2005 SUMMARY REPORT
of
St. Mary's Lake

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

St. Mary's Lake is a privately owned, 105-acre impoundment located in central Lake County, with ¾ in the Village of Mundelein and ¼ in the Village of Libertyville. The lake was created sometime between 1915 and 1920 by damming Bull Creek, which enters the lake on the southwest corner. This is a "flow through" system, with the water entering the lake from Loch Lomond Lake via Bull Creek and then exiting on the east side over a spillway that flows to Butler Lake eventually reaching the Des Plaines River. Seminary students use St. Mary's Lake for fishing, non-motorized boating and aesthetics.

The water quality in St. Mary's is poor with low water clarity, high total suspended solid (TSS) concentrations, high total phosphorous (TP) concentrations, and no aquatic plants. The lake is classified as eutrophic, and ranked 78th out of 162 lakes in Lake County based on average TP.

Water quality parameters, such as nutrients, suspended solids, oxygen, temperature and water clarity were measured each month from May-September 2005. St. Mary's Lake was weakly thermally stratified all season and epilimnetic oxygen concentrations remained high. The epilimnetic TP concentration was near the county median, but hypolimnetic concentrations remained below the county median. The average hypolimnetic TP concentration was more than twice the epilimnetic concentration, but this phosphorus remained isolated in the hypolimnion throughout the season, limiting algal blooms in the surface waters. TSS concentrations were also relatively high all summer and, as a result, Secchi transparency (water clarity) was lower than the county average. Conductivity in both the epilimnion and the hypolimnion was much higher than the county average and has increased dramatically since 2002. Since conductivity is related to chloride ions in urban areas, the chloride concentrations were also measured and found to be moderately high. These elevated conductivity and chloride levels are cause for concern, as it may be negatively impacting aquatic life.

No aquatic plants were present in St. Mary's Lake, possibly due to carp activity, morphometry of the lake, and the hard, rocky substrate of the lake bottom. Despite the absence of aquatic plants, a large number of upland plants and trees were observed along the shoreline. These plants and trees provide valuable habitat for a large number of birds and other wildlife species and should be preserved as much as possible.

LAKE FACTS

Lake Name:	St. Mary's Lake
Historical Name:	Lake Saint Mary's
Nearest Municipality:	Mundelein, Libertyville
Location:	T44N, R11E, Section 19,20
Elevation:	714.0 feet
Major Tributaries:	Bull Creek
Watershed:	Des Plaines River
Sub-watershed:	Bull Creek
Receiving Waterbody:	Butler Lake
Surface Area:	104.57 acres
Shoreline Length:	3.55 miles
Maximum Depth:	18.0 feet
Average Depth:	9.0 feet (estimated)
Lake Volume:	951.30 acre-feet (estimated)
Lake Type:	Impoundment
Watershed Area:	2944.65 acres
Major Watershed Land Uses:	Single Family, Public and Private Open Space, Forest and Grassland, and Agricultural
Bottom Ownership:	Private
Management Entities:	University of Saint Mary of the Lake/Mundelein Seminary
Current and Historical Uses:	Seminary students use the lake for fishing and non-motorized boating
Description of Access:	No public access

SUMMARY OF WATER QUALITY

Water samples were collected monthly from May through September at the deepest point in the lake (Figure 1, See Appendix A for water sampling methods). St. Mary's Lake was sampled at 3 feet and 11-13 feet (depending on water level). St. Mary's Lake was also sampled in 1995 and 2002 and the results will be compared to the 2005 data (See Table 1 for water quality data). Appendix C explains the various water quality parameters measured, how these parameters relate to each other, and why the measurement of each parameter is important.

St. Mary's Lake was weakly thermally stratified during the summer. Thermal stratification occurs when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the hypolimnion typically experiences anoxic conditions (dissolved oxygen (DO) <1 mg/L) by mid-summer. This phenomenon is a natural occurrence in deep lakes and is not necessarily a bad thing if enough of the lake volume remains oxygenated. Stratification in St. Mary's Lake was strongest during June and anoxic conditions began to occur around 9 feet. Since a bathymetric map does not exist for St. Mary's Lake, it is impossible to know what volume of the lake lies below 9 feet and was therefore experiencing low DO concentration. After June, the lake wasn't stratified due to water temperature, although the lake experienced anoxia below 9 to 11 feet. A DO concentration of 5.0 mg/L is considered adequate to support a sunfish/bass fishery, since these fish can suffer oxygen stress below this amount. The surface waters of St. Mary's Lake were well oxygenated during the summer, and DO concentrations did not fall below 5.0 mg/L at any time during the sampling period (Appendix B). On the other hand, hypolimnetic DO concentrations were below 1.0 mg/L for the entire season. This is expected in a stratified lake, and, as mentioned above, is only a problem if too much of the water column is part of this anoxic volume.

A large carp population was present in St. Mary's Lake based on communication with people who fish the lake on a regular basis. These bottom-feeding fish can stir up a large amount of sediment during feeding and spawning activities, and were likely contributing to a high density of clay and sediment particles in the water column. Sediment resuspended by carp and wind and wave action, along with the algal blooms, created poor water clarity. Secchi disk depth averaged 2.79 feet during 2005, which is below the Lake County median of 3.17 feet (Appendix E). This is a slight increase from the 2002 sampling when the average Secchi depth was 2.68 feet. Water clarity is related to the amount of TSS concentration in the water column, which is composed of nonvolatile suspended solids, non-organic clay or sediment materials, and volatile suspended solids, algae and other organic matter. As the TSS increased over the summer, the water clarity decreased (Figure 2). The 2005 average TSS of 10.8 mg/L was 37% greater then the Lake County median of 7.9 mg/L and was slightly higher 2002 (11.8 mg/L). The lakes in the Bull Creek watershed were all sampled during 2005 and include Loch Lomond Lake, IMC Lake, St. Mary's Lake, and Butler Lake (Table 2). Loch Lomond Lake had the lowest average Secchi depth and highest TSS, while Butler Lake had the highest average Secchi depth and lowest TSS. This is unusual since lakes on the top of a watershed generally have better water quality. The poor water quality in Loch Lomond and St. Mary's may be caused by the lack of aquatic plants and extensive algal growth in both lakes. In May and June the water clarity in St. Mary's Lake

Figure 1. Water quality sampling site on St. Mary's Lake, 2005

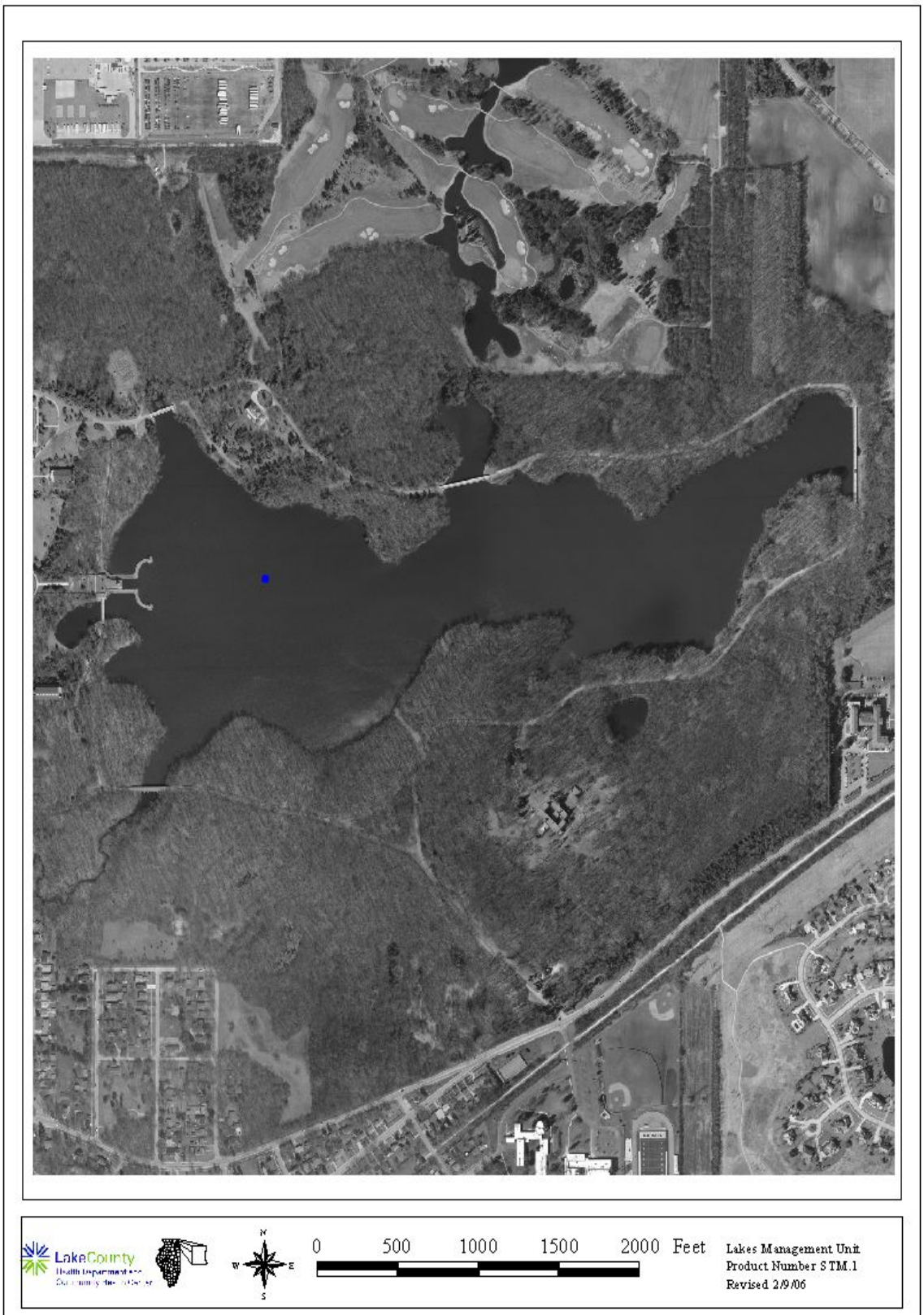

Table 1. Water quality data for St. Mary's Lake, 2002 and 2005.

