Aquatic Plant Management Plan
for
Lower Spring Lake
2018

Jefferson County
Land and Water Conservation Department

This plan was approved by the Lower Spring Lake Protection and Rehabilitation District at their meeting on DATE.

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INTRODUCTION

Lower Spring Lake is a 109 acre lake located in Jefferson County. The western shore of the lake is located in the Village of Palmyra, with the remainder of the shoreline in the Town of Palmyra. The 27.1 square mile watershed is located in both Jefferson and Waukesha Counties.

The 2 aquatic invasive plant species in the lake are Eurasian water milfoil and curly-leaf pondweed.

In 2008, the Department of Natural Resources (DNR) developed a new protocol for determining the need for herbicide applications to treat invasive plants and evaluating the results of chemical applications on both invasive and native plants. In 2011, the Lower Spring Lake Protection and Rehabilitation District adopted an Aquatic Plant Management Plan. In order to follow the DNR protocols and obtain a permit for future herbicide applications, the aquatic plant management plan must be updated.

This document is an update to the 2011 Aquatic Plant Management Plan for Lower Spring Lake. It was developed by the Jefferson County Land and Water Conservation Department and the Lower Spring Lake Protection and Rehabilitation District with the assistance of the Wisconsin Department of Natural Resources.

CHARACTERISTICS OF LOWER SPRING LAKE

Lower Spring Lake is an impoundment on the Scuppernong River and is located in the Town and Village of Palmyra, Jefferson County. The watershed of Lower Spring Lake includes portions of Jefferson and Waukesha Counties (Appendix A). A DNR public boat launch is accessible on the north shore of the lake. The Village of Palmyra has a public park located on the western side of the lake and includes a beach.

Table 1. Physical Characteristics of Lower Spring Lake

Watershed Area (mi^2)	Lake Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Shoreline Length (miles)
27.1	109	12	4	3.2

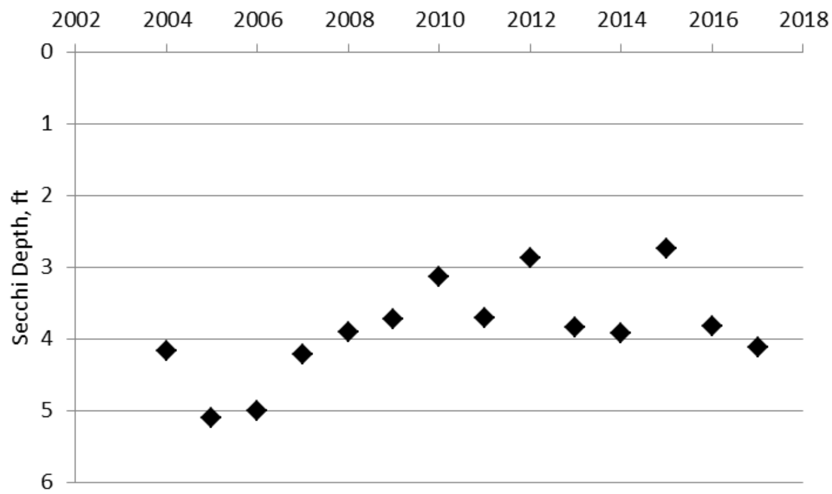
As part of the 2017 summer aquatic plant survey, depths throughout the lake were recorded and a new bathymetry map was developed (Appendix A).

Water Quality

Water quality sampling for water clarity, chlorophyll *a*, and total phosphorus has been performed for several years by citizen monitors at the deepest point of the lake. This monitoring is done as part of the Department of Natural Resources Citizen Lake Monitoring Network program.

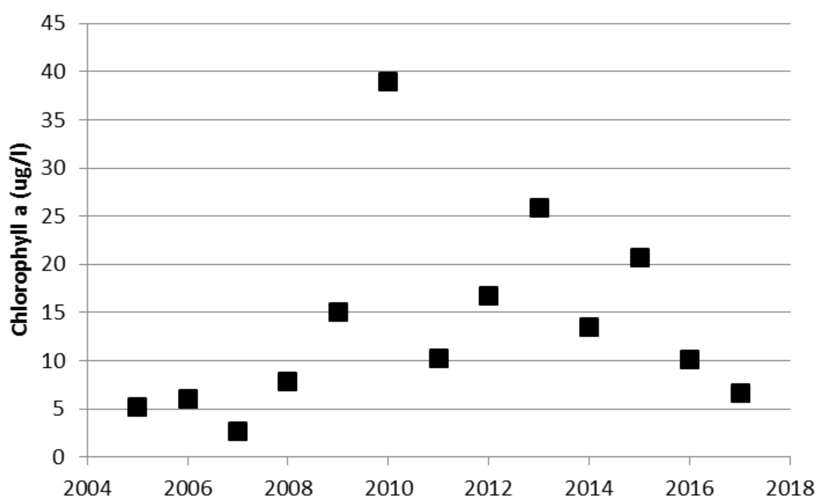
A Secchi disc, which is used to measure water clarity, is an 8-inch disc that is painted black and white. It is lowered into the water until it disappears from sight, then raised until it becomes visible – that depth is recorded as the water clarity reading. Materials suspended (especially algae) and dissolved in the water will impact the water clarity of a lake. Water clarity measurements can indicate the overall water quality of a lake. Chart 1 displays the average water clarity readings which have been measured since 2004.

Chart 1. Average Summer Water Clarity Measurements for Lower Spring Lake



Chlorophyll *a* is the photosynthetic pigment found in plants. When filtered from lake water, it will signify the lake's algae biomass with higher concentrations indicating algal blooms. For most Wisconsin lakes, concentrations less than 7 µg/l indicate good water quality. Lower Spring Lake's average summer (July-August) chlorophyll *a* concentrations from 2005 through 2017 range from 2.69 µg/l to 39 µg/l (Chart 2).

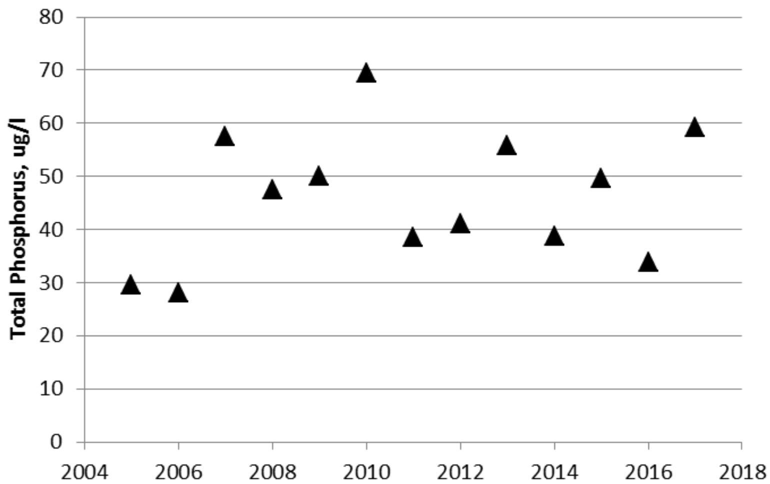
Chart 2. Average Summer Chlorophyll *a* in Lower Spring Lake



Phosphorus is a nutrient that is often referred to as the "limiting nutrient" because its concentration in the water will affect the amount of algae and plant growth more than nitrogen. One pound of phosphorus delivered to a lake can produce up to 500 pounds of algae. Sources of phosphorus include runoff from farmland, animal lots, construction sites, and lawns, as well as shoreline erosion. Phosphorus mostly is held in insoluble particles with calcium, iron, and aluminum. Phosphorus is released from particle form when the water is anoxic (has no oxygen). From 2005 to 2017, the average summer

(July-August) phosphorus concentrations in Lower Spring Lake ranged from 28 µg/l to 69.5 µg/l (Chart 3).

Chart 3. Average Summer Phosphorus in Lower Spring Lake



By determining a lake's trophic state, its water quality can be characterized as eutrophic, mesotrophic, or oligotrophic. These trophic states are based on water clarity, total phosphorus concentration, and chlorophyll *a* concentration.

Oligotrophic lakes are clear, deep, and are mostly free of aquatic plants or large algae blooms. They contain low amounts of nutrients and therefore do not support large fish populations. However, they can develop a food chain capable of sustaining a desirable fishery of large game fish. Mesotrophic lakes have moderately clear water. They can have deep waters that are low in dissolved oxygen during the summer, and as a consequence, can limit cold water fish and cause phosphorus release from the bottom sediments. Eutrophic lakes are high in nutrients and support a large biomass that includes dense aquatic plants, or frequent algae blooms, or both. Rough fish, such as carp, are often common in eutrophic lakes.

A natural aging process occurs in all lakes to shallower and more eutrophic lakes. It is important to point out that this aging process is accelerated by human activities that increase sediment and nutrient delivery to our lakes. These activities include agriculture, existing and new development, fertilizers, storm drains, etc.

The Trophic State Index (TSI) is determined using mathematical formulas that convert water clarity, total phosphorus, and chlorophyll *a* measurements into a TSI score on a scale of 0 to 110. Lakes that are less fertile have a low TSI. The scale is described in Table 2.

