TSS in the epilimnion was 2.4 mg/L while in 2001 it averaged 4.1 mg/L. Both values were below the county median of 7.9 mg/L.

Another factor affecting water clarity was the amount of nutrients in the water. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant and/or algal growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting, ratios greater than or equal to 15:1 indicate phosphorus is limiting, and ratios greater than 10:1, but less than 15:1 indicate there are enough of both nutrients to facilitate excess algae or plant growth. Timber Lake had a TN:TP ratio of 41:1 in 2001 and 59:1 in 2006, indicating the lake was highly phosphorous limited. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of

Figure 1. Water quality sampling site on Timber Lake, 2006.

Table 1. Water quality data for Timber Lake, 2001 and 2006.

2006	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
10-May	3	210	1.20	<0.1	0.177	0.027	<0.005	41	NA	4.5	395	124	4.46	0.6130	NA	12.80
14-Jun	3	191	0.98	<0.1	<0.05	0.012	<0.005	42	NA	1.7	293	140	12.53	0.5870	8.16	9.80
12-Jul	3	192	1.01	<0.1	<0.05	0.015	<0.005	43	NA	1.6	393	136	12.10	0.5930	7.77	7.58
09-Aug	3	192	1.02	<0.1	<0.05	0.016	<0.005	45	NA	2.5	389	129	8.86	0.6030	8.54	8.55
13-Sep	3	195	0.92	<0.1	<0.05	0.020	<0.005	45	NA	1.8	370	118	13.81	0.6020	8.15	6.80
	Average	196	1.03	<0.1	0.177[k]	0.018	<0.005	43	NA	2.4	368	129	10.35	0.5996	8.16[a]	9.11

2001	**Epilimnion**															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
15-May	3	211	1.35	<0.1	<0.05	0.056	0.008	NA	314	9.9	336	111	2.72	0.5106	8.24	9.19
25-Jun	3	219	1.25	<0.1	<0.05	0.029	<0.005	NA	332	3.5	352	134	7.74	0.5093	8.32	8.78
30-Jul	3	204	1.09	<0.1	<0.05	0.016	<0.005	NA	320	2.1	332	125	9.65	0.4980	8.06	7.59
27-Aug	3	198	0.90	<0.1	<0.05	0.016	<0.005	NA	302	2.7	345	145	5.60	0.4944	8.07	7.60
24-Sep	3	206	0.96	<0.1	<0.05	0.018	<0.005	NA	298	2.4	322	113	9.88	0.5011	7.88	6.88
	Average	208	1.11	<0.1	<0.05	0.027	0.008[k]	NA	313	4.1	337	126	7.12	0.5027	8.11	8.01

Glossary

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

a = Does not include May due to bad pH probe
k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable
* = Prior to 2006 only Nitrate - nitrogen was analyzed

Table 1. Continued.

2006	Hypolimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
10-May	31	216	2.01	1.010	0.550	0.081	0.060	38	NA	2.3	369	114	NA	0.6215	NA	0.27
14-Jun	30	239	3.48	2.490	<0.05	0.190	0.139	41	NA	4.0	412	139	NA	0.6290	7.53	0.09
12-Jul	30	253	4.12	3.000	<0.05	0.143	0.090	41	NA	4.5	393	121	NA	0.6410	7.24	0.21
09-Aug	30	265	5.38	4.010	<0.05	0.259	0.182	42	NA	4.8	396	123	NA	0.6610	7.27	0.11
13-Sep	30	263	4.74	1.770	<0.05	0.186	0.126	41	NA	4.8	400	128	NA	0.6760	7.24	0.14
	Average	247	3.95	2.456	0.550[k]	0.172	0.119	41	NA	4.1	394	125	NA	0.6457	7.32[a]	0.16

2001	Hypolimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
15-May	28	285	3.67	2.850	<0.05	0.068	0.027	NA	394	4.2	417	154	NA	0.6542	6.69	0.00
25-Jun	30	297	4.85	3.610	<0.05	0.157	0.123	NA	404	3.1	426	156	NA	0.6329	6.70	0.05
30-Jul	30	313	5.54	4.440	<0.05	0.215	0.167	NA	408	3.7	421	188	NA	0.6509	6.47	0.00
27-Aug	29	327	5.66	5.380	<0.05	0.224	0.153	NA	384	2.3	415	132	NA	0.6697	6.43	0.01
24-Sep	31	343	7.86	6.760	<0.05	0.392	0.297	NA	394	3.7	407	116	NA	0.6880	6.58	0.01
	Average	313	5.52	4.608	<0.05	0.211	0.153	NA	397	3.4	417	149	NA	0.6591	6.57	0.01

Glossary

ALK = Alkalinity, mg/L $CaCO_3$
TKN = Total Kjeldahl nitrogen, mg/L
NH_3-N = Ammonia nitrogen, mg/L
NO_2+NO_3-N = Nitrate + Nitrite nitrogen, mg/L
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SECCHI = Secchi disk depth, ft.
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a = Does not include May due to bad pH probe
k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable
* = Prior to 2006 only Nitrate - nitrogen was analyzed

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

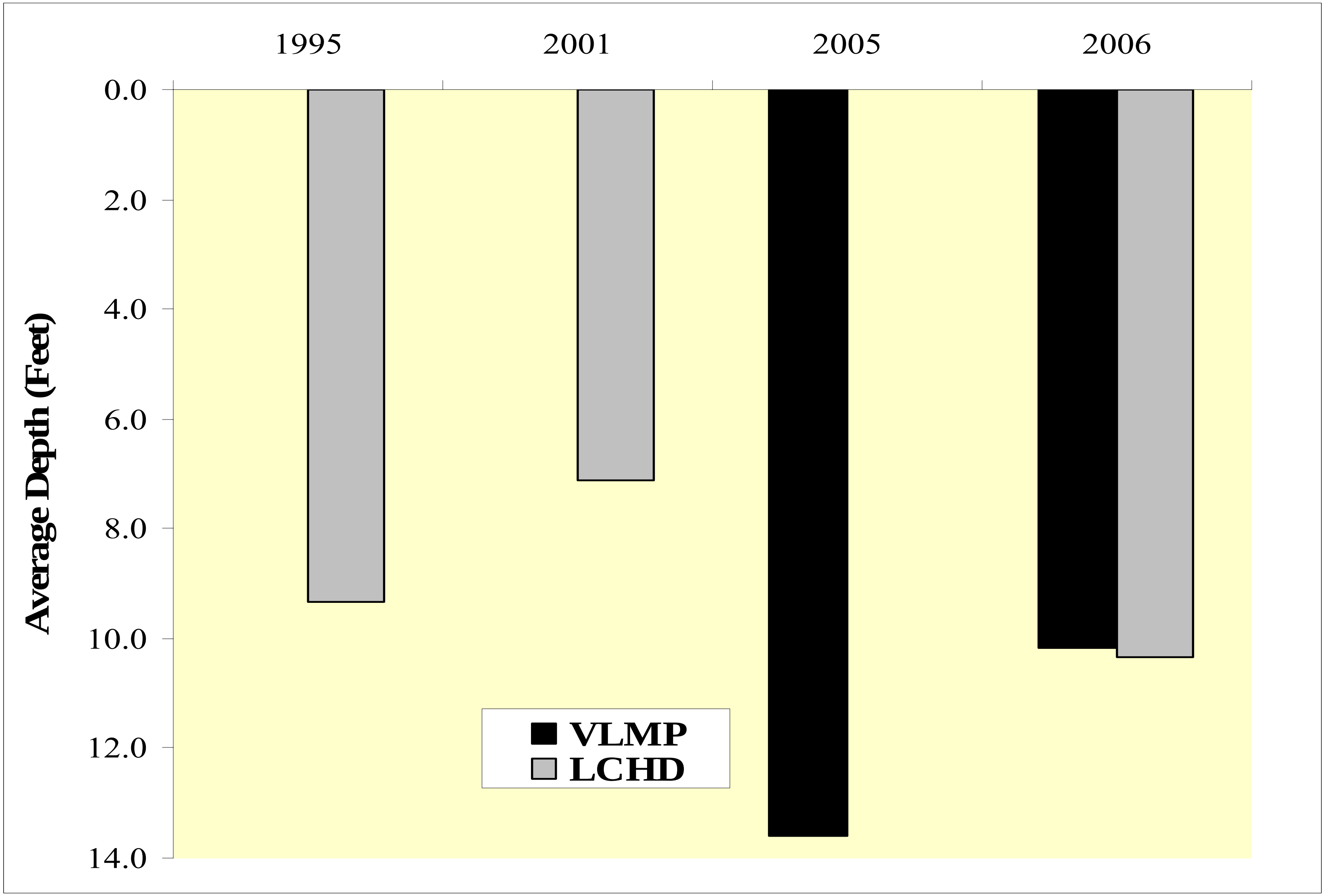
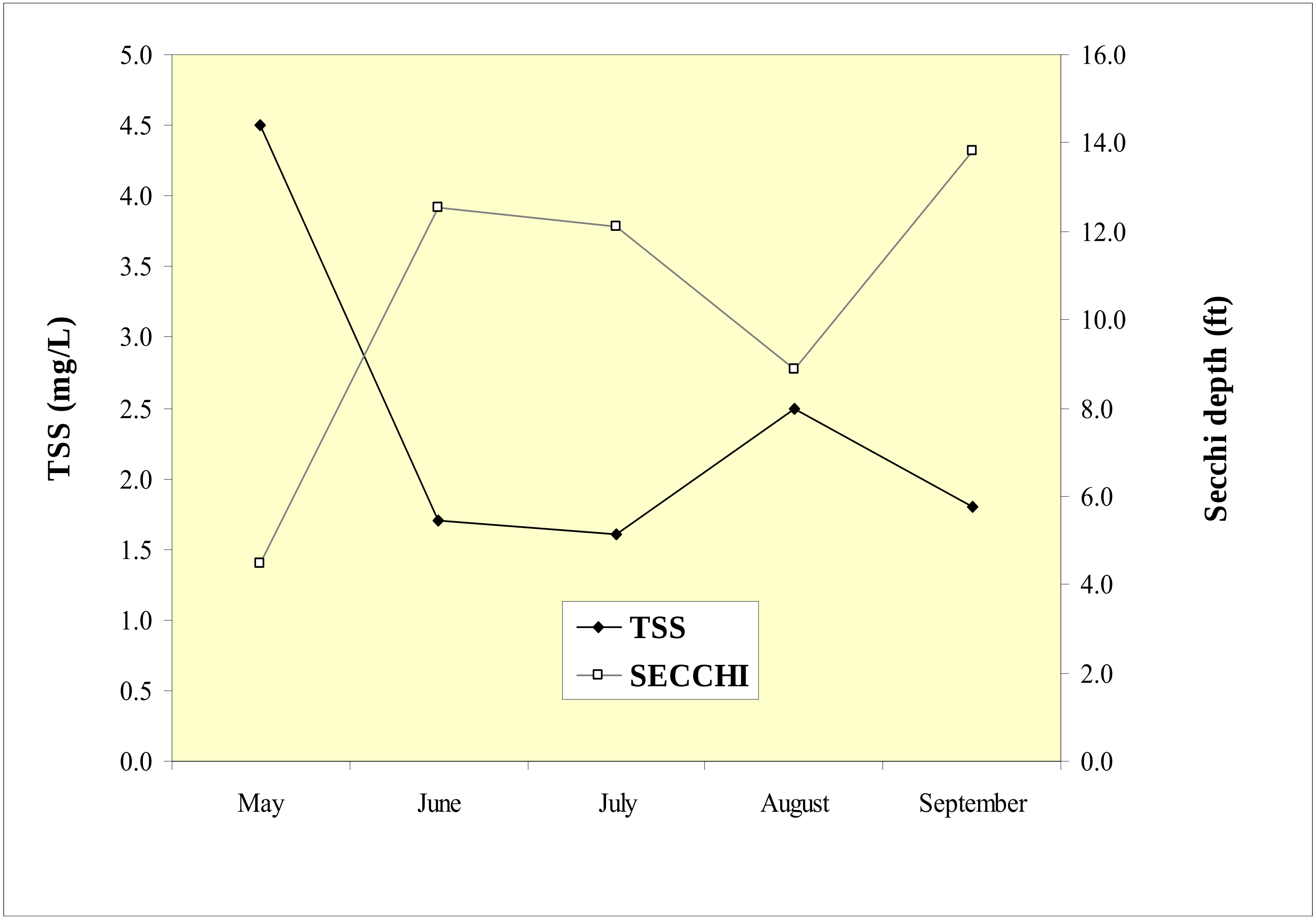


