The Finger Lake Stewardship Program

Report on Finger Lake Littoral Zone, Near-shore Riparian Area, and Watershed

(Washington Township, Vilas County, Wisconsin)

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Finger Lake
(Angie Stine photo)

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INTRODUCTION & REPORT ORGANIZATION

The *Finger Lake Adaptive Management Plan* results from a small-scale project funded by a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant. The project was submitted by the Friends of Finger Lake (FOFL). White Water Associates, Inc., an independent ecological consulting firm and environmental laboratory, served as a consultant to the FOFL.

The FOFL has had a long history of stewardship for Finger Lake. It was incorporated in 1997 and is a qualified lake association. FOFL has had an active presence on Finger Lake since its establishment. A core group of lake residents has continued to provide leadership throughout the organization's existence. More significant projects led by the association include re-zoning properties adjoining the lake to the most stringent R1 residential zoning designation, fish population studies, a detailed history of lake residents, aquatic plant studies, fish stocking, loon nesting studies, lake mapping initiatives, invasive species education and monitoring, adopt-a-highway projects, and citizen water monitoring program. The FOFL is actively involved with the Vilas County Lakes Association and is a member of Wisconsin Lakes.

The project reported on herein was possible because of a small scale lake planning grant awarded to the FOFL. The intent was to begin the process of understanding the watershed and shoreland area of Finger Lake to learn how it may influence the chemistry and biology of the lake. The project gathered existing and new information about the lake's littoral zone, near-shore riparian area, and watershed. The project gleaned concerns from the FOFL membership about the environmental threats that confront Finger Lake.

This Introduction describes the organization of the report. The next section (Conclusions & Recommendations) summarizes items that members of FOFL and others who care about Finger Lake can consider and implement. The principal data for this study are reported in three Appendices, each with a report component. These appendices are:

- Appendix A - Finger Lake Littoral Zone and Shoreline Survey
- Appendix B - Finger Lake Watershed, Water Quality, and WiLMS Modeling
- Appendix C - Threats to Finger Lake

CONCLUSIONS & RECOMMENDATIONS

The FOFL has had a solid history of stewardship for Finger Lake. A core group of lake residents has provided leadership throughout the organization's existence. This group is key to educating Finger Lake landowners and lake users. It can be the coordinating organization for projects that benefit the lake ecosystem. Based on our work on Finger Lake, we consider the elements in the bullet list below as those that can be (1) accomplished by individual residents and (2) can be the most beneficial to the lake. They are the most straightforward to implement, will provide the greatest benefit, and are supported by the information that is known about Finger Lake and reported in Appendices A, B, and C. In most cases, taking action is as easy as letting nature take its course. The focus of attention is on the two most important drivers of lake health: the near-shore riparian area and the littoral zone (shallow water area). Restoring and protecting these areas benefit the lake in many ways. Educating the landowners about the benefits of these areas is a key role for FOFL. The FOFL should provide landowners education and guidance that promotes:

- Minimal lawn sizes and minimal fertilization of lawns;
- Minimal amount of impervious surfaces (e.g., paved drives and parking areas);
- Maximum vegetated buffers (the wider the better);
- Natural riparian areas with diverse herbaceous plants, shrubs, and trees;
- A naturally vegetated littoral zone, with dead woody material that provides habitat for aquatic organisms;
- An ecological outlook on the importance of aquatic plants to the lake ecosystem; and
- The importance of minimizing opportunities for transfer of aquatic invasive species into Finger Lake (e.g., dedicating watercraft and other gear to the lake or through washing and drying of any gear brought to Finger Lake from other water bodies).

Appendix A

Finger Lake Littoral Zone and Shoreline Survey

Finger Lake Littoral Zone and Shoreline Survey

Introduction

Finger Lake's littoral and shoreline zones were assessed in 2016 by White Water field biologists using the US Environmental Protection Agency's (EPA) National Lakes Assessment (NLA) protocol and the Wisconsin Department of Natural Resources (WDNR) Supplemental Lakeshore Assessment protocol. The intention of the National Lakes Assessment (NLA) project was to provide a comprehensive assessment for lakes, ponds, and reservoirs across the United States (USEPA, 2009). This assessment at Finger Lake will stand as a baseline against which future changes can be measured and can be used to compare Finger Lake with other lakes measured using the same protocols.

Methods

Ten physical habitat (P-Hab) stations were spaced equidistantly around the lake (Figure 1 and 2). At each site, biologists recorded information about the littoral zone bottom substrate, littoral zone aquatic macrophytes (plants), littoral zone fish cover, riparian zone canopy, understory and ground cover, shoreline substrates, human influences, classification of fish habitat, bank features, any invasive species observed (terrestrial or aquatic), land cover, human development and the number of piers between sites.

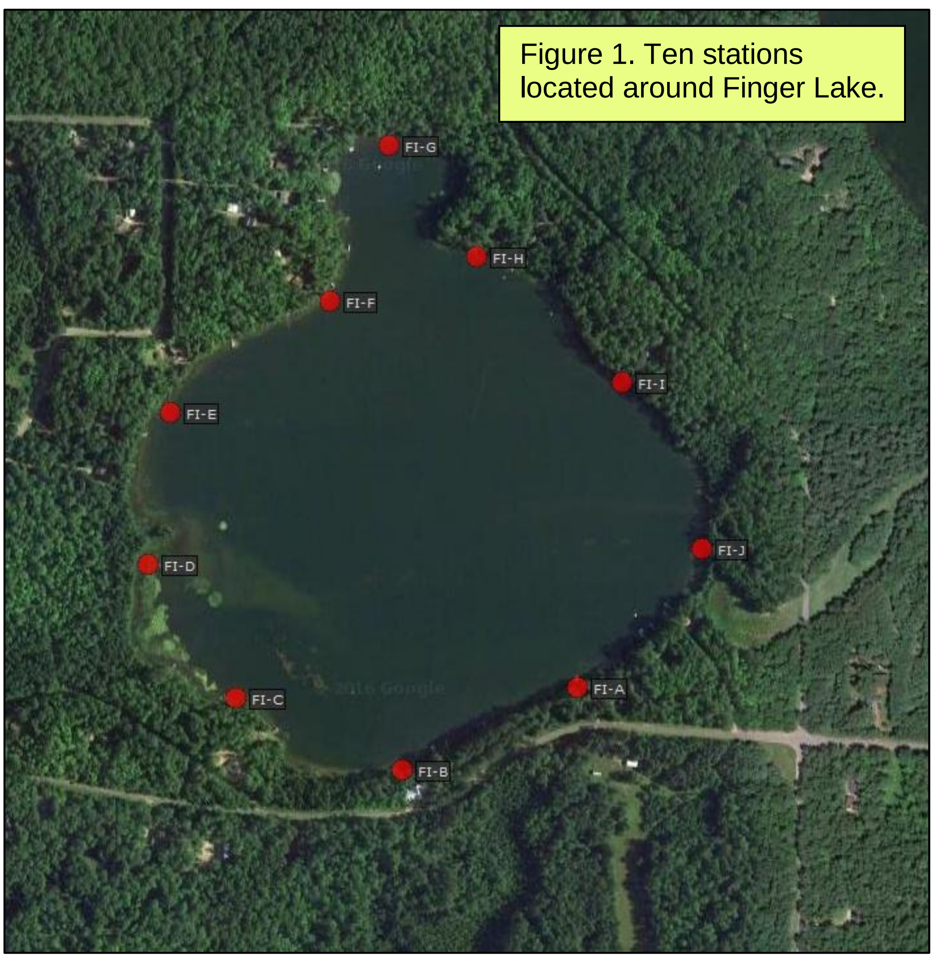


Figure 1. Ten stations located around Finger Lake.

