Alfred Thompson Bricher: ***Drifting*, 1886**

Lake Management Plan for Muskellunge Lake, Vilas County, Wisconsin

July 2005

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with contributions from Wisconsin Department of Natural Resources and the Muskellunge Lake Association

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Lake Management Plan for
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1. Introduction and Project Setting

Muskellunge Lake is located in Vilas County, Wisconsin (Figure 1). Muskellunge Lake characteristics are shown in Table 1.

The objectives of this study were to characterize existing lake conditions and to make recommendations to protect and improve the lake environment where feasible.

Table 1. Lake statistics (Robertson et al 2003).

	Muskellunge Lake
Size (acres)	272
Mean depth (ft)	9.3
Maximum depth (ft)	19

Figure 1. Muskellunge Lake is located in Vilas County, Wisconsin.

2. Glaciers and Soils

Muskellunge Lake was formed approximately 10,000 years ago during the last glacial retreat of the Wisconsin Valley Lobe (Figure 2). The soils deposited by the Wisconsin Valley Lobe glacier were primarily sands and loamy-sands. Beneath these soils, at depths of about 50-350 feet, is Precambrian bedrock that is over one billion years old. The bedrock is referred to as the North American shield.

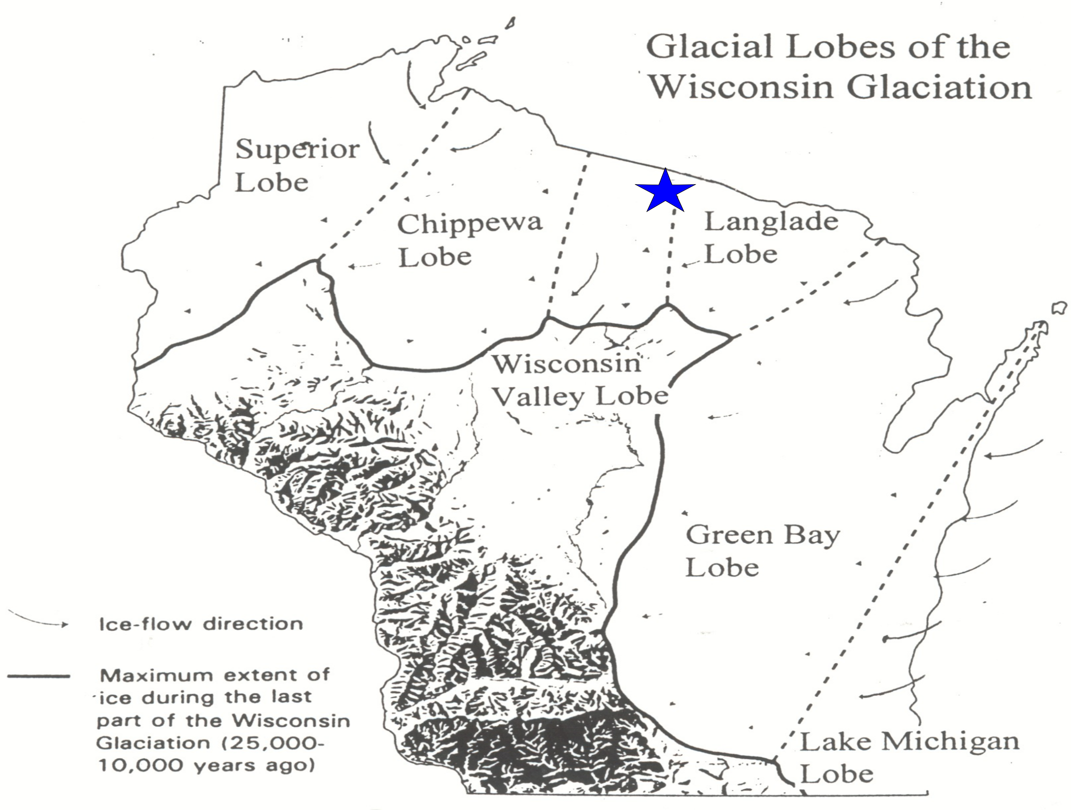


Figure 2. Glacial lobes of the Wisconsin glaciation. Muskellunge Lake is located in the Wisconsin Valley lobe.

Soil composition reflects the parent material that is present. Muskellunge Lake is located in an area dominated by forested silty soils and adjacent to forested loamy soils (Figure 3).

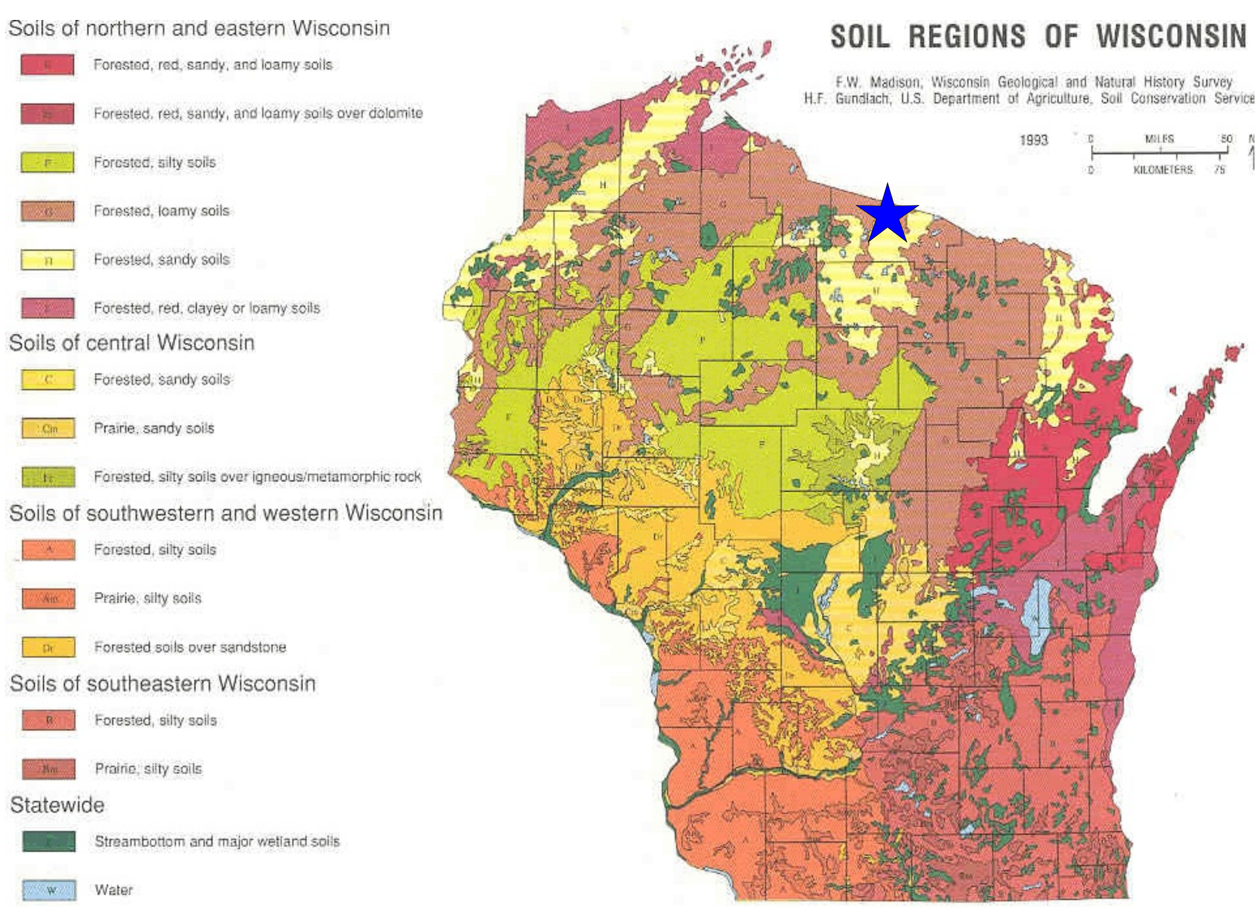


Figure 3. Muskellunge Lake is located within a soils group characterized as forested silty soils.

3. Watershed Features

3.1. Drainage Area and Land Use of Muskellunge Lake

Muskellunge Lake and its watershed is located within Vilas County and is composed of wetlands and forested land. The Muskellunge Lake outflow drains to St. Germain Lake to the southwest.

The direct drainage area to Muskellunge Lake is 550 acres (from a report Robertson et al 2003) and the delineation is shown in Figure 4. The watershed to lake ratio of Muskellunge Lake is 2 to 1. Typically a small watershed like this should yield low phosphorus loads to the lake resulting in good water clarity. However, the overall watershed includes more area than just the direct drainage area.

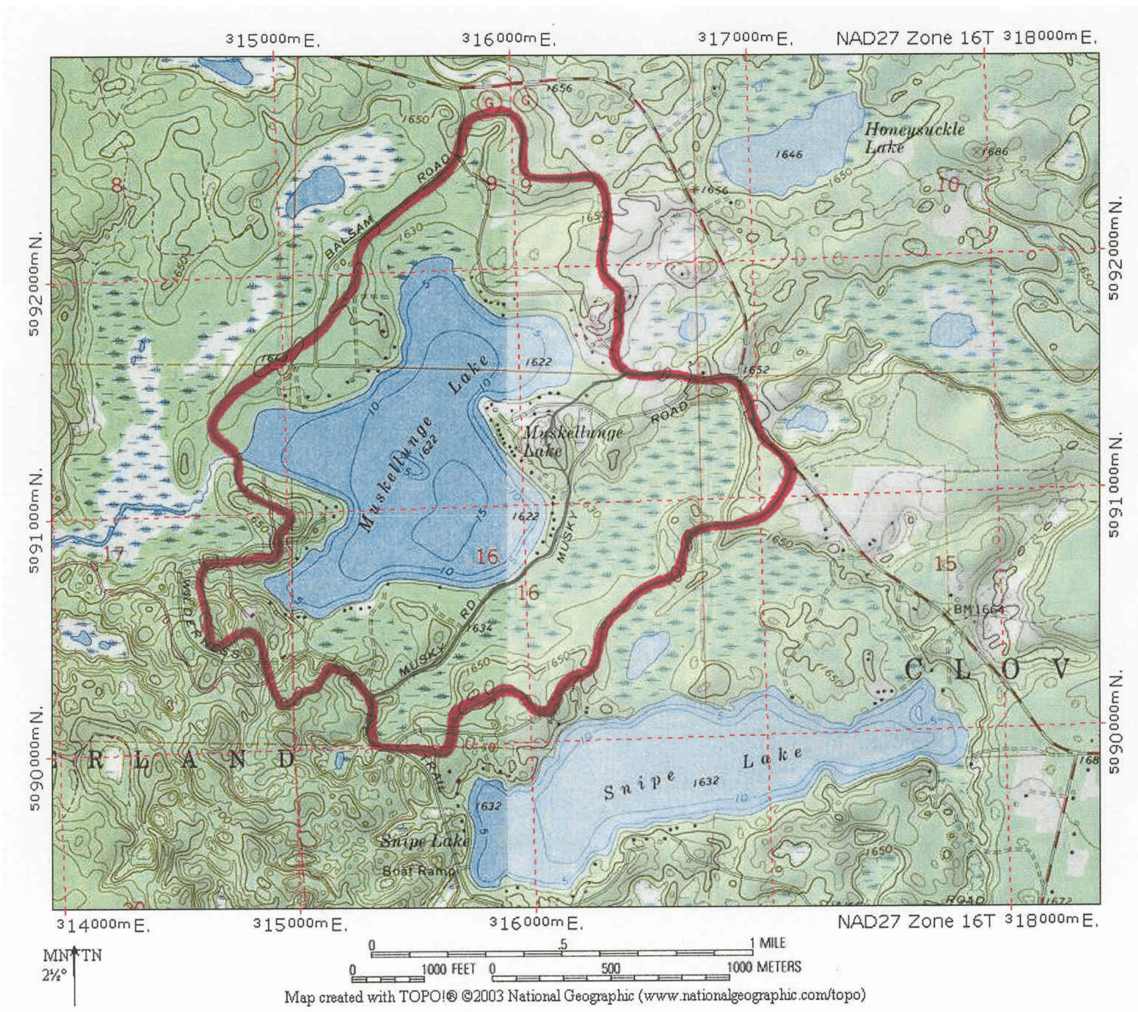


Figure 4. The direct drainage watershed area for Muskellunge Lake is outlined in red (source: Robertson et al 2003).

In another USGS report (Rose et al 2002, page 102) the watershed is given as 2,874 acres (which includes the lake area) or 2,602 acres not including 272 acre Muskellunge Lake. This Muskellunge Lake watershed is shown in Figure 5 and the map is from a report on Little St. Germain Lake (from Robertson and Rose 2000). This watershed delineation includes Snipe Lake and encompasses a larger watershed than just the surface water runoff watershed. This larger watershed area includes surface water and groundwater inputs to Muskellunge Lake. The revised watershed area to lake area ratio is now about 10 to 1. This may explain why Muskellunge Lake produces algae blooms in the summer. The larger drainage area may bring in more nutrients.

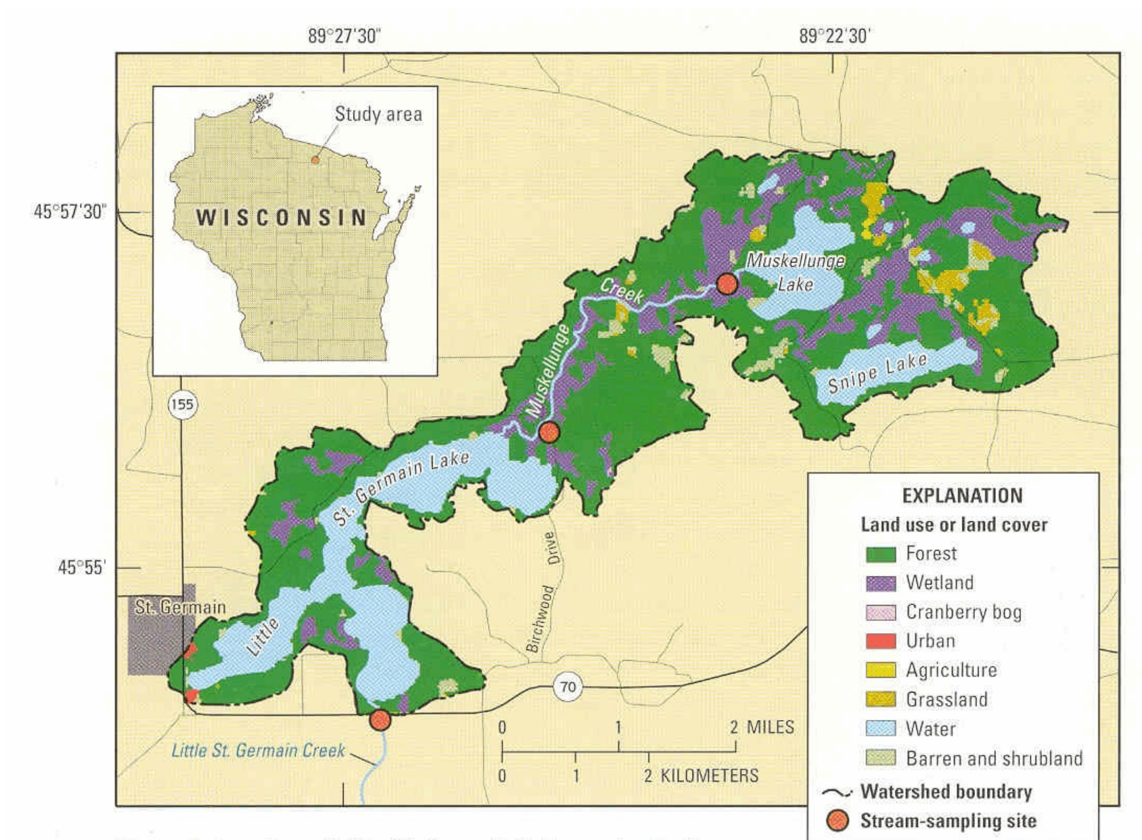


Figure 1. Location of Little St. Germain Lake, watershed characteristics, and location of stream-sampling sites.

Figure 5. A larger watershed area was delineated in a report on Little St. Germain Lake (figure from Robertson and Rose 2000).

3.2. Source of Water and Nutrients to Muskellunge Lake

Water: The source of water to Muskellunge Lake is from a combination of surface runoff, rainfall, and groundwater. The amount of water flowing into and out of Muskellunge Lake is estimated to be about 2 cubic feet per second. Flows were estimated based on runoff amounts listed for Vilas County in the Wisconsin Spreadsheet Lake Model (Table 2). Much of the flow is through groundwater springs.

Table 2. Average annual water flow into Muskellunge Lake.

Drainage area (not including the lake) (acre)	550 (Robertson et al 2003) (surface drainage)	2,602 (Rose et al 2002) (contributing area)
Average yearly runoff for Vilas County (feet)(from WDNR WILMS Model)	1.17	1.17
Total water inflow (acre-feet)	644	3,044

The estimated 3,044 acre-feet of water flowing into Muskellunge Lake in one year would be enough water to fill a swimming pool the size of a football field to a depth of 3,000 feet. It would also be enough drinking water to supply a town of 36,000 for a year.

Although this is a lot of water coming into Muskellunge Lake, the volume of Muskellunge Lake is 2,530 acre-feet. If Muskellunge Lake completely dried up, it would take 10 months to fill.

Watershed Nutrients: The primary source of phosphorus from the watershed of Muskellunge Lake is from forested and wetland areas. There is very little agricultural acreage contributing phosphorus to Muskellunge Lake. In a previous study by the USGS, phosphorus inputs from groundwater inflow were considered to be significant.

3.3. Shoreland Inventory

The shoreland area encompasses three components: the upland fringe, the shoreline, and shallow water area by the shore. A photographic inventory of the Muskellunge Lake shoreline was conducted on August 7, 2004 by lake resident volunteers and Blue Water Science. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For analysis, each photograph was evaluated by Blue Water Science staff for shoreline and upland conditions. Our criteria for natural conditions were the presence of 50% native vegetation in the understory and at least 50% natural vegetation along the shoreline in a strip at least 15 feet deep. Although the shoreline recommendations for new development is a 35-foot deep buffer, a 15-foot deep buffer is about the minimum needed to achieve some degree of runoff water quality treatment. We evaluated shorelines and uplands at the 75% natural level as well (Figure 6 illustrates the methodology).

A summary of the inventory results is shown in Table 3. Based on our subjective criteria over 80% of the parcels in the Muskellunge Lake shoreland area meet the natural ranking criteria for shorelines and upland areas. This is about average for “northern Wisconsin lakes” where 50% of the parcels meet the “natural” criteria. Country lakes are defined as lakes found about 1 to 2 hours driving time outside of a major Metropolitan area such as Minneapolis/St. Paul or Milwaukee.

In the next 10 years proactive volunteer native landscaping could improve the natural aspects of a number of parcels.

A comparison of Muskellunge Lake conditions to other lakes in Minnesota and Wisconsin is shown in Table 4 and in Figure 7.

Table 3. Summary of shoreline buffer and upland conditions in the shoreland area of Muskellunge Lake. Approximately 129 parcels were examined.

	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
MUSKELLUNGE LAKE TOTALS (no. of parcels = 129)	88% (114)	76% (98)	81% (104)	62% (80)	8% (10)	17% (22)	1% (1)

Figure 6. [top] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory with greater than 50% natural cover.
[bottom] This parcel would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also understory in the upland area would be rated as having less than 50% natural cover.

Table 4. Summary of shoreland inventories from Muskellunge Lake and 35 other lakes in Minnesota and Wisconsin.