Figure 3. Total suspended solid (TSS) concentrations vs. Secchi depth for Timber Lake, 2006.



sources (soil, air, etc.), which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon.

Total Kjeldahl nitrogen (TKN) concentration averages for both the epilimnion and hypolimnion in 2006 decreased from 2001. The near surface samples in 2001 had a TKN average of 1.11 mg/L, which decreased slightly to 1.03 mg/L in 2006. The TKN averages in the hypolimnion decreased from 5.516 mg/L in 2001 to 3.95 mg/L in 2006. Ammonia nitrogen (NH_3-N) concentrations also decreased in the hypolimnion from an average of 4.608 mg/L in 2001 to 2.456 mg/L in 2006, the epilimnetic concentrations were below the detection limit in 2001 and 2006.

Total phosphorus (TP) concentrations in 2006 in Timber Lake averaged lower than the Lake County epilimnetic median of 0.060 mg/L and higher than the hypolimnetic median of 0.163 mg/L. The TP has decreased since 2001 when the epilimnetic TP averaged 0.027 mg/L and the hypolimnetic TP averaged 0.211 mg/L. The 2006 average TP concentration was 0.018 mg/L in the epilimnion and 0.172 mg/L in the hypolimnion. TP concentrations in the hypolimnion increased from May through August. As the thermocline weakened in September, the hypolimnion mixed with the epilimnion which caused the TP concentrations to become uniform throughout the water column.

There were external sources of TP affecting Timber Lake such as stormwater from the 412.07 acres within its watershed (Figure 4). Agriculture (33%), forest and grassland (16%), and wetland (14%) were the major land uses within the watershed (Figure 5). For Timber Lake single family (24%) and agriculture (20%) were the land uses contributing the highest percentages of estimated runoff (Table 2). It is important to keep in mind that although the amount of estimated runoff from certain areas may be low, they can still deliver high concentrations of TSS and TP. Cattle allowed to enter the lake were likely contributing to the phosphorous loading of Timber Lake. A fence should be erected to keep the cattle out of the lake. The retention time (the amount of time it takes for water entering a lake to flow out of it again) was calculated to be approximately 6.27 years.

Total phosphorous can be used to calculate the trophic state index (TSIp), which classifies lakes according to the overall level of nutrient enrichment. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those with excessive nutrients, nuisance algae growth reminiscent of “pea soup,” and have a TSI score greater than 70. Lakes with a TSI score of 50 or greater are classified as eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae. Mesotrophic and oligotrophic lakes have lower nutrient levels. These are very clear lakes, with little algal growth. Most lakes in Lake County are eutrophic. The trophic state of Timber Lake in terms of its phosphorus concentration during 2001 was eutrophic, with a TSIp score of 51.7. In 2006 the TSIp score was lower at 45.8, which classified Timber Lake as mesotrophic and ranked 6th out of 162 lakes in Lake County based on average TP concentrations (Table 3).

The Illinois Environmental Protection Agency (IEPA) has assessment indices to classify Illinois lakes for their ability to support aquatic life, swimming, and recreational uses. The guidelines

Figure 4. Approximate watershed delineation for Timber Lake, 2006.

Figure 5. Approximate land use within the Timber Lake watershed, 2006.

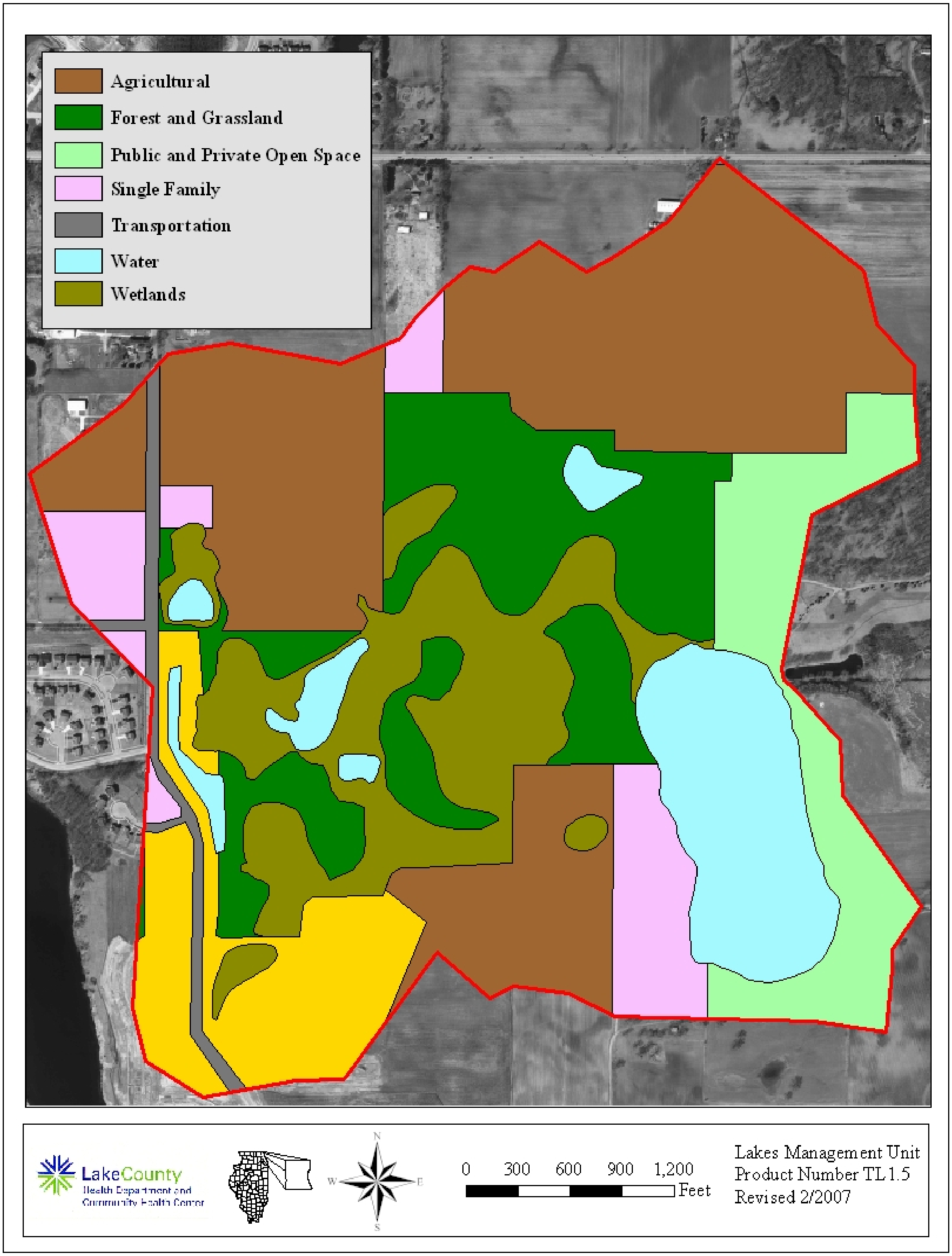


Table 2. Approximate land uses and retention time for Timber Lake, 2006.

