

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.

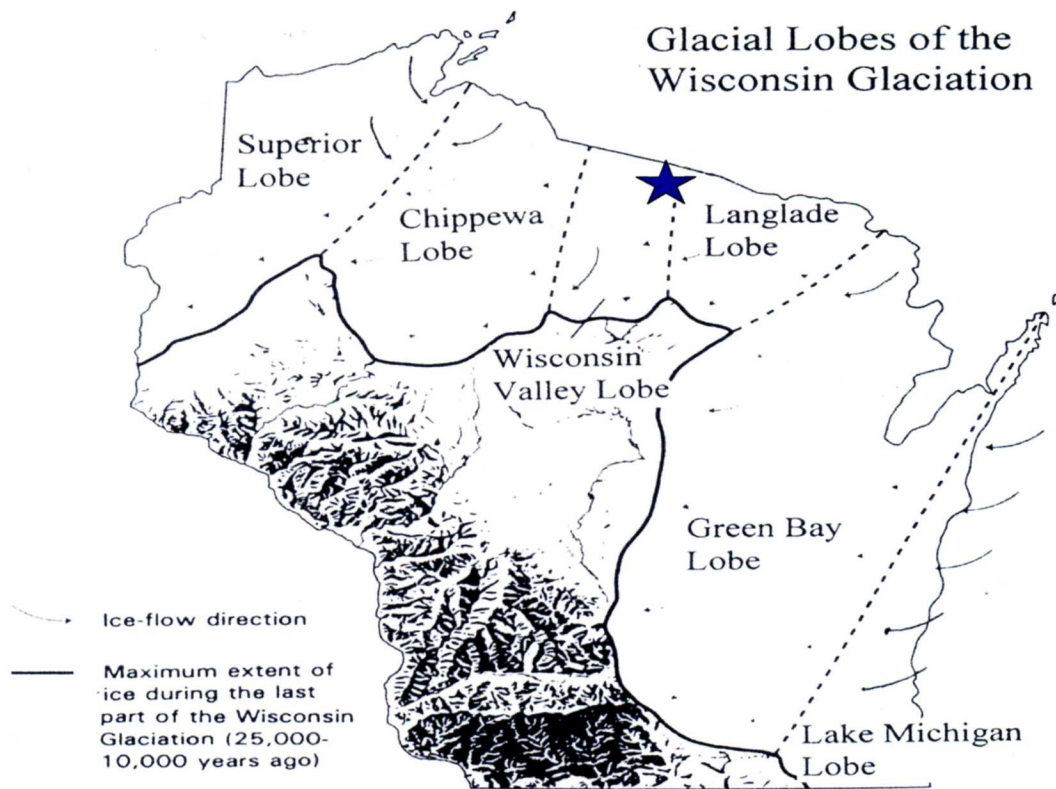


Figure 2. Glacial lobes of the Wisconsin glaciation. Muskellunge Lake is located in the Wisconsin Valley lobe.

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).

