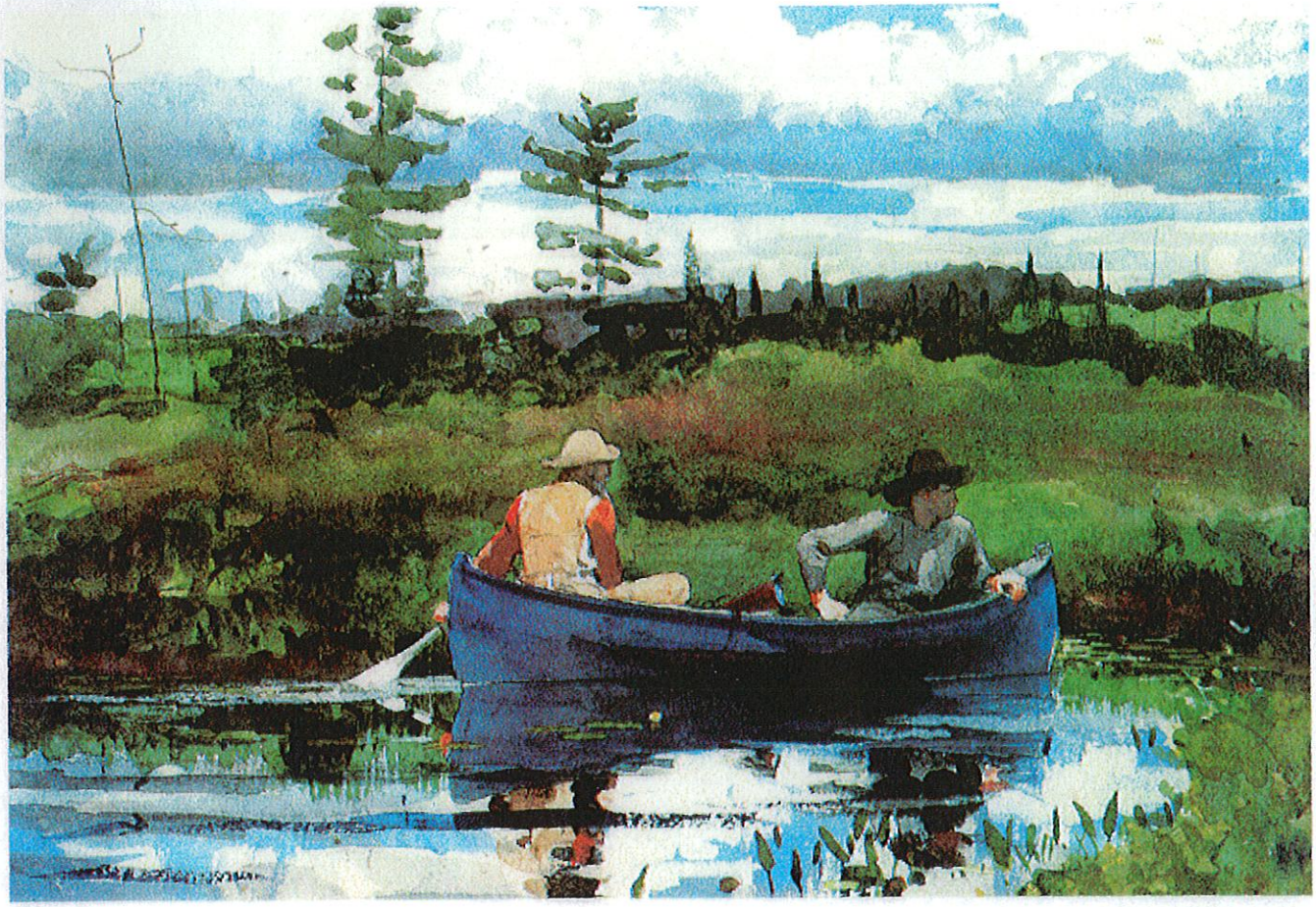

Winslow Homer: *The Blue Boat*, 1892

Lake Management Plan for Little Elk Lake Sherburne County, Minnesota

February 2002

Prepared for
Little Elk Lake Association

Prepared by
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Little Elk Lake
Sherburne County, Minnesota

LAKE REPORT **2001**

Little Elk Lake Improvement Program Formulated

Little Elk Experiences Annual Summer Blooms

LARGE WATERSHED CAUSE OF PROBLEM

Little Elk Lake is eutrophic, meaning it has elevated phosphorus levels resulting in algae blooms and diminished clarity. However, Little Elk Lake has had that condition going back to the first clarity records of 1982. It appears that wind mixing may produce sediment resuspension and further reduce clarity on some days in the summer.

The present watershed is in relatively good shape from the perspective that there is a high percentage of wetland, forest, and grassland acreage. This type of land use generally is good for a lake since low amounts of phosphorus are expected to runoff the land, and into streams that flow into lakes. However because of the relatively large watershed, there is apparently enough phosphorus getting to Little Elk Lake to cause substantial algae growth.

Improvement projects have been developed to address both watershed and lake areas. It appears that reestablishing native aquatic plants will be the key to better water clarity.

Little Elk Lake is a 360 acre lake located in Sherburne County, Minnesota.

Lake Statistics

Major tributary:	Battle Brook
Lake surface area:	360 acres
Maximum depth:	12 feet
Mean depth:	7 feet
Lake volume:	2,520 acre-feet
Retention time:	0.2 - 0.8 years
Watershed size:	20,599 acres

ABOUT THIS REPORT

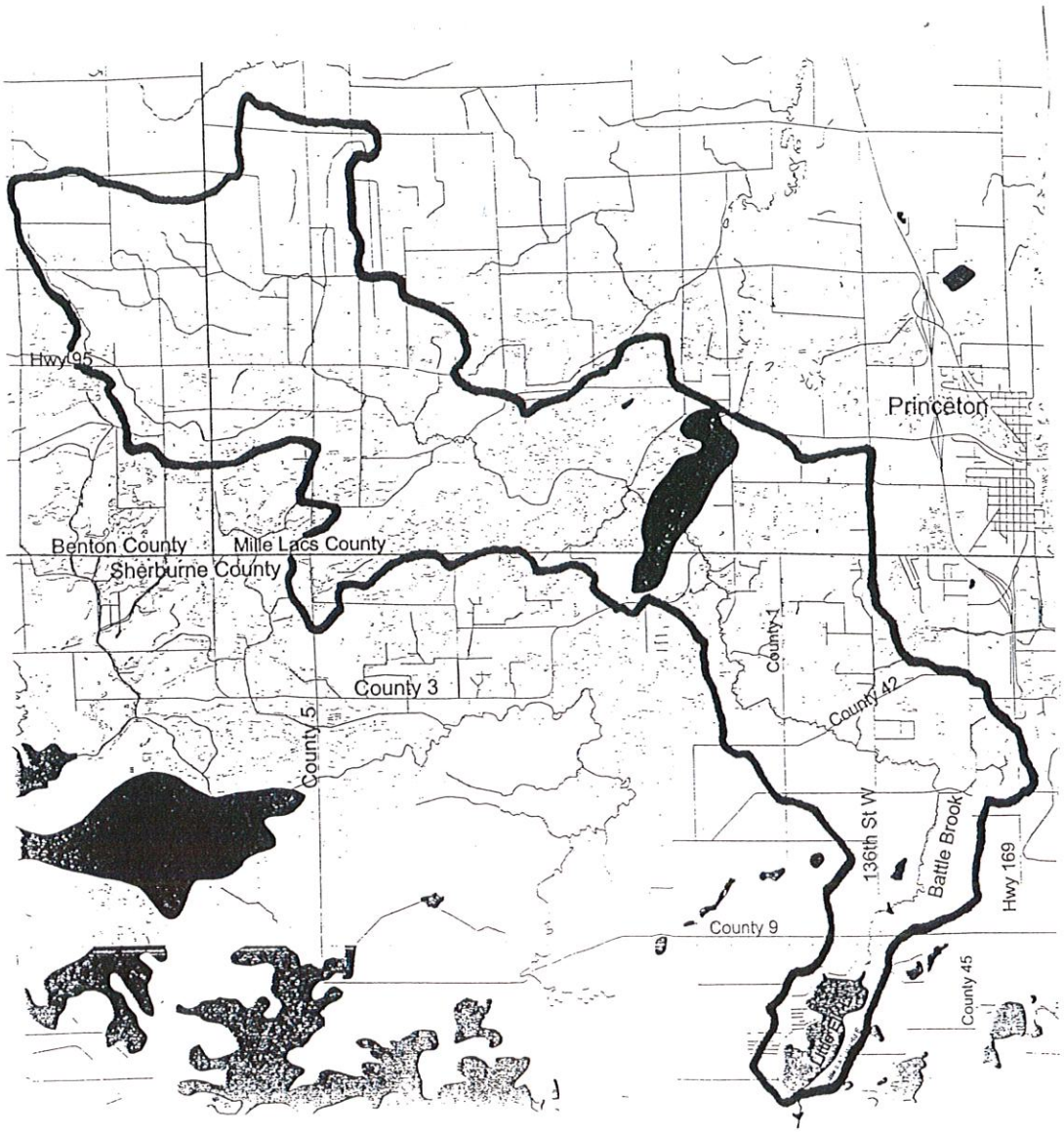
The Little Elk Lake management plan was a collaborative effort among the Lake Association, the Board of Water and Soil Resources, and the Sherburne County Soil and Water Conservation District.

Funds were raised by the Little Elk Lake Improvement Association and a grant from BWSR helped fund the study. The lake report was prepared by Steve McComas of Blue Water Science.

Little Elk Watershed Influences Lake Water Quality

Watershed Status: The entire watershed area, as described by the Sherburne Soil and Water Conservation District is 20,599 acres. An outline of the watershed is shown to the right. More than one half of the watershed drains to Rice Lake. The outlet from Rice Lake is Battle Brook. Battle Brook is the main tributary to Little Elk Lake.

Battle Brook was sampled on six occasions in 2000. The average phosphorus concentration for the sampling season was low at 65 parts per billion (ppb). A typical seasonal average for a stream in this part of the state is around 150 ppb (referred to as the ecoregion value). It appears water quality in Battle Brook is fairly good.



The Little Elk Lake watershed is outlined above. The land area that drains to Little Elk Lake is dominated by cultivated acreage (over 40%) followed by wetlands (20% or more). Nearly 50% of the watershed is composed of forests, wetlands, and grasslands. The whole watershed is 20,599 acres in size. The watershed area south of Rice Lake is 7,900 acres.

What is a watershed?

A watershed is the land area around the lake that captures rainfall and where all the drainage and runoff goes into the lake. It is also called a drainage basin. If the watershed has pollution sources, then the pollution will be carried into the lake with runoff. It is important to reduce the source of pollution in the watershed because this in turn will reduce the amount of pollution that gets into the lake.

Lake Water Quality Is Somewhat Stable But in Poor Condition

A somewhat surprising finding of this study was that it appears Little Elk Lake exhibits lake phosphorus concentrations that are close to what would be expected for a lake with a large watershed in this part of the state.

Little Elk Lake is in the North Central Hardwood Forest Ecoregion. Glacial lakes are typical in this ecoregion and often their watersheds are about 10 times bigger than the lake surface. However, Little Elk Lake is not a typical glacial lake of the North Central Hardwood Forest Ecoregion. It has a watershed to lake surface ratio of 57 when using the full watershed and a watershed to lake surface ratio of 22 when using the watershed area south of Rice Lake. So although the water quality in Battle Brook is good for this ecoregion, because of the larger than average watershed, the phosphorus loading to Little Elk Lake is sufficient to create nuisance algae blooms. The result is the water quality of Little Elk lake is not as good compared to other lakes in the region with smaller watersheds.

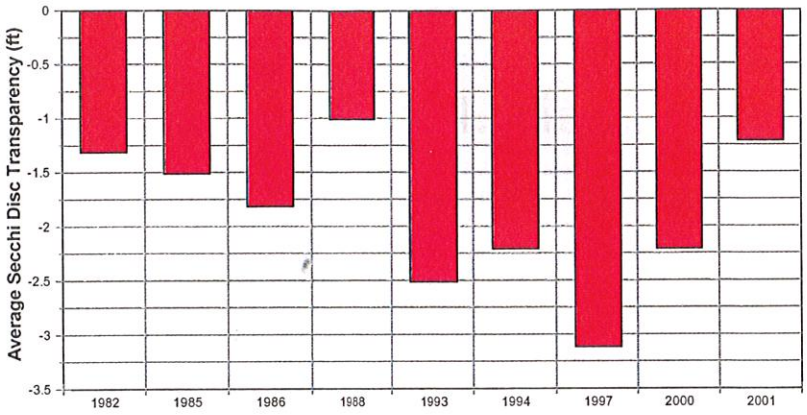
What Goes Into Water Quality

One of the most popular parameters for gaging water quality is the water clarity measurement which commonly is taken using a Secchi disc.

A Secchi disc is a black and white disc lowered into the lake until it disappears from sight. The depth from the water surface where it is just barely visible is recorded. This is the Secchi disc transparency and is a measure of water clarity or turbidity depending on you perspective.

Other parameters are evaluated as well and included phosphorus concentrations, suspended sediment concentrations, algae and fecal coliform levels.

Little Elk Lake Water Clarity
Growing Season Secchi Disc Averages



Seasonal water clarity results have varied over the years from a low of 1.5 feet in 2001 to a high of 3.1 feet in 1997. Aquatic plants are good and necessary for lakes and help keep the water clear. An ongoing challenge for Little Elk Lake is to find a balance between plants and algae so that neither is an extreme nuisance.

Battle Brook flows under County Highway 9 and into Little Elk Lake.

Projects and Programs Designed to Protect Little Elk Lake

Following an intensive study of Little Elk Lake and its watershed, a program was formulated to address water quality issues.

The program was jointly funded by BWSR and the Lake Association. An outline of the improvement program is shown below.

Several of the project areas build on programs already initiated. The overall goals are to reduce lake turbidity associated with algae blooms and resuspended lake sediments and to address nuisance aquatic plant growth. These goals were formulated in part from responses from a lake survey conducted in 2000.