Lake	Eco-region	Date of Survey	Total Number of Parcels (#)	Undevel. Parcels % (#)	Natural Upland Condition		Natural Shoreline Condition		Parcels with Erosion % (#)	Parcels with Shoreline Revetment % (#)
					> 50% % (#)	>75% % (#)	> 50% % (#)	>75% % (#)		
NORTHWOODS LAKES										
Ballard chain Vilas Co, WI	LF	7.23.99	110	--	98 (108)	96 (106)	96 (106)	95 (105)	--	0
Pike Chain Price & Vilas Co, WI	LF	2001	722	380	92 (633)	87 (626)	95 (684)	91 (654)	--	5 (34)
Bear Oneida Co, WI	LF	6.8.99	115	6 (7)	93 (107)	78 (90)	84 (97)	77 (89)	1 (1)	8 (9)
Van Vliet Vilas Co, WI	LF	6.04	100	20 (20)	93 (93)	65 (65)	82 (82)	68 (68)	8 (8)	11 (11)
Muskellunge Vilas Co, WI	LF	8.7.04	129	8 (10)	81 (104	62 (80)	88 (114)	76 (98)	2 (2)	18 (23)
Big Bear Lake Burnett Co, WI	LF	9.11.02	87	13 (11)	82 (71)	62 (54)	86 (75)	76 (66)	0	9 (8)
Nancy Lake Washburn Co, WI	LF	9.21.00	217	19 (41)	77 (167)	65 (141)	80 (174)	72 (156)		5 (11)
Plum Lake Vilas Co, WI	LF	7.26.01	225	13 (30)	75 (169)	58 (130)	81 (182)	708(158)	--	9(4)
Big Bearskin Oneida Co, WI	LF	8.10.99	130	--	73 (95)	63 (82)	80 (104)	67 (87)	--	0
COUNTRY LAKES										
North Pipe Lake Polk Co, WI	CHF	8.03	80	45 (36)	100 (80)	96 (77)	94 (75)	91 (73)	0	1 (1)
Upper Turtle Lake Baron Co, WI	CHF	7.23-24.02	309	28 (85)	72 (224)	58 (178)	76 (234)	68 (209)	0	20 (63)
Lower Turtle Barron Co, WI	CHF	7.23.04	127	9 (12)	43 (54)	29 (37)	82 (104)	71 (90)	1 (1)	6 (8)
Pipe Lake Polk Co, WI	CHF	8.03	217	8 (17)	67 (144)	50 (108)	63 (137)	56 (121)	0	22 (48)
Little Pelican Otter Tail Co, MN	CHF	9.16.04	119	33% (39)	55% (65)	61% (51)	66% (79)	61% (73)	33 (39)	23 (27)
Comfort Chisago Co, MN	CHF	10.9-11.2.98	100	--	62 (62)	--	50 (50)	--	--	12 (12)
Lake Volney Le Sueur Co, MN	CHF	9.21.02	79	25 (20)	54 (43)	42 (33)	56 (44)	47 (37)	0	30 (24)
Rush Lake Chisago Co, MN	CHF	9.16.00	524	11 (58)	48 (253)	28 (147)	51 (267)	38 (201)	1 (3)	18 (92)
West Rush Lake, Chisago Co, MN	CHF	9.16.00	332	12 (40)	52 (171)	31 (103)	55 (184)	43 (142)	1 (2)	15 (50)
East Rush Lake, Chisago Co, MN	CHF	9.16.00	192	9 (18)	43 (82)	23 (44)	43 (83)	31 (59)	1 (1)	22 (42)
Fish Otter Tail Co, MN	CHF	9.16.04	95	21% (20)	38% (36)	36% (34)	43% (41)	36% (38)	48 (46)	7 (7)
Big Round Lake, Polk Co, WI	CHF	8.03	74	14 (10)	27 (20)	24 (18)	39 (29)	34 (25)	1 (1)	14 (10)
Bass Otter Tail Co, MN	CHF	9.16.04	22	0% (0)	6% (27)	3% (14)	41% (9)	41% (9)	68 (15)	2 (2)
Pelican Otter Tail Co, MN	CHF	9.16.04	881	14% (2)	21% (183)	14% (123)	21% (181)	16% (142)	2 (14)	80 (706)
Green Lake Kandiyohi Co, MN	CHF	9.19.01	721	1 (9)	20 (146)	12 (88)	19 (140)	14 (100)	0	62 (446)
Diamond Lake Kandiyohi Co, MN	CHF	8.13 & 14.02	344	2 (7)	13 (44)	11 (39)	16 (56)	12 (42)	1 (5)	49 (168)

Lake	Eco-region	Date of Survey	Total Number of Parcels (#)	Undevel. Parcels % (#)	Natural Upland Condition		Natural Shoreline Condition		Parcels with Erosion % (#)	Parcels with Shoreline Revetment % (#)
					> 50% % (#)	>75% % (#)	> 50% % (#)	>75% % (#)		
METROPOLITAN LAKES										
Ravine Lake Washington Co, MN	CHF	7.19.01	9	100 (9)	100 (9)	100 (9)	100 (9)	100 (9)	0	0
Pike Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	9	56 (5)	100 (9)	100 (9)	100(9)	100 (9)	0	0
Powers City of Woodbury, MN	CHF	1998	30	90 (27)	90 (27)	90 (27)	97 (29)	97 (29)	0	0
Lake Edward, City Maple Grove, MN	CHF	9.30 - 10.12.99	34	12 (4)	91 (31)	88 (30)	76 (26)	71 (24)	6 (2)	3 (1)
Rice Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	137	33 (45)	71 (97)	64 (87)	81 (111)	74 (102)	0	19 (25)
Lee Lake Dakota Co, MN	CHF	5.31.02	30	37 (11)	73 (22)	50 (15)	77 (23)	67 (20)	0 (0)	10 (3)
Fish Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	170	7 (12)	74 (126)	44 (75)	57 (97)	41 (70)	1 (1)	20 (34)
Alimagnet Lake Dakota Co, MN	CHF	8.6.03	108	37 (40)	54 (58)	47 (51)	69 (75)	61 (66)	0	16 (17)
Eagle Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	90	14 (13)	64 (58)	52 (47)	47 (42)	41 (37)	0	35 (32)
Cedar Island Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	93	5 (5)	62 (58)	35 (33)	55 (51)	39 (36)	0	22 (21)
Orchard Lake Dakota Co, MN	CHF	9.17.01	109	4 (4)	47 (51)	30 (33)	53 (58)	32 (35)	0	54 (59)
Lac Lavon Dakota County, MN	CHF	9.9.03	110	7 (8)	54 (59)	44 (48)	42 (46)	30 (33)	0	8 (9)
Upper Prior Scott Co, MN	CHF	9.30 - 10.12.99	366	10 (37)	51 (187)	36 (132)	35 (128)	31 (113)	4 (15)	46 (168)
Weaver Lake, City Maple Grove, MN	CHF	9.30 - 10.12.99	111	5 (5)	47 (52)	28 (31)	44 (49)	29 (32)	0	14 (16)
Lower Prior Scott Co, MN	CHF	9.24-30.99	691	10 (66)	36 (249)	24 (166)	22 (152)	17 (117)	5 (35)	54 (373)
Maple Grove Lake Summary, MN	CHF	9.30 - 10.12.99	644	14 (89)	67 (431)	48 (312)	60 (385)	48 (310)	1 (3)	20 (129)

* CHF = Central Hardwood Forest Ecoregion
** LF = Lake and Forests Ecoregion

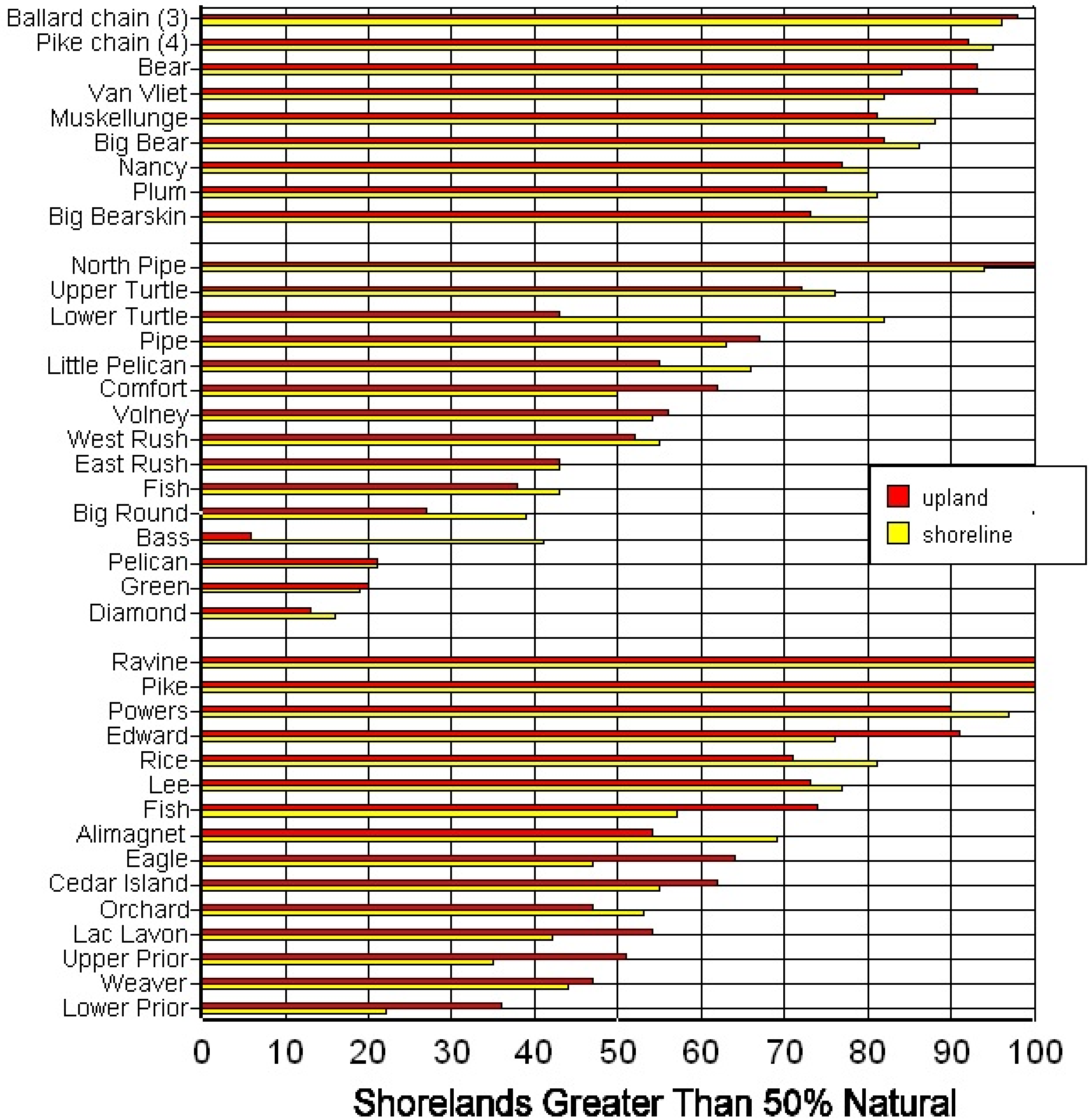


Figure 7. A summary of shoreland inventory results for lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown. The first tier of lakes are located in northern Wisconsin. The lower tier of lakes are in the Twin City Metropolitan area and are considered urban lakes. Although several lakes are "urban" lakes most of the shoreland is owned by the city and there is a high percentage of natural conditions. The middle tier of lakes are about an hour or two drive from the Twin Cities, and are not considered to be urban lakes, but are referred to as "country" lakes.

Muskellunge Lake is in the northern Wisconsin tier of lakes. It's natural shoreland conditions are about average compared to the other northern Wisconsin lakes.

3.4. Muskellunge Lake Wildlife Inventory - 2004

Wildlife were observed in the Muskellunge Lake shoreland area through 2004 (as reported by the Muskellunge Lake Association and submitted by Justine White-Richards).

BIRDS

- Indigo Bunting
- Grosbeak
- Eastern Kingbird
- Blue Heron
- Baltimore Oriole
- Osprey
- Hummingbirds
- Kingfisher
- Robin
- Cowbird
- Cardinal
- Bluejay
- Mourning Dove
- Gray Jay
- Loon
- Eagle
- Whip-poor-will
- Finch
- Duck
- Merganser
- Wood
- Mallard
- Buffel Head

MAMMALS

- Whitetail Deer
- Otter
- Fischer
- Beaver
- Weasel/Ermine
- Muskrat
- Black Bear
- Coyote
- Wolf
- Porcupine
- Raccoon
- Squirrel
- Red/pine
- Gray/black
- Flying
- Red Fox
- Mice/Moles
- Turtle

3.5. Groundwater and On-site Wastewater Treatment Systems

Groundwater inflow was evaluated by the US Geological Survey in 2000 and reported in 2003 (Robertson et al 2003).

Muskellunge Lake may be receiving groundwater inflows about 2,000 acres (Figure 8). It is not surprising that springs are found in Muskellunge Lake. This was an active glacial area is the past and often leads to subsurface groundwater inflows. The estimated area that contributes groundwater is close to the estimated contributing area shown previously in Figure 5.

In the lake modeling section of this report, a contributing watershed area of 2,602 acres is used. This combines surface and groundwater contributing areas.

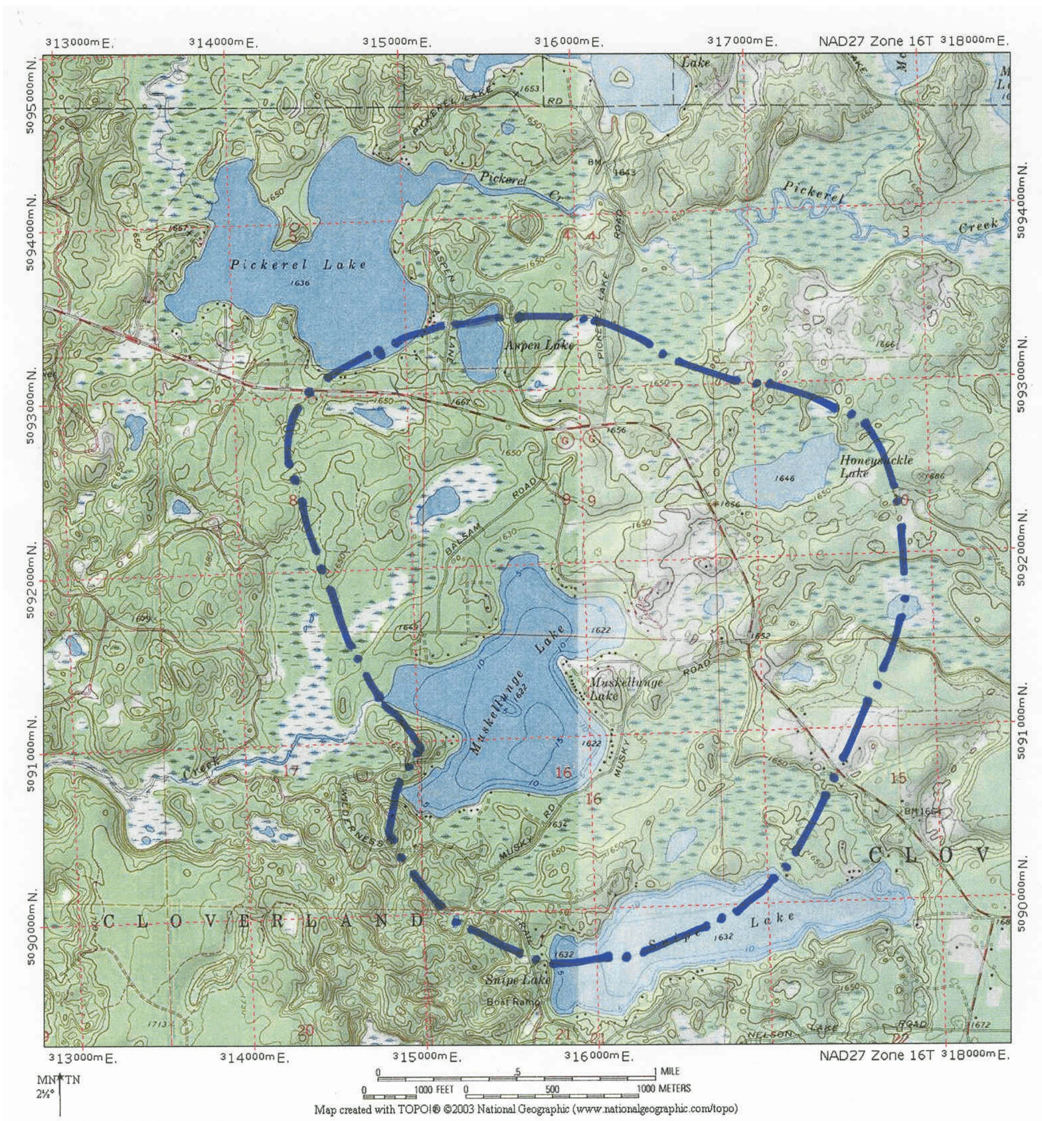


Figure 8. Muskellunge Lake ground watershed based on USGS estimates.

Onsite Systems Status: Onsite systems appear to be in mostly good condition based on the surrounding soils which are conducive to good infiltration, and the setback of the cabins and homes. A conventional onsite system is shown in Figure 9. With proper maintenance (such as employing a regular pumping schedule) onsite systems are an excellent wastewater treatment option. The challenge is to maintain systems in good working condition.

Based on this setting and from feedback from the questionnaire survey (shown on page 45) onsite system functions should be comparable to many other lake settings in the county. Most of the systems are probably operating satisfactorily but there are a few old systems or undersized systems that are probably operating poorly. It was not the aim of this study to evaluate individual onsite systems. That could be a future project but it does not appear to be necessary at this time.

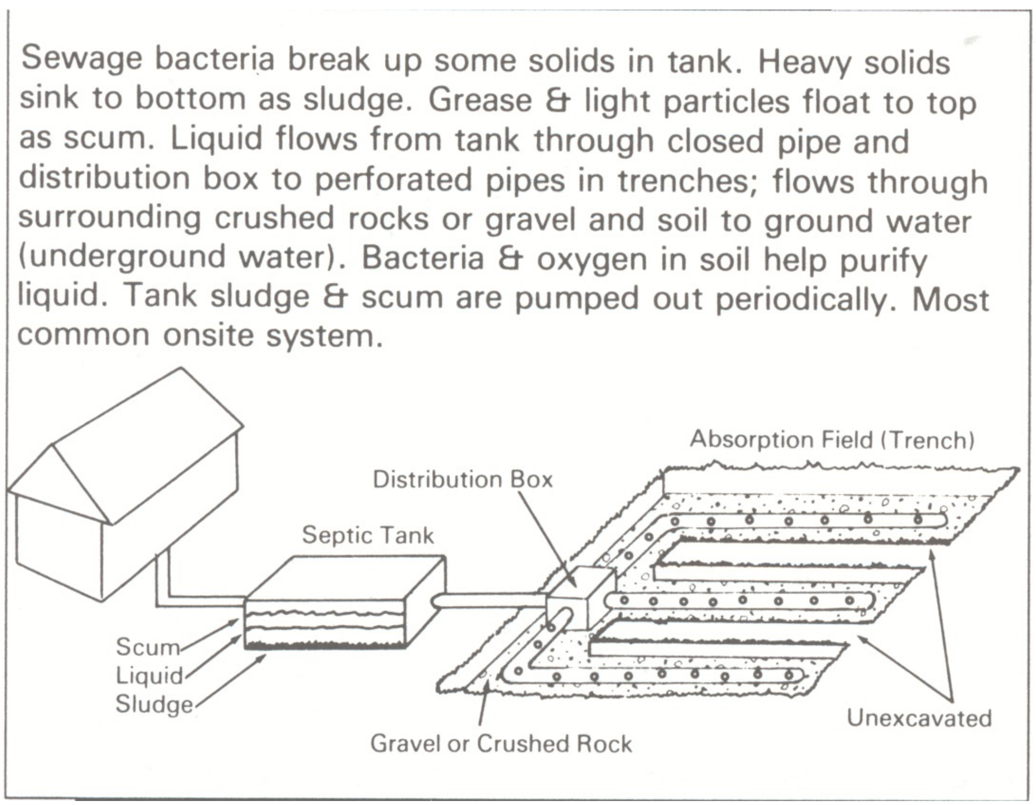


Figure 9. Typical onsite wastewater treatment system found in the Muskellunge Lake watershed.