The Trophic State Index for Lower Spring Lake over time is displayed in Chart 4. It represents average July and August measurements of water clarity, total phosphorus, and chlorophyll *a*. Lower Spring Lake is characterized as a mesotrophic lake in terms of chlorophyll and a eutrophic lake in terms of water clarity and phosphorus. The chlorophyll data reveals that Lower Spring Lake is dominated by plants instead of algae. In addition, it shows the importance of protecting and enhancing native plant species as the exotic species are targeted for management. If the native plants are not protected, then the amount of algae in the lake will likely increase.

A water quality index was developed for Wisconsin lakes using data collected in July and August (Lillie and Mason 1983). Table 3 shows this index and contains the 2017 average summer values for Lower Spring Lake.

Table 2. Description of the Trophic State Index Scale

TSI Score	Description
TSI < 30	Classical oligotrophic: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae blocks sunlight).
TSI > 80	Algal scums, summer fish kills, few plants, rough fish dominant. Very poor water quality.

Chart 4. Trophic State Index for Lower Spring Lake
(Note: This chart does not contain the entire Trophic State Index scale. Not shown is classic oligotrophic of 0-30 and eutrophic scales of 70 and greater.)

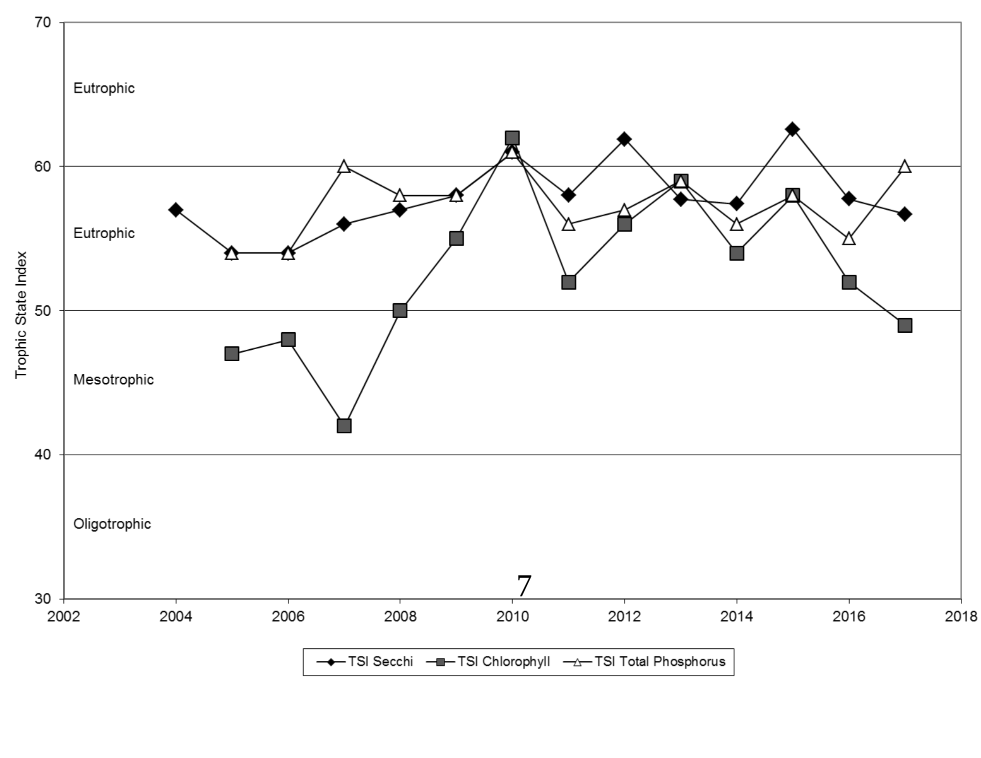


Table 3. Water Quality Index for Wisconsin Lakes with the 2017 summer averages from Lower Spring Lake (adapted from Lillie and Mason 1983)

Water Quality Index	Secchi Depth (feet)	Chlorophyll a (ug/l)	Total Phosphorus (ug/l)
Excellent	> 19.7	< 1	< 1
Very Good	9.8-19.7	1-5	1-10
Good	6.6-9.8	5-10 Lower Spring = 6.65	10-30
Fair	4.9-6.6	10-15	30-50
Poor	3.3-4.9 Lower Spring = 4.13	15-30	50-150 Lower Spring = 59.25
Very Poor	< 3.3	> 30	> 150

Fish and Wildlife

Freshwater sponges have been found in Lower Spring Lake. Freshwater sponges are aquatic animals that feed by filtering small particles from the water. They are thought to be sensitive indicators of pollution.

The following information on freshwater sponge identification is from the DNR:

- Size can vary from marble-sized to elongated masses; can be thin or thick encrusting layers
- Surface may be smooth, textured or wavy, or have finger-like projections
- Color may be green (because of algae that live inside their cells) or may be beige to brown or pinkish
- Feel delicate to very firm, but are not slimy or filmy

The best time to look for sponges is in late summer and early fall because they die back in the winter and begin a new growth cycle in the spring, and grow through the summer. In the late summer, the sponges form gemmules which are small spherical protective structures that contain cells from which the new sponges will grow in the spring. The gemmules are approximately the size of poppy seeds and are tan in color. Sponges grow in shallow water. Some sponges prefer the underside of logs and sticks.

The DNR reports that the fish population in Lower Spring Lake includes smallmouth bass (abundant), largemouth bass (common), and bluegill (common). Other fish species documented in Lower Spring lake include: yellow perch, northern pike, rock bass, black crappie, golden shiner, common carp, white sucker, lake chubsucker, black bullhead, yellow bullhead, pumpkinseed, brook silverside, green sunfish, grass pickerel, and warmouth.

Both the DNR and the Palmyra Lions Club have both stocked fish in Lower Spring Lake. Table 4 reports the details of the DNR fish stocking. Table 5 reports the details of the Palmyra Lions Club fish stocking.

Table 4. DNR Fish Stocking of Lower Spring Lake

Year	Species	Age Class	Number Stocked	Average Fish Length (inches)
2017	Northern Pike	Small fingerling	1058	2.5
2016	Northern Pike	Small fingerling	2040	1.92
2015	Northern Pike	Small fingerling	1040	2.55
2014	Northern Pike	Small fingerling	1040	2.7
2013	Northern Pike	Small fingerling	1040	3.2
2012	Northern Pike	Small fingerling	1040	2.9
2011	Northern Pike	Small fingerling	1040	2.6
2010	Northern Pike	Small fingerling	1040	2.76
2009	Northern Pike	Small fingerling	1040	2
2008	Northern Pike	Small fingerling	1040	1.8
2006	Northern Pike	Small fingerling	1040	2.4
2002	Northern Pike	Small fingerling	468	2.9
2000	Northern Pike	Large fingerling	208	7.4
1999	Northern Pike	Large fingerling	208	7.3
1997	Northern Pike	Large fingerling	208	8.0

Table 5. Palmyra Lions Club Fish Stocking of Lower Spring Lake

Year	Species	Number Stocked
2013	Northern Pike	450
2009	Northern Pike	300
2005	Northern Pike	200
1996	Northern Pike	570
1995	Northern Pike	350

AQUATIC PLANTS

Aquatic plants are a vital part of a healthy lake ecosystem. In fact, 90% of a lake's ecosystem depends of what happens in the vegetated shallow areas. Some valuable characteristics of aquatic plants are the following:

- Aquatic plants create a thriving habitat supplying food, shade, and shelter for a large variety of aquatic and terrestrial animals.
- Fruits and tubers of aquatic plants provide food for mammals, waterfowl, insects and fish.
- Aquatic plants are essential to the spawning success of many fish species.
- Aquatic plants photosynthesize, creating oxygen for the animals that live in the shallow area.
- Aquatic plants filter runoff from uplands to protect lake water quality.
- Plant roots create networks that stabilize sediments at the water's edge where waves might otherwise erode the lakeshore.
- Submersed plants absorb phosphorus and nitrogen over their leaf surface and through their roots.
- Plant use nutrients, making them less available for nuisance algae.
- Native aquatic plants can limit growth of exotic plants.

There have been many summer aquatic plant surveys in Lower Spring Lake: 1993, 2005, and 2008 through 2017. The surveys performed in 1993 and 2005 used a transect survey approach to sampling. The 2008 through 2017 surveys used the point intercept method that is now the DNR-recommended survey approach (Hauxwell et al. 2010). Samples of pressed aquatic plants from many of the surveys were also given to the Wisconsin State Herbarium.

During the 2008 flooding events, the dam at Upper Spring Lake was compromised on June 9 and the entire Upper Spring Lake impoundment was drained through Lower Spring Lake. It took more than 2 weeks for the water levels to get back to normal (and rain events didn't help the matter). Citizens noted that a large amount of sediment was deposited on the east side of the lake, and sediment settled out in other parts of the lake. One citizen estimated that 4 inches of sediment was deposited by his pier.

It is significant to note that the 2008 plant survey was performed on June 18 and 19, 2008 after the extreme flooding event and upper dam failure.

Aquatic Plants in Lower Spring Lake

The species found in Lower Spring Lake in the 2008-2017 surveys are listed in Table 6 with a description of their ecological significance. It should be noted that there are non-navigable locations of the lake that were not sampled due to shallowness or aquatic plant mass (mostly white-water lilies).

