2005 SUMMARY REPORT
of
Wooster Lake

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Wooster Lake is a natural glacial lake resulting from the last glaciation several thousand years ago. It is part of the Fish Lake drainage of the Fox River watershed. The Fish Lake Drain flows from south to north, from Fish Lake into Fischer Lake then into Wooster Lake. Water leaves Wooster Lake by a small creek along the northern shoreline and flows into Duck Lake, eventually draining into the Fox River. Wooster Lake is listed as an ADID (advanced identification) wetland by the U.S. Environmental Protection Agency (USEPA). This indicates that the lake and surrounding natural environments have potential to have high quality aquatic resources. The lake is also on the Illinois Department of Natural Resources (IDNR) Natural Area Inventory (NAI).

The lake was assessed through many parameters from April-October, 2005. Water clarity in the lake was good, with an average Secchi depth of 9.54 feet. This was an increase of nearly two feet since the 2003 sampling season (7.83 feet). Due to the high Secchi depth, total suspended solids (TSS) concentration was low (2.9 mg/L). This average TSS in 2005 was a decrease from the 2003 average (3.4 mg/L), as well as the 1999 average (4.3 mg/L). Conductivity is the measure of ions within water. The higher the conductivity, the more ions and the better the water can conduct electricity. In Wooster Lake, average conductivity in 2005 was 0.6945 mS/cm. This is a slight increase from the 2003 value of 0.6437 mS/cm. The overall increase in water quality was due to minimal flow into the lake from the Fish Lake Drain, due to the drought like conditions.

Nitrogen and phosphorus are the two nutrients that can limit plant and algal growth. The average epilimnetic total phosphorus concentration in Wooster Lake was 0.032 mg/L, which is half of the county median (0.063 mg/L). The average total Kjeldahl nitrogen concentration in Wooster Lake in 2005 (1.36 mg/L) increased from 2003 (1.13 mg/L).

The aquatic plant community in the lake consisted of 16 species in May, and 12 species in August. Coontail was the most dominant species in both May and August.
Plant diversity stayed similar between 2003 and 2005. Leafy Pondweed, Spatterdock and Whitestem Pondweed were the only species found in 2003, but not in 2005. The changes can probably be attributed to natural annual variation and the drought-like conditions in 2005.

Shoreline erosion slightly increased on the lake from the initial 2003 assessment, both in overall erosion, and in severity where erosion was documented before. Exotic shoreline plant species were observed as well.

LAKE FACTS

Lake Name:	Wooster Lake
Historical Name:	None
Nearest Municipality:	Grant
Location:	T45N, R9E, Section 23
Elevation:	742.0 feet
Major Tributaries:	None
Watershed:	Fox River
Sub-watershed:	Fish Lake Drainage
Receiving Water body:	Duck Lake
Surface Area:	98.5 acres
Shoreline Length:	2.03 miles
Maximum Depth:	28 feet
Average Depth:	16.3 feet
Lake Volume:	1,634.9 acre-feet
Lake Type:	Glacial
Watershed Area:	4,657 acres
Major Watershed Land uses:	Agriculture, forest and grassland
Bottom Ownership:	Village of Round Lake and Private
Management Entities:	Village and Private
Current and Historical uses:	Fishing, swimming and boating
Description of Access:	No public access

SUMMARY OF WATER QUALITY

Wooster Lake has a fairly large watershed area (Figure 1) encompassing two other main waterbodies to the south (Fish Lake and Fischer Lake). Wooster Lake receives runoff from a diverse watershed where agriculture covers the highest percentage of area. Single-family homes also cover a large portion of land, as well as wetland and forest/grassland (Figure 2). Directly surrounding Wooster Lake are mostly single-family homes, with a large wetland area on the southwest end, and small forest/grassland areas intermixed. The large amount of impervious surfaces associated with residential areas (rooftops, driveways, and roads) increase the amount of direct stormwater runoff into a lake (Table 1).

Water samples were taken monthly from April through October at the deepest location in the lake (Figure 3). Two samples were taken; one from the upper water layer (epilimnion) and one from the lower water layer (hypolimnion). They were analyzed for nutrients, solids concentration, and other physical parameters. The epilimnion sample was taken from three feet each month, while the hypolimnion sample varied from 23-26 feet deep, as these samples are always taken three feet above the bottom, and the water level fluctuated throughout the season (Appendix A). Wooster Lake was stratified from April until October, with the strongest thermal stratification occurring from June to August. Thermal stratification is measured in relative thermal resistance to mixing (RTRM). RTRM values that fall below 20 allow water within the entire waterbody to mix freely, while values of 20 and higher generally do not allow mixing. In most lakes, the size of this strongly stratified layer increases throughout the summer. This was the case in Wooster Lake, where stratification was weak in April and May, set-up strongly in June, and experienced the strongest stratification in July. Stratification was strong through September and was still present but very weak during October sampling, indicating fall turnover probably occurred soon after.

The average epilimnetic dissolved oxygen (DO) concentration was 8.03 mg/L (Table 2), with the highest reading in May (11.95 mg/L) and the lowest in October (5.58 mg/L). The average hypolimnetic DO concentration was 0.48 mg/L, with the highest reading in April (2.51 mg/L) and the lowest in June (0.05 mg/L). The hypoxic layer (where DO concentrations fall below 5.0 mg/L) went from approximately 21 feet in April to approximately 11 feet in August (Appendix B). This pattern of decreased oxygen content as the summer progresses is normal. As water heats up, it holds less oxygen. Also, as organisms start to die and fall to the bottom to decay, more oxygen is used to breakdown the dead material. Anoxic conditions (DO < 1.0 mg/L) were present in April, but only occurred at the lowest sampling depth (28 feet). By June, the anoxic layer began at approximately 16 feet and peaked in August at 14 feet. Since only an old bathymetric map (1971) of Wooster Lake exists, an accurate assessment of the volume of water affected by low DO conditions cannot be made. The creation of a new bathymetric map is recommended (Appendix D1).

Figure 1. Approximate watershed delineation of Wooster Lake, 2005.

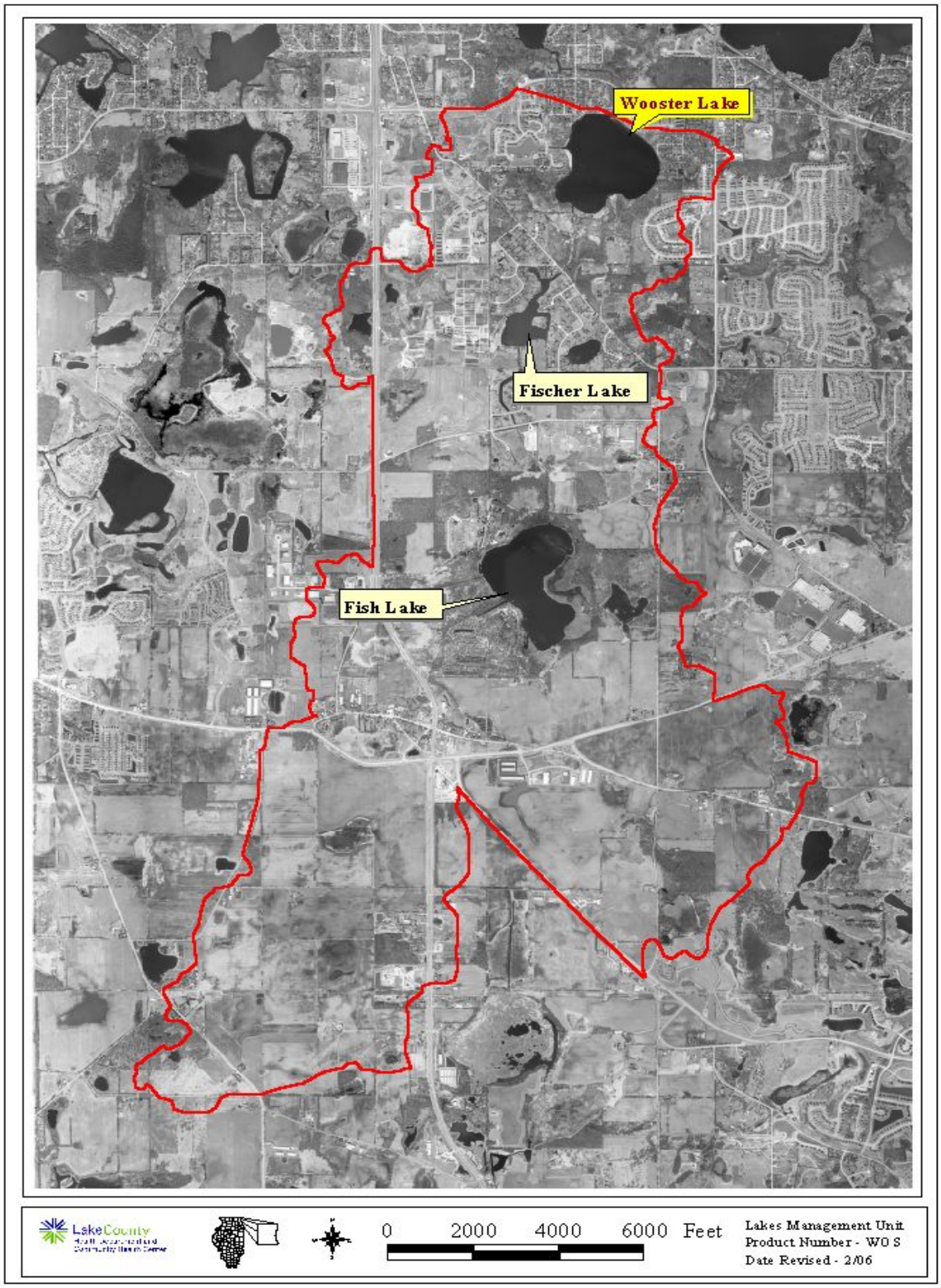


Figure 2. Approximate land use in the Wooster Lake watershed, 2005.

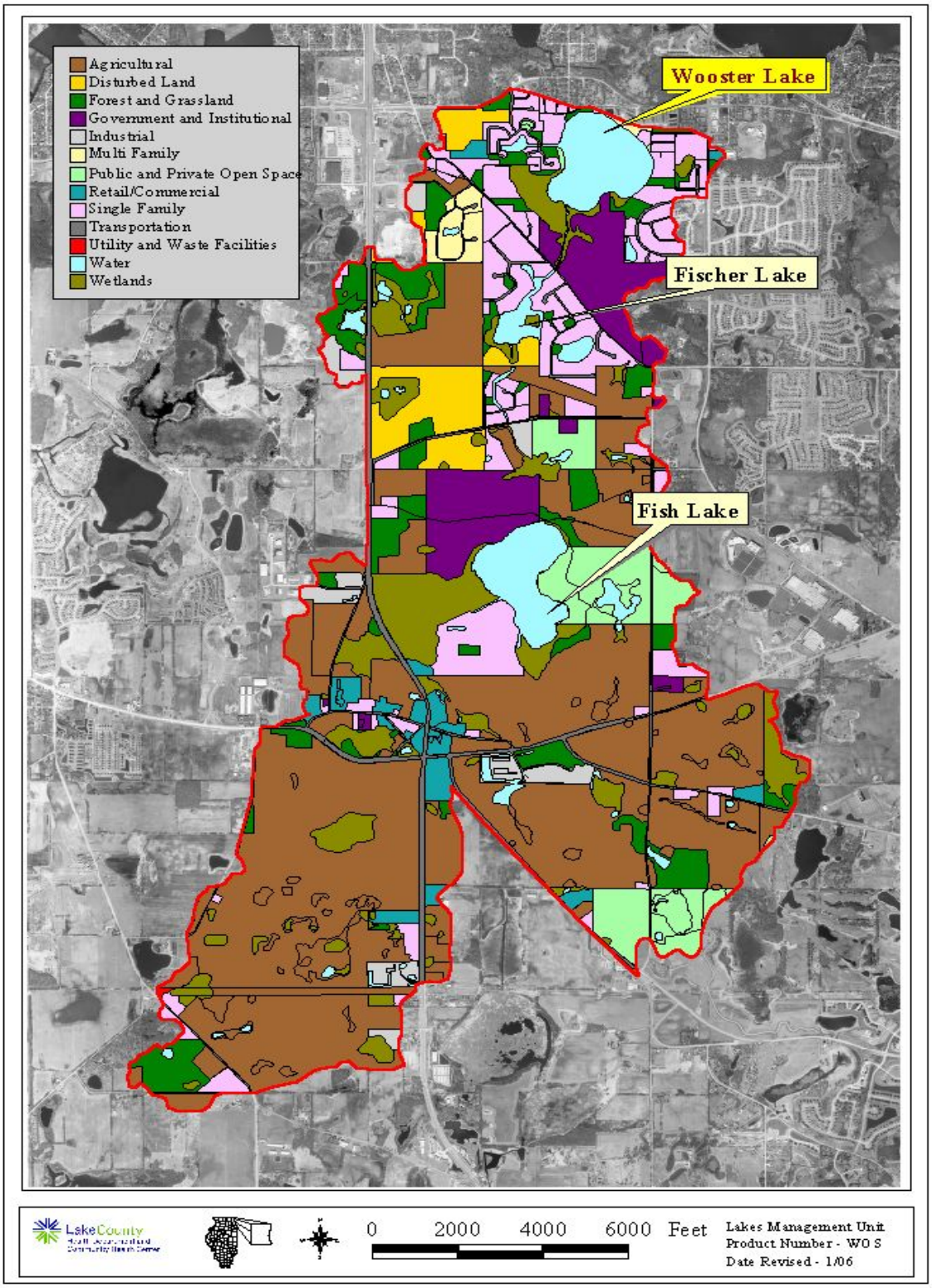


Table 1. Approximate land uses and retention time for Wooster Lake, 2005.