4. Lake Features

4.1. Lake Map and Lake Statistics

Muskellunge Lake is approximately 272 acres in size, with a watershed of 550 acres and a contributing watershed of 2,602 acres (not including the lake acreage). The average depth of Muskellunge Lake is 2.8 meters (9.3 feet) with a maximum depth of 5.8 meters (19 feet) (Table 5). A lake contour map is shown in Figure 10. Muskellunge Lake is located in an area of Wisconsin that is dominated by forests and wetlands.

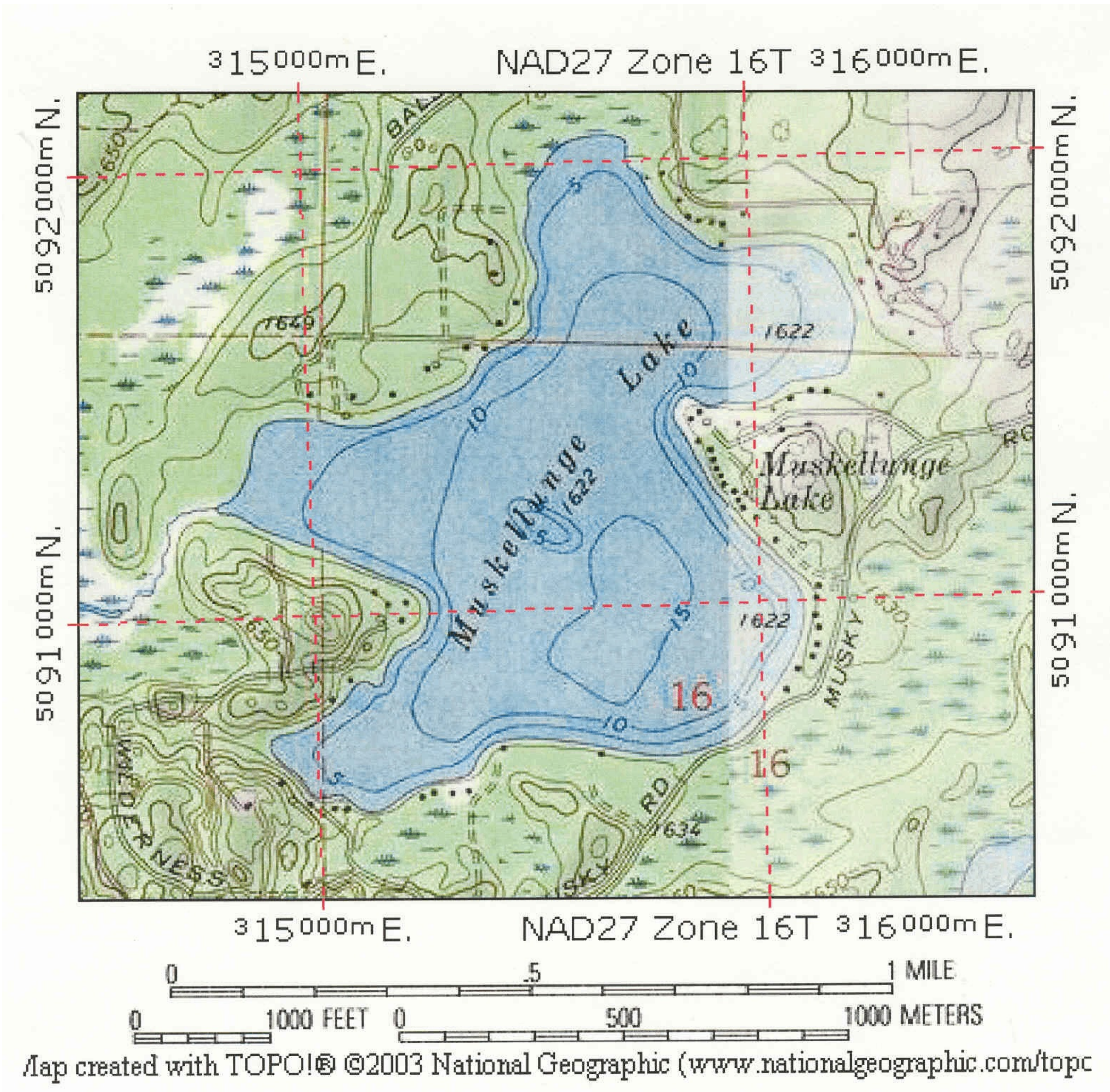


Figure 10. Muskellunge Lake, Vilas County, Wisconsin.

Table 5. Muskellunge Lake Characteristics

Area (Lake):	272 acres (110 ha)
Mean depth:	9.3 feet (2.8 m)
Maximum depth:	19 feet (5.8 m)
Volume:	2,530 acre-feet
Watershed area (including lake area):	2,874 acres (333 ha)
Watershed: Lake surface ratio	10:1
Public accesses (#):	1
Inlets:	1 or 2 intermittent streams (Intermittent means streams are sometimes dry and only flow when it rains or with snowmelt)

Figure 11. Outlet area, May 2004.

4.2. Dissolved Oxygen and Temperature

A number of dissolved oxygen and temperature profiles have been acquired over the years. Examples for 1998 - 2001 are shown on the next page. By examining the profiles, one can learn a great deal about the condition of a lake and the habitat that is available for aquatic life.

For example, the July 1999 profile shows that the lake was thermally stratified. **Thermally stratified** means that the water column of the lake is segregated into different layers of water based on their temperature. Just as hot air rises because it is less dense than cold air, water near the surface that is warmed by the sun is less dense than the cooler water below it and it "floats" forming a layer called the *epilimnion*, or *mixed layer*. The water in the epilimnion is frequently mixed by the wind, so it is usually the same temperature and is saturated with oxygen.

Below this layer of warm, oxygenated surface water is a region called the *metalimnion*, or *thermocline* where water temperatures decrease precipitously with depth. Water in this layer is isolated from gas exchange with the atmosphere. The oxygen content of this layer usually declines with depth in a manner similar to the decrease in water temperature.

Below the thermocline is the layer of cold, dense water called the *hypolimnion*. This layer is completely cut off from exchange with the atmosphere and light levels are very low. So, once the lake stratifies in the summer, oxygen concentrations in the hypolimnion progressively decline due to the decomposition of plant and animal matter and respiration of benthic (bottom-dwelling) organisms.

Because Muskellunge Lake is relatively shallow, it appears the lake can mix over the summer. For example, in August of 1999, the lake was mostly mixed from top to bottom.

Muskellunge Lake - dissolved oxygen and temperature profiles for 1998-2001

4.28.98
SD (ft): 4.5
TP (ppb): 59

Depth	Temp	DO
3	55	10.5
5	55	10.4
7	54	10.5
9	54	10.5
12	54	10.6
15	53	10.3
17	53	6.0

6.16.98
SD (ft): 5.5
TP (ppb): 30

Depth	Temp	DO
3	70	12.0
5	67	12.0
7	65	10.7
9	62	10.3
12	60	1.9
15	60	1.5

7.22.98
SD (ft): 3.8
TP (ppb): 81

Depth	Temp	DO
3	76	7.3
5	76	7.3
7	76	7.3
9	75	7.4
12	72	7.6
15	73	1.1

8.24.98
SD (ft): 3
TP (ppb): 57

Depth	Temp	DO
3	73	8.4
5	73	8.7
7	73	8.7
9	73	8.2
12	73	8.1
15	71	5.5
17	70	0.9

5.26.99
SD (ft): 4.8
TP (ppb): 36

Depth	Temp	DO
3	55	9.6
6	55	11.4
9	55	12.9
12	55	15.2
15	55	16.3

6.29.99
SD (ft): 3.3
TP (ppb): 43

Depth	Temp	DO
3	70	8.2
6	70	9.0
9	70	10.7
12	70	12.8
15	70	8.8

7.27.99
SD (ft): 2.5
TP (ppb): 51

Depth	Temp	DO
3	79	11.3
6	77.5	8.5
9	73	14.2
12	68	2.3
15	67	3.5

8.14.99
SD (ft): 2.0
TP (ppb): 71

Depth	Temp	DO
3	69	12.5
6	69	9.0
9	69	8.0
12	69	2.3
15	68	7.7

10.19.99
SD (ft): 5.6
TP (ppb): 41

Depth	Temp	DO
3	55	14.3
6	55	10.6
9	55	8.4
12	55	9.1
15	55	13.0

5.16.00
SD (ft): 10.3
TP (ppb): 21

Depth	Temp	DO
3	14.5	10.3
6	14.3	9.7
9	14.3	9.8
12	14.2	7.9
15	14	6.1

6.13.00
SD (ft): 6.0
TP (ppb): 28

Depth	Temp	DO
3	20.5	9.3
6	20.4	8.1
9	19.9	8.1
12	19.1	6.7
15	17	3.5

7.24.00
SD (ft): 3.5
TP (ppb): 41

Depth	Temp	DO
3	20.4	8.6
6	20.1	8.3
9	19.5	8.1
12	19.2	7.5
15	18.5	6.6

8.23.00
SD (ft): 3.8
TP (ppb): 54

Depth	Temp	DO
3	21.2	10.0
6	20.9	9.0
9	20.6	7.3
12	20.3	3.1

5.14.01
SD (ft): 5.3
TP (ppb): 37

Depth	Temp	DO
3	16.5	8.8
6	16.3	8.4
9	16	8.9
12	15.6	7.7
15	14.4	3.6
17	13.9	0.5

6.18.01
SD (ft): 4.5
TP (ppb): 46

Depth	Temp	DO
3	19.5	7.6
6	19.3	7.7
9	19.2	7.5
12	19	7.5
15	16.5	1.2

7.23.01
SD (ft): 4.0
TP (ppb): 49

Depth	Temp	DO
3	26.3	9.3
6	26.4	9.3
9	23.4	3.4
12	21.3	0.2
15	19.9	0.2
17	18.4	0.2

8.20.01
SD (ft): 2.5
TP (ppb): 75

Depth	Temp	DO
3	20.6	9.9
6	20.5	8.4
9	20.3	8.2
12	20.1	5.4
15	19.8	1.8
17	19.3	0.2

10.16.01
SD (ft): 3.8
TP (ppb): 63

Depth	Temp	DO
3	11.1	9.6
6	10.5	9.7
9	10.4	9.5
12	10.3	9.4
15	10.2	8.5
17	10.4	1.8

4.3. Lake Water Quality Summary

Summer water quality data were collected in 1991 - 2002, and 2004. Overall, the three water quality indicators (Secchi disc, total phosphorus, and chlorophyll a) indicate Muskellunge is moderately fertile.

Additional water quality evaluations are found in the next several sections.

Table 6. Summary of summer water quality data collected through the Citizen Self-Help Monitoring Program.

Date	Secchi Disc (ft)	TP - top (ppb)	Chlorophyll a (ppb)
1991			
7.30	3		
8.8	5		
8.15	4.5		
8.23	4		
9.1	3.75		
9.9	3		
9.16	2.75		
9.25	4		
Jul - Sept Avg	***3.6***		
1992			
5.4	5.5		
5.14	5.7		
5.30	6		
6.14	5.3		
6.29	4.7		
7.14	5.5	31	9
7.28	5.3		
8.13	3.5	38	15
8.15	4		
8.31	3.5		
9.14	4		
9.21	4	36	12
9.30	3.5		
May - Sept Avg	***4.7***	***35***	***12***

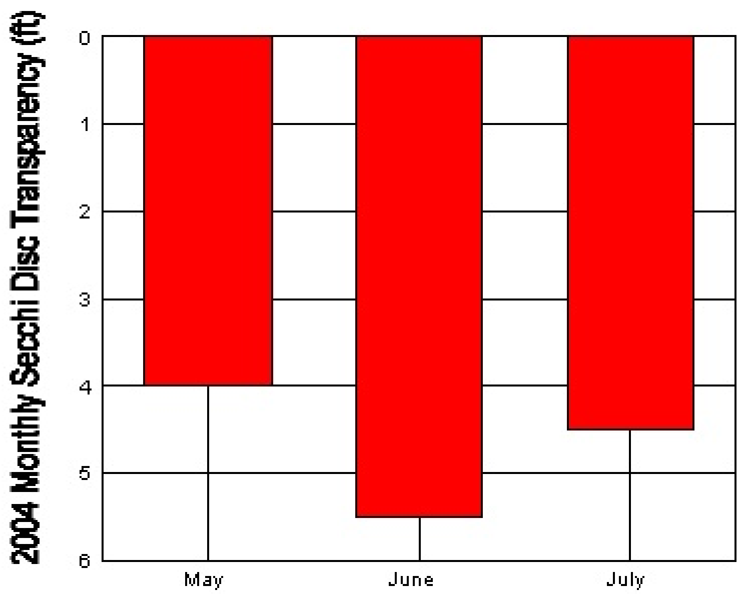
Date	Secchi Disc (ft)	TP - top (ppb)	Chlorophyll a (ppb)
1993			
5.12	6		
5.17	4	39	12
5.26	5		
6.9	4.5		
6.15	4	23	9
6.23	5.5		
7.7	4		
7.20	5	30	12
7.21	5		
8.4	4.25		
8.18	4		
8.23	3	39	14
9.1	4.5		
9.27	4.75		
May - Sept Avg	***4.6***	***33***	***12***
1994			
5.2	4.5		
5.16	4		
5.23	5.5	19	6
6.15	4		
6.29	3.5	39	20
7.1	3.75		
7.6	3.75		
7.11	3.5	44	21
7.21	3.75		
8.4	4		
8.18	3.25		
8.29	4	43	16
8.31	3.75		
9.14	4.25		
May - Sept Avg	***4.0***	***36***	***16***
1995			
5.18	3.5	46	14
6.20	6	21	6
6.28	9.5		
7.12	3	46	
7.16	15		
7.30	7.5		
8.7	3.5	50	
8.19	6.5		
May - Aug Avg	***6.2***	***41***	***10***

Date	Secchi Disc (ft)	TP - top (ppb)	Chlorophyll a (ppb)
1996			
5.29	2.5	58	37
6.25	3	43	14
7.29	2.75	52	22
8.21	4.75	30	18
May - Sept Avg	***3.3***	***46***	***23***
1997			
5.28	4.25	78	
6.22	4.75	74	8
7.28	3.75	51	23
8.25	3.5	63	29
May - Aug Avg	***4.1***	***67***	***20***
1998			
5.30	2.5		
6.15	3.5		
6.16	5.5	30	11
6.30	4		
7.8	4.5		
7.22	3.75	81	16
8.4	4		
8.18	3		
8.24	3	57	28
9.3	2.75		
9.30	3		
Avg	***3.4***	***56***	***18***
1999			
5.26	4.75	36	
6.29	3.25	43	23
7.27	2.5	51	35
8.14	2	71	91
May - Aug Avg	***3.1***	***50***	***50***
2000			
5.16	10.25	21	
6.13	6	28	8
6.26		27	
7.20		35	
7.24	3.5	41	11
8.18		57	
8.23	3.75	54	12
9.6	2.75		
9.25	4		
May - Sept Avg	***5.4***	***36***	***10***

Date	Secchi Disc (ft)	TP - top (ppb)	Chlorophyll a (ppb)
2001			
5.1		27	
5.14	5.25	34	
6.18	4.5	37	
6.19	3.75	46	9
7.2	4		
7.14	4		
7.20	3		
7.23	4	49	15
8.1	3.25		
8.15	3.5		
8.20	2.5	75	47
8.27		53	
9.4	4		
9.20	4.5		
May - Sept Avg	***4.1***	***46***	***24***
2002			
6.18		33	
June Avg	***--***	***33***	***--***
2004			
5.11	4	41	
6.13	5.5	41	9
7.19	4.5	19	43
May - July Avg	***4.7***	***34***	***26***

4.3.1. Secchi Disc Transparency

Water clarity is commonly measured with a Secchi disc. A typical seasonal pattern in lakes shows good clarity in May and June with a drop off in July and August. The low water clarity in late summer is usually due to algae growth. This pattern is not always found in Muskellunge. Water clarity summer averages from 1991 through 2004 are shown in Figure 12. The summer average for clarity in 2004 was less than 5 feet. Many lakes in the area have better clarity than Muskellunge.



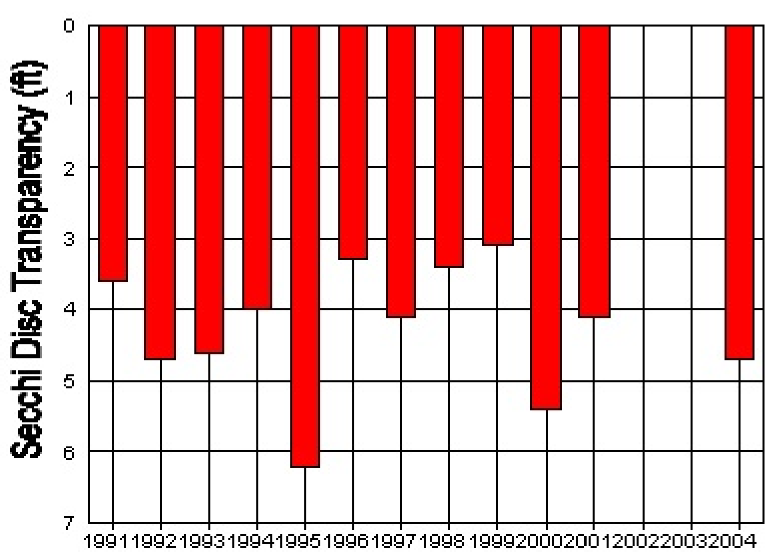


Figure 12. [top] Monthly Secchi disc readings in Muskellunge Lake in 2004. [bottom] Yearly Secchi disc readings for Muskellunge Lake.

4.3.2. Total Phosphorus

Phosphorus is the nutrient most often associated with stimulating nuisance algae growth. The more phosphorus in the lake, the more algae will be produced. Records of summertime lake phosphorus concentrations for Muskellunge Lake are shown in Figure 13. Phosphorus concentrations in Muskellunge Lake are moderate to high. When phosphorus concentrations get over 30 parts per billion (ppb) of phosphorus, that is high enough to produce algae growth that results in water clarity of 4 to 5 feet.

