2006 SUMMARY REPORT
of
Duck Lake

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Duck Lake is a 110-acre natural slough pothole lake located near the Village of Fox Lake, Illinois. The northern third of the lake is within Fox Lake village boundaries, with the remainder of the lake in unincorporated Lake County. Duck Lake is at the bottom of the Fish Lake Drain watershed that flows through Fish Lake, Fischer Lake, and Wooster Lake before entering Duck Lake. Water from Duck Lake eventually drains into the Fox River.

The lake was assessed through many parameters from May-September, 2006. Water clarity in the lake was just above the County median (3.27 feet), with an average Secchi depth of 3.49 feet. This was an increase of nearly a foot and a half since the 2001 sampling season (2.01 feet). Total suspended solids (TSS) concentration (9.1 mg/L) decreased over 50% from the 2001 average (20.6 mg/L). This decrease in TSS correlates to the increase in Secchi transparency. Conductivity is the measure of ions within water. The higher the conductivity, the more ions and the better the water can conduct electricity. In Duck Lake, average conductivity in 2006 was 0.7807 mS/cm. This is an increase from the 2001 value of 0.6071 mS/cm.

Nitrogen and phosphorus are the two nutrients that can limit plant and algal growth. The 2006 average epilimnetic total phosphorus concentration in Duck Lake was 0.043 mg/L, which is lower than the county median (0.060 mg/L), and more than a 50% decrease from the 2001 concentration (0.100 mg/L). The average total Kjeldahl nitrogen concentration in Duck Lake in 2006 (1.67 mg/L) decreased from 2001 (2.83 mg/L).

The aquatic plant community in the lake consisted of 14 species in July. Eurasian Watermilfoil was the most dominant species, with Coontail and White Water Lily also in high concentrations. Plant diversity increased by two species between 2001 and 2006, and plant composition changed as well. Leafy Pondweed, Small Pondweed, Curlyleaf Pondweed and Watermeal were found in 2001, but not in 2006. However, Elodea, Northern Water Milfoil, Southern Naiad and Spiny Naiad were found in 2006 and not in 2001. The changes can probably be attributed to natural annual variation and the timing of sampling.

Shoreline erosion increased slightly on the lake from the initial 2001 assessment, both in overall erosion, and in severity where erosion was documented before. Some shoreline areas improved due to the installment of rip rap or another form of restoration. Exotic shoreline plant species were observed as well.

LAKE FACTS

Lake Name:	Duck Lake
Historical Name:	None
Nearest Municipality:	Fox Lake
Location:	T45N, R9E, Section 14,15
Elevation:	738.0 feet
Major Tributaries:	Fish Lake Drain
Watershed:	Fox River
Sub-watershed:	Fish Lake Drain
Receiving Water body:	Fox River
Surface Area:	110.4 acres
Shoreline Length:	7.5 miles
Maximum Depth:	9.0 feet (estimated)
Average Depth:	4.5 feet (estimated)
Lake Volume:	496.9 acre-feet (estimated)
Lake Type:	Glacial
Watershed Area:	5324.7 acres
Major Watershed Land uses:	Agriculture, Single Family Homes and Wetland
Bottom Ownership:	Private
Management Entities:	Duck Lake Waterway Association
Current and Historical uses:	Fishing, swimming and boating
Description of Access:	No public access

SUMMARY OF WATER QUALITY

Duck Lake has a large watershed area (Figure 1) encompassing three other main waterbodies to the south (Fish Lake, Fischer Lake, and Wooster Lake). Duck Lake receives runoff from a diverse watershed where agriculture covers the highest percentage of area (38%). Single-family homes also cover a large portion of land (13%), as well as wetland (10%) (Figure 2). The area directly surrounding Duck Lake is mostly single-family homes, with wetland areas on the south, northeast and northwest. The large amount of impervious surfaces associated with residential areas (rooftops, driveways, and roads) increase the amount of direct storm water runoff into a lake (Table 1).

Water samples were taken monthly from May through September at the deepest location in the lake (Figure 3). One sample was taken from the upper water layer (epilimnion) at three feet and analyzed for nutrients, solids concentration, and other physical parameters (Appendix A). Due to the shallow nature of Duck Lake, wind and wave action kept the waters well mixed.

The average dissolved oxygen (DO) concentration was 7.81 mg/L (Table 2), with the highest reading in June (8.78 mg/L) and the lowest in July (5.72 mg/L). Hypoxic conditions (where DO concentrations fall below 5.0 mg/L and fish populations are stressed) occurred in June and August at the bottom depth only (8 feet), while the remainder of the water column stayed well oxygenated throughout the summer (Appendix B). Anoxic conditions (DO < 1.0 mg/L) were not present at all throughout the season.

Total suspended solids are made up of any type of solid particles in the water column, including algal cells and sediment. The average total suspended solids (TSS) concentration for Duck Lake in 2006 was 9.1 mg/L. This was above the Lake County median of 7.9 mg/L (Appendix E). The average TSS decreased dramatically from the 2001 average (20.1 mg/L). Directly upstream from Duck Lake is Wooster Lake, which had a TSS concentration of 5.1 mg/L in 2006 (Table 3). Wooster Lake sits above Fischer Lake, which had a TSS concentration of 28.0 mg/L in 2006, and Fischer Lake sits above Fish Lake, which had a TSS concentration of 11.0 mg/L in 2006. Both Fischer and Fish Lakes contain fewer plants that help hold sediment to the lake bottom. Duck Lake is heavily used for recreational purposes such as waterskiing. Both low plant diversity and motorboat activity in shallow systems can lead to high TSS concentrations in the water column.

Secchi depth (water clarity) in Duck Lake was just above the County median (3.27 feet) (Figure 4). The average Secchi depth in 2006 was 3.49 feet, which was an increase of nearly a foot and a half since the 2001 sampling season (2.01 feet). May 2006 had the deepest Secchi reading (5.25 feet) while August had the lowest reading (2.19 feet), probably due to plant die-off. Duck Lake had the second highest Secchi depth reading in 2006 in the Fish Lake Drain, with Wooster Lake at 7.78 feet, Fischer Lake at 1.96 feet and Fish Lake at 3.47 feet (Table 3). These Secchi depths correlate to the amounts of TSS found at the same sampling times.

Figure 1. Approximate watershed delineation for Duck Lake, 2006.

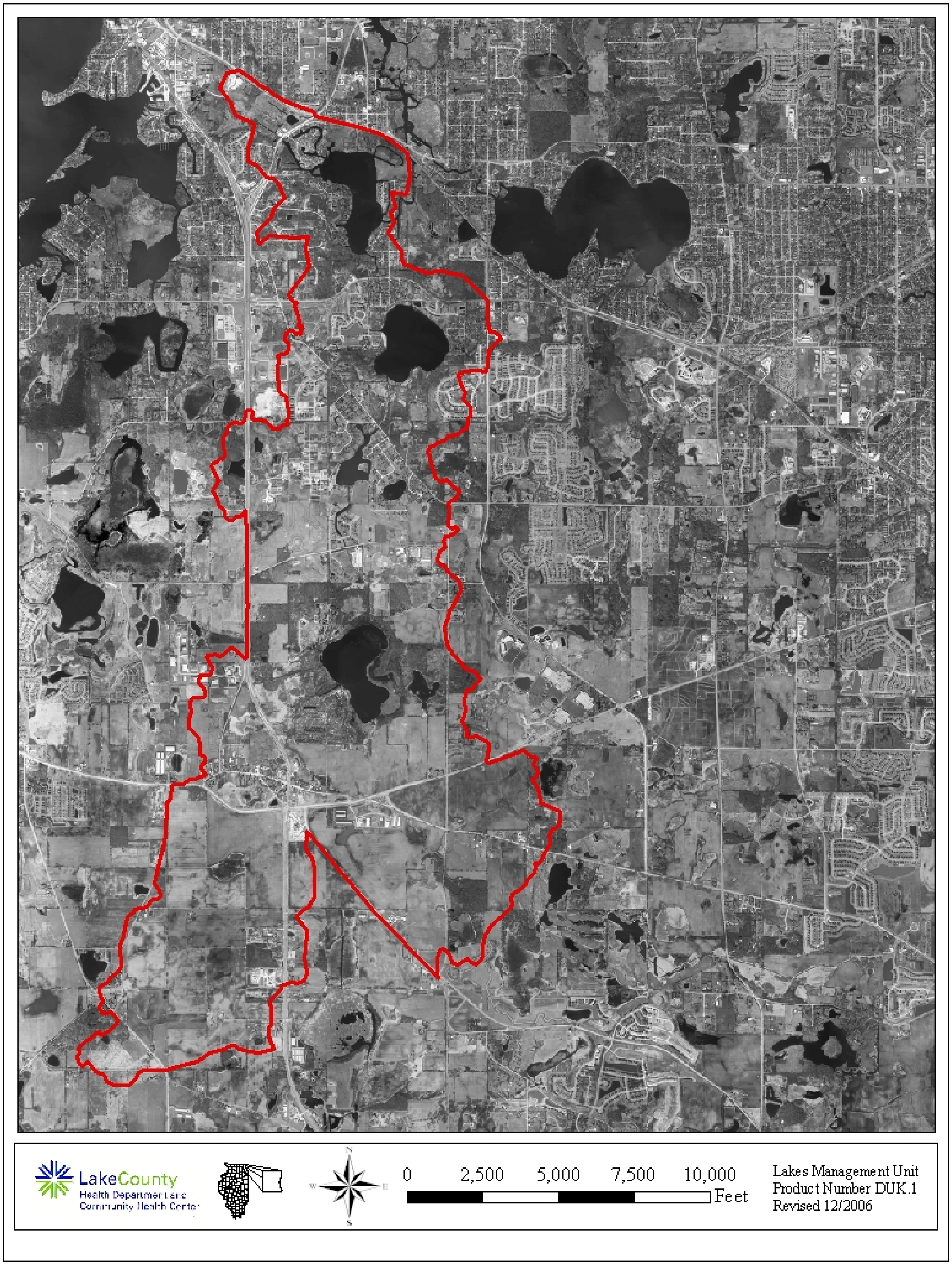


Figure 2. Approximate land use within the Duck Lake watershed, 2006.