Land Use	Acreage	% of Total
Agricultural	2046.02	43.8
Disturbed Land	29.62	0.6
Forest and Grassland	546.60	11.7
Government and Institutional	260.39	5.6
Industrial	60.92	1.3
Multi Family	3.55	0.1
Public and Private Open Space	255.85	5.5
Retail/Commercial	86.39	1.8
Single Family	396.83	8.5
Transportation	254.57	5.4
Utility and Waste Facilities	26.47	0.6
Water	300.73	6.4
Wetlands	406.52	8.7
Total Acres	**4674.5**	**100.0**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% total of Estimated Runoff
Agricultural	2046.02	0.05	281.3	14.0%
Disturbed Land	29.62	0.05	4.1	0.2%
Forest and Grassland	546.60	0.05	75.2	3.7%
Government and Institutional	260.39	0.5	358.0	17.8%
Industrial	60.92	0.8	134.0	6.7%
Multi Family	1.78	0.5	2.4	0.1%
Multi Family	1.78	0.4	2.0	0.1%
Public and Private Open Space	255.85	0.05	35.2	1.7%
Retail/Commercial	86.39	0.85	201.9	10.0%
Single Family	198.41	0.15	81.8	4.1%
Single Family	198.42	0.3	163.7	8.1%
Transportation	254.57	0.85	595.0	29.6%
Utility and Waste Facilities	26.47	0.3	21.8	1.1%
Water	300.73	0	0.0	0.0%
Wetlands	406.52	0.05	55.9	2.8%
TOTAL	**4674.4**		**2012.5**	**100.0%**

Lake volume	1612.07	acre-feet
Retention Time (years)= lake volume/runoff	0.80	years
	292.38	days

Note: Runoff calculations do not include the acreage of lake itself, which is a part of the total watershed.

Figure 3. Water quality sampling point on Wooster Lake, 2005.

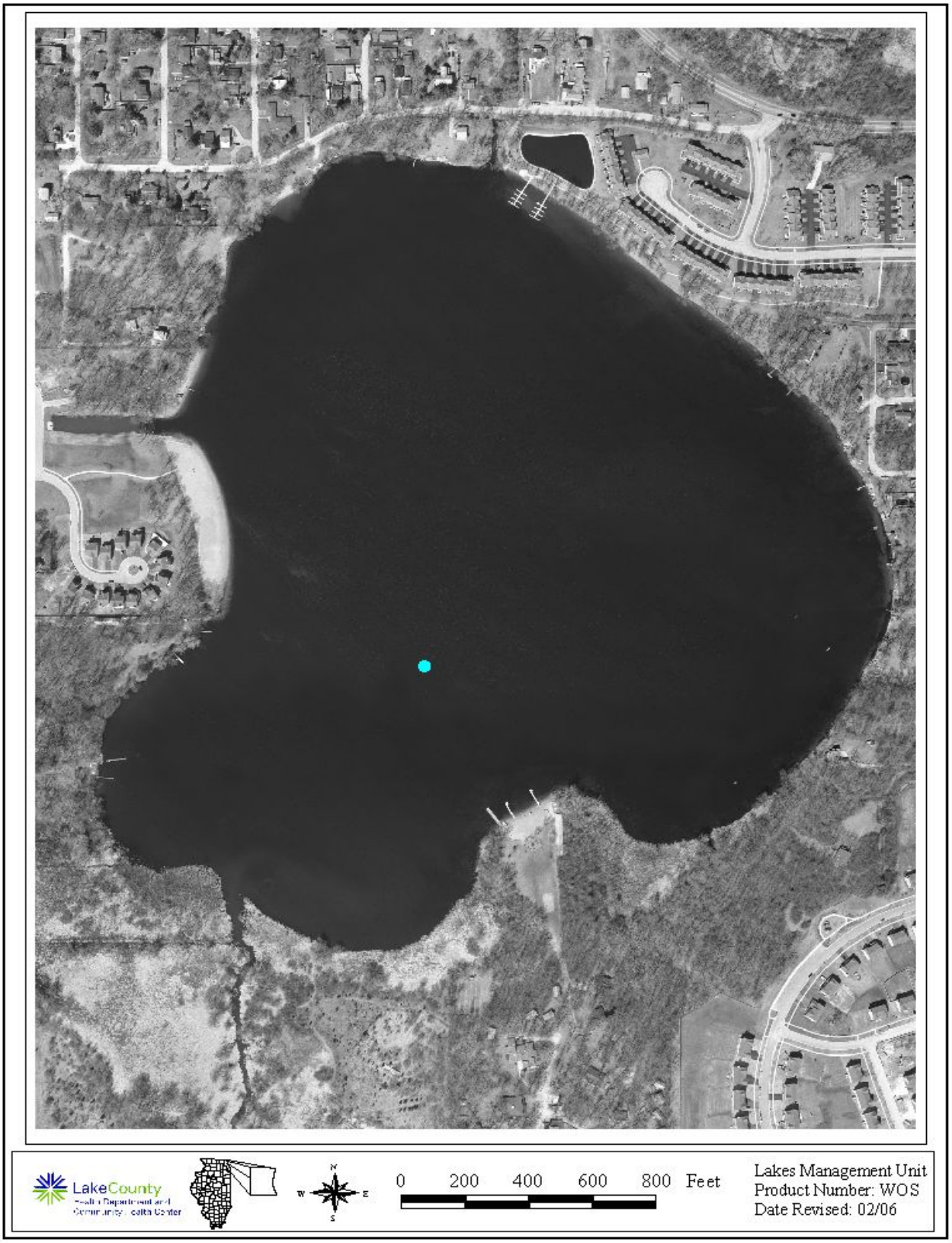


Table 2. Water quality data for Wooster Lake, 2003 and 2005.

2005	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	3	180	1.43	<0.1	0.200	0.050	<0.005	NA	90.2	3.7	431	117	6.00	0.6662	8.67	11.95
17-May	3	173	1.40	<0.1	0.058	0.035	<0.005	NA	92.1	3.2	412	114	9.02	0.6633	8.16	10.03
21-Jun	3	163	1.30	<0.1	<0.05	0.016	<0.005	NA	97.2	<1.0	421	115	17.45	0.6761	8.18	8.23
19-Jul	3	163	1.24	<0.1	<0.05	0.021	<0.005	NA	103.0	1.0	472	160	13.45	0.7094	8.05	6.53
16-Aug	3	167	1.34	<0.1	<0.05	0.038	<0.005	NA	101.0	3.3	458	151	5.90	0.7055	8.86	7.79
20-Sep	3	174	1.32	<0.1	<0.05	0.027	<0.005	NA	105.0	3.0	448	130	8.53	0.7232	8.28	6.12
18-Oct	3	180	1.46	0.209	<0.05	0.040	<0.005	NA	101.0	2.9	432	117	6.40	0.7181	8.08	5.58
	Average	171	1.36	0.209 [k]	0.130[k]	0.032	<0.005	NA	98.5	2.9[k]	439	129	9.54	0.6945	8.33	8.03

2003	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
27-May	3	181	1.06	<0.1	<0.05	0.026	<0.005	388	NA	1.3	409	133	14.08	0.6628	8.68	9.67
24-Jun	3	165	1.38	<0.1	<0.05	0.051	<0.005	362	NA	6.9	426	136	4.33	0.6392	8.78	10.40
29-Jul	3	149	1.13	<0.1	<0.05	0.023	<0.005	361	NA	3.7	401	121	6.69	0.6341	8.81	7.02
26-Aug	3	143	1.03	<0.1	<0.05	0.023	<0.005	332	NA	2.5	390	122	6.89	0.6228	8.96	7.46
30-Sep	3	167	1.06	0.115	<0.05	0.035	<0.005	362	NA	2.4	380	102	7.15	0.6597	8.47	6.32
	Average	161	1.13	0.115 [k]	<0.05	0.032	<0.005	361	NA	3.4	401	123	7.83	0.6437	8.74	8.17

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
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
Cl^- = Chlorides, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable

Table 2. Continued.

2005	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
11-Apr	26	186	2.09	0.95	0.133	0.065	0.022	NA	87.2	2.7	421	111	NA	0.6717	7.56	2.51
17-May	24	186	2.00	0.77	0.063	0.137	0.099	NA	89.8	<1.0	420	111	NA	0.6914	7.32	0.34
21-Jun	24	194	2.58	1.07	<0.05	0.210	0.129	NA	90.0	4.8	442	122	NA	0.7062	6.85	0.05
19-Jul	24	198	2.97	<0.10	<0.05	0.245	0.140	NA	91.4	8.4	456	132	NA	0.7297	6.87	0.06
16-Aug	23	225	4.60	3.10	<0.05	0.649	0.544	NA	91.0	5.2	476	156	NA	0.7413	6.85	0.10
20-Sep	24	173	1.48	<0.10	<0.05	0.041	0.000	NA	104.0	3.0	447	135	NA	0.7787	6.75	0.19
18-Oct	23	237	5.42	4.49	<0.05	0.713	0.617	NA	92.0	4.0	437	101	NA	0.7592	7.24	0.11
	Average	200	3.02	1.47[k]	0.098[k]	0.294	0.222	NA	93.7	4.68[k]	452	124	NA	0.7430	6.91	0.48

2003	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
27-May	26	192	1.63	0.552	<0.05	0.181	0.111	386	NA	1.3	411	128	NA	0.6754	7.53	0.12
24-Jun	27	213	3.40	1.760	<0.05	0.448	0.361	398	NA	5.9	425	141	NA	0.6926	7.22	0.06
29-Jul	26	220	3.42	2.180	<0.05	0.377	0.270	418	NA	5.5	430	138	NA	0.7248	7.30	0.14
26-Aug	25	231	4.54	3.080	<0.05	0.468	0.365	386	NA	7.6	437	164	NA	0.7207	7.23	0.07
30-Sep	25	211	3.43	2.440	<0.05	0.328	0.248	388	NA	7.5	408	113	NA	0.7600	7.14	0.24
	Average	213	3.28	2.002	<0.05	0.360	0.271	395	NA	5.6	422	137	NA	0.7147	7.28	0.13

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
TP = Total phosphorus, mg/L
SRP = Soluble reactive phosphorus, mg/L
TDS = Total dissolved solids, mg/L
Cl^- = Chlorides, mg/L
TSS = Total suspended solids, mg/L
TS = Total solids, mg/L
TVS = Total volatile solids, mg/L
SECCHI = Secchi disk depth, ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

k = Denotes that the actual value is known to be less than the value presented.
NA= Not applicable

Suspended solids are made up of any type of solid particles in the water column, including algal cells and sediment. The average epilimnetic total suspended solids (TSS) concentration for Wooster Lake was 2.9 mg/L. This was well below the County average of 7.9 mg/L (Appendix E). In April, before stratification was completely set-up, TSS was at its highest (3.7 mg/L), while the TSS concentration in June was below the detection limit (<1.0 mg/L). The average 2005 TSS decreased from the 2003 average (3.4 mg/L), as well as the 1999 average (4.3 mg/L). Directly upstream from Wooster Lake is Fischer Lake, which had a TSS concentration of 15.4 mg/L in 2001 (Table 3). Fish Lake sits above Fischer Lake at the top of the watershed and had a TSS concentration of 8.9 mg/L in 1997, and 11.3 mg/L in 2002. Fischer Lake and Fish Lake are shallower systems (hold a lower volume of water) than Wooster Lake and contain fewer plants that help hold sediment to the lake bottom. Duck Lake is not in the Wooster Lake watershed, but is at the bottom of Wooster Lake's larger watershed, the Fish Lake Drain. Duck Lake is a shallow system that has a decent plant community, but is heavily used for recreational purposes such as waterskiing. These activities stir up the shallow system, which leads to high TSS concentrations in the water column (20.6 mg/L in 2001).

Due to low TSS, Secchi depth (water clarity) in Wooster Lake was high (Figure 4). The average Secchi depth in 2005 was 9.54 feet, which was an increase of nearly two feet since the 2003 sampling season (7.83 feet). A possible reason for this increase in clarity may be that 2003 was a wet year with a lot of flow going into the lake, while 2005 was a dry year with much less inflow to the lake. The average county Secchi depth in 2005 was 3.17 feet; over three times lower than that of Wooster Lake. June 2005 had the deepest Secchi reading (17.35 feet) while August had the lowest reading (5.90 feet), probably due to plant die-off. Fischer Lake had a Secchi depth of 2.72 feet in 2001 and Fish Lake had a Secchi depth of 4.02 feet in 2002. Duck Lake has had the lowest Secchi depths in the Fish Lake Drain, with a value of 2.01 feet in 2001 (Table 3). These Secchi depths correlate to the amounts of TSS found at the same sampling times. The Volunteer Lake Monitoring Program (VLMP) has been continuously active on the lake since 1995 (data was also recorded in 1992). This program has been very successful and should continue in the future in order to detect any changes in water clarity trends (Figure 5). The differences between the VLMP data and LCHD-Lake Management Unit (LMU) data can be mostly attributed to discrepancies between samplers. Also, time of day and the number of readings the averages are compiled from have an affect.

Conductivity is the measure of ions within water. The higher the conductivity, the more ions and the better the water can conduct electricity. In Wooster Lake, average conductivity in 2005 was 0.6945 mS/cm. This is a slight increase from the 2003 value of 0.6437 mS/cm. While this is an increase for Wooster Lake, it is still below the County median (0.7748 mS/cm). Conductivity concentrations do not vary much throughout the Fish Lake Drain. Fish Lake had an average value of 0.6629 mS/cm in 2002, Fischer Lake had an average value of 0.6687 mS/cm in 2001, and Duck Lake had an average value of 0.6071 mS/cm in 2001 (Table 3). Almost all of the lakes in the county are experiencing similar increases in conductivity for the same reason. The drought-like conditions of 2005 likely concentrated the road salts used in winter road management. These salts build up in the lakes and increase both conductivity and chloride ion (Cl^-) concentrations, which are correlated (Figure 6). The median Cl^- concentration in the county is 183.0 mg/L, but Wooster Lake contains half of this concentration (98.5 mg/L). Conductivity and Cl^- concentrations, as well as alkalinity, increased from the beginning to the end of the 2005

Table 3. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity readings in the Fish Lake Drain (Fish Lake, Fischer Lake, Wooster Lake, and Duck Lake).

	Fish Lake	Fish Lake	Fischer Lake	Wooster Lake	Wooster Lake	Wooster Lake	Wooster Lake	Duck Lake	Duck Lake
Year	**1997**	**2002**	**2001**	**1995**	**1999**	**2003**	**2005**	**1997**	**2001**
Secchi (feet)	3.53	4.02	2.72	10.13	8.00	7.83	9.54	3.12	2.01
TSS (mg/L)	8.9	11.3	15.4	1.8	4.3	3.4	3.2	8.5	20.6
TP (mg/L)	0.134	0.102	0.198	0.024	0.027	0.032	0.032	0.047	0.100
Conductivity (milliSiemens/cm)	0.6984	0.6629	0.6687	0.5160	0.5744	0.6437	0.6945	0.6544	0.6071

Direction of Watershed Flow

Figure 4. Total suspended solids (TSS) concentration vs. Secchi depth in Wooster Lake, 2005. June TSS < 1.0 mg/L detection limit.