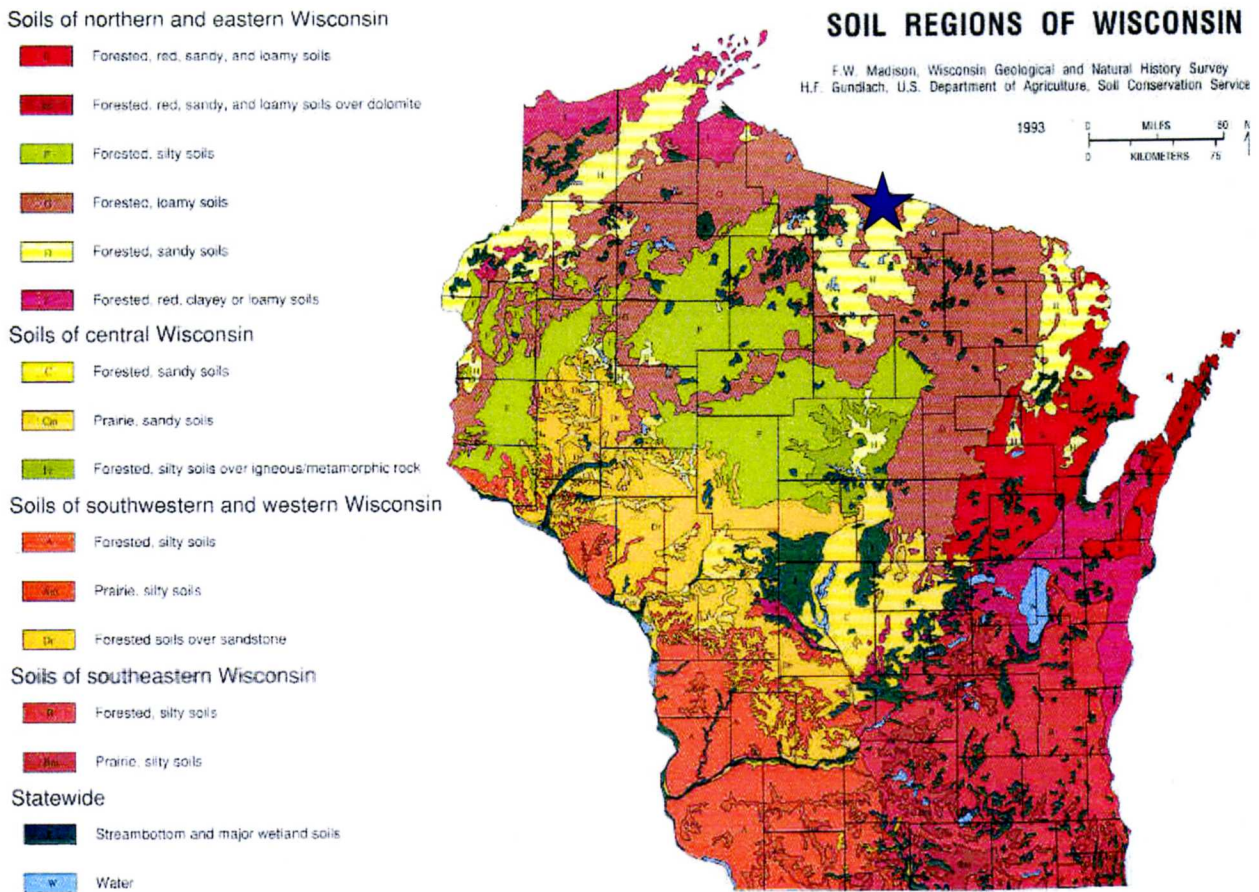


Figure 3. Muskellunge Lake is located within a soils group characterized as forested silty soils.

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.