Land Use	Acreage	% of Total
Agricultural	136.57	33.1%
Disturbed Land	36.52	8.9%
Forest and Grassland	65.76	16.0%
Public and Private Open Space	37.03	9.0%
Single Family	27.29	6.6%
Transportation	7.26	1.8%
Water	42.40	10.3%
Wetlands	59.24	14.4%
Total Acres	**412.07**	**100.0%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	136.57	0.05	18.8	19.6%
Disturbed Land	36.52	0.05	5.0	5.2%
Forest and Grassland	65.76	0.05	9.0	9.4%
Public and Private Open Space	37.03	0.15	15.3	16.0%
Single Family	27.29	0.30	22.5	23.5%
Transportation	7.26	0.85	17.0	17.7%
Water	42.40	0.00	0.0	0.0%
Wetlands	59.24	0.05	8.1	8.5%
TOTAL	**412.07**		**95.7**	**100.0%**

Lake volume	**600.48**	**acre-feet**
Retention Time (years)= lake volume/runoff	**6.27**	**years**
	2289.11	**days**

Table 3. Lake County average TSI phosphorous (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 Kathyrn	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

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
44	Diamond Lake	0.0372	56.30
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

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
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

Table 3. Continued.

RANK	LAKE NAME	TP AVE	TSIp
130	Forest Lake	0.1422	75.63
131	Antioch Lake	0.1448	75.89
132	Valley Lake	0.1470	76.11
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

consider several aspects, such as water clarity, phosphorus concentrations (TSIp), and aquatic plant coverage. According to this index, Timber Lake provides *Full* support of aquatic life and *Partial* support of swimming and recreational activities as a result of moderate TP concentrations. The lake provides *Partial* overall use.

Conductivity is a measurement of water's ability to conduct electricity and is correlated with chloride (Cl^-) concentrations (Figure 6). Compared to lakes in undeveloped areas, lakes with residential and/or urban land uses in their watershed often have higher conductivity readings and higher Cl^- concentrations because of the use of road salts. Stormwater runoff from impervious surfaces such as roads and parking lots can deliver high concentrations of this Cl^- to nearby waterbodies. The Lake County epilimnetic median conductivity reading was 0.7948 milliSiemens/cm (mS/cm). During 2006, the Timber Lake average epilimnetic conductivity reading was lower, at 0.5996 mS/cm. This was a slight increase from the 2001 average of 0.5027 mS/cm. The hypolimnetic averages were also lower than the county median of 0.8285mS/cm both in 2001 (0.6591 mS/cm) and 2006 (0.6457 mS/cm). In addition, Cl^- concentration in Timber Lake was lower than the Lake County epilimnetic median of 171 mg/L during 2006, with an epilimnetic average of 43 mg/L. Furthermore, the hypolimnetic average was the lowest in the county at 41 mg/L. The county hypolimnetic median was 116 mg/L. 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. Therefore, lakes can be negatively impacted by the high Cl^- concentrations.

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in July of 2006. Sampling sites were based on a grid system created by mapping software (ArcMap), with each site located 30 meters apart for a total of 148 sites. Eighty-two sites were sampled and plants were found at 55 sites (Figure 7), at a maximum depth of 13.9 feet (Table 4a, b). Overall, a total of 12 plant species and one macro-algae were found (Table 5). The most common species was Eurasian Watermilfoil (EWM) at 52% of the sampling sites, while White Water Lily was the second most abundant species at 50% of the sampling sites. In 2001 White Water Lily was the most common aquatic plant and EWM was found only in a small pocket on the southwestern portion of the lake. LMU has monitored the expansion of EWM since its discovery in 2001. In 2003, it had spread to several others areas of the lake and has only continued to expand (Figure 8). Species composition was greater in 2001 when 18 plant species and one macro-algae were found. The EWM expanding and the species composition decreasing is a concern. Two exotic aquatic plants, EWM and Curlyleaf Pondweed, were found in Timber Lake. Both of these exotics compete with native plants, eventually crowding them out, providing little or poor natural diversity in addition to limited uses by wildlife. Removal or control of exotic species is recommended. To maintain a healthy sunfish/bass fishery, the optimal plant coverage is 30% to 40% across the lake bottom. It was calculated that approximately 37% of the lake bottom was covered by plants and it was calculated that 29% of the lake bottom was covered with EWM. It is recommended that the LCFPD cooperate with the other two land owners and conduct a low-

Figure 6. Chloride (Cl^-) concentration vs. conductivity for Timber Lake, 2006.

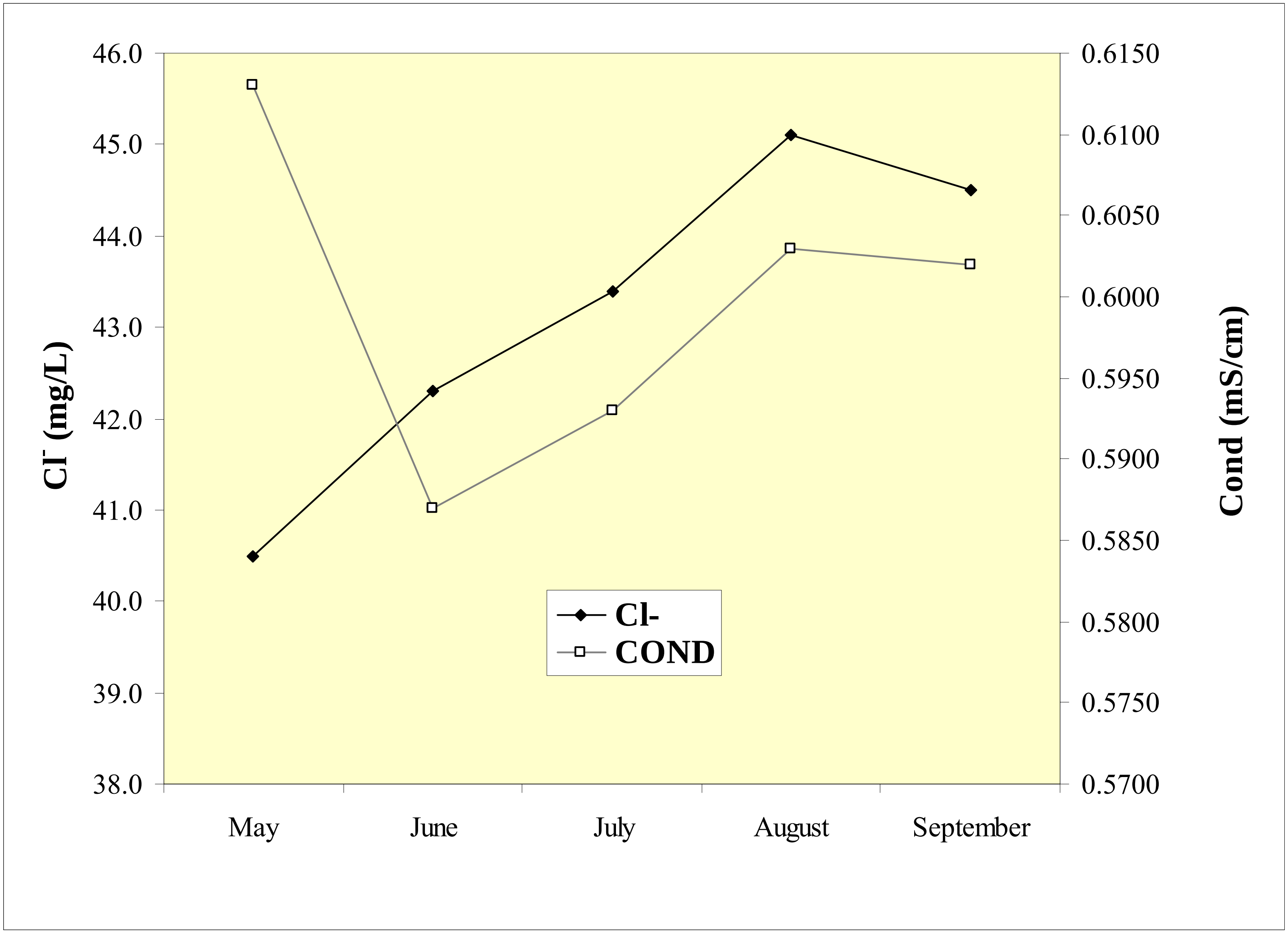


Figure 7. Aquatic plant sampling grid that illustrates plant density on Timber Lake, July 2006.