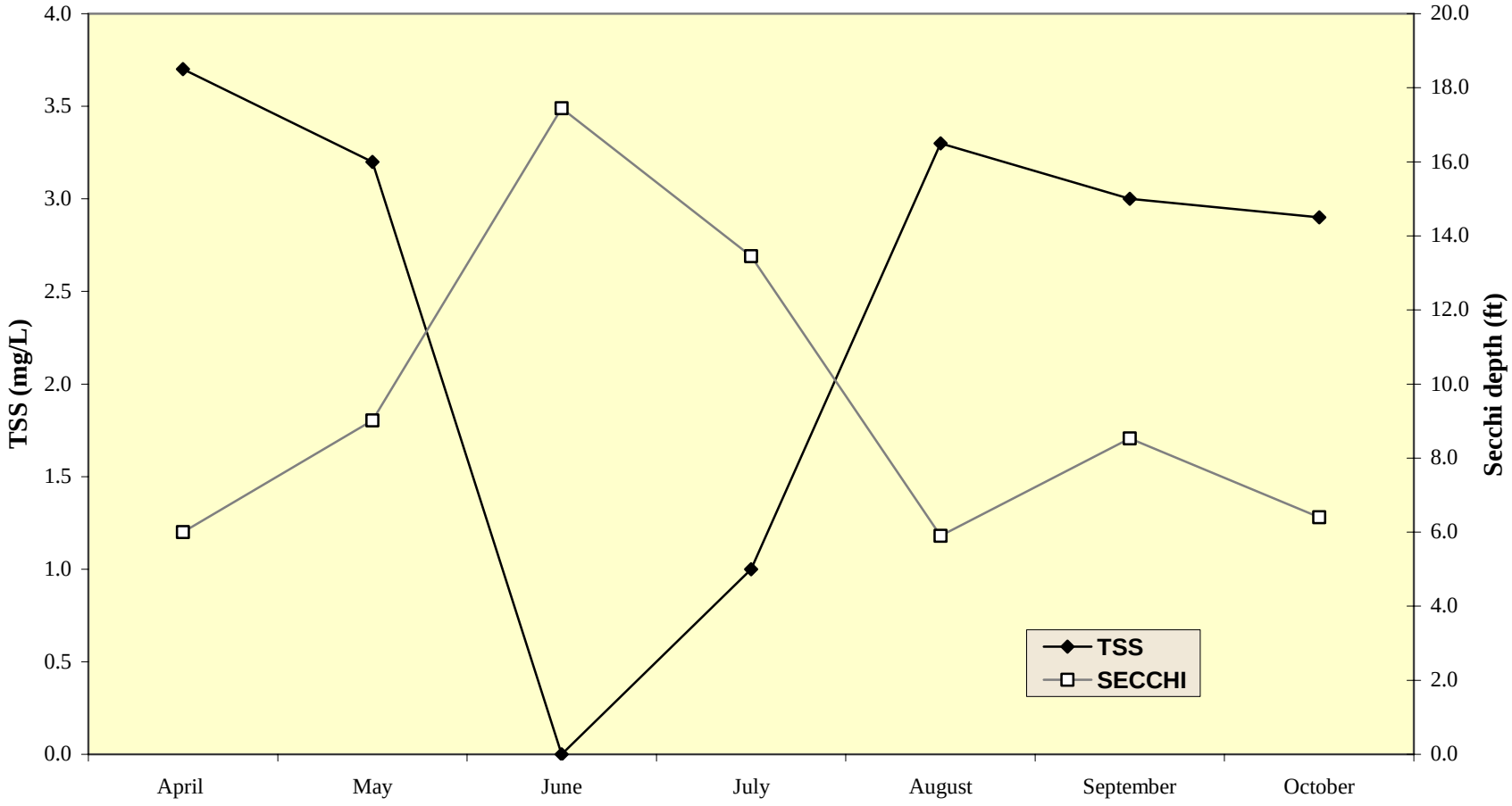


Figure 5. Comparison of average Secchi disk depths between VLMP records and LCHD records from 1992-2005 for Wooster Lake.

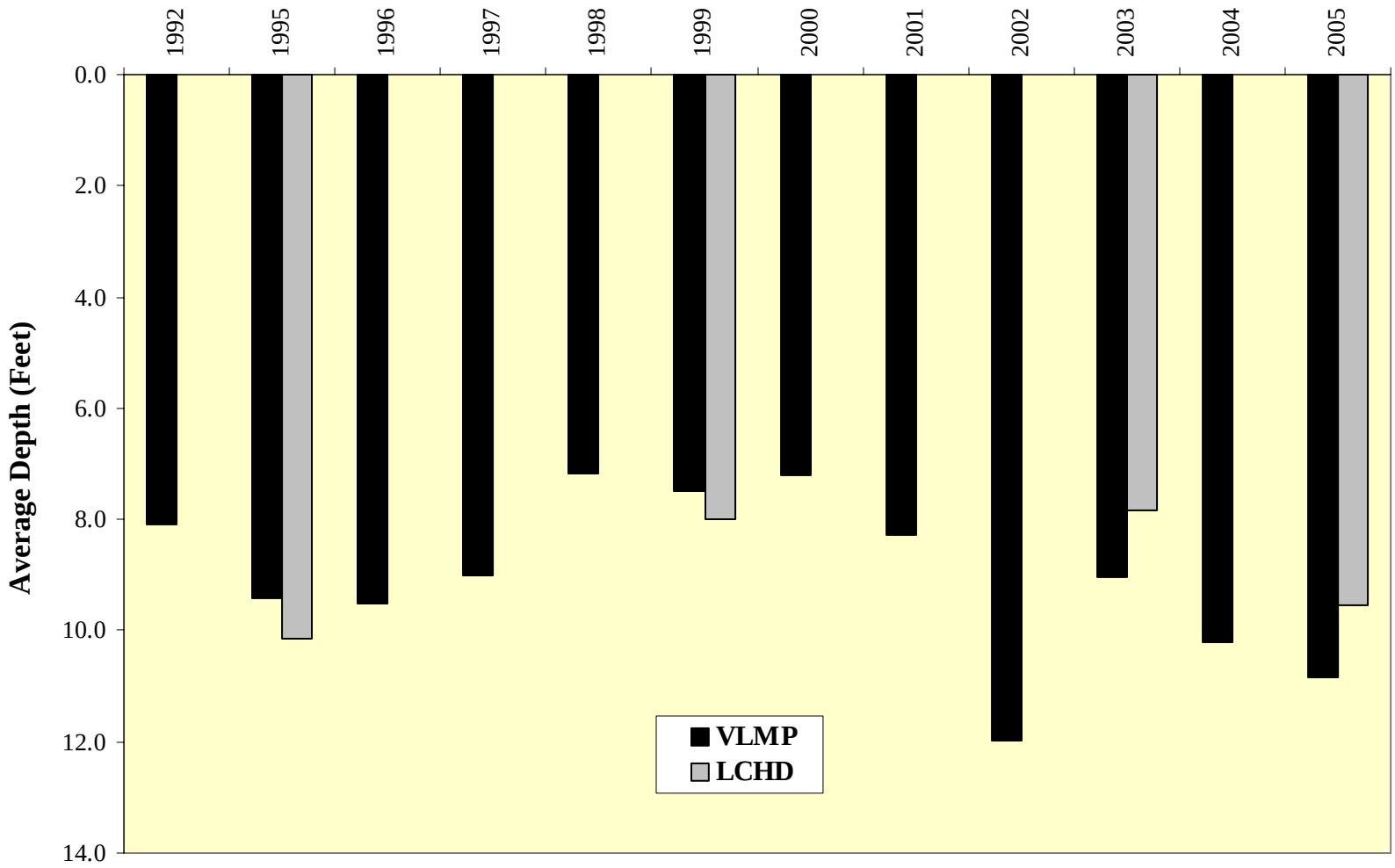
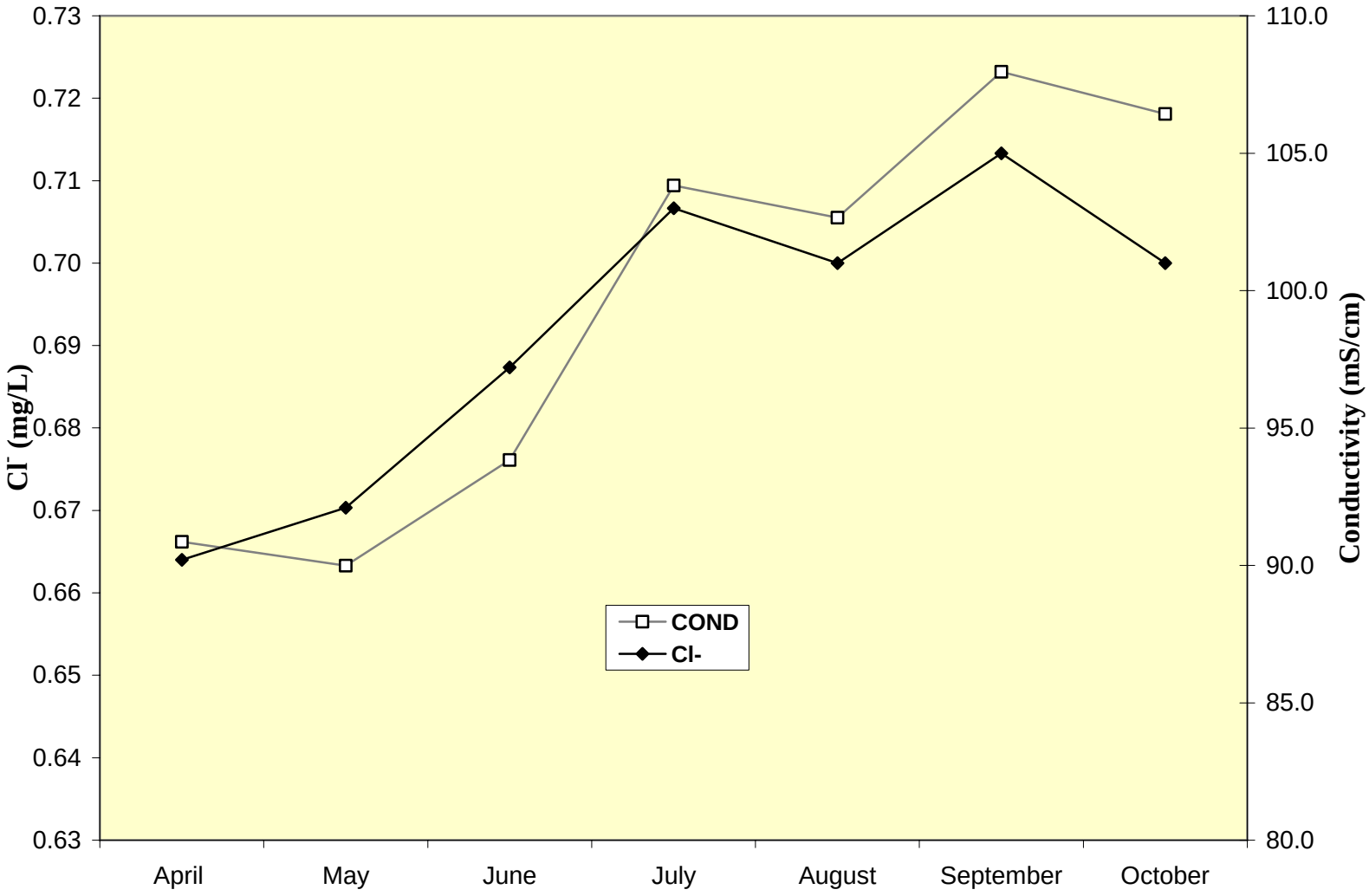


Figure 6. Chloride (Cl^-) concentration vs. conductivity for Wooster Lake, 2005.



sampling season. 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.

Another aspect of water quality is the nutrients within a water body, especially nitrogen (N) and phosphorus (P). These are the two nutrients that can limit plant and algal growth. Carbon and light are the other factors that control plant and algal growth, but these are not normally limiting. In 2005, the average epilimnetic total phosphorus (TP) concentration in Wooster Lake was 0.032 mg/L, which is half of the county median (0.063 mg/L). TP conditions have not changed since sampling was performed in 2003 (0.032 mg/L), but did increase from the 1999 sampling (0.027 mg/L) and the 1995 sampling (0.024 mg/L). The other lakes in the Fish Lake Drain experienced higher TP concentrations in past sampling years. Fish Lake had an average TP concentration of 0.102 mg/L in 2002, and Duck Lake had an average of 0.100 mg/L in 2001. Fischer Lake had the highest value within the Drain, with an average TP concentration of 0.198 mg/L in 2001 (Table 3). Again, these higher values compared to Wooster Lake are due to the other lakes being both shallower systems with either a low-density plant community, and/or high recreation utilization. Wooster Lake has a low TP concentration due in part to its extensive plant population, which competes with algae for phosphorus.

The average total Kjeldahl nitrogen (TKN) concentration in Wooster Lake in 2005 (1.36 mg/L) increased from 2003 (1.13 mg/L). This can be attributed to the nitrate portion of the TKN, which was at high concentrations in the spring months of April and May (0.200 mg/L; 0.058 mg/L). The April concentration was the only month with a nitrate concentration higher than the county median (0.116 mg/L). The rest of the sampling season (June-October) saw nitrate concentrations below detection limits (<0.05 mg/L). This is the normal seasonal cycle of nitrate in a eutrophic lake, where concentrations are high in the winter and spring, and then as stratification sets up and algae (phytoplankton) increase in abundance in the spring, nitrate is utilized and lake nitrate levels decrease until late fall. Phytoplankton utilize nitrogen in the form of nitrate more commonly than other forms, such as ammonia, which is the reason the nitrate concentrations decrease in the spring. This seasonal nitrate pattern was not seen in Wooster Lake in 2003, but was seen in 1999 and 1995. The overall increase in water quality was due to minimal flow into the lake from the Fish Lake Drain, due to the drought like conditions.

