2007 SUMMARY REPORT
of
Bangs Lake

Lake County, Illinois

Prepared by the

LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT

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LAKE FACTS

Lake Name:	Bangs Lake
Historical Name:	None
Nearest Municipality:	Village of Wauconda
Location:	T44N, R9E, Sections 24, 25, and 26
Elevation:	766.2 feet above mean sea level
Major Tributaries:	Slocum Lake Drain
Watershed:	Fox River
Sub-watershed:	Slocum Lake Drain
Receiving Waterbody:	Slocum Lake
Surface Area:	306.1 acres
Shoreline Length:	6.3 miles
Maximum Depth:	32.0 feet
Average Depth:	10.9 feet
Lake Volume:	3,323.6 acre-feet
Lake Type:	Glacial
Watershed Area:	3,027.0 acres
Major Watershed Land Uses:	Single Family and Agricultural
Bottom Ownership:	Private, Public (Village of Wauconda)
Management Entities:	Village of Wauconda
Current and Historical Uses:	Swimming, fishing, boating.
Description of Access:	All access locations are private, open to the public (with a permit sticker).

In 2005, Bangs Lake was chosen to be one of seven "sentinel" lakes in the county, which Lake County Health Department - Lakes Management Unit (LMU) will be monitoring annually for five years, beginning with the 2005 season. This report summarizes the water quality sampling results and aquatic plant surveys conducted in 2007 on Bangs Lake. Similar reports have been written on data collected in 1990, 1997, 2002, 2005 and 2006, and are available from the LMU.

SUMMARY OF WATER QUALITY

Water samples were collected from April to October in Bangs Lake at the deepest point near the center of the lake (Figure 1). Samples were taken at three feet below the surface and approximately three feet above the lake bottom (Appendix A). Water level was taken from the staff gauge at the park district launch. The water level decreased through July, but rose again with the rains in August. There was an overall decrease of 0.48 inches for the season.

Bangs Lake has exceptional water quality (Appendix C) with many parameters below the county medians. The lake nutrient concentrations remained relatively stable or have improved since 2002. Total suspended solid (TSS) concentrations averaged 1.8 mg/L in 2007, which is more than four times lower than the county median (8.0 mg/L) and lower than in 2006 and 2005 (2.3 mg/L and 3.4 mg/L, respectively). High TSS values are typically correlated with poor water clarity (Secchi disk depth) and can be detrimental to many aspects of the lake ecosystem such as the plant and fish communities. As a result of low TSS concentrations, the average Secchi depth for the season (14.12 feet) was much higher than the county median (3.28 feet; Figure 2). Bangs Lake participates in the Volunteer Lake Management Program, which recorded similar Secchi depths to the LMU in 2007 with an average of 10.29 feet. Differences between VLMP and LCHD data can be attributed to discrepancies between samplers, as well as date and time samples were taken. LMU Secchi disk readings far surpassed the county median in 2006 and 2005 as well, with an average of 12.76 and 13.76 feet, respectively. Although the increase in water clarity is good, it most likely is due to the presence of Zebra Mussels in the lake. Zebra Mussels are filter feeders and the long term affects are not completely known. Signage should be present at all boat launches informing lake users of the presence of Zebra Mussels to prevent their spread to other lakes. Signs are available from the LMU.

Stratification is typical of nutrient-enriched deep lakes like Bangs Lake. When stratified, the lower and upper layers of water do not mix, and the lower layer typically becomes anoxic (dissolved oxygen <1 mg/L). Nutrient concentrations were slightly higher in the lower layer than in the upper layer, which is expected in a stratified lake. The lake was only stratified in June through August of 2007. Dissolved oxygen (DO) concentrations became anoxic in the hypolimnion June through August. The maximum volume experiencing anoxia was approximately 3.4% (DO concentrations <1.0 mg/L below 20 feet in June through August), thus there are no apparent DO problems in Bangs Lake (Appendix B). Concentrations >5.0 mg/L are considered adequate to support aquatic life, since some aquatic life, such as fish, suffer from oxygen stress below this amount.

Phosphorus is a nutrient that limits plant and algal growth, therefore any addition of phosphorus to the lake would likely produce algal blooms. Total phosphorus (TP) in the epilimnion of Bangs Lake has remained relatively stable over the years. In 2007 and 2006 it averaged 0.022 mg/L (Table 1), which is nearly a third of the county median (0.063 mg/L) (Appendix D). This was a slight decrease from the 2005 TP average of 0.023 mg/L. Nitrogen is the other nutrient critical for algal growth. Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen, and is typically bound up in algal and plant cells. The average TKN for Bangs Lake was 0.85 mg/L, which was lower than the county median of 1.22 mg/L, but only slightly lower than in 2006 (0.89 mg/L) and higher than in 2005 (0.83 mg/L). The TN:TP (total nitrogen to total phosphorus) ratio looks at which nutrient is limiting plant and algal growth in a lake. Bangs Lake had a TN:TP ratio of 48:1 which indicated phosphorus was highly limiting. A general overall index that is commonly used is called a trophic state index (TSI). This index can be calculated using total phosphorus values obtained at or near the surface. In 2007 Bangs Lake was mesotrophic with a TSIp value of 48.2. Bangs Lake ranked 15th of 163 lakes in the county based on TSIp (Table 2). In 2006, Bangs Lake was also classified as mesotrophic with a TSIp of 48.7.

Another index used by the Illinois Environmental Protection Agency (IEPA) for assessing lakes for aquatic life and recreational use impairment is calculated using the mean TSIp, percent macrophyte coverage, and the median nonvolatile suspended solids concentration. This index can be calculated using total phosphorus values obtained at or near the surface. In 2007 Bangs Lake had *Full* support for aquatic life, recreational use, and total overall use. The use support was the same for 2006, however in 2005, the recreational use was classified as *Partial*.

Conductivity readings in Bangs Lake have increased slightly over the past three years (Table 3). The 2007 average conductivity was 0.6202 milliSiemens/cm, which was slightly higher than the 2006 average (0.6199 mS/cm) and 2.2% higher than in 2005 (0.6064 mS/cm), however still below the county median of 0.8038 mS/cm. The most likely cause for these increases in conductivity readings was input from dissolved solids washed into the lake from storm events. One of the most common dissolved solids is road salt used in winter road maintenance. Because of the high conductivity readings, one additional parameter, chlorides, was collected. Chloride concentrations help determine if road salt is the primary chloride source as most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. The seasonal average for chlorides in Bangs Lake in 2007 was 102 mg/L in the epilimnion and hypolimnion. The chloride concentration is down from 2006 (107 mg/L), most likely due to the large amount of rain in August which diluted September and October samples. However, the chloride concentration is up from 2005 (99 mg/L), which is a common trend in Lake County Lakes. The Village of Wauconda is encouraged to pursue alternatives to road salt.

Figure 1. Water quality sampling site on Bangs Lake, 2007.

Figure 2. Secchi depth vs. total suspended solid (TSS) concentrations in Bangs Lake, 2007.