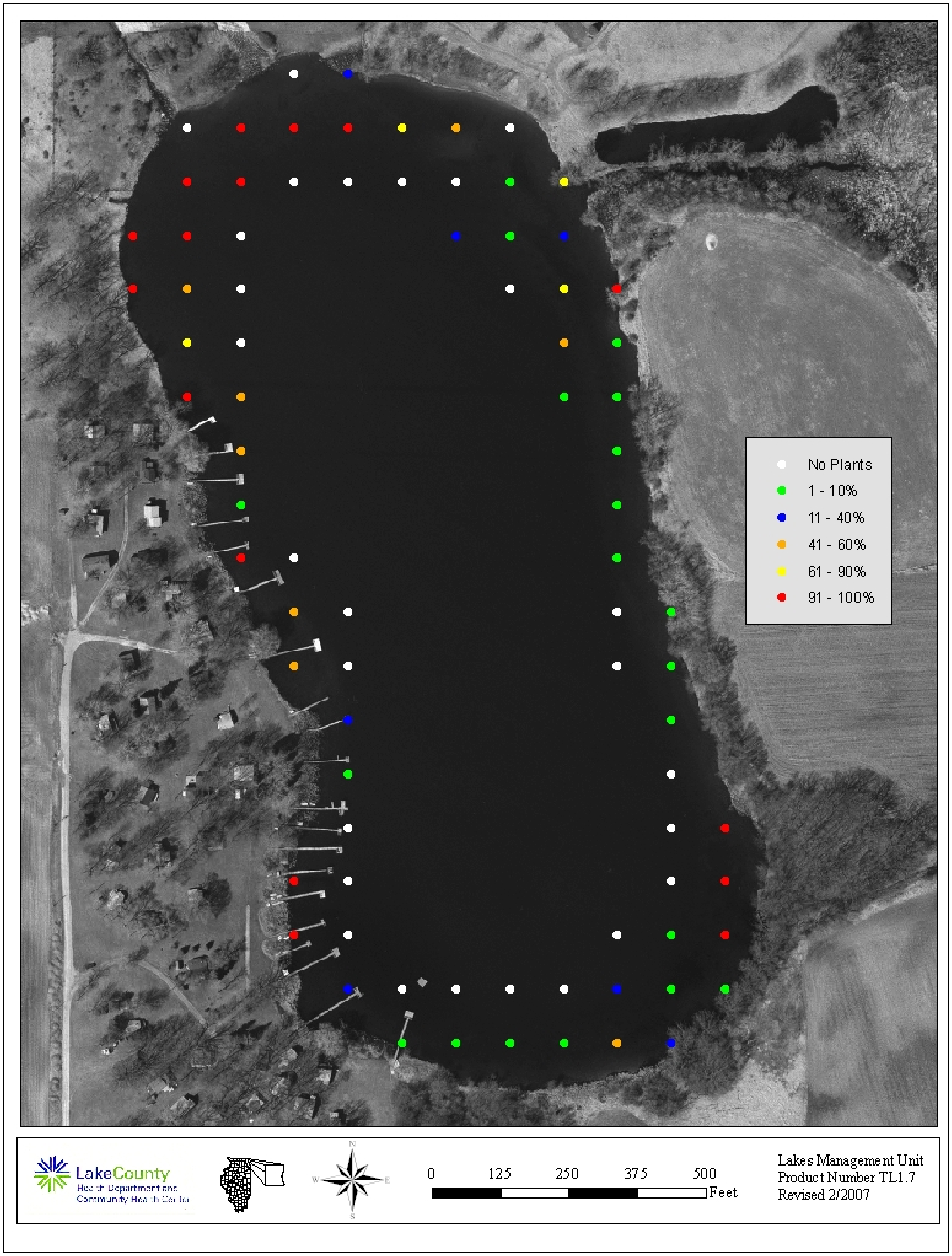


Table 4a. Aquatic plant species found at the 82 sampling sites on Timber Lake, July 2006. Maximum depth that plants were found was 13.9 feet.

Plant Density	American Pondweed	Bladderwort	Chara	Coontail	Curlyleaf Pondweed	Eurasian Watermilfoil	Floating Leaf Pondweed	Illinois Pondweed	Largeleaf Pondweed	Sago Pondweed	Spatterdock	Vallisneria	White Water Lily
Absent	71	65	65	73	80	39	70	66	78	44	76	76	41
Present	9	16	13	4	2	15	11	13	4	31	2	6	22
Common	2	1	4	2	0	10	1	3	0	7	3	0	5
Abundant	0	0	0	1	0	10	0	0	0	0	1	0	9
Dominant	0	0	0	2	0	8	0	0	0	0	0	0	5
% Plant Occurrence	13.4	20.7	20.7	11.0	2.4	52.4	14.6	19.5	4.9	46.3	7.3	7.3	50.0

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

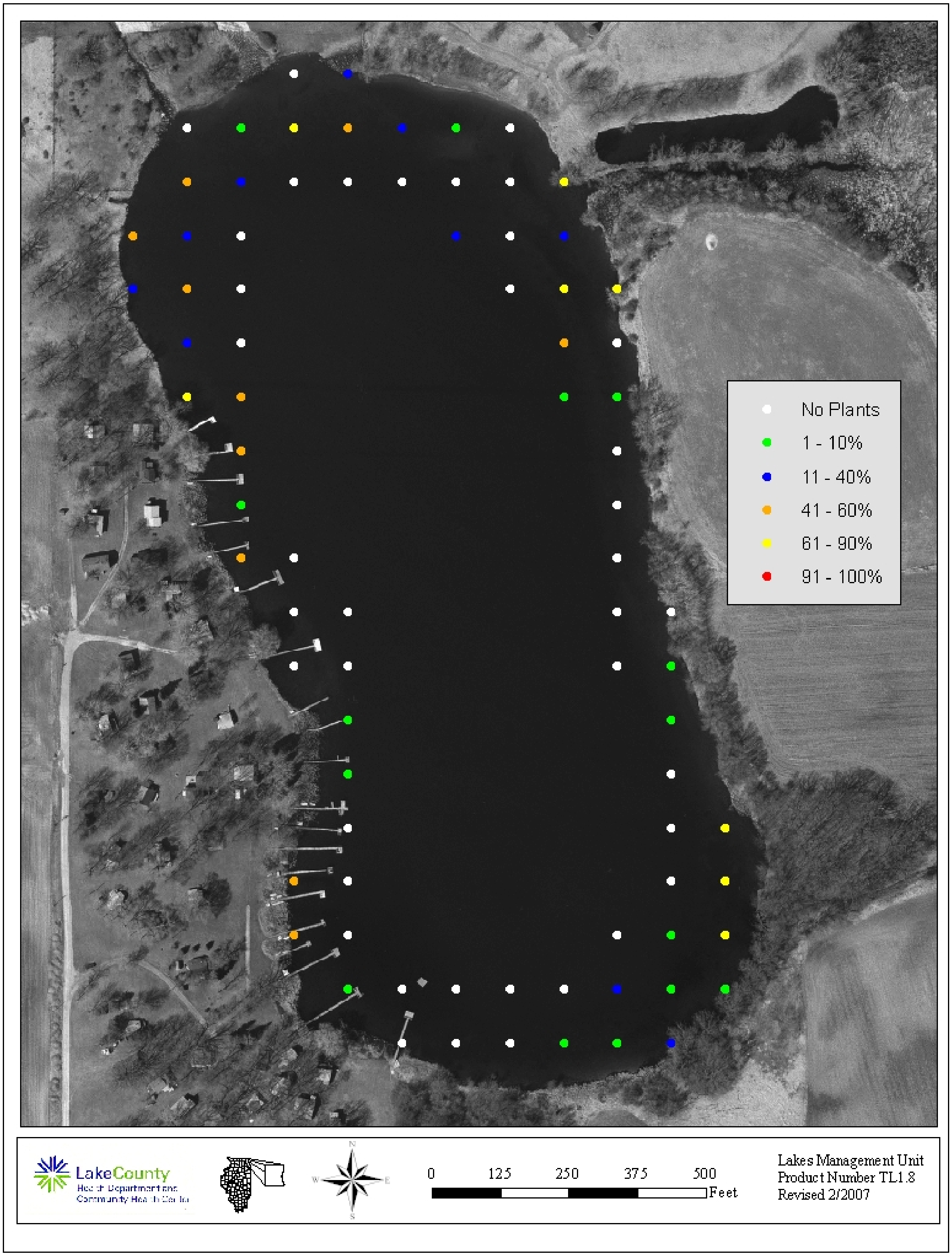
Rake Density (Coverage)	# of Sites	%
No plants	27	32.9
>0 to 10%	20	24.4
>10 to 40%	7	8.5
>40 to 60%	8	9.8
>60 to 90%	4	4.9
>90%	16	19.5
Total Sites with Plants	55	67.1
Total # of Sites	82	100.0

Table 5. Aquatic plant species found in Timber Lake in 2006.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara* spp.
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Largeleaf Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed^	*Potamogeton crispus*
Illinois Pondweed	*Potamogeton illinoensis*
Floatingleaf Pondweed	*Potamogeton natans*
American Pondweed	*Potamogeton nodosus*
Sago Pondweed	*Potamogeton pectinatus*
Common Bladderwort	*Utricularia vulgaris*
Eel Grass	*Vallisneria americana*

^ Exotic plant

Figure 8. Aquatic plant sampling grid that illustrates Eurasian Watermilfoil density on Timber Lake, July 2006.



dose, early season floridone herbicide treatment to reduce the EWM in the lake. The LCHD will provide a bathymetric map as part of the in-kind costs toward the project.

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize in water depths with less than 1% of the available sunlight. During 2006, the 1% light level was available down to 12 feet deep in May and increased throughout the remaining months. During June and July the 1% light level was 22 feet and 20 feet and due to a sensor malfunction, there was not a reading in August or September. Even though the 1% light level was 20 feet, plants were only found down to 13.9 feet in July. This could be due to other factors limiting plant growth in Timber Lake such as substrate type and the rapid depth changes. Along the southern and eastern near shore areas the substrate consists of more sand than silt or muck and the plants were scattered closer to the shore. The morphometry of Timber Lake is such that the depth increases dramatically relatively close to the southern and western shores.

The Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (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 indicate that there were large numbers of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2006 Lake County lakes was 13.6 (Table 6). Timber Lake had a FQI of 20.8 in 2006. This was a decrease from 2001 when the FQI was 25.5. However, the change in the aquatic plant sampling procedure could be a potential reason for this decrease. Also, plant community composition varied from year to year. In addition, the EWM could be out competing some of the native species.

Plankton is microscopic plants and animals that are free-floating within the water column. Samples were collected during water quality testing and analyzed for species content. *Aphanizomenon*, a blue-green algae species, was the dominant phytoplankton May through September, 2006 (Figure 9). Rotifers dominated the zooplankton community in Timber Lake in 2006 (Figure 10).