Table 6. Ecological Significance and Coefficient of Conservatism for Lower Spring Lake Aquatic Plants Identified in 2008-2017.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Carex comosa Bristly sedge	E	5	Nutlets are eaten by a variety of waterfowl.
Carex hystericina Bottlebrush sedge	E	3	Nutlets are eaten by a variety of waterfowl.
Ceratophyllum demersum Coontail	S	3	Provides good shelter for young fish, supports insects valuable as food for fish and ducklings, and fruits are eaten by waterfowl.
Chara spp. Muskgrass	S	7	A favorite food of waterfowl. Provides cover and food to young trout, largemouth and smallmouth bass.
Eleocharis sp. Spikerush species	E	varies	
Elodea canadensis Common waterweed	S	3	Valuable shelter and grazing opportunities for fish. Food for muskrats and waterfowl. Habitat for a wide variety of invertebrates.
Heteranthera dubia Water stargrass	S	6	Source of food for geese and ducks. Good cover and forage for fish.
Iris pseudacorus Yellow iris - Exotic species -	E		Grazed by muskrats and provides food for a variety of waterfowl. Provides cover for wildlife and waterfowl.
Iris versicolor Northern blue flag/Iris	E	5	Grazed by muskrats and waterfowl. Good cover for wildlife and waterfowl.
Lemna minor Small duckweed	FF	4	Important food source for ducks and geese. Consumed by muskrats, beaver, and fish. Shade and cover for fish and invertebrates. Extensive mats can inhibit mosquito breeding.
Lemna trisulca Forked duckweed	FF	6	Food source for waterfowl. Provides cover for fish and invertebrates.
Lythrum salicaria Purple loosestrife - Exotic species -	E		Little wildlife value: The seeds are low in nutrition, and the roots are too woody. The flowers are attractive to insects and produce nectar, regularly visited by honeybees.
Myriophyllum heterophyllum Various-leaved water milfoil	S	7	Fruit and foliage eaten by waterfowl. Foliage traps detritus for food and provides invertebrate habitat. Shade, shelter, and forage for fish.
Myriophyllum sibiricum Northern water milfoil	S	6	Leaves and fruit eaten by waterfowl. Foliage traps detritus and provides invertebrate habitat. Shade, shelter, and forage for fish.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Myriophyllum spicatum Eurasian water milfoil - Exotic species -	S		Waterfowl graze on fruit and foliage to a limited extent. Habitat for insects but not as good as other plants.
Najas flexilis Slender naiad/Bushy pondweed	S	6	One of the most important plants for waterfowl. Ducks eat the stems, leaves and seeds. Important to marsh birds and fish.
Najas guadalupensis Southern naiad	S	8	One of the most important plants for waterfowl. Ducks eat the stems, leaves and seeds. Important to marsh birds and fish.
Nelumbo lutea American lotus	FL	7	Fruit eaten by a variety of waterfowl. Rhizomes eaten by beaver and muskrat. Shade and shelter for fish and wildlife.
Nuphar variegata Spatterdock	FL	6	Food for waterfowl, muskrat, beaver and porcupine. Shade and shelter for fish. Habitat for invertebrates.
Nymphaea odorata White water lily	FL	6	Provides shade and cover for fish and invertebrates. A food source for waterfowl, muskrat, and beaver.
Potamageton amplifolius Large-leaf pondweed	S	7	The broad leaves offer shade, shelter and foraging opportunities for fish. Valuable waterfowl food.
Potamogeton crispus Curly-leaf pondweed - Exotic species -	S		Winter and spring habitat for fish and invertebrates. Mid-summer die-off releases nutrients which may trigger algae blooms and create turbid water conditions.
Potamogeton friesii Fries' pondweed	S	8	A food source for ducks and geese. Also eaten by muskrat, deer, and beaver. Food source and cover for fish.
Potamogeton gramineus Variable pondweed	S	7	Fruits and tubers food for waterfowl. Foliage and fruit eaten by muskrat, beaver, and deer. Invertebrate habitat and forage for fish.
Potamogeton illinoensis Illinois pondweed	S	6	Ducks and geese eat the fruit. Provides excellent shade and cover for fish and invertebrates.
Potamogeton nodosus Long-leaf pondweed	S	7	Offers invertebrate habitat and foraging opportunities for fish. Ducks eat the fruit.
Potamageton pusillus Small pondweed	S	7	Locally important food source for ducks and geese. It is also grazed by muskrat, deer, beaver and moose. Food and cover for fish.
Potamogeton zosteriformis Flatstem pondweed	S	6	Food source for waterfowl and wetland mammals. Provides cover for fish and invertebrates. Supports insects valuable as food source for fish and waterfowl.

Aquatic Plant *Species name* Common name	**Plant Type**	**Coefficient of Conservatism**	**Ecological Significance**
Ranunculus aquatilis Stiff water crowfoot	S	8	Fruit and foliage are eaten by waterfowl. Stems and leaves are valuable invertebrate habitat.
Sagittaria cuneata Arum-leaved arrowhead	E	7	Highly valued aquatic plant for wildlife. Waterfowl depend on high-energy tubers during migration. Shade and shelter to young fish.
Sagittaria latifolia Common arrowhead	E	3	Highly valued aquatic plant for wildlife. Waterfowl depend on high-energy tubers during migration. Shade and shelter to young fish.
Schoenoplectus acutus Hardstem bulrush	E	6	Habitat for invertebrates and shelter for young fish, especially northern pike. Nutlets eaten by waterfowl, marsh birds, and upland birds. Stems and rhizomes eaten by geese and muskrats. Nesting material and cover for waterfowl, marsh birds and muskrats.
Schoenoplectus tabernaemontani Soft stem bulrush	E	4	Habitat for invertebrates, shelter for young fish. Nutlets eaten by waterfowl, marsh birds, and upland birds. Stems and rhizomes eaten by geese and muskrats. Nesting material and cover for waterfowl, marsh birds and muskrats.
Spirodela polyrhiza Large duckweed	FF	5	Provides food for waterfowl, muskrat and fish. Rafts of duckweed offer shade and cover for fish and invertebrates.
Stuckenia pectinata Sago pondweed	S	3	Fruits and tubers are a very important food source for a variety of waterfowl. Supports insects that are eaten by game fish and also provides cover for young game fish.
Typha sp. cattail	E	1	Nesting habitat for many marsh birds. Shoots and rhizomes consumed by muskrats and geese. Submersed stalks provide spawning habitat and shelter for fish.
Utricularia vulgaris Common bladderwort	S	7	Provides food and cover for fish.
Vallisneria Americana Wild celery	S	6	Premiere source of food for waterfowl. All portions of plant are consumed. Good fish habitat providing shade, shelter and feeding opportunities.
Wolffia columbiana Common watermeal	FF	5	Ducks, geese, muskrats, and some fish eat this plant. A large floating mat can prevent mosquito larvae from reaching the surface for oxygen.

Key:
E = Emergent – plants with leaves that extend above the water surface
FL = Floating Leaf – plants with leaves that float on the water surface
FF = Free Floating – plants that float freely on the water surface

S = Submersed – plants with most of their leaves growing below the water surface
Eurasian water milfoil (EWM) is an invasive species that was documented in the first aquatic plant survey in 1993 on Lower Spring Lake. In some lakes, EWM crowds out native aquatic plant species so that there is a monoculture of Eurasian water milfoil and a reduction in the diversity of plants in a lake. Milfoil in dense stands can provide a refuge for panfish and thus interferes with predator-prey interactions. The results can be over-populated, slow growing panfish and slow growing gamefish. Dense stands of milfoil can also hinder the movement of larger fish. In addition, milfoil can adversely impact recreational uses by hindering boating, swimming and fishing and impair the aesthetic quality of the lake.

Eurasian water milfoil mainly reproduces via plant fragments that are separated from the main plant naturally or augmented by boat propellers. Landowners who cut or rake aquatic plants in front of their lots may also disperse plant fragments. These cleared areas more likely than not will be re-vegetated by Eurasian water milfoil.

Curly-leaf pondweed (CLP) is another exotic invasive species that was found in the 2005 aquatic plant survey on Lower Spring Lake. Curly-leaf pondweed starts growing under the ice and grows its spring and summer foliage in May. Because of this growth pattern, curly-leaf pondweed provides habitat for fish and insects in the winter and spring – a time when other plants are dormant. However, when curly-leaf pondweed dies-off (typically in late June to mid-July), it creates a sudden loss of habitat. When it dies off it can also cause algal blooms and turbid water conditions. In addition, curly leaf pondweed can interfere with recreational activities in the spring because it can grow to the water's surface.

American Lotus, a native plant, was documented in the lake in 1971 and 1993 but was absent in other plant surveys until it was found growing again in 2012. There were 2 lotus plants found in the lake in 2012. In 2017, the plant has found a home in several locations around the lake. It is a rooted aquatic plant whose large round leaves either float on or can be held above the surface of the water. Its flower is yellow and is positioned above the water. It is pointed out in this plan because it is not a native plant that is common to many lakes.