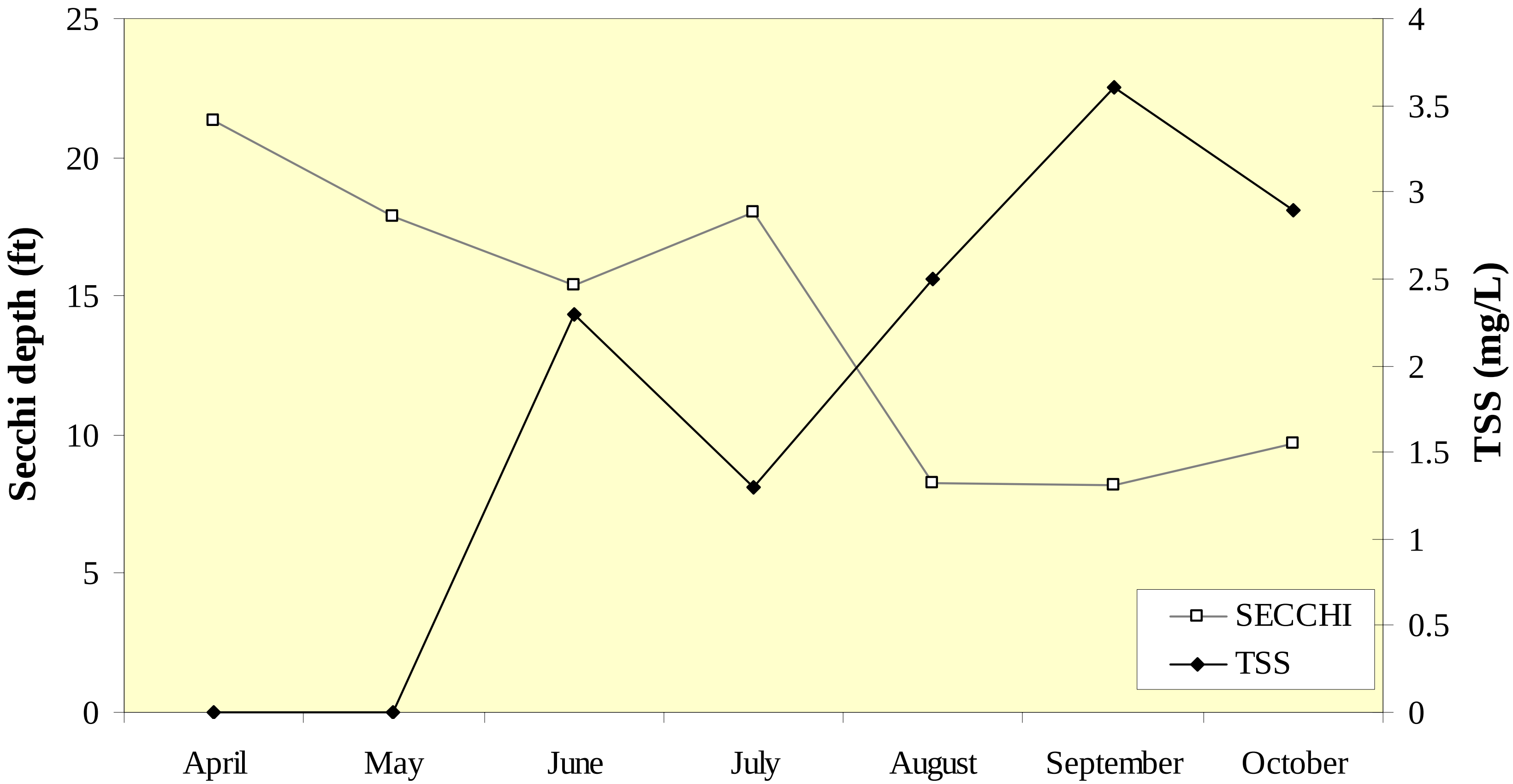

Table 1. Summary of water quality data for Bangs Lake, 2007.

2007	Epilimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
10-Apr	3	148	0.752	<0.1	<0.05	0.017	<0.005	104	<1	374	74	21.33	0.6369	8.34	12.22
15-May	3	149	0.758	<0.1	<0.05	0.015	<0.005	104	<1	382	81	17.88	0.6410	8.55	9.48
19-Jun	3	140	0.831	<0.1	<0.05	0.019	<0.005	105	2.3	367	88	15.42	0.6362	8.48	7.31
17-Jul	3	141	1.120	<0.1	<0.05	0.025	<0.005	107	1.3	362	78	18.04	0.6481	8.26	6.88
14-Aug	3	136	0.824	<0.1	<0.05	0.026	<0.005	103	2.5	364	89	8.27	0.6204	8.31	6.62
18-Sep	3	141	0.809	<0.1	<0.05	0.025	<0.005	97	3.6	362	85	8.20	0.6003	8.30	8.58
23-Oct	3	145	0.848	<0.1	<0.05	0.025	<0.005	97	2.9	352	86	9.68	0.5583	8.01	8.06
	Average	143	0.849	<0.1	<0.05	0.022	<0.005	102	2.5	366	83	14.12	0.6202	8.32	8.45

2006	Epilimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_2+NO_3	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	3	147	0.864	<0.1	0.059	0.021	<0.005	107	2.8	371	72	10.50	0.6412	8.23	10.54
17-May	3	136	0.858	<0.1	<0.05	0.024	<0.005	107	1.4	359	81	21.20	0.6222	8.04	9.08
21-Jun	3	126	0.818	<0.1	<0.05	0.024	<0.005	108	1.5	359	91	13.94	0.6129	8.91	6.88
19-Jul	3	124	0.884	<0.1	<0.05	0.018	<0.005	108	2.4	353	79	9.12	0.6140	8.80	7.59
16-Aug	3	125	0.950	<0.1	<0.05	0.024	<0.005	110	3.5	364	87	6.03	0.6186	8.75	7.82
20-Sep	3	129	0.990	<0.1	<0.05	0.023	0.005	106	3.1	358	82	6.72	0.6162	8.52	7.94
01-Nov	3	137	0.868	<0.1	<0.05	0.020	<0.005	106	1.5	366	89	21.82	0.6141	8.16	10.25
	Average	132	0.890	<0.1	0.008[k]	0.022	0.005[k]	107	2.3	361	83	12.76	0.6199	8.49	8.59

2005	Epilimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N*	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	3	142	0.726	<0.1	<0.05	<0.010	<0.005	90	3.2	350	85	10.50	0.5874	8.09	9.96
18-May	3	139	0.726	<0.1	<0.05	0.012	<0.005	93	<1.0	344	72	29.23	0.5948	7.61	9.92
22-Jun	3	128	0.844	<0.1	<0.05	0.016	<0.005	98	<1.0	349	95	18.41	0.5823	8.19	7.62
20-Jul	3	130	0.794	<0.1	<0.05	0.010	<0.005	102	<1.0	372	102	16.34	0.6089	8.07	7.36
18-Aug	3	134	0.800	<0.1	<0.05	0.031	<0.005	102	3.0	370	102	7.05	0.6099	8.67	7.67
21-Sep	3	139	1.000	<0.1	<0.05	0.044	<0.005	105	4.9	371	91	5.60	0.6211	8.67	7.18
19-Oct	3	141	0.900	<0.1	<0.05	0.027	<0.005	105	2.6	359	76	9.22	0.6405	8.37	8.16
	Average	136	0.827	<0.1	<0.05	0.023[k]	<0.005	99	3.4[k]	359	89	13.76	0.6064	8.24	8.27

Glossary

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

NA = Not Applicable

* = Prior to 2006 only Nitrate was analyzed

Table 1. Continued.

2007	Hypolimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
10-Apr	26	148	0.654	<0.1	0.052	0.014	<0.005	104	0.0	373	73	NA	0.6370	8.26	11.41
15-May	28	159	0.679	<0.1	<0.05	0.022	<0.005	103	1.5	384	75	NA	0.6593	7.65	0.72
19-Jun	26	166	0.933	0.211	<0.05	0.092	0.048	104	6.0	394	95	NA	0.6761	7.60	0.09
17-Jul	27	183	1.700	0.733	<0.05	0.455	0.131	104	12.0	395	82	NA	0.6985	7.58	0.09
14-Aug	27	176	1.830	0.835	<0.05	0.544	0.128	105	12.0	399	87	NA	0.7066	7.49	0.11
18-Sep	27	141	0.895	<0.1	<0.05	0.035	<0.005	97	4.7	365	91	NA	0.6012	8.17	7.25
23-Oct	27	146	0.83	<0.1	<0.05	0.024	<0.005	98	3.6	353	83	NA	0.5585	8.03	7.93
	Average	160	1.074	0.593	0.052	0.169	0.102	102	5.7	380	84	NA	0.6482	7.82	3.94

2006	Hypolimnion														
DATE	DEPTH	ALK	TKN	NH_3-N	NO2+NO3	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	20	147	0.778	<0.1	0.056	0.015	<0.005	106	2.8	373	74	NA	0.6409	8.22	10.36
17-May	24	137	0.782	<0.1	<0.05	0.021	<0.005	107	1.2	359	77	NA	0.6233	8.39	7.63
21-Jun	23	155	0.719	<0.1	<0.05	0.027	0.006	106	1.6	369	77	NA	0.6472	7.73	0.31
19-Jul	24	149	0.818	<0.1	<0.05	0.057	0.013	107	6.2	387	90	NA	0.6645	7.63	0.16
16-Aug	24	147	1.430	0.422	<0.05	0.146	0.048	109	7.2	382	97	NA	0.6789	7.49	0.12
20-Sep	23	129	0.960	<0.1	<0.05	0.020	<0.005	108	2.6	348	79	NA	0.6177	8.43	7.02
01-Nov	23	138	0.814	<0.1	<0.05	0.018	<0.005	105	1.0	365	87	NA	0.6139	8.17	10.11
	Average	143	0.900	0.422[k]	0.056[k]	0.043	0.023[k]	107	3.2	369	83	NA	0.6409	8.01	5.10