Proposed lake improvement projects for Little Elk Lake

Recommended Projects	Comments	Project Costs $
1. Watershed Projects		
Watershed stewardship	Work with Sherburne Soil Water Conservation District. Use State and Federal cost-share money where possible	5,000+
2. Shoreland Projects		
Shoreland inventory, Buffer strips, and erosion control	Catalog shorelands to set a benchmark and determine if areas can be enhanced -- design buffer strips where needed. Check out availability of MnDNR grants or assistance from the University of Minnesota-Extension	4,000
Custom fertilizer use	Lower fertilizer use saves money and helps the lake. Sampling results will indicate if fertilizer is required.	600
3. Algae Control Projects		
Copper sulfate for odor control	For nuisance odor conditions, copper sulfate may offer a short-term solution.	1,500+
Whole lake alum treatment	Conduct feasibility study first, then implement if appropriate in the future. If other nutrient reductions projects are successful alum may not be needed.	175,000
4. Aquatic Plant Projects		
Lake soil testing	Soil fertility may delineate areas that could support nuisance EWM growth.	2,500+
Nuisance curlyleaf control using cutters	Cut nuisance curlyleaf areas using a volunteer work force.	6,000+
Drawdown for nuisance plant control	Evaluate potential for drawdown and set-up a long term drawdown management plan. This is a last resort plan. It is only considered if other projects are not working.	30,000+
5. Fish Projects		
Carp reduction program	Use commercial fishermen to reduce carp population.	5,000+
Winter aeration	Conduct feasibility study, objective is to maintain fish population over winter.	20,000
6. Lake Monitoring Program		
Continue lake monitoring	Lake monitoring effort is based on budget.	100+
Continue to evaluate Battle Brook	Continue to monitor Battle Brook inflows. Check upstream areas as well.	400+

Lake Management Plan for Little Elk Lake
Sherburne County, Minnesota

Table of Contents

— ACKNOWLEDGMENTS —

The Little Elk Lake Improvement Association spearheaded the effort to produce this report. Laurie Knudson, Dean McDevitt, and others were instrumental. Mark Basiletti and Gina Hugo, Sherburne SWCD produced watershed and land use maps. Data collected by St. Cloud State University was helpful in establishing trends.

Field work, lab analysis, and report preparation was funded by the LELIA and a grant from the Board of Water and Soil Resources.

1. Introduction and Project Setting

Little Elk, located in Sherburne County, is a natural lake with a fixed crest outlet (meaning it has a dam). A summary of lake characteristics is shown in Table 1. Currently, Little Elk Lake has nuisance summertime algae blooms and has an exotic aquatic plant called curlyleaf pondweed.

The purpose of this lake report was to evaluate existing lake and watershed conditions and then to formulate a series of projects to improve overall lake conditions.

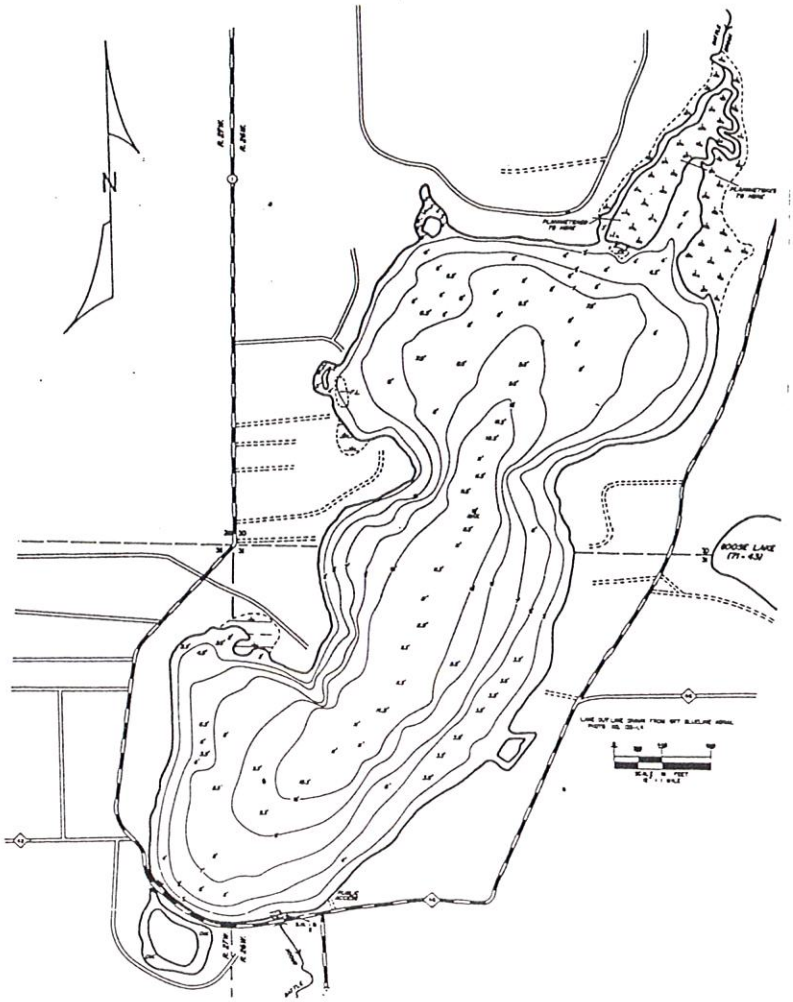


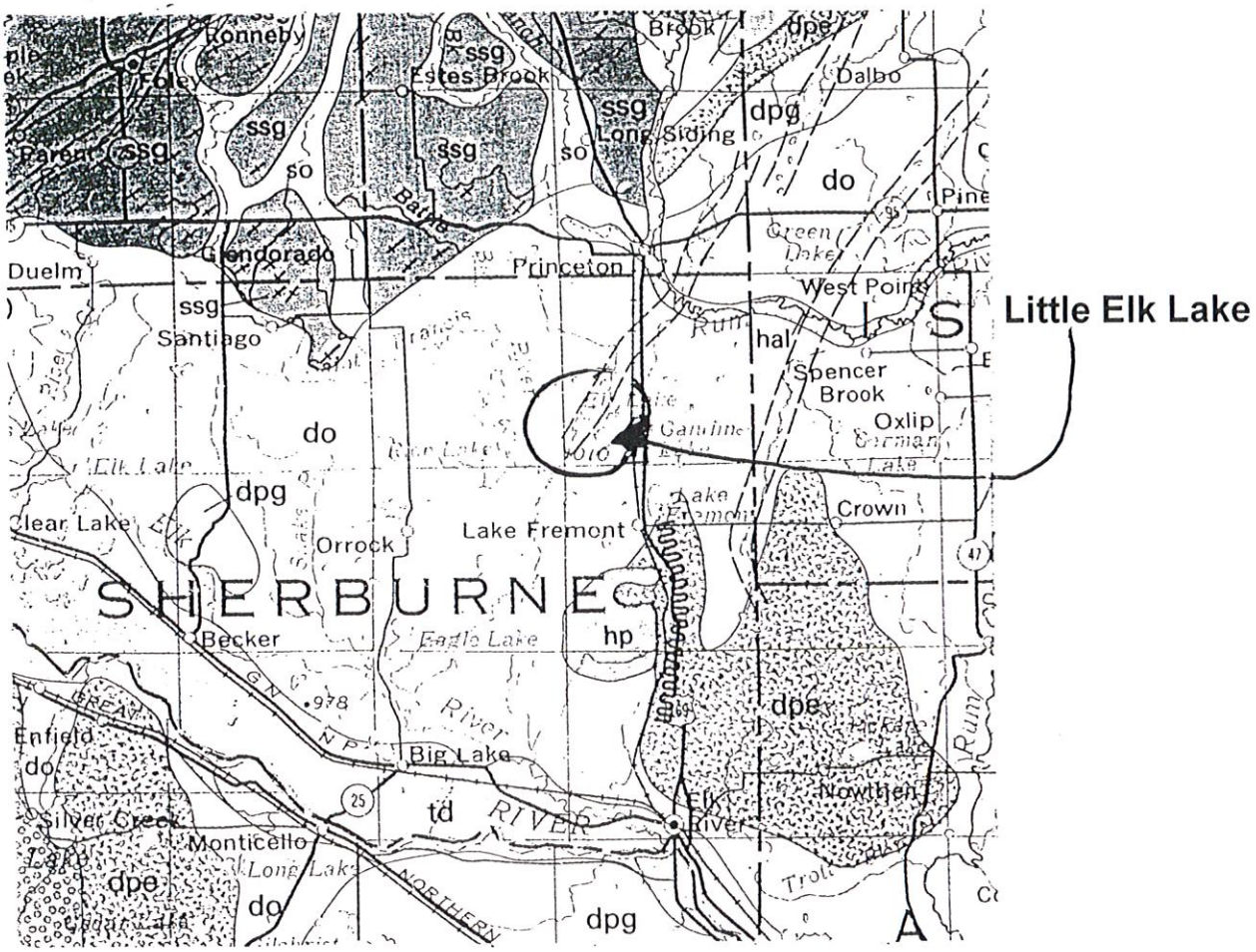
Table 1. Vital statistics.

Little Elk Lake DNR ID#:	71-55
Size (acres)	360
Mean depth (feet)	7
Maximum depth (feet)	12
Total watershed size (acres)	20,599

2. Historical Highlights

2.1. Glaciers and soils

The shallow basin of Little Elk Lake was formed by glacial action of the Des Moines lobe, around 9,000 years ago. Little Elk Lake sits in a glacial outwash plan.



DEPOSITS ASSOCIATED WITH THE DES MOINES LOBE (PLEISTOCENE, LATE WISCONSINAN)—*gray calcareous drift (buff to brown where oxidized); shale and limestone clasts generally common, derived from Manitoba and eastern North Dakota; combined silt and clay typically exceeds 50% of till.*

BEMIS MORAINE ASSOCIATION—*forms the outermost moraine association for the southern part of the Des Moines lobe.*

do OUTWASH—*undivided as to moraine association.*

Figure 1. Glacial features in the Little Elk Lake setting.

2.2. Lake history

Little Elk Lake has retained its basic shoreline configuation for a long time. A lake map from 1946 shows a maximum depth of 15 feet and a size of 336 acres (Figure 2). A lake map from 1988, shows a maximum depth of 12 feet and lists a size of 360 acres based on a 1977 aerial photo (Figure 1). Some sedimentation in the deep hole may have occurred over the last 60 years.

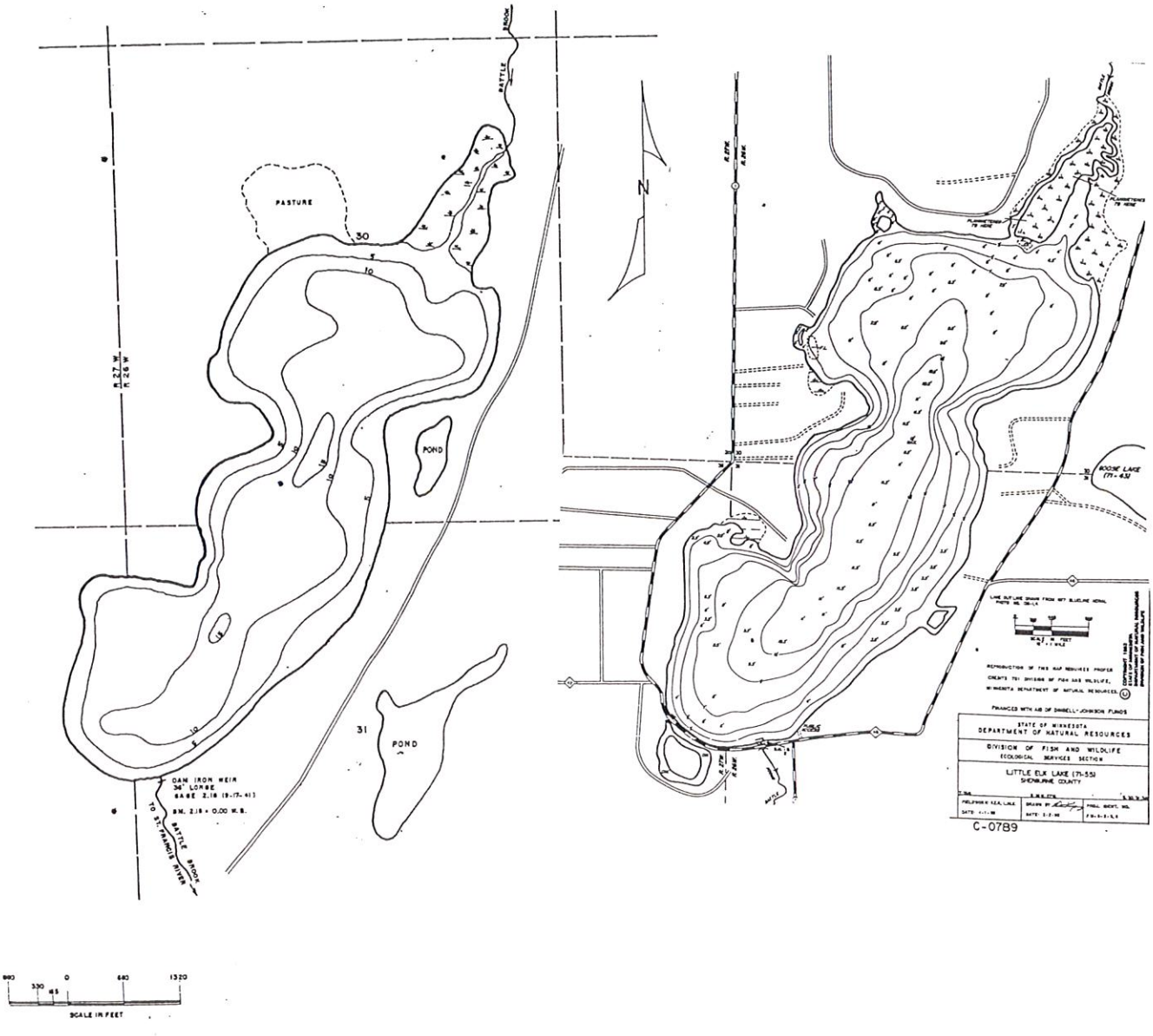


Figure 2. Little Elk Lake map from 1946 (left) and 1988 (right).

3. Watershed Features

3.1. Drainage area and source of water to Little Elk Lake

The drainage area represents the land area that sheds water into Little Elk Lake. The entire watershed area, as described by the Sherburne Soil and Water Conservation District is 20,599 acres. An outline of the watershed is shown in Figure 3. More than one half of the watershed drains to Rice Lake. The outlet from Rice Lake is Battle Brook. Battle Brook is the main tributary to Little Elk Lake.

Typical wetland watershed setting. Battle Brook flows through this wetland system on the way to Little Elk Lake.