Aquatic Plant Survey Data

When point-intercept surveys are performed, there is data generated that can be useful to not only determining the quality of the aquatic plant diversity in the lake, but also to compare data from different years. In addition, the data is essential for determining the effectiveness of and chemical treatments (which is covered in a separate section).

General statistics of all of the summer aquatic plant surveys is documented in Table 7.

Table 7. General Statistics of Summer Lower Spring Lake Aquatic Plant Surveys

	2008	**2009**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total # points sampled	220	226	213	219	195	188	189	177
Total # sites with vegetation	160	170	129	124	124	70	133	122
Max depth of plants	10 ft	9.5 ft	10 ft	8 ft	8 ft	8 ft	10 ft	9 ft
Average # species per site with vegetation	2.20	2.54	1.82	1.77	1.56	1.43	1.72	1.63
Average # native species per site with vegetation	2.16	2.07	1.82	1.01	1.45	1.39	1.32	1.48
Average rake fullness	1.50	*	1.57	1.44	1.53	1.48	1.43	1.66
Total number of species	26	22	24	22	26	22	23	16

* not calculated

There are several ways to analyze aquatic plant data for a lake. These include the coefficient of conservatism, the floristic quality index, and the frequency of occurrence.

The Coefficient of Conservatism is a number on a scale from 0 to 10 that represents an estimated probability that a plant species is likely to occur in a lake unaltered from what is believed to be pre-settlement conditions. A Coefficient of 10 indicates the plant is almost certain to be found in an un-degraded natural community, and a Coefficient of 0 indicates the probability is almost 0. Introduced plants were not part of the pre-settlement flora, so no coefficient is assigned to them.

Table 8. Average Coefficient of Conservatism for Lower Spring Lake

	2009	2012	2013	2014	2015	2016	2017
Ave Coefficient of Conservatism	5.56	5.31	5.08	5.1	5.06	5.22	5.45

The floristic quality index (FQI) is used to assess a lake's quality using the aquatic plants that live in it. Developed by Stan Nichols (WI Geological and Natural History Survey), the floristic quality index is the average coefficient of conservatism multiplied by the square root of the number of plants in the lake. The FQI varies around Wisconsin but ranges from 3.0 to 44.6 with a median of 22.2. Generally, higher FQI numbers mean better lake quality.

Table 9. Floristic Quality Index for Lower Spring Lake.

	2009	2012	2013	2014	2015	2016	2017
Floristic Quality Index	22.2	19.1	17.6	16.1	20.9	15.7	18.1

The frequency of occurrence for a plant species is the number of times a species is observed, divided by the total number of sampling points contained within the area shallower than the maximum depth of plants in a lake. The frequency of occurrence is expressed as a percentage and the results from the summer 2008 and 2017 surveys are displayed in Chart 5 and 6. The frequency of occurrence does not factor in plant species that were visually noted in the survey and not sampled with the rake.

Chart 5. Frequency of Occurrence of Plants in Lower Spring Lake, 2008

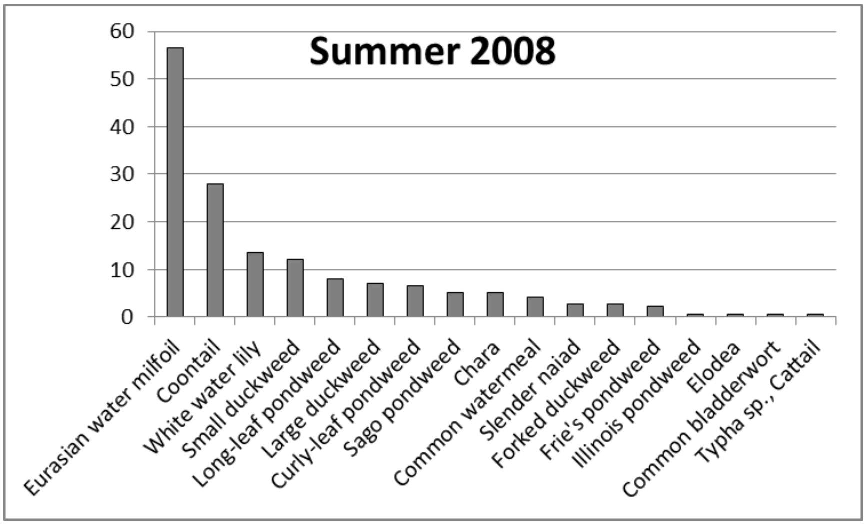
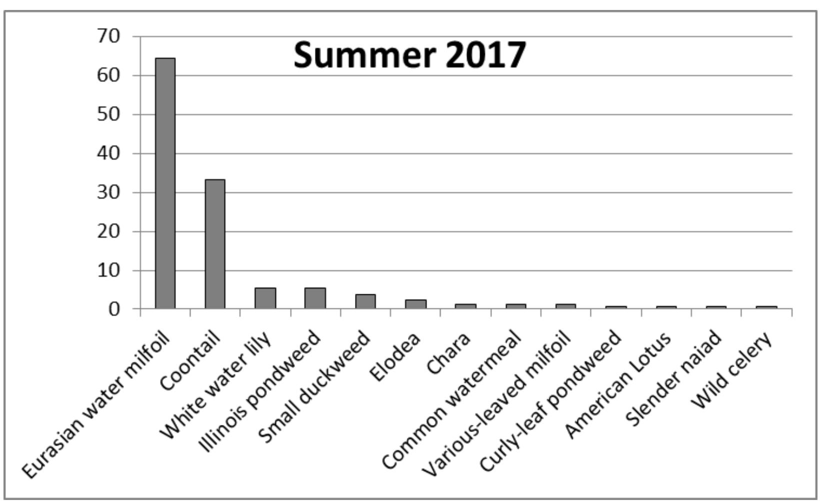


Chart 6. Frequency of Occurrence of Plants in Lower Spring Lake, 2017



PUBLIC INPUT

It is vital to have public input regarding aquatic plant management not only to determine the level of public acceptance for various control techniques but also to determine which areas of the lake are used or wanted to be used for different types of recreation.

October 2009 Meeting

On October 24, 2009, the Land and Water Conservation Department and the Lower Spring Lake Protection and Rehabilitation District invited citizens to a meeting to discuss the future of Lower Spring Lake recreation and aquatic plant management.

Table 10 contains a list of recreational activities and the current location in which the activity occurs, and the area that was identified as a desired location for the activity. It is important to note that desired locations for certain activities may not be achievable due to a variety of factors including depth, permit conditions, and laws.

Table 10. Public Input on Lake Use

Activity	Current Use Area	Future Wanted Use Area
Access to lake from properties with piers in bays containing shallow water and water lilies	2 properties on the south side of the lake	Same + 1 property on northeast side of lake for future pier
Boat access within lake	- north of small island west of boat landing when traffic south of the island is heavy	Same
Fast Boating	middle of lake	Same
Fishing	- throughout the lake - along Hwy 59 - edge of shallow bays	Same
Paddling	- throughout the lake - north of island east of boat launch - east side of lake to the river entering lake	Same
Swimming	- at Village Park - throughout the lake where there is adequate depth - in front of residential properties	Same + Wanted in the southeast corner of the bay east of Willow St
Habitat & Wildlife Viewing	- in southern bay containing water lilies - east side of lake - north of island that is east of boat landing	Same + Increase area on east side of lake
Winter Recreation	- motorcycles - ATVS - snowmobiles	May want to look into rules that would ensure safety of participants and residents

During the discussion on boating, it was also noted that boating access is sometimes limited in the bay east of Willow Street. In addition, it is important that boat access to the lake is maintained at the DNR boat landing on the north side of the lake.

When talking about the boat launch, it was noted that there is no charge for use of the boat landing, and around 3-4 boats/day use the launch. During the winter, the lake also attracts ice fisherman. [Note: In 2015, the boat launch and parking was updated by the DNR.]

During the public discussion, there was an idea to explore the placement of a fishing platform on the lakeshore adjacent to Hwy 59. Currently, the entire stretch of shoreline is mowed. This leaves the lake susceptible to runoff pollution from the highway. Native shoreline vegetation along this area could stop some of the road pollution (oil, grease, etc.) from entering the lake. Because this area is used by fisherman, a fishing platform could be built in order to accommodate fishermen. The Jefferson County Zoning Department and the Department of Natural Resources should be contacted for permit information for a fishing platform if this idea is pursued. The Jefferson County Land and Water Conservation Department should also be contacted regarding potential funding available to offset the costs of planting native vegetation along the lake.

In summary, the public expressed concerns about access to the lake from their properties in order to participate in a variety of recreational activities. They want the aquatic invasive plants controlled in such a way as their use of the lake is not impaired by them. Based on their input on fishing and wildlife viewing, the public was interested in maintaining and increasing the characteristics of the lake that support a good fishery and wildlife.

February 2010 Meeting

At the February 27, 2010 meeting of the Lower Spring Lake Management District, there was a discussion about future chemical treatment to control exotic aquatic plants. The group decided to move forward with a restoration approach to exotic plant management.

April 2017 Meeting

At the April 8, 2017 meeting, there was a discussion regarding the update to the aquatic plant management plan. Items of discussion included:

- Including a section regarding harvesting of white water lilies to provide access to lots located in the eastern regions of the lake.
- Situations when the mechanical harvester can access the finger bay.