2005	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
10-May	3	165	0.88	<0.1	<0.05	0.034	<0.005	215	NA	5.7	612	98	5.81	1.0940	8.37	13.50
14-Jun	3	166	1.03	<0.1	<0.05	0.046	<0.005	227	NA	11.0	678	132	2.85	1.1720	8.07	7.89
12-Jul	3	144	1.40	<0.1	<0.05	0.085	0.012	257	NA	12.0	729	174	0.98	1.1980	8.47	9.71
9-Aug	3	165	1.10	<0.1	<0.05	0.066	<0.005	246	NA	11.5	719	154	2.49	1.1920	8.61	13.57
13-Sep	3	126	1.94	<0.1	<0.05	0.102	0.006	273	NA	14.0	710	140	1.81	1.2310	8.71	9.50
	Average	153	1.27	<0.1	<0.05	0.067	0.009[k]	244	NA	10.8	690	140	2.79	1.1774	8.45	10.83

2002	Epilimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	Cl^-	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
6-May	3	174	0.99	<0.1	<0.05	0.074	<0.005	NA	600	10.2	618	124	2.79	1.0030	8.22	9.31
10-Jun	3	176	0.92	<0.1	0.191	0.043	<0.005	NA	612	8.5	665	169	3.45	1.0580	8.13	8.10
15-Jul	3	173	0.99	<0.1	<0.05	0.065	<0.005	NA	564	11.4	672	152	3.12	1.0770	8.57	9.64
12-Aug	3	149	1.38	<0.1	<0.05	0.079	<0.005	NA	582	13.0	590	146	2.05	1.0560	8.60	10.87
9-Sep	3	118	1.68	<0.1	<0.05	0.112	0.006	NA	521	15.7	551	120	1.97	0.9422	8.98	11.65
	Average	158	1.19	<0.1	0.19[k]	0.075	0.006[k]	NA	576	11.8	619	142	2.68	1.0272	8.50	9.91

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

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

Table 1. Continued.

2005	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
10-May	13	174	1.46	0.181	<0.05	0.081	<0.005	NA	216	29.1	643	101	NA	1.1140	7.35	2.07
14-Jun	12	184	1.67	0.529	<0.05	0.231	0.043	NA	225	45.0	704	122	NA	1.1850	7.12	0.06
12-Jul	11	154	1.41	0.114	<0.05	0.120	0.015	NA	255	13.0	704	140	NA	1.2160	7.44	0.12
9-Aug	11	176	1.20	<0.1	<0.05	0.140	0.035	NA	245	20.3	723	133	NA	1.2120	7.50	0.22
13-Sep	11	137	2.13	0.556	<0.05	0.178	0.054	NA	273	12.0	708	138	NA	1.2520	7.62	0.11
	Average	172	1.44	0.270[k]	<0.05	0.143	0.231[k]	NA	235	26.9	694	124	NA	1.1818	7.35	0.62

2002	Hypolimnion															
DATE	DEPTH	ALK	TKN	NH_3-N	NO_3-N	TP	SRP	TDS	Cl^-	TSS	TS	TVS	SECCHI	COND	pH	DO
6-May	13	177	1.06	<0.1	<0.05	0.087	<0.005	570	NA	22.4	601	132	NA	1.0040	7.64	4.22
10-Jun	13	181	1.18	0.318	0.058	0.074	0.005	652	NA	20.3	700	185	NA	1.0640	7.37	0.41
15-Jul	12	186	1.43	0.351	<0.05	0.233	0.025	566	NA	43.1	701	177	NA	1.0980	7.47	0.13
12-Aug	12	167	1.13	0.127	<0.05	0.090	0.010	606	NA	11.0	658	148	NA	1.0840	7.59	0.20
9-Sep	12	130	1.72	0.412	<0.05	0.176	0.046	514	NA	9.2	549	110	NA	0.9680	7.53	0.08
	Average	168	1.30	0.300[k]	0.058[k]	0.132	0.022[k]	582	NA	21.2	642	150	NA	1.0436	7.52	1.01

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
Cl^- = Chloride, mg/L
TDS = Total dissolved solids, mg/L
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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

Figure 2. Total suspended solid (TSS) concentrations vs. Secchi depth for St. Mary's Lake, 2005.

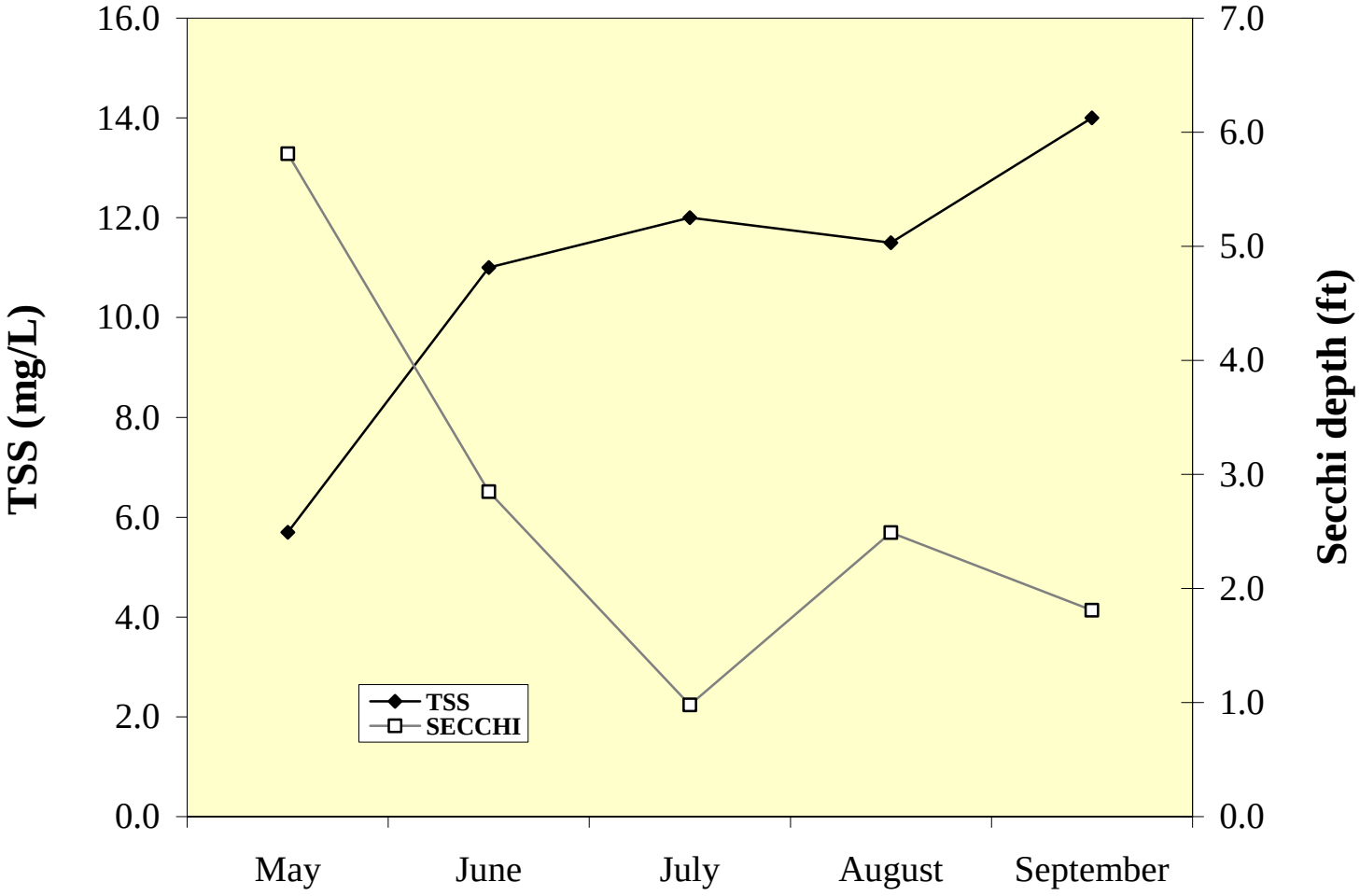


Table 2. Comparison of epilimnetic averages for Secchi disk transparency, total suspended solids, total phosphorus, and conductivity readings in the Bull Creek watershed (Loch Lomond Lake, St. Mary's Lake, and Butler Lake).