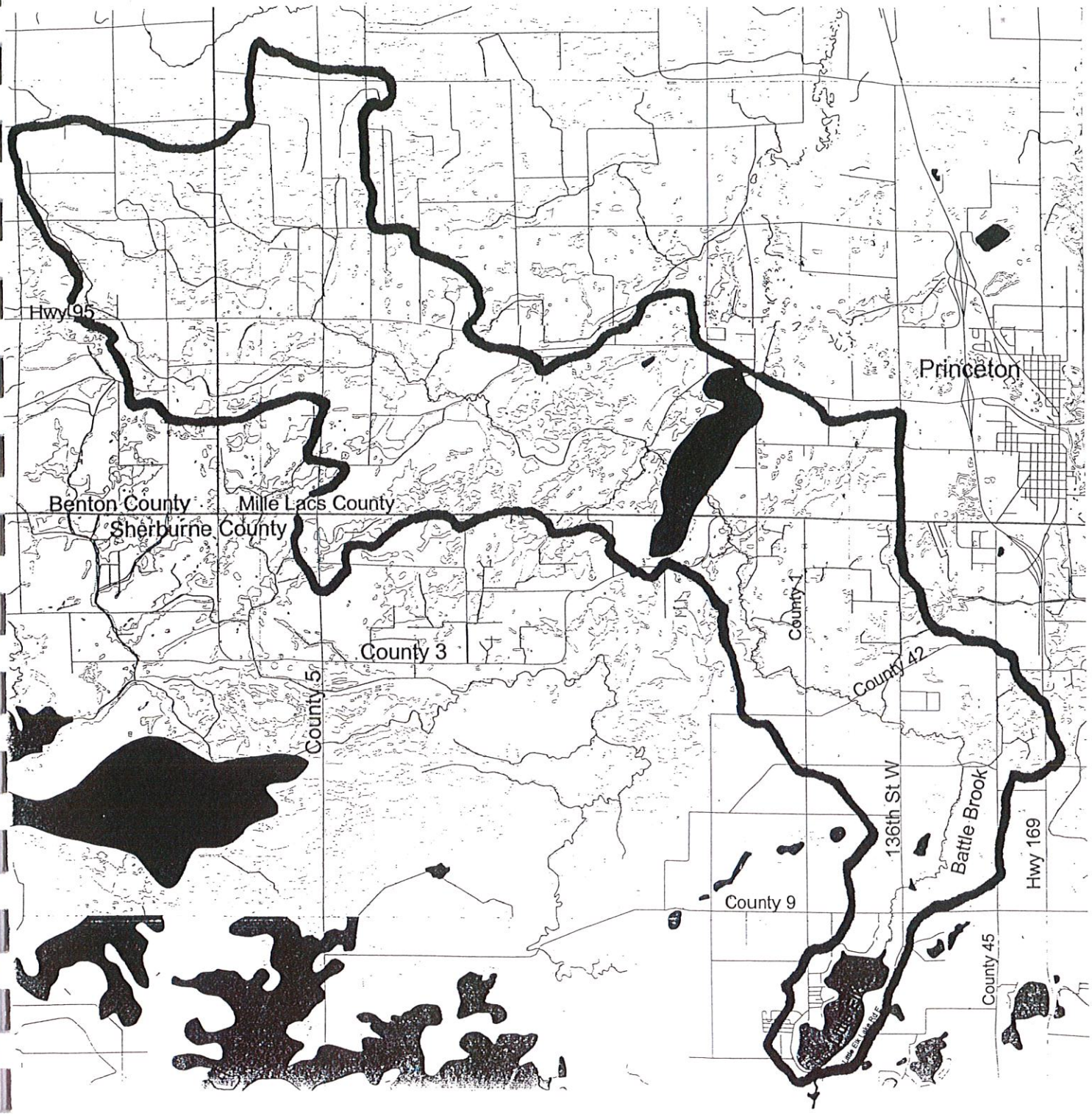


Figure 3. The drainage area to Little Elk Lake.

3.2. Land Use

The land area that drains to Little Elk Lake is dominated by cultivated acreage (over 40%) followed by wetlands (20% or more). A breakdown of land use is shown in Table 2. Nearly 50% of the watershed is composed of forests, wetlands, and grasslands.

The distribution of land use in the watershed is shown in Figure 4. An explanation to the various land uses is shown in Table 3.

Table 2. Land use and watershed size for Little Elk watershed. Acreage and percent calculated using ArcView GIS 3.2, prepared by Sherburne SWCD.

	Entire Watershed		Effective Watershed (area downstream from Rice Lake)		Upper Watershed	
	acres	%	acres	%	acres	%
Total	20,599	100%	7,899	100%	12,700	100%
Cultivated	8,446	41%	2,689	34%	5,757	45%
High Density Residential	217	1%	217	3%	0	0
Low Density Residential	1,347	6%	1,142	15%	205	2%
Forest & Forested Riparian Buffers	2,228	11%	1,122	14%	1,106	9%
Lakes, Water & Wetlands	5,710	28%	1,594	20%	4,116	32%
Grass & Pasture	2,651	13%	1,135	14%	1,516	12%

Although there are some feedlots within the watershed, they are not very large from the perspective of the number of animals and they do not appear to be major nutrient contributors to Battle Brook. A list of feedlots found in the watershed is shown in Table 4.

Table 3. Little Elk Lake watershed land use map.

The Little Elk Lake Land Use map was digitized in September and October of 2001, with ArcView 3.2 GIS. Land use types were digitized on 1991 geo-rectified digital ortho quads (DOQ's), 1997 non-geo-rectified DOQ's were referenced to account for changes in land use between 1991 and 1997. Land platted after 1997 was digitized according to the 2000 Sherburne County Plat Book.

For the purposes of this map refer to the following definitions for each land use.

Large Animal Inventory Locations: The points within Benton County were obtained though a windshield survey (level 2), in 2000. The points within Sherburne County were obtained though a windshield survey (level 2), in 1999. No current large animal data is available for Mille Lacs County.

Cultivated: Land that appeared to have features consistent with land under cultivation, such as row crops, or center pivot irrigation. The areas shown as cultivated may or may not include field windbreaks and/or farmsteads.

High Density Residential: Residential land use with a density of one or more houses per 2 ½ acres.

Low Density Residential: Residential land use with lots sizes of 2 ½ acres or more, with one home per lot.

Forest & Forested Riparian Buffers: Land that appeared to have significant forest canopy and sub-canopy, as well as forested buffers between cultivated land and lakes, water, or wetlands.

Lakes, Water, & Wetlands: The DNR National Wetland Inventory (NWI) was used to digitize this land use type. The NWI was completed in 1991.

Grass & Pasture: Land that showed no sign of cultivation, as it is described above. This land use type may or may not include scattered trees or trees without significant canopy that are void of sub-canopy.

Effective Watershed: The watershed area downstream from the outlet of Rice Lake. This area has the greatest affect on Little Elk Lake because the majority of the flow from Rice Lake was diverted to the Rum River.

Prepared by the Sherburne Soil & Water Conservation District
October 16, 2001

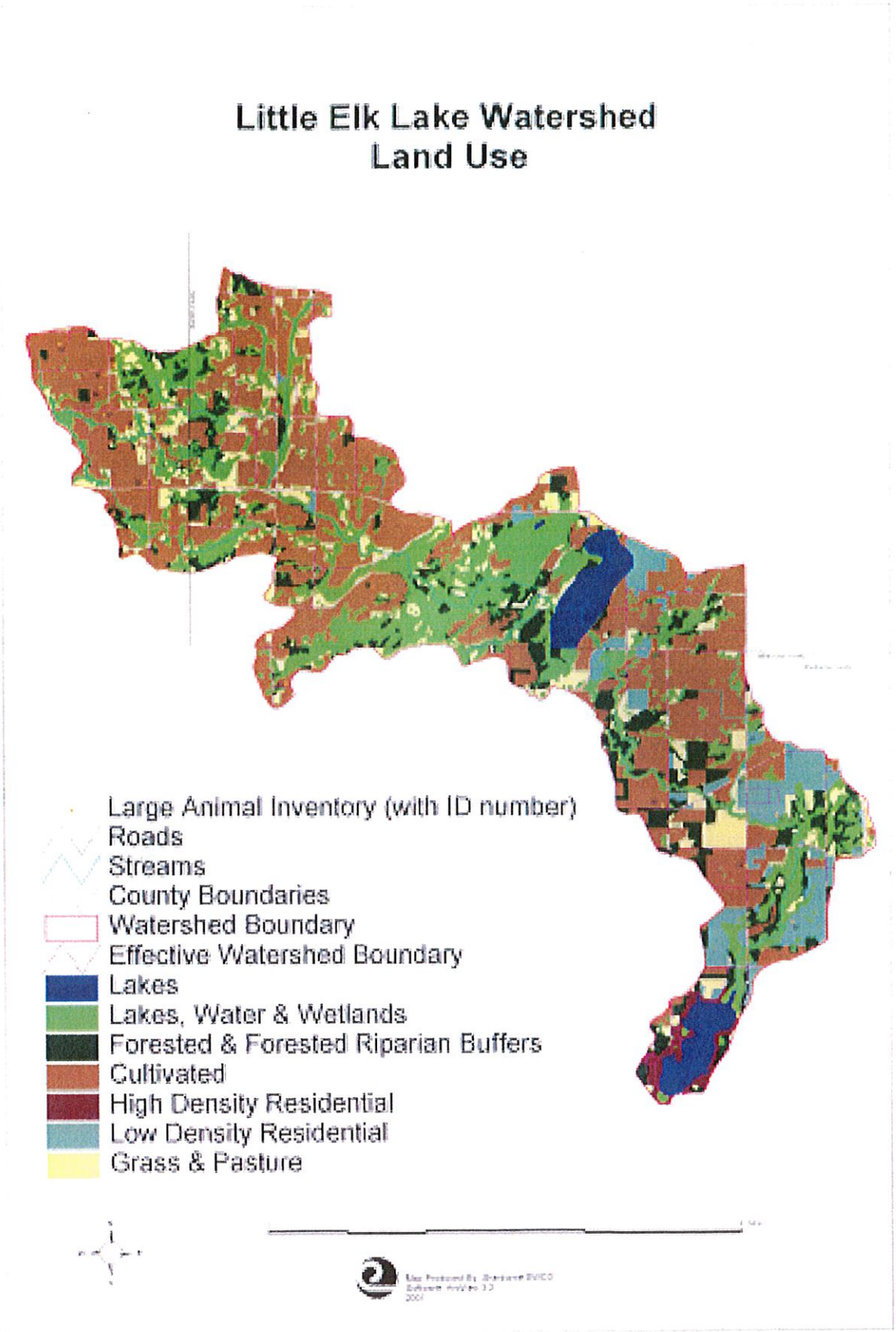


Figure 4. Land use in the Little Elk watershed (brown = cultivated land and green = ponds and wetlands).

Table 4. Livestock inventory 1999 for townships in Little Elk watershed.

ID	Township	Dist./Dir	Animal	Number	Feedlot	Fence	Wetland
105	Bluehill	30 ft E 144 St	Horse	2	No	N/A	N/A
106	Bluehill	40 ft N cty rd 3	Beef	16-20	Yes	No	None
93	Bluehill	350 ft N 313 Ave	Horse	5	No	N/A	N/A
90	Bluehill	300 ft W cty rd 1	Pheasant	31+	Yes	Yes	None
56	Baldwin	30 ft off road	Beef	1	Yes	Yes	None
55	Baldwin	15 ft E Hwy 1	Horse	4	No	N/A	N/A
53	Baldwin	600 ft E Co Rd 45	Beef	1	Yes	Yes	Out
50	Baldwin	S 308 Ave	Horse	2	No	N/A	N/A
51	Baldwin	Not noted	Horse	2	No	N/A	N/A
52	Baldwin	200 yds N Co Rd 42	Beef	5+	Yes	No	None
54	Baldwin	15 ft W 305 Ave	Beef	16-20	No	N/A	N/A
47	Baldwin	Not noted	Horse	4	No	N/A	N/A
48	Baldwin	30 ft S Co Rd 42	Horse	Unknown	No	N/A	N/A
49	Baldwin	500 ft SE Co 42	Beef	1	Yes	Yes	None
21	Baldwin	30 ft W. Hwy 169	Pheasant	>1000	Yes	Yes	Out

ID	Surface Waterway	Buffer Area	Stockpiling	Pollution Potential	Pasture	Fence	Wetland	Surface Waterway
105	N/A	N/A	N/A	N/A	Yes	Yes	None	None
106	None	N/A	Yes-on ground	No	Yes	Yes	None	None
93	N/A	N/A	N/A	N/A	Yes	Yes	None	None
90	None	N/A	No	No	No	N/A	N/A	N/A
56	None	N/A	No	No	No	N/A	N/A	N/a
55	N/A	N/A	N/A	N/A	Yes	Yes	None	None
53	None	N/A	Unknown	Yes	No	N/A	N/A	N/A
50	N/A	N/A	N/A	N/A	Yes	Yes	None	None
51	N/A	N/A	N/A	N/A	Yes	Yes	None	None
52	None	N/A	No	No	No	N/A	N/A	N/A
54	N/A	N/A	N/A	N/A	Yes	Yes	None	None
47	N/A	N/A	N/A	N/A	Yes	Yes	Out	Out-Ditch
48	N/A	N/A	N/A	N/A	Yes	Yes	In	In-Ditch
49	None	N/A	No	No	No	N/A	N/A	N/A
21	None	Yes >30 feet	Unknown	Unknown	No	--	--	--

ID	Buffer Area	Stockpiling	Condition	Follow-up	Other Information
105	N/A	No	Good	No	
106	N/A	No	Good	No	feedlot is within pasture w/o fence
93	N/A	No	Good	No	
90	N/A	N/A	N/A	No	Nelson Pheasant Farm Fire#S142
56	N/A	N/A	N/A	No	Stockpiling previously reported
55	N/A	No	Good	No	
53	N/A	N/A	N/A	No	
50	N/a	No	Good	No	
51	N/A	No	Good	No	
52	N/A	N/A	N/A	No	
54	N/A	No	Good	No	
47	Yes 90 feet	No	Fair	No	
48	No	No	Good	No	Ditch is in pasture
49	N/A	N/A	N/A	No	
21	--	--	--	No	Oakwood Game Farm

3.3. Battle Brook water quality status

Battle Brook is the main tributary to Little Elk Lake. It was sampled on six occasions in 2000. Results are shown in Table 5. The average phosphorus concentration for the sampling season was low at 65 parts per billion (ppb). A typical seasonal average for a stream in this part of the state is around 150 ppb. It appears water quality in Battle Brook is fairly good.

Table 5. Battle Brook phosphorus concentrations for 2000.

	Battle Brook at CO9 (ppb)	CR 42 (ppb)	Hwy 95 flowing away from the lake (ppb)
April 29	64	--	--
May 21	60	--	--
June 13	57	--	--
July 21	23	--	--
August 10	30	48	39
September 29	154	--	--
April-September Season Average	**65***	**--**	**--**

* Low concentration: Typical average is about 150 ppb.

Battle Brook is flowing under County 9 and into Little Elk Lake.

3.4. Watershed status: land use, septic systems, shorelands

Watershed land use: The majority of the watershed that contributes water to Little Elk Lake is composed of wetland, forests, or grass lands. This type of land use generally does not export large amounts of phosphorus to a stream. However, Little Elk has a large watershed. So the low amounts of phosphorus are multiplied by a large area. The end result is a phosphorus load entering Little Elk Lake that is large enough to produce nuisance algae blooms.

Septic systems: Observations of shoreland residences indicate the majority have proper septic system setbacks and most are on ground high enough to prevent flooded drainfields. From a water quality perspective, onsite septic systems do not appear to be a significant nutrient source to the lake.

Shorelands: Natural shoreland areas are present, but there could be better natural vegetative buffers along the shorelands. This would be a good project area to implement.

Open areas such as this in the Little Elk watershed generally export low amounts of phosphorus off the land.

4. Lake Features

4.1. Lake statistics

This section discusses lake features. Listed below are basic lake statistics.

Little Elk Lake statistics

Little Elk Lake MnDNR #	71-55
Size (acres)	360
Mean depth (feet)	7
Maximum depth (feet)	12
Total watershed size (acres)	20,599
Water size to lake ratio	57
Watershed size from Rice Lake outlet to Little Elk Lake	7,899
Small watershed size to lake ratio	22

Little Elk Lake is a drainage lake meaning it gets most of its water from a stream source. It is relatively shallow and has a large watershed.