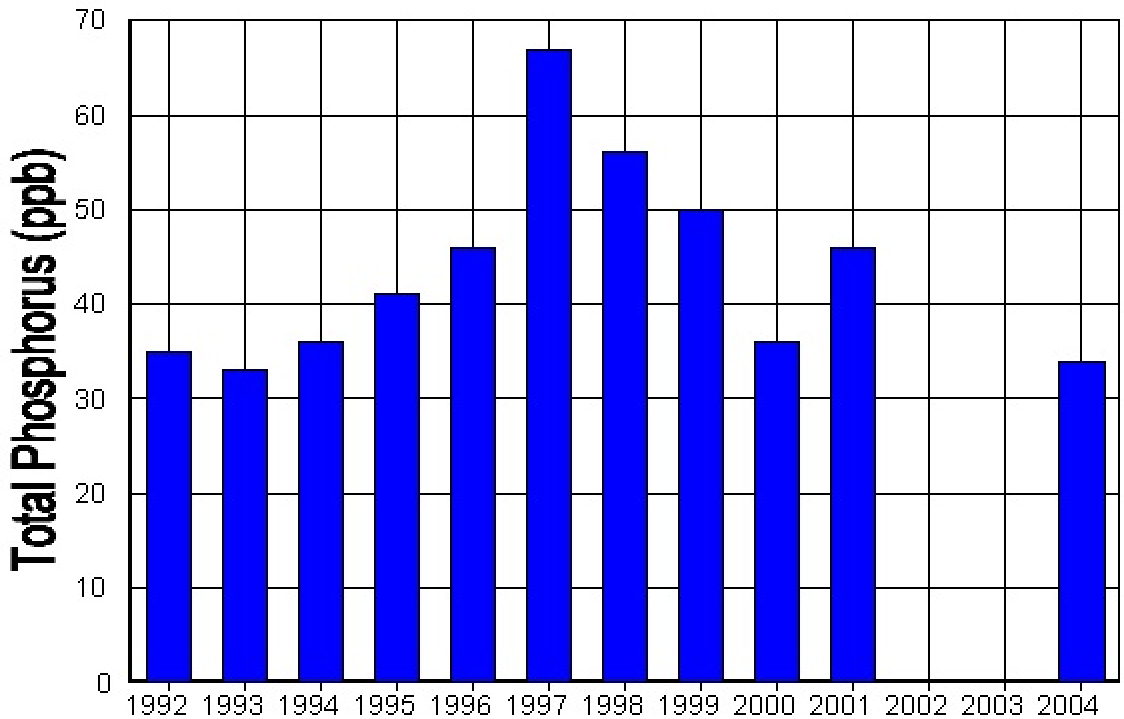


Figure 13. Yearly surface total phosphorus concentrations for Muskellunge Lake.

4.3.3. Chlorophyll a (a measure of algae)

Algae are small green plants, often consisting of single cells or grouped together in filaments (strings of cells). Because algae have chlorophyll, the amount of algae in the water can be characterized by measuring the chlorophyll content in lake water.

The amount of algae, as determined using chlorophyll measurements is directly influenced by the amount of phosphorus in the lake. Chlorophyll results from 1992 through 2004 are shown in Figure 14. Chlorophyll concentrations are moderate to high and this correlates with phosphorus concentrations which are also moderate to high.

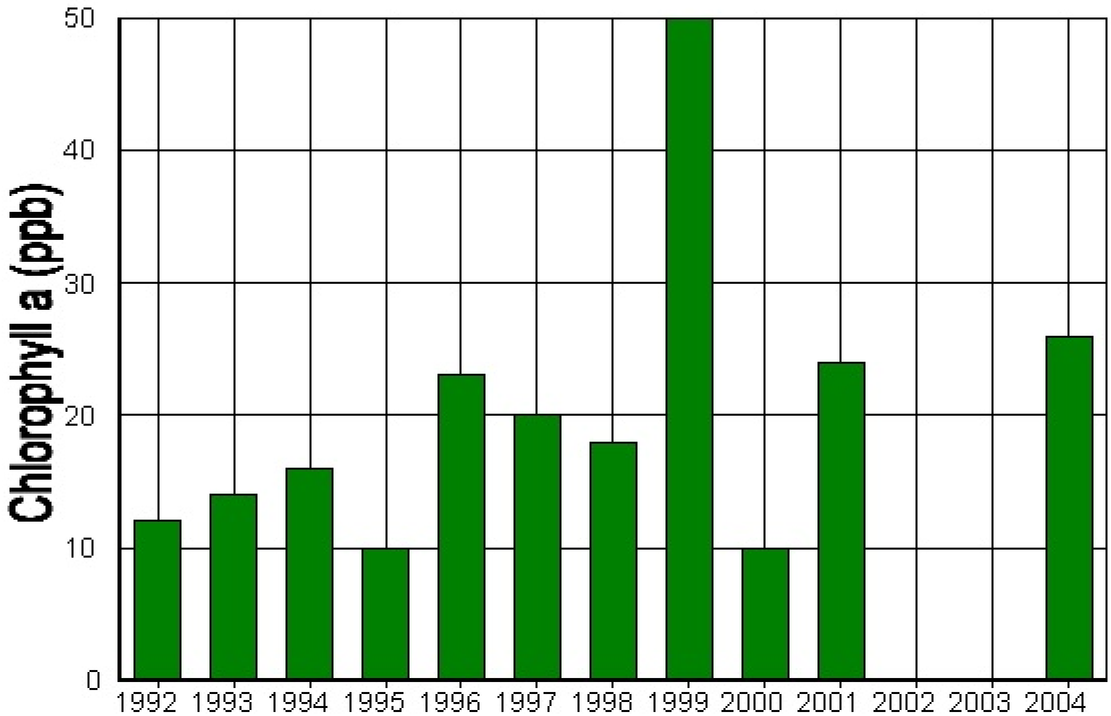


Figure 14. Yearly chlorophyll concentrations in Muskellunge Lake.

4.4. Algae

In mid to late summer, algae numbers increase and reduce transparency in Muskellunge Lake. The dominant late summer algal species in Muskellunge Lake in 2004 dinoflagellates and blue-green algae (Figure 15 shows a dinoflagellate). Both species had relatively high densities in August and are responsible for the low transparency in Muskellunge Lake.

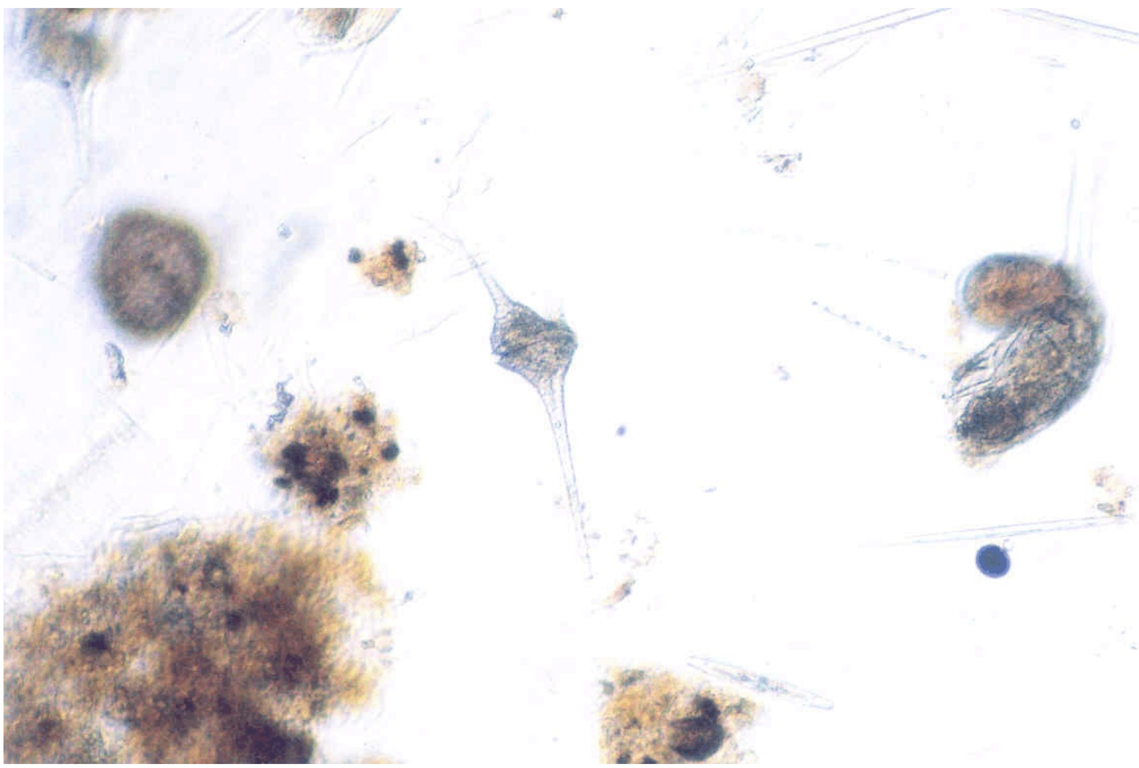


Figure 15. Dinoflagellate algae were present throughout the summer in Muskellunge Lake. A dinoflagellate is shown in the center of the picture.

4.5. Zooplankton

Zooplankton are small crustaceans that can feed on algae. A variety of different zooplankton are commonly found in lakes. An example of zooplankton species from Muskellunge Lake is shown in Figure 16. The zooplankton community in Muskellunge Lake is typical for lakes in Northern Wisconsin. In the photo, the image is magnified 150 times.

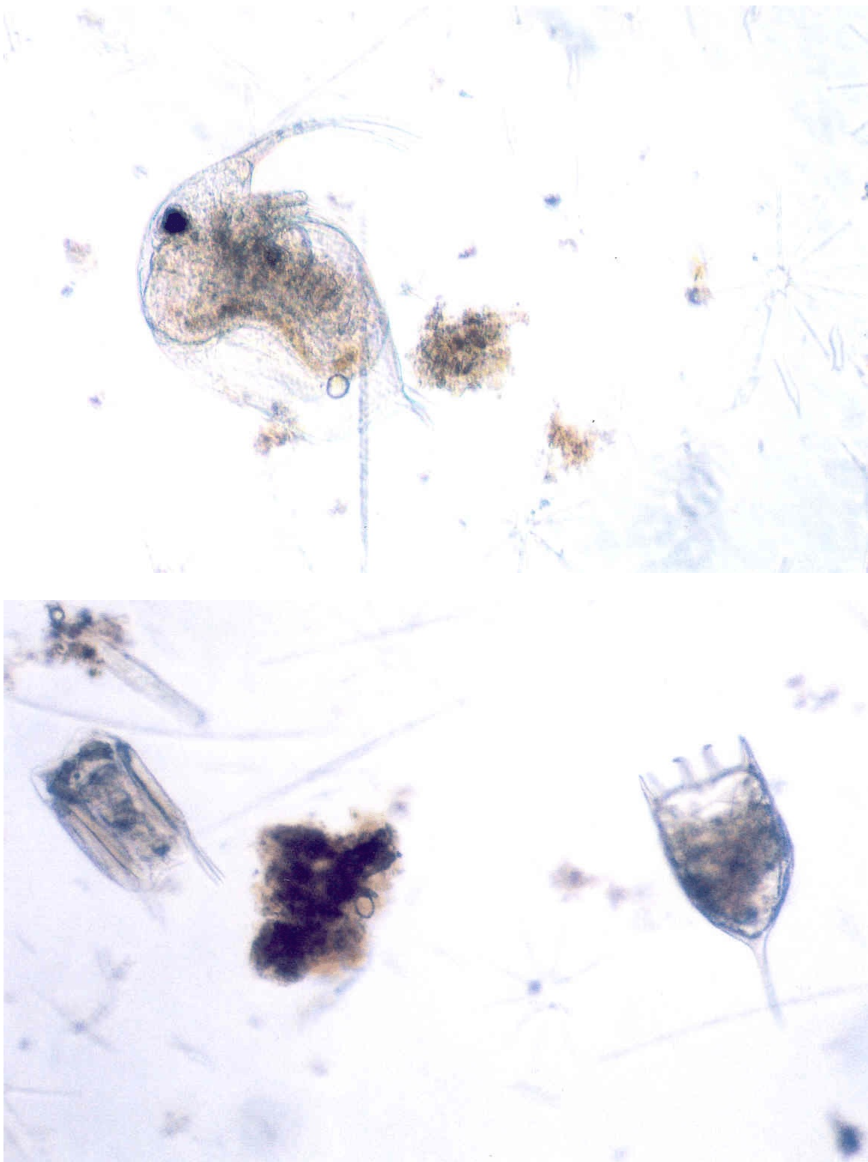


Figure 16. The animal in the upper left of the picture is a *Bosmina*, a cladoceran zooplankton that feeds on algae.

Zooplankton in Muskellunge Lake were sampled in May of 2004 and results are shown in Table 7. Chydorus was the dominant cladoceran but overall copepods and rotifers were the dominant zooplankton group. The number of large daphnids is somewhat low. This is a pattern found in many lakes, especially lakes with high panfish numbers.

Table 7. Zooplankton counts for Muskellunge Lake (organisms/liter).

(Tow length was 7 feet)	5.25.04 (#/l)
Big Daphnids	2
Little Daphnids	0
Ceriodaphnia	0
Bosmina	9
Chydorus	23
Cladoceran	**34**
Calonoids	3
Cyclopoids	31
Nauplii	28
Copepods	**62**
Rotifers	**222**
Total Zooplankton	**318**

4.6. Aquatic Plant Status

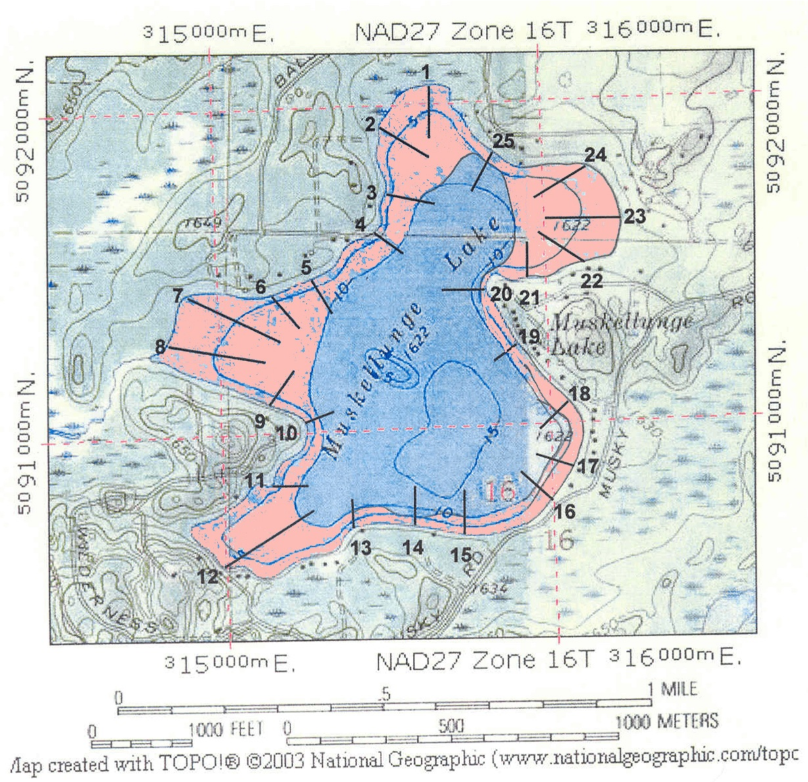
Aquatic plants are very important to lakes. They act as nurseries for small fish, refuges for larger fish, and they help to keep the water clear. Currently Muskellunge Lake has a fair diversity of aquatic plants and no exotic plants were detected.

Summary of Aquatic Plant Surveys for Muskellunge Lake in 2004: Two aquatic plant surveys were conducted in Muskellunge Lake in 2004. An early summer survey on May 25 and a late summer survey on August 25. A summary is shown in Table 8.

Table 8. Comparison of early and late summer surveys for Muskellunge Lake.

	% Occur	
	May 25	**August 25**
Sedges (*Carex sp*)	--	2
Arrowhead (*Sagittaria sp*)	--	2
Bulrush (*Scirpus sp*)	--	12
Floatingleaf burreed (*Sparganium sp*)	2	--
Cattails (*Typha sp*)	--	4
Wild rice (*Zizanis aquatica*)	--	2
Floatingleaf burreed (*Sparganium sp*)	2	--
Spatterdock (*Nuphar variegatum*)	6	12
White waterlily (*Nymphaea sp*)	10	14
Coontail (*Ceratophyllum demersum*)	74	80
Elodea (*Elodea canadensis*)	24	48
Water marigold (*Bidens Beckii*)	--	6
Northern watermilfoil (*Myriophyllum sibiricum*)	2	28
Naiads (*Najas flexilis*)	--	8
Stonewort (*Nitella sp*)	--	2
Cabbage (*Potamogeton amplifolius*)	26	30
Whitestem pondweed (*P. praelongus*)	28	42
Claspingleaf pondweed (*P. richardsonii*)	2	--
Fern pondweed (*P. robbinsii*)	2	2
Stringy pondweed (*P. sp*)	--	16
Flatstem pondweed (*P. zosteriformis*)	8	42
Water celery (*Vallisneria americana*)	--	36
Water stargrass (*Zosterella dubia*)	16	6

Early Summer Survey - May 25, 2004: Aquatic plants were surveyed in the early summer of 2004. The dominant plant was coontail, followed by whitestem pondweed. In May 2004, aquatic plant distribution was estimated to be at 143 acres (Figure 17). Of that coverage, plants grew to surface in a few areas.



Muskellunge Lake Transect Markers

Transect	GPS		Description
	East	North	
1	03 15 656	50 91 866	Landing.
2	03 15 602	50 91 839	Right of brown cabin.
3	03 15 640	50 91 578	Around the point, to the right of a little indentation, left of a gray shed on shore.
4	03 15 525	50 91 434	Red cabin.
5	03 15 292	50 91 391	Wooden dock with wooden porch on shore.
6	03 15 096	50 91 322	Right of brown shoreline boathouse.
7	03 14 988	50 91 296	Left of tan house and left of fallen trees.
8	03 14 988	50 91 268	Right into a dam.
9	03 15 100	50 91 210	Half way up peninsula.
10	03 15 331	50 91 087	On point.
11	03 15 257	50 90 833	Red house with second story white railing.
12	03 15 147	50 90 700	Down middle of bay.
13	03 15 314	50 90 771	Off of the point.
14	03 15 550	50 90 822	Right of shoreline bird house on pole.
15	03 15 775	50 90 810	Left of last dock, right of aeration system.
16	03 15 892	50 90 903	Right of log sided cabin.
17	03 15 954	50 90 967	Left of shoreline fish cleaning house.
18	03 15 866	50 91 073	Right of shoreline light house, by tan rambler.
19	03 15 848	50 91 191	Wooden steps down to lake with deck, green house.
20	03 15 755	50 91 341	Tan house with gazebo on the point.
21	03 15 835	50 91 529	First dock after the point.
22	03 15 986	50 91 570	Red cabin half log siding.
23	03 16 050	50 91 631	House with black paint job.
24	03 16 063	50 91 683	Gray house with gray garage.
25	03 15 732	50 91 743	Right of eagle's nest.

Figure 17. Aquatic plant coverage on Muskellunge Lake on May 25, 2004.

A summary of aquatic plant statistics is shown in Table 9 and line drawings of common Muskellunge Lake aquatic plants are shown on the next page.

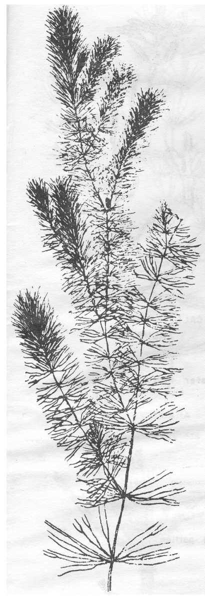
Table 9. Early summer aquatic plant survey summary.

	All Stations
Number of submerged aquatic plant species found	9
Common plant species	Coontail, whitestem pondweed
Rarest plant	Floatingleaf pondweed, claspingleaf, fern pondweed
Maximum depth of plant growth	9

Figure 18. Coontail is sampled on the rake at a density of 4 on Muskellunge Lake.