	Loch Lomond Lake	Loch Lomond Lake	Loch Lomond Lake	IMC Lake	IMC Lake	St. Mary's Lake	St. Mary's Lake	St. Mary's Lake	Butler Lake	Butler Lake	Butler Lake
Year	**1999**	**2004**	**2005**	**2003**	**2005**	**1995**	**2002**	**2005**	**1995**	**2001**	**2005**
Secchi (feet)	1.89	3.27	2.17	4.96	3.08	2.26	2.68	2.79	5.83	6.65	4.35
TSS (mg/L)	19.2	13.2	13.1	4.4	9.7	12.2	11.8	10.8	3.1	2.1	6.3
TP (mg/L)	0.235	0.245	0.295	0.039	0.095	0.065	0.075	0.067	0.031	0.048	0.053
Conductivity (milliSiemens/cm)	0.7076	0.8232	1.3298	1.9958	6.1436	0.5958	1.0272	1.1774	0.5852	1.0893	1.1602

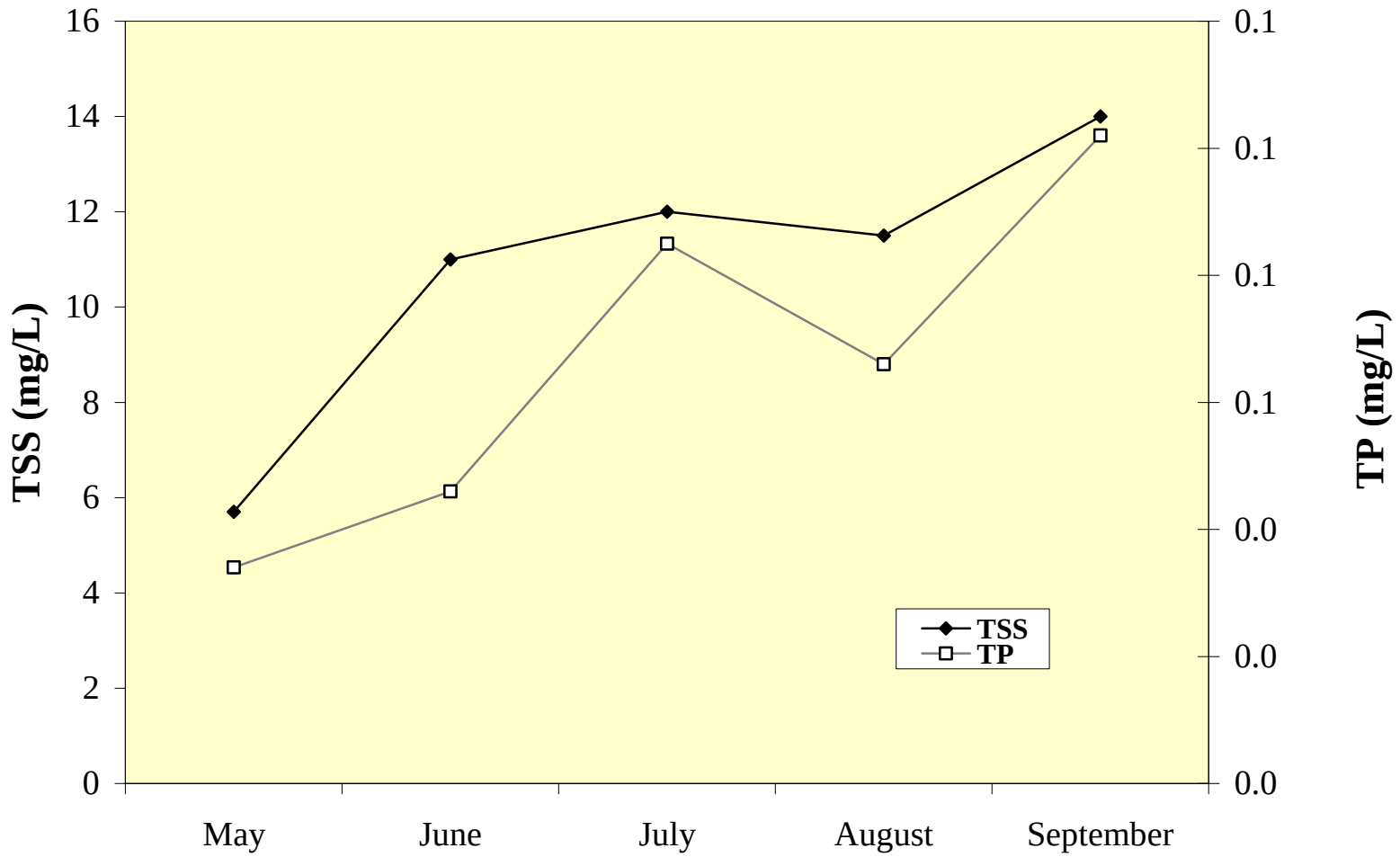
Direction of Watershed Flow

was better than the remainder of the summer, which is common in many lakes. Although some algae were present during these months, algal blooms that occurred in July, August, and September had greater affects on the water clarity.

-Another factor affecting water clarity is the amount of nutrients in the water. Algae require nutrients such as nitrogen and phosphorus, which are two key ingredients for growth and can regulate populations. Typically, lakes are either phosphorus or nitrogen limited. This means that one of the nutrients is in short supply and any addition of that nutrient to the lake will result in an increase of plant or algae growth. Most lakes in Lake County are phosphorus limited. To compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting. Ratios greater than or equal to 15:1 indicate phosphorus is limiting. Ratios greater than 10:1, but less than 15:1 indicate there are enough of both nutrients to facilitate excess algae or plant growth. St. Mary's had an average TN:TP ratio of 19:1 in 2005 and 18:1 in 2002. This indicates the lake was phosphorous limited. Phosphorus is a nutrient that can enter lakes through runoff or be released from lake sediment, and high levels of phosphorus typically trigger algal blooms or produce high plant density. TP concentrations increased during the summer corresponding with algal blooms, TSS concentration increase (Figure 3), and the subsequent decrease in water clarity. The 2005 average near surface TP concentration in St. Mary's Lake was 0.067 mg/L, while the hypolimnetic average TP concentration was 0.143 mg/L (Table 1). The epilimnetic concentration was slightly above the county median of 0.063 mg/L, while the hypolimnetic concentration was below the county median of 0.174 mg/L. The average epilimnetic TP concentration in 2002 (0.075 mg/L) was approximately 12% higher than in 2005 (0.067 mg/L). The main source of water to St. Mary's Lake is Loch Lomond Lake. The average epilimnetic TP concentration in Loch Lomond during 2005 was 0.295 mg/L (Table 2). This is a high TP concentration and it is possible that water from Loch Lomond Lake entered St. Mary's Lake during rain events, increasing the epilimnetic TP concentration, although this was minimal in 2005 due to the lack of rain. The hypolimnetic TP concentration was more than twice the epilimnetic concentration, which is expected in a stratified lake. During stratification, oxygen is nearly depleted in the hypolimnion, triggering chemical reactions at the sediment interface. These reactions result in the release of phosphorus from the sediment into the water column and are known as internal phosphorus loading. Since the hypolimnion is thermally isolated from the epilimnion during the summer, phosphorus builds up in the bottom waters and does not reach the sunlit surface waters of the epilimnion until fall turnover. However, in St. Mary's Lake, epilimnetic TP concentrations were relatively high throughout the season. St. Mary's Lake appears to be polymictic, which means the lake stratified, mixed, and then stratified again, which is common in shallow systems. Each time the lake mixes it distributes the hypolimnetic phosphorus throughout the water column and can produce algal blooms.

There is a wastewater treatment plant at St. Mary's of the Lake Seminary, which likely contributes to the nutrient loading of the St. Mary's Lake. Although specific phosphorus loading from this plant is not monitored, a conservative estimate of the loading was calculated using 1.0 mg/L as the daily load being discharged into St. Mary's Lake. Based on the 0.030 million gallons per day (MGD) design average flow (DAF), approximately 91.4 pounds of phosphorus enters St. Mary's Lake each year. The average hypolimnetic TP concentration in 2002 (0.132 mg/L) was lower than the average 2005 concentration (0.143 mg/L).

Figure 3. Total suspended solid (TSS) concentrations vs. total phosphorous (TP) concentrations for St. Mary's Lake, 2005.



Once TP reaches a lake, the process of internal loading described previously begins. There were also external sources of TP affecting St. Mary's Lake such as stormwater runoff from the 2944 acres within its watershed (Figure 4), which includes Loch Lomond Lake. The four largest land uses within the watershed were single family (25%), public and private open space (18%), forest and grassland (15%), and agricultural (10%)(Figure 5). Land uses within the watershed can contribute to external phosphorus loading (Table 3). For St. Mary's Lake, the land uses contributing the highest percentages of estimated runoff are single family and transportation (i.e., road) areas, which cover 30% and 22%, respectively. The retention time for water entering the lake was calculated to be approximately 174 days. It is likely that St. Mary's Lake is a source of TP and TSS to Butler Lake, because Butler Lake is downstream of St. Mary's Lake in the Bull Creek watershed.