2005	Hypolimnion														
DATE	DEPTH	ALK	TKN	NH3-N	NO3-N*	TP	SRP	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
12-Apr	28	145	0.822	<0.1	<0.05	<0.010	<0.005	91	3.1	356	81	NA	0.6040	7.54	2.98
18-May	28	140	0.700	<0.1	<0.05	0.021	<0.005	93	1.0	348	74	NA	0.5969	7.72	8.25
22-Jun	28	161	0.856	<0.1	<0.05	0.062	0.019	94	5.2	362	80	NA	0.6155	7.19	0.08
20-Jul	24	167	0.848	<0.1	<0.05	0.054	0.010	95	8.0	367	82	NA	0.6298	7.23	0.05
18-Aug	27	180	2.020	0.878	<0.05	0.505	0.114	95	18.0	386	91	NA	0.6705	7.68	0.11
21-Sep	26	144	1.460	0.416	<0.05	0.174	0.083	104	5.5	368	84	NA	0.6364	7.83	0.19
19-Oct	23	141	0.944	<0.1	<0.05	0.029	<0.005	105	2.7	363	79	NA	0.6406	8.42	7.39
	Average	154	1.093	0.647[k]	<0.05	0.141[k]	0.057	97	6.2	364	82	NA	0.6277	7.66	2.72

Glossary

ALK = Alkalinity, mg/L $CaCO_3$	Cl^- = Chloride ions, mg/L
TKN = Total Kjeldahl nitrogen, mg/L	TSS = Total suspended solids, mg/L
NH_3-N = Ammonia nitrogen, mg/L	TS = Total solids, mg/L
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TP = Total phosphorus, mg/L	SECCHI = Secchi Disk Depth, ft.
SRP = Soluble reactive phosphorus, mg/L	COND = Conductivity, milliSiemens/cm
TDS = Total dissolved solids, mg/L	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 2. Lake County average TSI phosphorous (TSIp) ranking 2000-2007.

RANK	LAKE NAME	TP AVE	TSIp
1	Lake Carina	0.0100	37.35
2	Sterling Lake	0.0100	37.35
3	Independence Grove	0.0114	39.24
4	Sand Pond (IDNR)	0.0132	41.36
5	Cedar Lake	0.0157	41.60
6	Windward Lake	0.0158	43.95
7	Pulaski Pond	0.0180	45.83
8	Timber Lake (North)	0.0180	45.83
9	Fourth Lake	0.0182	45.99
10	West Loon Lake	0.0182	45.99
11	Lake Kathyrn	0.0200	47.35
12	Lake of the Hollow	0.0200	47.35
13	Banana Pond	0.0202	47.49
14	Lake Minear	0.0204	47.63
15	**Bangs Lake**	**0.0212**	**48.17**
16	Cross Lake	0.0220	48.72
17	Dog Pond	0.0222	48.85
18	Stone Quarry Lake	0.0230	49.36
19	Cranberry Lake	0.0234	49.61
20	Deep Lake	0.0240	49.98
21	Druce Lake	0.0244	50.22
22	Little Silver Lake	0.0246	50.33
23	Round Lake	0.0254	50.80
24	Lake Leo	0.0256	50.91
25	Dugdale Lake	0.0274	51.89
26	Peterson Pond	0.0274	51.89
27	Lake Miltmore	0.0276	51.99
28	East Loon Lake	0.0280	52.20
29	Lake Zurich	0.0282	52.30
30	Lake Fairfield	0.0296	53.00
31	Gray's Lake	0.0302	53.29
32	Highland Lake	0.0302	53.29
33	Hook Lake	0.0302	53.29
34	Lake Catherine (Site 1)	0.0308	53.57
35	Lambs Farm Lake	0.0312	53.76
36	Old School Lake	0.0312	53.76
37	Sand Lake	0.0316	53.94
38	Sullivan Lake	0.0320	54.13
39	Lake Linden	0.0326	54.39
40	Countryside Lake	0.0332	54.66
41	Gages Lake	0.0338	54.92
42	Hendrick Lake	0.0344	55.17
43	Third Lake	0.0346	55.24
44	Diamond Lake	0.0372	56.30
45	Channel Lake (Site 1)	0.0380	56.60
46	Ames Pit	0.0390	56.98

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
47	White Lake	0.0408	57.63
48	Sun Lake	0.0410	57.70
49	Potomac Lake	0.0424	58.18
50	Duck Lake	0.0426	58.25
51	Old Oak Lake	0.0428	58.32
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	Lake Fairview	0.0648	64.30
78	Leisure Lake	0.0648	64.30
79	Tower Lake	0.0662	64.61
80	Wooster Lake	0.0663	64.63
81	St. Mary's Lake	0.0666	64.70
82	Mary Lee Lake	0.0682	65.04
83	Hastings Lake	0.0684	65.08
84	Honey Lake	0.0690	65.21
85	Spring Lake	0.0726	65.94
86	ADID 203	0.0730	66.02
87	Bluff Lake	0.0734	66.10
88	Harvey Lake	0.0766	66.71
89	Broberg Marsh	0.0782	67.01
90	Echo Lake	0.0792	67.19
91	Sylvan Lake	0.0794	67.23
92	Big Bear Lake	0.0806	67.45

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
93	Petite Lake	0.0834	67.94
94	Timber Lake (South)	0.0848	68.18
95	Lake Marie (Site 1)	0.0850	68.21
96	North Churchill Lake	0.0872	68.58
97	Grand Avenue Marsh	0.0874	68.61
98	Grandwood Park, Site II, Outflow	0.0876	68.65
99	North Tower Lake	0.0878	68.68
100	South Churchill Lake	0.0896	68.97
101	Rivershire Pond 2	0.0900	69.04
102	McGreal Lake	0.0914	69.26
103	International Mine and Chemical Lake	0.0948	69.79
104	Eagle Lake (Site I)	0.0950	69.82
105	Valley Lake	0.0950	69.82
106	Dunns Lake	0.0952	69.85
107	Fish Lake	0.0956	69.91
108	Lochanora Lake	0.0960	69.97
109	Owens Lake	0.0978	70.23
110	Woodland Lake	0.0986	70.35
111	Island Lake	0.0990	70.41
112	McDonald Lake 1	0.0996	70.50
113	Longview Meadow Lake	0.1024	70.90
114	Long Lake	0.1029	70.96
115	Lake Barrington	0.1053	71.31
116	Redwing Slough, Site II, Outflow	0.1072	71.56
117	Lake Forest Pond	0.1074	71.59
118	Bittersweet Golf Course #13	0.1096	71.88
119	Fox Lake (Site 1)	0.1098	71.90
120	Osprey Lake	0.1108	72.04
121	Bresen Lake	0.1126	72.27
122	Round Lake Marsh North	0.1126	72.27
123	Deer Lake Meadow Lake	0.1158	72.67
124	Taylor Lake	0.1184	72.99
125	Columbus Park Lake	0.1226	73.49
126	Nippersink Lake (Site 1)	0.1240	73.66
127	Grass Lake (Site 1)	0.1288	74.21
128	Lake Holloway	0.1322	74.58
129	Lakewood Marsh	0.1330	74.67
130	Summerhill Estates Lake	0.1384	75.24
131	Redhead Lake	0.1412	75.53
132	Forest Lake	0.1422	75.63
133	Antioch Lake	0.1448	75.89
134	Slocum Lake	0.1496	76.36
135	Drummond Lake	0.1510	76.50
136	Pond-a-Rudy	0.1514	76.54
137	Lake Matthews	0.1516	76.56
138	Buffalo Creek Reservoir	0.1550	76.88

Table 2. Continued.