At each P-Hab site, biologists collected macroinvertebrates for later identification. A fecal indicator sample was collected at one site to be analyzed for levels of *E. coli*.

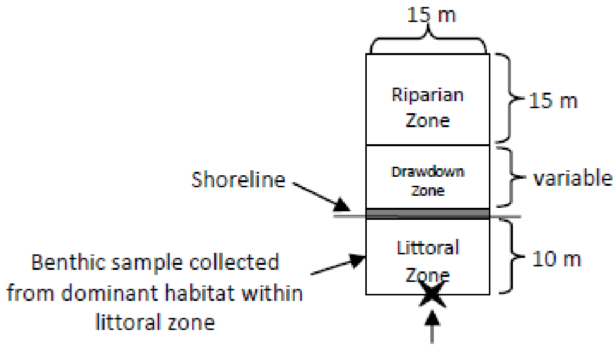


Figure 2. Dimensions and layout of a P-Hab station.

Results

The average depth of the ten stations was 2.79 feet (the range was from 1.6 to 5.3 feet). No surface film was observed at any of the ten stations.

Table 1 contains the littoral zone bottom substrate data collected from the ten Finger Lake sampling stations. Bedrock and boulders were not observed as a bottom substrate at any station. Cobble was present at two stations. Gravel was present at three stations. Sand was present at nine stations. Silt, clay and muck were encountered at two stations. Woody debris was present at nine stations. Brown colored sediment occurred at all the stations. No odor was associated with the substrate at any station.

Table 1. USEPA Habitat Characterization – Littoral Zone Bottom Substrate.

Station	A	B	C	D	E	F	G	H	I	J
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	0	0
Cobble	0	0	0	0	0	0	0	0	1	2
Gravel	1	0	0	0	0	0	0	0	2	2
Sand	4	0	4	1	4	4	4	4	4	4
Silt, Clay, Muck	0	4	0	3	0	0	0	0	0	0
Woody Debris	3	1	2	0	3	2	1	1	1	1
Color	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown
Odor	None	None	None	None	None	None	None	None	None	None

Bedrock (>4000mm); Boulders (250-4000mm); Cobble (64-250mm); Gravel (2-64mm); Sand (0.02-2mm); Silt, Clay, or Muck (<0.06mm, not gritty). 0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)

Table 2 presents the observations made on aquatic macrophytes in the littoral zone. Submergent aquatic plants were observed at nine stations. Emergent macrophytes were observed at all stations. Two of the ten stations had floating macrophytes present. Total macrophyte cover had sparse (four stations), moderate (one station), heavy (three stations), and very heavy (two stations) coverage. Macrophytes extended lakeward at four stations.

Table 2. USEPA Habitat Characterization – Littoral Zone Aquatic Macrophytes.

Station	A	B	C	D	E	F	G	H	I	J
Submergent	0	1	2	2	2	1	1	1	1	1
Emergent	2	3	4	4	2	4	3	1	1	1
Floating	0	0	0	3	1	0	0	0	0	0
Total Aquatic Macrophyte Cover	1	3	4	4	2	3	3	1	1	1
Do macrophytes extend lakeward from plot?	No	No	Yes	Yes	Yes	No	Yes	No	No	No
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Littoral zone fish cover observations are presented in Table 3. Aquatic and/or inundated herbaceous vegetation was observed at all ten stations, having coverage's of sparse (three stations) and moderate (two stations). Woody debris and snags greater than 0.3 meters in diameter were observed at nine stations and had sparse (seven stations) and moderate (two stations) coverage. Woody brush/woody debris less than 0.3 meters in diameter was found at eight stations and had sparse (five stations), moderate (two stations), and heavy (one station) coverage. Inundated live trees (greater than 0.3 meters in diameter) were observed at four sites. Overhanging vegetation within one meter of the surface was observed at six stations. Ledges or sharp drop-offs were not observed. Boulders were not observed. Finally, human structures (such as docks, landings, etc.) were observed at two stations and were sparse.

Table 3. USEPA Habitat Characterization – Littoral Zone Fish Cover.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Aquatic & Inundated Herbaceous Cover	3	3	4	4	2	3	2	1	1	1
Woody Debris/Snags >0.3 m dia.	1	1	2	0	2	1	1	1	1	1
Woody Brush/ Woody Debris <0.3 m dia.	2	0	3	1	1	1	2	0	1	1
Inundated Live Trees >0.3 m dia.	0	0	2	0	1	2	0	0	0	1
Overhanging veg. w/in 1 m of surface	2	1	3	0	3	3	0	0	0	2
Ledges or Sharp Drop-offs	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	0	0
Human Structures (docks, landings, etc.)	1	0	1	0	0	0	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Table 4 shows observations made at the riparian zone canopy (>5 meters high), understory (0.5 to 5 meters), and ground cover (<0.5 meters). Mixed (conifer and deciduous) canopy type was observed at all ten stations. The coverage of big trees (>0.3 meters diameter) was moderate (two stations), heavy (seven stations), and very heavy (one station). Coverage of small trees (<0.3 meters diameter) was sparse (two stations), moderate (five stations), and heavy (three stations). Mixed understory type was observed at all then stations. Coverage of understory woody shrubs and saplings was moderate (eight stations), and heavy (one station) coverage. Understory tall herbs, grasses, and forbs were present at five stations with sparse coverage and moderate at three stations. Ground cover of woody shrubs and saplings were observed at nine stations with coverages of sparse (four stations), moderate (three stations), and heavy (two stations). Groundcover herbs, grasses, and forbs were observed at seven stations with sparse (five stations), and moderate (one station) coverage. Standing water or inundated vegetation was not observed. Barren, bare dirt or buildings was not observed.