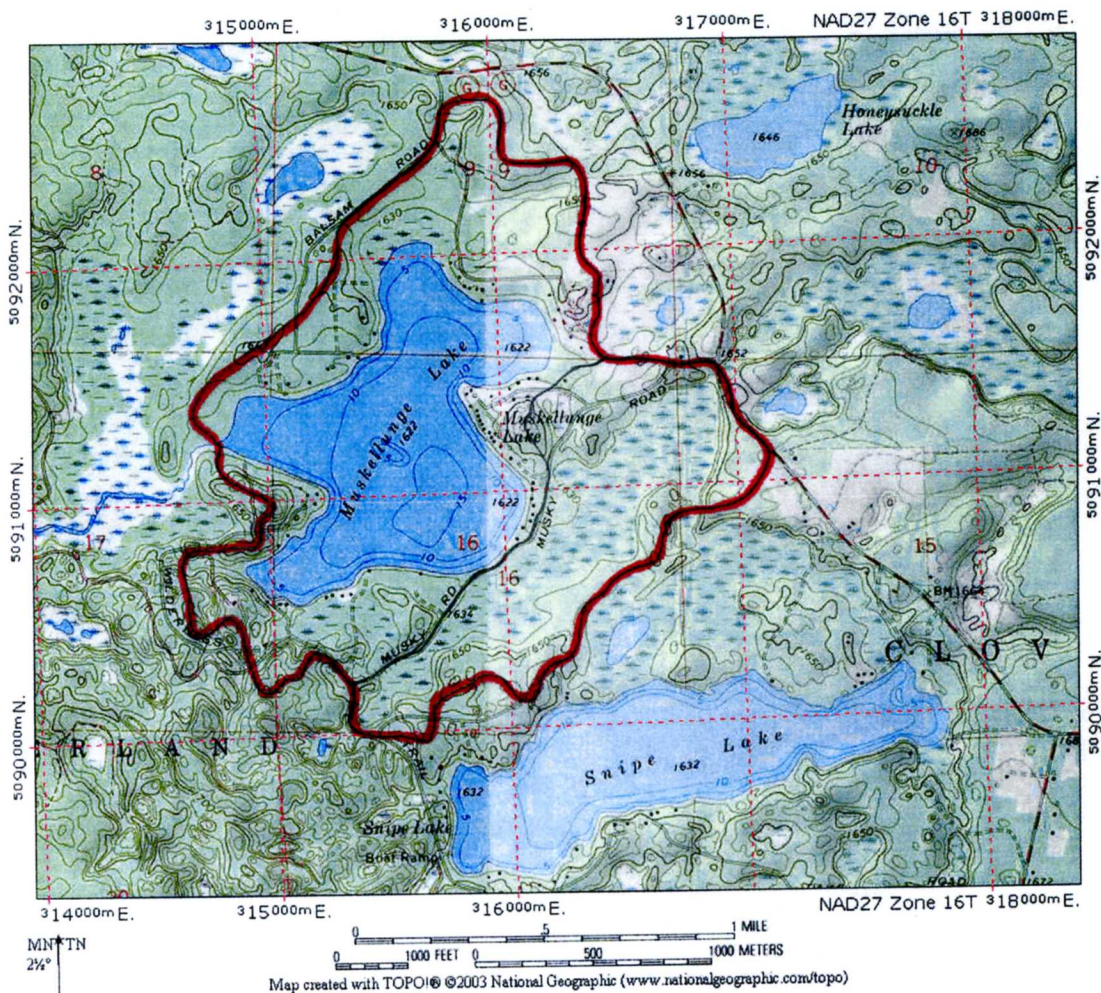


Figure 4. The direct drainage watershed area for Muskellunge Lake is outlined in red (source: Robertson et al 2003).

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.