4.2. Water quality analysis: dissolved oxygen levels, clarity, and nutrients

Dissolved oxygen levels in Little Elk Lake were found to be high throughout the summer from the top to the bottom of the lake (Table 7). This is not unexpected since Little Elk is shallow and wind mixing should keep the lake unstratified. However, temperature and conductivity readings, as well as oxidation/reduction measurements hint that the bottom of Little Elk Lake may have episodes of short-term stratification and possibly oxygen depletion.

Table 7. Temperature, dissolved oxygen, and other parameters collected for Little Elk Lake on August 10, 2000.

	Temperature (C)	Dissolved Oxygen (ppb)	Conductivity (umhos)	Redox (ORP) (mV)
Little Elk Lake				
North - surface	28.8	13.1	224	329
- 6 ft	24.0	4.8	239	289
South - surface	28.2	13.4	220	334
- 6 ft	23.7	3.6	245	288
Battle Brook at Cr 9	21.2	8.6	362	346

Water clarity in Little Elk Lake is poor. Over the growing season in 2000, clarity averaged 2.2 feet (Table 8) and was even less in 2001 (Table 9). A typical summer average for glacial lakes in this area is 5 to 6 feet.

Total phosphorus results averaged 70 ppb over the summer months of 2000. These are high enough to produce nuisance algae blooms. The chlorophyll results show that nuisance algae blooms were occurring over the growing season as well (Table 8).

Table 8. Little Elk Lake water quality chemistry results for 2000. The numbers in parentheses indicate a bottom phosphorus sample.

	Secchi Disc (ft)		Total Phosphorus (ppb)		Chlorophyll a (ppb)
	North	South	North	South	
April 29	--	3.7	--	40	<0.5
May 21	5.4	5.1	30	80	3
June 13	--	2.2	47	43 (47)	19
July 21	--	1.3	--	89 (121)	47
August 10	1.0	0.9	100 (133)	78 (130)	30
September 29	1.8	1.5	85	74	28
May-September Season Average	--	**2.2**	**66**	**73**	**25**

Summer water clarity averages have fluctuated between 1.2 feet to 3.1 feet since 1982 (Table 9 and Figure 6).

Table 9. Long term water quality results for Little Elk Lake (SCSU - St. Cloud State University, and BWS = Blue Water Science).

	Secchi Disc (ft)		Total Phosphorus (ppb)		Chlorophyll a (ppb)	
	Citizen monitoring	SCSU	SCSU	BWS	SCSU	BWS
1982	--	1.3	--		38	--
1985	1.5 (7)	--	--		--	--
1986	1.5 (4)	2.0	170		47	--
1988	--	1.0	160		59	--
1993	2.0 (6)	3.0	160		10	--
1994	2.2 (14)	--	--		--	--
1997	--	3.1	130		15	--
2000	2.2	--	--	70	--	25
2001	1.2 (8)	--	--	--	--	--

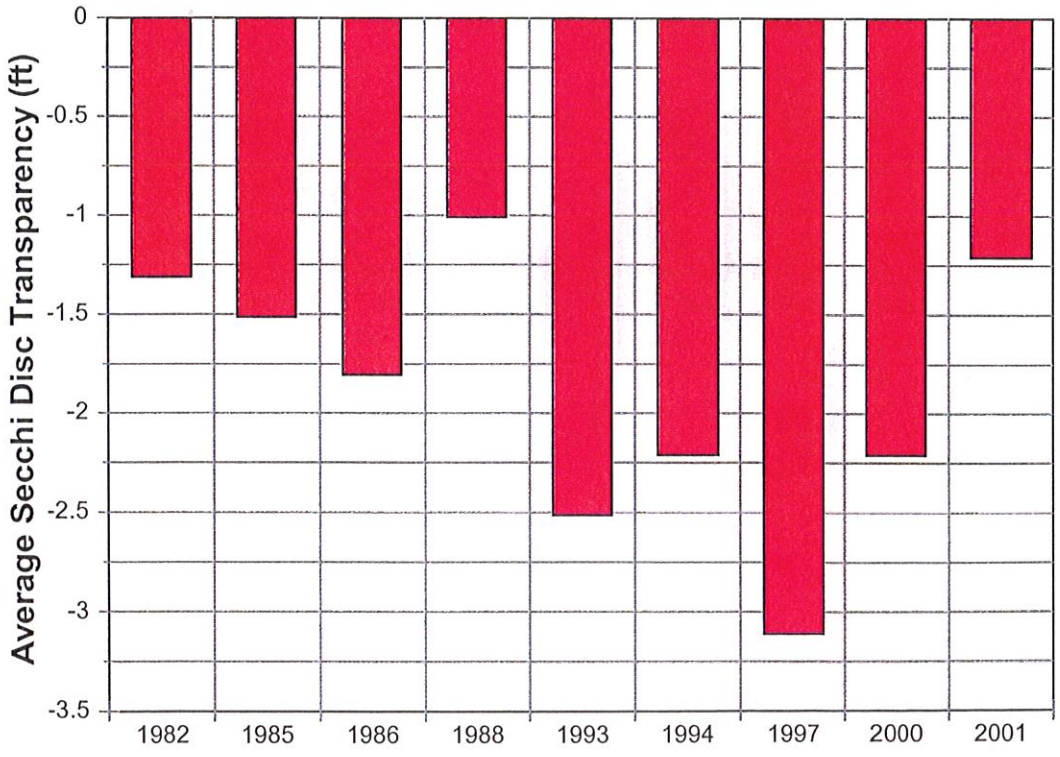


Figure 6. Long term Secchi disc records for Little Elk Lake.

Little Elk Lake phosphorus records from 1986 through 2000 are shown in Figure 7. Records from 1986-1997 were taken by St. Cloud State University and phosphorus was higher than what was found in 2000. Water clarity has also fluctuated over the years, but is not directly correlated with phosphorus. Some of the turbidity in Little Elk Lake may be from sediment resuspension.

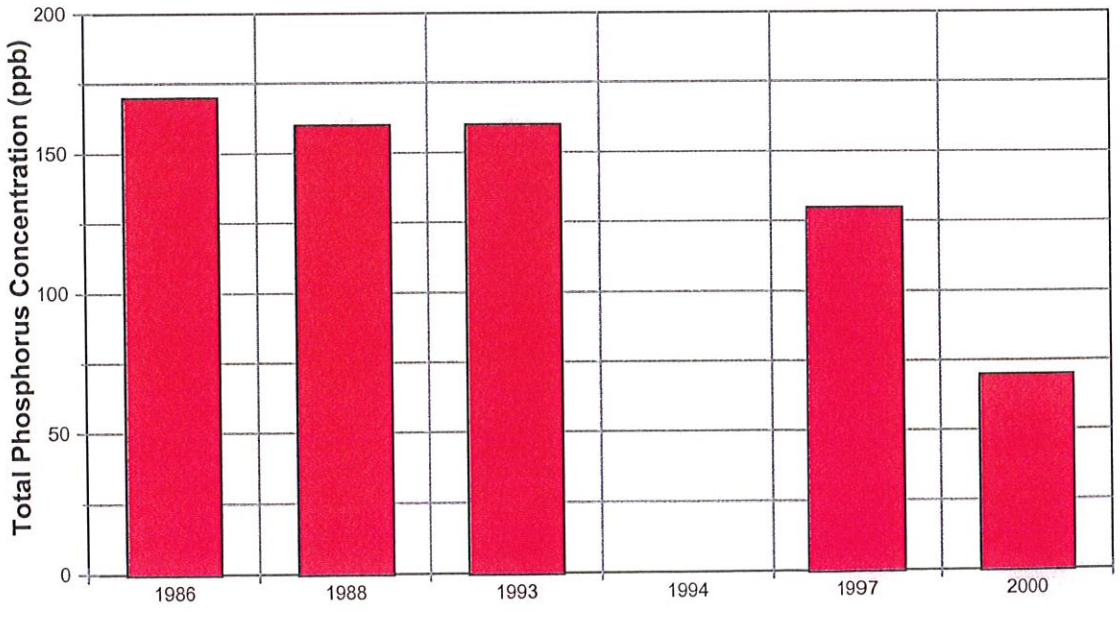


Figure 7. Long term total phosphorus concentrations in Little Elk Lake.

4.3. Algae status

Typical algae were found in Little Elk Lake in 2000. In the early summer, diatoms were dominant (Figure 8) and later in the summer, blue-green algae were dominant. This sequence is common in eutrophic lakes.

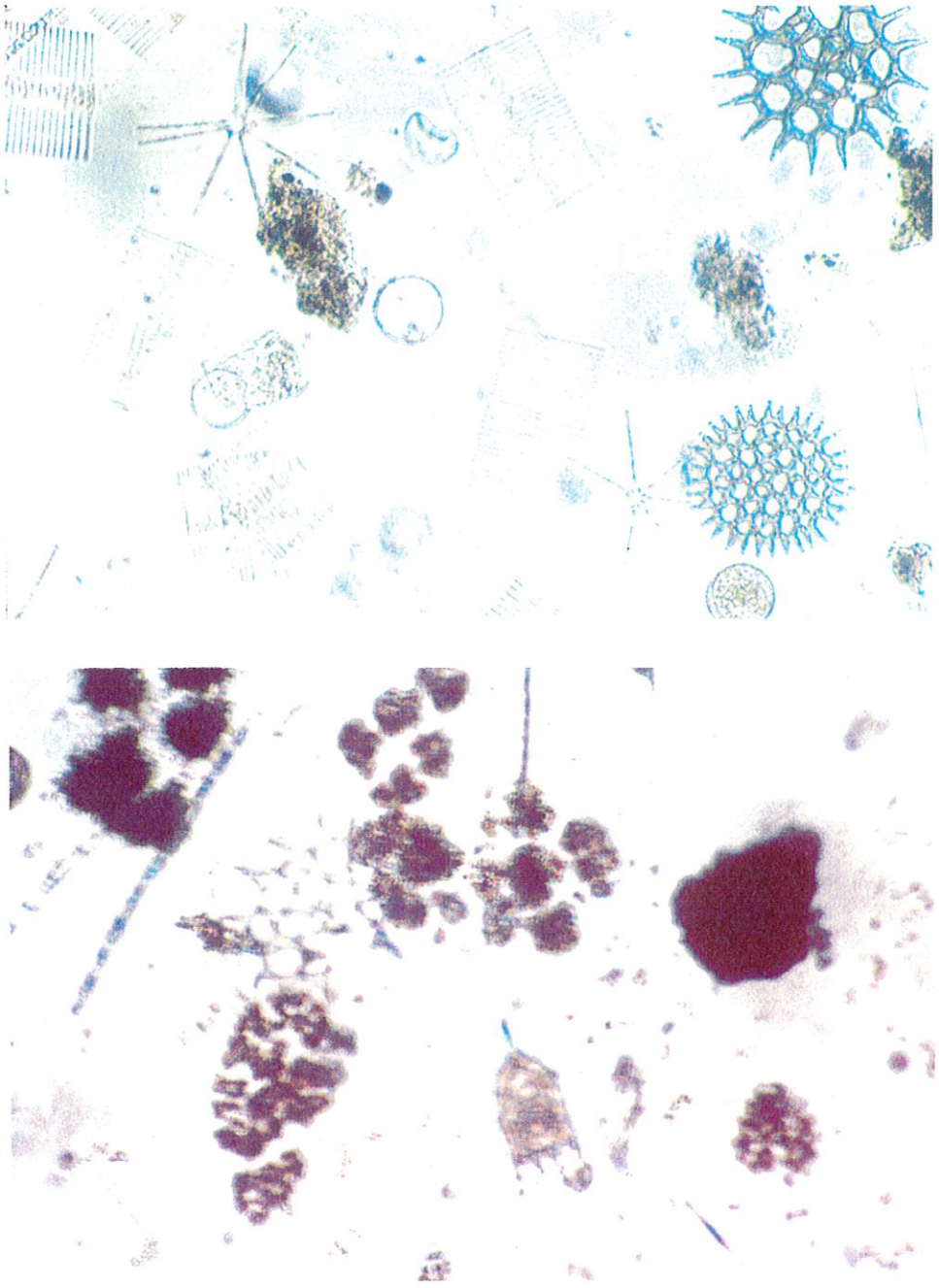


Figure 8. [top] Diatoms dominate algae on June 13, 2000.
[bottom] Blue-green algae dominate the algae community in Little Elk Lake on July 21, 2000.

4.4. Zooplankton status

Zooplankton were monitored over the summer in Little Elk Lake in 2000. A mix of different types of zooplankton were found at densities (in number/liter) that are typical for eutrophic lakes (Table 10). Examples of a cladoceran and a copepod from Little Elk Lake are shown in Figure 9.

Table 10. Zooplankton found in Little Elk Lake based on zooplankton tows taken in the middle of the lake. Results are shown as organisms per liter.

	5.21.00	6.13.00	7.21.00	8.10.00
Big Daphnia	40	10	10	33
Little Daphnia	11	12	8	10
Bosmina	17	149	2	35
Chydorus	2	10	36	224
Total Cladocerans	**70**	**181**	**56**	**302**
Calonoids	4	16	19	10
Cyclopoids	2	12	16	13
Nauplii	15	4	14	8
Total Copepods	**21**	**32**	**49**	**31**
Rotifers	**28**	**10**	**4**	**3**
Total Number of Zooplankton	119	223	109	336

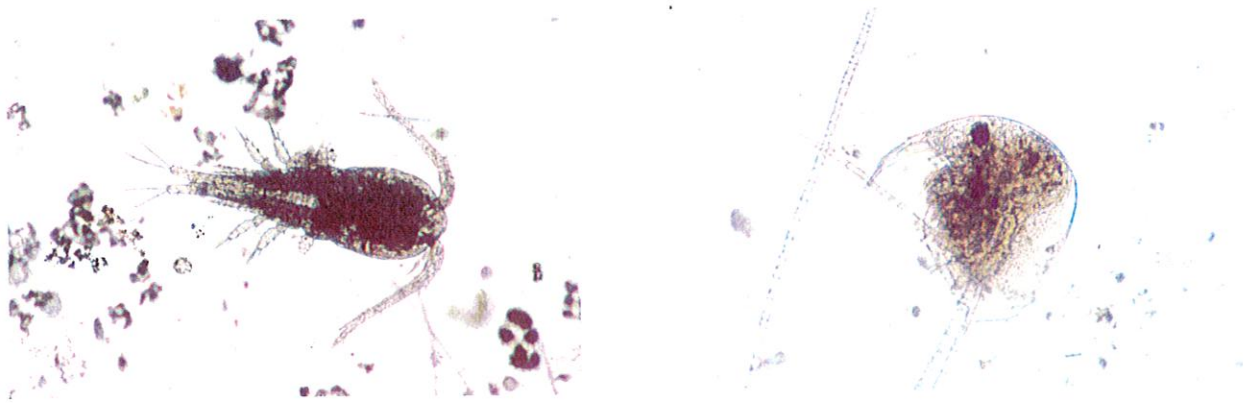


Figure 9. Typical Little Elk Lake zooplankton found on July 21, 2000 were cyclopoid copepods (left) and Bosmina cladocerans (right).