Table 4. USEPA Habitat Characterization – Riparian Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
CANOPY (>5 m high)										
Type	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix
Big Trees (Trunk >0.3 m dia.	3	2	3	3	3	3	4	2	3	3
Small Trees (Trunk <0.3 m dia.	2	3	3	2	2	1	3	2	1	2
UNDERSTORY (0.5 to 5 m high)										
Type	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix	Mix
Woody Shrubs and Saplings	2	2	3	2	2	2	2	0	2	2
Tall Herbs, Grasses, Forbes	1	1	0	2	2	2	1	0	1	1
GROUND COVER (<0.5 m high)										
Woody Shrubs and Saplings	1	2	3	3	2	2	1	0	1	1
Herbs, Grasses and Forbes	1	1	0	1	2	0	1	1	0	0
Standing Water/ Inundated Veg.	0	0	0	0	0	0	0	0	0	0
Barren, Bare Dirt, or Buildings	0	0	0	0	0	0	0	0	0	0
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%); Mix = Mixed conifer and deciduous; Dec = Deciduous										

Table 5 presents observations recorded on the riparian shoreline substrate zone. Bedrock and boulders was not observed at any of the ten stations. Cobble substrate was observed at one station with coverage of sparse. Gravel substrate was observed at three stations and was sparse (one station) and moderate (two stations) in coverage. Sand substrate was observed at all then stations and was sparse (one station) and very heavy (nine stations). Silt, clay, or muck substrate was observed at one station and was sparse. Woody debris was observed at nine stations with sparse (three stations), moderate (four stations), heavy (one station), and very heavy (one station) coverage. Vegetation or other was observed at eight stations with coverage’s of sparse (two stations), moderate (one station), heavy (two stations), and very heavy (three stations).

Table 5. USEPA Habitat Characterization – Riparian Zone – Shoreline Substrate Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Bedrock	0	0	0	0	0	0	0	0	0	0
Boulders	0	0	0	0	0	0	0	0	0	0
Cobble	0	0	0	0	0	0	0	0	1	0
Gravel	2	1	0	0	0	0	0	0	2	0
Sand	4	4	4	1	4	4	4	4	4	4
Silt, Clay, Muck	0	0	0	4	0	0	0	0	0	0
Woody Debris	2	2	4	0	2	3	2	1	1	1
Vegetation or other	0	0	3	4	3	4	4	2	1	1
0=Absent (0%); 1=Sparse (<10%); 2=Moderate (10-40%); 3=Heavy (40-75%); 4=Very Heavy (>75%)										

Observations of human influence in the riparian zone are shown in Table 6. Human influence was moderately low. Buildings were observed inside the plot at two stations and outside the plot at six stations. Docks or boats were observed inside the plot at two stations and outside the plot at seven stations. Roads or railroads were observed outside the plot at eight stations. Lawn was observed inside the plot at three stations and outside the plot at four stations. All other human influences (commercial development, park facilities/manmade beach, walls, dykes, revetments, landfill/trash, powerlines, row crops, pasture/range/hayfield, and orchards) were not observed at any of the ten stations.

Table 6. USEPA Habitat Characterization – Riparian Zone – Human Influence Zone.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Buildings	P	C	P	0	0	P	P	PC	0	P
Commercial	0	0	0	0	0	0	0	0	0	0
Park Facilities/ manmade beach	0	0	0	0	0	0	0	0	0	0
Docks/Boats	PC	0	C	0	P	P	P	P	P	P
Walls, dykes, revetments	0	0	0	0	0	0	0	0	0	0
Landfill/Trash	0	0	0	0	0	0	0	0	0	0
Roads or Railroad	P	P	P	0	0	P	P	P	P	P
Powerline	0	0	0	0	0	0	0	0	0	0
Rowcrops	0	0	0	0	0	0	0	0	0	0
Pasture/Range/Hayfield	0	0	0	0	0	0	0	0	0	0
Orchard	0	0	0	0	0	0	0	0	0	0
Lawn	PC	PC	0	0	0	P	0	C	0	P
0 = Not Present; P = Present outside plot; C = Present within plot										

Table 7 reports the observations made on littoral fish macrohabitat classification. Human disturbance was observed at six stations. Cover class was patchy (five stations), continuous (four stations), and no or little coverage (one station). Cover type was recorded as woody and vegetated at nine stations and only vegetation at one station. Dominant substrate was sand/gravel at nine stations, mud/muck at one station, and cobble/boulder at one station.

Table 7. USEPA Habitat Characterization – Littoral Zone Macrohabitat Classification.

Station	A	B	C	D	E	F	G	H	I	J
Human Disturbance	Low	Low	Low	None	None	None	None	Low	Low	Low
Cover Class	Cont	Patchy	Cont	Cont	Patchy	Cont	Patchy	No/Lit	Patchy	Patchy
Cover Type	Woody Veg	Woody Veg	Woody Veg	Veg	Woody Veg	Woody Veg	Woody Veg	Woody Veg	Woody Veg	Woody Veg
Dominant Substrate	S/G	S/G	S/G	M/M	S/G	S/G	S/G	S/G	S/G C/B	S/G

Mod = Moderate; Cont = Continuous Cover; Art = Artificial; No/Lit = No or Little Cover; Bould = Boulder; Veg = Vegetation; M/M = Mud/Muck; C/B = Cobble/Boulder; S/G = Sand/Gravel

Plot bank features are presented in Table 8. Bank angle was considered gradual at six stations, steep at two stations, and near vertical at two stations. The vertical height from waterline to the high water mark was zero. The horizontal distance from waterline to the high water mark was zero.

Table 8. USEPA Habitat Characterization – Within Plot Bank Features.

Station	A	B	C	D	E	F	G	H	I	J
Angle	Steep	Steep	Grad	Grad	Grad	Grad	Grad	Grad	NV	NV
Vertical Height (m) to HWM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Horizontal Distance (m) to HWM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

HWM = High Water Mark; Flat = <5 degrees; Grad = Gradual (5-30 degrees); Steep (30-75 degrees); NV=Near vertical/undercut (>75°)

Table 9 displays the invasive plant and invertebrate species found in Finger Lake. Chinese mystery snails were present at nine stations.

Table 9. USEPA Habitat Characterization – Invasive Plant and Invertebrate Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Target Invasive Species in Littoral Plot	CMS	CMS	CMS	None	CMS	CMS	CMS	CMS	CMS	CMS
Target Invasive Species in Shore-line/Riparian Plot	None	None	None	None	None	None	None	None	None	None
Target Invasive Species include: Zebra or Quagga Mussel, Eurasian Water-milfoil, Hydrilla, Curly Pondweed, African Waterweed, Brazilian Waterweed, European Water Chestnut, Water Hyacinth, Parrot Feather, Yellow Floating Heart, Giant Salvinia, Purple Loosestrife, Knotweed (Giant or Japanese), Hairy Willow Herb, Flowering Rush, Other Banded Mystery Snail (BMS) and Chinese Mystery Snail (CMS)										

The WDNR Supplemental Methodology data are presented in Tables 10 and 11. Table 10 shows thirty-nine pieces of small woody material (>5cm diameter) counted at eight of the ten littoral zone transects. Forty-seven pieces of large woody material were found at eight stations. None of the five target invasive species (Japanese stiltgrass, reed canary grass, Phragmites, cattails, or yellow iris) were observed. The Chinese mystery snail was observed at nine stations.

Table 10. WDNR Supplemental Methodology– Wood and Invasive Plant Species.										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Wood: >5cm diameter	7	7	7	0	3	4	4	0	6	1
Wood: >10cm diameter	8	6	9	0	8	5	8	2	1	0
Invasive: Japanese stiltgrass	No	No	No	No	No	No	No	No	No	No
Invasive: Reed canary grass	No	No	No	No	No	No	No	No	No	No
Invasive: Phragmites	No	No	No	No	No	No	No	No	No	No
Invasive: Cattails	No	No	No	No	No	No	No	No	No	No
Invasive: Yellow Iris	No	No	No	No	No	No	No	No	No	No
Chinese mystery snail presences see Table 9.										