Another way to look at phosphorus levels and how they affect productivity of the lake is to use a Trophic State Index (TSI) based on phosphorus (TSIp). TSIp values are commonly used to classify and compare lake productivity levels (trophic state). The higher the phosphorus levels the greater the amount of algal biomass, which leads to a higher TSIp and corresponding trophic state. Based on a TSIp value of 54, Wooster Lake is classified as eutrophic ($\geq$50, <70 TSI). A eutrophic lake is defined as a productive system that has above average nutrient levels and high algal biomass (growth). Based on a Secchi TSI of 45, Wooster Lake is classified as mesotrophic (moderately productive). Overall, the trophic state of the lake is borderline between eutrophic and mesotrophic and is dependent on which parameter is used to calculate the TSI. Based on the TSIp, Wooster Lake ranks 43rd out of 162 lakes studied by the Lakes Management Unit between 2000-2005 (Table 4). This illustrates the good quality of Wooster Lake.

Table 4. Lake County average TSI phosphorous (TSIp) ranking, 2000-2005.

RANK	LAKE NAME	TP AVE	TSIp
1	Windward Lake	0.0158	43.9
2	Sterling Lake	0.0162	44.3
3	Lake Minear	0.0165	44.6
4	Pulaski Pond	0.0180	45.8
5	Fourth Lake	0.0182	46.0
6	West Loon Lake	0.0182	46.0
7	Cedar Lake	0.0183	46.1
8	Third Lake	0.0190	46.6
9	Lake Carina	0.0193	46.9
10	Independence Grove	0.0194	46.9
11	Lake Kathyrn	0.0200	47.3
12	Lake of the Hollow	0.0200	47.3
13	Banana Pond	0.0202	47.5
14	Cross Lake	0.0220	48.7
15	Dog Training Pond	0.0222	48.9
16	Sand Pond	0.0230	49.4
17	Stone Quarry Lake	0.0230	49.4
18	Bangs Lake	0.0233	49.6
19	Cranberry Lake	0.0236	49.7
20	Deep Lake	0.0240	50.0
21	Druce Lake	0.0244	50.2
22	Little Silver Lake	0.0246	50.3
23	Round Lake	0.0254	50.8
24	Lake Leo	0.0256	50.9
25	Timber Lake	0.0270	51.7
26	Dugdale Lake	0.0274	51.9
27	Peterson Pond	0.0274	51.9
28	Lake Miltmore	0.0276	52.0
29	Ames Pit	0.0278	52.1
30	East Loon Lake	0.0280	52.2
31	Lake Zurich	0.0282	52.3
32	Lake Fairfield	0.0296	53.0
33	Gray's Lake	0.0302	53.3
34	Highland Lake	0.0302	53.3
35	Hook Lake	0.0302	53.3
36	Lake Catherine (Site 1)	0.0308	53.6
37	Lambs Farm Lake	0.0312	53.8
38	Old School Lake	0.0312	53.8
39	Sand Lake	0.0316	53.9
40	Waterford Lake	0.0318	54.0
41	Potomac Lake	0.0318	54.0
42	Sullivan Lake	0.0320	54.1

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
43	**Wooster Lake**	**0.0324**	**54.3**
44	Gages Lake	0.0338	54.9
45	Hendrick Lake	0.0356	55.7
46	Diamond Lake	0.0372	56.3
47	Channel Lake (Site 1)	0.0380	56.6
48	Sun Lake	0.0410	57.7
49	Lake Linden	0.0420	58.0
50	Old Oak Lake	0.0428	58.3
51	Schreiber Lake	0.0434	58.5
52	Nielsen Pond	0.0448	59.0
53	Turner Lake	0.0458	59.3
54	Seven Acre Lake	0.0460	59.4
55	Willow Lake	0.0464	59.5
56	Lucky Lake	0.0476	59.9
57	Davis Lake	0.0476	59.9
58	East Meadow Lake	0.0478	59.9
59	College Trail Lake	0.0496	60.4
60	Countryside Lake	0.0512	60.9
61	Lake Lakeland Estates	0.0524	61.2
62	Butler Lake	0.0528	61.3
63	Lake Christa	0.0530	61.4
64	West Meadow Lake	0.0530	61.4
65	Deer Lake	0.0542	61.7
66	Heron Pond	0.0545	61.8
67	Little Bear Lake	0.0550	61.9
68	Lucy Lake	0.0552	62.0
69	Lake Charles	0.0580	62.7
70	White Lake	0.0588	62.9
71	Lake Naomi	0.0616	63.6
72	Lake Tranquility S1	0.0618	63.6
73	Werhane Lake	0.0630	63.9
74	Liberty Lake	0.0632	63.9
75	Countryside Glen Lake	0.0642	64.2
76	Leisure Lake	0.0648	64.3
77	Hastings Lake	0.0664	64.7
78	St. Mary's Lake	0.0666	64.7
79	Mary Lee Lake	0.0682	65.0
80	Honey Lake	0.0690	65.2
81	Redwing Slough, Site II, Outflow	0.0718	65.8
82	North Tower Lake	0.0718	65.8
83	Lake Fairview	0.0724	65.9
84	Spring Lake	0.0726	65.9
85	ADID 203	0.0730	66.0
86	Bluff Lake	0.0734	66.1

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
87	Long Lake	0.0761	66.6
88	Harvey Lake	0.0766	66.7
89	Broberg Marsh	0.0782	67.0
90	Echo Lake	0.0792	67.2
91	Sylvan Lake	0.0794	67.2
92	Big Bear Lake	0.0806	67.4
93	Petite Lake	0.0834	67.9
94	Lake Marie (Site 1)	0.0850	68.2
95	North Churchill Lake	0.0872	68.6
96	Grandwood Park, Site II, Outflow	0.0876	68.6
97	South Churchill Lake	0.0896	69.0
98	Rivershire Pond 2	0.0900	69.0
99	McGreal Lake	0.0914	69.3
100	International Mine and Chemical Lake	0.0948	69.8
101	Eagle Lake (Site I)	0.0950	69.8
102	Dunns Lake	0.0952	69.8
103	Lake Barrington	0.0956	69.9
104	Lochanora Lake	0.0960	70.0
105	Owens Lake	0.0978	70.2
106	Woodland Lake	0.0986	70.4
107	Island Lake	0.0990	70.4
108	Duck Lake	0.0996	70.5
109	Tower Lake	0.1000	70.6
110	Crooked Lake	0.1014	70.8
111	Fish Lake	0.1022	70.9
112	Longview Meadow Lake	0.1024	70.9
113	Lake Forest Pond	0.1074	71.6
114	Bittersweet Golf Course #13	0.1096	71.9
115	Fox Lake (Site 1)	0.1098	71.9
116	Bresen Lake	0.1126	72.3
117	Round Lake Marsh North	0.1126	72.3
118	Timber Lake S	0.1128	72.3
119	Deer Lake Meadow Lake	0.1158	72.7
120	Taylor Lake	0.1184	73.0
121	Grand Avenue Marsh	0.1194	73.1
122	Columbus Park Lake	0.1226	73.5
123	Nippersink Lake (Site 1)	0.1240	73.7
124	Grass Lake (Site 1)	0.1288	74.2
125	Lake Holloway	0.1322	74.6
126	Lakewood Marsh	0.1330	74.7
127	Summerhill Estates Lake	0.1384	75.2
128	Redhead Lake	0.1412	75.5

Table 4. Continued.

RANK	LAKE NAME	TP AVE	TSIp
129	Antioch Lake	0.1448	75.9
130	Forest Lake	0.1470	76.1
131	Valley Lake	0.1470	76.1
132	Slocum Lake	0.1496	76.4
133	Drummond Lake	0.1510	76.5
134	Pond-a-Rudy	0.1514	76.5
135	Lake Matthews	0.1516	76.6
136	Buffalo Creek Reservoir	0.1550	76.9
137	Pistakee Lake (Site 1)	0.1592	77.3
138	Salem Lake	0.1650	77.8
139	Half Day Pit	0.1690	78.1
140	McDonald Lake 1	0.1722	78.4
141	Lake Eleanor Site II, Outflow	0.1812	79.1
142	Lake Farmington	0.1848	79.4
143	ADID 127	0.1886	79.7
144	Lake Louise Inlet	0.1938	80.1
145	Grassy Lake	0.1952	80.2
146	Fischer Lake	0.1978	80.4
147	Dog Bone Lake	0.1990	80.5
148	Redwing Marsh	0.2072	81.1
149	Stockholm Lake	0.2082	81.1
150	Bishop Lake	0.2156	81.6
151	Hidden Lake	0.2236	82.2
152	Lake Napa Suwe (Outlet)	0.2304	82.6
153	Patski Pond (outlet)	0.2512	83.8
154	Slough Lake	0.2634	84.5
155	McDonald Lake 2	0.2706	84.9
156	Oak Hills Lake	0.2792	85.4
157	Loch Lomond	0.2954	86.2
158	Fairfield Marsh	0.3264	87.6
159	ADID 182	0.3280	87.7
160	Flint Lake Outlet	0.4996	93.8
161	Rasmussen Lake	0.5025	93.8
162	Albert Lake, Site II, outflow	1.1894	106.3

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 (*High* use impairment), and exotic species (*Slight* use impairment). Furthermore, based on IEPA indices, Wooster Lake has *Partial* support for recreational use and *Full* support of swimming and aquatic life use. Based on these indices, this lake is listed as providing *Full* overall use support.

In 2005, the Village of Round Lake passed a no-wake ordinance for Wooster Lake. This ordinance will help ensure the continuation of high water clarity in the lake, as well as preserve the diverse aquatic plant community. This plant community perpetuates the diverse fish community also present in the lake, which includes Illinois threatened and endangered species. The current plant density on Wooster Lake would only allow an approximate 45-acre area with a one-mile loop available for motorboat traffic (Figure 7). This would only allow two boats to be on the lake at a time in order to meet the safety recommendation of 20-30 acres/boat (Jaakson et al, 1989; Wagner, 1991; and Warbach et al, 1994). Increased boat traffic on small lakes can lead to an increase in boat related accidents. Accidents of this nature have occurred on Sand Lake, Gages Lake, and Round Lake in recent years, and these lakes are of comparable size to Wooster Lake. Also, the introduction of exotic species (e.g. Zebra Mussels) is highly reduced when motorboats are not allowed.

There are two swimming beaches on Wooster Lake: one for Camp Henry Horner, and one for Holiday Park Homes. Both were sampled for bacteria (*E. coli*) levels every two weeks, from the beginning of May to the end of August, by the LCHD in 2005. Neither experienced beach closings related to bacteria levels.

SUMMARY OF AQUATIC MACROPHYTES

An aquatic plant (macrophyte) survey was conducted in May and August of 2005. These sample times allowed the determination of plant growth at the beginning and end of the season. 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 this year. Sampling sites were based on a grid system created by mapping software (ArcGIS), with each site located 60 meters (200 feet) apart. On Wooster Lake, there were 66 sampling sites in May and 57 in August that covered all but the deepest parts of the lake (Figure 8; Figure 9). Overall, there were 16 species found in May, with Coontail having the highest density (found at 74% of the sites). White Water Lily was also abundant and was found at 29% of the sites (Table 5a). A total of 12 species were found in August, with Coontail being the most abundant (found at 84% of the sites). White Water Lily (found at 51% of the sites) and *Chara* spp. (found at 28% of the sites) were also present at many sites (Table 5c). Plants need at least 1% of surface light levels in order to survive. In May, plants were found down to a depth of 17.5 feet, which relates to the 1% light level depth of 17 feet. In August, the 1% light level depth was around 12.5 feet, while plants were found at depths of 12.8 feet, which also correlates well. Out of the 66 May sample sites, plants were found at 54 of them (82%) (Table 5b). In August, plants were found at 53 of the 57 sites (93%) (Table 5d).

Figure 7. Approximate plant coverage and correlating open-water boating area on Wooster Lake.

Figure 8. Aquatic plant sampling grid that illustrates plant density on Wooster Lake, May 2005.

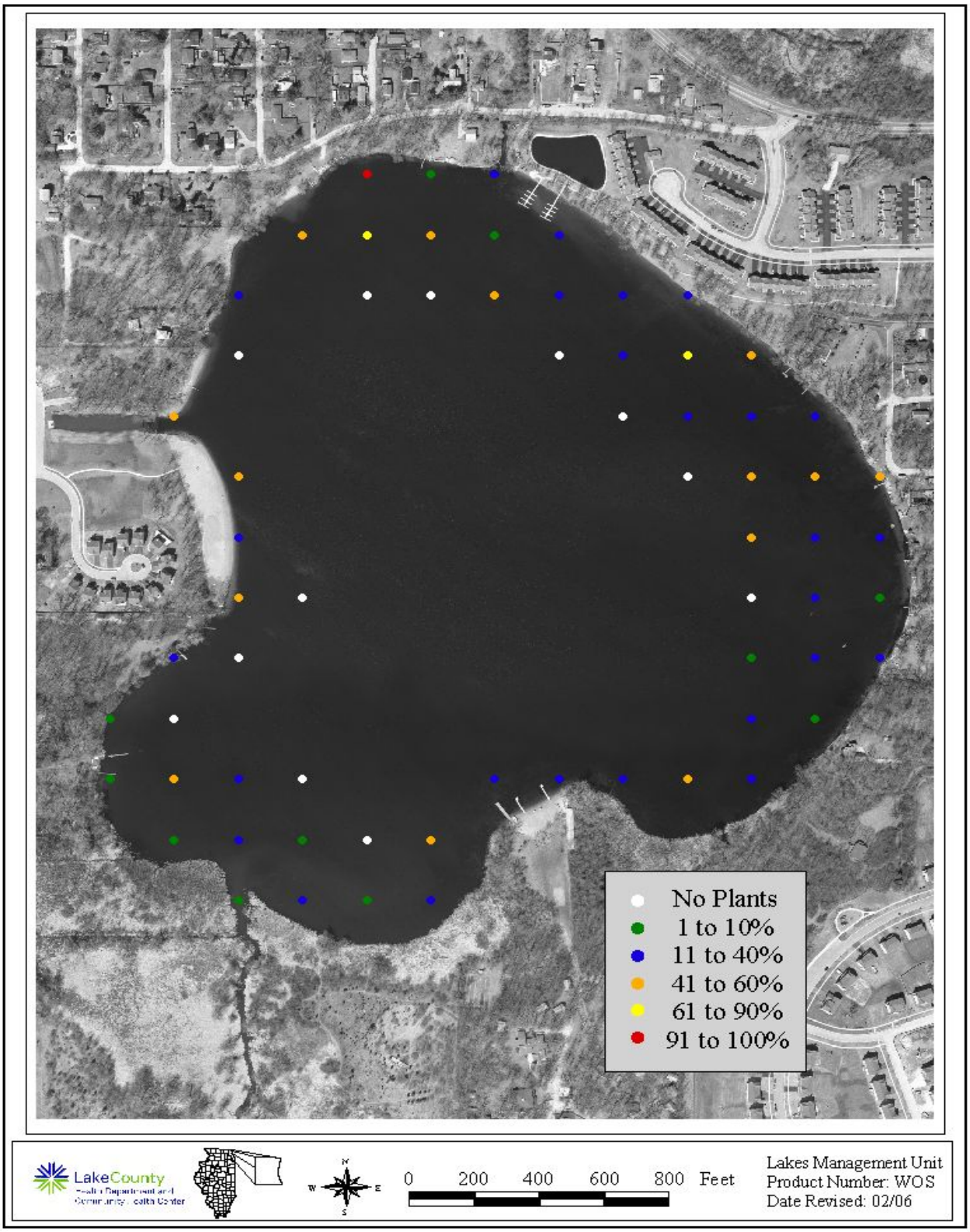


Figure 9. Aquatic plant sampling grid that illustrates plant density on Wooster Lake, August 2005.