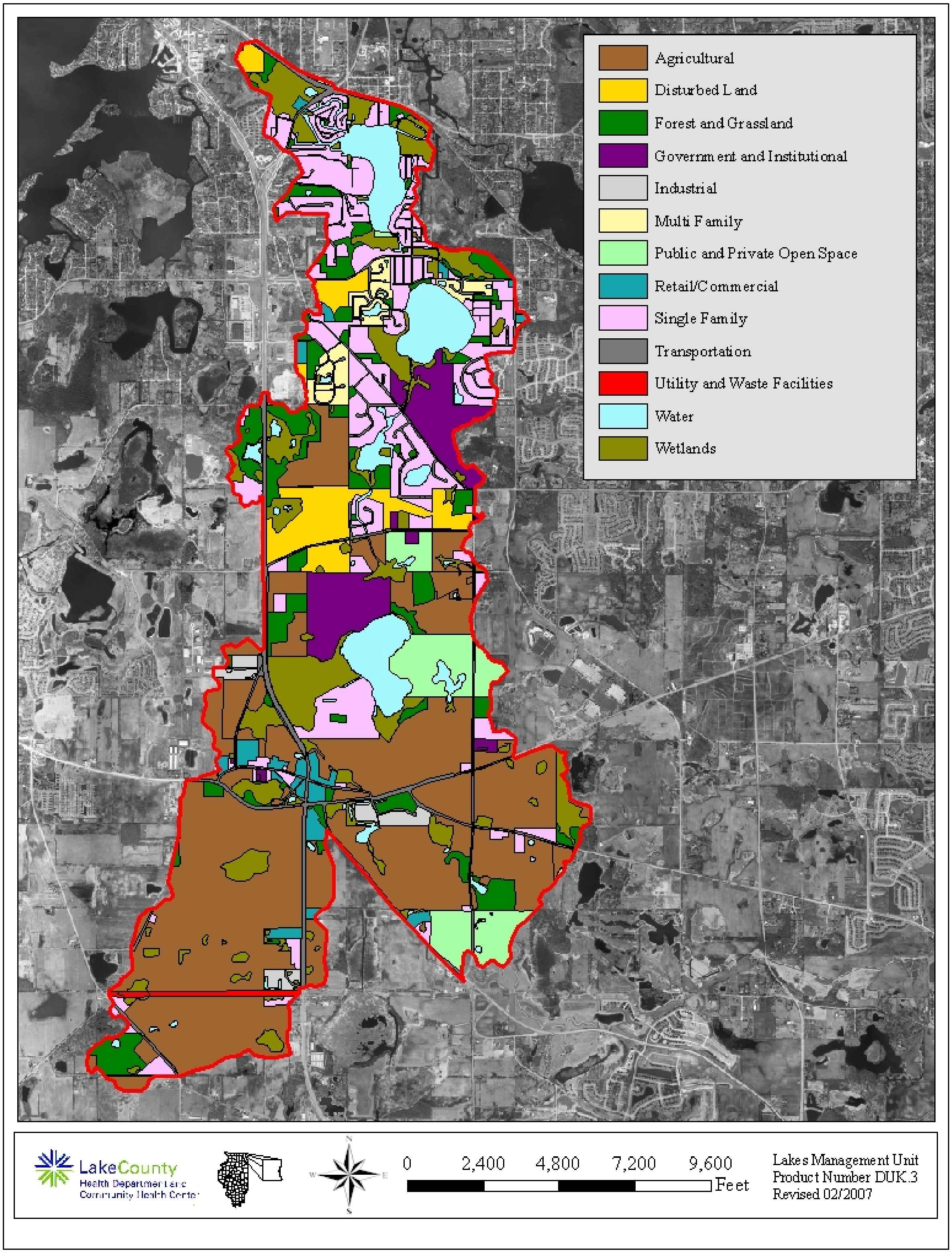


Table 1. Approximate land uses and retention time for Duck Lake, 2006.

Land Use	Acreage	% of Total
Agricultural	2093.74	37.72%
Disturbed Land	270.35	4.87%
Forest and Grassland	413.38	7.45%
Government and Institutional	260.74	4.70%
Industrial	56.23	1.01%
Multi Family	89.55	1.61%
Public and Private Open Space	254.82	4.59%
Retail/Commercial	93.83	1.69%
Single Family	738.74	13.31%
Transportation	285.43	5.14%
Utility and Waste Facilities	26.41	0.48%
Water	400.08	7.21%
Wetlands	567.96	10.23%
TOTAL	**5551.25**	**100.00%**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agricultural	2093.74	0.05	287.89	10.88%
Disturbed Land	270.35	0.05	37.17	1.40%
Forest and Grassland	413.38	0.05	56.84	2.15%
Government and Institutional	260.74	0.50	358.52	13.55%
Industrial	56.23	0.85	131.43	4.97%
Multi Family	89.55	0.30	73.88	2.79%
Public and Private Open Space	254.82	0.15	105.11	3.97%
Retail/Commercial	93.83	0.85	219.33	8.29%
Single Family	738.74	0.30	609.46	23.03%
Transportation	285.43	0.85	667.19	25.21%
Utility and Waste Facilities	26.41	0.30	21.79	0.82%
Water	400.08	0.00	0.00	0.00%
Wetlands	567.96	0.05	78.09	2.95%
TOTAL	**5551.25**		**2646.70**	**100.00%**

Lake volume	**110.40**	**acre-feet**
Retention Time (years)= lake volume/runoff	**0.04**	**years**
	15.22	**days**

NOTE: Runoff calculations do not include the acreage of the lake itself, which is part of the total watershed area

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

Table 2. Water quality data for Duck Lake, 2001 and 2006.

2006	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3*	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
16-May	3	183	1.610	<0.1	<0.05	0.048	<0.005	NA	115	4.1	474	110	5.25	0.7667	8.40	7.97
20-Jun	3	166	1.720	<0.1	<0.05	0.052	<0.005	NA	117	12.0	498	151	3.11	0.7639	8.86	8.78
18-Jul	3	161	1.650	<0.1	<0.05	0.041	<0.005	NA	121	9.4	488	147	3.61	0.7821	8.47	5.72
15-Aug	3	169	1.780	<0.1	<0.05	0.038	<0.005	NA	129	11.0	524	159	2.19	0.8090	8.68	8.61
19-Sep	3	169	1.580	<0.1	<0.05	0.034	<0.005	NA	119	8.8	482	126	3.28	0.7820	8.29	7.96
	Average	170	1.668	<0.1	<0.05	0.043	<0.005	NA	120	9.1	493	139	3.49	0.7807	8.54	7.81

2001	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
21-May	3	185	0.729	<0.1	<0.05	0.056	<0.005	378	NA	6.1	393	129	4.63	0.6247	8.27	7.51
19-Jun	3	181	1.630	<0.1	<0.05	0.099	0.006	384	NA	15.0	408	131	2.60	0.6215	7.95	5.74
24-Jul	3	177	3.490	<0.1	<0.05	0.107	0.026	394	NA	26.0	439	141	0.95	0.6224	7.84	4.59
21-Aug	3	151	4.520	<0.1	<0.05	0.129	0.032	390	NA	31.0	428	153	0.72	0.5727	8.08	6.57
18-Sep	3	165	3.770	<0.1	<0.05	0.107	0.034	368	NA	25.0	404	155	1.15	0.5943	7.88	6.89
	Average	172	2.828	<0.1	<0.05	0.100	0.025^k	383	NA	20.6	414	142	2.01	0.6071	8.00	6.20

Glossary

- ALK = Alkalinity, mg/L $CaCO_3$
- TKN = Total Kjeldahl nitrogen, mg/L
- NH_3-N = Ammonia nitrogen, mg/L
- NO_3-N = Nitrate nitrogen, mg/L
- NO2+NO3 = Nitrite and Nitrate nitrogen, mg/L
- TP = Total phosphorus, mg/L
- SRP = Soluble reactive phosphorus, mg/L
- TDS = Total dissolved solids, mg/L
- Cl^- = Chloride ions, 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

Note: "k" denotes that the actual value is known to be less than the value presented.

NA = Not Applicable

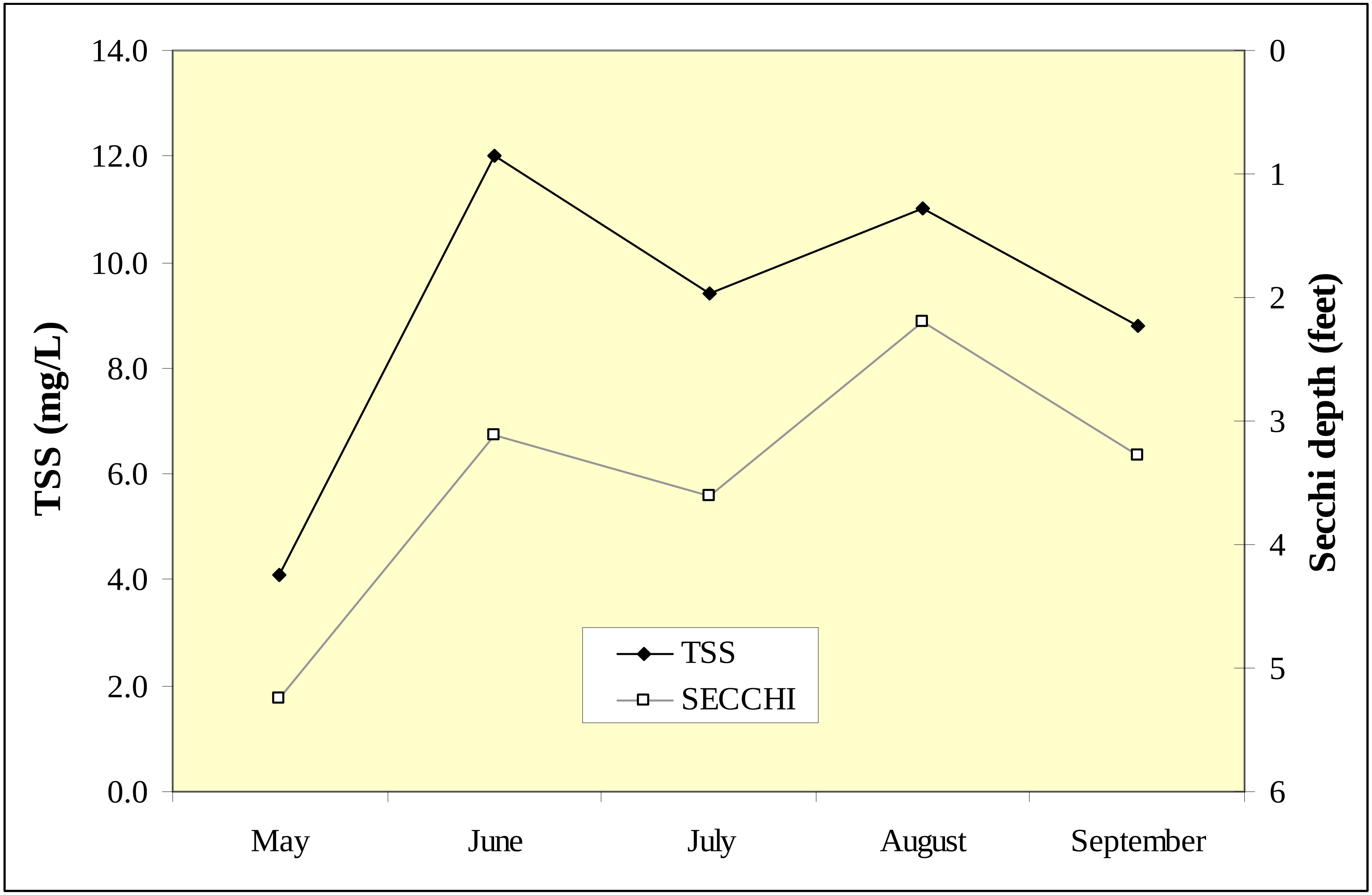
* = Prior to 2006 only Nitrate was analyzed

Table 3. Comparison of epilimnetic averages for selected water quality parameters in the Fish Lake Drain watershed.

	Fish Lake	Fish Lake	Fish Lake	Fischer Lake	Fischer Lake	Wooster Lake	Wooster Lake	Wooster Lake	Wooster Lake	Wooster Lake	Duck Lake	Duck Lake	Duck Lake
Year	**1997**	**2002**	**2006**	**2001**	**2006**	**1995**	**1999**	**2003**	**2005**	**2006**	**1997**	**2001**	**2006**
Secchi (feet)	3.53	4.02	3.47	2.72	1.96	10.13	8.00	7.83	9.54	7.87	3.12	2.01	3.49
TSS (mg/L)	8.9	11.3	11.0	15.4	28.0	1.8	4.3	3.4	3.2	5.1	8.5	20.6	9.1
TP (mg/L)	0.134	0.102	0.096	0.198	0.228	0.024	0.027	0.032	0.03	0.043	0.047	0.100	0.043
Conductivity (milliSiemens/cm)	0.6984	0.6629	0.8688	0.6687	0.8524	0.5160	0.5744	0.6437	0.7100	0.7388	0.6544	0.6071	0.7807

Direction of Watershed Flow

Figure 4. Total suspended solid (TSS) concentrations vs. Secchi disk depth for Duck Lake, 2006.