TP can be used for the trophic state index (TSIp), which classifies lakes according to the overall level of nutrient enrichment. The TSIp score falls within the range of one of four categories: hypereutrophic, eutrophic, mesotrophic and oligotrophic. Hypereutrophic lakes are those with excessive nutrients, nuisance algal growth reminiscent of "pea soup" and have a TSI score greater than 70. Lakes with a TSI score of 50 or greater are classified as eutrophic or nutrient rich, and are productive lakes in terms of aquatic plants and/or algae and fish. Mesotrophic and oligotrophic lakes have lower nutrient levels. These are very clear lakes, with little algal growth. Most lakes in Lake County are eutrophic. The trophic state of St. Mary's Lake in terms of its phosphorus concentration during 2002 was eutrophic, with a TSIp score of 66.4. In 2005 it was still eutrophic even though the TSIp score decreased to 64.7. St. Mary's Lake was 78th out of 162 lakes in Lake County based on average TP concentrations (Table 4). Loch Lomond Lake ranked 157th, IMC Lake ranked 100th, while Butler Lake ranked 62nd.

The IEPA has assessment indices to classify Illinois lakes for their ability to support aquatic life, swimming, or recreational uses. The guidelines consider several aspects, such as water clarity, phosphorus concentrations (for the trophic state index) and aquatic plant coverage. According to this index, St. Mary's Lake provides *Full* support of aquatic life and *Partial* support of swimming and recreational activities (such as boating) as a result of high TP and nonvolatile suspended solids (clay particles) in the water column. The lake provides *Partial* overall use.

Conductivity is a measurement of water's ability to conduct electricity and is correlated with chloride (Cl^-) concentration (Figure 6). Compared to lakes in undeveloped areas, lakes with residential and/or urban land uses in their watersheds often have higher conductivity readings and higher Cl^- concentrations because of the use of road salts. Stormwater runoff from impervious surfaces such as roads and parking lots can deliver high concentrations of this Cl^- to nearby lakes and ponds. The median conductivity reading for near surface samples is 0.7748 milliSiemens/cm (mS/cm) for Lake County lakes. During 2005, the average conductivity reading for St. Mary's Lake was higher at 1.1774 mS/cm. This was up 15% from the 2002 average of 1.0272 mS/cm and 98% higher than the 1995 average of 0.5958 mS/cm. The 2005 readings remained relatively consistent throughout the season. Typically lakes that receive road salts have higher readings early in the year as spring rains flush salts from the watershed with readings dropping off as the summer goes on. Road salt was probably the reason for such high readings because chloride concentrations detect sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts, which make up most road salt.

Figure 4. Approximate watershed delineation for St. Mary's Lake, 2005.

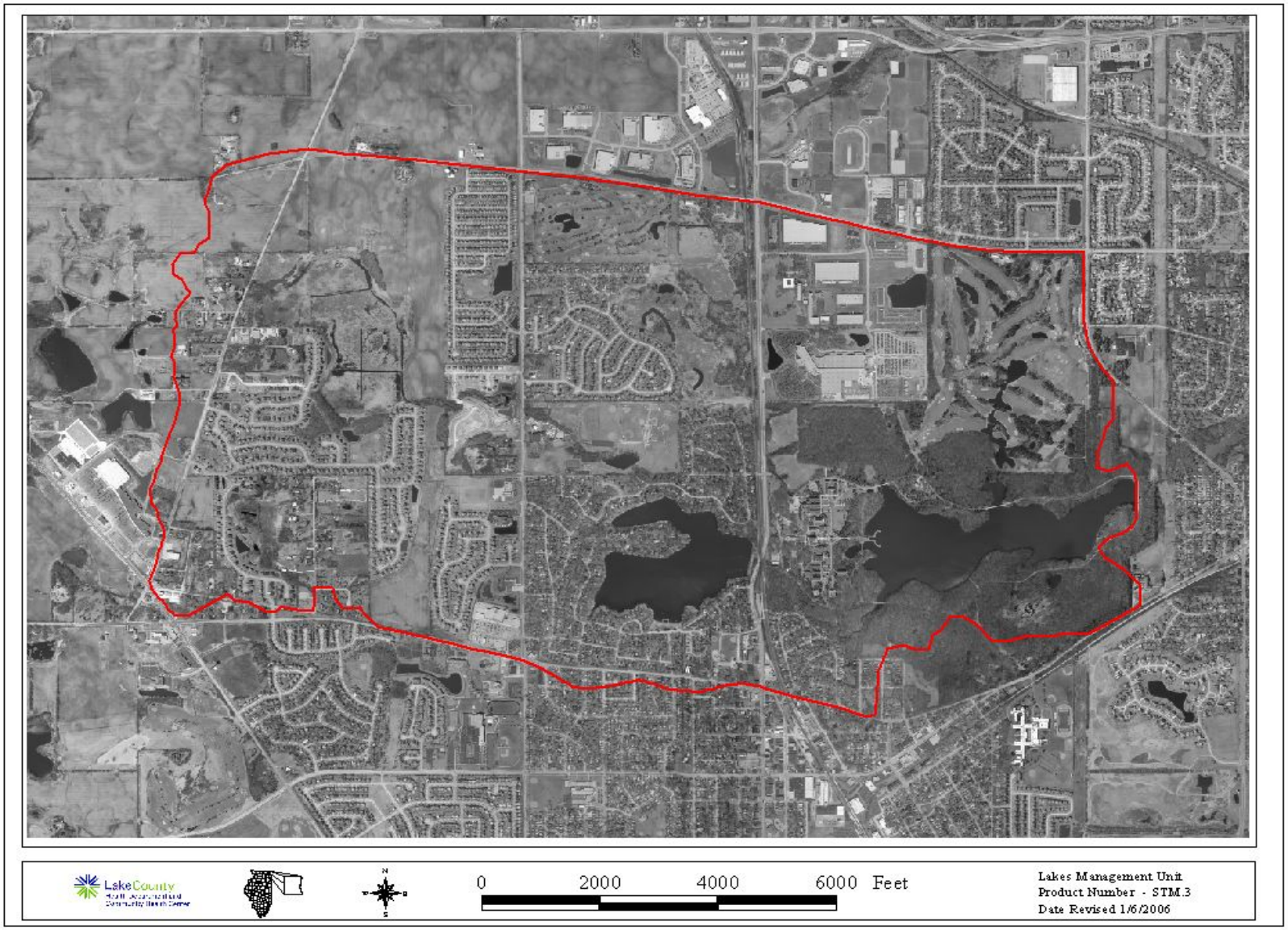


Figure 5. Approximate land use within St. Mary's Lake watershed, 2005

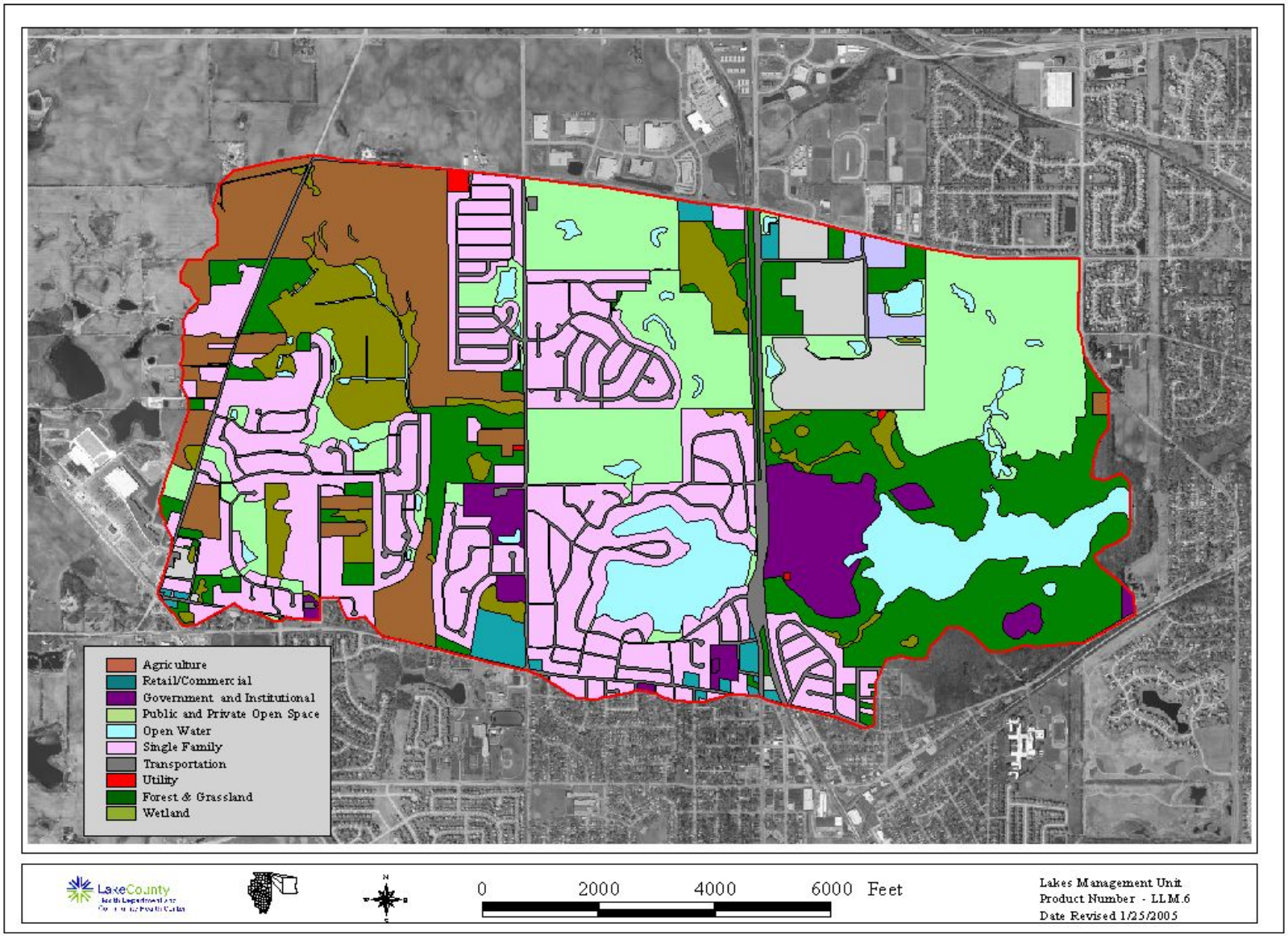


Table 3. Approximate land uses and retention time for St. Mary's Lake, 2005.