4.5. Aquatic plant status

Two plant surveys were conducted in 2000; one in May and another in September. Results are summarized in the next four pages. In May, the exotic plant, curlyleaf pondweed, was the dominant plant (Table 11) followed by elodea. Although curlyleaf is widespread, it is the thickest at the north end of the lake. Plant statistics are shown in Table 12 and a location of sample sites is shown in Figure 8.

Table 11. Little Elk Lake aquatic plant occurrence and density for the May 21, 2000 survey based on 16 transects and 2 depths, for a total of 32 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (n=16)			Depth 5-8 feet (n=16)			All Stations (n=32)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Curlyleaf pondweed (*Potamogeton crispus*)	11	69	0.9	16	100	1.2	27	84	1.1
Elodea (*Elodea canadensis*)	9	56	1.3	7	44	0.8	16	50	1.1
Coontail (*Ceratophyllum demersum*)	11	69	1.5	2	13	1.0	13	41	1.4
Claspingleaf pondweed (*P. richardsonii*)	1	6	0.5	1	6	0.5	2	6	0.5
Flatstem pondweed (*P. zosteriformis*)	4	25	0.9	1	6	0.5	5	16	0.8
Narrowleaf pondweed (*P. spp*)	2	13	0.8	--	--	--	2	6	0.8
Northern watermilfoil (*Myriophyllum sibiricum*)	4	25	1.0	1	6	1.0	5	16	1.0
Spatterdock (*Nuphar variegatum*)	1	6	1.0	--	--	--	1	3	1.0
Water stargrass (*Zosteriformis dubia*)	7	44	0.9	7--	--	--	7	22	0.9

In the second survey, conducted on September 29, 2000, curlyleaf was much more scarce, as is typical. The most common plants were coontail, northern watermilfoil, and water stargrass (Tables 13 and 14). Plants were generally found in low densities and no plants were found in the 5-8 foot depth range (Table 13).

Table 12. Individual transect data for Little Elk Lake for May 21, 2000.

	T1		T2		T3		T4		T5		T6	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Coontail	1		1		2	0.5	3		1		1	
Curlyleaf pondweed	3	2	2	1.5	1	0.5	3.5	1.5	1	0.5	1	
Claspingleaf pondweed												
Elodea	1		1			0.5			2	1		0.5
Flatstem pondweed												
Narrowleaf pondweed							0.5					
Northern watermilfoil											1	
Spatterdock	1											
Water stargrass											1	

	T7		T8		T9		T10		T11		T12	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Coontail	1		1								2	
Curlyleaf pondweed	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
Claspingleaf pondweed				0.5			0.5					
Elodea		0.5	1		1						1	0.5
Flatstem pondweed	1	0.5	1		1							
Narrowleaf pondweed												
Northern watermilfoil			1								1	
Spatterdock												
Water stargrass	1		1		0.5						1	

	T13		T14		T15		T16		T1a			
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Coontail	1	1					2		0.5			
Curlyleaf pondweed	2		1	0.5	0.5		0..5		1.5			
Claspingleaf pondweed												
Elodea	3	2	1	0.5			1					
Flatstem pondweed			0.5									
Narrowleaf pondweed												
Northern watermilfoil		1					1					
Spatterdock												
Water stargrass			1				1					

Curlyleaf pondweed in Little Elk Lake, May 21, 2000.

Table 13. Little Elk Lake aquatic plant occurrence and density for the September 29, 2000 survey based on 16 transects and 2 depths, for a total of 32 stations. Density ratings are 1-5 with 1 being low and 5 being most dense. Unlike the May survey, no plants were found in the 5 to 8 foot range in September.

	Depth 0-4 feet (n=16)			Depth 5-8 feet (n=16)			All Stations (n=32)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Chara (*Chara sp*)	3	19	0.7	0	--	--	3	9	0.7
Coontail (*Ceratophyllum demersum*)	12	75	1.2	0	--	--	12	38	1.2
Curlyleaf pondweed (*Potamogeton crispus*)	3	19	0.8	0	--	--	3	9	0.8
Elodea (*Elodea canadensis*)	9	56	1.0	0	--	--	9	28	1.0
Naiads (Najas sp)	1	6	1.0	0	--	--	1	3	1.0
Northern watermilfoil (*Myriophyllum sibiricum*)	12	75	1.0	0	--	--	12	38	1.0
Sago pondweed (*P. pectinatus*)	3	19	0.7	0	--	--	3	9	0.7
Spatterdock (*Nuphar variegatum*)	1	6	2.0	0	--	--	1	3	2.0
Water celery (*Vallisneria americana*)	2	13	0.5	0	--	--	2	6	0.5
Water stargrass (*Zosteriformis dubia*)	11	69	1.6	0	--	--	11	34	1.6

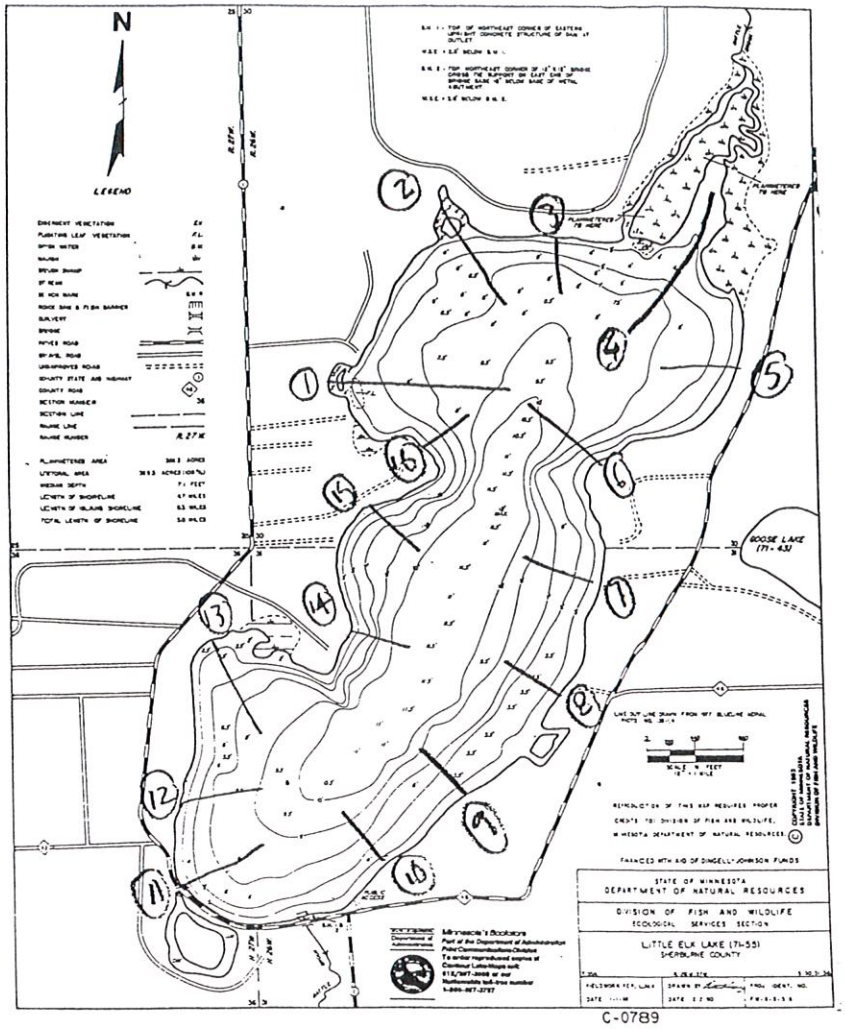
Coontail, northern watermilfoil, and water stargrass all found on the sample rake and all found at a density of "1" on 9.29.00.

Table 14. Individual transect data for Little Elk Lake for September 29, 2000.

	T1		T2		T3		T4		T5		T6	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Chara												
Coontail	1						3.5		0.5		2	
Curlyleaf pondweed			1				1					
Elodea			2		0.5				0.5			
Naiads												
Northern watermilfoil	0.5								0.5			
Sago pondweed			0.5						0.5			
Spatterdock	2											
Water celery												
Water stargrass	1.5		1.5		2.5				0.5			

	T7		T8		T9		T10		T11		T12	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Chara			0.5		1		0.5					
Coontail	1		1				0.5				2	
Curlyleaf pondweed									0.5			
Elodea			1		0.5						1	
Naiads							1					
Northern watermilfoil	1.5		1		0.5		0.5		1		2	
Sago pondweed									1			
Spatterdock												
Water celery							0.5		0.5			
Water stargrass			1				1				2	

	T13		T14		T15		T16	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Chara								
Coontail	1		0.5		0.5		0.5	
Curlyleaf pondweed								
Elodea	1		2		0.5			
Naiads								
Northern watermilfoil	2		1		1		1	
Sago pondweed								
Spatterdock								
Water celery								
Water stargrass	2		1		3		2	



Transect Number	Transect Marker
1	Coming in on a sandbar.
2	Coming in on a sand bank in the cove.
3	Coming in on a willow next to a keystone wall.
4	Going into mouth of Battle Creek.
5	Coming in-between two steps going uphill.
6	Right by knotty pine boathouse.
7	Between two big rock rip-rap walls.
8	Right before the channel.
9	Going in on a big brown boathouse.
10	Going in on the deck before the landing.
11	Going in on the big culvert (south side).
12	Going in on a timberwall.
13	Coming in on a double boathouse with rip-rap.
14	Coming in on four wood stair cases together with white house.
15	Coming in on a big grey house with big deck.
16	Coming in on a big brown "A" frame house.

Figure 10. Aquatic plant transect map and location descriptions.

4.6. Fishery status - MnDNR

The last recorded fish survey for Little Elk Lake was in 1993. Walleyes, yellow perch, and sunfish were found in good numbers, in the upper bracket of regional averages. Black bullheads were present in moderate numbers, but at a higher density than yellow bullheads. The black to yellow bullhead ratio for Little Elk Lake is a broad indicator of a lake with significant algae blooms.

Table 13. Fish Sampled up to the 1993 Survey Year (source: MnDNR).

		Number of fish per net			
Species	Gear Used	Caught	Normal Range	Average Fish Weight (lbs)	Normal Range (lbs)
All Species	Gill net	0.2	0.8 - 7.0	ND	0.2 - 0.4
Black Bullhead	Gill net	17.0	30.3 - 150.6	ND	0.2 - 0.4
	Trap net	4.3	11.5 - 132.6	ND	0.2 - 0.4
Black Crappie	Gill net	8.5	1.4 - 13.8	0.17	0.2 - 0.4
	Trap net	5.3	1.2 - 20.5	ND	0.2 - 0.5
Bluegill	Gill net	0.7	N/A - N/A	0.27	N/A - N/A
	Trap net	26.5	1.2 - 20.0	ND	0.1 - 0.4
Brown Bullhead	Gill net	0.2	0.5 - 5.6	1.01	0.3 - 0.7
Common Carp	Gill net	0.3	1.0 - 13.8	3.60	0.8 - 3.7
	Trap net	0.7	1.0 - 5.5	ND	1.4 - 4.6
Golden Shiner	Gill net	0.2	0.5 - 2.6	0.07	0.1 - 0.1
	Trap net	0.2	0.2 - 1.1	0.08	0.1 - 0.1
Green Sunfish	Trap net	0.3	0.2 - 1.9	0.07	0.1 - 0.2
Hybrid Sunfish	Trap net	0.5	N/A - N/A	ND	N/A - N/A
Largemouth Bass	Trap net	0.8	0.2 - 0.7	0.98	0.3 - 1.5
Northern Pike	Gill net	1.0	1.1 - 8.0	4.98	1.8 - 3.4
	Trap net	0.2	N/A - N/A	4.96	N/A - N/A
Pumpkinseed Sunfish	Gill net	0.2	N/A - N/A	0.08	N/A - N/A
	Trap net	6.2	0.3 - 4.9	ND	0.1 - 0.2
Spotfin Shiner	Trap net	0.7	N/A - N/A	ND	N/A - N/A
Snapping Turtle	Trap net	0.8	N/A - N/A	ND	N/A - N/A
Walleye	Gill net	15.2	2.3 - 18.1	ND	1.0 - 2.3
	Trap net	0.2	0.5 - 3.0	3.97	0.8 - 2.3
White Crappie	Gill net	1.7	0.5 - 8.4	0.07	0.2 - 0.3
	Trap net	2.5	0.3 - 6.0	ND	0.3 - 0.6
White Sucker	Gill net	1.2	0.8 - 6.5	2.06	0.9 - 2.0
	Trap net	0.2	0.3 - 2.6	4.41	1.0 - 2.0
Yellow Bullhead	Trap net	0.2	0.5 - 2.5	0.55	0.3 - 0.7
Yellow Perch	Gill net	26.3	2.7 - 25.0	ND	0.1 - 0.3
	Trap net	10.8	0.3 - 3.8	ND	0.1 - 0.3

Normal Ranges represent typical catches for lakes with similar physical and chemical characteristics.

Table 13. Concluded.

Length of Selected Species Sampled for All Gear for the 1993 Survey Year

	Number of fish caught in each category (inches)								
Species	0-5	6-8	9-11	12-14	15-19	20-24	25-29	>29	Total
Black Bullhead	0	3	120	0	0	0	0	0	123
Black Crappie	29	26	21	2	0	0	0	0	78
Bluegill	110	24	0	0	0	0	0	0	134
Brown Bullhead	0	0	0	1	0	0	0	0	1
Green Sunfish	2	0	0	0	0	0	0	0	2
Hybrid Sunfish	1	0	0	0	0	0	0	0	1
Largemouth Bass	3	1	0	0	1	0	0	0	5
Northern Pike	0	0	0	0	1	2	2	2	7
Pumpkinseed Sunfish	35	2	0	0	0	0	0	0	37
Walleye	0	16	7	0	59	7	2	0	91
White Crappie	8	3	13	0	0	0	0	0	24
Yellow Bullhead	0	0	1	0	0	0	0	0	1
Yellow Perch	56	142	4	0	0	0	0	0	202

Fish Stocked by Species for the Last Five Years

Year	Species	Age	Number
1995	Walleye	Fry	174,150
1996	Walleye	Fry	175,000
1998	Walleye	Fry	175,000
2000	Walleye	Fry	175,000

Status of the Fishery (as of 07/01/1993)(prepared by MnDNR)

The 1993 fish population assessment on Little Elk Lake revealed the following information about the lake. The catch rate of walleye (15.2/gill net) significantly increased from the previous survey (6.2/gill net). The majority of fish caught (93%) were one and two year olds, which corresponded to the two most recent fry stockings. Walleye caught in gill nets ranged in size from 7.9-26.8 inches and averaged 15.1 inches in length. The average weight of walleye caught in gill nets (1.4 lbs) also appeared to have increased reaching nearly the state average for this lake type (1.5 lbs). The catch rate of yellow perch in gill nets (26.3/gill net) also significantly increased from the previous survey (6.2/gill net). Yellow perch caught ranged in size from 5.1-10.3 inches and averaged 7.1 inches in length. The catch rate of northern pike appeared to decrease from the previous survey, however the average size northern caught (5.0 lbs) increased to over twice the state average (2.3 lbs). Northern pike caught ranged in length from 19.4-34.1 inches and averaged 26.3 inches. No dominant year class appeared and 2 to 6 year old fish were sampled. The growth rate for northerns was fast for 1 to 4 year olds, and average for age 5 to 6 fish. The catch rate of black crappie decreased sharply in both gill and trap nets, falling below the state average for lakes like Little Elk. The average weight of black crappie (0.5 lbs) did increase rising above the state average for this lake type (0.3 lbs). Crappies caught ranged in size from 4.1-14.0 inches The catch rate of bluegills appeared to increase in the 1993 assessment (21.7/trap net) from the 1988 survey levels (4.5/lift). Bluegills caught ranged in size from 3.6-8.5 inches and averaged 5.3 inches in length.