RANK	LAKE NAME	TP AVE	TSIp
139	Pistakee Lake (Site 1)	0.1592	77.26
140	Salem Lake	0.1650	77.78
141	Half Day Pit	0.1690	78.12
142	Lake Eleanor Site II, Outflow	0.1812	79.13
143	Lake Farmington	0.1848	79.41
144	ADID 127	0.1886	79.71
145	Lake Louise Inlet	0.1938	80.10
146	Grassy Lake	0.1952	80.20
147	Dog Bone Lake	0.1990	80.48
148	Redwing Marsh	0.2072	81.06
149	Stockholm Lake	0.2082	81.13
150	Bishop Lake	0.2156	81.63
151	Hidden Lake	0.2236	82.16
152	Fischer Lake	0.2278	82.43
153	Lake Napa Suwe (Outlet)	0.2304	82.59
154	Patski Pond (outlet)	0.2512	83.84
155	Oak Hills Lake	0.2792	85.36
156	Loch Lomond	0.2954	86.18
157	McDonald Lake 2	0.3254	87.57
158	Fairfield Marsh	0.3264	87.61
159	ADID 182	0.3280	87.69
160	Slough Lake	0.4134	91.02
161	Flint Lake Outlet	0.4996	93.75
162	Rasmussen Lake	0.5025	93.84
163	Albert Lake, Site II, outflow	1.1894	106.3

Table 3. Epilimnetic averages for select water quality parameters from previous studies of Bangs Lake.

DATE	TKN	TP	TSS	SECCHI	COND
2007	0.849	0.022	1.8	14.12	0.6202
2006	0.890	0.022	2.3	12.76	0.6199
2005	0.827	0.023	3.4	13.76	0.6064
2002	0.964	0.027	3.4	8.05	0.5538
1997	0.87	0.026	2.6	8.08	0.5228
1990	0.03	0.029	2.6	7.69	NA

Glossary

TKN = Total Kjeldahl nitrogen, mg/L
TP = Total phosphorus, mg/L
TSS = Total suspended solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm

SUMMARY OF AQUATIC MACROPHYTES

Plant sampling was conducted twice on Bangs Lake in 2007, once in May and again in July. There were 17 species of plants present (Table 4) with species differing between the two sampling periods. In May the three most abundant species were Curlyleaf Pondweed (60% of sites), Eurasian Watermilfoil (EWM; 20% of sites), and *Vallisneria* sp. (17% of sites) (Table 5). This shifted a bit in July (Table 6) with EWM as the dominant species (46% of sites), *Vallisneria* sp. as the second most dominant (31% of sites), and Coontail (28% of sites) as the third most abundant species. Also present in July, but not in May, were Largeleaf Pondweed, Southern Naiad, Spatterdock, and Water Stargrass. Small Pondweed and Northern Milfoil were present in 2006, but were not found in 2007.

EWM and Curlyleaf Pondweed are invasive, exotic species, and were found in the lake throughout the summer. Aquatic plant harvesting has been carried out for removal of both species since the 1990's. Since 2005, the Village of Wauconda has provided LMU with weekly maps of the areas harvested. Harvesting began in late-May and ended by mid-September and was concentrated in areas where EWM and Curlyleaf Pondweed are the most dense, (Figure 3; Figure 4) which tended to be the deeper areas of the lake. Many of the native pondweeds were found in greater densities in the shallow littoral zones. The harvesting technique appears to be an acceptable form of plant management at this time. Herbicide treatments have been done by private landowners in the past, however at this time the LMU does not recommend herbicides to be a long-term management strategy. Extensive herbicide treatments generally cause an overall decline in water quality, clarity, and species diversity. Diversity is also important for fish habitat. Bangs Lake harbors three Illinois endangered and threatened fish species (Blacknose Shiner, Iowa Darter, and Blackchin Shiner) which should be taken into consideration when planning plant management techniques. In addition, two threatened and endangered plant species have been historically found in Bangs Lake (White-stemmed Pondweed and Grass-leaved Pondweed).

Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a lake. When the light level in the water column falls below 1% of the surface light level, plants can no longer grow. The 1% light level in Bangs Lake ranged from 14 feet in August and 18 feet September/October to 26 feet in May. In May plants were found down to 24 feet and in July they were found to 18.6 feet. These plant depths correlate well with the 1% light level depths.

Floristic quality index (FQI) is an assessment tool designed to evaluate the closeness the flora of an area is to that of undisturbed conditions. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). Non-native species were counted in the FQI calculations for Lake County lakes. In 2007, Bangs Lake had an FQI of 24.5 and ranked #14 of 152 lakes in the county (Table 7). The median FQI of lakes that we have studied from 2000-2007 is 12.5. Bangs Lake had a FQI of 26.4 in 2006, slightly higher than 2007, most likely due to annual variation in plant abundance.

Table 4: Aquatic plant species found in Bangs Lake, 2007.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara* spp.
American Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Duckweed	*Lemna* spp.
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Southern Naiad	*Najas guadalupensis*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Largeleaf Pondweed	*Potamogeton amplifolius*
Curlyleaf Pondweed^	*Potamogeton crispus*
Illinois Pondweed	*Potamogeton illinoensis*
Sago Pondweed	*Potamogeton pectinatus*
Flatstem Pondweed	*Potamogeton zosteriformis*
White Water Crowfoot	*Ranunculus longirostris*
Eel Grass	*Vallisneria americana*
Watermeal	*Wolffia columbiana*

*** Endangered in Illinois**
^ Exotic plant

Table 5. Aquatic plant species found at the 316 sampling sites on Bangs Lake in May, 2007. The maximum depth plants were found was 24.0 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed	Illinois Pondweed
Present	27	13	82	6	8	51	21	26
Common	8	8	40	1	3	4	10	13
Abundant	1	6	37	0	0	7	5	5
Dominant	0	0	32	0	1	2	0	4
% Plant Occurrence	11.4	8.5	60.4	2.2	3.8	20.3	11.4	15.2

Plant Density	Sago Pondweed	Vallisneria	White Crowfoot	Watermeal	White Water Lily
Present	21	39	6	6	3
Common	5	13	1	1	0
Abundant	0	2	0	4	0
Dominant	0	1	0	1	0
% Plant Occurrence	8.2	17.4	2.2	3.8	0.9

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

Rake Density (coverage)	# of Sites	% of Sites
No Plants	67	21.2
>0-10%	76	24.1
10-40%	64	20.3
40-60%	56	17.7
60-90%	33	10.4
>90%	20	6.3
Total Sites with Plants	249	78.8
Total # of Sites	316	100.0

Table 6. Aquatic plant species found at the 265 sampling sites on Bangs Lake in July, 2007. The maximum depth plants were found was 18.6 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Duckweed	Elodea	Eurasian Watermilfoil	Flatstem Pondweed	Illinois Pondweed	Largeleaf Pondweed
Present	24	44	32	29	9	74	25	20	14
Common	9	10	0	3	3	22	9	10	2
Abundant	6	11	0	2	1	17	4	5	1
Dominant	4	10	0	2	1	9	0	0	2
% Plant Occurrence	16.2	28.3	12.1	13.6	5.3	46.0	14.3	13.2	7.2

Plant Density	Sago Pondweed	Southern Naiad	Spatterdock	Vallisneria	White Crowfoot	Watermeal	Water Stargrass	White Water Lily
Present	26	14	1	30	6	21	16	9
Common	8	1	0	24	0	2	14	2
Abundant	2	2	0	20	0	5	13	0
Dominant	0	0	0	8	0	3	21	0
% Plant Occurrence	13.6	6.4	0.4	30.9	2.3	11.7	24.2	4.2

Table 6b. Distribution of rake density across all sampling sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	45	17.0
>0-10%	68	25.7
10-40%	24	9.1
40-60%	29	10.9
60-90%	33	12.5
>90%	66	24.9
Total Sites with Plants	220	83.0
Total # of Sites	265	100.0

Figure 3. Aquatic plant sampling grid illustrating plant density on Bangs Lake, May 2007.