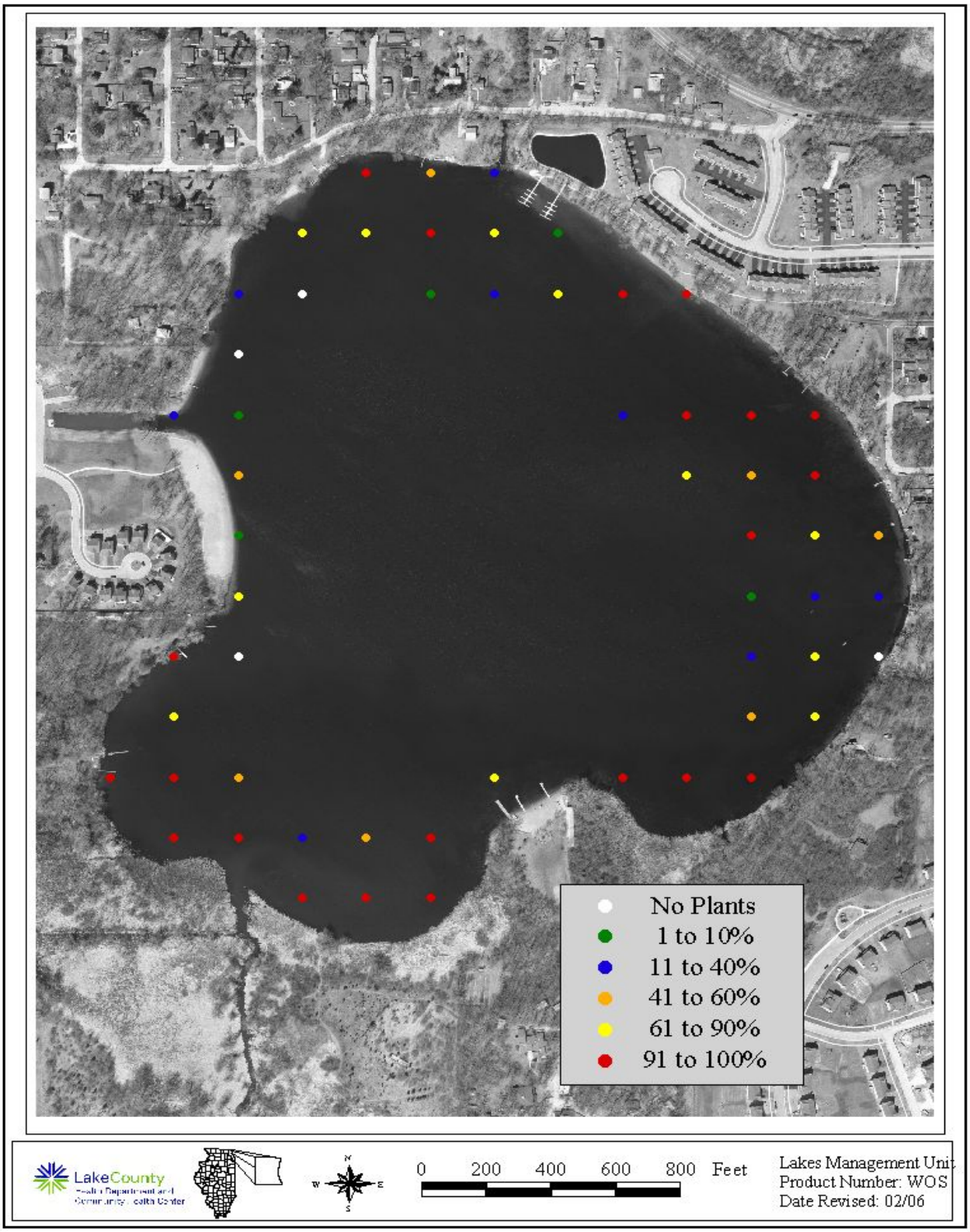


Table 5a. Aquatic vegetation species found at the 66 sample sites on Wooster Lake in May 2005. The maximum depth plants were found was 17.5 feet.

Plant Density	Chara	Coontail	Curlyleaf Pondweed	Small Duckweed	American Elodea	Eurasian Watermilfoil	Flatstem Pondweed	Horned Pondweed
Present	10	7	10	6	4	5	3	1
Common	4	23	2	0	0	1	1	1
Abundant	0	16	1	0	0	0	0	0
Dominant	0	3	0	0	0	0	0	0
% Plant Occurrence	21.2	74.2	19.7	9.1	6.1	9.1	6.1	3.0

Plant Density	Northern Watermilfoil	Sago Pondweed	Small Pondweed	Star Duckweed	Vallisneria	Watermeal	White Water Lily	Milfoil spp.
Present	7	9	1	8	1	6	16	1
Common	1	0	0	0	0	2	3	0
Abundant	1	0	0	0	0	0	0	0
Dominant	0	0	0	0	0	0	0	0
% Plant Occurrence	13.6	13.6	1.5	12.1	1.5	12.1	28.8	1.5

Table 5b. Distribution of rake density across all May sample sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	12	18
>0-10%	11	17
10-40%	26	39
40-60%	14	21
60-90%	2	3
>90%	1	2
Total Sites with Plants	54	82
Total # of Sites	66	23

Table 5c. Aquatic vegetation species found at the 57 sampling sites on Wooster Lake in August 2005. The maximum depth plants were found was 12.5 feet.

Plant Density	Chara	Coontail	Duckweed	American Elodea	Grassed-leaved Arrowhead	Sago Pondweed	Slender Naiad	Star Duckweed	Vallisneria	Watermeal	Water Stargrass	White Water Lily
Present	6	7	6	1	1	4	0	8	2	3	3	5
Common	7	23	6	1	0	2	1	5	5	3	0	7
Abundant	3	15	0	0	0	0	0	0	1	9	0	12
Dominant	0	3	0	0	0	0	0	0	0	0	0	5
% Plant Occurrence	28.1	84.2	21.1	3.5	1.8	10.5	1.8	22.8	14.0	26.3	5.3	50.9

Table 5d. Distribution of rake density across all August sample sites.

Rake Density (coverage)	# of Sites	% of Sites
No Plants	4	7
>0-10%	5	9
10-40%	9	16
40-60%	7	12
60-90%	11	19
>90%	21	37
Total Sites with Plants	53	93
Total # of Sites	57	19

These sample sites only covered 60% of the lake (the remaining area was too deep for plants to grow), and therefore the lake has approximately 48% plant coverage (Figure 10), with approximately 20% topped out (plants reaching and crowding the surface of the lake) (Table 6). This amount of plants is one reason water clarity is so high in the lake. A majority of the nutrients are taken up by macrophytes, leaving a small amount for plankton growth. This results in low algal densities, which could cloud the water. Ideally, a lake should have 30-40% plant coverage, according to the IDNR. While Wooster has a slightly higher than recommended plant community, the fishery in the lake is good. Also, the highly agricultural watershed surrounding the lake inevitably has high nutrient inputs. Wooster's high-density plant community helps utilize these nutrients and keep the water clarity high. If plants were reduced, algal populations may increase and cloud the water. Also, the threatened and endangered fish in the lake require high densities of plants.

The aquatic plant community in the lake consisted of 16 species in May, and 12 species in August. Coontail was the most dominant species in both May and August.
Plant diversity stayed similar between 2003 and 2005. Leafy Pondweed, Spatterdock and Whitestem Pondweed were the only species found in 2003, but not in 2005. The changes can probably be attributed to natural annual variation and the drought-like conditions in 2005. Wooster Lake continues to have two invasive species in its plant community: Eurasian Watermilfoil (EWM) and Curlyleaf Pondweed. The coverage of both species seemed to increase in May 2005, compared to May 2003. EWM was not detected in August of 2005, while it was found in August of 2003 (Curlyleaf Pondweed is an early season species and was not detected in August of either 2003 or 2005).

To the Lakes Management Unit's knowledge, Wooster Lake implements the following plant management techniques. Aquatic Weed Control was hired in 2005 to apply 2,4-D to 18 different ownership plots. 2,4-D is a systematic herbicide that can be used to selectively control broadleaved, dicot plants (Eurasian Watermilfoil is commonly the target). The beach by Holiday Park homes was treated with Diquat (Reward®) to remove plants from the recreational area. Also, a contractor was hired by a property owner to mechanically remove plants from their sections of lake bottom. Due to the good overall quality of the plant community and the desire to preserve native, beneficial species, the continuation of spot treatments where EWM is present is recommended as opposed to any whole lake treatments.

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 (See Appendix A for methods). An algal bloom was noted in May, and was probably the result of excess Aphanizomenon growth (a blue-green algal species). While the blue-green algal species seemed to peak in May, they were also present in high densities in September and October. Flagellate species (species motored by a flagella) were present in fairly high numbers from May to September, with a definite peak in July (Figure 11).

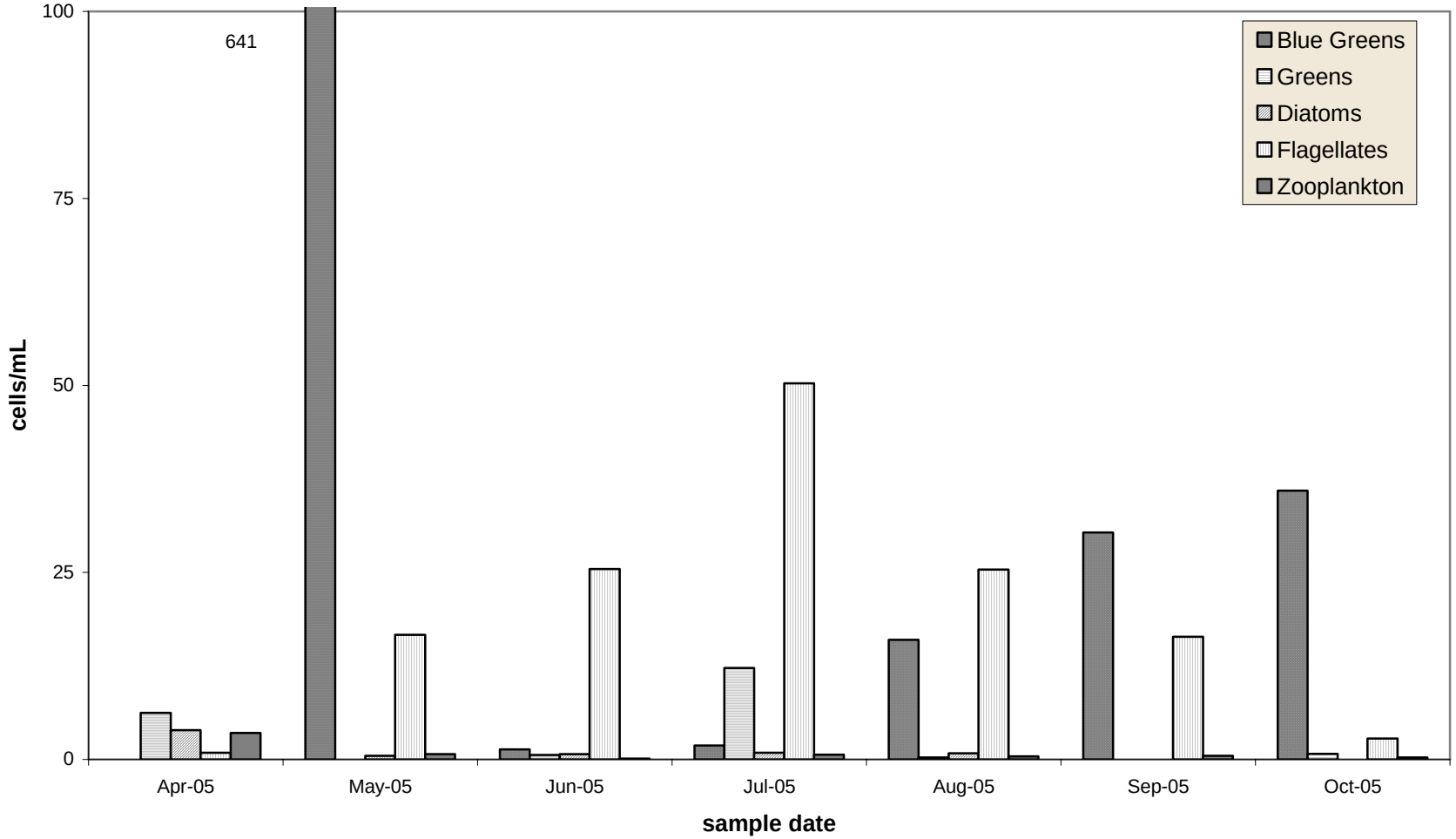
Figure 10. Approximate plant coverage on Wooster Lake, 2005.

Table 6. Aquatic plant species found in Wooster Lake, 2005.