Land Use	Acreage	% of Total
Agricultural	298.5	10.1
Forest and Grassland	446.1	15.1
Government and Institutional	136.0	4.6
Industrial	119.1	4.0
Office	21.9	0.7
Public and Private Open Space	536.6	18.2
Retail/Commercial	37.8	1.3
Single Family	736.2	25.0
Transportation	184.2	6.3
Utility and Waste Facilities	4.2	0.1
Water	224.8	7.6
Wetlands	199.9	6.8
Total Acres	**2945.2**	**100.0**

Land Use	Acreage	Runoff Coeff.	Estimated Runoff, acft.	% Total of Estimated Runoff
Agriculture	298.5	0.05	41.0	2.1%
Commercial	37.8	0.85	88.4	4.4%
Forest & Grassland	446.1	0.05	61.3	3.1%
Govt. & Institution	136.0	0.50	187.0	9.4%
Industrial	119.1	0.85	278.4	13.9%
Public & Private Open Space	536.6	0.15	221.3	11.1%
Office	21.9	0.85	51.2	2.6%
Open water	224.8	0.00	0.0	0.0%
Single-Family	736.2	0.30	607.4	30.4%
Transportation	184.2	0.85	430.6	21.6%
Utility & Waste	4.2	0.30	3.5	0.17%
Wetlands	199.9	0.05	27.5	1.4%
TOTAL	**2945.3**		**1997.6**	**100.0%**

Lake volume **951.3 acre-feet**
Retention Time (years)= lake volume/runoff **0.48 years**
173.82 days

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

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 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

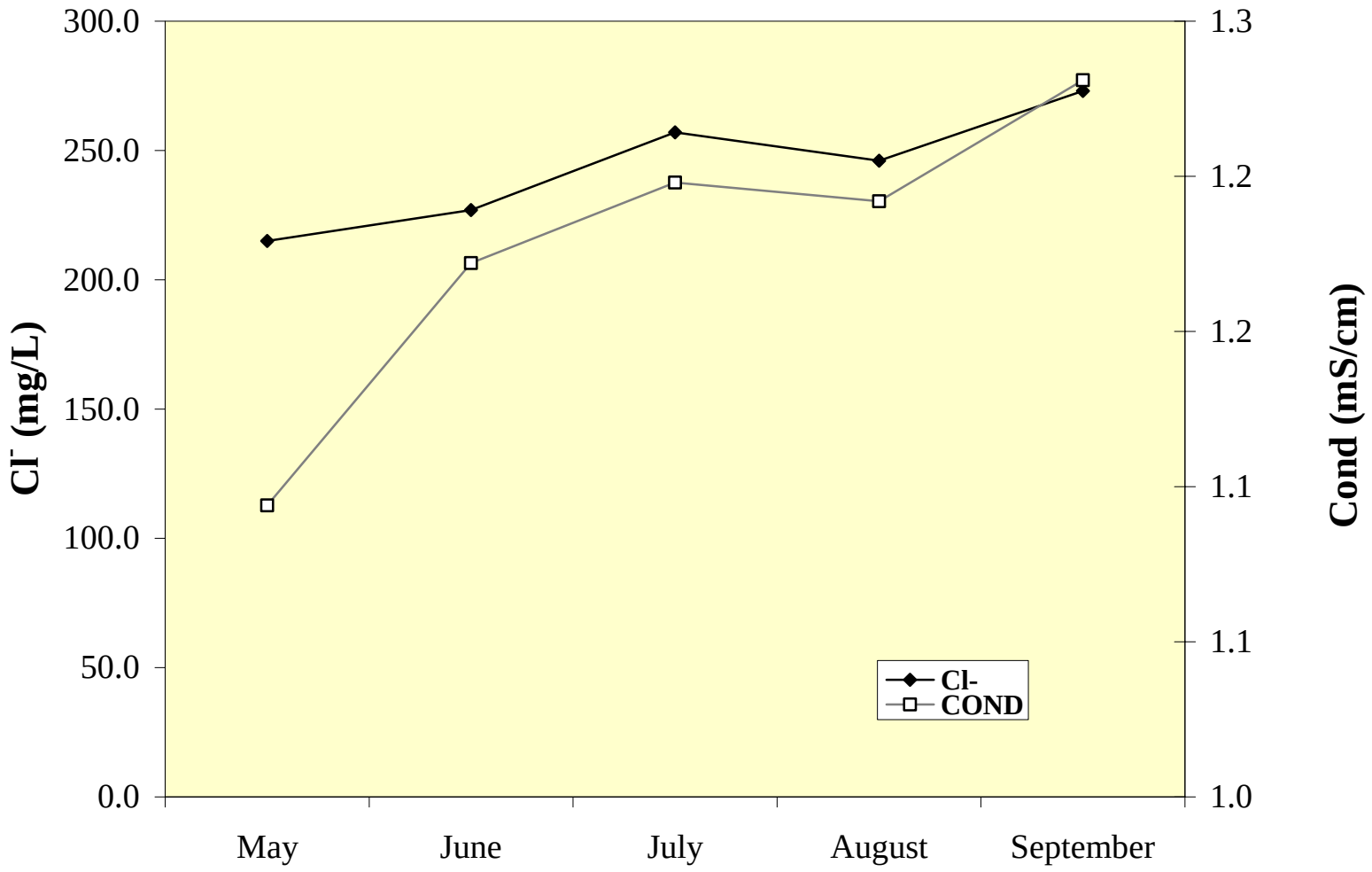
Table 4. Continued.

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

Figure 6. Chloride (Cl^-) concentrations vs. conductivity for St. Mary's Lake, 2005



The readings most likely didn't drop off due to the lack of precipitation during the summer not replenishing the lake volume and concentrating the Cl^-. Chloride concentration in St. Mary's Lake was higher in 2005 than the Lake County median of 183 mg/L, with a seasonal epilimnetic average of 244 mg/L. Loch Lomond Lake, IMC Lake, and Butler Lake also had high Cl^- concentrations of 287 mg/L, 1852 mg/L, and 244 mg/L, respectfully. The Illinois Environmental Protection Agency (IEPA) standard for chloride is 500 mg/L. Once values exceed this standard, the waterbody is deemed to be impaired, thus impacting aquatic life. Approximately 71% of IMC Lake's watershed consists of impervious surfaces that can contribute road salt. A study done in Canada reported 10% of aquatic species are harmed by prolonged exposure to chloride concentrations greater than 220 mg/L. Additionally, shifts in algal populations in lakes were associated with chloride concentrations as low as 12 mg/l. Therefore, it is likely these lakes are being negatively impacted by the high Cl^- concentrations.

SUMMARY OF AQUATIC MACROPHYTES

To maintain a healthy sunfish/bass fishery, the Illinois Department of Natural Resourced suggest the optimal plant (macrophyte) coverage be 30% to 40% across the lake bottom. Water clarity and depth are the major limiting factors in determining the maximum depth at which aquatic plants will grow in a specific lake. Aquatic plants will not photosynthesize at water depths with less than 1% of the available sunlight at the surface. If a bathymetric map exists, this information can be used to determine how much of the lake has the potential to support aquatic plant growth. Based on 1% light level, St. Mary's Lake could have supported plants to a depth of 9.0 feet in May, June, and August, a depth of 10.0 feet in July, and a depth of 7.0 feet in September. However, possibly due to carp activity, morphometry of the lake, and the hard, rocky substrate of the lake bottom, there were no aquatic plants present in 2002 or 2005. Despite the absence of aquatic plants, a large number of upland plants and trees were observed along the shoreline. These plants and trees provide valuable habitat for birds and other wildlife species and should be preserved.

SUMMARY OF SHORELINE CONDITION

In 2002 an assessment was conducted to determine the condition of the shoreline at the water/land interface. Approximately 34% of St. Mary's Lake's shoreline was developed and the majority of the developed shoreline was comprised of lawn (42.1%), riprap (29.5%) and seawall (14.4%). The remainder of the developed shoreline consisted of woodland (11.4%) and buffer (2.6%). The undeveloped portions of the lake were primarily woodland and a small amount of riprap and lawn.