The Volunteer Lake Monitoring Program (VLMP) has been continuously active on the lake since its inception in 1984. This program has been very successful and should continue in the future in order to detect any changes in water clarity trends. The VLMP Secchi depth average for 2006 was 3.5, which was almost identical to the LCHD value. Any differences between the VLMP data and LCHD-Lake Management Unit (LMU) data can be mostly attributed to discrepancies between samplers. Also, time of day and the number of readings the averages are compiled from have an affect (Figure 5).

Conductivity is the measure of ions within water. In Duck Lake, average conductivity in 2006 was 0.7807 mS/cm. This was a 29% increase from the 2001 value of 0.6071 mS/cm. While this is an increase for Duck Lake, it is still below the County median (0.7948 mS/cm). Conductivity concentrations do not vary much throughout the Fish Lake Drain. In 2006, Fish Lake had an average value of 0.8688 mS/cm, Fischer Lake had an average value of 0.8524 mS/cm, and Wooster Lake had an average value of 0.7388 mS/cm (Table 3). Almost all of the lakes in the county are experiencing similar increases in conductivity for the same reason. Road salts used in winter road management runoff into lakes and build up since aquatic organisms cannot use them. This leads to an increase in both conductivity and chloride ion (Cl^-) concentrations, which are correlated (Figure 6). The median Cl^- concentration in the county is 171.0 mg/L, but Duck Lake contains less than this concentration (120.0 mg/L). Conductivity and Cl^- concentrations increased from May to August. This was most likely due to the overall drop in water volume throughout the summer. When there is a drop in water level, everything within the lake is concentrated into a smaller volume, and even though inputs did not increase, constituent levels are elevated in the remaining water. There was a slight drop in both Conductivity and Cl^- concentrations in September, which is most likely correlated to the lower TSS concentration as well as precipitation.

Another aspect of water quality is the nutrients within a water body, especially nitrogen (N) and phosphorus (P), as these are the two nutrients that can limit plant and algal growth. Carbon and light are the other factors that control plant and algal growth, but these are not normally limiting. In 2006, the average total phosphorus (TP) concentration in Duck Lake was 0.043 mg/L, which is lower than the county median (0.060 mg/L). TP conditions have decreased by about 55% since sampling in 2001 (0.100 mg/L). The other lakes in the Fish Lake Drain experienced higher TP concentrations this year, except Wooster Lake (0.043 mg/L). Fish Lake had an average TP concentration of 0.096 mg/L, and Fischer Lake had the highest concentration in the watershed with an average of 0.228 mg/L. Wooster Lake has a low TP concentration due in part to its greater volume and extensive plant population, which competes with algae for phosphorus. Fish and Fischer Lakes are most likely higher due to their low water volumes and lower plant populations that allow more phosphorus to remain available in the water column.

The average total Kjeldahl nitrogen (TKN) concentration in Duck Lake in 2006 (1.67 mg/L) decreased from 2001 (2.83 mg/L). This correlates to the decrease in both TSS and TP concentrations, and to the lower amount of rainfall received compared to 2001. The nitrate+nitrite concentration never went above the detection limit (<0.05 mg/L). The overall increase in water quality was due to minimal flow into the lake from the Fish Lake Drain, due to the dry conditions, and from the continued effects of the drought-like conditions in 2005.

Figure 5. Comparison of average Secchi disk depths between VLMP records and LCHD records from 1997-2006 for Duck Lake.

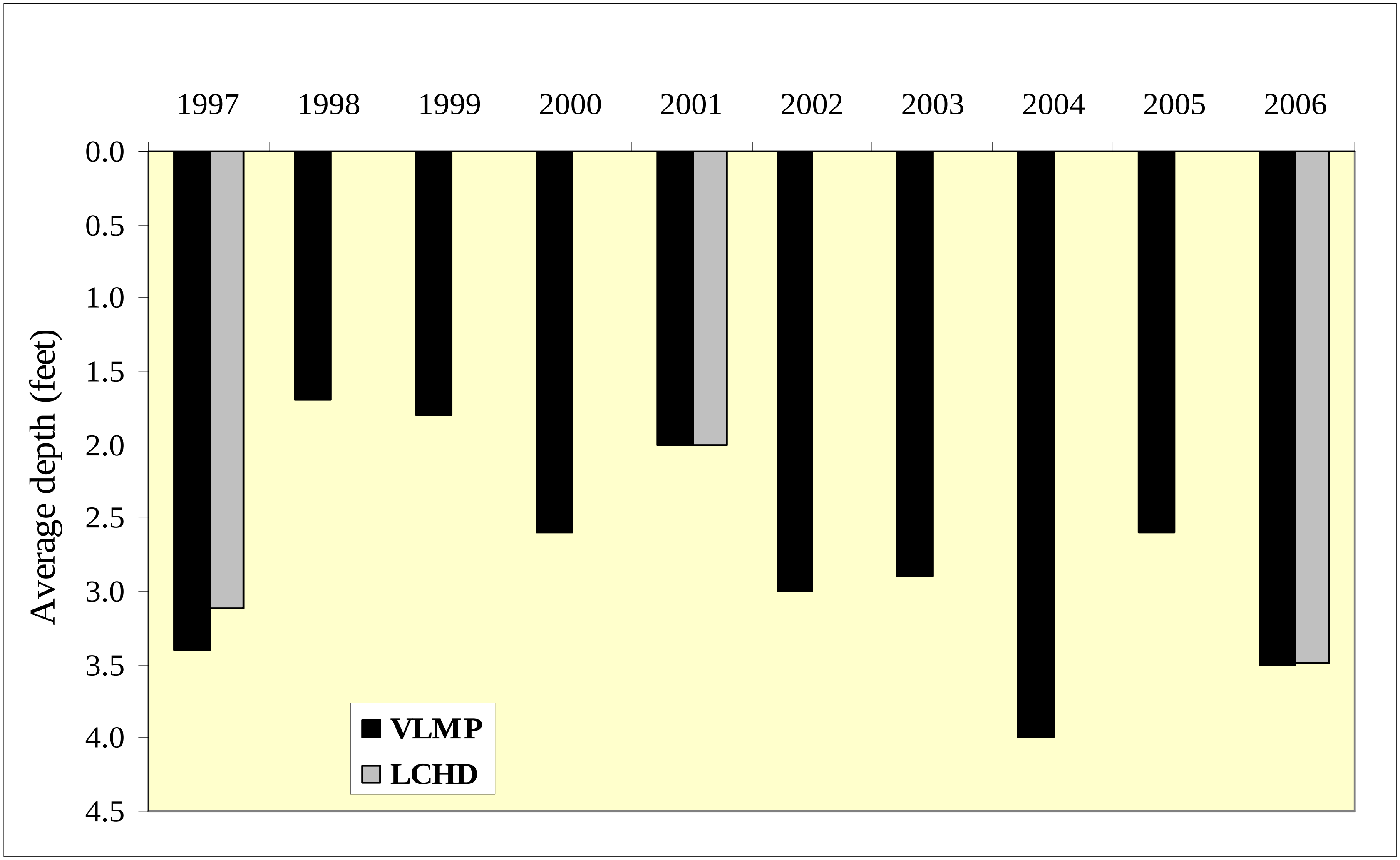
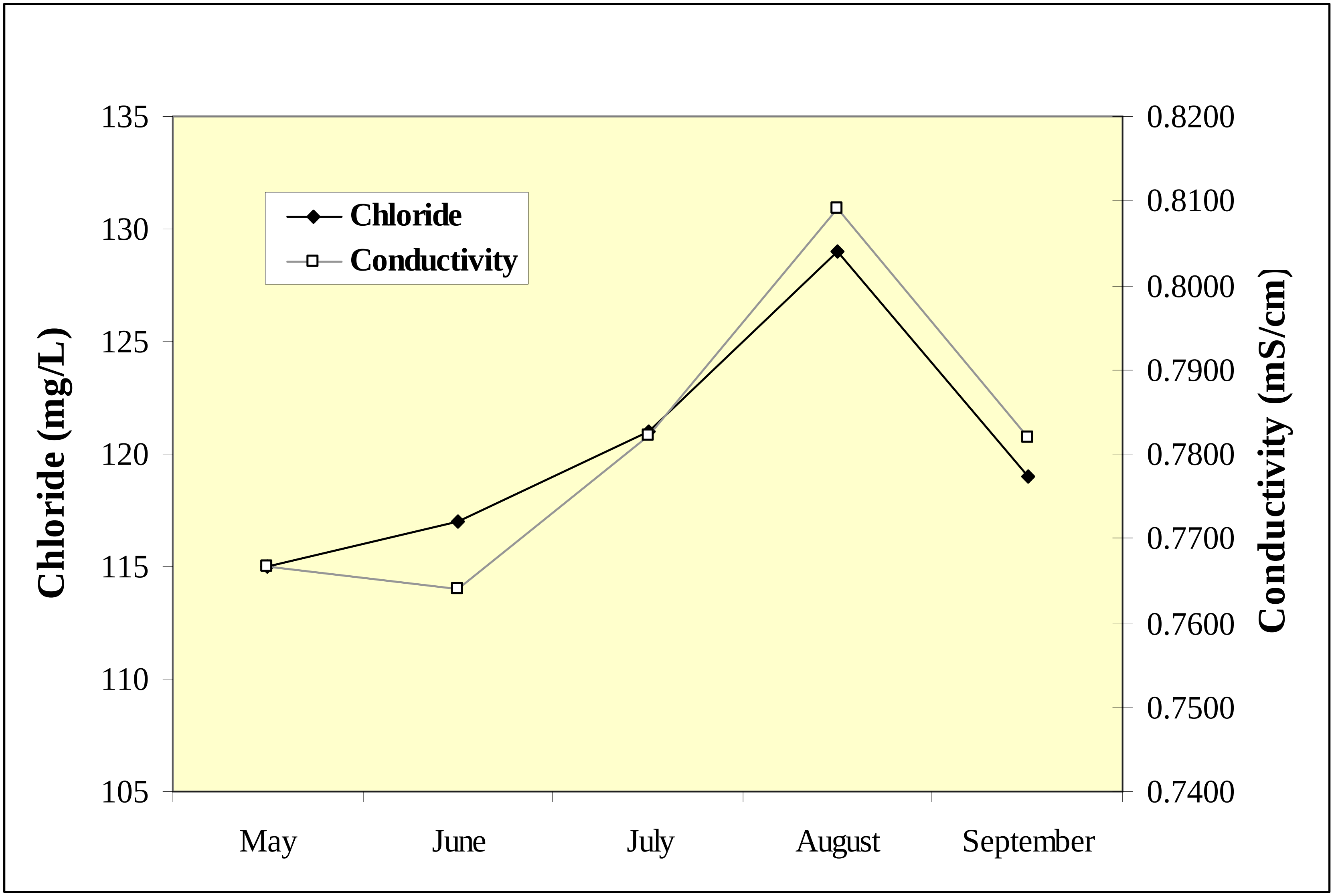


Figure 6. Chloride vs. conductivity concentrations in Duck Lake, 2006.



Another way to look at phosphorus levels and how they affect productivity of the lake is to use a Trophic State Index (TSI) based on phosphorus (TSIp) and Secchi disk depth (TSIs). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). The higher the phosphorus levels the greater the amount of plant and algal biomass, which leads to a higher TSIp and corresponding trophic state. Based on a TSIp value of 58.3, Duck Lake was classified as eutrophic (≥50, <70 TSI). A eutrophic lake is defined as a productive system that has above average nutrient levels and high algal biomass (growth). This was a great improvement from the 2001 TSIp value of 70.5 that ranked the lake as hypereutrophic (>70 TSI). Based on a Secchi TSI of 59.1, Duck Lake was also classified as eutrophic. Overall, the trophic state of the lake is eutrophic. Based on the TSIp, Duck Lake ranks 49th out of 162 lakes studied by the Lakes Management Unit from 2000-2006 (Table 4). This is a slight decrease since 2001 when it was ranked 49th out of 102 lakes sampled.