Table 11 tabulates that lawn (three stations riparian plant and two stations for upland plot) were found in Finger Lake. Pavement was found in one riparian plot and three upland plots. Seawalls rip rap and artificial beaches were not present on the study plots. Residences were observed in the riparian plot of three stations and were observed in the upland plot at seven stations. Commercial buildings were not observed. Structures were observed in one upland plot. There were no boat lifts or swim rafts observed at any of the stations. A dock was observed at two stations. The WDNR protocol called for counting piers between each of the ten stations. Thirty-one piers were counted between stations on the perimeter of Finger Lake.

Table 11. WDNR Supplemental Methodology– Land cover, Human Development, and Piers. (1 number given for riparian plot; if 2 numbers, 1st for riparian plot & 2nd for upland plot)										
Station	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
LANDCOVER Key: 0 (0-1%), 1 (>1-10%), 2 (>10-40%), 3 (>40-75%), 4 (>75%)										
Seawall	0	0	0	0	0	0	0	0	0	0
Rip Rap	0	0	0	0	0	0	0	0	0	0
Artificial beach	0	0	0	0	0	0	0	0	0	0
Lawn	1/0	1/1	0	0	0	0/1	0	1/0	0	0
Pavement	0/0	1/1	0	0	0	0/1	0	0	0/1	0
HUMAN DEVELOPMENT										
Residences	1/0	1/1	0/1	0	0/2	0/1	0/1	1/1	0/1	0
Commercial buildings	0	0	0	0	0	0	0	0	0	0
Structures (sheds/boat houses)	0/1	0	0	0	0	0	0/1	0	0	0
Boat lifts	0	0	0	0	0	0	0	0	0	0
Swim rafts	0	0	0	0	0	0	0	0	0	0
Docks	1	0	1	0	0	0	0	0	0	0
NUMBER OF PIERS BETWEEN STATIONS										
From:	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-A
Count	4	1	2	2	4	6	3	4	2	3

The USEPA protocol called for a composite sample of aquatic benthic macroinvertebrates, combining net sweeps from each station into one sample. Table 12 provides the identified invertebrate taxa and counts of individuals by taxa for the composite sample. A total of thirty-two taxa and 821 individual organisms were identified.

Table 12. Composite Benthic Macroinvertebrate Sample from Finger Lake.				
Taxon	**Count**		**Taxon**	**Count**
Nematomorpha	2			
Annelida: Hirudinea (1),Oligochaeta (26)	27		Trichoptera (caddisflies): Hydroptilidae (17), Leptoceridae (2), Molannidae (1), and Odontoceridae (2)	22
Crustacea: Amphipoda (2), Decapoda (1)	3		Coleoptera (aquatic beetles): Dytiscidae (2 larvae), Elmidae (18), Gyrinidae (2 adults), and Haliplidae (2 adults)	24
Arachnoidea: Hydracarina	3		Diptera (true flies): Ceratopogonidae (12), Chaoboridae (1), and Chironomidae (325)	338
Ephemeroptera (mayflies): Baetidae (5), Caenidae (204), Ephemerellidae (3), Heptageniidae (1), and Siphlonuridae (2)	215		Mollusca: Gastropoda: Bithyniidae (40), Physidae (6), Planorbidae (41), Viviparidae-banded mystery snail (10)	97
Anisoptera (dragonflies): Aeshnidae (14), Gomphidae (5), and Libellulidae (15)	34		Mollusca: Pelecypoda: Sphaeriidae	46
Zygoptera (damselflies): Coenagrionidae (9) and Lestidae (1)	10		**Total Taxa**	**821**

Finally, the USEPA protocol called for a fecal indicator sample at the final sampling station (Station J). The collected sample was analyzed for *Escherichia coli* (*E. coli)*. The *E. coli* analysis resulted in 7.2 CFU (Colony Forming Units) per 100 milliliters of sample. To place this value in context, the USEPA recommends a water quality advisory (for swimming) when a level of the indicator bacterium *E. coli* exceeds a limit is 235 CFU per 100 milliliters of water.

Table 13 indicates the coordinates of Stations A-J. A photo was taken at each of the ten stations. The station photos are displayed below.

Table 13. Finger Lake USEPA & WDNR Physical Habitat Locations.		
Station	*Latitude*	*Longitude*
A	45.9632223	-89.1796674
B	45.9622753	-89.1825533
C	45.9630963	-89.1852722
D	45.9646143	-89.1867081
E	45.9663473	-89.1863371
F	45.9676123	-89.1837342
G	45.9693893	-89.1827572
H	45.9681213	-89.1813153
I	45.9666863	-89.1789434
J	45.9648003	-89.1776374

An aquatic plant survey was conducted at each of the ten sites by dropping a rake at two, five, and eight meters from shore. The plants were ranked with rake fullness as 1-3 with 3 being the fullest. A depth was recorded with the rake. Table 14 displays the results.

Table 14. WDNR Supplemental Methodology – Aquatic Plant Survey

Plant	Site	Depth (ft)	Shore Distance (m)	Rake Fullness (1-3)
Chara sp. **(muckgrass)**	A	2.1	2	1
	G	3.5	8	1
Dulichium arundinaceum **(Three-way sedge)**	B	2.5	2	1
	F	1.5	2	1
Eleocharis palustris **(Creeping spikerush)**	F	1.5	5	1
Isoetes **(quilwort)**	A	5.3	8	1
Juncas pelocarpus **(Brown-fruited rush)**	B	3.5	5	1
	I	2	2	1
Najas quadalupensis **(Southern naiad)**	B	2.5	2	1
	E	1.5	5	1
	G	3.5	8	1
	H	2.5	5	1
	H	3	8	1
Nitella sp.	C	3.0	8	2
	D	1.5	2	1
	D	2.0	5	1
	D	2.0	8	1
	F	2.5	8	2
Nuphar variegata **(Spatterdock)**	D	1.5	2	1
Pontederia cordata **(Pickerelweed)**	C	1.5	2	1
	E	2.5	8	1
	G	2.0	2	1
Ranunculus aquatilus **(White water crowfoot)**	D	1.5	2	1
	E	1.5	5	1
Schoenoplectus tabernaemontani **(Softstem bulrush)**	D	1.5	2	1
	D	2.0	5	1
	D	2.0	8	1
Sparganium floating **(bur-reed)**	B	3.5	5	1
	C	1.5	2	1
	D	2.0	8	1
	E	2.5	8	1
Utricularia resupinata **(small purple bladderwort)**	A	2.1	5	1
	H	2.5	5	1
Vallisneria americana **(Wild celery)**	B	4.0	8	1
	H	3	8	1

Station A – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station B – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station C – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station D – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station E – Finger Lake