5. Lake and Watershed Assessment

Little Elk Lake is eutrophic, meaning it has elevated phosphorus levels resulting in algae blooms and diminished clarity. However, Little Elk Lake has had that condition going back to the first clarity records of 1982. It appears that wind mixing may produce sediment resuspension and further reduce clarity on some days in the summer.

The present watershed is in relatively good shape from the perspective that there is a high percentage of wetland, forest, and grassland acreage. This type of land use generally is good for a lake since low amounts of phosphorus are expected to runoff the land, and into streams that flow into lakes. However because of the relatively large watershed, there is apparently enough phosphorus getting to Little Elk Lake to cause problems.

This is discussed later in this section.

In the upper watershed, much of the runoff goes through wetland systems. The Battle Brook water quality that comes out of these systems is relatively good.

5.1. Little Elk Lake questionnaire results

A lake questionnaire was sent to lake residents in 2000 to get input on lake resident perceptions of water quality and lake improvement ideas. A total of 41 responses were received. A summary of results is shown below.

1. What do you enjoy most about Little Elk Lake?

	Ranking of Projects									
	1	2	3	4	5	6	7	8	*Relative Scores*	*Rank*
Aesthetics	20	5	3	2	4	1	0	0	*73*	*1*
Boating	15	9	7	3	3	0	0	0	*81*	*2*
Wildlife	6	1	6	7	7	2	0	0	*101*	*3*
Water sports	5	4	6	5	4	1	5	1	*120*	*4*
Fishing	8	3	3	2	2	5	6	1	*121*	*5*
Swimming	3	5	7	5	5	3	3	2	*134*	*6*
Ice fishing	2	1	1	2	2	6	7	5	*150*	*7*
Other	1					1			*2*	--
Don't use	3	0	0	0	0	0	1	2	*26*	--

2. What is the current water quality of Little Elk Lake? (Water quality indicators were described as water clarity, algae, weeds or plants, swimming conditions, or fishing conditions.)

0 Excellent
4 Good
19 Fair
18 Poor

Comments: Would like to see city sewer; Pretty soon won't be able to get boat out; Our north end weeds are terrible and clarity is poor; Too green; However I remember visiting over the years and have notice it is much cleaner than 10 years ago.

3. Since you have lived on or near Little Elk Lake, the quality has:

5 Improved
13 Remained the same
9 Degraded slightly
11 Degraded considerably
1 No opinion/can't tell

Other: Water was clear but weedy; Mostly with regard to weeds (2); Two winters of early ice off seemed to increase weed growth; There are fewer weeds than 20 years ago; It has gone up and down with weeds, but our lake bottom is sandy and solid. We found when the children used it regularly, the weed problem improved; The lagoon on the south end used to be clear and easy to use and fish in. It's now full of weeds and hard to access. Fishing from the shore is not as easy as it was 20 years ago. Too many weeds; The lake was clearer before about 1970 or so, however this clearness also caused a much heavier weed crop then we have today; 1957-1965 Water quality good - weeds normal mix, 1965-1980 we treated the lake 3 times a year with copper sulphate. 1400 pounds per year. Water was clear which encouraged weed growth. Curlyleaf pondweed covered the lake to the 10 ft depth (stopped treating). 1980-2000 water clarity went down to a point it killed the weed. Heavy snow on ice was also a factor.

Average time for using Little Elk Lake for 23.1 years.

Number of years using Little Elk Lake	0-5	6-10	11-15	16-20	21-25	26+
Number of respondents	4	5	5	4	4	16

4. Where does the lake experience fit in your personal priorities?

23 High priority
15 Medium priority
1 Low priority

5. What do you see as the biggest problem of the lake?

	Ranking of Projects											
	1	2	3	4	5	6	7	8	9	10	*Relative Score*	*Rank*
Excessive algae	10	14	5	1	0	3	1	0	1	0	*74*	*1*
Water quality	16	6	2	3	6	0	1	1	1	0	*100*	*2*
Weeds	12	8	6	3	3	1	0	2	0	1	*105*	*3*
Poor fishing	3	1	6	3	5	5	3	2	1	2	*156*	*4*
Lake crowding	6	3	5	0	2	1	3	2	8	1	*162*	*5*
Wildlife	3	0	2	3	6	5	4	1	3	2	*164*	*6*
Erosion	1	3	2	5	3	3	3	2	3	4	*170*	*7*
Lake water levels	3	1	2	7	1	1	2	5	3	4	*171*	*8*
Development	4	3	1	1	2	2	5	6	3	4	*189*	*9*
Water craft	5	0	2	4	5	4	1	5	0	7	*193*	*10*
Other												

Other: Poor sewage systems and lawn fertilizer are a problem (4); Limit the number of boats/day at public landing; Noise from jet boats and jet skies (4); Shoreland maintenance (1); Glass in beach area

6. What should be done to improve or protect the quality of the lake?

Hopefully stop the pollutants (2); Sewer systems by the lake should be closed (1); Public awareness, respect for nature, visiting boats do not remove weeds; Battle Brook, city sewer, no phosphate fertilizer; Dredge, stop agricultural runoff; Get rid of weeds (2), redirect Rice Lake back to Battle Brook (3), restock lake; Continue studies (2); Open up lagoons, larger culvert for access, work on weeds in some areas. Stop major housing projects, fertilizers on lawns, etc.;

7. Because Little Elk Lake is moderately fertile, there will be some type of plant growth in the lake. If you could manage Little Elk Lake for plant growth what aquatic plant condition would you prefer?

2 A. Existing conditions are acceptable.

12 B. Reduce nuisance exotic plant growth associated with curlyleaf pondweed. Algae growth remains the same with 3 foot transparency in midsummer. Native aquatic plant distribution remains about the same.

24 C. Reduce nuisance exotic plant growth and reduce algae growth so summer transparency increases to 5-6 feet. No noticeable algae bloom with this condition. Native aquatic plants probably will grow to deeper water depths, and in some years reach the surface in water depths out to 8 feet.

____ D. Here is my plan: Poor sewage systems and lawn fertilizers are a problem

8. Who do you think is responsible for protecting and improving the lake. Enter the three most important groups or agencies by putting their letter in the spaces provided.

	Ranking of Projects								
	A	B	C	D	E	F	G	H	I (DNR)
1st	2	5	7	0	5	**12**	1	8	1
2nd	0	8	3	**9**	8	6	2	0	0
3rd	1	5	5	3	**8**	6	3	1	2

A. Federal government
B. State government
C. County government (Sherburne County)
D. Local government (Baldwin and Blue Hill Townships) (ranked 2nd)
E. Property Owners Association (ranked 3rd)
F. Individual lake residents (ranked 1st)
G. The general public
H. All equally
I. Other

9. What do you believe would be *realistic* goals to accomplish on your lake?
(Please check all that apply.)

__8__ A crystal clear lake such as found in Northern Wisconsin.
__4__ Eliminate all submerged weeds.
__32__ Eliminate weeds that create a nuisance.
__10__ Eliminate algae blooms for the whole summer.
__31__ Reduce intensity of algae blooms.
__22__ Increase gamefish fishing opportunities.
__0__ The lake cannot be improved.
____ Other: Better stewardship practices.

Comments: Curlyleaf weeds were much worse in 1950s and 1960s. When copper sulfate was applied to clear lake curlyleaf was solid out at least 150 feet from all shores. Impossible to get boats out to clear water without stopping and raising motor to clear. Lasted thru July.

10. How do you think the goals can be accomplished?

I am not certain; Fish stocking (6); Buffer strips (4); Educational materials (4); Watershed (3); Weed control (4); Wetland-Battle Brook restoration (2); Work with DNR; Septic systems (2); Raise water level (higher dam; Stop fertilized laws on or near lake shore properties;

11. How is your yard maintained? (Please check all that apply)

26 No fertilizer applied
12 Fertilizer is applied:
- 8 One;
- 2 Two;
- 2 Three times per year;
- 0 Use a commercial fertilizer service

13 Natural landscaped area
18 Vegetative buffer between lake and mowed lawn.

Comments: Use organic fertilizer; Our 250 ft lot is all natural except for a small area by the dock;

12. Are you interested in participating in a Lake Management Program on a personal level? Yes: 34 No: 2 No Answer: 5

Are you willing to do any of the following:

12 Fertilize your yard based on soil test recommendations?
16 Plant native wildflowers, grasses, etc to attract wildlife?
16 Leave as is or restore natural shoreland vegetation?
18 Volunteer to help control nuisance growth of aquatic plants as part of a whole lake effort?
___ Other ideas

Comments: Help contribute garage sale items; Committee;

13. Where do you get your information on how lakes work?

29 Lake newsletters
7 Minnesota Lake Association (MLA)
9 Newspapers
9 Television
___ Other Internet; DNR; 33 years as a biologist; Personal viewing-visiting several lakes; LELIA; Extension office; Watching Elk Lake for 43 years; State publications; Work;

Survey Summary

Results of the survey indicate that the number one lake enjoyment of lake residents is viewing the lake's natural setting (aesthetics) followed by boating and wildlife. Residents recall that the lake has been both weedier and clearer in the past. It appears the water quality has fluctuated over the years based on personal observations of lake residents. The majority of respondents listed excessive algae and weeds as the primary problems in Little Elk Lake. Likewise, most residents stated that reduction of nuisance aquatic weeds and algae were the primary goals of a lake improvement program.

5.2. How does Little Elk Lake rate?

A somewhat surprising finding of this study was that after running a lake model, it appears Little Elk Lake exhibits lake phosphorus concentrations that are close to what would be expected for a relatively unimpacted lake with a large watershed in this part of the state (Figure 11).

Little Elk Lake is in the North Central Hardwood Forest Ecoregion. Glacial lakes are typical in this ecoregion and often their watersheds are about 10 times bigger than the lake surface. However, Little Elk Lake is not a typical glacial lake of the North Central Hardwood Forest Ecoregion. It has a watershed to lake surface ratio of 57 when using the full watershed and a watershed to lake surface ratio of 22 when using the watershed area south of Rice Lake. So although the water quality in Battle Brook is good for this ecoregion, because of the larger than average watershed, the phosphorus loading to Little Elk Lake is sufficient to create nuisance algae blooms. The result is the water quality of Little Elk lake is not as good compared to other lakes in the region with smaller watersheds.

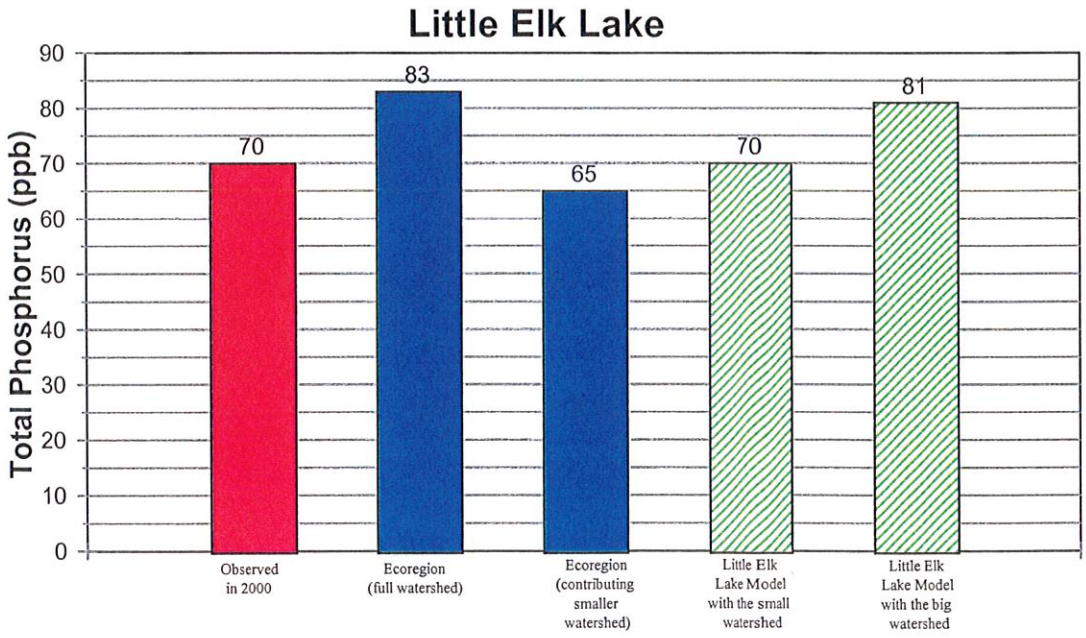


Figure 11. The above bars represent phosphorus concentrations in Little Elk Lake for several situations. The phosphorus concentration in 2000 was 70 ppb and the predicted lake phosphorus concentration was 83 ppb for a large watershed condition and 65 ppb for the smaller watershed using ecoregion values. Using Battle Brook phosphorus concentrations, we modeled Little Elk Lake using the full watershed and smaller watershed. The smaller watershed produced lower phosphorus concentrations.

5.3. Factors affecting water quality and corrective actions needed

Ecoregion values for phosphorus concentrations in Battle Brook were found in 2000. Normally this would produce good water quality in the receiving water body. However, the watershed is larger than normal. Therefore, this results in more phosphorus flowing into Little Elk Lake than would be expected for this ecoregion. In turn, algae blooms are produced.

The lake model indicates that lake phosphorus levels would go up slightly with increasing or diverting more water into Little Elk Lake, but there would be little observable impact to water clarity.

Corrective actions that would improve water quality are a broad-based watershed approaches coupled with lake projects that would help bring back native plants.

Because Little Elk is shallow and fertile, some type of plant growth will occur. The challenge is to find a balance between algae and aquatic plant growth so neither is a problem.

6. Lake Project Ideas for Protecting Water Quality and Wildlife

Listed below are a variety of projects to improve Little Elk Lake water quality. Project details then follow in the next few pages.