The shoreline was reassessed on July 27, 2005 for significant changes in erosion since the previous survey in 2002. This survey, however, was not as extensive as in 2002. Based on this assessment, it was found most areas that had erosion in 2002 were still in the same condition or had deteriorated further. In addition, new erosion had appeared along with some undercutting of the shoreline.

Manicured lawn is undesirable because it provides a poor shoreline-water interface due to the poor root structure of turf grasses. These grasses are poor at stabilizing the shoreline and

typically lead to erosion. In 2002, 98% of the lawn around St. Mary's Lake was slightly to severely eroded. Although riprap is not an appealing shoreline type with regard to wildlife habitat, it does help to prevent shoreline erosion if it is properly installed and maintained. The riprap along St. Mary's Lake was not properly installed with filter fabric and has not been maintained over time. As a result, the riprap shoreline was exhibiting erosion. Typically, buffer and woodland are ideal shoreline types because they help prevent shoreline erosion, as well as provide wildlife habitat. However, if these types of shoreline are not properly maintained, and exotic plant or tree species such as Buckthorn are allowed to colonize, buffered and woodland shorelines can become eroded. The 2002 survey showed that 35% of the wooded shoreline and 100% of the buffered shoreline had erosion along it. As was recommended in the 2002 report, buffer and woodland shorelines should be improved and maintained as much as possible with re-grading and removal of some or all of the exotic plant and tree species. Additionally, old, deteriorating riprap and manicured lawn areas should be removed and replaced with new riprap (properly installed with filter fabric) or a buffer of native plants.

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

SUMMARY OF WILDLIFE AND HABITAT

The dominance of woodland around the entire perimeter of St. Mary's Lake provides habitat for a variety of wildlife. Various species of birds were observed, along with several small mammals, reptiles, and amphibians. Woodland and buffer areas around the lake should be improved and maintained to provide the appropriate habitat for birds and other wildlife in the future. Additional habitat could be established in areas where manicured lawn has become eroded with the addition of buffer strips, which can also aid in erosion reduction. Enhancing habitat for terrestrial wildlife such as birds and small mammals can be accomplished through the addition of shoreline buffer zones and are recommended as one aspect of shoreline protection. Erecting birdhouses or allowing brush or trees that have fallen into the water to remain creates additional habitat for birds, fish, reptiles, and amphibians.

To the best of our knowledge, no formal fisheries assessment has been done on St. Mary's Lake. Managers at the Mundelein Seminary believe no official stocking has ever taken place.

LAKE MANAGEMENT RECOMMENDATIONS

St. Mary's Lake is surrounded by forest and grassland habitat that helps filter run-off and when properly maintained will help with erosion control. It also provides wildlife habitat and opportunities for students and guests to fish and enjoy the outdoors. To improve the quality of St. Mary's Lake, the Lake County Health Department – Lakes Management Unit (LCHD-LMU) has the following recommendations.

- **Creating a bathymetric map**

  Creating a bathymetric map of St. Mary's Lake can help with improvements on the lake and will help with management strategies. (Appendix D1).

- **Nuisance algae management, reducing bacteria inputs into a lake, watershed nutrient reduction, and watershed sediment reduction**

  St. Mary's Lake has poor water clarity, high phosphorus concentrations, and had seasonal algal blooms, which all can be related. High phosphorus triggers algal blooms and as a result water clarity declines (Appendix D2). Reducing nutrients and sediment entering the lake from the watershed may minimize algal blooms (Appendix D3-5).

- **Participate in the Volunteer Lake Monitoring Program (VLMP)**

  To track future water quality trends, it is recommended the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October (Appendix D6). In addition to the VMLP, a staff gauge should be installed to monitor the lake level each month.

- **Lakes with shoreline erosion**

  There are some areas around the lake that have erosion. These eroded areas should be repaired to prevent additional loss of shoreline and prevent continued degradation of the water quality through sediment inputs. When possible, the shorelines should be repaired using natural vegetation instead of riprap or seawalls (Appendix D7).

- **Assess your lake's fishery, lakes with a high carp population**

  No known formal fisheries survey has been conducted on St. Mary's Lake. It appears that common carp dominate the fish community in St. Mary's Lake. This fish species reproduces at a high rate and its spawning and feeding activities disturb bottom sediment. The presence of these fish in St. Mary's Lake may be contributing to high TSS and TP levels, as well as very low Secchi depths, and, most likely, the lack of aquatic plants. One of the major uses of the lake is fishing and it is recommended that a fish assessment be conducted to determine the diversity and health of the fish community and to obtain an estimate of the size of the current carp population (Appendix D8-9).

Grant program opportunities

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

APPENDIX A. METHODS FOR FIELD DATA COLLECTION AND LABORATORY ANALYSES.

Water Sampling and Laboratory Analyses

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

Plant Sampling

The plant survey consisted of canoeing around the lake and noting areas with plants and the plants were identified. The areas were recorded on an aerial photo of the lake. The survey was all visual.

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
Total dissolved solids	SM 18th ed, Method #2540C
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 ST. MARY'S LAKE IN 2005.

Countryside Lake 2005 Multiparameter data

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.76
5/11/2005	11:31:59	0.25	0.21	17.80	9.37	101.3	0.7146	8.00	970	Surface		
5/11/2005	11:33:01	1	1.10	17.85	9.30	100.7	0.7139	8.03	534	Surface	100%	
5/11/2005	11:34:36	2	2.03	17.87	9.36	101.3	0.7134	8.05	192	0.28	36%	3.65
5/11/2005	11:35:20	3	3.00	17.88	9.34	101.2	0.7135	8.05	165	1.25	31%	0.16
5/11/2005	11:36:01	4	4.01	17.87	9.31	100.8	0.7134	8.06	135	2.26	25%	0.20
5/11/2005	11:36:51	5	5.00	17.82	9.44	102.1	0.7134	8.06	72	3.25	13%	0.63
5/11/2005	11:38:19	6	6.04	16.14	11.80	123.2	0.7005	8.14	83	4.29	16%	-0.14
5/11/2005	11:39:51	7	7.02	14.41	12.70	127.5	0.6974	8.17	93	5.27	17%	-0.12
5/11/2005	11:41:30	8	8.02	13.22	9.52	93.3	0.7166	7.97	37	6.27	7%	0.92

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	1.02
6/15/2005	11:18:22	0.25	0.52	24.87	5.14	64.7	0.7794	7.66	2175	Surface		
6/15/2005	11:19:39	1	0.96	24.87	4.95	62.3	0.7791	7.64	2000	Surface	100%	
6/15/2005	11:21:14	2	2.05	24.88	4.85	61.0	0.7788	7.63	576	0.30	29%	4.15
6/15/2005	11:22:13	3	3.03	24.88	4.85	61.1	0.7788	7.63	386	1.28	19%	0.41
6/15/2005	11:23:23	4	3.99	24.89	4.86	61.2	0.7786	7.62	223	2.24	11%	0.57
6/15/2005	11:24:26	5	5.07	24.88	4.86	61.2	0.7785	7.61	106	3.32	5%	0.69
6/15/2005	11:25:16	6	5.99	24.88	4.82	60.7	0.7786	7.61	58	4.24	3%	0.66
6/15/2005	11:26:04	7	7.01	24.88	4.75	59.8	0.7787	7.60	37	5.26	2%	0.44
6/15/2005	11:27:06	8	7.98	24.88	4.65	58.5	0.7786	7.60	29	6.23	1.5%	0.25

Countryside Lake 2005 Multiparameter data

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	1.00
7/13/2005	11:32:36	0.25	0.40	26.04	6.00	76.3	0.7852	7.71	2300	Surface		
7/13/2005	11:33:43	1	0.99	26.03	6.02	76.6	0.7854	7.71	2085	Surface	100%	
7/13/2005	11:35:07	2	1.98	26.04	6.01	76.4	0.7852	7.72	499	0.23	24%	6.22
7/13/2005	11:36:11	3	3.03	26.01	5.89	74.9	0.7855	7.71	554	1.28	27%	-0.10
7/13/2005	11:37:21	4	4.03	26.02	5.88	74.8	0.7854	7.71	348	2.28	17%	0.46
7/13/2005	11:38:25	5	5.05	26.03	5.94	75.6	0.7853	7.71	268	3.30	13%	0.26
7/13/2005	11:39:37	6	6.01	25.98	5.87	74.6	0.7854	7.70	215	4.26	10%	0.23
7/13/2005	11:42:25	7	7.04	25.98	5.78	73.4	0.7856	7.69	233	5.29	11%	-0.08
7/13/2005	11:43:34	8	8.04	25.83	5.39	68.4	0.7860	7.65	231	6.29	11%	0.01