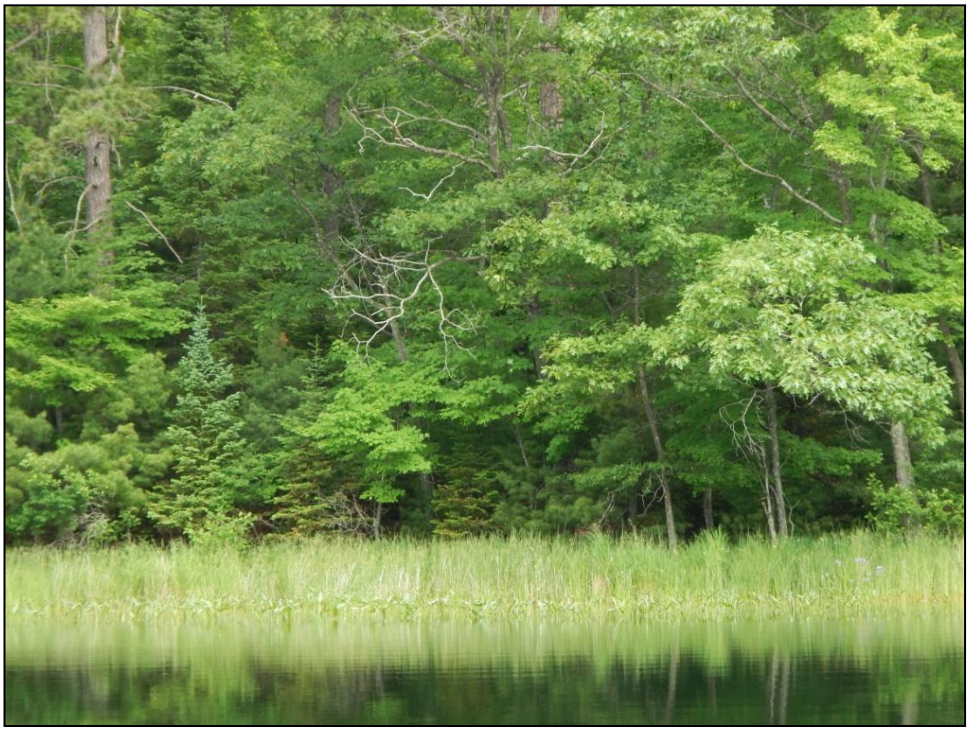
Photograph taken 6/23/2016, White Water Associates, Inc.

Station F – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station G – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.



Station H – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station I – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

Station J – Finger Lake

Photograph taken 6/23/2016, White Water Associates, Inc.

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Appendix B

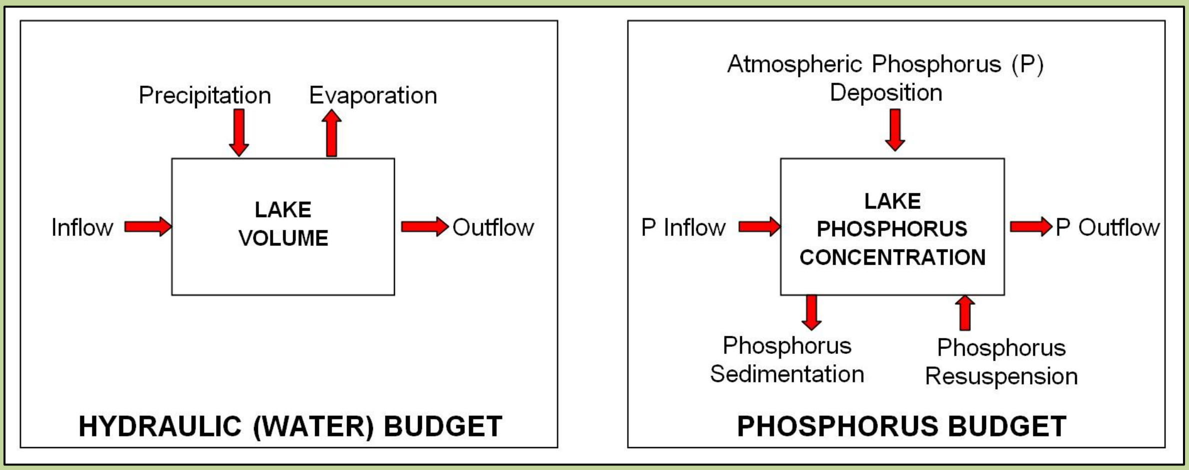
Finger Lake Watershed, Water Quality, and WiLMS Modeling

Finger Lake Watershed, Water Quality, and WiLMS Modeling

Freshwater algae and rooted aquatic plants (macrophytes) require a number of nutrients in order to grow. Two of these nutrients, phosphorus and nitrogen, are often present in small amounts and limit algae and macrophyte growth. In fact, phosphorus is the nutrient that most often limits the growth of aquatic plants in freshwater systems and, when present in high concentrations, is most often responsible for algal blooms, rampant growth of rooted plants, and lake eutrophication. This is the reason that phosphorus is such a focus when it comes to concerns of lake water quality.

The water (hydraulic) budget of a lake is closely associated with the phosphorus budget (both illustrated in Figure 1). The graphics show in general terms the overall movement of water and phosphorus into and out of a lake ecosystem.

Figure 1. Hydraulic (water) and phosphorus budgets in lakes.



Modified from Brylinsky (2004)

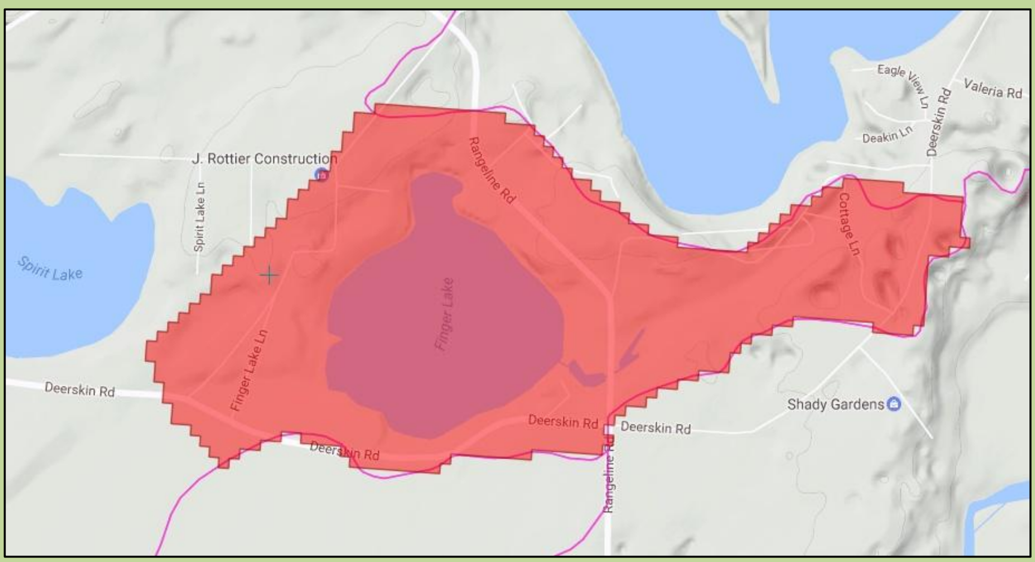
Several interrelated factors are at play when it comes to the water quality of a lake. These include water source, watershed size, retention time, watershed cover types, and internal loading. Because each lake and its watershed have unique characteristics and interactions, no two lakes behave in exactly the same way. Nevertheless, being familiar with these factors and how they interrelate is helpful for lake planning and stewardship.