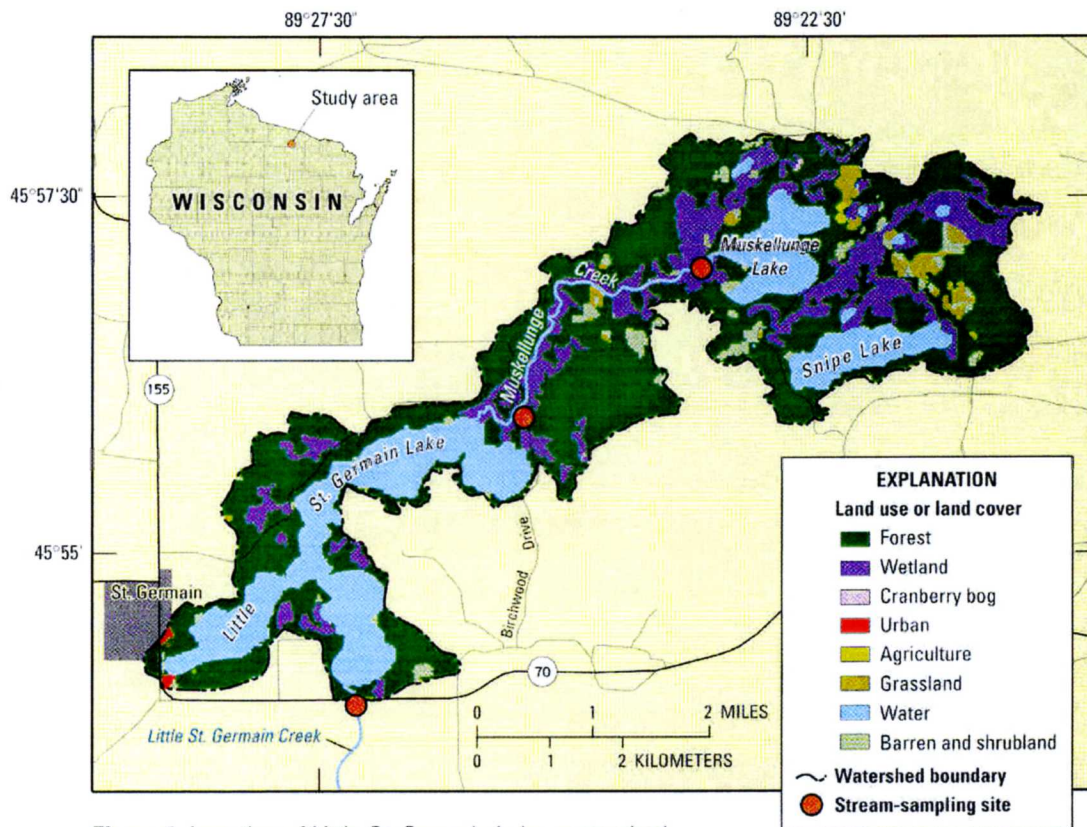


Figure 1. Location of Little St. Germain Lake, watershed characteristics, and location of stream-sampling sites.

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 (#)	Undeveloped 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 (#)	Undeveloped 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