AQUATIC PLANT MANAGEMENT

Manual Removal of Aquatic Plants

Shallow Areas Adjacent to Developed Lots

An option for every landowner is the manual removal of Eurasian water milfoil or curly-leaf pondweed. Manual removal of aquatic plants is regulated by Wisconsin Administrative Code NR 109. A DNR permit is not required for the manual removal of aquatic plants provided that the removal meets ALL of the following:

- Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured parallel to the shoreline. Any piers, boatlifts, swim rafts, and other recreational and water use devises must be located within that 30 foot wide zone.
- Removal of nonnative plants designated by the DNR (such as Eurasian water milfoil, curly-leaf pondweed) is allowed when performed in a manner that does not harm the native aquatic plant community.
- Removal of plants from the water is required. This is very important because some plants can effectively re-root if they are left to float in the water.
- The location is not in a sensitive area or in an area known to contain threatened or endangered resources. Sensitive areas in Lower Spring Lake have not been designated by the DNR.
- The removal does not interfere with the rights of other lakeshore owners.

A permit is required from the Department of Natural Resources if the manual removal does not adhere to all of the requirements listed above.

Manual removal of plants other than Eurasian water milfoil and curly-leaf pondweed is not recommended. If native plants are removed from an area, then that location will be prone to colonization by Eurasian water milfoil and curly-leaf pondweed. The growth of these two species is much more of a nuisance than native plants because of their tendency to grow in dense populations and to grow to the surface of the water.

If landowners are not sure which plants are exotic and which are native, they can contact the LWCD or the DNR for identification assistance.

Harvesting White Water Lilies for Navigational Access

There are some properties on Lower Spring Lake in which the adjacent water has an abundance of white water lilies. It is clear that the properties that regularly use their boat are able to keep an area with open water from their pier to the area of the lake that doesn’t have white water lilies. However, there are some properties that don’t currently have piers or don’t use their boat enough to keep an area open for navigation past the lilies.
Harvesting of the white water lily tubers could be done by a nursery who is interested in re-selling them. A DNR permit is not needed for this type of manual removal if the

removal happens in a single area parallel to shore that is no more than 30 feet wide. This area must include any piers, boats, or other structures in the water associated with the lot. Once a navigation lane is open, then the landowners should keep it open by regularly accessing the lake. Otherwise, the white water lilies will re-colonize the area. It should also be noted that taking out the white water lilies will also make the area prone to the growth of Eurasian water milfoil or coontail – both of which will likely lead to navigation difficulties.

In 2014, J&J Aquatic Transplant Nursery removed about 1,000 white water lilies in an area on the northeast side of the lake. This was done to try to provide a landowner with access to the lake through the water lilies. The practice was repeated at least for 2 years. The landowner reported that the practice worked well however he was too busy to install a pier.

There was also some discussion by the District to have the white water lilies harvested to provide boaters navigational access to the river. Given the depth of the water in this area, the access would likely only be for paddle craft. Because the area that would need to be cut is not attached to the land, it would require a permit from the DNR. The lake district would need to apply for the permit.

Mechanical Removal of Aquatic Plants

Harvesting

The Department of Natural Resources, through Administrative Code NR 109, regulates the harvesting of aquatic plants. An aquatic plant management plan and a DNR permit is required to use a mechanical harvester. The DNR permit is issued for a 5-year period.

Mechanical harvesting is done to cut and collect nuisance plants to obtain reasonable use of the lake for recreation. It is important to understand that mechanical harvesting could lead to adverse impacts if not implemented properly. Native plants could be harvested – which impedes the success of the plant management goals because native plants need to be able to grow and expand into areas that were once populated by invasive plants. In addition, plant fragments from exotic species (such as Eurasian water milfoil) that are not captured by the harvester could take root and maintain the density of exotics in the lake. Native plants should be protected from harvesting in order to achieve the goals of invasive species control.

The Lower Spring Lake Protection and Rehabilitation District has used mechanical harvesting for many years. Harvesting has been a useful tool to ensure control of invasive aquatic plants in areas where the water depths are conducive to active recreational activities. The District purchased the harvester and works with the Village of Palmyra to hire someone to operate the harvester during the summer. The harvester is docked at the boat launch during the summer.

In 2009 and 2010, the DNR and the Lower Spring Lake Protection and Rehabilitation District worked together to identify the areas of the lake where harvesting is permitted. A harvesting map (Appendix B) was the result of this work.

Mechanical harvesting guidelines on Lower Spring Lake include:

- No harvesting in areas with less than 3 feet of water depth so that bottom sediments are not disturbed. Disturbed bottom sediments have the potential to release phosphorus into the water column which could lead to increased algae blooms.
- Any plants floating in the water after the cutting should be collected by the harvester to prevent these plants from re-rooting and continuing to grow in the lake.
- The harvester cannot be operated north of the two islands located in the lake.
- The harvester should only be operated in the designated areas identified in the harvesting map included in Appendix C.
- District representatives should monitor the harvesting operations to ensure that the permit conditions are being followed.

The DNR also has allowed cutting with the harvester in the finger bay (narrow bay located in the south west) under some conditions:

- The water depths in the center of the channel must be greater than 3 feet. Once in the bay, the harvester may not cut in depths of less than 3 feet.
- The DNR should be notified prior to cutting so they have the opportunity to evaluate and document plant growth in this area, as well as monitor the harvesting itself.
- The sediments in this bay are very flocculent, and the goal is to allow careful cutting so as not to create a plume of mud in the water.

In other area lakes, a policy has been established that requires the cutter blades be no closer than 2 feet from the bottom.

The District should update the Department of Natural Resources and the Jefferson County Land and Water Conservation Department when they see improvements or problems with the aquatic vegetation in any area of the lake. If there are concerns about navigation in areas not permitted for harvesting that are at least 3 feet of depth, then the District should contact the DNR to inquire about possible amendments to their plan and harvesting permit.

Table 11 shows the approximate amount of vegetation removed from the lake with the harvester. During years with an effective chemical treatment, it is the case that there are less plants and thus the harvester is deployed less and harvests fewer amounts of plants.

Table 11. Estimated Vegetation Removed with the Harvester

Year	Estimated Vegetation Removed	Details on Estimates
2005	810,000 lbs	
2006	396,000 lbs	
2007	756,000 lbs	
2008	499,000 lbs	
2009	461,610 lbs	
2010*	62,440 lbs	14 boat loads, 6 truck loads
2011*	68,000 lbs	16 partial boat loads, 8 partial truck loads
2012*		
2013*	88,000 lbs	32 boat loads, 11 truck loads
2014*	89,000 lbs	35 boat loads, 21 truck loads
2015*		Due to launch construction, only cut one day in the finger bay
2016	203,424 lbs	48 truck loads
2017*	250,000 lbs	59 truck loads

* Years when a chemical treatment occurred.

Diver Assisted Suction Harvesting

Diver Assisted Suction Harvesting (DASH) is a relatively new nuisance plant management technique. It is regulated by NR 109 as it is a form of both manual and mechanical harvesting. Scuba divers remove nuisance plants manually, making sure to pull the roots and remove the entire plant. They then feed the plant into a suction hose that is part of a hydraulic harvester which delivers the plants to a boat where the plants are caught by a screen and the water is returned to the lake. The plants are placed in bags and removed from the lake.

There are some factors that will impact the effectiveness of DASH. These include:

- Sediment type – loose mucky sediments will end up getting disturbed in the process of removing the plant, and then will impact the visibility of the diver
- Depth – shallow area are hard to access with this technique
- Time of year – on some lakes, the clarity of the water may be better in the early part of the summer compared to the end of summer
- Age of plants – some plants may be more likely to fragment when pulled; or the plants may have already released their seeds
- Associated plant community – if the target species is mixed in with a variety of native species, then the process will be slow because the diver needs to make sure they are only removing the target species
- Density of aquatic plants – if there is a large amount of target species that need to be removed, then the removal process will take a long time
- Size of area to be covered – if there is a large area to be covered, then the removal process will take a long time

Winter Water Drawdowns

Winter water level drawdown to manage invasive aquatic plants is a tool that can be used on Lower Spring Lake because there is an outlet dam. Basically, the water is drawndown in the fall to a certain level and not returned to normal levels until the spring. The exposed soil freezes resulting in killing invasive species and their reproductive structures. There will also be sediment compaction that occurs.

Water level drawdowns require a permit from the Department of Natural Resources and cooperation and cooperation from the Village of Palmyra. The water must be drawn down by October 1 to ensure that amphibians and turtles hibernate in the areas under the water. Otherwise, they will freeze and perish. Lower Spring Lake is confined to a 4 foot drawdown due to the size of a box culvert under Highway 59. This would result in 63 acres exposed and 46 acres under water. The District could choose a smaller drawdown. It is important to expose the area south of the island during a drawdown because this area has historically had navigation problems due to the abundance of Eurasian water milfoil and coontail. A 4 foot drawdown would expose this area whereas a 3 foot drawdown would not.