Common Plants in Muskellunge Lake

Coontail



Coontail (*Ceratophyllum demersum*) is dominant in all water depths.

Cabbage

Cabbage (*Potamogeton amplifolius*) is present in all water depths.

Figure 19. [top] Two common plant species found in Muskellung Lake in May 2004. [bottom] Here a Muskellunge Lake volunteer holds a sample of whitestem pondweed.

Table 10. Muskellunge Lake aquatic plant occurrences and densities for the May 25, 2004 survey based on 25 transects and 2 depths, for a total of 50 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-5 feet (n= 25)			Depth 6-10 feet (n= 25)			All Stations (n= 50)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Spatterdock (*Nuphar variegatum*)	3	12	1.5	--	--	--	3	6	1.5
White waterlily (*Nymphaea sp*)	5	20	0.7	--	--	--	5	10	0.7
Floatingleaf burreed (*Sparganium sp*)	1	4	0.5	--	--	--	1	2	0.5
Coontail (*Ceratophyllum demersum*)	16	64	1.8	21	84	1.6	37	74	1.7
Elodea (*Elodea canadensis*)	9	36	1.0	3	12	0.5	12	24	0.9
Northern watermilfoil (*Myriophyllum sibiricum*)	1	4	0.5	--	--	--	1	2	0.5
Cabbage (*Potamogeton amplifolius*)	9	36	1.1	4	16	0.8	13	26	1.0
Whitestem pondweed (*P. praelongus*)	5	20	0.7	9	36	0.8	14	28	0.8
Claspingleaf pondweed (*P. richardsonii*)	1	4	1.0	--	--	--	1	2	1.0
Fern pondweed (*P. robbinsii*)	--	--	--	1	4	0.5	1	2	0.5
Flatstem pondweed (*P. zosteriformis*)	4	16	0.8	--	--	--	4	8	0.8
Water stargrass (*Zosterella dubia*)	8	32	0.9	--	--	--	8	16	0.9

Table 11. Individual transect data for Muskellunge Lake for May 25, 2004.

	T1		T2		T3		T4		T5		T6		T7	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Floatingleaf burreed													0.5	
Cabbage	1										0.8			
Claspingleaf pondweed						1								
Coontail	2.25	1	0.5	2		1	1	0.5	0.5	0.5	1	2	1.5	2.5
Elodea	0.5		2.5	0.5		0.5	0.5		0.5				1	
Fern pondweed				0.5										
Flatstem pondweed														
Northern watermilfoil														
Spatterdock													0.5	
Water stargrass					1				0.5					
White waterlily	0.5										1		0.5	
Whitestem pondweed			0.5								1	0.5		1
No plants														

	T8		T9		T10		T11		T12		T13		T14	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Floatingleaf burreed														
Cabbage		1		1				0.8		0.5			0.5	
Claspingleaf pondweed														
Coontail	2	3.5	2	2.5		1	3	1	2.3	2		0.5	1	
Elodea	2		0.5						1.3					
Fern pondweed														
Flatstem pondweed			0.5						1.3				0.5	
Northern watermilfoil					0.5									
Spatterdock									1					
Water stargrass					0.5									
White waterlily													0.5	
Whitestem pondweed		1		1					0.5	0.5	0.5			
No plants														X

	T15		T16		T17		T18		T19		T20		T21	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Floatingleaf burreed														
Cabbage			1				1				1		1	
Claspingleaf pondweed														
Coontail		2.3	0.5	1		0.5				0.5			3.5	1
Elodea				0.5										
Fern pondweed														
Flatstem pondweed													1	
Northern watermilfoil														
Spatterdock	3													
Water stargrass					0.5		1		0.5		2			
White waterlily													1	
Whitestem pondweed		0.5												0.5
No plants								X				X		

	T22		T23		T24		T25	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Floatingleaf burreed								
Cabbage	2.3				1			
Claspingleaf pondweed								
Coontail	1.5	3	2	2	4	2.3		
Elodea							0.5	
Fern pondweed								
Flatstem pondweed								
Northern watermilfoil								
Spatterdock								
Water stargrass							1	
White waterlily								
Whitestem pondweed		1	1	1				
No plants								X

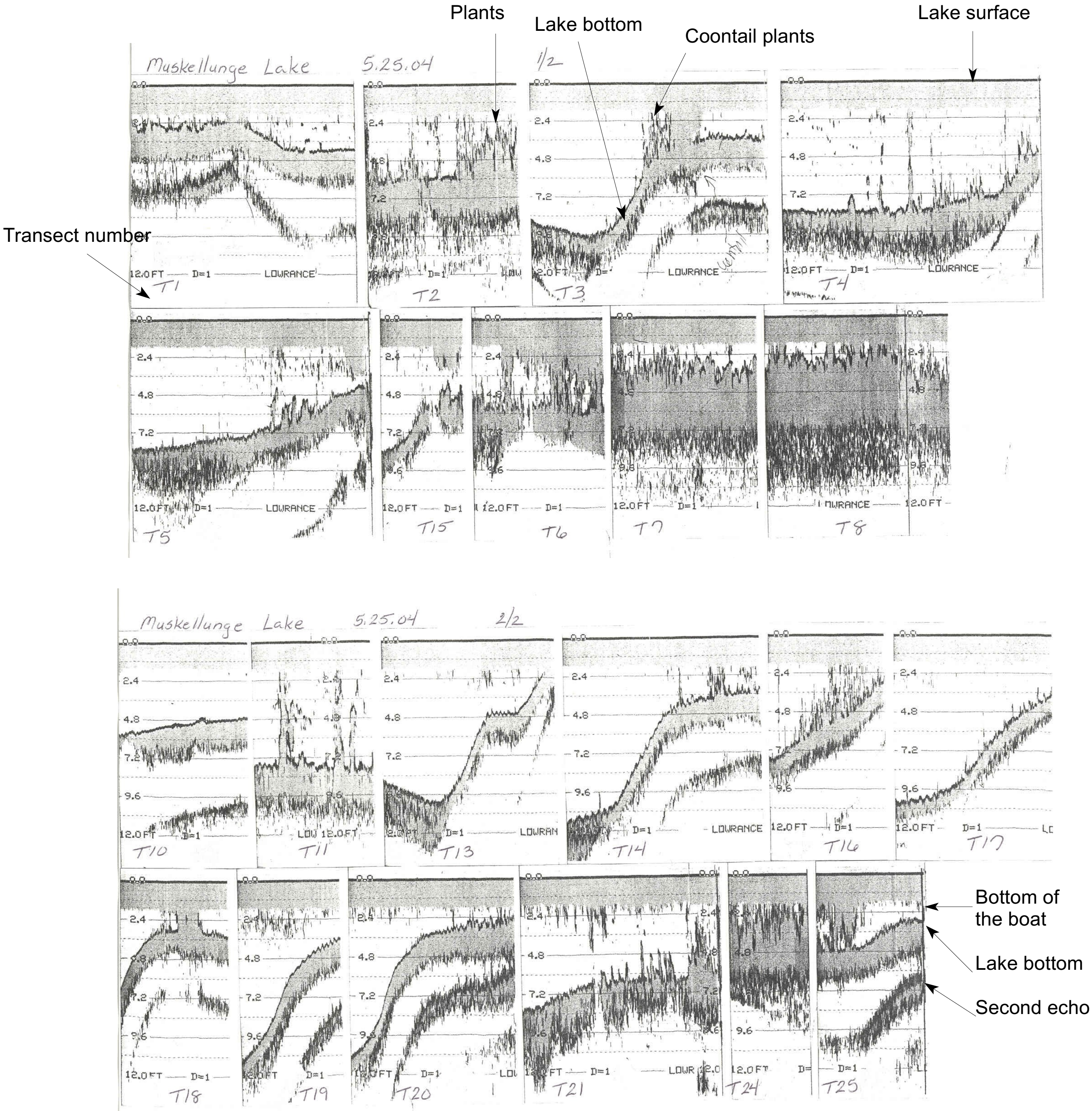


Figure 20. Sonar graphs show the aquatic plant canopy in Muskellunge Lake on May 25, 2004.

Late Summer Survey - August 25, 2004: On August 25, 2004 the dominat aquatic plant was coontail (Table 12).

In August 2004 aquatic plant distribution was estimated to be at 145 acres (Figure 21). Of that coverage, there were only a few areas where native plants grew to the lake surface.

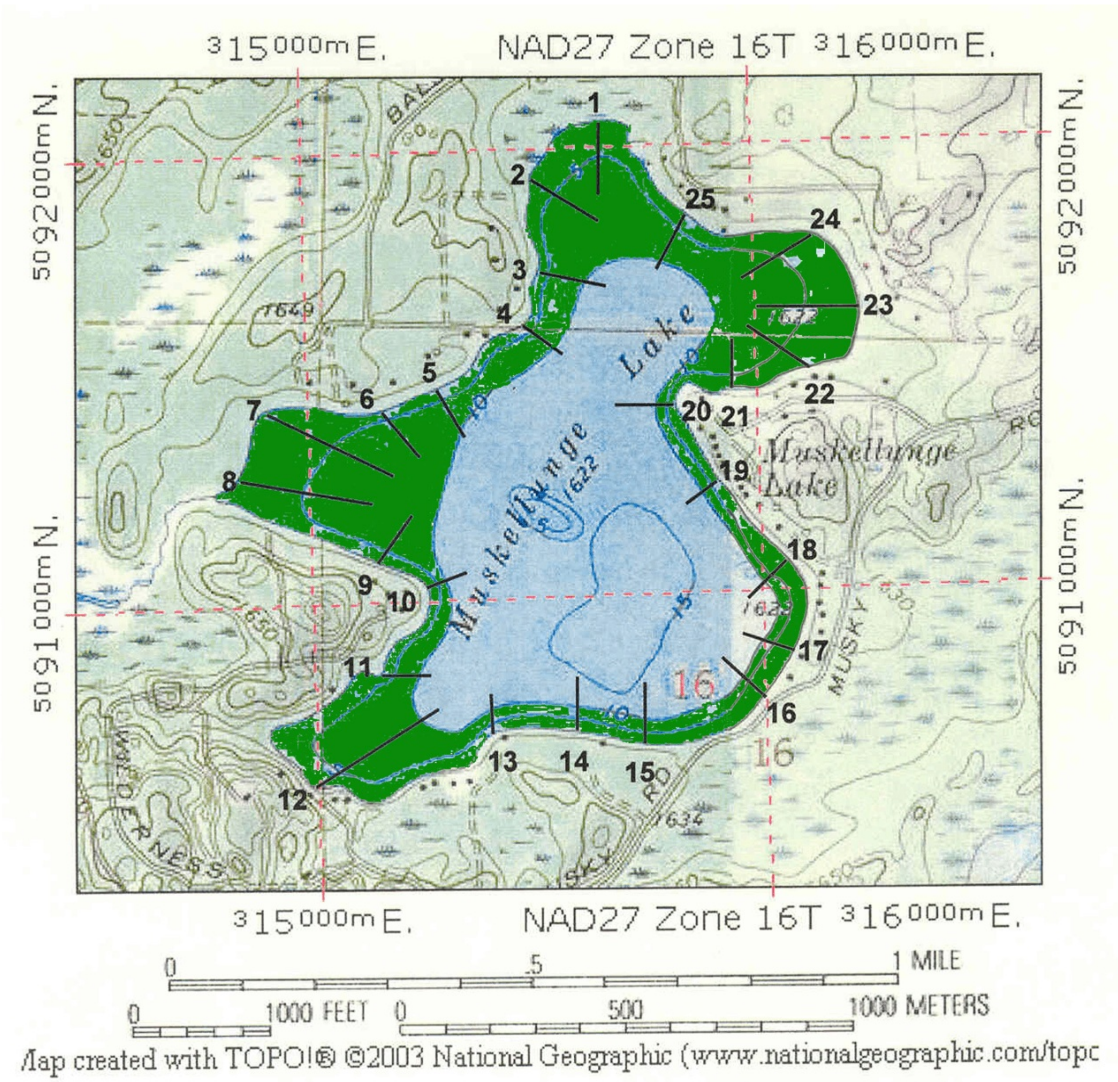


Figure 21. Aquatic plant coverage on Muskellunge Lake on August 25, 2004.

A summary of aquatic plant statistics is shown in Table 12 and line drawings of common Muskellunge Lake aquatic plants are shown on the next page.

Table 12. Early summer aquatic plant survey summary.

	All Stations
Number of submerged aquatic plant species found	13
Common plant species	Coontail, elodea
Rarest plant	Stonewort, fern pondweed
Maximum depth of plant growth	9

Figure 22. Aquatic plants on a sample rake on August 25, 2004. Whitestem pondweed is shown on the left and coontail is on the right.

Common Plants in Muskellunge Lake

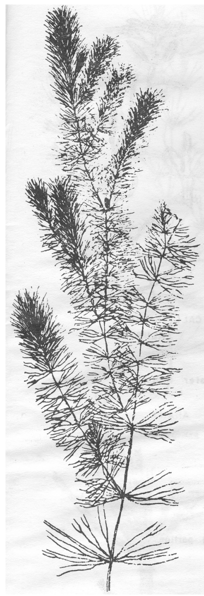
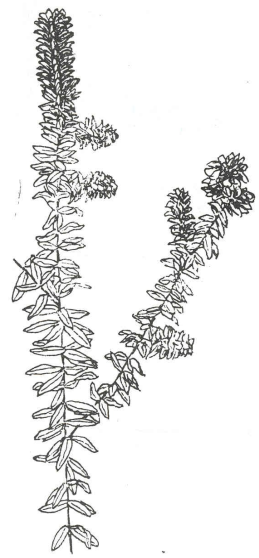
Coontail	**Elodea**
	
Coontail (*Ceratophyllum demersum*) is dominant in all water depths.	Elodea (*Elodea canadensis*) is present in all water depths.

Figure 23. [top] Two of the common plants found in Muskellunge Lake on August 25, 2004. [bottom] Fern pondweed mixed in with cabbage was common in the August 25 Muskellunge Lake aquatic plant survey.

Table 13. Muskellunge Lake aquatic plant occurrences and densities for the August 25, 2004 survey based on 25 transects and 2 depths, for a total of 50 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-5 feet (n= 25)			Depth 6-10 feet (n= 25)			All Stations (n= 50)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Sedges (*Carex sp*)	1	4	0.5	--	--	--	1	2	0.5
Arrowhead (*Sagittaria sp*)	1	4	0.5	--	--	--	1	2	0.5
Bulrush (*Scirpus sp*)	6	24	0.8	--	--	--	6	12	0.8
Cattails (*Typha sp*)	2	8	0.5	--	--	--	2	4	0.5
Wild rice (*Zizanis aquatica*)	1	4	0.5	--	--	--	1	2	0.5
Spatterdock (*Nuphar variegatum*)	6	24	1.2	--	--	--	6	12	1.2
White waterlily (*Nymphaea sp*)	6	24	0.8	1	4	0.5	7	14	0.8
Coontail (*Ceratophyllum demersum*)	20	80	1.8	20	80	2.3	40	80	2.0
Elodea (*Elodea canadensis*)	14	56	0.8	10	4	0.9	24	48	0.8
Water marigold (*Bidens Beckii*)	3	12	0.7	--	--	--	3	6	0.7
Northern watermilfoil (*Myriophyllum sibiricum*)	13	52	0.7	1	4	1.0	14	28	0.7
Naiads (*Najas flexilis*)	1	4	1.0	3	12	1.2	4	8	1.1
Stonewort (*Nitella sp*)	1	4	2.0	--	--	--	1	2	2.0
Cabbage (*Potamogeton amplifolius*)	14	56	1.0	1	4	1.0	15	30	1.0
Whitestem pondweed (*P. praelongus*)	1	40	0.6	11	44	1.2	21	42	0.9
Fern pondweed (*P. robbinsii*)	1	4	0.5	--	--	--	1	2	0.5
Stringy pondweed (*P. sp*)	6	24	0.8	2	8	0.8	8	16	0.8
Flatstem pondweed (*P. zosteriformis*)	18	72	0.9	3	12	1.7	21	42	1.0
Water celery (*Vallisneria americana*)	14	56	0.8	4	16	0.9	18	36	0.8
Water stargrass (*Zosterella dubia*)	3	12	0.7	--	--	--	3	6	0.7

Table 14. Individual transect data for Muskellunge Lake for August 25, 2004.

	T1		T2		T3		T4		T5		T6		T7	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Sedges											0.5			
Arrowhead													0.5	
Bulrush					0.5		0.5		1					
Cattails													0.5	
Wild rice			0.5											
Spatterdock			1										0.5	
White waterlily							0.5				0.5		0.5	
Coontail	0.5	2	1	4	1.5	2	1.5	2	1	1.5	3	2	3	3
Elodea	0.5	2	0.5		0.5	0.5	0.5	0.5		0.5			1.5	1
Water marigold					0.5						0.5			
Northern watermilfoil			0.5		0.5		0.5		1		0.5		0.5	
Naiads														
Stonewort														
Cabbage	1		1				0.5				1		1	
Whitestem pondweed		1		1						0.5	0.5	1	0.5	
Fern pondweed							0.5							
Stringy pondweed								0.5	1	1				
Flatstem pondweed	0.5				0.5								1	
Water celery	0.5				0.5		1	1			1			
Water stargrass							0.5				0.5			
No plants														

	T8		T9		T10		T11		T12		T13		T14	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Sedges														
Arrowhead														
Bulrush														
Cattails							0.5							
Wild rice														
Spatterdock							1						2	
White waterlily							1		1.5	0.5				
Coontail	2.5	3.5	1	2			1.5	2	1.5	2.5			1	1
Elodea	1		1	1	0.5				1			0.5		
Water marigold			1											
Northern watermilfoil	1		1				1						1	
Naiads												1.5		1
Stonewort											2			
Cabbage	1		1						1					
Whitestem pondweed	0.5			2			0.5	2.5	0.5	0.5			1	1
Fern pondweed														
Stringy pondweed			1											
Flatstem pondweed	1	2	1		1		0.5		1.5				1	
Water celery	1				1	1					1	0.5		
Water stargrass					1									
No plants														

Table 14. Individual transect data for Muskellunge Lake for August 25, 2004 concluded.