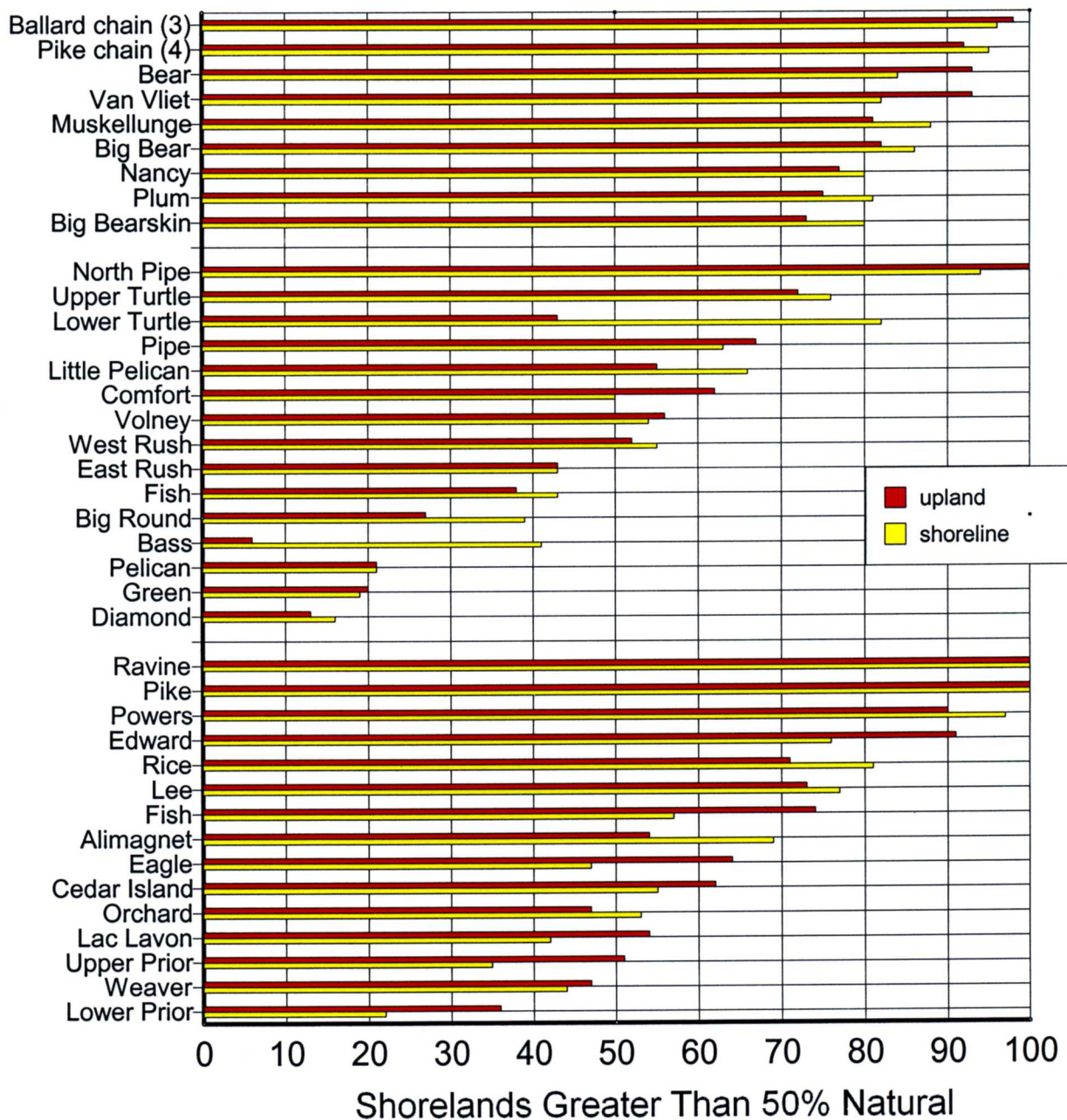


Figure 7. A summary of shoreland inventory results for lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown. The first tier of lakes are located in northern Wisconsin. The lower tier 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 in 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.