In order to determine how long it will take to draw the lake down by 4 feet, calculations can be done given the hydraulic residence time of the lake. The DNR has calculated the median (17 days), lower 90% confidence limit (8 days), and upper 90% confidence limit (31 days) for the hydraulic residence time. Given the size of the lake, a volume per day for each residence time can be determined. Then the volume of water that will be drawn down can be divided by the volume per day to determine how long it will take to both draw down the lake by 4 feet and to return the 4 feet to the lake. These are as follows:

- The smallest amount of time = 7.5 days
- The median amount of time = 15.8 days
- The maximum amount of time = 28.9 days

The benefits of a drawdown include the following:

- 30% permanent compaction of the sediment – if the conditions are cold and dry during the winter. Not as much compaction happens with snow cover.
- Management of Eurasian water milfoil in areas where the sediment is exposed and freezes over the winter.
- Dense stands of Eurasian watermilfoil and coontail in Lower Spring Lake may be reduced, which will allow for better fish movement.
- Native aquatic plant species that predominately reproduce by seeds will benefit.

The disadvantages of a drawdown include the following:

- Native aquatic plant species that reproduce mainly by fragmentation or cloning are negatively impacted by winter drawdowns.
- There is a potential for a cyanobacteria (blue-green algae) bloom after a winter drawdown.

If there are springs that continue to flow during the winter drawdown, then those areas will not have good invasive species control or sediment compaction.

Winter water drawdowns will impact aquatic plants in different ways. Table 12 includes a list of aquatic plants in Lower Spring Lake and information on whether a winter drawdown will potentially increase the plant's coverage or decrease the plant's coverage. Another column indicates that the effects of winter drawdown have been variable from lake to lake. Species not listed mean that the data is not available on how they react to a winter drawdown. Duckweeds and water meal, though not in the chart, will be decreased initially, but will recover.

There is evidence that if the winter soil conditions remain moist, or if the soil is not frozen for several weeks, then Eurasian water milfoil may survive the drawdown.

Table 12. Potential Winter Drawdown Impacts on Aquatic Plants Found in Lower Spring Lake (Cooke et al. 2005; Nichols and Vennie 1991; and personal communication with Scott Provost, DNR)

Species	**Increase**	**Decrease**	**Variable**
Carex spp., sedges	I		
Ceratophyllum demersum, coontail		D	
Chara spp., muskgrass	I		
Elodea Canadensis, common waterweed			V
Heteranthera dubia, waterstar grass	I		
Myriophyllum heterophyllum, various-leaved water milfoil			V
Myriophyllum spicatum¸ Eurasian water milfoil		D	
Najas flexilis, slender naiad	I		
Najas guadalupensis, southern naiad		D	
Nulembo lutea, American lotus			V
Nuphar variegate, spatterdock		D	
Nymphaea odorata, white water lily		D	
Potamogeton amplifolius, large-leaf pondweed			V
Potamogeton crispus, curly-leaf pondweed		D	
Potamogeton gramineus, variable pondweed	I		
Potamogeton Illinoiensis, Illinois pondweed	I		
Potomogeton nodosus, long-leaf pondweed	I		
Potamogeton zosteriformis, flatstem pondweed	I		
Schoenoplectus spp., bulrushes	I		
Stuckenia pectinata, sago pondweed	I		
Utricularia vulgaris, common bladderwort		D	
Vallisneria Americana, wild celery	I		

The extent of curly-leaf pondweed control is unknown until we know the conditions during the drawdown. Curly-leaf pondweed turions (winter seeds) will only be killed if the sediments freeze. If there is a lot of snow cover or a mild winter, then most will not be killed.

An important consideration for winter drawdowns is what will happen with the fish in the lake during drawdown. The fish will either concentrate in the deep areas of the lake or swim up or down stream. Given that there is a dam upstream from Lower Spring Lake, there are not extensive areas for the fish to go.

A winter drawdown can have both negative and positive impacts to the fishery. If the drawdown coincides with a cold winter with little snow cover, then the ice could become very thick. This would mean that the fish don't have much water and that water could become anoxic leading to a fish kill. If this doesn't happen, then the fishery can naturally rebound after a few years. During a winter drawdown, fish predators can reduce the amount of forage fish over the winter. This increases the amount of larger zooplankton which in turn could result in greater water clarity and become a good food source for fish.

It is important to have a restocking plan to assist the fishery to rebound quicker. This plan should be in place prior to drawdown. Stocking can happen in Spring or Fall. It would be important to work with the Palmyra Lions Club that does fish stocking. The DNR has seen a positive response from fisheries after restocking. Fish growth is accelerated, the health of the fish will be better, and there is a good invertebrate response.

During a winter drawdown, there can be a temporary emergency fishing closure. The Lake District would apply for this closure with the DNR, there would be a public input session and published notice of the request. The fishery could then be re-opened when the lake reaches normal water levels – which could be done prior to the spring fishing opener.

Other Factors

- During a drawdown will be the best time to accomplish any dredging. DNR permits are required for dredging.
- Because water drawdowns are a good tool to managing invasive aquatic plant species, it is important to work with the Village on the dam repairs to make sure they choose repairs that enable the lake to be drawn down in the future.

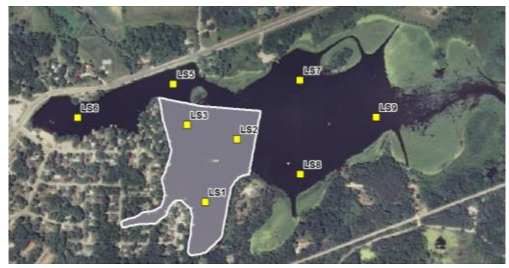
Chemical Treatment

The control of aquatic plants through chemicals is regulated by the Department of Natural Resources through Administrative Code NR 107. Among other things, an annual permit for chemical control is required through the DNR.

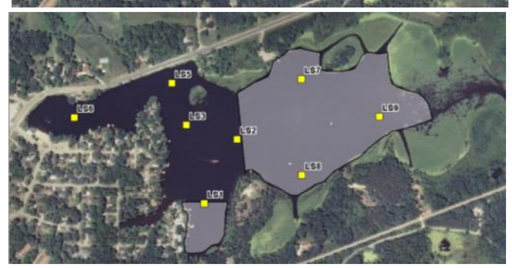
When Lower Spring Lake first started to use chemical treatment, areas along residential properties were targeted. Later, a 5-acre section that is south and west of the boat landing was added for a total of 15 acres of treatment. A granular formulation of the chemical 2, 4-D (Navigate) was used. These treatments occurred in late May or early to mid June. It is important to note that these treatments took place during a time when native plants were actively growing and likely had a detrimental impact on the natives. In addition, since there was probably more plants killed, the decomposition likely resulted in algal blooms.

In the last 7 years, the science of chemical treatments (especially those using 2, 4-D) has greatly advanced in Wisconsin due to pre-treatment and post-treatment plant surveys, and the collection of water samples to track the amount and location of chemicals in the water after treatment.

The whole-lake chemical treatments that have happened on Lower Spring Lake to reduce the Eurasian water milfoil and curly-lead pondweed populations are detailed below:



2010 Treatment for Eurasian Water Milfoil
- May 4, 2010, whole-lake treatment
- 25 acres (10 acres adjacent to riparian lots, 15 acres in middle of lake)
- Liquid 2, 4-D
- Target application concentration of 0.33 mg/l ae



2011 Treatment for Eurasian Water Milfoil
- May 16, 2011, whole lake treatment
- 39 acres (5 acres in SW bay, 34 acres in eastern part of lake)
- Liquid 2, 4-D
- Target application concentration of 0.275 mg/l ae

2012 Treatment for Eurasian Water Milfoil
- April 11, 2012, whole-lake treatment
- Liquid 2, 4-D
- 27.3 acres on east side of lake; target application concentration of 1 mg/l ae
- 1.1 acres in finger bay; target application concentration of 0.5 mg/l ae

2012 Treatment for Curly-Leaf Pondweed
- April 11, 2012, whole-lake treatment
- Endothall (Aquathol K)
- 61 acres

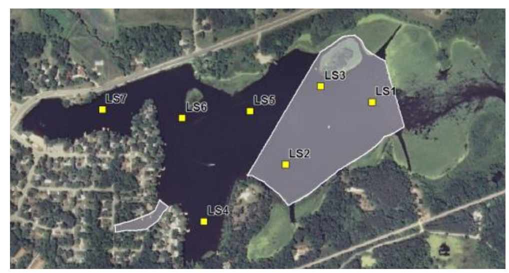
- Target application concentration of 1 mg/l ai (0.71 mg/l ae)

2013 Treatment for Curly-Leaf Pondweed
- May 13, 2013, whole-lake treatment
- Endothall (Aquathol K)
- 61 acres (chemical placed in entire lake except for northwest finger)
- Target application concentration of 1 mg/l ai (0.71 mg/l ae)

2014 Treatment for Eurasian Water Milfoil
- May 19, 2014, whole lake treatment
- Liquid 2, 4-D applied
- 66 acres
- Target application concentration of 0.35 mg/l ae

2015 Treatment for Curly-Leaf Pondweed
- May 12, 2015, whole lake treatment
- Endothall (Aquathol K) applied
- 61 acres
- Target application concentration of 1 mg/l ai (0.71 mg/l ae)