	T15		T16		T17		T18		T19		T20		T21	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Sedges														
Arrowhead														
Bulrush											0.5			
Cattails														
Wild rice														
Spatterdock														
White waterlily														
Coontail	3	2		1	0.5	2					0.5		2	2
Elodea					1	0.5							1.5	1
Water marigold														
Northern watermilfoil	0.5	1												
Naiads											1	1		
Stonewort														
Cabbage			1				1							
Whitestem pondweed	1	1	0.5	2										
Fern pondweed														
Stringy pondweed	0.5				0.5				1					
Flatstem pondweed					0.5		1		1		1	2	1	
Water celery	1	1	0.5		0.5		1		1		0.5		1	
Water stargrass														
No plants								X		X				

	T22		T23		T24		T25	
	0-5	6-10	0-5	6-10	0-5	6-10	0-5	6-10
Sedges								
Arrowhead								
Bulrush	1						1.5	
Cattails								
Wild rice								
Spatterdock	1.5		1					
White waterlily			1					
Coontail	3.5	3	2.5	3	3	2	1	3
Elodea			0.5		1	1	0.5	
Water marigold								
Northern watermilfoil	0.5				0.5			
Naiads								
Stonewort								
Cabbage	1		1	1	1		1.5	
Whitestem pondweed	0.5	1			0.5			
Fern pondweed								
Stringy pondweed							0.5	
Flatstem pondweed	0.5		1		1	1	1	
Water celery								
Water stargrass								
No plants								

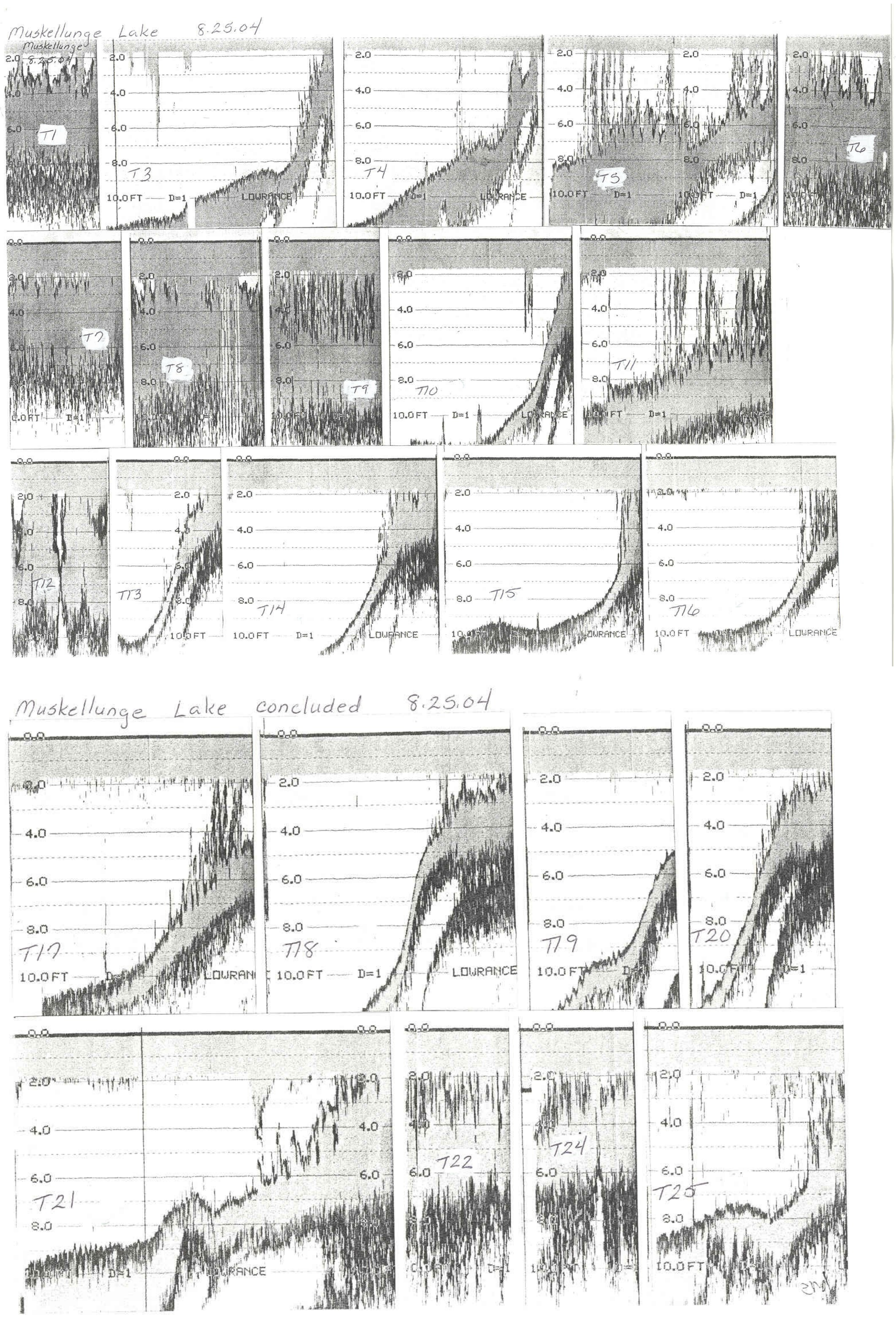


Figure 24. Sonar graphs show the aquatic plant canopy in Muskellunge Lake on August 25, 2004.

4.7. Fishery Status (prepared by WDNR)

The fishery status of Muskellunge has been characterized by the WDNR. Currently, the lake is managed for walleyes and muskies. These two species are stocked into the lake. The results of a boomshocker survey revealed a couple of findings. Walleyes are naturally reproducing a Muskellunge Lake. However, the overall walleye and muskie catch rate is considered low.

Walleye recruitment survey conducted on October 4, 2000. Sampling was conducted using a boomshocker for 1.5 hours and 3.6 miles of shoreline (full shoreline) were sampled.

Species	Number Caught	Size Range	Catch/Unit	
Walleye (age 0+)	47	5.3 - 7.3	31/hour	13.1/mile
Walleye (other)	52	10.2 - 20.9	35/hour	14.4/mile
Largemouth Bass	3	2.6 - 6.9	2/hour	0.8/mile
Muskellunge	1	16.0 - 16.4	0.7/hour	0.3/mile
Walleye (age 1+)	0	--	--	--
Smallmouth	0	--	--	--
Northern pike	0	--	--	--

Several other fish species are present in Muskellunge and panfish are abundant.

It's possible that the abundance of bluegills could be impacting water clarity. In some lakes, this sequence occurs: too few gamefish (walleyes, bass, etc) are present to keep the numbers of smaller fish in check. Therefore, the number of smallfish, such as bluegills, increase in number. One of the food items in a bluegill's diet is zooplankton. Zooplankton, especially daphnia, which are about the size of a pinhead, are good grazers on algae. High numbers of bluegills will keep the daphnia numbers down, and algae numbers can increase. To reduce algae, sometimes enhancing the gamefish population will reduce the panfish numbers and zooplankton will increase and algae numbers will decrease. This may be a future biomanipulation project.

5. Lake and Watershed Assessment

5.1. Lake Questionnaire Results

The Muskellunge Lake questionnaire was developed to better understand the concerns, goals, and attitudes of homeowners living around the lake. Their thoughts and ideas about the use and the quality of your lake are shown below. The questionnaire was sent to 123 property owners, and 97 property owners responded to the Muskellunge Lake questionnaire.

Muskellunge Lake Management Plan Survey 2004

1. How long have you lived on Muskellunge Lake?
The average time people have lived on the lake is approximately 15.7 years

2. What do you enjoy the most about Muskellunge Lake? (Rank 1 through 8 with 1 being the highest rank. The lower the score, the higher the preference.)

	Rating							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Fishing	60	17	12	7	7	3	0	0
Boating/Canoeing	8	19	19	27	12	5	0	0
Swimming	2	8	8	14	12	11	10	7
Asthetics/Viewing	39	25	12	6	11	2	0	0
Wildlife	20	28	25	13	9	5	1	0
Water sports	6	2	0	6	12	32	11	5
Ice fishing	1	12	4	9	11	9	14	8
Others*	0	1	1	1	0	2	2	19

*moderate size, lesser boat traffic, snowmobiling, cross country skiing, peace and quite during week

3. What is the current water quality of Muskellunge Lake? (Water quality indicators are things such as water clarity, algae, weeds or plants, swimming conditions, or fishing conditions.
1 Excellent
10 Very good
39 Good
39 Fair
13 Poor

4. Since you have lived on or near Muskellunge Lake, the quality has:
9 Improved
22 Degraded considerably
23 Remained the same
39 Degraded slightly
7 No opinion/can't tell
1 Other--Degraded

5. What do you see as the most important issue regarding the lake?

	Rating										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Exotic species	31	1	1	0	0	1	2	0	0	1	0
Poor fishing	9	3	2	0	2	1	0	0	1	0	0
Weeds	63	2	4	1	2	0	0	1	0	0	0
Algae	23	2	0	4	2	1	1	1	0	0	0
Water clarity	32	2	1	4	2	1	0	0	1	0	0
Water level	10	0	0	0	1	1	1	1	0	1	0
Shoreline development	13	3	1	0	0	0	1	0	0	1	0
Crowding on the lake	16	0	1	0	0	1	0	1	0	1	0
Noise	8	2	3	1	0	0	1	0	0	0	1
Harassment of wildlife	4	1	1	1	1	0	1	1	0	1	0
Muck	31	0	2	1	0	0	0	1	1	2	1

6. Because Muskellunge Lake is very fertile, there is plant growth in the lake. Aquatic plants are good for lakes. However, some aquatic plants can create nuisance conditions. If you could manage Muskellunge Lake for plant growth, what plant condition would you prefer?

	Rating				
	1	**2**	**3**	**4**	**Additional responses not ranked**
Mechanical harvesting	10	13	1	0	21
Chemical control with herbicides	23	11	2	0	19
Hand pulling	8	6	7	3	27

7. Do you think individuals have an impact on lake water quality? (either positively or negatively)

YES 43

NO 3 (positively 17 negatively 22)

COMMENTS fertilizing lawns, not updating septics

8. Of the following, which do you think are the most responsible for protecting and improving the lake? (rank with 1 being the most important).

	Rating							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Federal government	2	3	2	1	3	11	14	5
State government	13	2	7	12	12	11	3	0
County government	5	7	14	13	15	3	1	1
Local government/Cloverland Township	7	9	16	14	7	3	0	0
MLA	25	25	3	4	4	1	0	0
Individual property owners	43	17	6	0	5	3	1	0
General public	7	7	12	6	7	6	4	0
All of the above equally	28	2	2	2	1	2	1	0

COMMENTS: The DNR can help.

9. What is the age of your septic system?

45 System is ten years old or less--low risk

22 System is between ten and twenty years old--medium risk

19 System is more than twenty years old--high risk

10. Where is your septic system located in relationship to the lake?
83 Drain field is over 50 feet from surface water--low risk
1 Drain field is 50 feet or less from surface water--high risk

11. What is your septic tank maintenance program?
67 The tank is pumped on a regular basis as determined by inspection every 1-3 years-- low risk
4 The tank is pumped, but not regularly--medium risk
1 The tank is not pumped--high risk
8 The tank is pumped on a regular basis_7_yearly_2_every two years_4_every three years

12. Is your system exhibiting any problems?
81 Household drains flow freely. There are no sewage odors inside. There is no ponding (water or effluent) over the drain field--low risk
0 Household drains run slowly. Soil over drain field is sometimes wet--medium risk
0 Household drains back up. Sewage odors can be noticed in the house or yard. Soil is wet or spongy in the drain field area--high risk

13. What specific things would you like to see changed or improved on/in Muskellunge Lake?
Mandatory inspection; Improve fishing habitat
Promote catch and release; Improve fish stocking program with DNR
Decrease weeds and algae; Get more people involved (8)
No fertilizer on lawns; Dredge to get rid of muck (4)
Keep septics up to date; Shoreline management/natural shoreline
Enforce no wake (6); Boat wash at boat landing
Decrease no wake by one hour; Close boat landing
Ban personal water craft (2) Use it, but don't abuse it.
No jet skis, large boats and motors; Permanent marker(low area)center of lake; Get rid of floating rafts;
Reduce water fertility
Limit horsepower; Improve water quality
Boaters to stay out of weeds; Control weeds (8)

14. You have options for managing your yard. How is your yard maintained?
62 No fertilizer applied
3 Fertilizer is applied_5_one_1_two_0_three times per year
0 Use a commercial fertilizer service
39 Maintain natural landscaped area
38 Maintain a vegetative buffer between lake and mowed lawn
2 Other (please specify) Milorganite

15. Are you interested in participating in a Lake Management Program on a personal level?
31 Yes
19 No 23 No answer

Are you willing to do any of the following?
21 Use soil recommendations for fertilizer application
42 Plant native wildflowers, grasses, etc. to attract wildlife
47 Leave as is or restore natural shoreline vegetation
29 Volunteer to help control aquatic plant growth as part of a whole lake effort
1 Other ideas-- Not specified.

16. Where do you get your information on how our lake works?

76 Lake association newsletters COMMENTS = MLA meetings
25 Wisconsin DNR Lake Tides (newsletter) 3
18 Newspapers Very little info from newsletters
6 Television
1 Internet
0 Other (please specify)

The following are comments by 35 respondents to the MLA 2004 survey question:
How long have you lived on the lake? and What was the lake like back then?

A resident who first came to the lake in 1945 stated that there was more wildlife to be seen then and less noise.

In the 1960's the weeds were primarily lily pads, cabbage weeds, and (?) pinocle weeds. There were whippoorwills in the spring, bats in the evening air, More bank and tree swallows, and beaver lodges in the southwest bay. Loons were on the lake all summer. Chipmunks, mice,and eagles continue to be observed.

In 1966, we used to be able to drink the water if the pump didn't work.

It was more peaceful in 1975 when there were only rowboats and excellent fishing. There were fewer homes and less boat traffic.

In 1977-78 the water level was 12 inches higher with a fraction of the weeds and muck. There were a few beaches. The water was clearer. The shoreline had 50% fewer cottages. There were fewer speed boats.

Fishing was better in 1983 when there was less boat traffic and the boat landing was not used as much by boats from the outside.

One resident emphatically stated that People are the problem.

Almost all commented on the increase in residential structures/piers. Lawns/yards reach to the shoreline. More and bigger boats/motors including pontoon boats and the dawn of personnel water craft have
contributed to the status of our lake today.

The lake has turned into a recreational lake. There is more noise,bigger power boats,bigger houses, and jet skis. There is no respect for the "no wake" rule.

Weeds are a major concern. Comments from 1965/1970--the types of weeds have changed and the density has increased. They are thicker and extend further out from the shores. Some bays cannot be fished. Swimming must occur in the middle of the lake, if it is done at all. The Northeast bay is unfishable and unboatable.

The creek bay is especially full of weeds. Our fish are healthier because of all of the weeds, believes a resident from 1989. Some believe that fishing is not as good due to increased pressure on the fishery and more difficult due to the weeds.

There is more algae bloom and earlier. More floating weeds due to power boats and personal water craft.

Overview of Lake Milestones Over the Years (submitted by the Muskellunge Lake Association)

Historically, the Railroad Commission of the State of Wisconsin had jurisdiction over the property where the dam now exists. At some time this was turned over to the Public Service Commission of Wisconsin and eventually to the DNR in the 1960's.

At a hearing on September 18, 1945 between the Public Service Commission of Wisconsin and residents of Muskellunge Lake to determine the normal water level of the lake the following was excerpted from the testimony given.

"Muskellunge Creek is meandering (approximately 3 miles from the Lake to Little St. Germain Lake), narrow, and of low gradient. It was subject to the accumulation of logs, brush, and debris. It seems to be the habitat of the beaver for many years. The beavers would build their dams in the stream and maintain the same until the timber in the vicinity used for food became exhausted and then moved to a different location. As far as the record shows, beavers had dams in the stream as far back as 31 years ago. From time to time until about 1935, some of the dams were abandoned by the beavers and rebuilt in different locations, whereas some of the dams were destroyed by man. From 1932-1935 the beavers "finally got out of control" and their dams were blasted from time to time because they caused high water which inundated the town road. Thus the activities of the beavers resulted in undesirable fluctuations of the water level of the lake. Their dams were finally removed about 1935-1937. It also appears that a crew from the C.C.C. camps cleared Muskellunge Creek of brush and other obstructions, including beaver dams."

At this hearing various testimony was given regarding the water level of the lake. This hearing established that the normal water level is 91.84 feet elevation with reference to specific benchmarks described at this hearing. A recommendation was given at this hearing that the residents of Muskellunge lake, the town of Cloverland, or Vials county construct, maintain, and operate a dam in the outlet stream for the purpose of maintaining the lake at normal level.

A note of interest was that a descriptor of the lake in 1945 indicated the lake contained a water surface of about 272 acres. The same as it is in 2004. A government survey map recorded June 9,1864 indicates the Lake's bays were smaller and in the case of the north bays considerably smaller. In 1881 Vilas and Oneida Counties were created from Lincoln County. Survey/plat maps from that era to about 1908 show that Muskellunge Lake was labeled John Scott Lake at that time.

In the fall of 1948, the Muskellunge Lake Property Owners Association was granted permission to construct, maintain and operate said dam to maintain the normal water/lake level for conservation of the lake.

Not all residents of the lake agreed with the normal level of 91.84 as set by the Public Service commission. Some believed that the lake level needed to be higher, so they attempted to build up the dam with old bedsprings, sheet metal, logs, etc. Others believed that the water level needed to be lowered and would "blow" up the dam. This would occur about every three years. This ongoing dispute occurred at least between 1956 and and into the mid 1980's.

The Muskellunge Lake boat landing has been evolving since it's inception. It has always belonged to one department or another in Vilas County. In spite of some reports, the DNR has never had jurisdiction over it.

The first "public" boat landing is noted around 1966. Boats could be "dragged" into the lake in the area of the culvert on Musky Road. Because this landing was so close to the public road, Vilas County had the right away to the property. In 1973 when a subdivision was approved for the area, the boat landing was moved to its present location after an easement was granted to the Vilas County Forestry Department from the nearby property owner. Pictures from that era show a rudimentary approach with a small pier. It consisted of a concrete plank landing, parking for 6 cars with trailers, and a gravel road. The Forestry Department has upgraded the landing through the years with the latest occurring in 2003-2004 making it handicapped accessible and a fine improvement for boat launching.

Aerial photos from the Forestry Department show a significant increase in shoreline structures from 1950-2000. in 1950 there were approximately 16 structures including two resorts. In 2000 there were indications of at least 85 structures/piers.

MUSKELLUNGE LAKE ASSOCIATION HISTORY

October 20, 1990 an organizational meeting was held with 47(37 property owners) in attendance to establish a lake association. Guest speakers from the DNR and the Wisconsin Federation of Lakes, Inc. spoke on who and why to establish a lake association. By-laws were approved.

Sixty of the 93 parcel owners on the lake became members at this time. (Currently there are 105 members.) In 1990, the primary concerns of the members were the disrepair of the dam and the weed growth on the lake.

Association membership fee is set at $10 per year to carry on the business of the association. An optional lake improvement fee is set at $20 per year. This fund is used for dam maintenance and lake improvements as needed.

Muskelunge Lake Association Achievements

Spring,	1991	Water sample testing began using sampling kits purchased through and tested by UW-Stevens Point.
	1992	The DNR provided water sampling testing kits at no cost.
Winter	1992	A freeze out on the lake killed much of the fish population. (Over the years, the lake experienced several freeze-outs.) As a result the Lake Association decided to install an aerator to supply adequate oxygen levels to prevent future fish kills. A 1/10 acre of land on Musky Road which includes 176 feet of lake frontage was deeded to the association in 1993 by Milo Schandelmeir for $1.00. The DNR and the Sport Fishing Restoration Club provided the funding for the aerator system and the small building that houses the aerator, fencing, and other miscellaneous equipment.
	1993	Dam repair work was completed.
Winter	1994	The aerator was in place and operating. Maintenance of the aerator is the responsibility of the lake association. It is now put into operation every year when the ice reaches a thickness of 12 inches.
	1994	A general plant survey was conducted by the DNR Rhineland, Wisconsin office.
July	1994	A petition was circulated to all property owners to rezone privately owned land around and adjacent to Muskellunge Lake from All Purpose-General Business to R-1 single family residential. County owned forestry land was exempted.
January	1995	The Vilas County Board approved the rezoning resolution.
	1995	The Lake Association purchased their own testing equipment allowing for sampling and testing time to be reduced from 21/2-3 hours to 20 minutes. The unit can be used to take water samples in freezing temperatures.
	1996	A macro-invertebrate study was completed as part of a research project sponsored by the Wisconsin Academy of Science.
	2002	Completion of a three year USGS study for lake hydrology,water quality, and phosphorus loading.

Over the years, the association has held various social events including family picnics, chilifests on the ice, winter social dinners. Fund raisers have included auctions, rummage sales, Association logo on T-shirts, hats and sweatshirts.