The sources of water for a lake strongly influence the lake's water quality because the water carries with it nutrients such as phosphorus. The four water sources include precipitation, runoff from the surrounding land, upwelling groundwater, and inflow from a stream. The relative importance of each of these sources depends on several things. For example some lakes have no incoming stream, so these lakes depend on precipitation, runoff, and groundwater. A lake with a small drainage basin (watershed) receives relatively less water as runoff. Water can leave a lake through an outflow, evaporation, and groundwater seeping back into the aquifer (water table).

Water source is the factor that lake scientists use to classify lakes into four categories (Shaw et al., 2004). A "seepage lake" is fed by precipitation, limited runoff, and groundwater and has no inlet or outlet. A "groundwater drainage lake" is fed by groundwater, precipitation, and limited runoff and has a stream outlet. A "drainage lake" is fed by one or more streams, groundwater, precipitation, and runoff and has a stream outlet. Finally, an "impoundment" is a manmade lake formed by damming a stream and is also drained by a stream. When water comes into a lake from its various sources, it also carries other materials to the lake. Some of these are dissolved in the water (like phosphorus, nitrogen, and calcium). Some of the materials are suspended in the water (like silt and small bits of detritus). Precipitation (rain and snow) also carries with it dissolved and suspended materials to the lake (acid precipitation and dust are examples).

The size of a lake's watershed (drainage basin) relative to the lake's surface area is important in determining the amount of nutrients and other materials that come into the lake (Shaw et al., 2004). The Finger Lake watershed is depicted in Figure 2. This ratio of drainage basin area to lake area is a measure of how important the watershed is as the lake's source of water, nutrients (like phosphorus), and other materials. A higher DB/LA ratio means the watershed is relatively more important and runoff contributes more water and nutrients to the lake. With their small watersheds, seepage lakes receive fewer nutrients from runoff than drainage lakes and tend to be higher in water quality.

Figure 2. Finger Lake watershed.



Another important concept in a lake's water and nutrient "budget" (that is, inputs and outputs) is "retention time" (also called "water residence time"), the average length of time that water stays in the lake. This is determined by a lake's size (volume), water sources, and watershed size. For some lakes and impoundments, retention time can be quite short (days or weeks). In other lakes, retention time can be as long as decades or centuries. Retention time also indicates how long nutrients stay in the lake. In short retention time lakes, nutrients are flushed through the system rather quickly. In long retention time lakes, nutrients stay around a longer time and can move into the sediments where they become a long-term part of the lake's chemistry.

The type of land cover (for example, forest, grassland, row crops, or human development) is also an important variable in determining amounts and kinds of materials (like nutrients and sediment) that are carried off the land and into the water. This is especially important close to the lake (the riparian area), but the entire watershed is a contributor and we often map the cover types and measure their acreages to give us some idea of how at risk the lake might be to receiving unwanted materials. Certain kinds of agriculture (tilled row crops) and urban areas (with their impervious surfaces) have a tendency to give up sediments and nutrients to runoff. In contrast, native vegetation (forests, wetlands, and grasslands), tend to slow runoff of water and nutrients, allowing the soil to absorb them. When excessive nutrients and sediment reach a lake they can cause increased growth of aquatic plants, algal blooms, and reduced water clarity.

The DB/LA (drainage basin/lake area) ratio interacts in an interesting way with drainage basin cover type when it comes to nutrient runoff to a lake. For lakes where the ratio is relatively high (greater than 15:1), the role of drainage basin size in delivering water and nutrients to the lake tends to dominate the role of cover type. In small ratio lakes, the kind of cover type on the watershed has the greater influence than the absolute size of the watershed. For these small DB/LA ratio lakes maintaining or restoring good quality native cover type in the watershed will likely have a positive and observable influence on the lake.

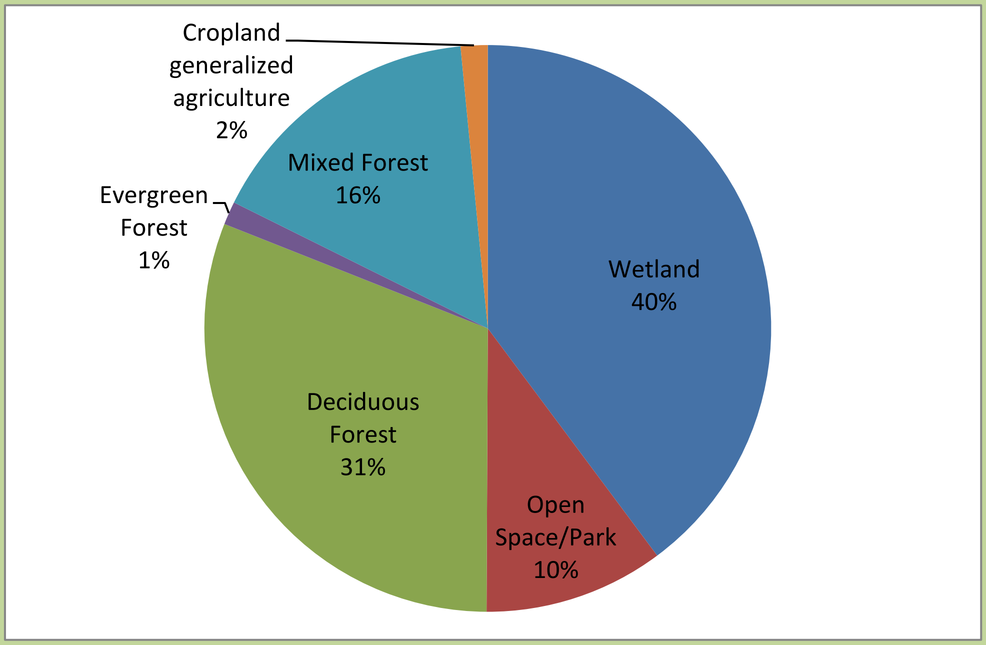
Internal loading refers to phosphorus (and other nutrients) that are present in the lake bottom sediment. Some of the phosphorus in a lake ecosystem continually falls to the bottom and becomes part of the sediment layer and is generally unavailable for plants. Under conditions of low dissolved oxygen, however, this phosphorus can go back into the water column and be taken up by algae and macrophytes. The amount of phosphorus contained in the sediment can be quite high, resulting from centuries of deposition. The phenomenon of internal loading can therefore make available a large amount of phosphorus to the algae and plants of the lake and typically happens at spring and fall overturn periods. Even if sources of phosphorus outside of the lake are reduced, the internal loading can still enrich the lake and cause eutrophic conditions.

Because it is often challenging to work out how these several factors interact to influence the water quality of a specific lake, the Wisconsin Department of Natural Resources developed the "Wisconsin Lake Modeling Suite" (WiLMS) as a lake water quality planning tool (WDNR, 2003). WiLMS is a computer program into which the user enters information about the lake (e.g., surface area, depth, and nutrient measures) and the watershed (e.g., acreage and cover type). The model also has information about average rainfall, aerial deposition of materials, and cover type characteristics that it uses to help predict nutrient (phosphorus) loading scenarios to the lake.