TSI values along with other water quality parameters can be used to make other analyses based on use impairment indexes established by the Illinois Environmental Protection Agency (IEPA). Most water quality standard impairment assessments were listed as *None*. However, widespread aquatic vegetation was the source of impairments based on excessive plant growth (*Moderate* use impairment). Furthermore, based on IEPA indices, Duck Lake had *Partial* support for recreational use and *Full* support of swimming and aquatic life use. Based on these indices, this lake was listed as providing *Full* overall use support.

There is one swimming beach on Duck Lake at Duck Lake Woods. It was sampled for bacteria (*E. coli*) levels every two weeks, from the beginning of May to the end of August, by the LCHD in 2006. This beach has been monitored off and on since 1988 and has only had two closings since the beginning. There were no LCHD recommended closings during the 2006 swimming season.

Table 4. Lake County average TSI phosphorus (TSIp) ranking, 2000-2006.

RANK	LAKE NAME	TP AVE	TSIp
1	Cedar Lake	0.0154	43.61
2	Windward Lake	0.0158	43.95
3	Sterling Lake	0.0162	44.31
4	Lake Minear	0.0165	44.57
5	Pulaski Pond	0.0180	45.83
6	Timber Lake	0.0180	45.83
7	Fourth Lake	0.0182	45.99
8	West Loon Lake	0.0182	45.99
9	Lake Carina	0.0193	46.86
10	Independence Grove	0.0194	46.91
11	Lake 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
44	Diamond Lake	0.0372	56.30

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
45	Channel Lake (Site 1)	0.0380	56.60
46	White Lake	0.0408	57.63
47	Sun Lake	0.0410	57.70
48	Potomac Lake	0.0424	58.18
49	Duck Lake	0.0426	58.25
50	Old Oak Lake	0.0428	58.32
51	Wooster Lake	0.0433	58.48
52	Deer Lake	0.0434	58.52
53	Schreiber Lake	0.0434	58.52
54	Nielsen Pond	0.0448	58.98
55	Turner Lake	0.0458	59.30
56	Seven Acre Lake	0.0460	59.36
57	Willow Lake	0.0464	59.48
58	Lucky Lake	0.0476	59.85
59	Davis Lake	0.0476	59.85
60	East Meadow Lake	0.0478	59.91
61	College Trail Lake	0.0496	60.45
62	Lake Lakeland Estates	0.0524	61.24
63	Butler Lake	0.0528	61.35
64	West Meadow Lake	0.0530	61.40
65	Heron Pond	0.0545	61.80
66	Little Bear Lake	0.0550	61.94
67	Lucy Lake	0.0552	61.99
68	Lake Christa	0.0576	62.60
69	Lake Charles	0.0580	62.70
70	Crooked Lake	0.0608	63.38
71	Waterford Lake	0.0610	63.43
72	Lake Naomi	0.0616	63.57
73	Lake Tranquility S1	0.0618	63.62
74	Werhane Lake	0.0630	63.89
75	Liberty Lake	0.0632	63.94
76	Countryside Glen Lake	0.0642	64.17
77	Leisure Lake	0.0648	64.30
78	St. Mary's Lake	0.0666	64.70
79	Long Lake	0.0680	65.00
80	Mary Lee Lake	0.0682	65.04
81	Hastings Lake	0.0684	65.08
82	Honey Lake	0.0690	65.21
83	North Tower Lake	0.0718	65.78
84	Lake Fairview	0.0724	65.90
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71

Table 4. Continued.

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

Table 4. Continued.

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

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in July of 2006. In previous years, the sampler, with the goal of covering most of the lake and finding all species present, chose sampling sites randomly. While this method worked well, a new sampling technique was implemented in 2005. Sampling sites were based on a grid system created by mapping software (ArcGIS), with each site located 60 meters (200 feet) apart. On Duck Lake, there were 105 sampling sites in 2006 (Figure 7). Overall, there were 14 species found, with Eurasian Watermilfoil (EWM) having the highest density (found at 66% of the sites). Coontail and White Water Lily were also abundant and were found at 46% and 41% of the sites, respectively (Table 5a). Plants need at least 1% of surface light levels in order to survive. Plants were found down to a depth of 7.0 feet, which relates to the 1% light level depth of 7.5 feet. Out of the 105 sample sites, plants were found at 86 of them (82%) (Table 5b).

These sample sites covered almost the entire lake (the remaining area was too shallow to reach by boat, especially the back channels), and therefore the lake had approximately 85% plant coverage, with approximately 35% topped out (plants reaching and crowding the surface of the lake). Ideally, a lake should have 30-40% plant coverage in order to sustain a healthy fishery, according to the IDNR. Duck has a higher than recommended plant community (85% total). Because Duck Lake is shallow and at the bottom of its watershed, it experiences a high nutrient and TSS load, which makes it difficult to improve water clarity. However, the high-density plant community helps utilize the high nutrient load that Duck Lake experiences, and helps to keep the water clarity at a decent level. If plants were reduced, algal populations may increase and cloud the water.

Plant diversity stayed similar between 2001 and 2006 (Table 6). Curlyleaf Pondweed, Largeleaf Pondweed, Small Pondweed, and Watermeal were the species found in 2001, but not in 2006. The changes can probably be attributed to natural annual variation, and the timing of sampling. Curlyleaf is an early season plant that was present in July of 2001, and likely was present earlier in 2006, but not in July of 2006. Duck Lake continues to have an invasive species in its plant community: EWM. The coverage of this species increased from 2001 when it was found at 4% of the sampling sites in July. In 2006 EWM was found at 66% of the sampling sites. This increase may have been due in part to the change in sampling technique. The old technique (prior to 2005) focused on shallow areas of the lake and may not have documented all of the EWM sites.

To the Lakes Management Unit's knowledge, Duck Lake implemented the following plant management techniques in 2006. In late April, granular 2,4-D was applied to both the north end of the lake and to the south end, and also from McNeal's Island to the north shore. Other areas were spot treated as needed to control EWM. Chemical quantity was reduced in 2006 from previous years. This led to more plants, but in turn improved water clarity and nutrient concentrations. 2,4-D is a systematic herbicide that can be used to selectively control broadleaved, dicot plants (EWM commonly the target). Due to the good overall quality of the plant community and the desire to preserve native, beneficial species, the continuation of spot treatments for EWM is recommended as opposed to any whole lake treatments.

Figure 7. Aquatic plant sampling grid that illustrate plant density in July on Wooster Lake, 2006.

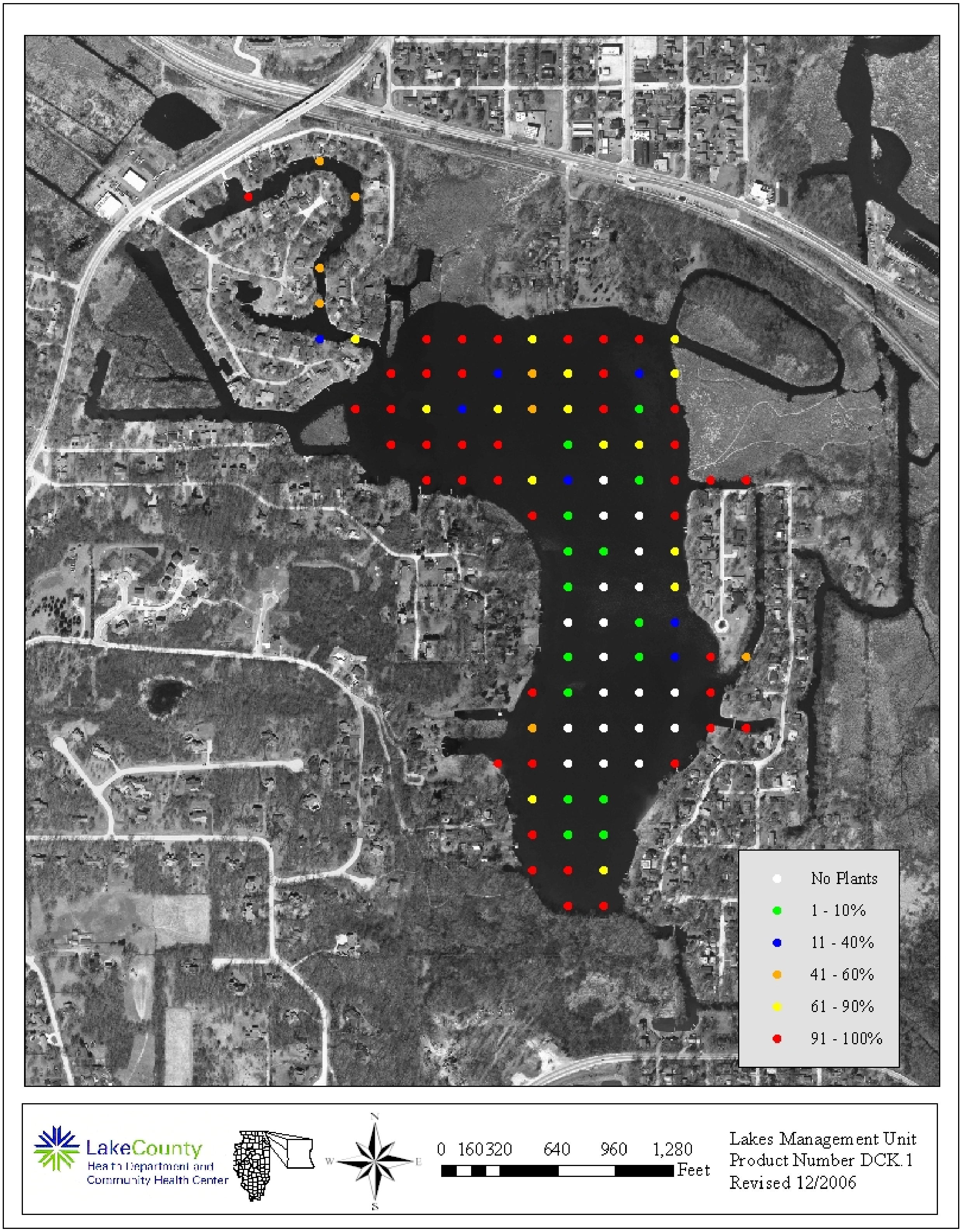


Table 5a. Aquatic plant species found at the sampling sites on Duck Lake, 2006. Maximum depth that plants were found was 7 feet.

Plant Density	Common Bladderwort	Chara	Coontail	Duckweed	Elodea	Eurasian Milfoil	Giant Duckweed	Northern Milfoil	Sago Pondweed
Absent	88	102	57	103	101	36	104	104	84
Present	8	2	13	1	4	21	1	1	14
Common	8	0	8	1	0	16	0	0	6
Abundant	1	1	14	0	0	14	0	0	1
Dominant	0	0	13	0	0	18	0	0	0
% Plant Occurrence	16	3	46	2	4	66	1	1	20

Plant Density	Southern Naiad	Spatterdock	Spiny Naiad	White Water Lily
Absent	103	102	102	62
Present	2	1	2	11
Common	0	1	1	8
Abundant	0	0	0	7
Dominant	0	1	0	17
% Plant Occurrence	2	3	3	41

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

Rake Density (coverage)	# of Sites	% of Sites
No Plants	19	18
>0-10%	15	14
10-40%	7	7
40-60%	8	8
60-90%	15	14
>90%	41	39
Total Sites with Plants	86	82
Total # of Sites	105	100

Table 6. Aquatic plant species found in Duck Lake, 2006.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara spp.*
American Elodea	*Elodea canadensis*
Small Duckweed	*Lemna minor*
Northern Watermilfoil	*Myriophyllum sibiricum*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Southern Naiad	*Najas guadalupensis*
Spiny Naiad	*Najas marina*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Sago Pondweed	*Potamogeton pectinatus*
Giant Duckweed	*Spirodella polyrhiza*
Small Bladderwort*	*Utricularia minor*
Common Bladderwort	*Utricularia vulgaris*

*** Endangered species in Illinois**
^ Exotic species

Floristic Quality Index (FQI) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (Nichols, 1999). Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates there are a large number of sensitive, high quality plants species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2006 Lake County lakes was 13.6. Duck Lake had a FQI of 21.1 in 2006, which ranked it 23rd (Table 7). This was an increase from 2001 when the FQI was 17.1, which may be related to the absence of Curlyleaf Pondweed during our sampling time. For comparison, Fish Lake, Fischer Lake, and Wooster Lake have recent FQIs of 19.3, 9.0, and 19.8, respectively.