Coontail	*Ceratophyllum demersum*
Chara (Macro algae)	*Chara spp.*
American Elodea	*Elodea canadensis*
Water Stargrass	*Heteranthera dubia*
Small Duckweed	*Lemna minor*
Star Duckweed	*Lemna trisulca*
Northern Watermilfoil	*Myriophyllum sibiricum*
Eurasian Watermilfoil^	*Myriophyllum spicatum*
Slender Naiad	*Najas flexilis*
Spatterdock	*Nuphar variegata*
White Water Lily	*Nymphaea tuberosa*
Curlyleaf Pondweed^	*Potamogeton crispus*
Sago Pondweed	*Potamogeton pectinatus*
Small Pondweed	*Potamogeton pusillus*
Flatstem Pondweed	*Potamogeton zosteriformis*
Grass-leaved Arrowhead	*Sagittaria gramminea*
Vallisineria (Eel Grass)	*Vallisineria americana*
Watermeal	*Wolffia columbiana*
Horned Pondweed	*Zannichellia palustrus*

^ **Exotic species**

Figure 11. Results of plankton counts for Wooster Lake, 2005.



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 plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2005 Lake County lakes is 13.1. Wooster Lake had a FQI of 25.2 in 2005, which ranked it 14th (Table 7). This is only a slight decrease since 2003 when the FQI was 25.7. For comparison, Fish Lake, Fischer Lake, and Duck Lake have recent FQIs of 18.1, 16.0, and 17.1, respectively.

SUMMARY OF SHORELINE CONDITION

In 2003, a complete shoreline assessment was performed in July. This assessment found 70% of Wooster's shoreline was developed, with shrub habitat being the most common (22%). Other shoreline types found were lawn, wetland, buffer strips, and beach. It was recommended that lawn be converted to buffer consisting of native plants in order to help stabilize the shoreline and prevent/reverse erosion. In 2003, approximately 35% of the shoreline was eroded to some degree. A reassessment of shoreline erosion in 2005 saw a slight increase in overall erosion, and an increase in severity where erosion was documented before (Figure 12). For example, the area categorized as moderately eroded to the east of the docks at Tanneron Bay was reclassified as severely eroded in 2005. Again, buffer areas should be created in order to prevent further erosion and to stabilize areas that already have erosion problems.

Several exotic species were found along the shoreline, including Buckthorn, Reed Canary Grass, and Common Reed (*Phragmites* sp.). Removal of these species is recommended as they can have a detrimental affect on native, beneficial species that provide better wildlife habitat.

SUMMARY OF WILDLIFE AND HABITAT CONDITIONS

Habitat conditions around Wooster Lake are fairly good, with the wetland/shrub habitat on the southern end providing a valuable environmental surrounding. Improvement of other areas around the lake should be taken into serious consideration (See Appendix D3 for further details). There was a good bird population on the lake, as well as the presence of Softshell Turtles.

During each sampling visit, a large number of Canada Geese and Mute Swans were observed. This is mostly due to the conservation efforts of one lake resident. As stated in the 2003 report, these efforts are commendable, but at the same time, large concentrations of waterfowl can lead to disease among the population. They can also have detrimental effects on water quality, as their feces are high in nutrients (such as nitrogen and phosphorus) and *E. coli* bacteria.

A reassessment of the 1997 IDNR fish population survey was conducted in September of 2004. A total of 14 species were collected in 2004, while 13 species were found in 1997. A seining survey conducted by researchers from Southern Illinois University-Carbondale (SIU-C) in 2002 (discussed in 2003 Wooster Lake report) found 15 species. Overall, the fish community diversity remains similar. The IDNR 2004 report found that Bluegill remain as the dominant species (same as their survey in 1997), followed by Largemouth Bass, Brook Silverside, and Lake Chubsucker. Other species present were: Pumpkinseed Sunfish, Warmouth, Black Crappie, Yellow Perch, Northern Pike, Bowfin, and the Golden Shiner. The Starhead Topminnow (*Fundulus dispar*) was also found in the survey, and is threatened in Illinois. Both the state threatened Blackchin Shiner (*Notropsis heterodon*) and the state endangered Blacknose Shiner (*Notropsis heterolepsis*) were also found. These species were also found in 2002 by the SIU-C researchers. The 2004 IDNR survey did not find the Iowa Darter (*Etheostoma exile*), a threatened species in Illinois, which was found by the SIU-C researchers in 2002. They may still be present, but were not detected by the IDNR, most likely due to differences in sampling technique.

The recommendations placed in the 2004 IDNR report of the fish population survey included plant management. They suggested reducing Eurasian Watermilfoil populations and stated, “a diverse aquatic plant assemblage is generally associated with many of the species found in your lake, i.e. eliminating vegetation is detrimental to the overall health of a lake.” They also stated to maintain the minimum 15” length limit and one per day catch limit on Largemouth Bass that was set in 1997. Another suggestion was to post “do not dump bait” signs (contact Illinois-Indiana Sea Grant program for ideas and information). Also, watch for and remove Yellow Bass (stripers) and Common Carp.

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	35.6	37.8
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	Cranberry Lake	28.3	28.3
6	Sullivan Lake	28.2	29.7
7	Deer Lake	27.9	30.2
8	Little Silver Lake	27.9	30.0
9	Schreiber Lake	26.8	27.6
10	Redwing Slough	26.0	26.9
11	West Loon Lake	26.0	27.6
12	Timber Lake (North)	25.5	27.1
13	Cross Lake	25.2	27.8
14	**Wooster Lake**	**25.2**	**26.9**
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	Sterling Lake	21.8	24.1
24	Butler Lake	21.4	23.1
25	Bangs Lake	21.2	23.7
26	ADID 203	20.5	20.5
27	Broberg Marsh	20.5	21.4
28	Davis Lake	20.5	21.4
29	McGreal Lake	20.2	22.1
30	Lake Kathryn	19.6	20.7
31	Third Lake	19.6	21.7
32	Owens Lake	19.3	20.2
33	Redhead Lake	19.3	21.2
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	Fish Lake	18.1	20.0
39	McDonald Lake 1	17.7	18.7
40	Potomac Lake	17.3	18.5
41	Hendrick Lake	17.2	19.0
42	Duck Lake	17.1	19.1

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
43	Summerhill Estates Lake	17.1	18.0
44	Ames Pit	17.0	18.0
45	Seven Acre Lake	17.0	15.5
46	Grand Avenue Marsh	16.9	18.7
47	Gray's Lake	16.9	19.8
48	White Lake	16.9	18.7
49	Bresen Lake	16.6	17.8
50	Waterford Lake	16.6	17.8
51	Diamond Lake	16.3	17.4
52	Lake Barrington	16.3	17.4
53	Lake Napa Suwe	16.3	17.4
54	Windward Lake	16.3	17.6
55	Fischer Lake	16.0	18.1
56	Dog Bone Lake	15.7	15.7
57	Independence Grove	15.5	16.7
58	Long Lake	15.5	17.3
59	Tower Lake	15.2	17.6
60	Heron Pond	15.1	15.1
61	Lake Linden	15.1	16.5
62	Lake Tranquility (S1)	15.0	17.0
63	North Churchill Lake	15.0	15.0
64	Dog Training Pond	14.7	15.9
65	Island Lake	14.7	16.6
66	Highland Lake	14.5	16.7
67	Lake Fairview	14.3	16.3
68	Taylor Lake	14.3	16.3
69	Dugdale Lake	14.0	15.1
70	Eagle Lake (S1)	14.0	15.1
71	Longview Meadow Lake	13.9	13.9
72	Bishop Lake	13.4	15.0
73	Hook Lake	13.4	15.5
74	Timber Lake (South)	13.4	15.5
75	Buffalo Creek Reservoir	13.1	14.3
76	Mary Lee Lake	13.1	15.1
77	Old School Lake	13.1	15.1
78	Dunn's Lake	12.7	13.9
79	Old Oak Lake	12.7	14.7
80	Echo Lake	12.5	14.8
81	Sand Lake	12.5	14.8
82	Stone Quarry Lake	12.5	12.5
83	Honey Lake	12.1	14.3

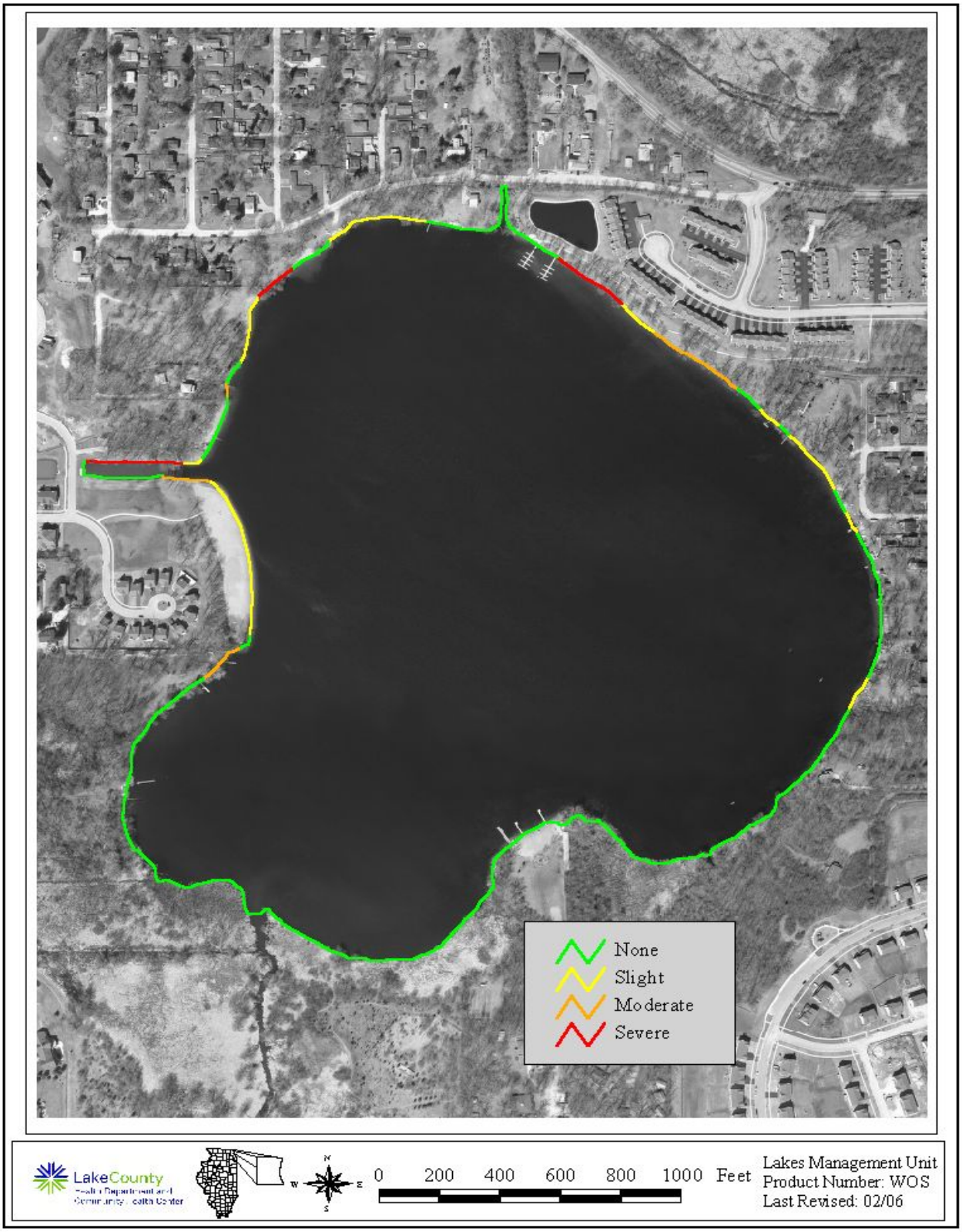
Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
84	Lake Leo	12.1	14.3
85	Lambs Farm Lake	12.1	14.3
86	Pond-A-Rudy	12.1	12.1
87	Stockholm Lake	12.1	13.5
88	Lake Matthews	12.0	12.0
89	McDonald Lake 2	12.0	12.0
90	Flint Lake	11.8	13.0
91	Harvey Lake	11.8	13.0
92	Rivershire Pond 2	11.5	13.3
93	Antioch Lake	11.3	13.4
94	Lake Charles	11.3	13.4
95	Lake Naomi	11.2	12.5
96	Pulaski Pond	11.2	12.5
97	Lake Christa	11.0	12.7
98	Redwing Marsh	11.0	11.0
99	West Meadow Lake	11.0	11.0
100	Nielsen Pond	10.7	12.0
101	Lake Holloway	10.6	10.6
102	Lake Carina	10.2	12.5
103	College Trail Lake	10.0	10.0
104	Lake Lakeland Estates	10.0	11.5
105	Crooked Lake	9.8	12.0
106	Hastings Lake	9.8	12.0
107	Werhane Lake	9.8	12.0
108	Big Bear Lake	9.5	11.0
109	Little Bear Lake	9.5	11.0
110	Loch Lomond	9.4	12.1
111	Sand Pond (IDNR)	9.4	12.1
112	Columbus Park Lake	9.2	9.2
113	Sylvan Lake	9.2	9.2
114	Grandwood Park Lake	9.0	11.0
115	Lake Fairfield	9.0	10.4
116	East Meadow Lake	8.5	8.5
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

Table 7. Continued.

Rank	Lake Name	FQI (w/A)	FQI (native)
126	Lake Louise	7.5	8.7
127	Patski Pond	7.1	7.1
128	Rasmussen Lake	7.1	7.1
129	Lucky Lake	7.0	7.0
130	Lake Forest Pond	6.9	8.5
131	Leisure Lake	6.4	9.0
132	Peterson Pond	6.0	8.5
133	Countryside Lake	5.8	7.1
134	Gages Lake	5.8	10.0
135	Grassy Lake	5.8	7.1
136	Slocum Lake	5.8	7.1
137	Deer Lake Meadow Lake	5.2	6.4
138	ADID 127	5.0	5.0
139	Drummond Lake	5.0	7.1
140	IMC	5.0	7.1
141	Liberty Lake	5.0	5.0
142	Oak Hills Lake	5.0	5.0
143	Slough Lake	5.0	5.0
144	North Tower Lake	4.9	7.0
145	Forest Lake	3.5	5.0
146	Half Day Pit	2.9	5.0
147	Lochanora Lake	2.5	5.0
148	Hidden Lake	0.0	0.0
149	St. Mary's Lake	0.0	0.0
150	Valley Lake	0.0	0.0
151	Willow Lake	0.0	0.0
	Mean	**14.0**	**15.4**
	Median	**13.1**	**14.8**

Figure 12. Shoreline erosion on Wooster Lake, 2005.