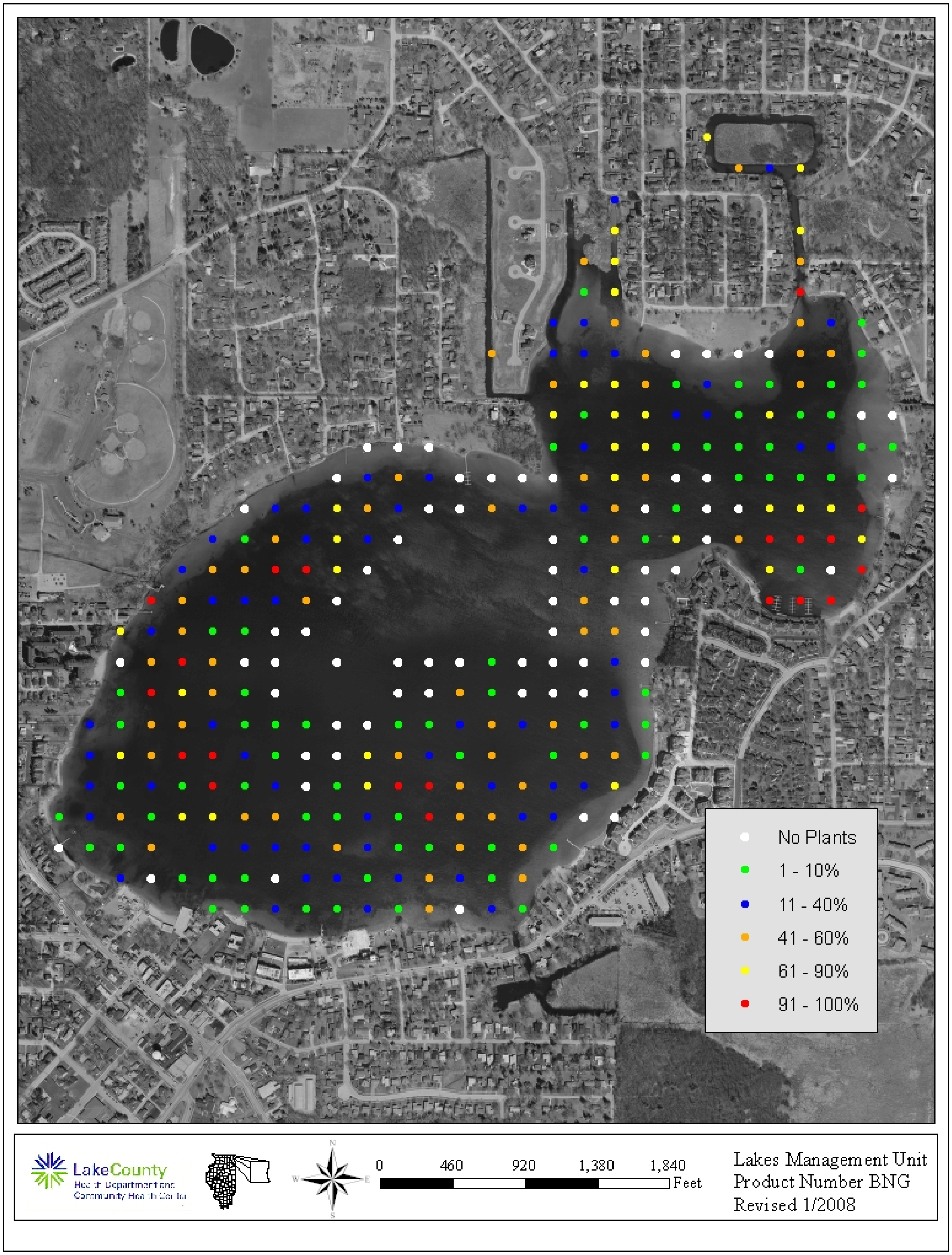

Figure 4. Aquatic plant sampling grid illustrating plant density on Bangs Lake, July 2007.

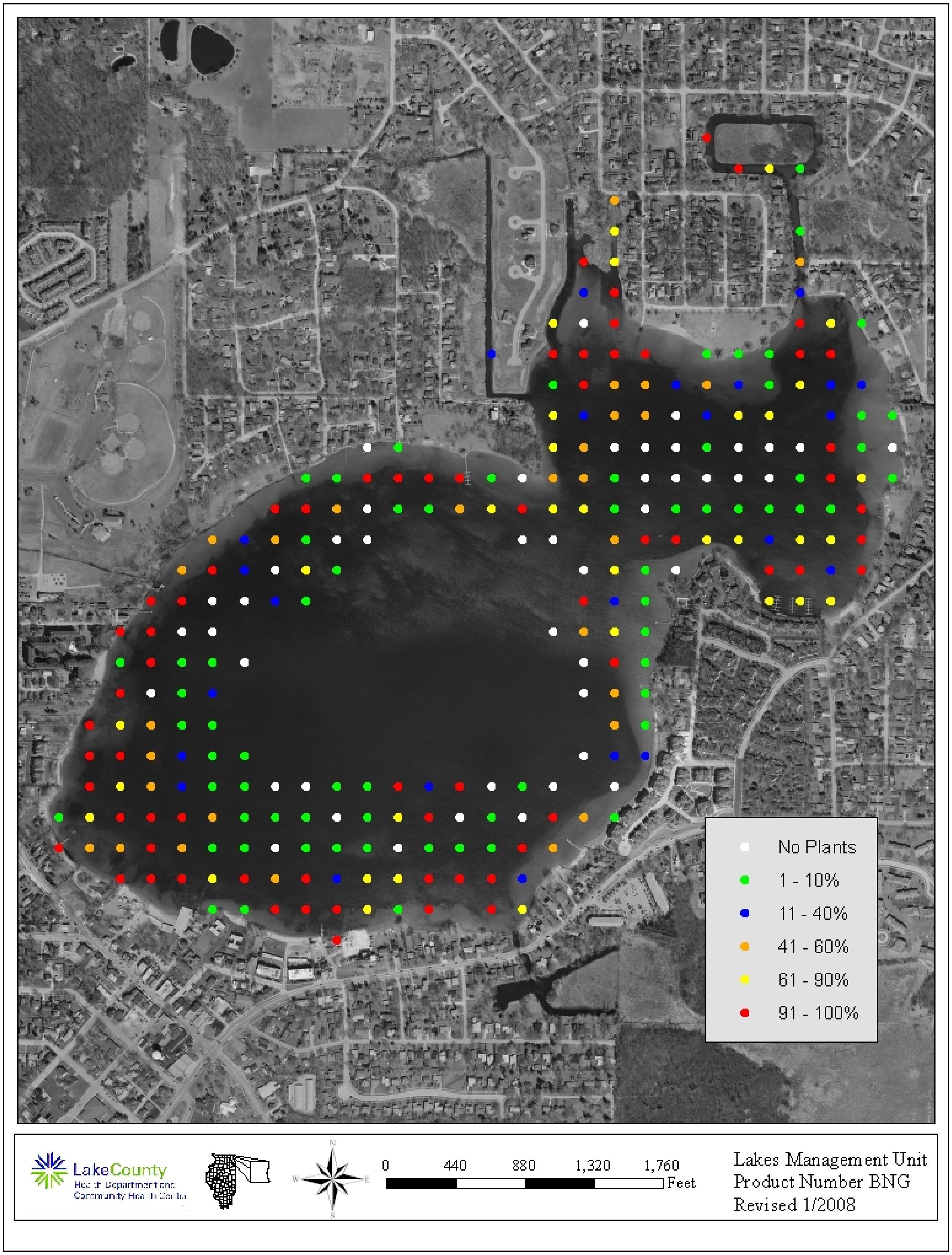

Table 7. Floristic quality index (FQI) of lakes in Lake County, calculated with exotic species (w/Adventives) and with native species only (native).

RANK	LAKE NAME	FQI (w/A)	FQI (native)
1	Cedar Lake	35.1	37.3
2	Deep Lake	33.9	35.4
3	Cranberry Lake	30.1	31.0
4	Round Lake Marsh North	29.1	29.9
5	East Loon Lake	28.4	29.9
6	Deer Lake	28.2	29.7
7	Sullivan Lake	28.2	29.7
8	Little Silver Lake	27.9	30.0
9	Schreiber Lake	26.8	27.6
10	West Loon Lake	26.0	27.6
11	Cross Lake	25.2	27.8
12	Independence Grove	24.6	27.5
13	Sterling Lake	24.5	26.9
14	**Bangs Lake**	**24.5**	**26.2**
15	Lake Zurich	24.0	26.0
16	Lake of the Hollow	23.8	26.2
17	Lakewood Marsh	23.8	24.7
18	Round Lake	23.5	25.9
19	Fourth Lake	23.0	24.8
20	Druce Lake	22.8	25.2
21	Sun Lake	22.7	24.5
22	Countryside Glen Lake	21.9	22.8
23	Butler Lake	21.4	23.1
24	Duck Lake	21.1	22.9
25	Timber Lake (North)	20.8	22.8
26	Wooster Lake	20.8	22.6
27	Broberg Marsh	20.5	21.4
28	Davis Lake	20.5	21.4
29	ADID 203	20.5	20.5
30	McGreal Lake	20.2	22.1
31	Lake Kathryn	19.6	20.7
32	Fish Lake	19.3	21.2
33	Redhead Lake	19.3	21.2
34	Owens Lake	19.3	20.2
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	Seven Acre Lake	17.0	15.5
41	Gray's Lake	16.9	19.8
42	Lake Barrington	16.7	17.7
43	Bresen Lake	16.6	17.8
44	Windward Lake	16.3	17.6