Plankton are microscopic plants and animals that are free-floating within the water column. Samples were collected during water quality testing and analyzed for species content (Appendix A). Phytoplankton are the algae (plant-like) organisms of the plankton. An algal bloom was noted in July and August. The noted July algal bloom was caused by green algae called Microspora, while the August bloom was the result of excess Aphanizomenon growth (a blue-green algal species) and excess Microspora growth (Figure 8a). Zooplankton are the animal group of the plankton that feed on the phytoplankton. Rotifers dominated the zooplankton community throughout the summer, especially in May. Copepods and cladocerans were also observed in high numbers most months (Figure 8b).

SUMMARY OF SHORELINE CONDITION

In 2001, a complete shoreline assessment was performed in July. This assessment found 56% of Duck's shoreline was developed, with wetland being the most common shoreline type (30%). Other shoreline types found were rip rap, seawall and lawn. In 2001, approximately 30% of the shoreline was eroded to some degree. A reassessment of shoreline erosion in 2006 found some minor eroded areas no longer had erosion (northwest channels) and some areas that did not experience erosion in 2001 were categorized as having erosion in 2006 (Figure 9). For example, a large part of the area around the entrance to the western channel (just north of the beach) was categorized as moderately eroded. Buffer areas should be created in order to prevent further erosion and to stabilize areas that already have erosion problems. In 2004, a grant project was completed on the south end of the lake that installed a buffer comprised of native plant species in order to help control erosion. This may have helped decrease TSS and nutrient levels by filtering runoff before it entered the lake. Installation of more of these buffer zones may help further reduce nutrients and help water clarity.

Table 7. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/A) and with native species only (native).

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

Table 7. Continued.

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

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
86	Lake Matthews	12.0	12.0
87	Flint Lake	11.8	13.0
88	Harvey Lake	11.8	13.0
89	Rivershire Pond 2	11.5	13.3
90	Antioch Lake	11.3	13.4
91	Lake Charles	11.3	13.4
92	Lake Linden	11.3	11.3
93	Lake Naomi	11.2	12.5
94	Pulaski Pond	11.2	12.5
95	Redwing Marsh	11.0	11.0
96	West Meadow Lake	11.0	11.0
97	Nielsen Pond	10.7	12.0
98	Lake Holloway	10.6	10.6
99	Lake Carina	10.2	12.5
100	Crooked Lake	10.2	12.5
101	Lake Lakeland Estates	10.0	11.5
102	College Trail Lake	10.0	10.0
103	Werhane Lake	9.8	12.0
104	Big Bear Lake	9.5	11.0
105	Little Bear Lake	9.5	11.0
106	Loch Lomond	9.4	12.1
107	Sand Pond (IDNR)	9.4	12.1
108	Columbus Park Lake	9.2	9.2
109	Sylvan Lake	9.2	9.2
110	Fischer Lake	9.0	11.0
111	Grandwood Park Lake	9.0	11.0
112	Lake Fairfield	9.0	10.4
113	McDonald Lake 1	8.9	10.0
114	East Meadow Lake	8.5	8.5
115	South Churchill Lake	8.5	8.5
116	Lake Christa	8.5	9.8
117	Lake Farmington	8.5	9.8
118	Lucy Lake	8.5	9.8
119	Bittersweet Golf Course #13	8.1	8.1
120	Woodland Lake	8.1	9.9
121	Albert Lake	7.5	8.7
122	Lake Eleanor	7.5	8.7
123	Fairfield Marsh	7.5	8.7
124	Lake Louise	7.5	8.7
125	Banana Pond	7.5	9.2
126	Patski Pond	7.1	7.1
127	Rasmussen Lake	7.1	7.1
128	Slough Lake	7.1	7.1
129	Lucky Lake	7.0	7.0

Table 7. 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 8a. Phytoplankton community assemblage for Duck Lake, 2006.

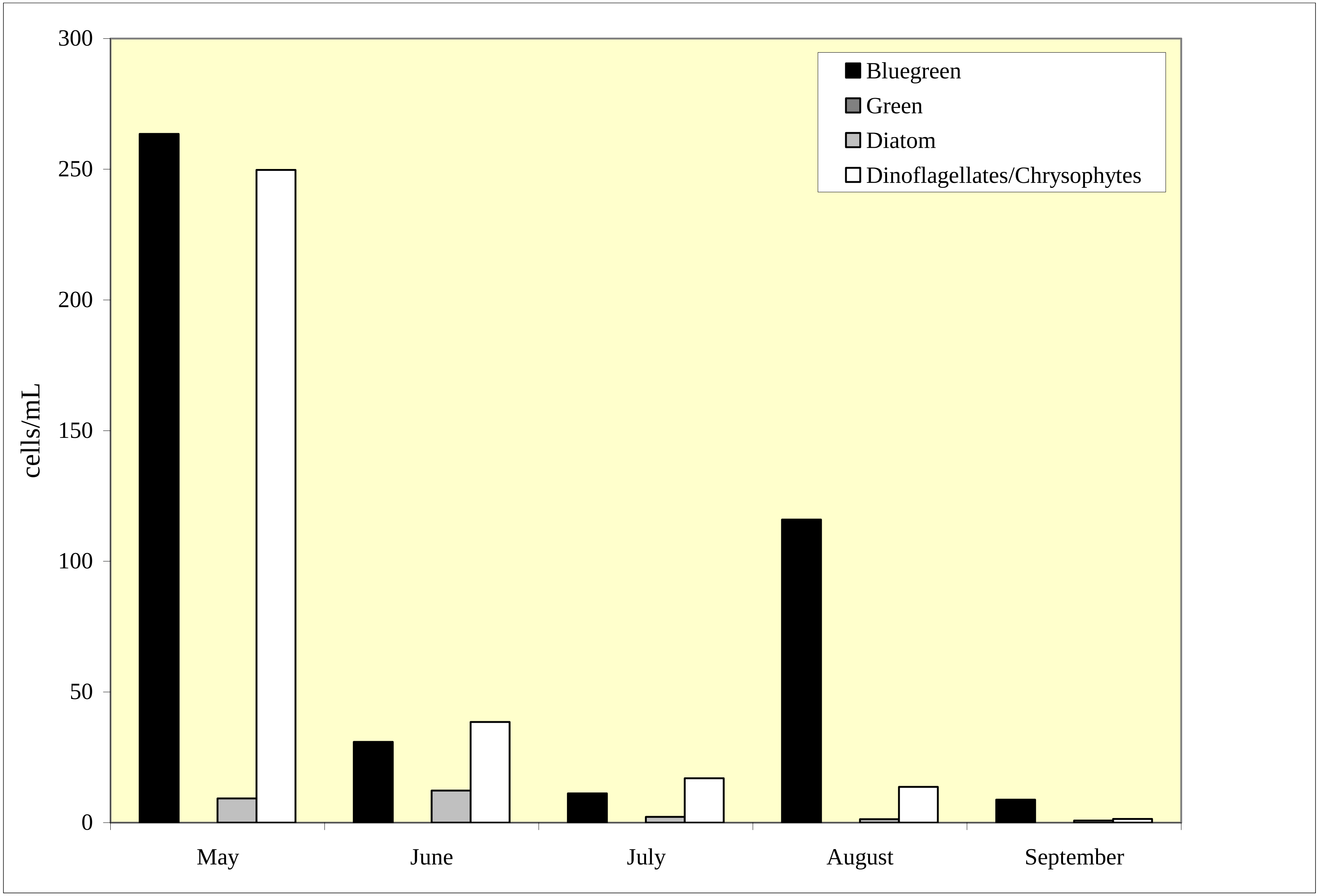


Figure 8b. Zooplankton community assemblage in Duck Lake, 2006.