LAKE MANAGEMENT RECOMMENDATIONS

Wooster Lake continues to have good water quality and a diverse plant community. Efforts are being made to keep the lake in its current condition. Grants are being applied for in order to remediate shoreline erosion, and a no-wake ordinance has been put in place to ensure the perseverance of a high quality plant community. Also, a Fish Lake Watershed Committee is being organized in order to look at and improve the health of the watershed in which Wooster Lake is encompassed. There are still a few issues that could be looked at further in order to help maintain and improve the lake's ecosystem:

- **Creating a bathymetric map**

  The creation of a current bathymetric (depth contour) map on Wooster Lake would aide in lake management practices. With new technology available through the LMU, it is possible to create a detailed depth contour map that includes the calculation of plant density throughout the lake (See Appendix D1 for more details).

- **Shoreline erosion**

  Shoreline erosion has increased in severity since the last assessment in 2003. This erosion can lead to elevated levels of TSS and nutrients in the lake (See Appendix D2 for more details).

- **Eliminate or control exotic species**

  Invasive shoreline plant species such as Buckthorn and Reed Canary Grass were observed. Removal of these species is recommended and should be paired with a plan for erosion control as they do provide some bank stabilization (See Appendix D3 for more details).

- **Lakes with high Canada Geese populations**

  High numbers of Canada Geese, as well as Mute Swans were observed on the lake. The feces from these birds can have adverse affects on water quality, as well as deter people from using areas where they congregate (See Appendix D4 for more details).

- **Reduce or eliminate user conflicts**

  This can be one of the most challenging issues surrounding lake management procedures. Many people have different views on what the lake they live on or by should look like and be used for. These conflicts can create lake management issues. Reducing user conflicts is best for the lake and allows a more stress free environment in which to enjoy everything the lake has to offer (See Appendix D5 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 (ArcGIS 3.2) overlaid a grid pattern onto a 2004 aerial photo of Lake County and placed points 60 meters apart. 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 was sampled at the same location as water quality samples. Using the Hydrolab DataSonde® 4a 1% light level depth (depth where the water light is 1% of the surface irradiance) was determined. A plankton net/tow, with 80μm mesh, was then lowered to the pre-determined 1% light level depth and retrieved vertically. On the way up the water column, plankton are 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. 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 on 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 with a depth of 1 mm. The slide was then placed under the microscope and counted at a 20X magnification. Twenty fields of view were randomly counted with all species within each field counted. Through calculations, it was determined how many of each species were in 1 mL of lake water.

Shoreline Assessment

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

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

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

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

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

Wildlife Assessment

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

Table A1. Analytical methods used for water quality parameters.

Parameter	***Method***
Temperature	Hydrolab DataSonde® 4a or YSI 6600 Sonde®
Dissolved oxygen	Hydrolab DataSonde ®4a or YSI 6600 Sonde®
Nitrate nitrogen	Brucine method Standard Methods (SM) 14th ed 419D 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 WOOSTER LAKE IN 2005

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	0.83
41105	104321	0.25	0.35	13.99	12.02	120.0	0.6655	8.63	3801	Surface		
41105	104454	1	1.04	14.03	11.98	119.7	0.6660	8.65	3670	Surface	100%	
41105	104630	2	1.93	14.00	11.96	119.4	0.6659	8.66	1446	0.18	39%	5.17
41105	104750	3	2.97	14.01	11.93	119.1	0.6662	8.67	1068	1.22	29%	0.29
41105	104914	4	4.05	13.97	11.90	118.7	0.6657	8.67	820	2.30	22%	0.24
41105	105055	6	5.98	13.94	12.07	120.3	0.6654	8.66	352	4.23	10%	0.44
41105	105253	8	7.97	13.96	12.02	119.9	0.6650	8.68	219	6.22	6%	0.24
41105	105500	10	10.00	13.80	11.98	119.1	0.6648	8.67	109	8.25	3%	0.34
41105	105711	12	11.99	12.95	9.51	92.8	0.6527	8.44	57	10.24	1.6%	0.33
41105	105915	14	14.02	10.37	8.15	74.9	0.6562	8.15	29	12.27	0.8%	0.33
41105	110145	16	16.04	8.50	7.25	63.8	0.6571	7.95	14	14.29	0%	0.36
41105	110351	18	18.16	7.14	6.70	57.0	0.6553	7.84	4	16.41	0%	0.59
41105	110543	20	19.84	6.69	5.89	49.6	0.6608	7.76	1	18.09	0%	0.83
41105	110733	22	21.91	6.50	4.54	38.0	0.6635	7.69	0	20.16		
41105	110917	24	24.00	6.39	3.48	29.1	0.6680	7.63	0	22.25		
41105	111128	26	25.92	6.25	2.48	20.6	0.6717	7.56	0	24.17		
41105	111316	28	28.10	6.14	0.98	8.1	0.6780	7.51	0	26.35		

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	0.66
51705	90140	0	0.23	14.08	9.96	99.5	0.6635	8.17	2193	Surface		
51705	90243	1	1.00	14.05	9.95	99.3	0.6635	8.16	1864	Surface	100%	
51705	90359	2	1.97	14.04	9.92	99.0	0.6634	8.16	569	0.22	31%	5.39
51705	90521	3	3.02	14.05	10.01	99.9	0.6634	8.16	302	1.27	16%	0.60
51705	90648	4	3.99	14.03	9.94	99.1	0.6633	8.16	525	2.24	28%	-0.57
51705	91148	6	6.01	14.03	9.99	99.6	0.6635	8.20	232	4.26	12%	0.40
51705	91342	8	8.04	14.02	9.89	98.6	0.6634	8.20	177	6.29	9%	0.13
51705	91547	10	10.00	13.99	9.74	97.1	0.6635	8.20	101	8.25	5%	0.29
51705	91728	12	11.98	13.98	9.76	97.2	0.6638	8.20	67	10.23	4%	0.21
51705	91943	14	14.06	13.66	9.13	90.3	0.6637	8.16	36	12.31	2%	0.30
51705	92210	16	15.99	12.44	7.50	72.2	0.6738	7.95	22	14.24	1.2%	0.26
51705	92356	18	17.99	10.86	7.03	65.3	0.6795	7.80	12	16.24	0.6%	0.30
51705	92525	20	20.06	10.07	5.85	53.4	0.6810	7.68	7	18.31	0%	0.26
51705	92701	22	21.97	9.66	2.74	24.7	0.6850	7.48	4	20.22	0%	0.29
51705	92847	24	24.04	9.19	0.28	2.5	0.6924	7.32	0	22.29	0%	
51705	93009	26	26.06	8.66	0.17	1.5	0.7002	7.19	0	24.31	0%	

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 0.68
62105	90143	0	0.25	24.38	8.16	100.5	0.6770	8.13	3642	Surface		
62105	90243	1	1.00	24.38	8.10	99.4	0.6759	8.16	3633	Surface	100%	
62105	90359	2	1.97	24.37	8.13	100.3	0.6759	8.17	998	0.22	27%	5.87
62105	90521	3	3.02	24.35	8.23	101.3	0.6761	8.18	698	1.27	19%	0.34
62105	90648	4	3.99	24.32	8.13	99.9	0.6760	8.19	753	2.24	21%	-0.08
62105	91148	6	6.01	23.85	8.08	99.2	0.6748	8.18	437	4.26	12%	0.27
62105	91342	8	8.04	23.07	7.52	90.2	0.6754	8.11	349	6.29	10%	0.11
62105	91547	10	10.00	22.43	7.54	89.7	0.6747	8.09	317	8.25	9%	0.05
62105	91728	12	11.98	21.14	6.85	79.3	0.6767	7.99	187	10.23	5%	0.27
62105	91943	14	14.06	16.78	6.48	68.8	0.6716	7.81	117	12.31	3%	0.23
62105	92210	16	15.99	13.72	0.87	8.6	0.6859	7.31	75	14.24	2%	0.23
62105	92356	18	17.99	12.13	0.37	4.0	0.6930	7.14	40	16.24	1%	0.31
62105	92525	20	20.06	11.27	0.36	3.3	0.6928	7.07	25	18.31	1%	0.23
62105	92701	22	21.97	10.36	0.03	0.8	0.6992	6.96	12	20.22	0%	0.38
62105	92847	24	24.04	9.63	0.05	0.5	0.7062	6.85	1	22.29	0%	1.20
62105	93009	26	26.06	8.86	0.03	0.3	0.7384	6.67	0	24.31	0%	

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	0.61
71905	83621	0	0.26	27.40	6.60	85.3	0.7107	8.01	3397	Surface		
71905	83715	1	1.02	27.41	6.40	83.5	0.7097	8.03	3475	Surface	100%	
71905	83924	2	2.03	27.41	6.49	84.1	0.7097	8.04	1329	0.28	38%	3.43
71905	85402	3	2.98	27.40	6.53	84.7	0.7094	8.05	773	1.23	22%	0.57
71905	85504	4	4.02	27.38	6.41	83.5	0.7094	8.05	773	2.27	22%	0.00
71905	85607	6	6.01	27.31	6.10	79.3	0.7097	8.02	506	4.26	15%	0.21
71905	85800	8	7.94	27.24	5.90	76.6	0.7090	8.00	302	6.19	9%	0.27
71905	85919	10	9.98	26.47	4.97	63.6	0.7054	7.90	192	8.23	6%	0.22
71905	85953	12	11.98	23.96	6.19	75.6	0.6921	7.91	129	10.23	4%	0.20
71905	90144	14	14.03	19.93	3.07	34.8	0.6879	7.59	76	12.28	2%	0.26
71905	90417	16	15.97	17.23	1.49	16.0	0.6949	7.49	44	14.22	1.3%	0.28
71905	90715	18	17.90	15.04	0.48	4.9	0.6977	7.30	21	16.15	0.6%	0.38
71905	90837	20	20.04	12.25	0.24	2.3	0.7044	7.14	7	18.29	0%	0.51
71905	91004	22	22.03	10.81	0.07	0.6	0.7089	7.01	1	20.28	0%	0.98
71905	91124	24	24.02	9.76	0.06	0.5	0.7297	6.87	4	22.27	0%	-0.70
71905	91318	26	25.98	9.06	0.05	0.4	0.7740	6.58	6	24.23	0%	-0.21

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	0.71
81605	85301	0	0.39	25.32	8.02	100.1	0.7073	8.61	3392	Surface		
81605	85429	1	1.00	25.34	7.94	99.1	0.7061	8.63	3591	Surface	100%	
81605	85628	2	2.02	25.30	7.94	99.1	0.7056	8.76	1218	0.27	34%	4.00
81605	85757	3	2.97	25.29	7.74	96.6	0.7055	8.87	908	1.22	25%	0.31
81605	85900	4	3.92	25.29	8.02	100.1	0.7055	8.91	712	2.17	20%	0.26
81605	90126	6	5.99	25.23	8.01	99.9	0.7053	8.93	282	4.24	8%	0.45
81605	90418	8	8.03	25.08	6.68	83.1	0.7075	8.80	139	6.28	4%	0.35
81605	90824	10	10.06	24.93	6.55	81.3	0.7079	8.75	65	8.31	2%	0.37
81605	91034	12	12.02	24.10	3.20	39.1	0.7088	8.32	35	10.27	1.0%	0.32
81605	91621	14	14.03	22.31	0.12	1.3	0.6934	7.94	18	12.28	0.5%	0.33
81605	91759	16	16.07	18.66	0.13	1.4	0.6908	7.84	8	14.32	0%	0.40
81605	91913	18	18.05	15.91	0.10	1.0	0.6923	7.65	5	16.30	0%	0.24
81605	92017	20	20.01	12.99	0.10	1.0	0.7027	7.33	1	18.26	0%	0.82
81605	92113	22	21.97	10.92	0.11	1.0	0.7227	7.02	1	20.22	0%	
81605	92234	24	24.02	9.66	0.10	0.9	0.7611	6.71	1	22.27	0%	
81605	92334	26	25.94	9.33	0.09	0.8	0.7789	6.57	0	24.19	0%	

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	0.79
92005	84336	0	0.30	22.32	6.22	73.5	0.7235	8.23	3374	Surface		
92005	84442	1	1.03	22.31	6.20	73.2	0.7231	8.25	3591	Surface	100%	
92005	84540	2	2.01	22.29	6.06	71.5	0.7230	8.28	1031	0.26	29%	4.80
92005	84715	3	3.02	22.29	6.12	72.2	0.7229	8.30	686	1.27	19%	0.40
92005	84813	4	4.01	22.28	6.00	70.8	0.7229	8.34	406	2.26	11%	0.53
92005	84919	6	6.01	22.27	5.98	70.5	0.7236	8.38	187	4.26	5%	0.39
92005	85029	8	8.00	22.27	5.87	69.2	0.7232	8.41	118	6.25	3%	0.23
92005	85136	10	10.02	22.26	5.87	69.2	0.7232	8.43	66	8.27	2%	0.29
92005	85229	12	12.04	22.02	4.38	51.4	0.7252	8.25	36	10.29	1.0%	0.30
92005	85349	14	14.04	21.50	3.15	36.6	0.7242	8.09	20	12.29	0.6%	0.29
92005	85450	16	16.03	20.11	0.80	9.0	0.7108	7.85	11	14.28	0%	0.30
92005	85609	18	18.03	16.76	0.36	3.8	0.7032	7.54	6	16.28	0%	0.30
92005	85719	20	20.03	14.18	0.31	3.1	0.7202	7.30	1	18.28	0%	0.90
92005	85819	22	22.04	12.00	0.23	2.2	0.7427	7.01	0	20.29	0%	
92005	85929	24	24.09	10.82	0.19	1.8	0.7786	6.75	1	22.34	0%	
92005	90139	26	26.04	9.97	0.15	1.3	0.8019	6.58	0	24.29	0%	

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	0.35
101805	102126	0	0.32	15.42	5.81	60.2	0.7187	8.06	3520	Surface		
101805	102126	1	1.02	15.41	5.70	59.0	0.7183	8.08	3176	Surface	100%	
101805	102321	2	2.03	15.33	5.61	57.9	0.7183	8.08	1112	0.28	35%	3.75
101805	102421	3	3.02	15.24	5.60	57.7	0.7180	8.08	888	1.27	28%	0.23
101805	102510	4	4.06	15.19	5.60	57.6	0.7178	8.09	501	2.31	16%	0.55
101805	102602	6	6.04	15.18	5.58	57.4	0.7180	8.11	244	4.29	8%	0.36
101805	102701	8	8.05	15.16	5.40	55.5	0.7180	8.13	119	6.30	4%	0.36
101805	102820	10	10.06	15.15	5.34	54.9	0.7180	8.14	64	8.31	2%	0.31
101805	102945	12	12.02	15.13	5.37	55.3	0.7185	8.15	34	10.27	1.1%	0.32
101805	103059	14	14.03	15.12	5.61	57.7	0.7181	8.18	16	12.28	0.5%	0.38
101805	103221	16	16.05	15.05	5.92	60.8	0.7179	8.21	8	14.30	0%	0.34
101805	103337	18	18.03	14.91	2.76	28.3	0.7218	7.89	4	16.28	0%	0.35
101805	103441	20	20.00	14.74	0.91	9.3	0.7259	7.73	3	18.25	0%	0.15
101805	103646	22	22.02	14.16	0.10	1.0	0.7354	7.40	1	20.27	0%	0.54
101805	103817	24	24.03	11.69	0.08	0.8	0.7820	7.07	1	22.28	0%	
101805	103935	26	26.04	10.57	0.08	0.7	0.8152	6.91	0	24.29	0%	

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, 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	≥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 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.