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
45	Diamond Lake	16.3	17.4
46	Lake Napa Suwe	16.3	17.4
47	Long Lake	16.1	18.0
48	Dog Bone Lake	15.7	15.7
49	Redwing Slough	15.6	16.6
50	Osprey Lake	15.5	17.3
51	Lake Fairview	15.2	16.3
52	Heron Pond	15.1	15.1
53	Lake Tranquility (S1)	15.0	17.0
54	North Churchill Lake	15.0	15.0
55	Island Lake	14.7	16.6
56	Dog Training Pond	14.7	15.9
57	Highland Lake	14.5	16.7
58	Grand Avenue Marsh	14.3	16.3
59	Taylor Lake	14.3	16.3
60	Dugdale Lake	14.0	15.1
61	Eagle Lake (S1)	14.0	15.1
62	Longview Meadow Lake	13.9	13.9
63	Ames Pit	13.4	15.5
64	Hook Lake	13.4	15.5
65	Third Lake	13.4	15.5
66	Bishop Lake	13.4	15.0
67	Mary Lee Lake	13.1	15.1
68	Old School Lake	13.1	15.1
69	Buffalo Creek Reservoir	13.1	14.3
70	McDonald Lake 2	13.1	14.3
71	Old Oak Lake	12.7	14.7
72	Timber Lake (South)	12.7	14.7
73	White Lake	12.7	14.7
74	Dunn's Lake	12.7	13.9
75	Echo Lake	12.5	14.8
76	Hastings Lake	12.5	14.8
77	Sand Lake	12.5	14.8
78	Stone Quarry Lake	12.5	12.5
79	Honey Lake	12.1	14.3
80	Lake Carina	12.1	14.3
81	Lake Leo	12.1	14.3
82	Lambs Farm Lake	12.1	14.3
83	Stockholm Lake	12.1	13.5
84	Pond-A-Rudy	12.1	12.1
85	Lake Matthews	12.0	12.0
86	Flint Lake	11.8	13.0
87	Harvey Lake	11.8	13.0
88	Rivershire Pond 2	11.5	13.3
89	Antioch Lake	11.3	13.4
90	Lake Charles	11.3	13.4

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
91	Lake Linden	11.3	11.3
92	Lake Naomi	11.2	12.5
93	Pulaski Pond	11.2	12.5
94	Lake Minear	11.0	13.9
95	Redwing Marsh	11.0	11.0
96	Tower Lake	11.0	11.0
97	West Meadow Lake	11.0	11.0
98	Nielsen Pond	10.7	12.0
99	Lake Holloway	10.6	10.6
100	Countryside Lake	10.5	12.1
101	Crooked Lake	10.2	12.5
102	College Trail Lake	10.0	10.0
103	Lake Lakeland Estates	10.0	11.5
104	Valley Lake	9.9	9.9
105	Werhane Lake	9.8	12.0
106	Big Bear Lake	9.5	11.0
107	Little Bear Lake	9.5	11.0
108	Loch Lomond	9.4	12.1
109	Columbus Park Lake	9.2	9.2
110	Sylvan Lake	9.2	9.2
111	Fischer Lake	9.0	11.0
112	Grandwood Park Lake	9.0	11.0
113	Lake Fairfield	9.0	10.4
114	McDonald Lake 1	8.9	10.0
115	East Meadow 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	South Churchill Lake	8.5	8.5
120	Bittersweet Golf Course #13	8.1	8.1
121	Woodland Lake	8.1	9.9
122	Albert Lake	7.5	8.7
123	Banana Pond	7.5	9.2
124	Fairfield Marsh	7.5	8.7
125	Lake Eleanor	7.5	8.7
126	Lake Louise	7.5	8.7
127	Patski Pond	7.1	7.1
128	Rasmussen Lake	7.1	7.1
129	Slough Lake	7.1	7.1
130	Lucky Lake	7.0	7.0
131	Lake Forest Pond	6.9	8.5
132	Leisure Lake	6.4	9.0
133	Peterson Pond	6.0	8.5
134	Gages Lake	5.8	10.0
135	Grassy Lake	5.8	7.1
136	Slocum Lake	5.8	7.1

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
137	Deer Lake Meadow Lake	5.2	6.4
138	Drummond Lake	5.0	7.1
139	IMC Lake	5.0	7.1
140	ADID 127	5.0	5.0
141	Liberty Lake	5.0	5.0
142	Oak Hills Lake	5.0	5.0
143	Forest Lake	3.5	5.0
144	Sand Pond (IDNR)	3.5	5.0
145	Half Day Pit	2.9	5.0
146	Lochanora Lake	2.5	5.0
147	Hidden Lake	0.0	0.0
148	North Tower Lake	0.0	0.0
149	Potomac Lake	0.0	0.0
150	St. Mary's Lake	0.0	0.0
151	Waterford Lake	0.0	0.0
152	Willow Lake	0.0	0.0
	Mean	**13.6**	**14.9**
	Median	**12.5**	**14.3**

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.

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 BANGS LAKE IN 2007

Bangs Lake 2007 Multiparameter data

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.10
41707	92254	0.25	0.25	8.07	12.11	105.5	0.6367	8.34	4100	Surface		
41707	92354	1	0.99	8.07	12.17	106.1	0.6387	8.34	3136	Surface		
41707	92455	2	1.98	7.95	12.19	106	0.6377	8.34	2500	0.23	100%	
41707	92545	3	2.98	7.9	12.22	106.2	0.6369	8.34	1240	1.23	50%	0.57
41707	92631	4	3.99	7.84	12.18	105.6	0.637	8.34	1524	2.24	61%	-0.09
41707	92730	6	5.98	7.76	12.15	105.2	0.6368	8.34	578	4.23	23%	0.23
41707	92834	8	8.01	7.71	12.07	104.4	0.637	8.34	445	6.26	18%	0.04
41707	92951	10	10	7.68	12.02	103.8	0.637	8.33	212	8.25	8%	0.09
41707	93125	12	11.95	7.43	12.02	103.2	0.6368	8.32	161	10.2	6%	0.03
41707	93213	14	14.03	7.31	12.07	103.3	0.6373	8.32	110	12.28	4%	0.03
41707	93307	16	16.02	6.9	12.08	102.4	0.6358	8.33	114	14.27	5%	0.00
41707	93403	18	18	6.71	11.9	100.4	0.636	8.3	54	16.25	2%	0.05
41707	93523	20	20.01	6.62	11.56	97.3	0.6367	8.28	42	18.26	2%	0.01
41707	93625	22	22.01	6.61	11.52	96.9	0.6373	8.27	28	20.26	1.1%	0.02
41707	93714	24	23.99	6.6	11.47	96.5	0.6371	8.27	22	22.24	0.9%	0.01
41707	93809	26	25.99	6.6	11.41	96	0.637	8.26	17	24.24	0.7%	0.01
41707	93855	28	28.01	6.56	11.21	94.2	0.6383	8.23	13	26.26	0.5%	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	Extinction Coefficient
											Average	0.08
51607	95907	0.25	0.26	18.41	9.54	104.7	0.6413	8.44	2194	Surface		
51607	100002	1	0.99	18.42	9.51	104.3	0.6402	8.49	2214	Surface	100%	
51607	100120	2	1.95	18.42	9.52	104.4	0.6421	8.53	1999	0.2	90%	0.51
51607	100226	3	3.01	18.39	9.48	103.9	0.641	8.55	1482	1.26	67%	0.24
51607	100337	4	4.03	18.4	9.41	103.2	0.641	8.57	1327	2.28	60%	0.05
51607	100557	6	6	18.36	9.38	102.8	0.6416	8.59	790	4.25	36%	0.12
51607	100705	8	8.03	18.31	9.39	102.8	0.6404	8.59	656	6.28	30%	0.03
51607	100840	10	10.04	18.19	9.23	100.7	0.6415	8.59	488	8.29	22%	0.04
51607	101015	12	12.04	18.02	9.14	99.4	0.6421	8.57	241	10.29	11%	0.07
51607	101128	14	14.01	17.91	9.11	98.9	0.6424	8.56	212	12.26	10%	0.01
51607	101246	16	16.02	16.02	8.12	84.7	0.6454	8.32	133	14.27	6%	0.03
51607	101436	18	18.04	15.26	6.03	61.9	0.6495	8.09	104	16.29	5%	0.02
51607	101534	20	20.02	14.85	4.47	45.5	0.6517	7.96	76	18.27	3%	0.02
51607	101620	22	22.01	14.49	2.88	29.1	0.6548	7.85	53	20.26	2%	0.02
51607	101719	24	24.04	14.24	1.55	15.6	0.6569	7.76	36	22.29	2%	0.02
51607	101905	26	26.02	14.02	0.86	8.6	0.6583	7.68	28	24.27	1.3%	0.01
51607	102017	28	27.97	13.94	0.72	7.2	0.6593	7.65	20	26.22	0.9%	0.01
51607	102104	30	30.02	13.83	0.52	5.2	0.6606	7.63	13	28.27	0.6%	0.02