Table 14. Proposed lake improvement projects for Little Elk Lake

Recommended Projects	Comments	Project Costs $
1. Watershed Projects		
Watershed stewardship	Work with Sherburne Soil Water Conservation District. Use State and Federal cost-share money where possible	5,000+
2. Shoreland Projects		
Shoreland inventory, Buffer strips, and erosion control	Catalog shorelands to set a benchmark and determine if areas can be enhanced -- design buffer strips where needed. Check out availability of MnDNR grants or assistance from the University of Minnesota-Extension	4,000
Custom fertilizer use	Lower fertilizer use saves money and helps the lake. Sampling results will indicate if fertilizer is required.	600
3. Algae Control Projects		
Copper sulfate for odor control	For nuisance odor conditions, copper sulfate may offer a short-term solution.	1,500+
Whole lake alum treatment	Conduct feasibility study first, then implement if appropriate in the future. If other nutrient reductions projects are successful alum may not be needed.	175,000
4. Aquatic Plant Projects		
Lake soil testing	Soil fertility may delineate areas that could support nuisance EWM growth.	2,500+
Nuisance curlyleaf control using cutters	Cut nuisance curlyleaf areas using a volunteer work force.	6,000+
Drawdown for nuisance plant control	Evaluate potential for drawdown and set-up a long term drawdown management plan. This is a last resort plan. It is only considered if other projects are not working.	30,000+
5. Fish Projects		
Carp reduction program	Use commercial fishermen to reduce carp population.	5,000+
Winter aeration	Conduct feasibility study, objective is to maintain fish population over winter.	20,000
6. Lake Monitoring Program		
Continue lake monitoring	Lake monitoring effort is based on budget.	100+
Continue to evaluate Battle Brook	Continue to monitor Battle Brook inflows. Check upstream areas as well.	400+
Costs		

6.1. Watershed projects

Watershed stewardship

The watershed area draining to Little Elk Lake is over 20,000 acres. This is a large watershed. Watershed phosphorus reduction projects will improve water quality in Little Elk Lake in the long run. Nonpoint sources of pollution (from farmlands, wetlands, and urban) if detected should be reduced. Within the watershed project areas to address include buffer strips along Battle Brook, nutrient management on croplands and possibly feedlot improvements.

A natural setting in the Little Elk Lake watershed. Stream is naturally buffered.

6.2. Shoreland projects

Shoreland Inventory, Buffer Strips, and Erosion Control

The shoreland area is valuable for promoting a natural lake environment and a natural lake experience for lake users. The shoreland is defined as the upland area about 300 to 1,000 feet back from the shoreline, and out into the lake to about the end of your dock (Figure 11). A shoreland with native vegetation offers more wildlife and water quality benefits than a lawn that extends to the lake's edge. A summary of attributes and functions of native plants in the shoreland area is shown in Table 15.

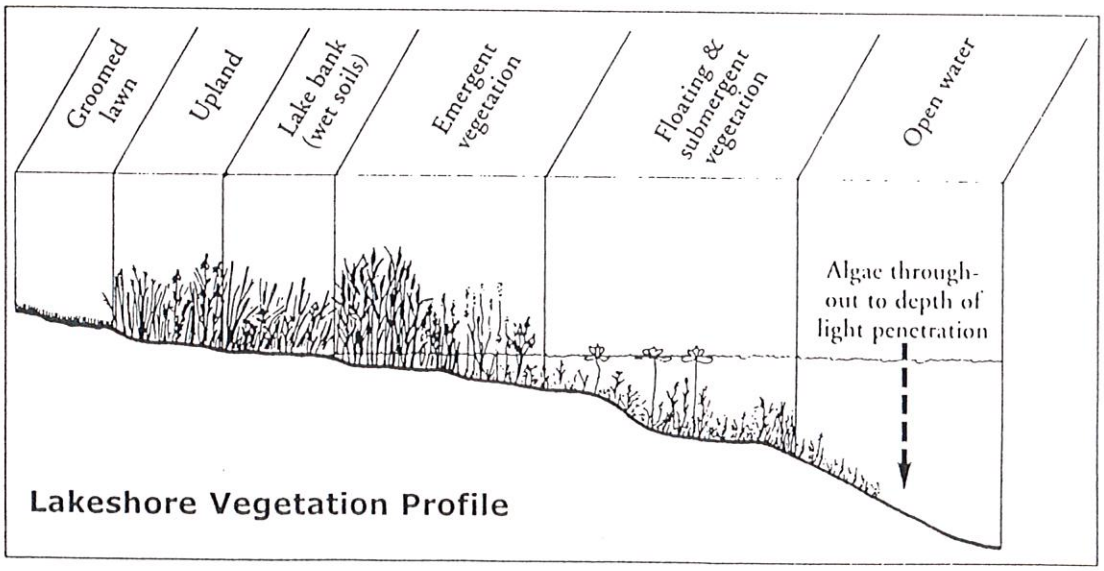


Figure 11. Cross section of the lake shoreland habitat (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR.).

Table 15. Attributes and functions of native plants in the shoreland area (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR)).

Important functions of plants in and around lakes

Submergent and emergent plants

- Plants produce leaves and stems (carbohydrates) that fuel an immense food web.
- Aquatic plants produce oxygen through photosynthesis. The oxygen is released into lake water.
- Submerged and emergent plants provide underwater cover for fish, amphibians, birds, insects, and many other organisms.
- Underwater plants provide a surface for algae and bacteria to adhere to. These important microorganisms break down polluting nutrients and chemicals in lake water and are an important source of food for organisms higher in the food chain.
- Emergent plants break the energy of waves with their multitude of flexible stems, lessening the water's impact on bank and thus preventing erosion.
- Plants stabilize bottom sediments, which otherwise can be resuspended by currents and wave action. This reduces turbidity and nutrient cycling in the lake.

Shoreline and upland plants

- Shoreline and upland plants provide food and cover for a variety of birds, amphibians, insects, and mammals above the water.
- The extensive root systems of shoreline plants stabilize lake-bank soils against pounding waves.
- Plants growing on upland slopes that reach down to lake hold soil in place against the eroding forces of water running over the ground, and help to keep lake water clean.
- Upland plants absorb nutrients, like phosphorus and nitrogen, found in fertilizers and animal waste, which in excessive concentrations are lake pollutants.

Shoreland Inventory: An initial step in a shoreland improvement program is to inventory existing conditions. It may turn out that many residences have shoreland conditions that are already lake and wildlife friendly. An inventory will show other areas that could be improved or upgraded.

A shoreland inventory is conducted by taking photographs from the lakeside of shorelines around the lake. The photos are evaluated and existing conditions are noted. The results serve as a reference point for comparison to future conditions.

Any shoreland improvements by lake homeowners will be voluntary. The Lake Association can make available the results of the inventory, and interested property owners can find out from the association where to get more information or names of contractors that could improve the natural shoreland conditions.

Buffer Strips: Techniques for instituting shoreland projects will be outlined in a series of fact sheets. One of the first and easiest of the shoreland projects to implement is to install a buffer strip along your shoreline. One approach is to let a strip of lawn 10 to 30 feet wide grow up. You will be surprised at the diversity of plant species in an area like this. This approach is referred to as "natural recovery". An example is shown in Figure 12.

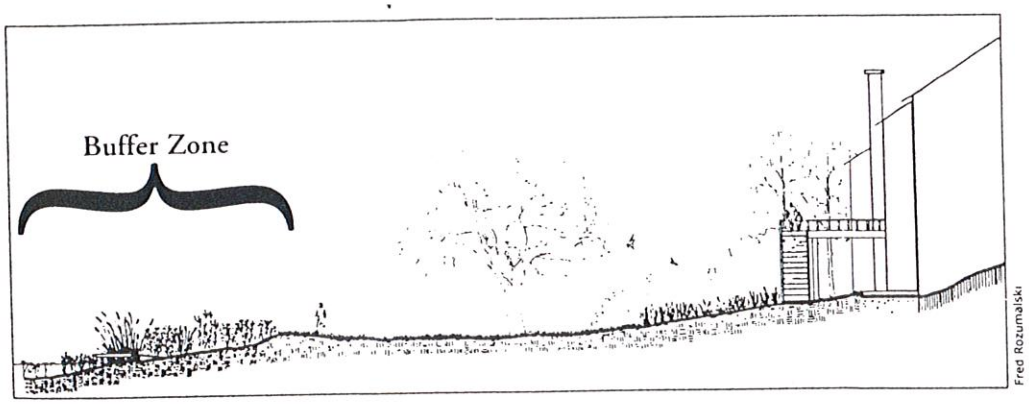


Figure 12. Example of a buffer strip employing "natural recovery". The homeowner just let a 20 foot wide strip of lawn go back to a natural state (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR).

Another approach for installing buffer strips is to be more aggressive and go in and do native plantings conducive to the area. This is sometimes referred to as accelerated natural recovery. Examples are shown in Figures 13 and 14.

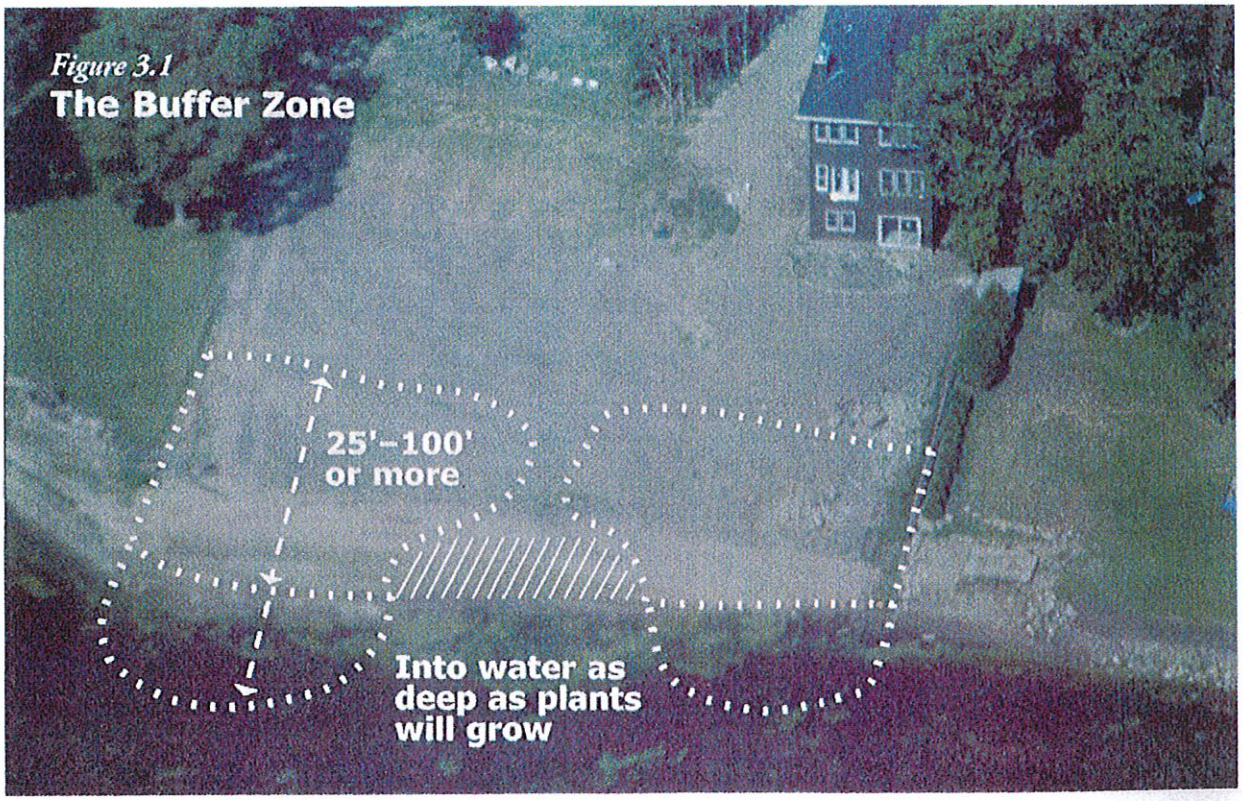
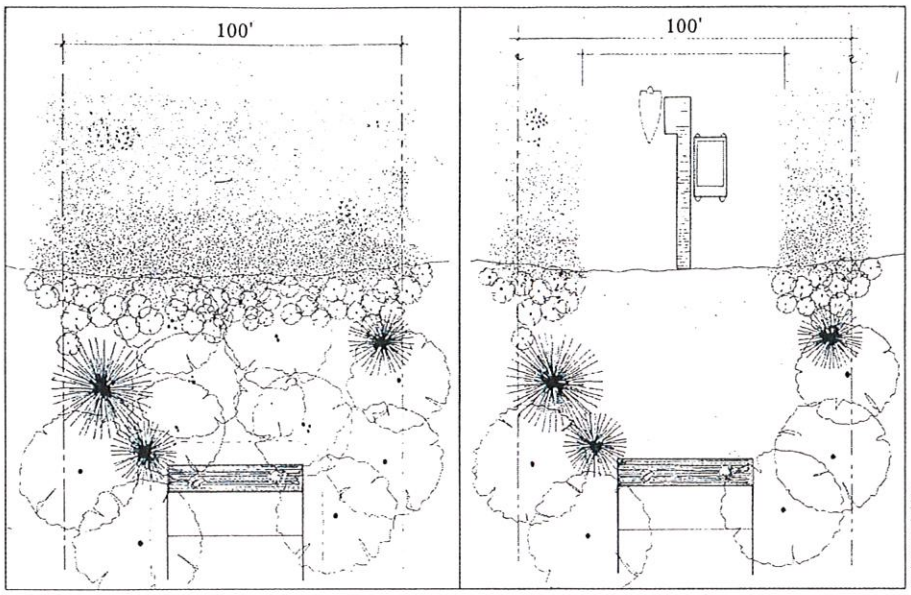


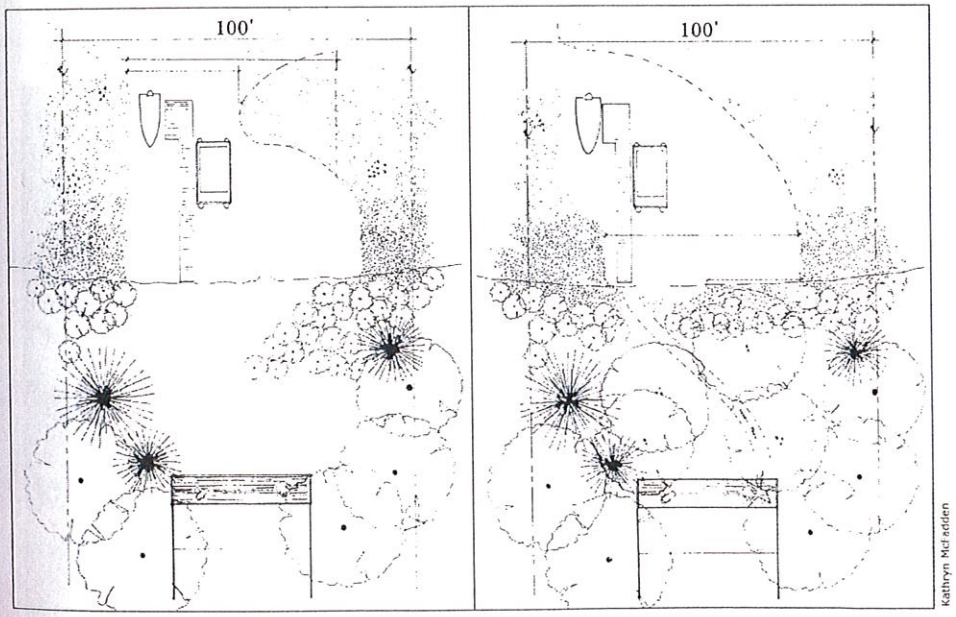
Figure 13. Converting a lawn setting to a naturalized shoreline can be accelerated by native plantings. The first step is drawing up a plan (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR).