SUMARY OF SHORELINE CONDITION

Lakes with stable water levels potentially have less shoreline erosion problems. Fluctuating water levels do not appear to be an issue on Timber Lake. The highest level was found in May with the lowest level in August. The total water level decreased by 4.38 inches from May to August.

In 2001 an assessment was conducted to determine the condition of the shoreline at the water/land interface. Most of the shoreline remained undeveloped (57%). Of the developed

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

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	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
43	Grand Avenue Marsh	16.9	18.7

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
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
86	Lake Matthews	12.0	12.0

Table 6. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
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
	Mean	**13.6**	**14.9**
	Median	**12.5**	**14.3**

Figure 9. Phytoplankton counts for Timber Lake, 2006.

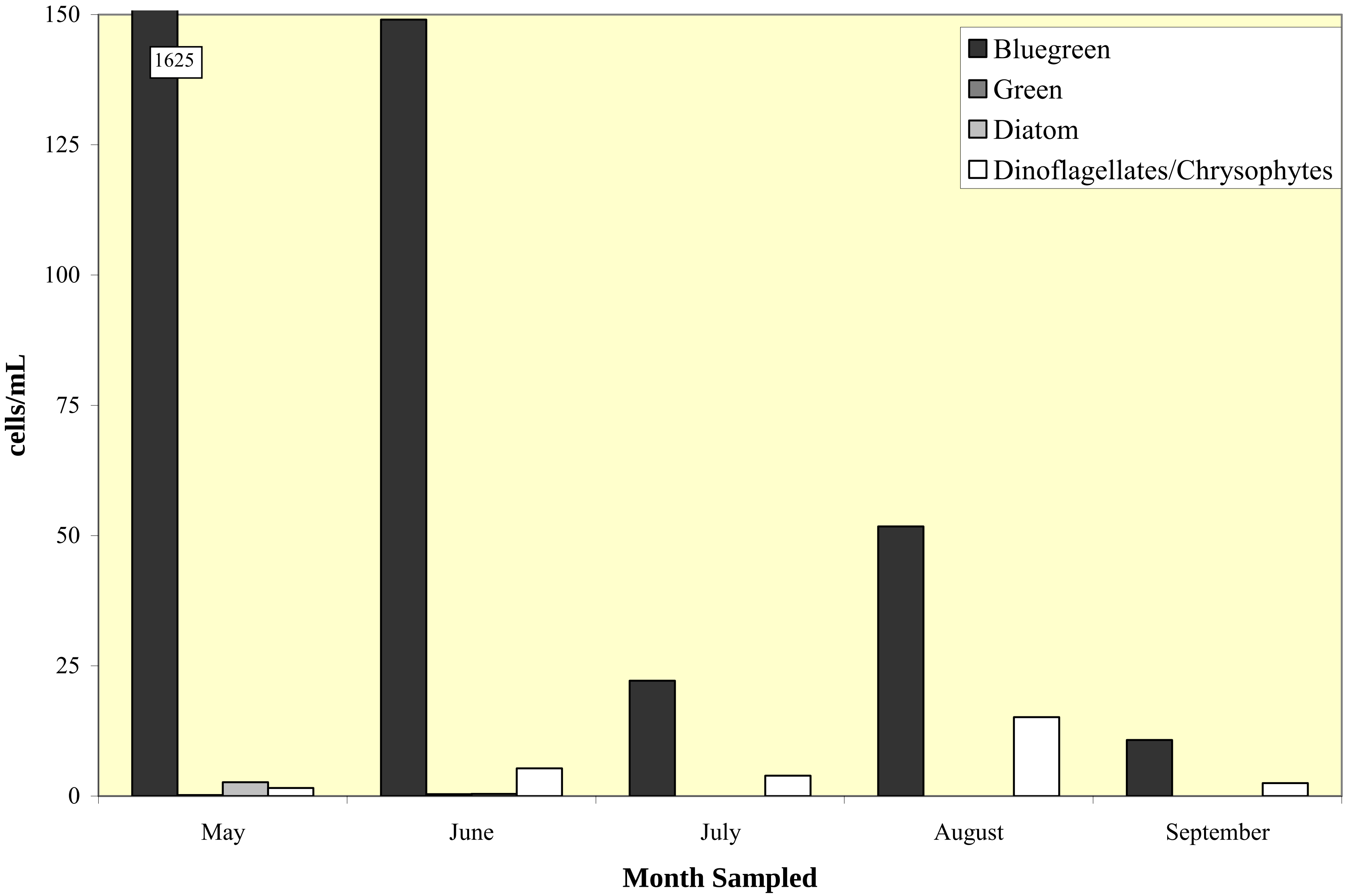
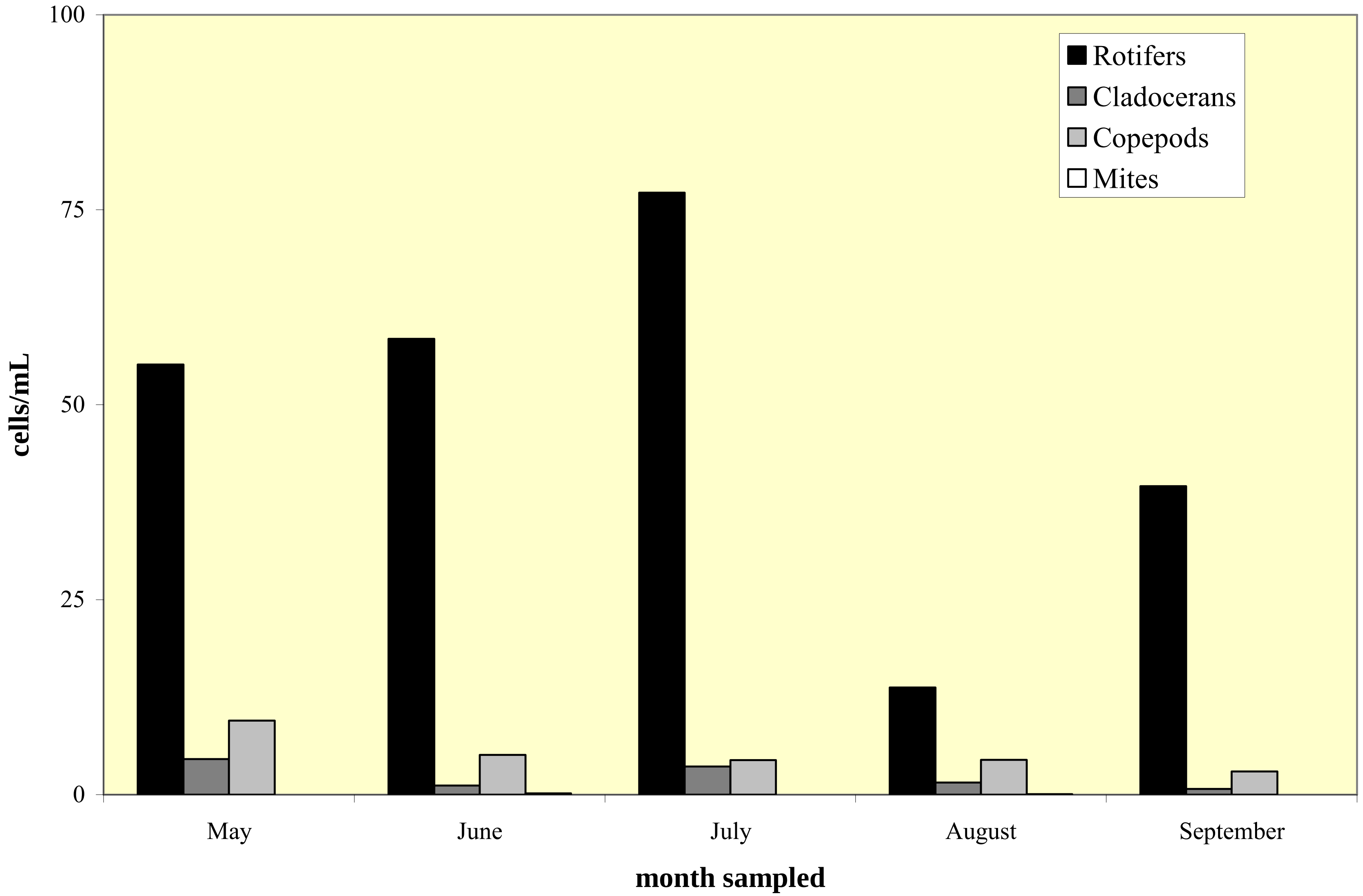


Figure 10. Zooplankton counts for Timber Lake, 2006.



shoreline, the majority had good buffer strips of native vegetation that help prevent shoreline erosion and add wildlife habitat. However, there were some nonnative aggressive plants growing within the buffer strips and other locations along the shoreline. These included Purple Loosestrife, Reed Canary Grass and Buckthorn.

In 2001, the shoreline was also assessed for the degree of erosion. The north shore, where an agricultural area meets the lake, was severely eroded due to cattle entering and leaving the lake. This represented less than 5% of the total shoreline, and was the only area classified as severely eroded. No sections of shoreline were moderately eroded and 23.4% of the total shoreline was slightly eroded. The shoreline was reassessed in 2006 for significant changes in erosion since the 2001. Based on the 2006 assessment, there was an area of slight erosion near the outlet that had been repaired. However, an area long the east shore was reclassified from none to slight (Figure 11). Overall, 63% of the shoreline had no erosion, 33% had slight erosion, and 4% had severe erosion. The area of severe erosion should be addressed soon. Cattle entering the lake likely caused the severe erosion. To protect the shoreline and preserve the lake a fence should be erected to keep the cattle out of the lake.

It is much easier and less costly to mitigate slightly eroding shorelines than those with more severe erosion. If these shorelines are repaired by the installation of a buffer strip with native plants, the benefits can be three-fold. First, the erosion is repaired and the new native plants can stabilize the shoreline to prevent future erosion. Second, the addition of native plants adds habitat for wildlife to a shoreline that is otherwise limited in habitat. Thirdly, buffer habitat can help filter pollutants and nutrients from the near shore areas and keep geese and gulls from congregating, as it is not desirable habitat for them.