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.26
62007	94936	0.25	0.47	25.73	7.34	92.2	0.6356	8.52	3669	Surface		
62007	95109	1	1.14	25.75	7.33	92.2	0.636	8.49	3535	Surface	100%	
62007	95228	2	2.02	25.74	7.29	91.6	0.6358	8.49	1491	0.27	42%	3.20
62007	95346	3	3.07	25.75	7.31	91.9	0.6362	8.48	886	1.32	25%	0.39
62007	95517	4	4.01	25.64	7.29	91.4	0.6358	8.48	911	2.26	26%	-0.01
62007	95647	6	6.13	25.4	7.4	92.4	0.6357	8.49	609	4.38	17%	0.09
62007	95844	8	8.16	25.33	7.43	92.6	0.6358	8.48	497	6.41	14%	0.03
62007	100028	10	9.97	25.3	7.3	90.9	0.6361	8.48	412	8.22	12%	0.02
62007	100135	12	12.05	25.17	6.84	85	0.637	8.44	272	10.3	8%	0.04
62007	100342	14	14.04	24.62	5.15	63.4	0.6386	8.29	184	12.29	5%	0.03
62007	100433	16	16.02	22.37	3.41	40.2	0.6401	7.99	128	14.27	4%	0.03
62007	100609	18	18.05	20.86	1.2	13.7	0.6461	7.77	78	16.3	2.2%	0.03
62007	100807	20	20	19.75	0.36	4	0.6522	7.64	60	18.25	1.7%	0.01
62007	100902	22	22.11	17.83	0.12	1.3	0.666	7.64	33	20.36	0.9%	0.03
62007	101013	24	24.08	16.8	0.1	1.1	0.6688	7.61	20	22.33	0.6%	0.02
62007	101204	26	26.12	15.67	0.09	1	0.6761	7.6	13	24.37	0.4%	0.02
62007	101426	28	28.08	15.27	0.07	0.8	0.6802	7.61	8	26.33	0.2%	0.02

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.17
71807	95619	0.25	0.36	25.2	6.9	82.7	0.6491	8.25	3817	Surface		
71807	95659	1	1.03	25.2	6.84	82	0.6478	8.26	2984	Surface	100%	
71807	95842	2	2.14	25.2	6.73	80.6	0.6481	8.26	1436	0.39	48%	1.88
71807	100023	3	3.18	25.2	6.88	82.4	0.6481	8.26	1224	1.43	41%	0.11
71807	100113	4	4.06	25.18	6.83	81.8	0.6479	8.27	928	2.31	31%	0.12
71807	100323	6	5.99	25.16	6.81	81.5	0.6481	8.28	705	4.24	24%	0.06
71807	100441	8	8.04	25.1	7	83.8	0.6483	8.28	433	6.29	15%	0.08
71807	100559	10	9.95	25.01	7.02	83.8	0.6483	8.29	419	8.2	14%	0.00
71807	100818	12	11.99	24.9	7	83.4	0.6485	8.28	248	10.24	8%	0.05
71807	100945	14	13.97	24.88	6.82	81.2	0.6489	8.26	164	12.22	5.5%	0.03
71807	101118	16	16.07	24.84	6.51	77.5	0.6491	8.24	107	14.32	3.6%	0.03
71807	101229	18	17.89	24.74	6.16	73.2	0.6493	8.22	81	16.14	2.7%	0.02
71807	101407	20	20.07	23.35	2.03	23.5	0.6549	7.76	56	18.32	1.9%	0.02
71807	101807	22	22.12	21.08	0.1	1.1	0.668	7.54	37	20.37	1.2%	0.02
71807	102002	24	24.01	19	0.08	0.8	0.6777	7.53	20	22.26	0.7%	0.03
71807	102129	26	26.04	16.86	0.07	0.8	0.6946	7.57	8	24.29	0.3%	0.04
71807	102243	28	28.08	16.14	0.1	1	0.7023	7.58	3	26.33	0.1%	0.04
71807	102354	30	30	15.92	0.08	0.8	0.7203	7.53	0	28.25		

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.58
81507	95914	0.25	0.3	24.05	7.61	89.1	0.6555	8.39	468	Surface		
81507	100008	1	1.04	26.93	6.62	81.8	0.6209	8.35	344	Surface	100%	
81507	100113	2	1.96	26.93	6.65	82.1	0.6209	8.33	93	0.21	27%	6.23
81507	100214	3	3.02	26.93	6.62	81.8	0.6204	8.31	81	1.27	24%	0.11
81507	100311	4	4.01	26.93	6.58	81.2	0.6208	8.31	49	2.26	14%	0.22
81507	100406	6	6.01	26.94	6.61	81.6	0.6209	8.3	39	4.26	11%	0.05
81507	100504	8	8.03	26.93	6.57	81.1	0.6211	8.29	23	6.28	7%	0.08
81507	100608	10	10.02	26.93	6.55	80.8	0.6212	8.28	15	8.27	4%	0.05
81507	100707	12	12.02	26.91	6.4	79	0.6212	8.26	11	10.27	3%	0.03
81507	100805	14	14.09	26.62	5.78	71	0.6224	8.18	7	12.34	2.0%	0.04
81507	100950	16	16.08	26.23	3.45	42	0.6284	7.89	4	14.33	1.2%	0.04
81507	101050	18	18.03	25.46	1.89	22.7	0.6341	7.71	3	16.28	0.9%	0.02
81507	101156	20	20.04	24.56	0.18	2.1	0.6438	7.59	1	18.29	0.3%	0.06
81507	101305	22	22.11	22.54	0.12	1.4	0.6646	7.51	1	20.36	0.3%	0.00
81507	101403	24	24.11	21.17	0.11	1.2	0.6764	7.5	0	22.36	0.0%	
81507	101518	26	25.98	19.08	0.11	1.1	0.7	7.5	0	24.23		
81507	101608	28	28.02	18.03	0.11	1.1	0.7131	7.47	0	26.27		
81507	101656	30	30.09	17.28	0.1	1	0.7222	7.44	0	28.34		

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.38
91907	94804	0.25	0.22	19.7	9.14	97.9	0.0091	8.3	3636	Surface		
91907	94852	1	1.07	20.2	8.68	94.1	0.6004	8.26	3732	Surface	100%	
91907	94929	2	1.98	20.19	8.65	93.7	0.6003	8.28	1451	0.23	39%	4.11
91907	95008	3	2.95	20.2	8.58	93	0.6002	8.29	931	1.2	25%	0.37
91907	95049	4	3.98	20.14	8.56	92.6	0.6003	8.3	507	2.23	14%	0.27
91907	95153	6	6.03	20.11	8.54	92.4	0.6004	8.3	445	4.28	12%	0.03
91907	95223	8	8.09	20.09	8.5	91.9	0.6004	8.3	185	6.34	5%	0.14
91907	95307	10	10.07	20.08	8.42	91.1	0.6005	8.31	121	8.32	3.2%	0.05
91907	95348	12	12.03	20.03	8.47	91.5	0.6004	8.31	70	10.28	1.9%	0.05
91907	95422	14	14.07	20.02	8.45	91.3	0.6006	8.3	36	12.32	1.0%	0.05
91907	95506	16	16	20.01	8.5	91.8	0.6006	8.3	22	14.25	0.6%	0.03
91907	95549	18	17.98	19.83	8.08	86.9	0.6012	8.27	13	16.23	0.3%	0.03
91907	95626	20	20.02	19.72	7.83	84.1	0.601	8.24	7	18.27	0.2%	0.03
91907	95657	22	21.98	19.54	7.59	81.2	0.6015	8.2	4	20.23	0.1%	0.03
91907	95727	24	23.98	19.43	7.33	78.3	0.6018	8.18	2	22.23	0.1%	0.03
91907	95805	26	25.98	19.21	7.26	77.2	0.6014	8.17	1	24.23	0.0%	0.03
91907	95839	28	28.02	19.17	7.23	76.8	0.6015	8.16	0	26.27		
91907	95926	30	29.92	19.04	6.32	67	0.6045	8.05	0	28.17		