Buffer Zone Scenarios

LEFT: *In this design, upland and aquatic vegetation is left intact while land is cleared for homesite only.*

RIGHT: *A typical 100-foot lake front where 60% of the upland and aquatic vegetation is removed. Leaving 40% of lake vegetation in place provides some protection to the lakeshore.*





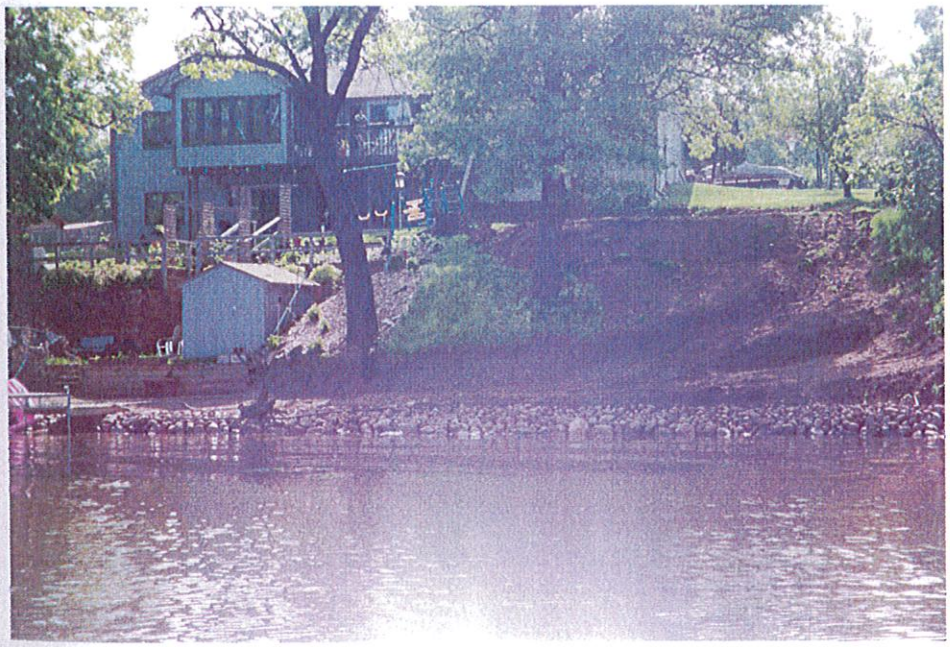
LEFT: *In this more protective design, 60% of the vegetation is removed near shore, but only 30% beyond the swimming area. Emergent vegetation protects the beach and prevents sand from washing into the lake.*

RIGHT: *This design maintains 25% of shore for swimming, while vegetation left in place beyond the dock greatly reduces exposure of the shoreline to waves.*

Figure 14. Buffer zone scenarios (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR.).

Erosion Control and Custom Fertilizer Use: Erosion control at construction sites is a proactive way to reduce sediment and nutrient loading to a lake. The County helps enforce the building permit erosion control practices.

Fertilizers are used by some lake residents. Soils test should be encouraged to determine if fertilizers are even needed. This is a good project for the Lake Association to oversee.



Erosion control at the time of construction prevents soil from entering the lake. This site could have used better erosion control methods.

6.3. Algae control projects

Copper Sulfate for Odor Control

Copper sulfate is toxic to algae and offers some short-term relief, but is not a long-term solution. The advantages and disadvantages of copper sulfate use have been summarized by the MnDNR and the Internet has additional information. If watershed, shoreland, and in-lake projects are successfully implemented, copper sulfate use should be unnecessary.

Whole Lake Alum Treatment

Alum is a compound composed of aluminum sulfate. It is a non-toxic chemical addition to lakes that controls algae by inactivating sediment-released phosphorus thus lowering the availability of phosphorus for algae growth. Alum is applied from a boat or a barge, usually in liquid form (Figure 15). Alum is most effective when phosphorus release from bottom lake sediments is documented to be a significant source of phosphorus to algae blooms. At this time lake sediments are suspected to be a phosphorus source but it is not documented. An initial step is to evaluate the potential for an alum application. The actual application would not be scheduled for several years. In the mean time, watershed and shoreland projects would be implemented. Alum may not be necessary. If it was to be applied in the future the cost could be about $500/acre or about $175,000.

Figure 15. Alum application on Lake Susan, Chanhassen in 1998.

6.4. Aquatic plant projects

Lake Soil Testing

Eurasian watermilfoil can grow to nuisance conditions in some lakes. Little Elk Lake does not have Eurasian watermilfoil at this time. The question is how might Eurasian watermilfoil respond if it is introduced into Little Elk Lake.

One approach is to test lake sediment fertility levels. There is a strong correlation between high sediment nitrogen levels and nuisance milfoil growth. This project area has three steps:

1. Sample Little Elk Lake sediments. About 25 samples @ $25/sample should be adequate.
2. Construct a map showing milfoil hotspots or areas where nuisance growth would be expected.
3. Work with MnDNR and the Lake Association to develop a management plan. For example, in the future some milfoil infested areas could be treated while other areas would be left alone.

Nuisance Curlyleaf Control Using Cutters

Curlyleaf pondweed is an exotic plant that can grow to nuisance levels. It dies back in mid-summer and decomposition contributes to the nutrient levels in the lake.

Currently it is found growing to the water's surface creating nuisance conditions in the north end and west side of Little Elk Lake and in several other areas. The nuisance extent is less than 30 acres. The management strategy is to implement a program to reduce the nuisance condition of curlyleaf pondweed. There are several options and include: herbicide use, mechanical harvesting, and/or boat-towed cutting.

For Little Elk Lake, the first choice to consider is the pre-emptive cutting technique. It involves organizing a half dozen or more teams of 2 to 3 people to cut curlyleaf pondweed using a boat-towed, 6-foot wide cutter (Figure 16). A curlyleaf pondweed checklist is shown on the next page and a map of curlyleaf distribution is shown in Figure 17.

Figure 16. Weaver Lake cutting crew at work in 1998 cutting curlyleaf pondweed. The Little Elk Lake Association could organize a similar effort if they wanted to control curlyleaf.

Little Elk Lake Curlyleaf Pondweed Cutting Project Checklist:

- ☑ Make a map of the curlyleaf distribution in your lake. Note other plant species as well.
- ☑ Calculate acres of curlyleaf pondweed.
- ☑ Set-up a demonstration site. Cut an acre or so to see how the technique works, how much effort is involved, etc.
- ❑ Divide lake into workable segments and assign a shore captain for each segment.
- ❑ Assume a large-scale program will be a 3-year project. Put aside a budget: 1st year costs range from $100/acre to about $200/acre. Second and third year costs are about half your first year costs.
- ❑ Order cutters, buoys, gloves, rope, and sharpeners. About one cutter for every five to ten acres is needed.
- ❑ Get a plant permit from the MnDNR.
- ❑ Set up a plant collection plan.
- ❑ Produce and distribute one or more flyers that explain the project. Also ask for volunteers.
- ❑ Consider the liability issue - do volunteers sign release waivers, do they let their insurance handle hospital bills, or is there some other arrangement.
- ❑ Order t-shirts, coffee mugs, etc for volunteer workers.
- ❑ Start scouting curlyleaf in early May.
- ❑ Set up a training session for cutting crews.
- ❑ When curlyleaf is about 15 nodes, notify shore captains that they can get their crews going.
- ❑ Sharpen cutters often . . . some do it every day.
- ❑ Notify plant pickup crews that plants will be coming in.
- ❑ Take notes on percent of the segment that has been cut.
- ❑ Keep track of the amount of plants you take out of the lake.
- ❑ In fall, check stem densities in areas you cut and in areas that were not cut.
- ❑ Store equipment, make repairs, and prepare for next year.

Observations from Multi-lake Cutting Projects

- ☻ Experience has shown you will be able to cut about 50% of the curlyleaf acreage in the lake.
- ☻ It is hard to exactly cut non-overlapping lanes.
- ☻ Cutting curlyleaf was harder work than most thought it would be.
- ☻ It is a little tricky to keep track of who has the cutters and where they all are at the end of the year.
- ☻ Two of the biggest problems encountered were going to fast which lifts the cutter off the bottom and cutting for too long of a period and not removing the weeds that overlapped on the cutting edge of the blades.

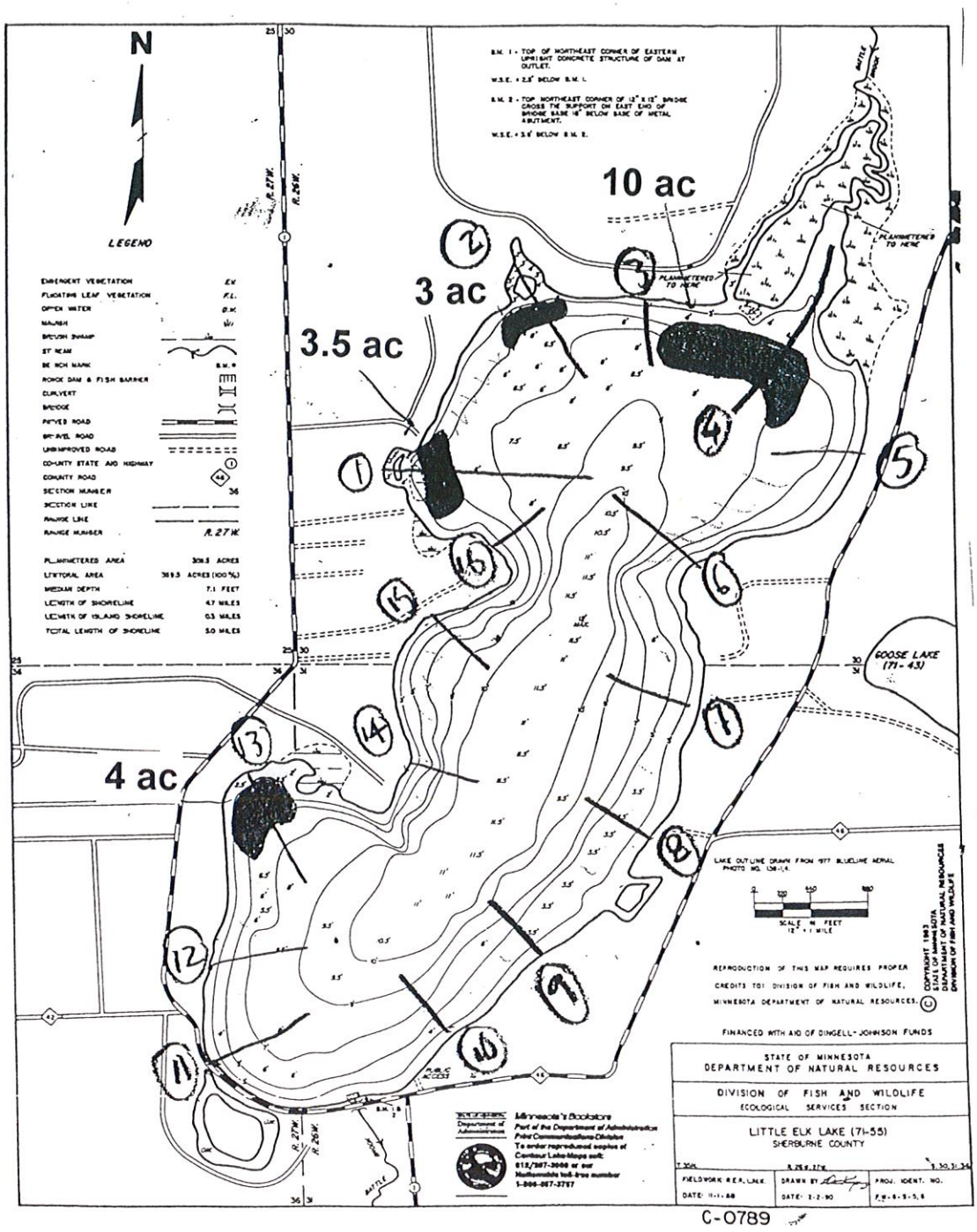


Figure 17. Curlyleaf pondweed map of Little Elk Lake based on the May 2000 plant survey. Areas of nuisance growth are shown in black. Transects used in the plant survey are represented by lines and a number within a circle.

Drawdown for Nuisance Plant Control

Lowering the lake level is a lake management technique going back to the days of Issac Walton in the 1500s. A drawdown in Little Elk Lake could help control curlyleaf pondweed and also reestablish the fish community. A drawdown could control curlyleaf pondweed by freezing and killing the turions (plant buds) exposed in the sediments over winter. A drawdown in Rice Lake, Maple Grove, Minnesota in 1997 and in 1998 eliminated up to 95% of the curlyleaf in the areas where sediments were exposed. In addition, native plants are returning to areas once dominated by curlyleaf pondweed. The downside is that the fish community would be severely impacted. Fish would come back from Battle Creek and from stocking.

For Little Elk Lake, the first step would be to evaluate the feasibility of a drawdown from an environmental, economic, and lake user perspective. After a feasibility study and lake meetings, a decision would be made on a drawdown project. The lake would have to be pumped to drain it. It is estimated that pumps would be used for around 50 days at a cost up to $1,000 per day. The total drawdown project could cost up to $50,000.

The existing water level control structure only holds back about 2 feet of water. To lower Little Elk Lake further would require pumping.

6.5. Fish management projects

Carp Reduction Program

Carp can be significant contributors to sustaining poor water quality in lakes. For Little Elk Lake, the carp program has three phases. The first phase is to get a better estimate on the carp population in Little Elk Lake. This is done by observing spawning activity and by setting trap nets. The second phase is to devise a long term plan that involves different methods needed for carp control. The third phase is implementation with the various netting and trapping methods employed.

Winter Aeration

The Little Elk survey results showed that fishing was the third major recreational activity on the lake. Occasional fish winterkills have adversely impacted the fish population.

If a fish community is to be sustained, winter aeration is recommended. Two types of aeration system are considered. One is a cascade system and the other is a buffer/diffusion. If lake improvement projects actually improve water clarity and sustaining a fishery is requested by the Lake Association, aeration systems would be evaluated more closely with the pro's and con's, and costs described in detail.

6.6. Lake monitoring program

Continue Lake Monitoring

To evaluate Little Elk Lake, a monitoring program should be ongoing. This program will address the issues of:

- Effectiveness of watershed projects in regard to phosphorus in runoff.
- Changes in lake quality as measured by total phosphorus, Secchi disc, algae, and macrophyte distribution.

Lake monitoring details: Secchi disc transparencies should continue to be taken monthly through the summer (from May through September). The lake association should stay in the Citizens Lake Monitoring Program, sponsored by the MPCA, to carry out the Secchi disc monitoring program. If the funds are available lake surface water samples should be collected and analyzed for total phosphorus and chlorophyll a. Samples should be collected once per month from May through September. The cost would be about $400.

If the budget or MnDNR manpower is available, an aquatic plant survey should be conducted once per year to measure the coverage in acres of plants and to characterize the dominant plant species, especially if the lake management projects are being implemented.

Continue to Evaluate Battle Brook

It would be helpful to have additional information on water quality and the water quantity characteristics of Battle Brook. If the funds are available, a flow monitoring stations at County Road 9 would be appropriate. These stations cost about $5,000 a year to run and collect data. It would be less if the SWCD could operate the station.