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	1.10
8/10/2005	9:58:38	0.25	0.33	27.98	8.32	109.5	0.7525	8.76	3727	Surface		
8/10/2005	10:00:03	1	1.00	27.97	8.34	109.8	0.7520	8.82	3961	Surface	100%	
8/10/2005	10:02:10	2	1.99	27.95	8.13	107.0	0.7518	8.90	1158	0.24	29%	5.12
8/10/2005	10:04:02	3	3.04	27.85	8.07	106.1	0.7518	8.95	1005	1.29	25%	0.13
8/10/2005	10:06:07	4	4.06	27.79	8.29	108.9	0.7523	8.92	588	2.31	15%	0.53
8/10/2005	10:07:19	5	5.08	27.74	7.91	103.7	0.7524	8.91	339	3.33	9%	0.54
8/10/2005	10:08:43	6	6.12	27.65	7.08	92.8	0.7538	8.84	287	4.37	7%	0.16
8/10/2005	10:10:10	7	7.02	27.60	6.05	79.2	0.7555	8.70	189	5.27	5%	0.46
8/10/2005	10:11:41	8	8.01	27.56	5.22	68.3	0.7570	8.60	93	6.26	2%	0.72

Countryside Lake 2005 Multiparameter data

Date MMDDYY	Time HHMMSS	Text Depth feet	Dep25 feet	Temp øC	DO mg/l	DO% Sat	SpCond mS/cm	pH Units	PAR æE/s/mý	Depth of Light Meter feet	% Light Transmission	Extinction Coefficient
											Average	0.81
9/14/2005	10:42:39	0.25	0.26	24.78	6.60	82.3	0.7430	8.75	3716	Surface		
9/14/2005	10:44:03	1	1.04	24.80	6.57	81.9	0.7430	8.76	2789	Surface	100%	
9/14/2005	10:45:01	2	2.00	24.82	6.53	81.5	0.7432	8.77	1435	0.25	51%	2.66
9/14/2005	10:46:40	3	3.01	24.78	6.53	81.3	0.7435	8.77	862	1.26	31%	0.50
9/14/2005	10:47:58	4	4.06	24.78	6.44	80.2	0.7439	8.78	518	2.31	19%	0.49
9/14/2005	10:49:23	5	5.06	24.71	6.17	76.8	0.7440	8.76	321	3.31	12%	0.48
9/14/2005	10:50:47	6	6.03	24.69	5.99	74.5	0.7443	8.76	184	4.28	7%	0.57
9/14/2005	10:52:24	7	7.00	24.66	5.64	70.1	0.7449	8.74	119	5.25	4%	0.45
9/14/2005	10:53:37	8	7.92	24.62	5.24	65.1	0.7456	8.70	72	6.17	3%	0.55

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

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

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

Temperature and Dissolved Oxygen:

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

Monthly temperature profiles were established on each lake by measuring water temperature every foot (lakes $\leq$ 15 feet deep) or every two feet (lakes > 15 feet deep) from the lake surface to the lake bottom. These profiles are important in understanding the distribution of chemical/biological characteristics and because increasing water temperature and the establishment of thermal stratification have a direct impact on dissolved oxygen (DO) concentrations in the water column. If a lake is shallow and easily mixed by wind, the DO concentration is usually consistent throughout the water column. However, shallow lakes are typically dominated by either plants or algae, and increasing water temperatures during the summer speeds up the rates of photosynthesis and decomposition in surface waters. When many of the plants or algae die at the end of the growing season, their decomposition results in heavy oxygen consumption and can lead to an oxygen crash. In deeper, thermally stratified lakes, oxygen production is greatest in the top portion of the lake, where sunlight drives photosynthesis, and oxygen consumption is greatest near the bottom of a lake, where sunken organic matter accumulates and decomposes. The oxygen difference between the top and bottom water layers can be dramatic, with plenty of oxygen near the surface, but practically none near the bottom. The oxygen profiles measured during the water quality study can illustrate if

this is occurring. This is important because the absence of oxygen (anoxia) near the lake bottom can have adverse effects in eutrophic lakes resulting in the chemical release of phosphorus from lake sediment and the production of hydrogen sulfide (rotten egg smell) and other gases in the bottom waters. Low oxygen conditions in the upper water of a lake can also be problematic since all aquatic organisms need oxygen to live. Some oxygen may be present in the water, but at too low a concentration to sustain aquatic life. Oxygen is needed by all plants, virtually all algae and for many chemical reactions that are important in lake functioning. Most adult sport-fish such as largemouth bass and bluegill require at least 3 mg/L of DO in the water to survive. However, their offspring require at least 5 mg/L DO as they are more sensitive to DO stress. When DO concentrations drop below 3 mg/L, rough fish such as carp and green sunfish are favored and over time will become the dominant fish species.

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

Nutrients:

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

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

it moves into the sunlit surface water at that time. Accordingly, many of the lakes in Lake County are plagued by dense algae blooms and excessive, exotic plant coverage, which negatively affect DO levels, fish communities and water clarity.

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

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

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

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

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

Solids:

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

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

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

Water Clarity:

Water clarity (transparency) is not a chemical property of lake water, but is often an indicator of a lake's overall water quality. It is affected by a lake's water color, which is a reflection of the amount of total suspended solids and dissolved organic chemicals. Thus, transparency is a measure of particle concentration and is measured with a Secchi disk. Generally, the lower the clarity or Secchi depth, the poorer the water quality. A decrease in Secchi depth during the summer occurs as the result of an increase in suspended solids (algae or sediment) in the water column. Aquatic plants play an important role in the level of water clarity and can, in turn, be negatively affected by low clarity levels. Plants increase clarity by competing with algae for

resources and by stabilizing sediments to prevent sediment resuspension. A lake with a healthy plant community will almost always have higher water clarity than a lake without plants. Additionally, if the plants in a lake are removed (through herbicide treatment or the stocking of grass carp), the lake will probably become dominated by algae and Secchi depth will decrease. This makes it very difficult for plants to become re-established due to the lack of available sunlight and the lake will, most likely, remain turbid. Turbidity will be accelerated if the lake is very shallow and/or common carp are present. Shallow lakes are more susceptible to sediment resuspension through wind/wave action and are more likely to experience clarity problems if plants are not present to stabilize bottom sediment.

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

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

Alkalinity, Conductivity, Chloride, pH:

Alkalinity:

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

Conductivity and Chloride:

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

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 Nuisance Algae Management

Option 1: Algaecides

Algaecides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ($CuSO_4$) and chelated copper products are the two main algaecides in use. There is also a non-copper based algaecide on the market called GreenClean™ from BIOsafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, all forms act as contact killers. This means that the product has to come into contact with the algae to be effective. Algaecides come in two forms: granular and liquid. Granular algaecides are mainly used on filamentous algae where they are spread over their mats. Liquid algaecides are mixed with a known amount of water to achieve a known concentration and sprayed onto/into the water. Liquid forms are used on both filamentous and planktonic algae. When applying an algaecide it is important that the label is completely read and followed. If too much of the lake is treated, an oxygen crash caused by the decomposition of treated algae may cause fish kills. Additionally, treatments should never be applied when blooms/mats are at their fullest extent. It is best to divide the lake into at least two sections depending on the size of the lake, (larger lakes will need to be divided into more sections), and then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algaecides should never be done in extremely hot weather (>90°F) or when dissolved oxygen concentrations are low. It is best to treat in spring or when the blooms/mats start to appear.

A properly implemented plan can often provide season long control with minimal applications. The fishery and waterfowl populations of the lake would also benefit due to a decrease in nuisance algal blooms, which would increase water clarity. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would improve spawning habitat and food source availability for fish. Waterfowl population would also benefit from increases in quality food sources. By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae.

The most obvious drawback of using algaecides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. As the algae are continuously exposed to copper, some species are becoming more and more tolerant. This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are showing up. These species can often be more difficult to control due to an inherent resistance to copper products. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

Option 2: Alum Treatment

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom making it unavailable, thus reducing algal growth. This flocculent layer can then prevent sediment bound phosphorus from entering the water column. Alum treatments typically last 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ratio (thermally stratified lakes) will see more longevity from an alum application due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited.

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lakes ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food/habitat sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations.

There are also several drawbacks to alum. In order for alum to provide long-term effectiveness, external nutrient inputs must also be reduced or eliminated. With larger watersheds this could prove to be physically and financially difficult. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied, toxicity problems may occur. Due to these concerns, it is recommended that a lake management professional plans and administers the alum treatment.

Option 3: Revegetation With Native Aquatic Plants

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a sparse to non-existent plant population. This is due to reduction in light penetration by excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Planting depth light levels must be greater than 1-5% of the surface light levels for plant growth. If aquatic herbicides are being used to control existing vegetation, their use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake should be allowed to naturally expand into adjacent areas filling the niche left by the nuisance algae. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with each other to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire should be erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. A list can be obtained from the Lake Management Unit that lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants (pondweeds, *Vallisneria*, etc).

By revegetating opened areas, the lake will benefit in several ways. Once established, native plant populations will help to control growth of nuisance algae by shading and competition for resources. This provides a more natural approach as compared to other management options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also improve due to the improvement in water quality and the suppression of weedy species.