In this project, we applied the WiLMS models to Finger Lake. The 87 acre lake has a watershed of 318.5 acres and a drainage basin/lake area ratio of about 4 to 1. This is a relatively low ratio. Lakes with this size ratio combined with a mostly natural watershed cover type are likely to have high quality (oligotrophic) characteristics, although this is not the case with Finger Lake (mesotrophic). The lake volume is 869.2 acre-feet and the mean lake depth is 9.99 feet. The WiLMS model calculates the annual runoff volume as 371.5 acre-feet and the annual difference between precipitation and evaporation (precipitation minus evaporation) as 5.5 inches. The hydraulic loading for Finger Lake is 411.3 acre-feet per year and the areal water load is 4.7 feet per year. The WiLMS model calculates the annual lake flushing rate as 0.47 times per year and the water residence time (retention time) as 2.11 years.

The cover types in the Finger Lake watershed are shown in Figure 3 with their respective acreages. Wetland cover type is the predominant land cover at 40%. Deciduous forest cover is also important, comprising about 31% of the watershed.

Figure 3. Finger Lake watershed land cover types.



Note: the "wetlands" category also includes the surface area of the lake.

Table 1 presents output from the WiLMS model for non-point source phosphorus input to Finger Lake. No point-source data is available for Finger Lake. The WiLMS model indicated that 24.2 kg (53.4 pounds) of phosphorus are most likely delivered to the lake each year from watershed runoff and from direct deposition onto the lake surface (via precipitation and airborne particles). The WiLMS model predicts that most of the phosphorus delivered to Finger Lake comes from wetland and forest cover types, the most prevalent cover types in the watershed.

Table 1. WiLMS estimated non-point source phosphorus loading based on watershed land use type and acres.								
Land Use	Land Use Acres	Loading (kg/ha-year)				Loading kg/year		
		Low	Most Likely	High	Loading %	Low	Most Likely	High
Row Crop Ag.	0	0.50	1.00	3.00	0	0	0	0
Mixed Agricultural	4.89	0.30	0.80	1.40	6.5	1	2	3
Pasture/Grass	0	0.10	0.30	0.50	0	0	0	0
High Density Urban (1/8 acre)	0	1.00	1.50	2.00	0	0	0	0
Mid Density Urban (1/4 acre)	0	0.30	0.50	0.80	0	0	0	0
Rural Residential (>1 acre)	32.69	0.05	0.10	0.25	5.5	1	1	3
Wetlands	126.74	0.10	0.10	0.10	21.2	5	5	5
Forest	154.1	0.05	0.09	0.18	23.2	3	6	11
Lake Surface	87.0	0.10	0.30	1.00	43.6	4	11	35
				Totals	100.0	14	25	57

The WiLMS generated an estimate of internal loading of phosphorus. These data are presented in Table 2. The model predicts that about 2 pounds (1 kg) of phosphorus are released each year from Finger Lake sediments and available to algae and aquatic plants. The model calculates a predicted phosphorus retention coefficient as 0.77 (this represents the fraction of phosphorus entering the lake that is lost by settling to the sediment). The observed phosphorus retention coefficient is 0.74 indicating that phosphorus is available about as the model predicts.

Table 2. WiLMS Method 1 – Complete Phosphorus Mass Budget.	
Parameter	**Value**
Phosphorus Concentration of Lake (input into model)	12.5 mg/m^3
Phosphorus Inflow Concentration	47.7 mg/m^3
Areal External Loading	68.8 mg/m^2-year
Predicted Phosphorus Retention Coefficient *(the predicted fraction of phosphorus entering the lake that is lost by settling to the sediment)*	0.77
Observed Phosphorus Retention Coefficient	0.74
Internal Load (amount released annually from the sediment)	2 pounds (1 kg)

The WiLMS also allow us to manipulate the cover type acreages as an illustration of how watershed cover can influence the delivery of phosphorus to a lake. As an example, we re-ran the non-point source data model, but altered landscape composition to simulate the effect of converting 200 acres of the forest cover type to row crop agriculture. The results are dramatic. Under the hypothetical agricultural condition, 99.5 kg of phosphorus would be delivered to the lake each year from runoff as compared to the 24.2 kg estimated as the most likely loading to come from the existing watershed (under the actual conditions in the watershed).

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Appendix C

Threats to Finger Lake

Threats to Finger Lake

Compiled by William Abba with contributions by White Water Associates, Inc.

Introduction

A key step in the completion of the small scale lake planning project for Finger Lake was to collect perceived threats to the lake and the surrounding area as seen by lake residents. One of the activities conducted at the Friends of Finger Lake Association annual meeting on July 17, 2016, was to ask each resident to fill out a questionnaire during the meeting to collect concerns, threats, and risks to the lake as they perceive them. The purpose of the exercise was explained as the opportunity for White Water Associates to collect resident concerns to ensure they were included in the grant analysis process and to ensure important concerns were not missed. No limitations were given, whatever they felt were the issues and threats to the lake should be included. Residents were allowed to collect their thoughts over the entire hour and a half meeting and were told to leave the questionnaire on the tables at the end of the meeting. No attempt to collate and discuss the issues was made at the meeting. We received 12 questionnaires back at the meeting, about a 50% return. The questionnaire is presented in Exhibit 1.

Results

The results of the survey are summarized in this section. A few general conclusions can be drawn from reading all of the input. First, and expectedly so, the comments from residents mimicked recently discussed issues included in the Association newsletter distributed approximately two months earlier and the topics actually discussed at the annual meeting. This is positive in that it seems to indicate at least some success in our communication tools in highlighting important issues residents need to be aware of and focused on. Some residents did not appear to have awareness of, or possibly enough understanding of, the many issues impacting lakes to include them or comment on them. A small number of residents who are actively involved in lake groups and causes had much to include in their questionnaires. This seems to underscore that communication can have an impact on residents understanding of issues, and the Association needs to continue to improve in this area. Interestingly, this was the most interactive meeting with attendees in recent memory, so clearly members are interested and willing to be engaged.

The results have been collated and summarized below. A brief explanation of each is included. Three topics stood out as most concerning based upon the number of residents mentioning the issue:

1. The Southern Naiad infestation. Not a surprise given this is the first time a significant problem plant has infested the lake. Even though this plant is not designated an "invasive" species, it is none-the-less a significant nuisance on the lake. Many residents have had to deal with heavy plant growth on their shorelines and navigation can be impacted in heavy growth areas. Another concerning aspect of this issue is that the source of this plant will never be known, creating concern over what else could happen in the future and highlighting the inability to completely stop nuisance organisms. Residents

have accepted that this plant is here to stay, but still desire a means to mitigate the negative impacts of its heavy growth.