SUMMARY OF WILDLIFE AND HABITAT

Timber Lake is located in a rural setting with the shoreline mainly undeveloped. This provides excellent habitat for a variety of birds, mammals, and other wildlife. Good numbers of wildlife, particularly birds, were noted on and around Timber Lake (Table 7). The Sandhill Crane, a threatened species in Illinois, was noted in both 2001 and 2006.

Habitat around Timber Lake was good. The undeveloped areas had a mix of open fields and small woods. Deadfalls were located along the southern and eastern shorelines providing habitat for many species. The developed areas provided some habitat in the form of the buffer strips located between the lake and manicured lawns. Increasing the widths of the buffer strips would provide more habitats for wildlife and help reduce future inputs of nutrients and pollutants. Additional habitat was created by LCFPD as they convert the old campground and adjacent farm fields on the eastern shoreline to natural areas.

In 2003, the Lakes Management Unit with the Max McGraw Wildlife Foundation found the Iowa Darter, endangered in Illinois, during a non-game fish survey. The most common species collected were Brook Silverside, Bluegill, Bluntnose Minnow, and Largemouth Bass. Also found during the survey were Black Crappie, Green Sunfish, Johnny Darter, Yellow Perch, and Yellow Bass. Catch and release only fishing is allowed through the LCFPD Raven Woods access.

Figure 11. Shoreline erosion on Timber Lake, 2006.

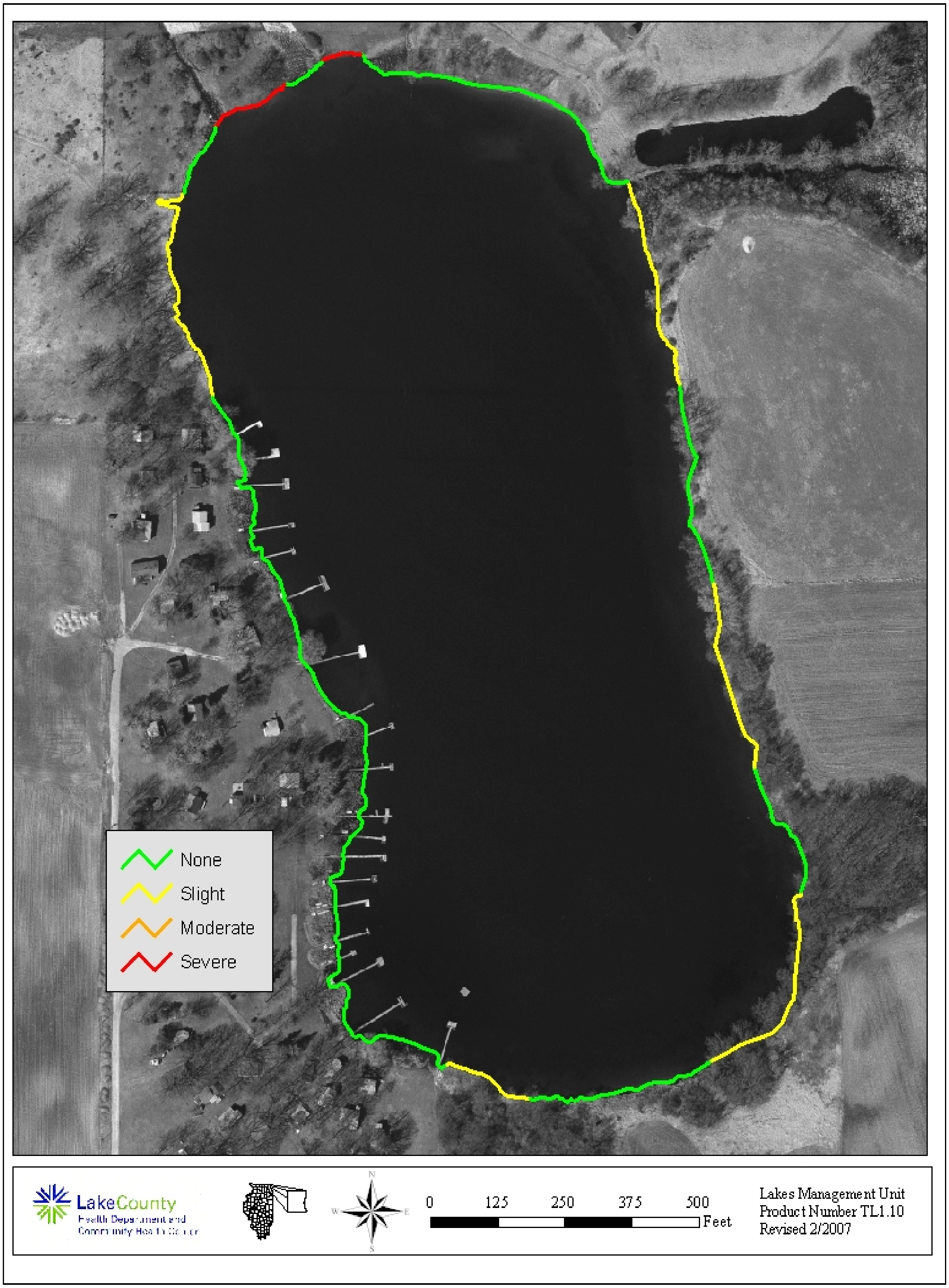


Table 7. Wildlife species observed around Timber Lake, May – September 2006.

Birds	
Sandhill Crane+	*Grus canadensis*
Common Flicker	*Colaptes auratus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
American Crow	*Corvus brachyrhynchos*
Blue Jay	*Cyanocitta cristata*
Black-capped Chickadee	*Poecile atricapillus*
House Wren	*Troglodytes aedon*
Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Warbling Vireo	*Vireo gilvus*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat	*Geothlypis trichas*
Red-winged Blackbird	*Agelaius phoeniceus*
Brown-headed Cowbird	*Molothrus ater*
Common Grackle	*Quiscalus quiscula*
Starling	*Sturnus vulgaris*
Northern Oriole	*Icterus galbula*
Northern Cardinal	*Cardinalis cardinalis*
Song Sparrow	*Melospiza melodia*
Mammals	
Gray Squirrel	*Sciurus carolinensis*
Amphibians	
American Toad	*Bufo americanus*
Mussels	
Asian Clam*	*Corbicula fluminea*

* Exotic Species
+Threatened species in Illinois

LAKE MANAGEMENT RECOMMENDATIONS

Timber Lake has both positive and negative aspects. Some of the positives include a large portion of the shoreline being undeveloped providing good wildlife habitat, having the LCFPD involved in the management activities of the lake, and participation in the VLMP. Timber Lake has participated in the VLMP since 2005 providing valuable data from the years the LMU did not sample the lake. In addition to continuing to collect the VLMP data, the LMU recommends installing staff gauge to monitor the lake water level. To improve the quality of Timber Lake, the LMU has the following recommendations:

Creating a Bathymetric Map

Creating an updated bathymetric map can help with improvements to Timber Lake. A bathymetric map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management (Appendix D1). The LMU would be willing to create this map at no cost if the LCFPD agrees to conduct an early, under the ice EWM treatment study.

Aquatic Pant Management

A key to a healthy lake is a well-balanced aquatic plant population. Aquatic plants compete with algae for nutrients and stabilize bottom substrate, which in turn improves water clarity. Putting together a good aquatic plant management plan should not be rushed. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. Follow up is critical for an aquatic plant management plan to achieve long-term success. A good aquatic plant management plan considers both the short and long-term needs of the lake (Appendix D2). Approximately 29% of Timber Lake's bottom was covered with EWM. The plant diversity has decreased since 2001 and EWM's abundance has increased. Timber Lake had good plant diversity before the introduction of EWM and it is expected to return if EWM can be eliminated or controlled. The LMU would be willing to create this map if the LCFPD agrees to conduct an early, under the ice EWM treatment study.

Eliminate or control exotic species

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. The outcome is a loss of plant and animal diversity. Plants such as Purple Loosestrife (*Lythrum salicaria*), Buckthorn (*Rhamnus cathartica*), and Reed Canary Grass (*Phalaris arundinacea*) are three examples. During 2001 all of these were found along the shoreline and should be eliminated (Appendix D3).

Lakes with Shoreline Erosion

The area on the north side of the lake where the cattle enter and exit the lake was severely eroded. To protect the shoreline and preserve the lake a fence should be erected to keep the cattle out of the lake. This area should be addressed soon. All of the eroded areas should be remediated to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawalls (Appendix D4).

Assess Your Lake's Fishery

At this time little information about the fishery in Timber Lake is known. The LCFPD has installed several fishing piers which may increase the fishing pressure on the lake. A formal fisheries assessment should be conducted to determine the diversity and health of the fish community (Appendix D5).

Grant program opportunities

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

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

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

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.1) 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.

Shoreline Assessment

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

> None – Includes man-made erosion control such as beach, rip-rap and sea wall.
>
> Slight – Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as "slight".
>
> Moderate – Recession is characterized by past or recently eroded banks; area may exhibit some exposed roots, fallen vegetation or minor slumping of soil material; erosion control practices may be recommended although the section is not deemed to warrant immediate remedial action.
>
> Severe – Recession is characterized by eroding of exposed soil on nearly vertical banks, exposed roots, fallen vegetation or extensive slumping of bank material, undercutting, washouts or fence posts exhibiting realignment; erosion control practices are recommended and immediate remedial action may be warranted.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal.
Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical methods used for water quality parameters.