One drawback is the possibility of new vegetation expanding to nuisance levels and needing control. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

D3. Options for Reducing Bacteria Inputs to a Lake

Option 1: Algicides

Algicides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ($CuSO_4$) and chelated copper products are the two main algicides in use. There is also a non-copper based algaecide on the market called GreenClean™ from BIOsafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, they all act as contact killers. This means that the product has to come into contact with the algae to be affective. Algicides come in two forms, granular and liquid. Granular algicides are mainly used on filamentous algae where they are spread over the mats. Liquid algicides are mixed with a known amount of water to achieve a known concentration and sprayed onto/into the water. Liquid algicides are used on both filamentous and planktonic algae. When applying an algicide it is important that the label is completely read and followed. If too much of the lake is treated, fish kills may result from an oxygen crash caused by the decomposition of treated algae. Additionally, treatments should never be applied when blooms/mats are at their fullest extent. It is best to divide the lake into at least two sections depending on the size of the lake. Larger lakes will need to be divided into more sections. Then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algicides should never be done in extremely hot weather (>90°F) or when DO concentrations are low. It is best to treat in spring or when the blooms/mats starts to appear.

A properly implemented plan can often provide season long control with minimal applications. The fishery and waterfowl populations of the lake would also benefit due to a decrease in nuisance algal blooms, which would increase water clarity. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would improve spawning habitat and food source availability for fish. Waterfowl population would also benefit from increases in quality food sources.

By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae. The quality of fishing may recover due to improved habitat and feeding opportunities.

The most obvious drawback of using algicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. As the algae are continuously exposed to copper, some species are becoming more and more tolerant. This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are showing up. These species can often be more difficult to control due to an inherent resistance to copper products. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

Option 2: Alum Treatment

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom making it unavailable, thus reducing algal growth. This flocculent layer can then prevent sediment bound phosphorus from entering the water column. Alum treatments typically last 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ratio (thermally stratified lakes) will see more longevity from an alum application due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited.

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lakes ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food/habitat sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations.

There are several drawbacks to alum. External nutrient inputs must also be reduced or eliminated for alum to provide long-term effectiveness. With larger watersheds this could prove to be physically and financially difficult. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied, toxicity problems may occur. Due to these concerns, it is recommended that a lake management professional plans and administers the alum treatment.

Option 3: Revegetation With Native Aquatic Plants

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a sparse to no plant population. This is due to reduction in light penetration by excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Planting depth light levels must be greater than 1-5% of the surface light levels for plant growth. If aquatic herbicides are being used to control existing vegetation, their use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the

lake should be allowed to naturally expand into adjacent areas filling the niche left by the nuisance algae. Another technique utilizing existing plants is to transplant vegetation from one area to another. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with each other to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire should be erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. Appendix G lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants (pondweeds, *Vallisneria*, etc).

By revegetating opened areas, the lake will benefit in several ways. Once established, native plant populations will help to control growth of nuisance algae by shading and competition for resources. This provides a more natural approach as compared to other management options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also improve due to the improvement in water quality and the suppression of weedy species.

One drawback is the possibility of new vegetation expanding to nuisance levels and needing control. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

D4. Options for Watershed Nutrient Reduction

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

Option 1. Buffer Strips

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

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

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

Option 3. Street Sweeping

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

Option 4: Reduce Stormwater Volume from Impervious Surfaces

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

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

Option 5: Required Practices for Construction

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

Option 6. Organize a Local Watershed Organization

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

Option 8. Discourage Waterfowl from Congregating

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

D5. Options for Watershed Sediment Reduction

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

Option 1. Municipal Street Sweeping

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

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

Please refer to the Watershed Development Ordinance for requirements.

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

Option 3. Agricultural Practices

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

D6. Participate in the Volunteer Lake Monitoring Program

In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection Agency (Illinois EPA) to gather fundamental information on Illinois' inland lakes, and to provide an educational program for citizens. Approximately 165 lakes (of 3,041 lakes in Illinois) are sampled annually by approximately 300 volunteers. The volunteers are lakeshore residents, lake owners/managers, members of environmental groups, public water supply personnel, and/or citizens with interest in a particular lake.

The VLMP relies on volunteers to gather a variety of information on their chosen lake. The primary measurement is Secchi disk depth. Analysis of the Secchi disk measurement provides an indication of the general water quality condition of the lake, as well as the amount of usable habitat available for fish and other aquatic life.

Microscopic plants and animals, water color, and suspended sediments are factors that interfere with light penetration through the water column and lessen the Secchi disk depth. As a rule, one

to three times the Secchi depth is considered the lighted zone of the lake. In this region of the lake there is enough light to allow plants to grow and produce oxygen. Water below the lighted zone can be expected to have little or no dissolved oxygen. Other observations such as water color, suspended algae and sediment, aquatic plants, and odor are also recorded. The sampling season is May through October with volunteer measurements taken twice a month. After volunteers have completed one year of the basic monitoring program, they are qualified to participate in the Expanded Monitoring Program. In the expanded program, volunteers are trained to collect water samples that are shipped to the Illinois EPA laboratory for analysis of total and volatile suspended solids, total phosphorus, nitrate-nitrite nitrogen and ammonia nitrogen. Other parameters that are part of the expanded program include dissolved oxygen, temperature, and zebra mussel monitoring. Additionally, chlorophyll *a* monitoring has been added to the regiment for selected lakes.

For information, please contact:

VLMP Regional Coordinator:
Holly Hudson
Northeastern Illinois Planning Commission
233 S. Wacker Drive, Suite 880
Chicago, IL 60606
(312) 386-8700

D7. 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.

D8. Option to Assess Your Lake's Fishery

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

A simple, inexpensive way to collect information on the status of a fishery is to sample anglers actively involved in recreational fishing on the lake and evaluate the types, numbers and sizes of fish caught. Such information provides insight on the status of fish populations in the lake, as well as a direct measure of the quality of fishing and the fishing experience. However, the numbers and types of fish sampled by anglers are limited, focusing on game and catchable-sized fish. Thus, in order to obtain a comprehensive assessment of the fish community, including non-

game fish species, more quantitative methods such as gill netting, trap netting, seining, trawling, angling (hook and line fishing) and electroshocking must be employed. Each method has its advantages and limitations, and frequently multiple gears are employed. The best gear and sampling methods depend on the target species and life stage, the types of information desired, and the environment to be sampled.

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

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

D9. Option for Lakes with a High Carp Population

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants, making it biodegradable. It kills fish by chemically inhibiting the use of oxygen in biochemical pathways, therefore adult fish are much more susceptible than fish eggs. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal.

Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and Green Sunfish, are high enough to kill more desirable species such as bass, Bluegill, crappie, Walleye, and Northern Pike. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are $<50^{o}$F. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois, as it is a restricted use pesticide.

Rotenone is one of the only ways to effectively remove undesirable fish species, however it can be expensive. It allows for rehabilitation of the lake's fishery, which will allow for improvement of the aquatic plant community, and overall water quality. There are some negative impacts that may also occur with the use of rotenone. In the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. The IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species.

As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and Green Sunfish), 2.022 gal/AF is required. In waters with high turbidity and/or planktonic algal blooms, the ppm may have to be higher. An IDNR fisheries biologist will be able to determine if higher concentrations will be needed.

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

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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 OPPORTUNITES.

Table F1. A list of potential grant opportunities

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

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

Table F2. Grant Contacts

Chicago Wilderness (CW)
Elizabeth McCance, Director of Conservation Programs
Phone: (312) 580-2138
E-mail: emccance@chicagowilderness.org
http://www.chicagowilderness.org/

Illinois Clean Energy Community Foundation (ICECF)
2 N. LaSalle Street
Suite 950
Chicago, IL 60602
Phone: (312) 372-5191
Fax: (312) 372-5190
http://www.illinoiscleanenergy.org/

Illinois Department of Natural Resources (IDNR)
One Natural Resources Way
Springfield, IL 62702-1271
Phone: (217) 782-9740
http://dnr.state.il.us/orep/C2000

Illinois Emergency Management Agency (IEMA)
110 East Adams Street
Springfield, Illinois 62701
Phone: (217) 785-0229
http://www.state.il.us/iema/index.htm

Illinois Environmental Protection Agency (IEPA)
Bureau of Water - Surface Water Section
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
Telephone: (217) 782-3362
Fax: (217) 785-1225
http://www.epa.state.il.us/water/financial-assistance/non-point.html

Lake County Planning, Building, and Development Department (LCPBD)
18 N. County Street
Waukegan, IL 60085

Phone: (847) 377-2875
Fax: (847) 782-3016

Lake County Soil and Water Conservation District (LCSWCD)
100 N. Atkinson Road
Suite 102A
Grayslake, IL 60030
Phone: (847)-223-1056
Fax: (847)-223-1127
http://www.lakeswcd.org/

Lake County Stormwater Management Commission (LCSMC)
333-B Peterson Road
Libertyville, IL 60048
Phone: (847) 918-5260
Fax: (847) 918-9826
http://www.co.lake.il.us/smc

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

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

United States Army Corps of Engineers (USACE)
111 N. Canal Street
Chicago, Illinois 60606-7206
Telephone: (312)-846-5333
Fax: (312)-353-2169

http://www.lrc.usace.army.mil/

United States Fish and Wildlife Service (USFWS)
Chicago Field Office
1250 South Grove Avenue, Suite 103
Barrington, IL 60010
Phone: (847)-381-2253
Fax: (847)-381-2285

Other Related Contacts

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

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

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

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

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