2. The potential for an invasive species infestation. Residents have seen what a plant can do to the quality of a lake from the Southern Naiad infestation on Finger Lake. They are aware that steps need to be taken to ensure an infestation does not occur on Finger Lake. They are aware of the huge expense of trying to mitigate invasive species and eliminate them from lakes. They are also aware that a non-public access lake like Finger Lake with a very small number of residents could be financially overwhelmed in dealing with invasives. They recognize Finger Lake has some protection because of limited access to the lake, but they also recognize they must be diligent in preventing infestation in the first place.
3. Shoreline protection. Awareness the importance of shorelines has increased considerably. Residents are now understanding the important role shorelines play in protecting the lake from watershed issues and the role they play in habitat for fish and other lake animals. There is a need to understand exactly what needs to be done to protect shorelines and what the issues actually are. But at least there is a significant awareness that residents need to actively work to address shoreline preservation.

Four additional issues were mentioned but by a smaller number of residents. These include:

1. Zoning law changes/legislative changes. Recent changes to lake shore zoning accountability resulting in the State taking control away from local governments has huge implications. A small group of residents have a deep understanding of the extent of the change and ramifications. Concern continues in anticipation of the upcoming legislative sessions and the changes it may bring.
2. Global climate change. The documented changes to global climate have the potential to significantly impact lake environments. The uncertainty of future changes and impacts raises the level of concern.
3. Changes in fisheries, especially walleye. Over the past years, a well-documented shift in fish populations favoring bass and disadvantaging walleyes has occurred. Concern exists with some residents that we are experiencing this change on Finger Lake also. Bass populations in the lake have increased and catches of walleyes have dropped significantly. No data exists to substantiate this shift, but some residents are concerned about the change especially since little seems to be known on why this shift is taking place.
4. Lake access. Finger Lake has no public access point yet trespassing across private property is on the rise, especially with winter ice fisherman. Trespassing is clearly an issue, but other related concerns are also troubling. Are these fisherman a source of potential invasive species contamination? Are they harvesting the stocked fish without contributing to the cost? These trespassers not only trespass in the winter, but apparently sneak onto the lake after dark in the summer. Finger Lake is penalized in securing aid and grants because it does not have public access, yet when trespassing occurs it actually does have public access.

This list summarizes the issues collected on this questionnaire. The issues were collated into groups of similar concerns to create this summary. A follow up questionnaire mailed to all lake property owners and access lot residents could be sent if there is belief broader information would be obtained. It is unlikely the number of returned questionnaires would be large and it isn't expected many more issues would be identified beyond those detailed here, so this step is not recommended.

Exhibit 1. Finger Lake Threats Questionnaire

One of the key steps in the lake planning grant process is to collect the perceived risks and threats to Finger Lake and the surrounding area as seen by the residents. Collecting this information will ensure the grant report does not miss important concerns that have potential impact on the lake. This exercise will also ensure that the major concerns held by residents will be addressed in the process of conducting the grant analysis.

Please take some time to write down the most important threats, issues, and concerns that you believe could have a detrimental impact on the long and short term health of Finger Lake and the watershed around the lake. Any issue you believe important should be included, no matter the topic. Examples include zoning law changes, changing fisheries populations, invasive species, septic system leakage, run off, changing climate or any other issue that is concerning you. Write down these concerns below with a few sentence explanation to ensure we understand the issue. Use the back of this sheet if more space is needed.

1.) Concern/threat:

2.) Concern/threat:

3.) Concern/threat:

4.) Concern/threat:

Name (*optional but will help us get more info if needed*) ____

White Water Associates staff adds the following list of potential threats to Finger Lake along with a few suggestions as to how Finger Lake riparian residents might act to minimize the threats.

Recreational pressure – Finger Lake is a lightly-used fishing lake primarily for people who live on the lake. A few enter the lake through trespass. It is not likely that the recreational pressure on the lake will increase appreciably over time.

Development pressure – Finger Lake has some areas of residential development as well as areas with predominantly natural vegetation and diverse riparian areas. In some areas of the lake, old-style lawns, cropped short and in close proximity to the shore indicate a need for some educational effort to inform residents about more ecologically friendly waterfront vegetation. Likewise, well-intended activities meant to "clean up" the shoreline or shallow water zone of the lake diminish the habitat quality for invertebrates and fish and could be addressed with some targeted education.

Non-point source pollution – Surface runoff from the land, roadways, parking areas and other surfaces flows into Finger Lake. This runoff can carry with it sediment, nutrients (for example, from fertilizers) and contaminants (for example, herbicides) that can have detrimental effects on the Finger Lake ecosystem. Known as non-point source pollution (because it does not emanate from a discrete point like an effluent pipe from a paper mill), this kind of runoff can come from lawns, agricultural fields, clear-cuts, and impervious surfaces (for example, roads and paved parking lots). Sometimes the impact is physical, such as sediment covering gravel spawning areas. Sometimes it is chemical such as excess phosphorus from lawn fertilizers that might invoke an algal bloom. This type of pollution can be best controlled through education and protection of riparian buffers (natural vegetation near the waterways that absorb the pollutants before they reach the water).

Aquatic invasive species – Non-native plant and animal species have become a grave concern for aquatic, wetland, and terrestrial ecosystems. As more populations of aquatic plant and animal invasive species become established in lakes and streams in the region, the likelihood of AIS coming to Finger Lake increases. When it comes to non-native aquatic plant invaders, the best defense against establishment is a healthy community of native plants. A diverse native plant community presently exists. Effective education and diligent monitoring are important factors in avoiding establishment of aquatic invasive species. For landowners on Finger Lake, an effective approach to minimizing AIS introduction would be to dedicate watercraft and other recreational gear to the lake (in other words, do not use watercraft and gear on other lakes that you use on Finger Lake).

Riparian ecosystem integrity – Healthy riparian areas (the naturally vegetated land near the water) provide numerous important functions and values to Finger Lake. For example, they serve as habitat for many species, contribute important habitat to the lake (e.g., large wood), filter out non-point source pollution from entering the lake, and armors the shores against erosion. Educating riparian owners around Finger Lake as to the importance of riparian areas is crucial to the maintenance of these critical areas. This is one of the most important ecosystem components to protect in terms of long-term health of Finger Lake.

Littoral zone ecosystem quality – Much of the productivity of a lake comes from the shallow water areas known as the littoral zone. This is where plants grow, invertebrates live, fishes spawn, and aquatic birds and mammals spend much of their time. The presence of good aquatic vegetation, diverse substrate, and dead woody material (logs and branches) is crucial to this littoral zone ecosystem. Sometimes the human temptation is to "clean up" these areas, but in fact this process diminishes the habitat quality greatly. It is important to educate landowners and others about how to protect the littoral zone from degradation. Piers and swimming areas impact the littoral zone as well, but can coexist with a quality shallow water habitat if kept to a reasonable level.

Habitat degradation of nearby aquatic and wetland habitats (ponds, streams) – The wetland habitats, streams, small lakes, and ponds in the vicinity of Finger Lake all potentially contribute to the high quality of the lake. These smaller ecosystems can be overlooked in terms of their importance and therefore deserve some special attention. One of the first protective measures to take is to identify where these features are and characterize their size and ecological composition. This informs future protection and restoration efforts.