Contributors for the above history: Lake residents; Vilas Country Forestry Department; Public Service Commission of Wisconsin; Wisconsin DNR; Vilas County Survey Department; Town of Cloverland; Eagle River Historical Society/Museum; Eagle River Memorial Library

5.2. Muskellunge Lake Status

The status of Muskellunge Lake is slightly eutrophic meaning it has moderate fertility. Muskellunge has phosphorus concentrations that are slightly higher compared to many of the surrounding lakes. One way to compare the status of Muskellunge Lake is to compare it to other lakes in a similar setting or ecoregion.

Ecoregions are geographic regions that have similar geology, soils, and land use. The continental United States has been divided into 84 ecoregions, and there are six ecoregions in Wisconsin. A map of Wisconsin ecoregions is shown in Figure 25. Muskellunge Lake is in the Northern Lakes and Forests ecoregion (Figure 25). Lakes in this area of the state have some of the best water quality values in the State. A range of ecoregion values for lakes in the ecoregion along with actual Muskellunge Lake data is shown in Table 15.

Table 15. Muskellunge Lake data are compared to summer average quality characteristics for lakes in the Northern Lakes and Forest ecoregion (Minnesota Pollution Control Agency, 1988). Muskellunge Lake data from 2001 are used because there was a full summer of data.

Parameter	Northern Lakes and Forests	Muskellunge (2001)
Total phosphorus (ug/l) - top	14-27	46
Algae [as Chlorophyll (ug/l)]	<10	24
Chlorophyll - max (ug/l)	<15	47
Secchi disc (ft)	8-15	4.1

These comparisons indicate that the water quality of Muskellunge Lake is not within range compared to relatively unimpacted lakes within the Northern Lakes and Forests Ecoregion. The challenge will be to determine what kind of water quality can be achieved by Muskellunge Lake.

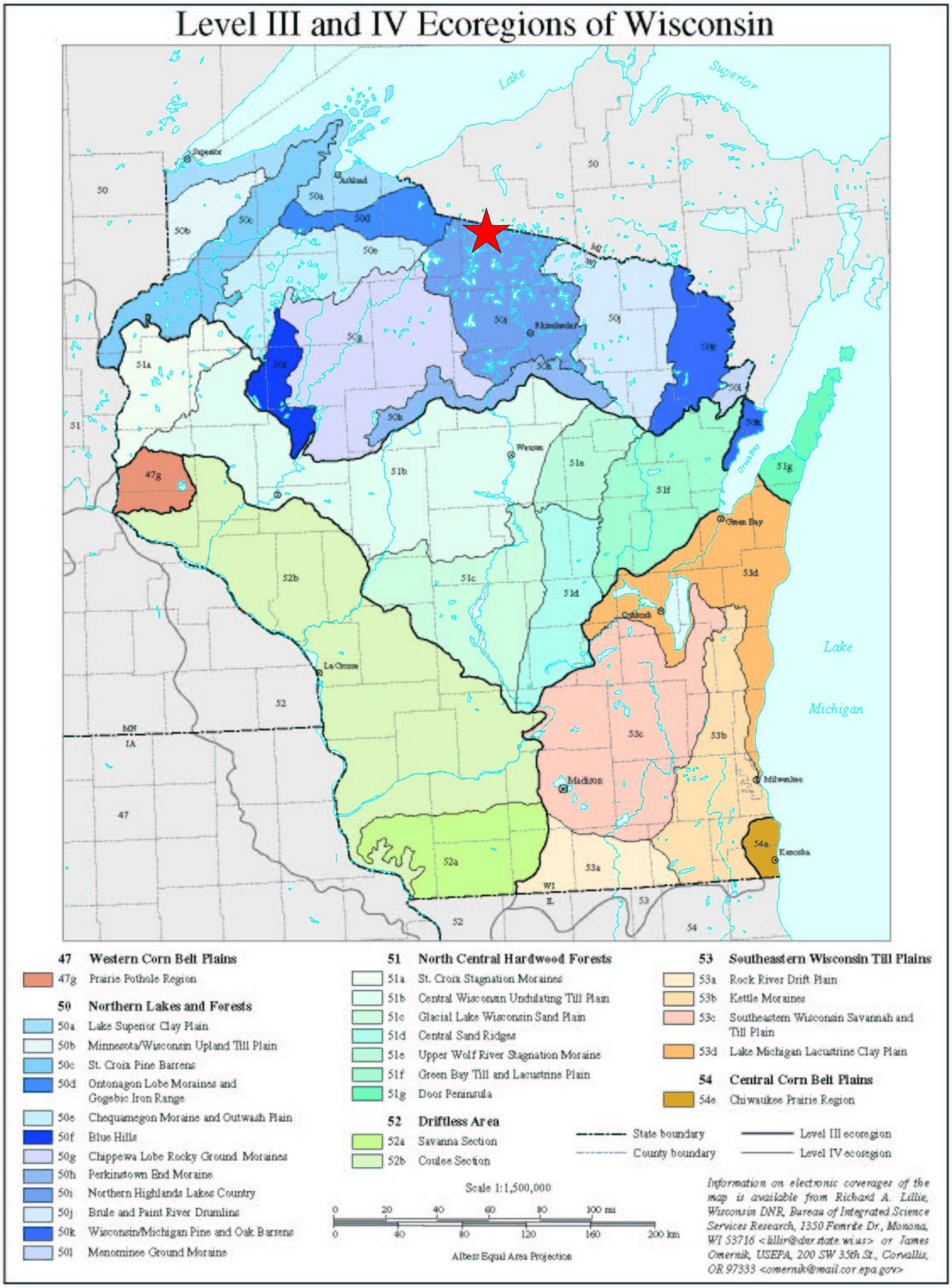


Figure 25. Ecoregion map for Wisconsin. Areas that are labeled with a "50" are within the Northern Lakes and Forest Ecoregion. Areas labeled with a "51" are in the Central Hardwood Forest Ecoregion. Muskellunge Lake, located in central Vilas County is officially in the Central Hardwood Forest Ecoregion but close to the Northern Lakes and Forest Ecoregion.

5.3. Nutrient Inputs to Muskellunge Lake

Based on Northern Lakes and Forests Ecoregion ranges, Muskellunge Lake has phosphorus levels that are out of range of lakes in this ecoregion. The reason for the high lake phosphorus concentration is not exactly clear, but is probably due to the amount of phosphorus coming into Muskellunge Lake from the watershed as well as from the lake sediments.

A summary of estimated phosphorus loads is shown in Figure 26. Using a lake model, a total annual phosphorus load of 675 pounds of phosphorus is estimated based on a lake phosphorus concentration of 46 ppb and a contributing watershed size of 2,602 acres. Estimates of the sources of phosphorus to Muskellunge Lake are based on a USGS study conducted in 2000-2001 with an estimated lake sediment contribution determined in this study (Figure 26). The lake sediment contribution was determined by subtracting the USGS estimated load of 437 pounds from a total estimated load used in this study of 675 pounds. Therefore the estimated phosphorus contribution from lake sediments is 238 pounds.

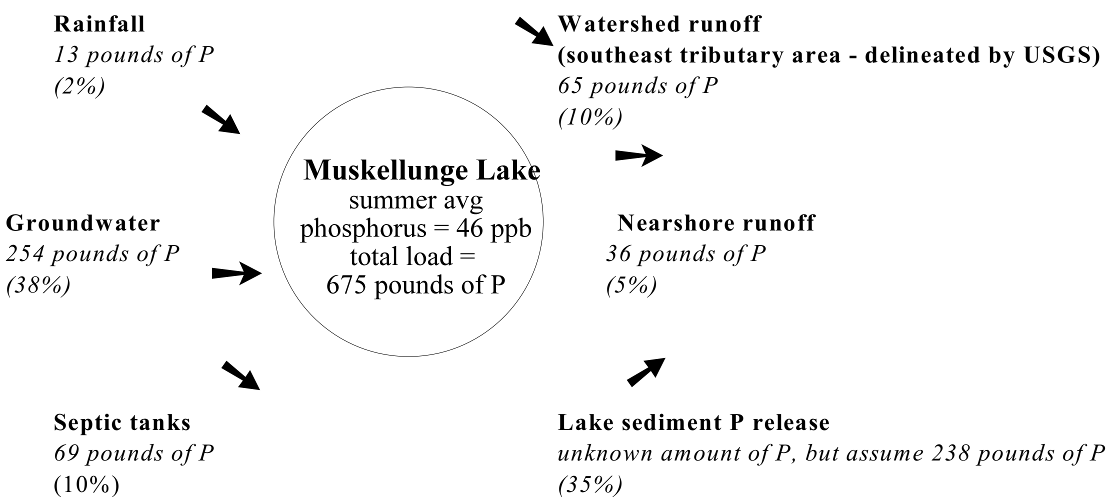


Figure 26. Sources of watershed phosphorus (P) that feed into Muskellunge Lake are shown above. It is estimated that approximately 675 pounds of phosphorus enter Muskellunge Lake on an annual basis.

5.4. Setting Water Quality Goals for Muskellunge Lake

It appears water quality in Muskellunge Lake has the potential to be better based on the ecoregion setting. Lake models were run to help determine feasible water quality goals for Muskellunge Lake. A lake model is a mathematical equation that uses phosphorus inputs along with lake and watershed characteristics to predict what a lake phosphorus concentration should be. Once a lake phosphorus concentration is determined, then seasonal water clarity and algae concentrations can be calculated as well.

Two lake models were run for the following conditions and then compared to existing observed conditions.

1. Phosphorus loading under ecoregion pre-development conditions (run-off phosphorus concentration at 20 ppb).
2. Phosphorus loading from relatively unimpacted lakes under current ecoregion conditions (runoff phosphorus concentration at 50 ppb).

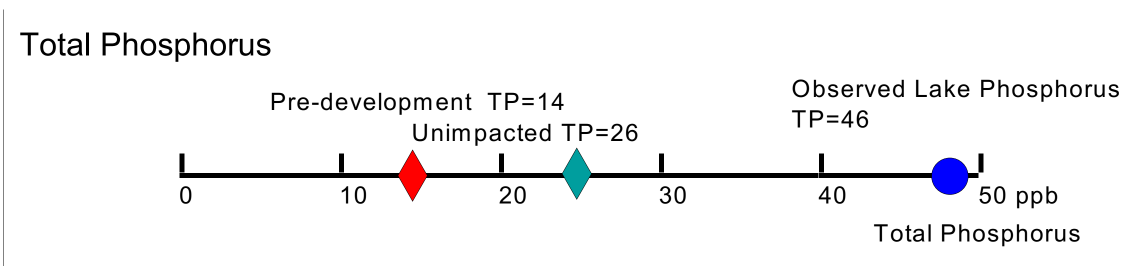


Figure 27. Comparison of total phosphorus (TP) conditions for Muskellunge Lake in 2001 (blue dot) to predicted conditions for a lake the size of Muskellunge Lake situated in the Northern Lakes and Forest (NLF) ecoregion under two runoff conditions: pre-development (red diamond) and unimpacted lake with some development (green diamond).

Results of the model run indicate Muskellunge Lake has the potential to maintain a seasonal phosphorus average of about 26 ppb compared to the 46 ppb observed in 2001. The reason for Muskellunge Lake having higher than expected phosphorus concentrations is because approximately 73% of the phosphorus load is coming from groundwater and the lake sediments. Most lakes do not have this high of a percentage input from groundwater and lake sediments.

The Secchi disc transparency is lower than expected and chlorophyll a is higher than expected when Muskellunge Lake is compared to other lakes in the ecoregion. The challenge to improving water quality is to address groundwater and lake sediment nutrient inputs.

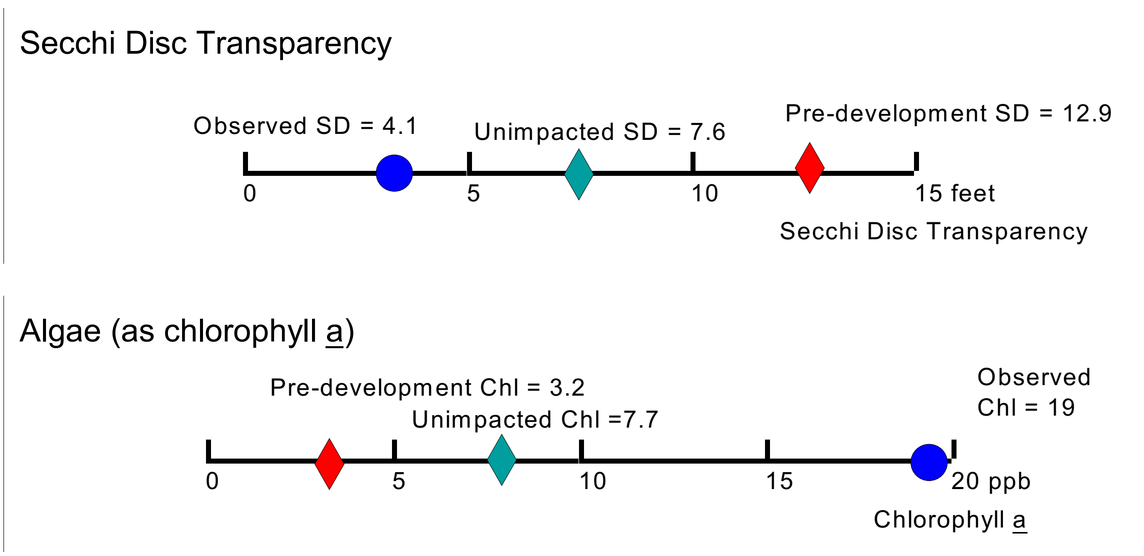


Figure 28. Comparison of Secchi disc transparency (feet) and algae (chlorophyll a – ppb) conditions for Muskellunge Lake in 2001 (blue dots) to predicted conditions for a lake the size of Muskellunge Lake situated in the Northern Lakes and Forest (NLF) ecoregion under two runoff conditions: pre-development (red diamond) and unimpacted lake with some development (green diamond).

Lake Goals

Based on lake modeling considerations it appears Muskellunge Lake has the potential for better water quality conditions.

The proposed water quality goal for lake phosphorus concentration is tentatively set at the ecoregion estimate of 26 ppb. However, this goal may be expensive to attain.

The key to achieving this lake phosphorus goal will be to maintain low nutrient inputs into Muskellunge Lake.

5.5. Significant Findings and Water Quality Strategy

- Water quality of Muskellunge is not within range of other lakes in the Lakes and Forests Ecoregion. Water quality parameters consisted of transparency readings, phosphorus, and chlorophyll.

- The watershed is in relatively good shape and does not appear to contribute excessive amounts of phosphorus to Muskellunge Lake.

- The findings of this study indicate the primary factors affecting water quality in Muskellunge Lake are nutrients from groundwater inputs and from phosphorus release from lake sediments.

- It may very well be that elevated levels of phosphorus have arrived in Muskellunge Lake by way of groundwater and this has occurred over a lengthy time period (at least the last 100 years).

- As phosphorus was delivered to the lake, not all of it left the lake. Much of the phosphorus was retained and has settled and accumulated in the lake sediments. Some of this phosphorus is released every year and contributes to algae blooms.

- It is possible that a high sediment pH (greater than 8.0) could account for some fo the phosphorus release from the lake sediments. Sediment pH should be checked over the summer.

- Water quality can be improved, but it would be costly. A lake sediment alum treatment could improve water quality for 5 to 10 years but the cost would be approximately $240,000.

- Native aquatic plants are diverse and no exotic aquatic plants were found in the two surveys conducted in 2004.

- Coontail, a native plant, grows abundantly in the northern bays. If control is considered, mechanical harvesting would be the recommended option.

- The winter aeration system is probably necessary to prevent winterkill in Muskellunge Lake.

6. Lake Project Ideas for Protecting the Lake Environment

Project ideas for Muskellunge Lake are geared toward long-term protection of water quality.

A list of projects has seven main components:

1. Watershed projects.
2. On-site system maintenance.
3. Aquascaping projects.
4. Aquatic plant projects.
5. Fish management options.
6. Sediment alum treatment for water clarity improvement
7. Ongoing education program.
8. Watershed and lake monitoring program.

Details for these projects areas are given in the next few pages.

Side Note: Several other lake management options were considered but not recommended and include the following:

- **Barley straw for algae control:** Barley straw can control algae growth but is best suited for ponds and small lakes. A typical dose is 250 pounds of barley per lake acre is recommended. At this rate it would take 68,000 pounds of barley to control algae for one season. This would not be a practical approach.

- **Dredging:** Like many lakes in the area, there are shallow mucky or peaty areas in some of the bays. Sometimes dredging is considered. However, it is rarely implemented because it is expensive. For example, consider dredging a one acre area, 3-feet deep. This would involve removing about 4,840 cubic yards of material at $10/yard. The cost would be roughly $50,000 per acre. Dredging costs do not justify the benefits.

- **Muck-eating enzymes:** Muck eating enzymes come from bacterial additions. Although used in wastewater treatment processes to help decompose organic wastes, the organics found in lake sediments have already been worked over by the bacteria present in the lake and the remaining organic compounds, especially the peat, are resistant to breaking down further. Muck eating enzymes won't do much for reducing the volume of lake sediments and are not recommended.

- **Grass carp to control weeds:** Grass carp, which are not really a carp, are exotic species which have been imported and sterilized and stocked in some southern states lakes and ponds. Typically, they destroy or remove all plants in a lake. This is not a desirable outcome. In addition, they are illegal to stock in Wisconsin lakes.

- **Biological treatment:** The use of biology in a lake to improve water quality is often referred to as biomanipulation. It has a role in lake management. Sometimes water clarity can be improved if more gamefish are stocked. They will eat the smaller fish and then the zooplankton population will increase. With more zooplankton available, they will eat the algae and reduce algae numbers. This is a potential future project.

Project 1. Watershed Projects

The main goal of the watershed projects program is to protect the natural character of the watershed which helps maintain good runoff water quality.

Although majority of the watershed is forested, the surrounding wetlands probably contribute phosphorus, by way of groundwater, to Muskellunge Lake. However, this is a natural pathway. Watershed project areas to monitor in the future involve erosion control for new development as well as with forest harvesting activities.

Project 2. On-site System Maintenance

The septic tank/soil absorption field has been one of the most popular forms of on-site wastewater treatment for years. When soil conditions are proper and the system is well maintained, this is a very good system for wastewater treatment. The on-site system is the dominant type of wastewater treatment found around Muskellunge Lake today.

However, problems can develop if the on-site system has not been designed properly or well-maintained. Around Muskellunge Lake there are probably some on-site systems that need maintenance or upgrades. At the same time, it is good practice to ensure that systems that are functioning adequately now will continue to do so in the future.

This project calls for an organized program to be developed that makes homeowners aware of all they can do to maintain their on-site systems.

A description of possible activities associated with the on-site maintenance program are described below:

- **Septic Tank Pumping Campaign**
  Vilas County requires every septic tank associated with a permanent residence pumped 2-3 years in the shoreland area to help reduce phosphorous loading to the septic system drainfield.

- **Ordinance Implementation**
  Work to maintain enforcement of the county ordinance, where septic systems must be "evaluated" at the time a property is transferred. The seller would obtain a septic system evaluation from Vilas County at the time of property transfer. The evaluation would determine if the septic system was "failing", "non-conforming", or "conforming". A "failing" septic system includes septic systems that discharge onto the ground surface, discharges into tiles and surface waters, and systems found to be contaminating a well. The county would require a "failing" system to be brought into compliance with the Vilas County ordinance within 90 days of property transfer.

Project 3. Aquascaping Projects

Controls are in place at the county level to guide new shoreland development. A number of excellent reference publications are available to assist in promoting shoreland stewardship. For existing shoreland properties, it is important to either maintain or to improve the natural vegetative buffer.

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 28). 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 16.