2015 Treatment for Eurasian Water Milfoil
- May 12, 2015 whole lake treatment
- Liquid 2, 4-D applied
- 27.3 acres on east side of lake with a target application concentration of 1.25 mg/l ae
- 1.1 acres in finger bay with a target application concentration of 0.5 mg/l ae



2016 – No Treatment

2017 Treatment for Eurasian Water Milfoil
- May 10, 2017 whole lake treatment
- Liquid 2, 4-D
- 27.3 acres on east side of lake with a target application concentration of 1.25 mg/l ae
- 1.1 acres in finger bay with a target application concentration of 0.5 mg/l ae

2017 Treatment for Curly-Leaf Pondweed
- May 10, 2017, whole lake treatment
- Endothall was applied
- 61 acres
- Target application concentration of 1 mg/l ai (0.71 mg/l ae)

Lower Spring Lake was one of the lakes that participated in advancing the science of chemical treatments. The Land and Water Conservation Department conducted the pre and post treatment plant surveys. In conjunction with the US Army Corps of Engineers and the Department of Natural Resources, lake district volunteers collected water samples after the chemical treatments to analyze them for chemical residuals. This sampling showed the amount of chemical and the length of time that the chemical was still active in the water. Coupled with the plant survey data, experts could then determine the effectiveness of each treatment.
The guidelines for whole lake chemical treatments in the last few years are as follows:

- A pre-treatment plant survey is performed in the spring to determine the frequency of occurrence for the target species.
- If the frequency of occurrence exceeds a certain percentage (Lower Spring Lake has used 10%), then whole lake chemical treatment could be permitted by the DNR.
- A DNR technical team reviews the results of the spring plant survey and previous summer plant survey. They determine if chemical treatment will be permitted. In addition, they will assist in the decisions on the amount of chemical and dosage that will be used for treatment and the location of chemical placement.
- An approved aquatic plant management plan is required as well as a DNR permit (regulated under Administrative Code NR 107).
- Chemical placement must occur in early spring prior to the emergence of the majority of native plants.
- Water samples are taken at multiple locations for several days after chemical placement to track the concentration and location of the chemicals.
- Summer aquatic plant survey to determine the effectiveness of the chemicals and the potential impact on native plants.

Data collected during summer plant surveys includes the location of the invasive species and the density of the population at each sampling location. Please note, that this information is documented when the surveyors can see through the water which can be impacted by water clarity, wind action, and sunlight availability.

According to research on lakes throughout Wisconsin, spot treatments of 2, 4-D have been found to be ineffective (DNR 2014). Thus, only whole lake treatments were permitted. One possible exception is the treatment of enclosed bays – bays that have a small opening to the rest of the lake. In Lower Spring Lake, the only bay that would qualify is the “finger bay” located adjacent to Locust Street.

Eurasian Water Millfoil Results

Table 13 provides the collected data for Eurasian water milfoil. The same date is not displayed for curly-leaf pondweed because given the dates of the summer survey, the plant may have already died back for the season.

Table 13. Eurasian Water Milfoil Data

	2008	2009	2012*	2013*	2014*	20015*	2016	2017*
# of points where plants are at surface	30	50	2	7	7	0	34	71
# of points where plants within 1 ft of surface	20	34	3	4	8	0	15	16
# of points where plants are > 1 ft from surface	80	52	1	14	9	4	50	28
# of points where density is sparse	39	25	4	13	15	1	41	47
# of points where density is dense	11	37	1	0	6	0	11	16
# of points where density is unknown	80	74	1	12	3	3	48	52

* Years when a chemical treatment occurred.

The average rake fullness of Eurasian water milfoil in the lake is determined for each summer plant survey. The rake fullness as defined as 1 = a few plants on the rake; 2 = approximately ½ the rake full with plants; 3 = rake overflowing with plants such that the rake head is not visable.

Table 14. Average Rake Fullness of Eurasian Water Milfoil

	2008	2009	2012	2013	2014	2015	2016	2017
Ave. Rake Fullness	1.31	1.1	1.5	1.10	1	1.25	1.26	1.38

The frequency of occurrence is one of the tools that is used to determine the effectiveness of a chemical treatment. The FOO at sites less than the maximum depth of plants for all of the sampling years since 2008 is displayed in Table 15. The 2008 survey has the FOO in order of largest to smallest for that year's data in order to illustrate the plants that have either increased or decreased in FOO in following years. Please note, emergent plants that grow along the shorelines were not included in the chart because they tend to be under-sampled by the survey techniques. The duckweeds and water meal was also not included in the table. Though curly-leaf pondweed is included, it should be noted that the summer surveys may have occurred after the plant naturally died back.

In years that had whole lake treatments, the FOO of Eurasian water milfoil is less than that in 2008 except for one year. The 2017 summer FOO of EWM was more than any other year since 2008. It is postulated that the chemical treatment was not effective during 2017 and therefore didn't have seasonal control. However, this cannot be stated for certain because the analysis of the chemicals in the lake after treatment is not yet available.

Table15. Frequency of Occurrence of Submerged and Floating Leaf Plants in Lower Spring Lake

	2008	**2009**	**2012***	**2013***	**2014* spring**	**2014* summer**	**2015* spring**	**2015* summer**	**2016 spring**	**2016 summer**	**2017* spring**	**2017* summer**
Chemical			*2, 4-D Endo.*	*Endo.*	*2, 4-D*		*2, 4-D Endo.*				*2, 4-D Endo.*	
Eurasian water milfoil	56.54	57.6	0.95	10.71	17.33	8.43	23.45	2.35	8.06	50.54	81.63	64.24
Coontail	28.04	49.77	38.57	35.71	66.22	62.92	55.31	20.59	11.83	31.18	21.43	33.33
White water lily	13.55	12.9	12.38	13.27	8	11.8	2.21	11.18	3.76	6.99	0.51	5.45
Long-leaf pondweed	7.94	4.61		0.51								
Curly-leaf pondweed	6.54	17.05	v(3)	1.02	4	v(2)	7.52	0	7.53	5.38	13.27	0.61
Sago pondweed	5.14	5.53	12.38	14.29	1.33	6.74		5.29	5.91	12.37		v(2)
Chara spp.	5.14	3.69	4.76	5.1	2.22		1.77	4.71	4.84	3.23	1.53	1.21
Slender naiad	2.8	3.23	1.43	1.53		0.56		0.59		1.61		0.61
Frie's pondweed	2.34		s		1.33							
Illinois pondweed	0.47	1.38	5.71	3.57	2.67	9.55		6.47	3.23	8.06	1.02	5.45
Elodea	0.47	1.38	17.14	8.67	1.33	2.81	3.1	4.71	5.38	2.69	3.57	2.42
Common bladderwort	0.47	0.92	s	v(1)	s	1.12		v(1)		v(1)		
Various-leaved milfoil	s		0.48	s	v(6)	s	0.44	s	0.54	v(1)	0.51	1.21
White water crowfoot	s		0.95				0.88			s		
Large-leaf pondweed	s	0.46					0.44					
American Lotus				v(1)		v(3)		1.18		0.54		0.61
Wild celery			0.48	s		v(2)		0.59		v(1)		0.61
Southern naiad					2.22	1.12						
Spatterdock			v(1)	v(1)		v(1)		s		0.54		
Flatstem pondweed		0.46				v(1)						
Waterstar grass				0.51	0.44							
Small pondweed		1.84										
Northern water milfoil				s								
Variable Pondweed									0.54			

* years in which a chemical treatment occurred.

Curly-Leaf Pondweed Results

Lower Spring Lake received a chemical treatment with Endothall for curly-leaf pondweed in 2012, 2013, 2015, and 2017. The spring plant surveys are used to assess the amount of CLP in the lake. Though the spring surveys started in 2010, the 2010-2013 surveys only included a subset of survey points. The spring surveys with all of the survey points have been implemented from 2014 to 2017. The frequency of occurrence at sites shallower than the maximum depth of plants is displayed in Table16.

Table 16. Curly-Leaf Pondweed Frequency of Occurrence During Spring Plant Surveys

	2014	2015	2016	2017
Curly-leaf pondweed	4.0	7.52	7.53	13.27

Changes in Native Plants

There are several plants that appear in earlier surveys (2008/2009) but have either reduced in FOO or have not been found in the lake in recent years. In order to determine if these reductions or disappearances are statistically significant, it is important to perform a statistical analysis called Chi Square. This evaluation can also assess whether the decrease in exotics with treatment are statistically significant.

The 2008 and 2015 summer aquatic plant data was compared with the Chi Square evaluation. 2008 was chosen as the baseline data because this survey pre-dates the whole lake treatments on the lake. 2015 was chosen because this is the year in which the treatment seemed to achieve the best seasonal management of the exotic species. The analysis resulted in 6 species that had statistically significant increases or decreases in population compared to 2008 (Table 17).