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.36
102407	94126	0.25	0.30	14.26	8.09	81.1	0.5572	7.99	3277	Surface		
102407	94342	1	1.05	14.26	8.12	81.3	0.5586	8	3540	Surface	100%	
102407	94515	2	2.05	14.27	8.06	80.8	0.5584	8.01	792	0.3	22%	4.99
102407	94558	3	3.06	14.28	8.06	80.8	0.5583	8.01	801	1.31	23%	-0.01
102407	94653	4	4.00	14.28	8.03	80.5	0.5581	8.01	500	2.25	14%	0.21
102407	94825	6	6.01	14.26	7.98	80	0.5584	8.01	341	4.26	10%	0.09
102407	94939	8	8.02	14.27	7.98	80	0.5587	8.01	203	6.27	6%	0.08
102407	95126	10	9.97	14.25	7.97	79.8	0.5586	8.01	120	8.22	3%	0.06
102407	95234	12	12.02	14.25	7.94	79.6	0.5584	8.02	74	10.27	2%	0.05
102407	95325	14	14.05	14.26	7.96	79.7	0.5591	8.02	46	12.3	1%	0.04
102407	95431	16	16.00	14.25	8.02	80.3	0.5584	8.02	30	14.25	1%	0.03
102407	95651	18	18.00	14.25	7.93	79.4	0.5583	8.02	19	16.25	1%	0.03
102407	95807	20	20.02	14.23	7.96	79.7	0.5582	8.02	11	18.27	0.3%	0.03
102407	95911	22	22.03	14.24	7.93	79.5	0.5582	8.02	8	20.28	0.2%	0.02
102407	100038	24	24.04	14.23	7.89	79	0.5582	8.03	5	22.29	0.1%	0.02
102407	100147	26	25.99	14.23	7.88	78.9	0.5582	8.03	4	24.24	0.1%	0.01
102407	100315	28	28.09	14.22	7.95	79.6	0.5588	8.03	2	26.34	0.1%	0.03
102407	100415	30	30.08	14.21	7.8	78.1	0.5588	8.02	1	28.33	0.03%	0.02

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

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

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

Temperature and Dissolved Oxygen:

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

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes ≤ 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:

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

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

County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

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

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

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

The ratio of TKN plus nitrate nitrogen to total phosphorus (TN:TP) can indicate whether plant/algae growth in a lake is limited by nitrogen or phosphorus. Ratios of less than 10:1 suggest a system limited by nitrogen, while lakes with ratios greater than 20:1 are limited by phosphorus. It is important to know if a lake is limited by nitrogen or phosphorus because any addition of the limiting nutrient to the lake will, likely, result in algae blooms or an increase in plant density.

Solids:

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

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

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

Water Clarity:

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

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

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

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

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

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

pH:

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

Eutrophication and Trophic State Index:

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

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

Table 1. Trophic State Index (TSI).

Trophic State	TSI score	Total Phosphorus (mg/L)	Secchi Depth (feet)
Oligotrophic	<40	≤ 0.012	>13.12
Mesotrophic	$\geq 40<50$	$>0.012 \leq 0.024$	$\geq 6.56<13.12$
Eutrophic	$\geq 50<70$	$>0.024 \leq 0.096$	$\geq 1.64<6.56$
Hypereutrophic	≥ 70	>0.096	< 1.64

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

2000 - 2007 Water Quality Parameters, Statistics Summary

	ALKoxic <=3ft00-2007			ALKanoxic 2000-2007	
Average	**167.3**		Average	**200**	
Median	**162.0**		Median	**193**	
Minimum	**64.9**	**IMC**	Minimum	**103**	**Heron Pond**
Maximum	**330.0**	**Flint Lake**	Maximum	**470**	**Lake Marie**
STD	**42.0**		STD	**48**	
n =	**803**		n =	**253**	

	Condoxic <=3ft00-2007			Condanoxic 2000-2007	
Average	**0.8856**		Average	**1.0035**	
Median	**0.8038**		Median	**0.8340**	
Minimum	**0.2542**	**Broberg Marsh**	Minimum	**0.3210**	**Lake Kathyrn**
Maximum	**6.8920**	**IMC**	Maximum	**7.4080**	**IMC**
STD	**0.5243**		STD	**0.7787**	
n =	**802**		n =	**252**	

	NO3-N, Nitrate+Nitrite,oxic <=3ft00-2007			NH3-Nanoxic 2000-2007	
Average	**0.515**		Average	**2.070**	
Median	**0.150**		Median	**1.340**	
Minimum	**<0.05**	***ND**	Minimum	**<0.1**	***ND**
Maximum	**9.670**	**South Churchill Lake**	Maximum	**18.400**	**Taylor Lake**
STD	**1.082**		STD	**2.296**	
n =	**808**		n =	**252**	

*ND = Many lakes had non-detects (74.5%)
Only compare lakes with detectable
concentrations to the statistics above
Beginning in 2006, Nitrate+Nitrite was measured.

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

	pHoxic <=3ft00-2007			pHanoxic 2000-2007	
Average	**8.31**		Average	**7.22**	
Median	**8.31**		Median	**7.21**	
Minimum	**7.07**	**Bittersweet #13**	Minimum	**6.24**	**Banana Pond**
Maximum	**10.28**	**Round Lake Marsh North**	Maximum	**8.48**	**Heron Pond**
STD	**0.44**		STD	**0.41**	
n =	**797**		n =	**252**	

	All Secchi 2000-2007	
Average	**4.57**	
Median	**3.28**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**21.33**	**Bangs Lake**
STD	**3.81**	
n =	**750**	

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2000 - 2007 Water Quality Parameters, Statistics Summary (continued)

	TKNoxic <=3ft00-2007	
Average	**1.457**	
Median	**1.220**	
Minimum	**<0.1**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.830**	
n =	**808**	

*ND = 4.5% Non-detects from 16 different lakes

	TKNanoxic 2000-2007	
Average	**2.910**	
Median	**2.320**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.272**	
n =	**252**	

*ND = 2.8% Non-detects from 4 different lakes

	TPoxic <=3ft00-2007	
Average	**0.100**	
Median	**0.063**	
Minimum	**<0.01**	***ND**
Maximum	**3.880**	**Albert Lake**
STD	**0.171**	
n =	**808**	

*ND = 2.4% Non-detects from 7 different lakes
(Carina, Minear,& Stone Quarry)

	TPanoxic 2000-2007	
Average	**0.294**	
Median	**0.177**	
Minimum	**0.012**	**Indep. Grove and W. Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.380**	
n =	**252**	

	TSSall <=3ft00-2007	
Average	**15.5**	
Median	**8.0**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**814**	

*ND = 1.8% Non-detects from 11 different lakes

	TVSoxic <=3ft00-2007	
Average	**135.3**	
Median	**132.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**39.9**	
n =	**758**	

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 <=3ft00-2007	
Average	**232**	
Median	**119**	
Minimum	**41**	**Timber Lake (N)**
Maximum	**2390**	**IMC**
STD	**400**	
n =	**102**	

	CLoxic <=3ft00-2007	
Average	**211**	
Median	**158**	
Minimum	**30**	**White Lake**
Maximum	**2760**	**IMC**
STD	**247**	
n =	**411**	

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77 of 163 lakes had anoxic conditions
Anoxic conditions are defined <=1 mg/l D.O.
pH Units are equal to the -Log of [H] ion activity
Conductivity units are in MilliSiemens/cm
Secchi Disk depth units are in feet
All others are in mg/L

Minimums and maximums are based on data from all lakes from 2000-2007 (n=1363).

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

LCHD Lakes Management Unit ~ 12/17/2007

APPENDIX E. GRANT PROGRAM OPPORTUNITES.

Table E1. Potential Grant Opportunities

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

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

Table E1. Continued

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

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