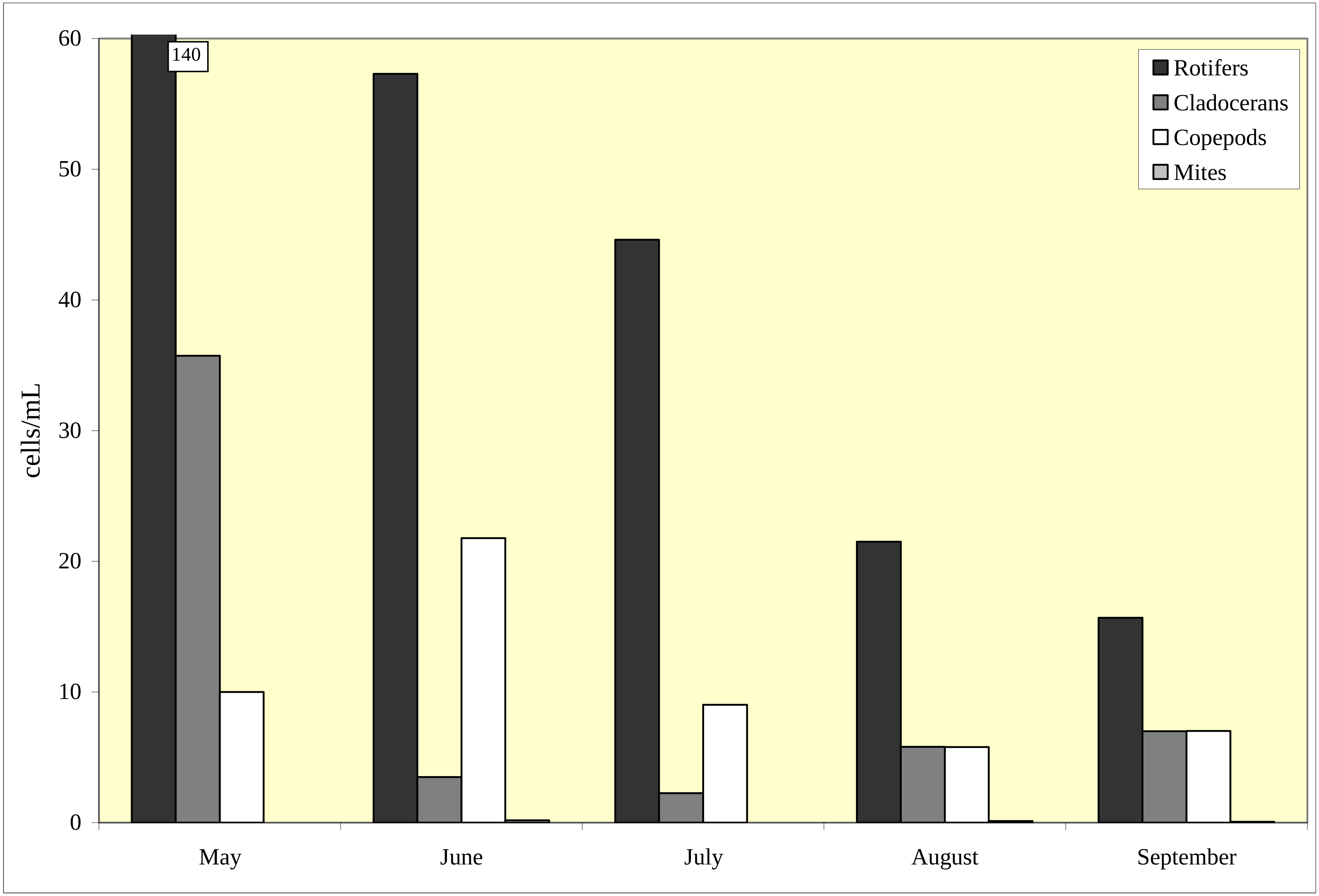
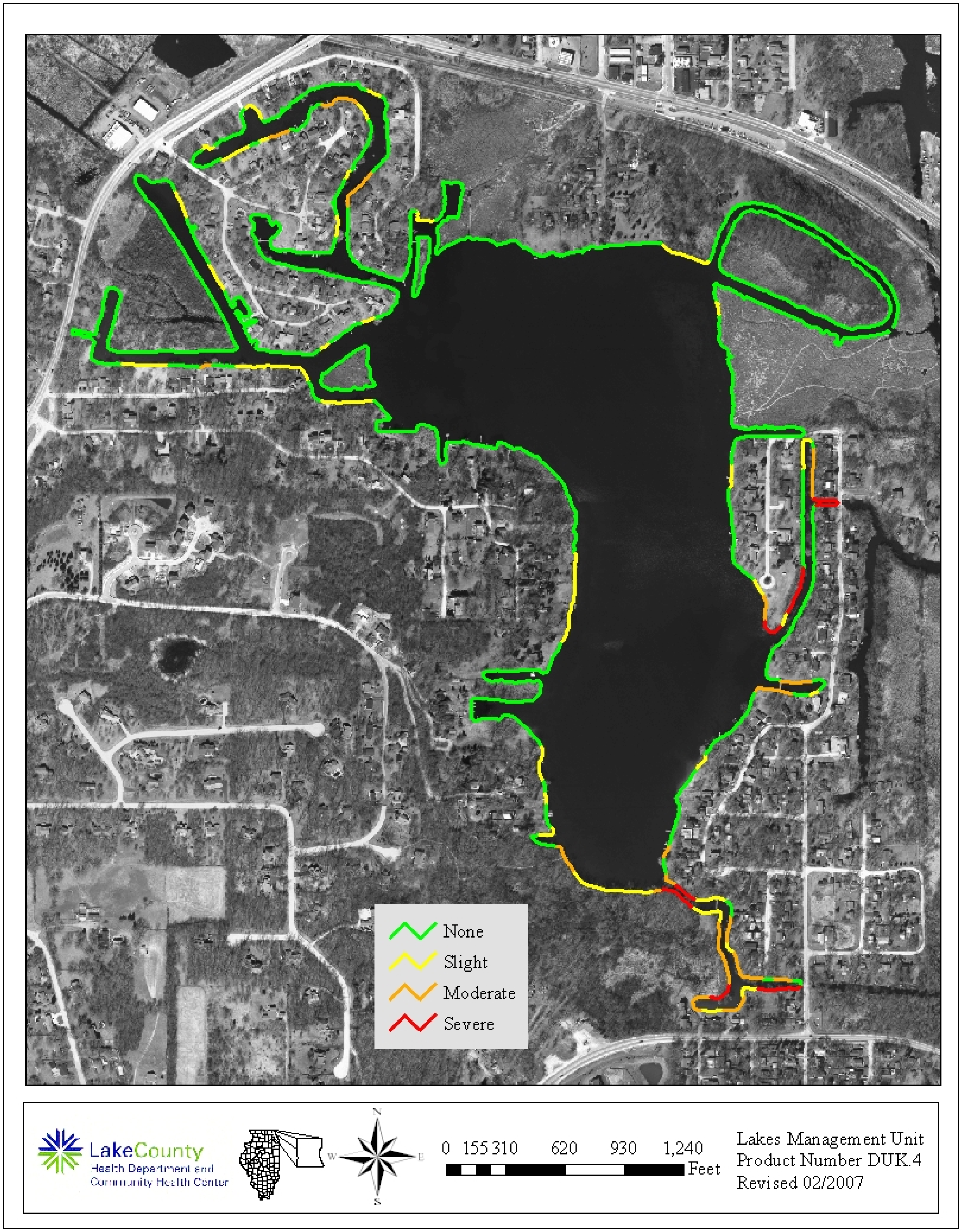


Figure 9. Shoreline erosion on Duck Lake, 2006.



SUMMARY OF WILDLIFE AND HABITAT CONDITIONS

Habitat conditions around Duck Lake are fairly good, with the wetland/shrub habitat on the southern and northeast end providing a valuable environmental surrounding. Improvement of other areas around the lake should be taken into serious consideration.

A reassessment of the 1996 IDNR fish population survey was conducted in September of 2004. A total of 15 species were collected in 2004, while 13 species were found in 1996. The IDNR 2004 report found that Bluegill remain as the dominant species (same as their survey in 1997), followed by Largemouth Bass and Yellow Bass. Other species present were: Black Crappie, Yellow Perch, Walleye, Northern Pike, Channel Catfish, Bowfin, Freshwater Drum, Common Carp, Spotfin Shiner, Bluntnose Minnow, Brook Silverside and the Golden Shiner.
The recommendations placed in the 2004 IDNR report of the fish population survey included reducing Largemouth Bass harvesting in May to maximize survival of breeding fish and their spawn; reducing all carp and Yellow Bass caught by fishermen as these species can dramatically impact reproduction of preferred species such as Bluegill and Largemouth Bass; and establishing a stocking program.

The Duck Lake Waterway Association has been stocking fingerling Largemouth Bass and either Northern Pike or Walleye every few years. They still observe large, old Common Carp, but have noticed a reduction in young carp being caught.

LAKE MANAGEMENT RECOMMENDATIONS

Duck Lake experienced many improvements in water quality since the last study was conducted in 2001, including a decrease in both TSS and TP concentrations. While progress is occurring, there are still actions that can be taken to improve the quality of the lake.

- **Creating a bathymetric map**

  A bathymetric map is a very useful tool used in lake management, especially on a lake that utilizes chemicals to control plant growth. The LCHD can provide services to create an accurate, up to date depth contour map of Duck Lake (See Appendix D1 for more details).

- **Lakes with shoreline erosion**

  While Duck Lake has taken steps in correcting shoreline erosion by installing native buffer strips, more could be installed to help other areas of shoreline experiencing erosion. It costs less to stop/prevent erosion at its early stages then to wait until it becomes a major issue where large portions of property have already fallen into the lake (See Appendix D2 for more details).

- **Aquatic plant management**

  Duck Lake has a high density plant community with approximately 85% of the lake bottom covered. With the exception of Eurasiam Watermilfoil (EWM), the lake has a good native plant community that helps utilize the nutrients that flow to the lake from its large watershed. Continued management of EWM is recommended while further treatment may cause a decrease in water clarity (See Appendix D3 for more details).

- **Eliminate or control exotic species**

  EWM has spread to more of lake than in 2001. While some of this increase may be attributed to sampling technique (as mentioned previously), this species is invasive and tends to take over lakes and choke out beneficial, native species. So far, Duck Lake still has a good native plant community and the continued use of chemicals to help suppress EWM should help control the species (See Appendix D4 for more details).

- **Watershed sediment reduction**

  TSS concentrations decreased dramatically from 2001, but still remain above the county median. The installation of more native buffer strips and less chemical plant treatment should help reduce TSS concentrations even more (See Appendix D5 for more details).

Reduce conductivity and chloride concentrations

While the chloride concentration in Duck Lake was below the county median, it was still high enough to have potential impacts on aquatic life, from algae, to plants, to fish. The use of road salts for safe winter driving is a major contributor to chloride and conductivity concentrations and there are proper application procedures and alternative methods that can be used in order to keep these concentrations under control (See Appendix D6 for more details).

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES

Water Sampling and Laboratory Analyses

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

Plant Sampling

In order to randomly sample each lake, mapping software (ArcMap 9.1) overlaid a grid pattern onto a 2006 aerial photo of Lake County and placed points 60 or 30 meters apart, depending on lake size. Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At designated sampling sites, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, plant coverage was assessed for overall abundance. Then plants were individually identified and placed in categories based on coverage. Plants that were not found on the rake but were seen in the immediate vicinity of the boat at the time of sampling were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation.

Plankton Sampling

Plankton were sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a or YSI 6600 Sonde® 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 63μm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton were collected within a small cup on the bottom of the tow. The collected sample was then emptied into a pre-labeled brown plastic bottle. The net was rinsed with deionized water into the bottle in order to ensure all the plankton were collected. The sample was then transferred to a graduated cylinder to measure the amount of milliliters (mL) that the sample was. The sample was then returned to the bottle and preserved with Lugol's iodine solution (5 drops/mL). The sample bottle was then closed and stored in a cooler until returning to the lab, where it was transferred to the refrigerator until enumeration. Enumeration was performed within three months, but ideally within one month, under a microscope. Prior to sub-sample being removed for enumeration, the sample bottle was inverted several times to ensure proper homogenization. An automated pipette was used to retrieve 1 mL of sample, which was then placed in a Sedgewick Rafter slide. This is a microscope slide on which a rectangular chamber has been constructed, measuring 50 mm x 20 mm in area and 1 mm deep. The slide was then placed under the microscope and counted at a 20X magnification (phytoplankton) or 10X magnification (zooplankton). For phytoplankton, twenty fields of view were randomly counted with all species within each field counted. Due to their larger size, zooplankton were counted throughout the entire slide. Through calculations, it was determined how many of each species were in 1 mL of lake water.

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

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

Shoreline Assessment

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

None – Includes man-made erosion control such as beach, rip-rap and sea wall.

Slight – Minimal or no observable erosion; generally considered stable; no erosion control practices will be recommended with the possible exception of small problem areas noted within an area otherwise designated as “slight”.

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

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 DUCK LAKE IN 2006.