Figure 28. Cross section of the lake shoreland habitat.

Table 16. 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.

Improving Upland Native Landscape Conditions: In the glacial lake states, three broad vegetative groups occur: pine forests with a variety of ground cover species including shrubs and sedges: hardwood forests with a variety of understory species, including ferns: and tallgrass prairie with a variety of grasses as well as bur oaks and willow trees. Residences around Muskellunge Lake are in the hardwood forest group.

Reestablishing native conditions in the shoreland area not only improves stormwater runoff quality, it also attracts a variety of wildlife and waterfowl to the shoreland area. Benefits multiply when other neighbors naturalize because the effects are cumulative and significant for water quality and wildlife habitat.

When installing native vegetation close to the shoreline residents are actually installing a buffer. A buffer is a strip of native vegetation wide-enough to produce water quality and wildlife improvements. Much of the natural vegetative buffer has been lost in shoreland areas with development where lawns have been extended right down to the shore.

Lawns are not necessarily bad for a lake. However they can be over fertilized and then runoff carries phosphorus to the lake. Also, lawns function as a low grade open prairie, with poor cover for wildlife and a food supply that is generally poor, except for geese who may find it attractive. Replacing lawn areas with native landscaping projects reduces the need for fertilizer, reduces the time it takes to mow, increases the natural beauty of a shoreland area, and attracts wildlife.

Lawns do not make very good upland buffers. With runoff, short grass blades bend and do not serve as a very effective filter. Tall grass that remains upright with runoff is a better filter. Kentucky bluegrass (which actually is an exotic grass) is shallow-rooted and does not protect soil near shorelines as well as deep-rooted native prairie grasses, shrubs, or other perennials. Grass up to the shoreline offers poor cover, so predators visit other hiding areas more frequently reducing the prey food base and limiting predator populations in the long run. Also with short ground cover, ground temperatures increase in summer, evapotranspiration increases and results in drying conditions, reducing habitat for frogs and shoreline dependent animals.

Buffer Strip Considerations: A functional upland buffer should be at least 15 feet deep. With this you start getting water quality and wildlife habitat benefits. But a 35 foot deep buffer is recommended. In the past, before lakeshore development, buffers ringed the entire lake. For lakeshore residents it is recommended the length of the buffer extend for 75% of the shoreline, although 50% would produce buffer benefits.

A buffer strip can address two problem areas right away. Geese are shy about walking through tall grass because of the threat of predators. There will always be a few who charge right through but it is a deterrent for most of them. Also, muskrats shouldn't be a problem. They may burrow into the bank, but generally not more then 10 feet. With a buffer going back 15 to 25 feet, you won't be mowing over their dens. An occasional den shouldn't produce muskrat densities that limit desirable aquatic vegetation.

Several types of buffers can be installed or propagated that offer nutrient removal as well as wildlife benefits. Examples include:

Tall grass, sedge, flower buffer: Provides nesting cover for mallards, blue-winged teal and Canada geese. Provides above ground nesting habitat for sedge wrens, common yellow throat and others.

Shrub and brush buffer: Provides nesting habitat for lakeside songbirds such as yellow warblers, common yellowthroat, swamp sparrows, and flycatchers. It also provides significant cover during migration.

Forested buffers: Provides habitat for nesting warblers and yellow-throated vireo, Diamond herons, woodducks, hocked mergansers, and others. Upland birds such as red-winged blackbirds, orioles, and woodpeckers use the forest edge for nesting and feeding habitat.

Even standing dead trees, which are referred to as snags, have a critical role. When they are left standing they serve as perching sites for kingfishers and provide nesting sites for herons, egrets, eagles, and ospreys. In the midwest over 40 bird species and 25 mammal species use snags. To be useful, they should be at least 15 feet tall and 6-inches in diameter.

The initial step for lake residents to get started is to simply make a commitment to try something. Just what the final commitment is evolves as they go through a selection process. The next step in the process is to conduct a site inventory. On a map with lot boundaries, house and buildings, driveway, turf areas, trees, shrubs, and other features are drawn. If there is a chance, the property is checked during a rainstorm. Look for sources of runoff and even flag the routes. Find out where the water from the roof goes, and see if there are temporary ponding and infiltration areas. Are the paths down to the lake eroding? Then the next step is to consider a planting approach.

Native Landscaping for Buffers: Three Approaches: Native landscaping efforts can be put into three categories:

1. Naturalization
2. Accelerated Naturalization
3. Reconstruction

1. Naturalization: With this approach, the resident is going to allow an area to go natural. Whatever is present in the seedbank is what will grow. If they want to install a buffer along the shoreline, let a band of vegetation grow at least 15 feet deep from the shoreline back and preferably 25 feet or deeper. Just by not mowing will do the trick. Residents can check how it looks at the end of the summer. It will take up to three years for flowers and native grasses to grow up and be noticed. Residents can also select other spots on their property to "naturalize".

2. Accelerated Naturalization: After developing a plant list of species from the area, residents may want to mimic some features right away. They can lay out a planting scheme and plant right into existing vegetation. Several Wisconsin nurseries can supply native plant stock and seeds. The nurseries can also help select plants and offer planting tips. Wildflowers can be interspersed with wild grasses and sedges. Mulch around the new seedlings. With this approach lake residents can accelerate the naturalization process. Contact the Wisconsin Department of Natural Resources for a nursery list.

3. Reconstruction: To reestablish a native landscape with the resident's input and vision, another option is to reconstruct the site with all new plants. Again plant selection should be based on plants growing in the area. Site preparation is a key factor. Residents will want to eliminate invasive weeds and eliminate turf. This can be done with either herbicides or by laying down newsprint or other types of paper followed by 4 to 6 inches of hardwood mulch. Plantings are made through the mulch. This is the most expensive of the three native landscaping categories. Residents can do the reconstruction all at once, or phase it in over 3 to 5 years. This allows them to budget annually and continue evolving the plan as time goes by.

Also mixing and matching the level-of-effort categories allows planting flexibility. Maybe a homeowner employs naturalization along the sides of the lot and reconstruction for half of the shoreline and accelerated naturalization for the other half. Examples of the three approaches are shown in Figure 29.

1. Naturalization: The easiest way to implement a natural shoreline setting is to select an area and leave it grow back naturally.

2. Accelerated Naturalization: To accelerate the naturalization, plant shrubs, wild flowers, or grasses into a shoreland area.

3. Restoration: This involves removing existing vegetation through the use of paper mats and/or mulching and planting a variety of native grasses, flowers, and shrubs into the shoreland area.

Figure 29. Examples of three shoreland management options.

Project 4. Aquatic Plant Projects

Currently, Muskellunge Lake has a variety of native emergent and submergent aquatic plant growth. Aquatic plants are vital for helping sustain clear water conditions and contribute to fish habitat. As of August 2004, there are no exotic plant species found in Muskellunge Lake. However, in a couple of areas, native aquatic plants can produce navigational hindrences in some summers.

The primary aquatic plant goal is to maintain and/or protect submerged aquatic plants in Muskellunge Lake. Two plant management ideas are given below:

1. Maintaining good shoreland conditions can sustain long-term shallow water plant communities. Ongoing shoreland maintenance and improvement will be important.

2. Aquatic plant removal using manual methods is an option for maintaining an open area in front of your property. Mechanical harvesting is another option if channels out to open water are deemed necessary. However, only the minimum amount of plants needed to reduce navigational hindrences should be removed.

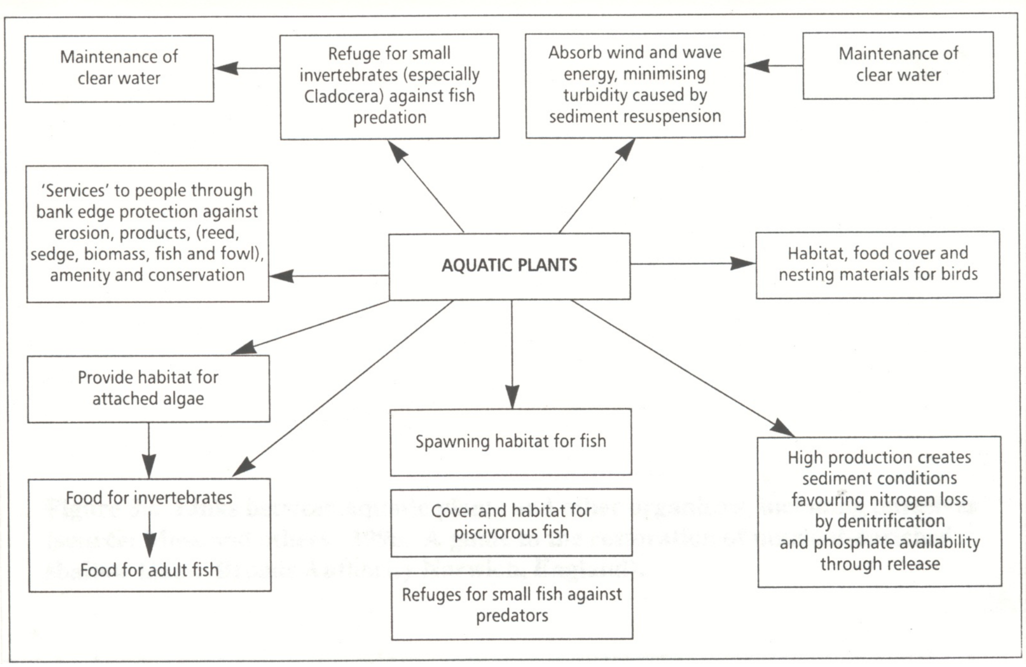


Figure 30. Links between aquatic plants and other organisms, including ourselves (source: Moss and others. 1996. A guide to the restoration of nutrient-enriched shallow lakes. Broads Authority Norwich, England).

Native aquatic plants flourish in the shallow, nearshore areas of Muskellunge Lake (Figure 31). They can create some navigational nuisances. Channels could be created through the plants to facilitate boating access, but it is recommended that only the minimum amount of plants be removed to reduce nuisance conditions.

Figure 31. [top] In the nearshore areas a variety of submerged and floatingleaf plants are present. [bottom] One of the most common plants in Muskellunge Lake is the native plant, coontail. It is difficult to control.

A variety of options are available for the creating channels through dense aquatic plant growth. An example of a manual method is the weed puller shown in Figure 32. It can be used to create a channel and remove plants at the same time. Rakes can also be used.

Another option is harvesting a channel about 20 to 30 feet wide through the surface matted growth would allow unrestricted navigation and should not harm the lake. Mechanical harvesters pick-up most of the plants that are cut (Figure 32). Hiring a mechanical harvester to cut channels or clear cut areas in the northern bays would cost about $600 - $800 per acre.

Figure 32. A mechanical harvester is recommended for picking up coontail in the northern bays if plant management is considered.

Project 5. Fish Management Options

The aeration system appears to be meeting the objective of keeping fish alive over winter. This winter aeration program probably needs to continue indefinitely. However, it would be helpful to take winter dissolved oxygen readings to make sure the aeration system is sustaining fish. There does not appear to be any benefit to running the aerator during the summer as a water quality project, at this time. However, if the pH of the sediments was greater than 8.0, then aeration could be considered. Sediments will release phosphorus at high pHs and aeration can sometimes lower the pH.

A future project could involve a fish and aquatic plant manipulation in an attempt to improve water clarity. Increasing gamefish with stocking and removing panfish by netting could help to restructure the fish community. Then, maintaining channels through the aquatic vegetation would allow gamefish better access to panfish and aid in sustaining panfish control.

Figure 33. The Muskellunge Lake Association operates the winter aeration system on Muskellunge Lake.

Project 6. Sediment Alum Treatment for Water Clarity Improvement

The best chance at improving lake water quality is to address the groundwater and lake sediment phosphorus release. These two sources represent over 70% of the nutrient input into the water column. The use of an alum sediment treatment would address both phosphorus release from lake sediments and phosphorus associated with groundwater inflow.

A common technique to reduce sediment phosphorus release from lakes when lake bottom phosphorus is a significant phosphorus source is a sediment alum treatment. Using an alum dosing determination methodology of Rydin and Welch (1999), helps to estimate an alum dose required to reduce phosphorus release to 1 mg-P/m^2/day. At this time, a dose requirement has not been made. However, for this discussion it is estimated that about 1,000 gallons of alum per lake acre would be needed. A dose of this magnitude would probably be applied with three treatments of 333 gallon of alum/ac over 3 or 6 years.

Under existing conditions, it is estimated that groundwater and p-release account for 492 pounds of phosphorus per year, the equivalent to 2.5 mg-P/m^2/day for 100 days. If the alum treatment was effective in reducing the excessive phosphorus release from lake sediments down to 1 mg-P/m^2/day, the bottom loading would be reduced to 200 pounds per year. The new annual phosphorus budget for the lake would not be 380 pounds of phosphorus per year. It is predicted lake phosphorus concentrations would drop to 30 ppb or less in the lake and transparency would increase to 6.6 feet compared to the observed 4.3 feet as a seasonal average. However, there is no guarantee the effect would last longer than several years.

Figure 34. An alum application is generally applied from a barge. This was a lake sediment alum application on Lake Susan in Chanhassen.

If an alum treatment was to be considered, several steps are necessary to move forward with implementation.

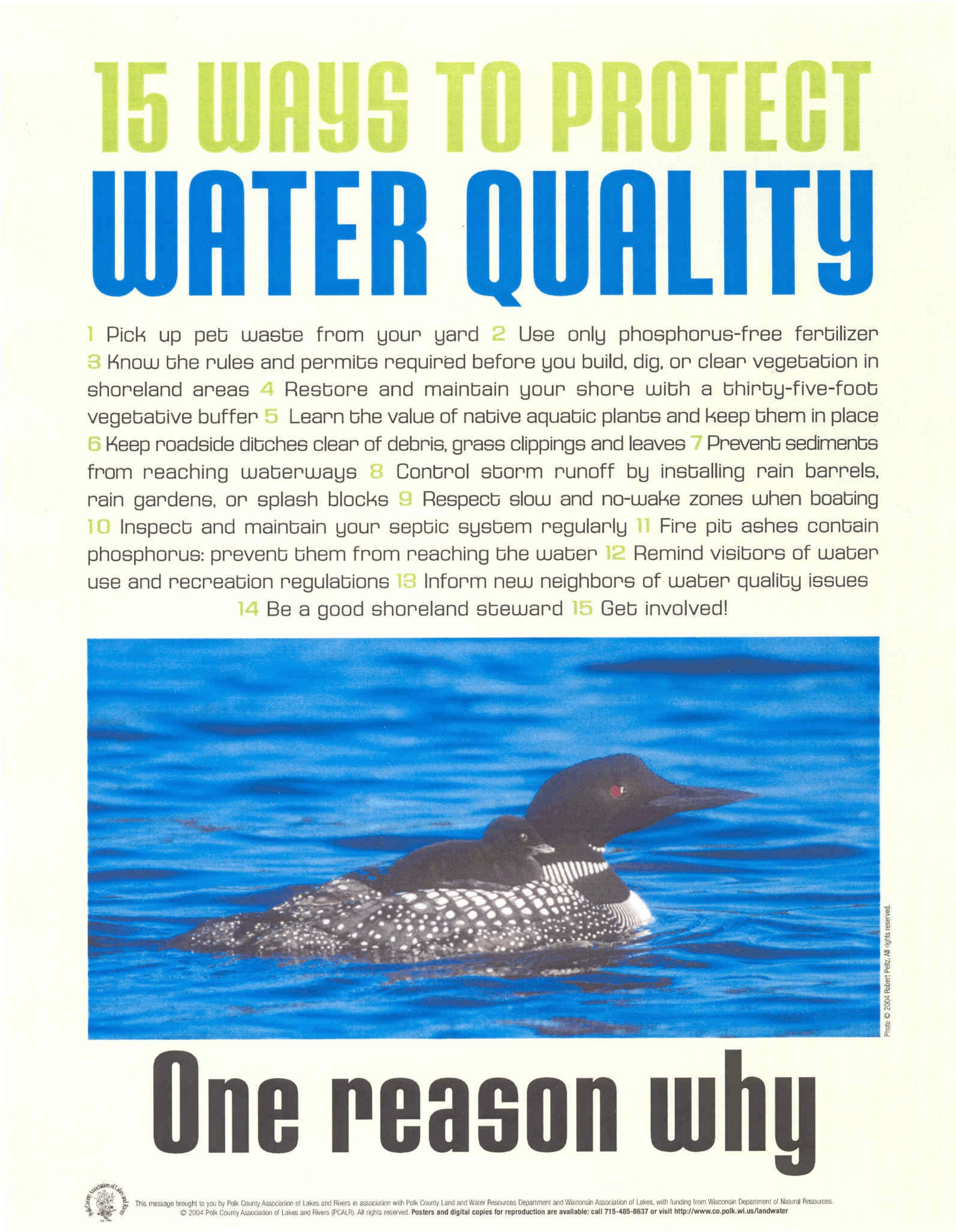
Sequence of events

1. Collect top and bottom water samples, twice a month, May through September and once per month October through April.
2. Monitor pH of lake water, incoming groundwater, and lake sediments for one year. Monthly measurements are probably adequate.
3. Test Muskellunge Lake sediments to determine the alum dose required.
4. Pursue funds for financing an alum project from the Wisconsin DNR.
5. Because water will clear up, set aside funds for additional aquatic plant harvesting.

Cost Range: It is assumed that 80% of the lake surface would be treated with alum and this is about 220 acres. Until more information is acquired, an assumed cost is $1,100/ac. The total cost for the alum project would be approximately $242,000.

Project 7. Ongoing Education Program

Lake residents get an important amount of lake protection information from the lake newsletter. Each issue should offer tips on lake protection techniques. There is abundant material available. An example of an informational piece is shown below. Additional information on preventing the introduction of exotic plants and animals is found in the Appendix.



Project 8. Watershed and Lake Monitoring Program

At this time, because of good runoff water quality, new watershed water quality monitoring is not proposed. A lake monitoring program is outlined in Table 16. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 16. Muskellunge Lake Water Quality Monitoring Program.

Category	Level	Alternative	Labor Needed	Cost/Year
A. Dissolved oxygen and temperature profiles	1	Check dissolved oxygen in Muskellunge Lake every two weeks in January, February, and March depending on winter conditions.	Moderate	$0
	2	Check dissolved oxygen in Muskellunge Lake every one to two weeks in December, January, February, and March, depending on winter conditions and collect phosphorus samples.	Moderate	$0
	3	Check dissolved oxygen and temperatures once per month from May - September.		
B. Water clarity	1	Secchi disc taken at spring and fall turnover.	Low	$0
	2	Secchi disc monitoring once per month May - October.	Low-moderate	$0
	3	Secchi disc monitoring twice per month, May - October.	Moderate	$0
C. Water chemistry	1	Spring and fall turnover samples are collected and sent to UW-Stevens Point. Selected parameters for analysis include: TP and chlorophyll.	Low	$200
	2	Sample for phosphorus and chlorophyll once per month from May - September (surface water only) with the Self-Help Monitoring Program.	Low-moderate	$300
	3	Sample for phosphorus and chlorophyll twice per month from May - October.	Moderate	$600
	4	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N once per month (May-October)	Moderate	$960
	5	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N twice per month (May-October).	Moderate	$1,920
D. Special samples or surveys	1	Special monitoring: suspended solids, BOD, chloride, turbidity, sampling bottom water, and other parameters as appropriate. Aquatic plant surveys, etc.	--	$100-$3,000

A recommended monitoring program consists of Level A1, A3, B2, and C2 annually. An aquatic plant survey (Level D1) should be conducted every three years. Lake sediment pH could be checked as well. In addition, a zooplankton sampling program could be considered.

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