Parameter	***Method***
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate and Nitrite nitrogen	USEPA 353.2 rev. 2.0 EPA-600/R-93/100 Detection Limit = 0.05 mg/L
Ammonia nitrogen	SM 18th ed. Electrode method, #4500 NH_3-F Detection Limit = 0.1 mg/L
Total Kjeldahl nitrogen	SM 18th ed, 4500-N_{org} C Semi-Micro Kjeldahl, plus 4500 NH_3-F Detection Limit = 0.5 mg/L
pH	Hydrolab DataSonde® 4a, or YSI 6600 Sonde® Electrometric method
Total solids	SM 18th ed, Method #2540B
Total suspended solids	SM 18th ed, Method #2540D Detection Limit = 0.5 mg/L
Chloride	SM 18th ed, Method #4500C1-D
Total volatile solids	SM 18th ed, Method #2540E, from total solids
Alkalinity	SM 18th ed, Method #2320B, patentiometric titration curve method
Conductivity	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Total phosphorus	SM 18th ed, Methods #4500-P B 5 and #4500-P E Detection Limit = 0.01 mg/L
Soluble reactive phosphorus	SM 18th ed, Methods #4500-P B 1 and #4500-P E Detection Limit = 0.005 mg/L
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a or YSI 6600 Sonde®, LI-COR® 192 Spherical Sensor

APPENDIX B. MULTI-PARAMETER DATA FOR TIMBER (N) LAKE IN 2006.

Timber (N) Lake 2006 Multiparameter data

Date MMDDYY	Time HHMMSS	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 0.30
05/10/2006		0.5	0.486	17.70	12.39	130.3	0.6140	NA	1814.1	Surface		
05/10/2006		1	1.009	17.60	12.69	133.1	0.6140	NA	1617.5	Surface	100%	
05/10/2006		2	2.009	17.47	12.83	134.3	0.6140	NA	431.9	0.339	27%	3.90
05/10/2006		3	2.997	17.26	12.80	133.4	0.6130	NA	249.2	1.327	15%	0.41
05/10/2006		4	4.001	17.11	12.44	129.2	0.6150	NA	159.0	2.331	10%	0.19
05/10/2006		6	5.984	16.82	11.43	118.0	0.6160	NA	101.0	4.314	6%	0.11
05/10/2006		8	7.907	16.37	12.03	123.1	0.6160	NA	59.9	6.237	4%	0.08
05/10/2006		10	9.954	14.85	12.11	119.9	0.6180	NA	36.4	8.284	2.3%	0.06
05/10/2006		12	11.914	13.69	12.42	119.9	0.6120	NA	16.6	10.244	1.0%	0.08
05/10/2006		14	13.801	12.80	10.53	99.6	0.6140	NA	6.5	12.131	0.4%	0.08
05/10/2006		16	15.948	11.37	8.18	75.0	0.6150	NA	3.1	14.278	0.2%	0.05
05/10/2006		18	18.012	9.77	6.78	59.9	0.6110	NA	1.9	16.342	0.1%	0.03
05/10/2006		20	19.868	8.85	6.44	55.7	0.6120	NA	1.4	18.198	0.1%	0.02
05/10/2006		22	21.846	8.07	6.52	55.2	0.6080	NA	1.1	20.176	0.1%	0.01
05/10/2006		24	23.869	7.54	6.49	54.3	0.6090	NA	0.7	22.199	0.0%	0.02
05/10/2006		26	26.011	7.14	3.31	27.4	0.6160	NA	0.6	24.341	0.0%	0.01
05/10/2006		28	28.021	6.96	1.08	8.9	0.6190	NA	0.4	26.351	0.0%	0.02
05/10/2006		30	30.005	6.90	0.34	2.8	0.6210	NA	0.4	28.335	0.0%	0.00
05/10/2006		32	31.998	6.85	0.20	1.7	0.6220	NA	0.3	30.328	0.0%	0.01

Date MMDDYY	Time HHMMSS	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 0.10
06/14/2006		0.5	0.516	22.57	9.94	115.1	0.5900	8.38	3263.5	Surface		
06/14/2006		1	1.023	22.23	9.87	113.6	0.5880	8.21	1581.9	Surface	100%	
06/14/2006		2	2.040	21.88	9.83	112.4	0.5870	8.17	1070.4	0.370	68%	1.06
06/14/2006		3	3.014	21.81	9.80	111.9	0.5870	8.16	877.7	1.344	55%	0.15
06/14/2006		4	4.004	21.72	9.78	111.4	0.5870	8.16	741.5	2.334	47%	0.07

06/14/2006		6	6.017	21.54	9.58	108.8	0.5870	8.16	511.3	4.347	32%	0.09
06/14/2006		8	8.003	20.95	9.39	105.4	0.5870	8.14	394.4	6.333	25%	0.04
06/14/2006		10	10.024	19.90	9.41	103.5	0.5910	8.10	257.5	8.354	16%	0.05
06/14/2006		12	12.026	16.55	9.87	101.4	0.6020	8.05	176.7	10.356	11%	0.04
06/14/2006		14	14.032	14.78	8.79	86.9	0.6080	7.98	123.4	12.362	8%	0.03
06/14/2006		16	16.000	12.53	6.08	57.2	0.6150	7.86	86.8	14.330	5%	0.02
06/14/2006		18	18.027	11.62	2.63	24.2	0.6130	7.74	51.5	16.357	3%	0.03
06/14/2006		20	19.997	10.79	0.75	6.8	0.6140	7.69	33.6	18.327	2%	0.02
06/14/2006		22	22.032	9.79	0.21	1.9	0.6120	7.62	22.1	20.362	1.4%	0.02
06/14/2006		24	23.994	8.14	0.15	1.3	0.6130	7.57	12.7	22.324	0.8%	0.02
06/14/2006		26	26.013	7.65	0.12	1.0	0.6160	7.58	5.4	24.343	0.3%	0.04
06/14/2006		28	28.001	7.55	0.09	0.8	0.6180	7.55	2.3	26.331	0.1%	0.03
06/14/2006		30	29.972	7.21	0.09	0.7	0.6290	7.53	1.0	28.302	0.1%	0.03
06/14/2006		32	31.998	7.16	0.07	0.6	0.6310	7.49	0.6	30.328	0.0%	0.02

Date MMDDYY	Time HHMMSS	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	Extinction Coefficient
											Average	-0.06
07/12/2006		0.5	0.494	24.59	7.55	90.9	0.5920	7.73	1884.7	Surface		
07/12/2006		1	0.998	24.61	7.55	90.9	0.5930	7.74	762.1	Surface	47%	
07/12/2006		2	2.000	24.60	7.56	91.0	0.5930	7.76	1610.8	0.330	100%	-2.27
07/12/2006		3	2.998	24.59	7.58	91.2	0.5930	7.77	708.9	1.328	44%	0.62
07/12/2006		4	4.003	24.58	7.57	91.1	0.5920	7.79	476.5	2.333	29%	0.17
07/12/2006		6	6.007	24.56	7.56	90.9	0.5920	7.77	644.5	4.337	40%	-0.07
07/12/2006		8	8.004	24.51	7.54	90.6	0.5920	7.81	388.7	6.334	24%	0.08
07/12/2006		10	9.996	23.32	7.43	87.2	0.6040	7.75	221.2	8.326	13.7%	0.07
07/12/2006		12	12.008	20.42	7.11	79.0	0.6100	7.66	87.2	10.338	5.4%	0.09
07/12/2006		14	13.985	17.91	6.36	67.2	0.6120	7.55	118.9	12.315	7.4%	-0.03
07/12/2006		16	16.001	14.66	3.28	32.3	0.6170	7.43	47.5	14.331	2.9%	0.06
07/12/2006		18	17.994	13.01	1.07	10.1	0.6170	7.38	48.7	16.324	3.0%	0.00
07/12/2006		20	19.996	11.66	0.44	4.0	0.6190	7.35	22.5	18.326	1.4%	0.04
07/12/2006		22	22.017	10.69	0.32	2.8	0.6170	7.33	5.7	20.347	0.4%	0.07
07/12/2006		24	23.993	9.40	0.30	2.7	0.6190	7.31	2.0	22.323	0.1%	0.05
07/12/2006		26	26.000	8.43	0.26	2.2	0.6200	7.28	0.6	24.330	0.0%	0.05

07/12/2006		28	27.999	7.77	0.23	2.0	0.6300	7.24	0.2	26.329	0.0%	0.04
07/12/2006		30	30.000	7.47	0.21	1.7	0.6410	7.24	0.2	28.330	0.0%	0.00
07/12/2006		32	32.006	7.34	0.18	1.5	0.6490	7.24	0.1	30.336	0.0%	0.02

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient NA
08/09/2006		0.5	0.495	27.20	8.87	111.9	0.6020	8.55	NA	Surface		
08/09/2006		1	1.000	27.16	8.79	110.8	0.6030	8.55	NA	Surface	NA	
08/09/2006		2	2.003	27.00	8.64	108.7	0.6030	8.54	NA	0.333	NA	NA
08/09/2006		3	2.994	26.82	8.55	107.1	0.6030	8.54	NA	1.324	NA	NA
08/09/2006		4	4.002	26.78	8.58	107.4	0.6020	8.55	NA	2.332	NA	NA
08/09/2006		6	6.003	26.73	8.35	104.5	0.6030	8.53	NA	4.333	NA	NA
08/09/2006		8	7.993	26.59	8.18	102.1	0.6020	8.53	NA	6.323	NA	NA
08/09/2006		10	9.996	26.07	7.39	91.4	0.6110	8.32	NA	8.326	NA	NA
08/09/2006		12	12.003	24.42	6.41	76.9	0.6170	8.17	NA	10.333	NA	NA
08/09/2006		14	14.006	20.81	5.26	58.8	0.6210	7.99	NA	12.336	NA	NA
08/09/2006		16	16.001	18.27	3.09	32.9	0.6240	7.84	NA	14.331	NA	NA
08/09/2006		18	17.998	15.76	1.67	16.9	0.6220	7.73	NA	16.328	NA	NA
08/09/2006		20	20.012	14.25	0.62	6.1	0.6220	7.65	NA	18.342	NA	NA
08/09/2006		22	22.007	11.88	0.21	2.0	0.6270	7.57	NA	20.337	NA	NA
08/09/2006		24	24.008	10.09	0.17	1.5	0.6280	7.50	NA	22.338	NA	NA
08/09/2006		26	25.999	8.48	0.15	1.3	0.6410	7.39	NA	24.329	NA	NA
08/09/2006		28	28.001	7.92	0.13	1.1	0.6530	7.30	NA	26.331	NA	NA
08/09/2006		30	30.009	7.75	0.11	0.9	0.6610	7.27	NA	28.339	NA	NA
08/09/2006		32	32.000	7.64	0.11	0.9	0.6640	7.26	NA	30.330	NA	NA