Duck Lake 2006 Multi-parameter 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
												0.87
51606	92450	0.25	0.35	13.62	8.02	80.0	0.7628	8.37	600	Surface		
51606	92538	1	1.01	13.63	7.88	78.6	0.7648	8.39	521	Surface	100%	
51606	92640	2	2.01	13.63	8.05	80.3	0.7663	8.39	163	0.26	31%	4.47
51606	92733	3	2.94	13.63	7.97	79.5	0.7667	8.40	107	1.19	21%	0.35
51606	92817	4	4.02	13.62	7.90	78.8	0.7664	8.40	62	2.27	12%	0.24
51606	92909	5	4.97	13.62	7.88	78.5	0.7672	8.40	51	3.22	10%	0.06
51606	93032	6	6.10	13.61	7.82	77.9	0.7674	8.40	37	4.35	7%	0.07
51606	93125	7	7.01	13.55	7.77	77.3	0.768	8.39	36	5.26	7%	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
												0.79
62006	81632	0.25	0.26	24.22	8.91	109.3	0.7652	8.83	3236	Surface		
62006	81730	1	1.02	24.30	8.96	110.1	0.7631	8.89	3098	Surface	100%	
62006	81824	2	2.06	24.29	8.83	108.5	0.7629	8.86	991	0.31	32%	3.68
62006	81956	3	3.04	24.27	8.78	107.8	0.7639	8.86	545	1.29	18%	0.46
62006	82111	4	4.02	24.23	8.80	108.0	0.7646	8.85	320	2.27	10%	0.23
62006	82242	5	5.05	24.22	8.52	104.6	0.7641	8.82	181	3.3	6%	0.17
62006	82348	6	6.02	24.11	7.92	97.0	0.7635	8.77	99	4.27	3%	0.14
62006	82444	7	7.02	23.98	6.90	84.3	0.7661	8.68	67	5.27	2%	0.07
62006	82544	8	8.01	23.57	4.56	55.3	0.7753	8.22	37		1%	

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
												0.82
71806	81650	0.25	0.62	28.38	5.89	77.9	0.7824	8.48	3117	Surface		
71806	81756	1	1.00	28.39	5.77	76.4	0.7822	8.48	3091	Surface	100%	
71806	81846	2	2.05	28.36	5.68	75.6	0.782	8.47	972	0.3	31%	3.86
71806	81950	3	2.99	28.36	5.72	75.7	0.7821	8.47	550	1.24	18%	0.46
71806	82116	4	4.09	28.33	5.66	74.8	0.7812	8.47	252	2.34	8%	0.33
71806	82524	5	4.98	28.18	5.49	71.9	0.781	8.45	179	3.23	6%	0.11
71806	82742	6	6.07	28.06	5.44	71.6	0.7814	8.44	121	4.32	4%	0.09
71806	82850	7	6.99	27.88	5.22	68.4	0.7815	8.40	84	5.24	3%	0.07

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
												0.77
81506	83931	0.25	0.52	24.37	8.79	108.2	0.8096	8.63	3275	Surface		
81506	84022	1	1.05	24.36	8.75	107.8	0.8095	8.64	3196	Surface	100%	
81506	84200	2	2.07	24.35	8.69	106.9	0.8091	8.66	1069	0.32	33%	3.42
81506	84346	3	3.05	24.36	8.61	106.1	0.809	8.68	537	1.3	17%	0.53
81506	84438	4	4.06	24.36	8.77	108.0	0.809	8.68	278	2.31	9%	0.29
81506	84622	5	5.05	24.34	8.74	107.5	0.8088	8.68	169	3.3	5%	0.15
81506	84733	6	6.04	24.28	8.64	106.3	0.809	8.69	97	4.29	3%	0.13
81506	84910	7	7.05	24.17	8.27	101.5	0.8096	8.67	57	5.3	2%	0.10
81506	85109	8	8.08	24.28	1.04	12.8	0.9392	7.22	36	6.33	1%	0.07

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
												0.90
91906	82224	0.25	0.36	18.94	7.96	88.9	0.7799	8.26	614	Surface		
91906	82319	1	1.06	18.93	7.93	88.5	0.7803	8.27	560	Surface	100%	
91906	82523	2	2.02	18.92	7.91	88.3	0.7813	8.28	160	0.27	29%	4.64
91906	82756	3	3.01	18.93	7.96	88.8	0.782	8.29	93	1.26	17%	0.43
91906	82907	4	4.00	18.93	7.90	88.1	0.782	8.30	67	2.25	12%	0.15
91906	83010	5	5.05	18.93	7.74	86.4	0.7815	8.30	55	3.3	10%	0.06
91906	83105	6	6.05	18.89	7.85	87.5	0.7818	8.30	36	4.3	6%	0.10
91906	83300	7	7.07	18.68	7.50	83.3	0.7823	8.27	32	5.32	6%	0.02

APPENDIX C. INTERPRETING YOUR LAKES WATER QUALITY DATA

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

The following pages will discuss the different water quality parameters measured by Lake County Health Department staff, how these parameters relate to each other, and why the measurement of each parameter is important. The median values (the middle number of the data set, where half of the numbers have greater values, and half have lesser values) of data collected from Lake County lakes from 2000-2005 will be used in the following discussion.

Temperature and Dissolved Oxygen:

Water temperature fluctuations will occur in response to changes in air temperatures, and can have dramatic impacts on several parameters in the lake. In the spring and fall, lakes tend to have uniform, well-mixed conditions throughout the water column (surface to the lake bottom). However, during the summer, deeper lakes will separate into distinct water layers. As surface water temperatures increase with increasing air temperatures, a large density difference will form between the heated surface water and colder bottom water. Once this difference is large enough, these two water layers will separate and generally will not mix again until the fall. At this time the lake is thermally stratified. The warm upper water layer is called the ***epilimnion***, while the cold bottom water layer is called the ***hypolimnion***. In some shallow lakes, stratification and destratification can occur several times during the summer. If this occurs the lake is described as polymictic. Thermal stratification also occurs to a lesser extent during the winter, when warmer bottom water becomes separated from ice-forming water at the surface until mixing occurs during spring ice-out.

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

External pollution in the form of oxygen-demanding organic matter (i.e., sewage, lawn clippings, soil from shoreline erosion, and agricultural runoff) or nutrients that stimulate the growth of excessive organic matter (i.e., algae and plants) can reduce average DO concentrations in the lake by increasing oxygen consumption. This can have a detrimental impact on the fish community, which may be squeezed into a very small volume of water as a result of high temperatures in the epilimnion and low DO levels in the hypolimnion.

Nutrients:

Phosphorus:

For most Lake County lakes, phosphorus is the nutrient that limits plant and algae growth. This means that any addition of phosphorus to a lake will typically result in algae blooms or high plant densities during the summer. The source of phosphorus to a lake can be external or internal (or both). External sources of phosphorus enter a lake through point (i.e., storm pipes and wastewater discharge) and non-point runoff (i.e., overland water flow). This runoff can pick up large amounts of phosphorus from agricultural fields, septic systems or impervious surfaces before it empties into the lake.

Internal sources of phosphorus originate within the lake and are typically linked to the lake sediment. In lakes with high oxygen levels (oxic), phosphorus can be released from the sediment through plants or sediment resuspension. Plants take up sediment-bound phosphorus through their roots, releasing it in small amounts to the water column throughout their life cycles, and in large amounts once they die and begin to decompose. Sediment resuspension can occur through biological or mechanical means. Bottom-feeding fish, such as common carp and black bullhead can release phosphorus by stirring up bottom sediment during feeding activities and can add phosphorus to a lake through their fecal matter. Sediment resuspension, and subsequent phosphorus release, can also occur via wind/wave action or through the use of artificial aerators, especially in shallow lakes. In lakes that thermally stratify, internal phosphorus release can occur from the sediment through chemical means. Once oxygen is depleted (anoxia) in the hypolimnion, chemical reactions occur in which phosphorus bound to iron complexes in the sediment becomes soluble and is released into the water column. This phosphorus is trapped in the hypolimnion and is unavailable to algae until fall turnover, and can cause algae blooms once it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

Lakes with an average phosphorus concentration greater than 0.05 mg/L are considered nutrient rich. The median near surface total phosphorus (TP) concentration in Lake County lakes from 2000-2005 is 0.063 mg/L and ranged from a non-detectable minimum of <0.010 mg/L on five lakes to a maximum of 3.880 mg/L on Albert Lake. The median anoxic TP concentration in Lake County lakes from 2000-2005 was 0.174 mg/L and ranged from a minimum of 0.012 mg/L in West Loon Lake to a maximum of 3.880 mg/L in Taylor Lake.

The analysis of phosphorus also included soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for plant and algae growth. SRP is not discussed in great detail in most of the water quality reports because SRP concentrations vary throughout the season depending on how plants and algae absorb and release it. It gives an indication of how much phosphorus is available for uptake, but, because it does not take all forms of phosphorus into account, it does not indicate how much phosphorus is truly present in the water column. TP is considered a better indicator of a lake's nutrient status because its concentrations remain more stable than soluble reactive phosphorus. However, elevated SRP levels are a strong indicator of nutrient problems in a lake.

Nitrogen:
Nitrogen is also an important nutrient for plant and algae growth. Sources of nitrogen to a lake vary widely, ranging from fertilizer and animal wastes, to human waste from sewage treatment plants or failing septic systems, to groundwater, air and rainfall. As a result, it is very difficult to control or reduce nitrogen inputs to a lake. Different forms of nitrogen are present in a lake under different oxic conditions. NH_4^+ (ammonium) is released from decomposing organic material under anoxic conditions and accumulates in the hypolimnion of thermally stratified lakes. If NH_4^+ comes into contact with oxygen, it is immediately converted to NO_2 (nitrite) which is then oxidized to NO_3^- (nitrate). Therefore, in a thermally stratified lake, levels of NH_4^+ would only be elevated in the hypolimnion and levels of NO_3^- would only be elevated in the epilimnion. Both NH_4^+ and NO_3^- can be used as a nitrogen source by aquatic plants and algae. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. Adding the concentrations of TKN and nitrate together gives an indication of the amount of total nitrogen present in the water column. If inorganic nitrogen (NO_3^-, NO_2^-, NH_4^+) concentrations exceed 0.3 mg/L in spring, sufficient nitrogen is available to support summer algae blooms. However, low nitrogen levels do not guarantee limited algae growth the way low phosphorus levels do. Nitrogen gas in the air can dissolve in lake water and blue-green algae can "fix" atmospheric nitrogen, converting it into a usable form. Since other types of algae do not have the ability to do this, nuisance blue-green algae blooms are typically associated with lakes that are nitrogen limited (i.e., have low nitrogen levels).

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1

suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

Although several forms of solids (total solids, total suspended solids, total volatile solids) were measured each month by the Lakes Management Staff, total suspended solids (TSS) have the most impact on other variables and on the lake as a whole. TSS are particles of algae or sediment suspended in the water column. High TSS concentrations can result from algae blooms, sediment resuspension, and/or the inflow of turbid water, and are typically associated with low water clarity and high phosphorus concentrations in many lakes in Lake County. Low water clarity and high phosphorus concentrations, in turn, exacerbate the high TSS problem by leading to reduced plant density (which stabilize lake sediment) and increased occurrence of algae blooms. The median TSS value in epilimnetic waters in Lake County is 7.9 mg/L, ranging from below the 1 mg/L detection limit (10 lakes) to 165 mg/L in Fairfield Marsh.

TVS represents the fraction of total solids that are organic in nature, such as algae cells, tiny pieces of plant material, and/or tiny animals (zooplankton) in the water column. High TVS values indicate that a large portion of the suspended solids may be made up of algae cells. This is important in determining possible sources of phosphorus to a lake. If much of the suspended material in the water column is determined to be resuspended sediment that is releasing phosphorus, this problem would be addressed differently than if the suspended material was made up of algae cells that were releasing phosphorus. The median TVS value was 132 mg/L, ranging from 34 mg/L in Pulaski Pond to 298 mg/L in Fairfield Marsh.

Water Clarity:

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

Common Carp are prolific fish that feed on invertebrates in the sediment. Their feeding activities stir up bottom sediment and can dramatically decrease water clarity in shallow lakes. As mentioned above, lakes with low water clarity are, generally, considered to have poor water quality. This is because the causes and effects of low clarity negatively impact the plant and fish communities, as well as the levels of phosphorus in a lake. The detrimental impacts of low Secchi depth to plants has already been discussed. Fish populations will suffer as water clarity decreases due to a lack of food and decreased ability to successfully hunt for prey. Bluegills are planktivorous fish and feed on invertebrates that inhabit aquatic plants. If low clarity results in the disappearance of plants, this food source will disappear too. Largemouth Bass and Northern Pike are piscivorous fish that feed on other fish and hunt by sight. As the water clarity decreases, these fish species find it more difficult to see and ambush prey and may decline in size as a result. This could eventually lead to an imbalance in the fish community. Phosphorus release from resuspended sediment could increase as water clarity and plant density decrease. This would then result in increased algae blooms, further reducing Secchi depth and aggravating all problems just discussed. The average Secchi depth for Lake County lakes is 3.17 feet. From 2000-2005, Fairfield Marsh and Patski Pond had the lowest Secchi depths (0.33 feet) and Bangs Lake had the highest (29.23 feet). As an example of the difference in Secchi depth based on plant coverage, South Churchill Lake, which had no plant coverage and large numbers of Common Carp in 2003 had an average Secchi depth of 0.73 feet (over four times lower than the county average), while Deep Lake, which had a diverse plant community and few carp had an average 2003 Secchi depth of 12.48 feet (almost four times higher than the county average).