Options for Lakes with High Canada Geese Populations

Option 1: Removal

Since Canada Geese are considered migratory waterfowl, both state and federal laws restrict taking or harassing geese. Under the federal Migratory Bird Treaty Act, it is illegal to kill or capture geese outside a legal hunting season or to harass their nests without a permit. If removal of problematic geese is warranted or if nest and egg destruction becomes an option, permits need to be obtained from the Illinois Department of Natural Resources (217- 782-6384) and the U.S. Fish and Wildlife Service (217-241-6700). Removing a significant portion of a problem goose population can have a positive effect on the overall health of a lake. However, if the habitat conditions still exist, more geese will likely replace any that were removed. Thus, money and time used removing geese may not be well spent unless there is a change in habitat conditions.

Option 2: Dispersal/Repellent Techniques

Several techniques and products are on the market that claim to disperse or deter geese from using an area. These techniques can be divided into two categories: harassment and chemical. With both types of techniques it is important to implement any action early in the season, before geese establish territories and begin nesting. Once established, the dispersal/repellant techniques may be less effective and geese more difficult to coerce into leaving. Harassment techniques include scaring off geese with noisemakers, or chasing them off using dogs or swans. Chemical repellents may also be used with some effectiveness. New products are continually coming out that claim to rid an area of nuisance geese.

With persistence, harassment and/or use of repellants can result reduced or minimal usage of an area by geese. Fewer geese may mean less feces and cleaner yards and parks, which may increase recreational uses along shorelines. However, the effectiveness of harassment techniques is reduced over time since geese will adapt to the devices.

Option 3: Exclusion

Erecting a barrier to exclude geese is another option. In addition to a traditional wood or wire fence, an effective exclusion control is to suspend netting over the area where geese are unwanted. Geese are reluctant to fly or walk into the area. A similar deterrent that is often used is a single string or wire suspended a foot or so above the ground along the length of the shoreline. This technique will not be effective if the geese are using a large

area. The single string or wire method may be effective at first, but geese often learn to go around, over, or under the string after a short period of time. Excluding geese from one area will force them to another area on a different part of the same lake or another nearby lake. While this solves one property owner's problem, it creates one for another.

Option 4: Habitat Alteration

One of the best methods to deter geese from using an area is through habitat alteration. Habitats that consist of mowed turfgrass to the edge of the shoreline are ideal for geese. Create a buffer strip (approximately 10-20 feet wide) between the shoreline and any mowed lawn by planting natural shoreline vegetation (i.e., bulrushes, cattails, rushes, grasses, shrubs, and trees, etc.) or allowing the vegetation to establish naturally. Aeration systems that run into the fall and winter prevent the lake from freezing, thus not forcing geese to migrate elsewhere. To alleviate this problem, turn aerators off during fall and early winter. Once the lake freezes over and the geese have left, wait a few weeks before turning the aerators on again if needed.

Altering the habitat in an area can not only make the habitat less desirable for geese, but may be more desirable for many other species of wildlife. A buffer strip has additional benefits by filtering run-off of nutrients, sediments, and pollutants and protecting the shoreline from erosion from wind, wave, or ice action. The more area that has natural vegetation, the less turfgrass needs to be constantly manicured and maintained.

Option 5: Do Not Feed Waterfowl!

There are few "good things", if any, that come from feeding waterfowl. Birds become dependent on handouts, become semi-domesticated, and do not migrate. This causes populations to increase and concentrate, which may create additional problems such as diseases within waterfowl populations. The nutritional value in many of the "foods" (i.e., white bread) given to geese and other waterfowl are quite low. Since geese are physiologically adapted to eat a variety of foods, they can actually be harmed by filling-up on human food. Geese that are accustomed to hand feeding may become aggressive toward other geese or even the people feeding the geese.

D5. Options to Reduce or Eliminate User Conflicts

One of the most challenging management issues on residential lakes involves their use by a variety of different interest groups (i.e., user conflicts). Problems occur when the lake is used at the same time for recreational activities that inherently conflict. Numerous potential conflicts can be cited. For example, fishermen may feel the quality of their fishing experience is greatly diminished when powerboats are using the lake. Often, the overriding priority when dealing with user conflicts is safety. Unfortunately, these conflicts are not limited to human-to-human conflicts. Fish and wildlife may also be adversely affected by human activities.

User conflicts can also have significant effects on how a lake is managed. For example, water skiers may feel that the aquatic plant population is impeding with their ability to safely use certain portions of the lake and want the plants removed or dramatically reduced. At the same time, the fishermen and wildlife enthusiasts do not want plant reductions because they believe the plants are enhancing the habitat in the lake.

Another important component to consider is the enforcement of any use conflict resolutions. As with any rule or regulation, it is only as good as the ability to enforce it. A significant factor is determining who has jurisdiction to enforce any regulations. Any law enforcement officer can enforce boating regulations or ordinances enacted by the State of Illinois or local government entities. Verbal or "gentlemen's" agreements that are more stringent than state laws are not legally binding. Similarly, a law enforcement officer may not enforce regulations adopted by a lake management association.

The following are several options that may help reduce some of the user conflicts that may be occurring on your lake.

Option 1: Time Zoning

As the name implies, time spacing requires that certain times of the day are allocated for various activities, while other activities are restricted or not permitted. For example, water skiing or jet skiing may only be permitted between certain periods of the day (i.e., 9AM to 6PM). This option may be combined with other options such as zone spacing or speed/power limits. Certain areas of the lake may be restricted only during parts of the day (i.e., early morning or evening) or users may be required to use "no-wake" speeds during these times. Time zoning allows various activities on the lake that may otherwise conflict. However, care should be taken in arrangement of times so all interest groups are considered.

Option 2: Space Zoning

Designating areas of the lake where uses are restricted or even not allowed is known as zone spacing. A "no-wake" zone is an example of using zone spacing to achieve a management goal. Zone spacing is generally used to isolate or consolidate certain lake activities for various reasons. Frequently, user safety is a priority and thus activities such as water skiing or jet skiing are limited to the deeper areas of the lake where they will not conflict with other lake users, such as swimmers.

Another reason zone spacing is implemented is for the prevention of shoreline erosion. Wave action generated by boat traffic can cause erosion, which can reduce property values and fish and wildlife habitat. In addition, the water quality of the lake may be degraded when wave activity suspends lake bottom nutrients and sediment. Shoreline erosion also adds nutrients and sediment to the lake, causing a decrease in water quality, which impacts all users of the lake. In some cases, certain areas of lakes may be zoned "no entry" or "restricted use only". This designation is usually to protect sensitive fish and wildlife habitat of threatened or endangered species. These areas may have this

restriction only during times of the year that are the most critical for a particular species (i.e., nesting or spawning season), or the restrictions may be year-round.

A “no wake” zone is generally established in a defined area from the shoreline out to a certain point in a lake and is usually marked by buoys. This area should be wide enough to allow wave action from boats to dissipate before reaching the shoreline.

Option 3: Speed/Power Limits

Powerboat motor limits or no motor areas may be warranted on small shallow lakes or in areas of a lake that are particularly susceptible to erosion or otherwise need protection. As mentioned previously, boat traffic may produce wave action that may cause shoreline erosion or degrade fish and wildlife habitat. Limited boat traffic may lead to less wave action battering shorelines and causing erosion, thus reducing the suspension of nutrients and sediment in the water column. Less nutrients and sediment in the water column may improve water quality by increasing water clarity and limiting nutrient availability for excessive plant or algae growth. Motor limits can reduce boat speeds however, the type of boat may be more important that the motor size or speed limit. Recent studies have shown that a boat traveling at “near plane” speed actually displaces more water and potentially resuspend lake bottom sediment at a greater volume than boats traveling at either idle speeds or speeds high enough to allow the boat to plane on the water’s surface. Enforcement would be the most difficult aspect of this option.

Another option is to limit the number of boats that use a lake at one time. This is generally most effective on private lakes where the number of boats can be more easily controlled. Large lakes with public access would have a difficult time enforcing regulations of this nature. To achieve this option, a lake management entity could issue a limited number of permits or require stickers for any boat using the lake.

APPENDIX E. WATER QUALITY STATISTICS FOR ALL LAKE COUNTY LAKES

2000 - 2005 Water Quality Parameters, Statistics Summary

	ALK (oxic) <=3ft 2000-2005	
Average	**167.0**	
Median	**162.0**	
Minimum	**64.9**	**IMC**
Maximum	**330.0**	**Flint Lake**
STD	**42.2**	
n =	**803**	

	ALK (anoxic) 2000-2005	
Average	**205**	
Median	**194**	
Minimum	**103**	**Heron Pond**
Maximum	**470**	**Lake Marie**
STD	**53**	
n =	**265**	

	Cond (oxic) <=3ft 2000-2005	
Average	**0.8536**	
Median	**0.7748**	
Minimum	**0.2305**	**White Lake**
Maximum	**6.8920**	**IMC**
STD	**0.5203**	
n =	**808**	

	Cond (anoxic) 2000-2005	
Average	**0.9606**	
Median	**0.8210**	
Minimum	**0.3031**	**White Lake**
Maximum	**7.4080**	**IMC**
STD	**0.7611**	
n =	**265**	

	NO3-N (oxic) <=3ft 2000-2005	
Average	**0.480**	
Median	**0.116**	
Minimum	**<0.05**	***ND**
Maximum	**9.670**	**South Churchill Lake**
STD	**1.019**	
n =	**808**	

*ND = Many lakes had non-detects (69%)
Only compare lakes with detectable
concentrations to the statistics above

	NH3-N (anoxic) 2000-2005	
Average	**2.296**	
Median	**1.560**	
Minimum	**<0.1**	***ND**
Maximum	**18.400**	**Taylor Lake**
STD	**2.483**	
n =	**265**	

*ND = 21% Non-detects from 32 different lakes

	pH (oxic) <=3ft 2000-2005	
Average	**8.31**	
Median	**8.30**	
Minimum	**7.06**	**Deer Lake**
Maximum	**10.28**	**Round Lake Marsh North**
STD	**0.46**	
n =	**807**	

	pH (anoxic) 2000-2005	
Average	**7.11**	
Median	**7.13**	
Minimum	**5.80**	**Third Lake**
Maximum	**8.48**	**Heron Pond**
STD	**0.41**	
n =	**265**	

	All Secchi 2000-2005	
Average	**4.39**	
Median	**3.17**	
Minimum	**0.33**	**Fairfield Marsh, Patski Pond**
Maximum	**29.23**	**Bangs Lake**
STD	**3.65**	
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

LCHD Lakes Management Unit ~ 12/8/2005

2000 - 2005 Water Quality Parameters, Statistics Summary continued

TKN (oxic)
<=3ft 2000-2005

Average	**1.457**	
Median	**1.220**	
Minimum	**<0.5**	***ND**
Maximum	**10.300**	**Fairfield Marsh**
STD	**0.831**	
n =	**808**	

*ND = 5% Non-detects from 19 different lakes

TKN (anoxic)
2000-2005

Average	**3.067**	
Median	**2.270**	
Minimum	**<0.5**	***ND**
Maximum	**21.000**	**Taylor Lake**
STD	**2.467**	
n =	**265**	

*ND = 5% Non-detects from 7 different lakes

TP (oxic)
<=3ft 2000-2005

Average	**0.098**	
Median	**0.063**	
Minimum	**<0.01**	**From 5 Lakes**
Maximum	**3.880**	**Albert Lake**
STD	**0.168**	
n =	**795**	

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

TP (anoxic)
2000-2005

Average	**0.320**	
Median	**0.174**	
Minimum	**0.012**	**West Loon Lake**
Maximum	**3.800**	**Taylor Lake**
STD	**0.412**	
n =	**265**	

TSS (all)
<=3ft 2000-2005

Average	**15.3**	
Median	**7.9**	
Minimum	**<0.1**	***ND**
Maximum	**165.0**	**Fairfield Marsh**
STD	**20.3**	
n =	**815**	

*ND = 2% Non-detects from 10 different lakes

TVS (oxic)
<=3ft 2000-2005

Average	**136.0**	
Median	**132.0**	
Minimum	**34.0**	**Pulaski Pond**
Maximum	**298.0**	**Fairfield Marsh**
STD	**40.4**	
n =	**758**	

No 2002 IEPA Chain Lakes

TDS (oxic)
<=3ft 2000-2004

Average	**470**	
Median	**454**	
Minimum	**150**	**Lake Kathryn, White**
Maximum	**1340**	**IMC**
STD	**169**	
n =	**745**	

No 2002 IEPA Chain Lakes, Data from 00-04.

CL (anoxic)
2004-2005

Average	**277**	
Median	**102**	
Minimum	**53**	**Banana Pond**
Maximum	**2390**	**IMC**
STD	**489**	
n =	**66**	

CL (oxic)
<=3ft 2004-2005

Average	**243.8**	
Median	**183.0**	
Minimum	**51.7**	**Heron Pond**
Maximum	**2760.0**	**IMC**
STD	**339.4**	
n =	**197**	

LakeCounty
Health Department and
Community Health Center

APPENDIX F. GRANT PROGRAM OPPORTUNITIES

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

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