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission Average	Extinction Coefficient NA
09/13/2006		0.5	0.503	20.17	7.05	78.0	0.6010	8.15	NA	Surface		
09/13/2006		1	0.999	20.18	7.02	77.6	0.6020	8.15	NA	Surface	NA	
09/13/2006		2	1.999	20.19	6.89	76.1	0.6020	8.15	NA	0.329	NA	NA

09/13/2006	3	3.000	20.18	6.80	75.1	0.6020	8.15	NA	1.330	NA	NA
09/13/2006	4	3.997	20.19	6.79	75.1	0.6020	8.15	NA	2.327	NA	NA
09/13/2006	6	5.991	20.19	6.75	74.7	0.5870	8.15	NA	4.321	NA	NA
09/13/2006	8	7.998	20.19	6.70	74.1	0.6020	8.15	NA	6.328	NA	NA
09/13/2006	10	10.001	20.19	6.75	74.6	0.6020	8.15	NA	8.331	NA	NA
09/13/2006	12	12.003	20.19	6.61	73.1	0.6010	8.15	NA	10.333	NA	NA
09/13/2006	14	13.996	20.16	6.70	74.1	0.6010	8.14	NA	12.326	NA	NA
09/13/2006	16	16.006	20.16	6.61	73.0	0.6020	8.15	NA	14.336	NA	NA
09/13/2006	18	18.003	19.70	6.05	66.2	0.6040	8.07	NA	16.333	NA	NA
09/13/2006	20	19.999	16.20	0.74	7.5	0.6270	7.70	NA	18.329	NA	NA
09/13/2006	22	22.002	13.98	0.20	1.9	0.6280	7.60	NA	20.332	NA	NA
09/13/2006	24	24.006	11.60	0.34	3.1	0.6320	7.50	NA	22.336	NA	NA
09/13/2006	26	26.011	9.55	0.20	1.8	0.6450	7.41	NA	24.341	NA	NA
09/13/2006	28	27.999	8.51	0.18	1.6	0.6620	7.31	NA	26.329	NA	NA
09/13/2006	30	30.004	8.16	0.14	1.2	0.6760	7.24	NA	28.334	NA	NA
09/13/2006	32	32.004	7.89	0.11	1.0	0.6920	7.19	NA	30.334	NA	NA

APPENDIX C. INTERPRETING YOUR LAKE'S WATER QUALITY DATA.

Lakes possess a unique set of physical and chemical characteristics that will change over time. These in-lake water quality characteristics, or parameters, are used to describe and measure the quality of lakes, and they relate to one another in very distinct ways. As a result, it is virtually impossible to change any one component in or around a lake without affecting several other components, and it is important to understand how these components are linked.

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2005 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, total dissolved solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) and total volatile solids (TVS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 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.

Total dissolved solids (TDS) are the amount of dissolved substances, such as salts or minerals, remaining in water after evaporation. These dissolved solids are discussed in further detail in the *Alkalinity* and *Conductivity* sections of this document. TDS concentrations were measured in Lake County lakes prior to 2004, but was discontinued due to the strong correlation of TDS to conductivity and chloride concentrations.

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.17 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 ($CO_3^{=}$) 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.

<u>pH:</u>
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	≥40<50	>0.012 ≤ 0.024	≥6.56<13.12
Eutrophic	≥50<70	>0.024 ≤ 0.096	≥1.64<6.56
Hypereutrophic	≥70	>0.096	< 1.64

APPENDIX D. LAKE MANAGEMENT OPTIONS.

D1. Option for Creating a Bathymetric Map

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

D2. 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.

D3. Options to Eliminate or Control Exotic Species

Option 1. Biological Control

Biological control (bio-control) is a means of using natural relationships already in place to limit, stop, or reverse an exotic species' expansion. In most cases, insects that prey upon the exotic plants in its native ecosystem are imported. Since there is a danger of bringing another exotic species into the ecosystem, state and federal agencies require testing before any bio-control species are released or made available for purchase.
Control of exotics by a natural mechanism is preferable to chemical treatments, however there are few exotics that can be controlled by biological means. Insects, being part of the same ecological system as the exotic plant (i.e., the beetles and weevils with Purple Loosestrife) are more likely to provide long-term control. Chemical treatments are usually non-selective while

bio-control measures target specific plant species. Bio-control can also be expensive and labor intensive.

Option 2. Control by Hand

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. Some exotics, such as Purple Loosestrife and Reed Canary Grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is removed. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored since regrowth of the removed species is common. Many exotic species, such as Purple Loosestrife, Buckthorn, and Garlic Mustard are proficient at colonizing disturbed sites. This method can be labor intensive but costs are low.

Option 3. Herbicide Treatment

Chemical treatments can be effective at controlling exotic plant species, and works best on individual plants or small areas already infested with the plant. In some areas where individual spot treatments are prohibitive or impractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option because in order to chemically treat the area, a broadcast application would be needed. Because many of the herbicides are not selective, meaning they kill all plants they contact, this may be unacceptable if native plants are found in the proposed treatment area.

Herbicides are commonly used to control nuisance shoreline vegetation by applying it to green foliage or cut stems. They provide a fast and effective way to control or eliminate nuisance vegetation by killing the root of the plant, preventing regrowth. Products are applied by either spraying or wicking (wiping) solution on plant surfaces. Spraying is used when large patches of undesirable vegetation are targeted. Herbicides are sprayed on growing foliage using a hand-held or backpack sprayer. Wicking is used when selected plants are to be removed from a group of plants. It is best to apply herbicides when plants are actively growing, such as in the late spring/early summer, but before formation of seed heads. Herbicides are often used in conjunction with other methods, such as cutting or mowing, to achieve the best results. Proper use of these products is critical to their success. Always read and follow label directions.

D4. 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.

D5. 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.

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

2000 - 2006 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2006			ALKanoxic 2000-2006	
Average	**167.0**		Average	**201**	
Median	**162.0**		Median	**192**	
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 =	**246**	

	Condoxic <=3ft00-2006			Condanoxic 2000-2006	
Average	**0.8834**		Average	**0.9968**	
Median	**0.7948**		Median	**0.8285**	
Minimum	**0.2542**	**Broberg Marsh**	Minimum	**0.3031**	**White Lake**
Maximum	**6.8920**	**IMC**	Maximum	**7.4080**	**IMC**
STD	**0.5389**		STD	**0.7821**	
n =	**797**		n =	**246**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2006			NH3-Nanoxic 2000-2006	
Average	**0.518**		Average	**2.112**	
Median	**0.150**		Median	**1.375**	
Minimum	**<0.05**	***ND**	Minimum	**<0.1**	***ND**
Maximum	**9.670**	**South Churchill Lake**	Maximum	**18.400**	**Taylor Lake**
STD	**1.058**		STD	**2.356**	
n =	**803**		n =	**246**	

*ND = Many lakes had non-detects (71.5%)
Only compare lakes with detectable
concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

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

	pHoxic <=3ft00-2006			pHanoxic 2000-2006	
Average	**8.31**		Average	**7.19**	
Median	**8.31**		Median	**7.18**	
Minimum	**7.06**	**Deer Lake**	Minimum	**6.24**	**Banana Pond**
Maximum	**10.28**	**Round Lake Marsh North**	Maximum	**8.48**	**Heron Pond**
STD	**0.45**		STD	**0.38**	
n =	**792**		n =	**246**	

	All Secchi 2000-2006	
Average	**4.48**	
Median	**3.27**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**29.23**	**Bangs Lake**
STD	**3.69**	
n =	**740**	

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

	TKNoxic <=3ft00-2006	
Average	**1.414**	
Median	**1.220**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.844**	
n =	**798**	

*ND = 3.6% Non-detects from 14 different lakes

	TKNanoxic 2000-2006	
Average	**2.973**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.346**	
n =	**246**	

*ND = 3.2% Non-detects from 5 different lakes

	TPoxic <=3ft00-2006	
Average	**0.098**	
Median	**0.060**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.171**	
n =	**798**	

*ND = 0.1% Non-detects from 5 different lakes
(Carina, Minear,& Stone Quarry)

	TPanoxic 2000-2006	
Average	**0.280**	
Median	**0.163**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.369**	
n =	**246**	

	TSSall <=3ft00-2006	
Average	**15.3**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**809**	

*ND = 1.3% Non-detects from 10 different lakes

	TVSoxic <=3ft00-2006	
Average	**137.7**	
Median	**134.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**41.2**	
n =	**753**	

No 2002 IEPA Chain Lakes

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

No 2002 IEPA Chain Lakes.

	CLanoxic <=3ft00-2006	
Average	**263**	
Median	**116**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**452**	
n =	**78**	

	CLoxic <=3ft00-2006	
Average	**220**	
Median	**171**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**275**	
n =	**318**	

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

Minimums and maximums are based on data from all lakes from 1988-2006 (n=3053).

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