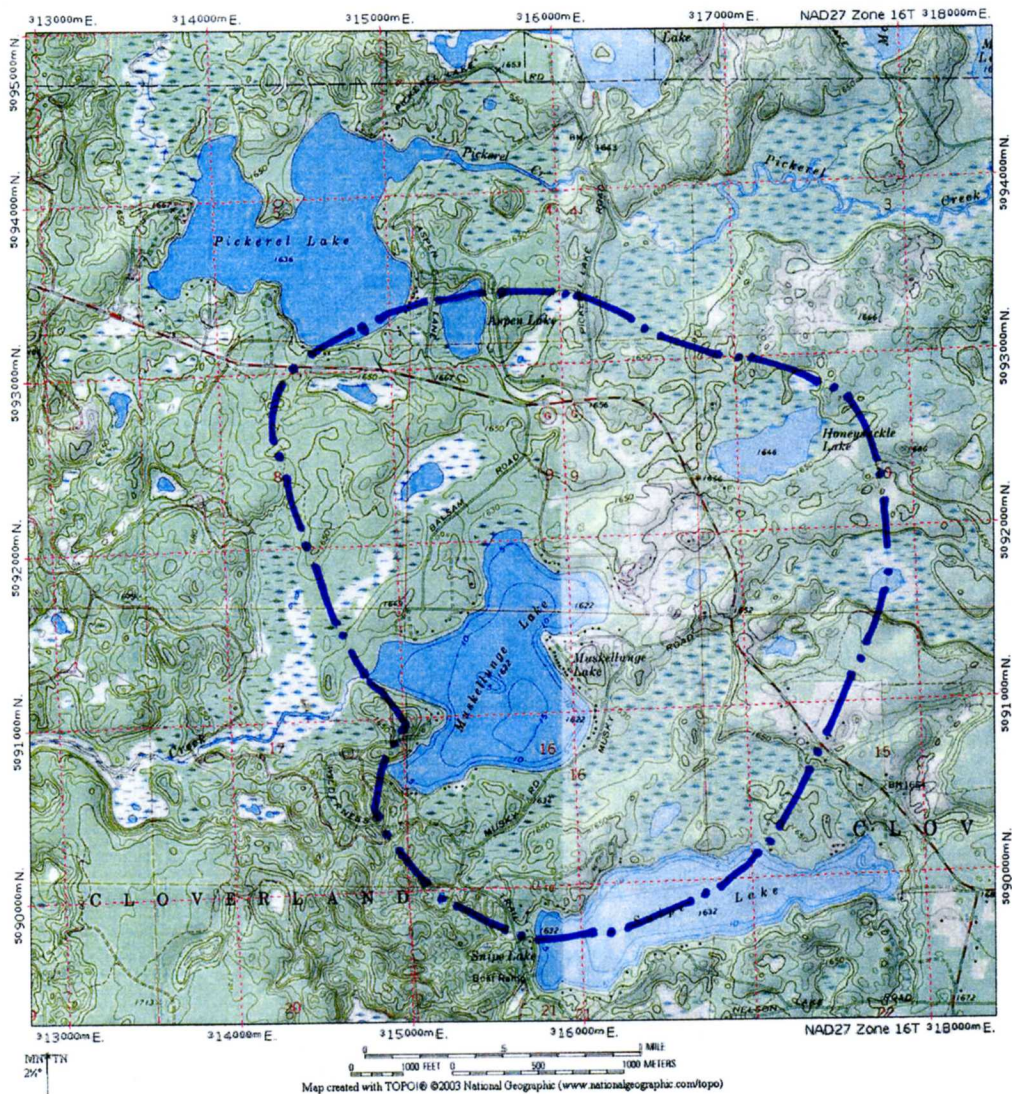


Figure 8. Muskellunge Lake ground watershed based on USGS estimates.

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.

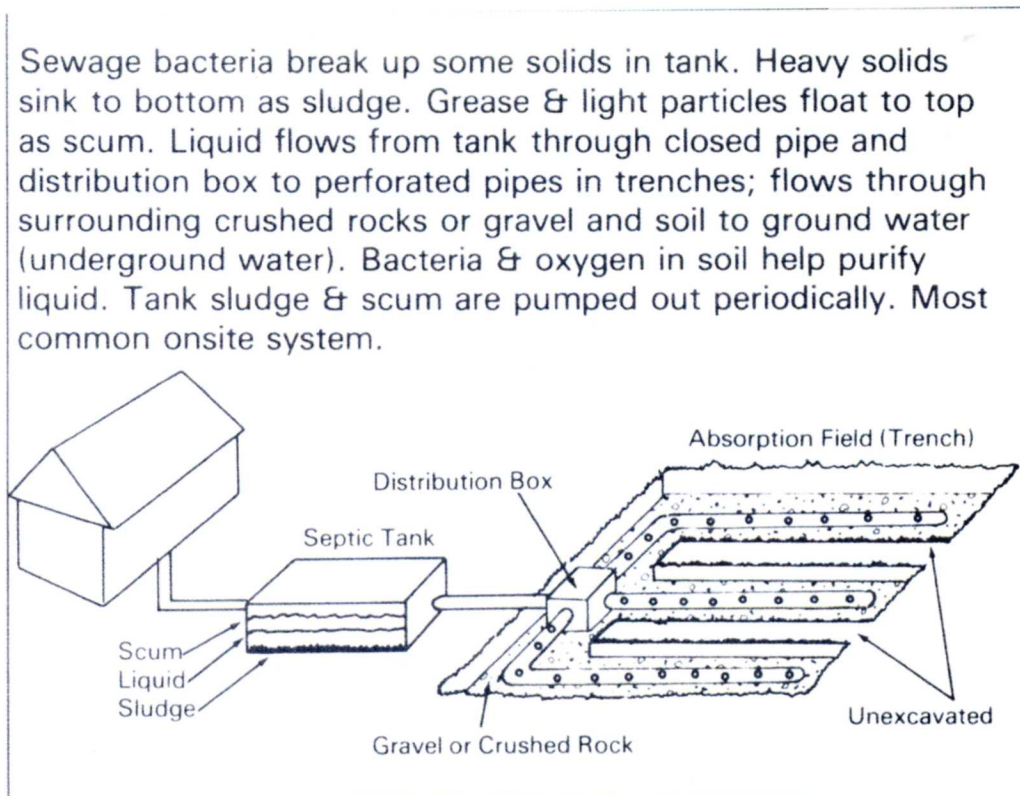


Figure 9. Typical onsite wastewater treatment system found in the Muskellunge Lake watershed.