Another measure of clarity is the use of a light meter. The light meter measures the amount of light at the surface of the lake and the amount of light at each depth in the water column. The amount of attenuation and absorption (decreases) of light by the water column are major factors controlling temperature and potential photosynthesis. Light intensity at the lake surface varies seasonally and with cloud cover, and decreases with depth. The deeper into the water column light penetrates, the deeper potential plant growth. The maximum depth at which algae and plants can grow underwater is usually at the depth where the amount of light available is reduced to 0.5%-1% of the amount of light available at the lake surface. This is called the euphotic (sunlit) zone. A general rule of thumb in Lake County is that the 1% light level is about 1 to 3 times the Secchi disk depth.

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

Alkalinity is the measurement of the amount of acid necessary to neutralize carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^{-}) ions in the water, and represents the buffering capacity of a body of water. The alkalinity of lake water depends on the types of minerals in the surrounding soils and in the bedrock. It also depends on how often the lake water comes in contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcium carbonate ($CaCO_3$) or dolomite ($CaMgCO_3$), alkalinity will be high. The median alkalinity in Lake County lakes (162 mg/L) is considered moderately hard according to the hardness classification scale of Brown, Skougstad and Fishman (1970). Because hard water (alkaline) lakes often have watersheds with fertile soils that add nutrients to the water, they usually produce more fish and aquatic plants than soft water lakes. Since the majority of Lake County lakes have a high alkalinity they are able to buffer the adverse effects of acid rain.

Conductivity and Chloride:
Conductivity is the inverse measure of the resistance of lake water to an electric flow. This means that the higher the conductivity, the more easily an electric current is able to flow through water. Since electric currents travel along ions in water, the more chemical ions or dissolved salts a body of water contains, the higher the conductivity will be. Accordingly, conductivity has been correlated to total dissolved solids and chloride ions. The amount of dissolved solids or conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Many Lake County lakes have elevated conductivity levels in May, but not during any other month. This was because chloride, in the form of road salt, was washing into the lakes with spring rains, increasing conductivity. Most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. Beginning in 2004, chloride concentrations are one of the parameters measured during the lake studies. Increased chloride concentrations may have a negative impact on aquatic organisms. Conductivity changes occur seasonally and with depth. For example, in stratified lakes the conductivity normally increases in the hypolimnion as bacterial decomposition converts organic materials to bicarbonate and carbonate ions depending on the pH of the water. These newly created ions increase the conductivity and total dissolved solids. Over the long term, conductivity is a good indicator of potential watershed or lake problems if an increasing trend is noted over a period of years. It is also important to know the conductivity of the water when fishery assessments are conducted, as electroshocking requires a high enough conductivity to properly stun the fish, but not too high as to cause injury or death.

pH:
pH is the measurement of hydrogen ion (H^+) activity in water. The pH of pure water is neutral at 7 and is considered acidic at levels below 7 and basic at levels above 7. Low pH levels of 4-5 are toxic to most aquatic life, while high pH levels (9-10) are not only toxic to aquatic life but may also result in the release of phosphorus from lake sediment. The presence of high plant densities can increase pH levels through photosynthesis, and lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night, depending on the rates of photosynthesis and respiration. Few, if any pH problems exist in Lake County lakes. Typically, the flooded gravel mines in the county are more acidic than the glacial lakes as they have less biological activity, but do not usually drop below pH levels of 7. The median near surface pH value of Lake County lakes is 8.30, with a minimum of 7.06 in Deer Lake and a maximum of 10.28 in Round Lake Marsh North.

Eutrophication and Trophic State Index:

The word *eutrophication* comes from a Greek word meaning “well nourished.” This also describes the process in which a lake becomes enriched with nutrients. Over time, this is a lake’s natural aging process, as it slowly fills in with eroded materials from the surrounding watershed and with decaying plants. If no human impacts disturb the watershed or the lake, natural eutrophication can take thousands of years. However, human activities on a lake or in the watershed accelerate this process by resulting in rapid soil erosion and heavy phosphorus inputs. This accelerated aging process on a lake is referred to as cultural eutrophication. The term trophic state refers to the amount of nutrient enrichment within a lake system. *Oligotrophic* lakes are usually deep and clear with low nutrient levels, little plant growth and a limited fishery. *Mesotrophic* lakes are more biologically productive than oligotrophic lakes and have moderate nutrient levels and more plant growth. A lake labeled as *eutrophic* is high in nutrients and can support high plant densities and large fish populations. Water clarity is typically poorer than oligotrophic or mesotrophic lakes and dissolved oxygen problems may be present. A *hypereutrophic* lake has excessive nutrients, resulting in nuisance plant or algae growth. These lakes are often pea-soup green, with poor water clarity. Low dissolved oxygen may also be a problem, with fish kills occurring in shallow, hypereutrophic lakes more often than less enriched lakes. As a result, rough fish (tolerant of low dissolved oxygen levels) dominate the fish community of many hypereutrophic lakes. The categorization of a lake into a certain trophic state should not be viewed as a “good to bad” categorization, as most lake residents rate their lake based on desired usage. For example, a fisherman would consider a plant-dominated, clear lake to be desirable, while a water-skier might prefer a turbid lake devoid of plants. Most lakes in Lake County are eutrophic or hypereutrophic. This is primarily as a result of cultural eutrophication. However, due to the fertile soil in this area, many lakes (especially man-made) may have started out under eutrophic conditions and will never attain even mesotrophic conditions, regardless of any amount of money put into the management options. This is not an excuse to allow a lake to continue to deteriorate, but may serve as a reality check for lake owners attempting to create unrealistic conditions in their lakes.

The Trophic State Index (TSI) is an index which attaches a score to a lake based on its average total phosphorus concentration, its average Secchi depth (water transparency) and/or its average chlorophyll *a* concentration (which represent algae biomass). It is based on the principle that as phosphorus levels increase, chlorophyll *a* concentrations increase and Secchi depth decreases. The higher the TSI score, the more nutrient-rich a lake is, and once a score is obtained, the lake can then be designated as oligotrophic, mesotrophic or eutrophic. Table 1 (below) illustrates the Trophic State Index using phosphorus concentration and Secchi depth.

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	≥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 Lakes with Shoreline Erosion

Option 1: Install a Seawall

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

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

Option 2: Install Rock Rip-Rap or Gabions

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

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

Option 3: Create a Buffer Strip

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

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

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

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

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

Option 5: Install A-Jacks®

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

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

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

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

D3. Options for Aquatic Plant Management

Option 1: Aquatic Herbicides

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

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

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

Option 2: Mechanical Harvesting

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

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

Option 3: Hand Removal

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

Option 4: Water Milfoil Weevil

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

If control with milfoil weevils were successful, the quality of the lake would be improved. Native plants could start to recolonize, and the fishery of the lake would improve due to more balanced predation and higher quality habitat. Waterfowl would benefit due to increased food sources and availability of prey. Use of milfoil weevils does have some drawbacks. Control using the weevil has been inconsistent in many cases. Also, milfoil control using weevils may not work well on plants in deep water. Furthermore, weevils do not work well in areas where plants are continuously disturbed by activities such as powerboats, swimming, harvesting or herbicide use. One of the most prohibitive aspects to weevil use is price. Typically weevils are stocked to achieve a density of 1-4 weevils per stem. This translates to 500-3000 weevils per acre.

Option 5: Reestablishing Native Aquatic Vegetation

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

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

D4. Options to 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.

D5. Options for Watershed Sediment Reduction

Continued sediment inflow can fill areas of the lake and cause the water to become turbid. Incoming sediment can smother fish eggs or cover young aquatic plants. Increased turbidity reduces sunlight penetration limiting aquatic plant growth. Damage to native aquatic plants from multiple sediment inputs can lead to the loss of these plant species and the animals that depend on them. Sight-feeding fish have a difficult time finding food in turbid water. Often nutrients, such as phosphorus, are attached to sediment particles that reach the lake through stormwater runoff, which can contribute to plant and algae growth.

Option 1. Municipal Street Sweeping

Street sweeping has been used by communities to help prevent debris from clogging stormsewer drains, but it also benefits a lake by removing excess sand, silt, phosphorus, and other pollutants. Leftover sand and salt applied to streets has been found to contain higher concentrations of silt, phosphorus and trace metals than new sand and salt mixes.

Option 2. Lake Friendly Lawn, Garden and Home Building Practices – Sediment

Please refer to the Watershed Development Ordinance for requirements.

a. Seed and mulch bare soil as soon as possible to minimize erosion and runoff.
b. During home building projects, disturb as little vegetation as possible to minimize erosion and runoff.
c. Incorporate a buffer strip of native vegetation next to the shoreline to improve the area for wildlife, enhance the aesthetics, and possibly increase the property value.
d. Minimize impervious surfaces when considering installing pathways or even driveways. Gravel can be a suitable and less expensive option than asphalt or concrete. This will allow water to infiltrate into the ground rather than flow across impervious surfaces.

Option 3. Agricultural Practices

Soil conservation practices such as leaving crop residue on agricultural fields helps protect the soil from erosion and potential delivery to lakes and streams by runoff. The soils and their nutrients stay where the crops can use them. In turn, less money is spent on fertilizers. Crop rotation can help rejuvenate soil that has been stripped of nutrients due to years of one crop being grown. Soil conservation practices can help protect soil from eroding and aid in maintaining the integrity of the soil.

D6. Options to Reduce Conductivity and Chloride Concentrations

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

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

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

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

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

Option 1. Proper Use on Your Property

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

Option 2. Examples of Alternatives

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

Calcium, Magnesium or Potassium Chloride

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

Calcium Magnesium Acetate (CMA)

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

Agricultural Byproducts

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

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

Option 3. Talk to Your Municipality About Using an Alternative

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

APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES

2000 - 2006 Water Quality Parameters, Statistics Summary

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

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

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

*ND = Many lakes had non-detects (71.5%)
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	**8.30**		Average	**7.20**	
Median	**8.30**		Median	**7.18**	
Minimum	**5.21**	**Redwing Slough**	Minimum	**6.24**	**Banana Pond**
Maximum	**10.28**	**Round Lake Marsh North**	Maximum	**8.48**	**Heron Pond**
STD	**0.48**		STD	**0.39**	
n =	**796**		n =	**247**	

	All Secchi 2000-2006	
Average	**4.48**	
Median	**3.27**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**21.82**	**Bangs Lake**
STD	**3.69**	
n =	**740**	

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

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

	TKNoxic <=3ft00-2006	
Average	**1.481**	
Median	**1.260**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.828**	
n =	**798**	

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

	TKNanoxic 2000-2006	
Average	**2.971**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.341**	
n =	**247**	

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

	TPoxic <=3ft00-2006	
Average	**0.101**	
Median	**0.061**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.179**	
n =	**798**	

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

	TPanoxic 2000-2006	
Average	**0.279**	
Median	**0.162**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.369**	
n =	**247**	

	TSSall <=3ft00-2006	
Average	**15.4**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.5**	
n =	**810**	

*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 =	**752**	

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	**261**	
Median	**116**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**450**	
n =	**79**	

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

LakeCounty
Health Department and
Community Health Center

APPENDIX F. GRANT PROGRAM OPPORTUNITES

Table F1. A list of potential grant opportunities

		Funding Focus				
Grant Program Name	**Funding Source**	**Water Quality**	**Flooding**	**Habitat**	**Cost Share**	**Typical Award**
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/