Table 17. Statistically Significant Changes in Lower Spring Lake Plants

Species	**Change between 2008 and 2015**	**Change between 2008 and 2017**
Myriophyllum spicatum, Eurasian water milfoil	Decrease	
Ceratophyllum demersum, coontail	Decrease	
Potamogeton nodosus, long-leaf pondweed	Decrease	Decrease
Potamogeton friesii, Fries' pondweed	Decrease	Decrease
Potamogeton Illinoensis, Illinois pondweed	Increase	Increase
Elodea canadensis, common waterweed	Increase	
Nymphaea odorata, white water lily		Decrease
Stuckenia pectinate, sago pondweed		Decrease
Chara spp., chara		Decrease

The Chi Square evaluation was also performed to compare the 2008 and the 2017 summer aquatic plant data. Again, the analysis resulted in six species that had statistically significant increases or decreases in population compared to 2008 (Table

17). In terms of white water lily differences, the decrease in population may be due to the way the survey was done between the two years. For instance, one sampling crew may have paddled into the shallow waters containing the lilies more than another crew.

Chemical Treatment Decisions

The data for each chemical treatment since 2010 was evaluated by a technical team with the Department of Natural Resources. This team also made determinations and recommendations on treatments based on the data.

For Eurasian water milfoil, the team agreed that the lake should not continue to receive chemical treatments every year. This is partially due to the impacts on native plant species. The decision is also related to the effectiveness of 2, 4-D in Lower Spring Lake. The treatments for EWM have shown seasonal declines, but the plant rebounds the next year. This can be explained with the chemical sampling results after treatments that showed that the 2, 4-D did not stay in the lake long enough to effectively kill the plant.

AQUATIC PLANT MANAGEMENT PLAN

Impacts of Aquatic Invasive Species

Nuisance levels of aquatic invasive plants will impede recreational use of the lake and can adversely impact native plant populations, fish and wildlife, and water quality.

Eurasian water milfoil and curly-leaf pondweed can grow to the surface of the water. This can significantly hamper boat passage and other recreational activities such as swimming. The recreational benefits of managing these species in Lower Spring Lake could include more areas open to navigation, motors tangled less often with plants, and more areas open for swimming (given adequate depth).

Both Eurasian water milfoil and curly-leaf pondweed can out-compete native plant species and form dense beds. These growth patterns negatively impact the native plants that provide many benefits to the lake. Reducing the extent and density of Eurasian water milfoil and curly-leaf pondweed in the lake will result in benefitting the growth of the native plants. As a result, the biological health of the system will improve.

Fish are also impacted by the growth patterns of invasive species because dense beds of exotic species can prevent fish passage and do not supply ideal fish habitat. With the switch to native plant populations, the fish will have more rearing and refuge areas available to them.

Curly-leaf pondweed complete their life cycle in June and July when they die off. The decaying plant matter releases phosphorus into the water, resulting in algae blooms and sometimes decreases in oxygen. By reducing the population of curly-leaf, these impacts will be lessened.

More information on aquatic invasive species and their impacts on recreation and lake ecology can be found on the DNR website.

Ensuring that native plants are not impacted by invasive species management techniques is integral to ensuring that the benefits of plant management are achieved. If native plants are not protected in the lake, then one of the outcomes would be increased algal blooms.

Plant Management Goals

The 2011 aquatic plant management goal for Lower Spring Lake was to manage the plants in the lake to reduce and maintain the coverage of Eurasian water milfoil and curly-leaf pondweed to 10% frequency of occurrence. In addition, the goal was to protect and enhance native plants in the lake. Another objective was to have a healthy native plant population which will benefit recreational uses, and the functioning of the lake ecology.

The Lower Spring Lake Protection and Rehabilitation District, with guidance provided by the Department of Natural Resources and the Jefferson County Land and Water Conservation Department, implemented whole-lake chemical treatments and mechanical harvesting to work on attaining the goals of the 2011 plan. The idea was that the chemical treatments would knock back the coverage of Eurasian water milfoil and curly-leaf pondweed so that the primary management of the plants would be through harvesting. The intent was not to implement chemical treatments every year into the future.

Unfortunately, the 2011 goals were not able to be met. Whole-lake chemical treatments only provided season control. The chemical used to target Eurasian water milfoil (2,4-D) did not stay in the lake long enough at the concentrations needed to effectively kill the plants. This was due to water flow and/or weather (wind and rain) that resulted in the chemical flushing out of the lake too quickly. Therefore, coverage of invasive species in the lake was not reduced. In addition, statistically significant data indicate that a few native plants have been negatively impacted by the chemicals.

It is not likely that the Department of Natural Resources will approve whole-lake treatments of 2, 4-D on Lower Spring Lake. Studies on Wisconsin lakes have shown that 2, 4-D quickly moves through the water to mix throughout the water body. Therefore, spot treatments are not effective as the chemical will dissipate before fulling impacting the plants. The one location on Lower Spring Lake where 2, 4-D could be used as a spot treatment is the finger bay located adjacent to Locust Street because this bay is small and the chemical may stay within the confines of the bay. The other bays of the lake are open to the rest of the lake and therefor small-scale treatment with 2, 4-D will not work.

It is recommended that the district maintain the implementation of their mechanical harvester according to the DNR guidelines. In addition, other techniques can be considered that may alleviate the abundance of invasive species that cause navigational problems.

Given that the harvester cannot operate in water less than 3 feet of depth, there may be a time when invasive species materially impede navigation in some shallower areas of the lake. When this is the case, some chemicals (such as Diquat) that have a short exposure time required for treatment may be allowed to be applied on a small scale (not as a whole-lake treatment). Winter water drawdowns may be a good option to consider. In addition, new techniques could be developed or changed to be applicable to the conditions on Lower Spring Lake.

With any treatment, it is good to fully understand the pros and cons of each management option. Table 18 provides information on the currently available options and outlines the pros and cons of each one. Please note that this analysis should be done with other practices that may become available in the future. There are some practices that the district has tried in the past (such as milfoil weevils) that were not successful for one reason or another. However, there is always advancements being made, so these practices may become better options in the future.

Table 18. Options for Management of Aquatic Invasive Species

Option	Notes	Pros	Cons
Manual Control: Hand pulling or manual raking	Mostly applicable adjacent to land Works best in soft sediments	Can be highly selective Can be done by shoreline property owners without permits by following certain guidelines Can be effective at removing problem plans, particularly following early detection of an invasive species No cost if being done by homeowners	Very labor intensive Native plants may be removed Invasive plants may re-populate area Roots, runners, and fragments of some plants (EWM) will start new plants, so all of the plant must be removed Small scale control only
Mechanical Control: Harvesting	Plants are "mowed," collected, and off-loaded on shore	Immediate results EWM removed before it has the opportunity to autofragment (EWM grows to surface, flowers, and then fragments) Usually minimal impact to lake ecology Harvested lanes through dense weed beds can increase growth and survival of some fish Can remove some nutrients from lake	Not selective in species removed Fragments of plants not collected can re-root Can remove some small fish and reptiles in lake Improper operation can cause turbidity which can negatively impact the lake environment On-land disposal of plants must be arranged Initial cost of harvester expensive Requires maintenance and associated costs

Option	Notes	Pros	Cons
Mechanical Control: Diver Assisted Suction Harvesting	Divers pull and feed plants into a suction hose for collection	Selective for species removed Limited non-target ecological impact	Labor and equipment intensive On-land disposal of plants must be arranged
Biological Control: Weevils on EWM	Native weevil prefers EWM to native milfoils	Native to WI Selective control of target species Longer-term control with limited management	Need to stock large numbers, even if some already present Need good shoreland habitat for overwintering (leaf litter) Bluegill populations decrease densities through predation
Physical Control: Winter Drawdown	Lake must be drawn down by October 1 Lake should be raised by spring fishing opener	Effective given drying and freezing occur Sediment compaction Mimics natural water fluctuation important for all aquatic ecosystems Not expensive Provide opportunity to consider other tools such as dredging	Plants with large seed bank or propagules that survive drawdown may become more abundant Can affect fish, particularly in shallow lakes if oxygen levels drop

Option	Notes	Pros	Cons
Physical Control: Dredging	Plants removed along with sediment Most effective when soft sediments overlay harder substrate For extremely impacted systems	Increases water depth Removes nutrient rich sediments	Severe impact on lake ecosystem Increases turbidity and releases nutrients Exposed sediments may be recolonized by invasive species Sediment testing may be necessary Removes benthic organisms Dredged materials must be disposed of Hydraulic dredging is very expensive
Chemical Control: 2,4-D	Herbicide absorbed by plant and moves into leaves, stems, and roots Can be used in combination with endotholl	Effective at treating Eurasian water milfoil	Impacts native plants including native milfoils, contain, naiads, elodea, duckweeds, lilies, spatterdock, and bladderworts among others May cause oxygen depletion after plants die and decompose Ester formulations are toxic to fish and some invertebrates Some endocrine disruption in amphibians can occur

Option	Notes	Pros	Cons
Chemical Control: Endothall	Contact herbicide that prevents plants from making proteins Can be combined with 2,4-D	Especially effective on CLP and also effective on EWM May be effective in reducing reestablishment of CLP if reapplied several years in a row in early spring	Impacts both monocots and dicots including native species of pondweeds, and coontail Some formulations also kill chara and wild celery Some formulations are toxic to fish
Chemical Control: Diquat	Contact herbicide that disrupts cell membranes and interfers with photosynthesis Non selective Ineffective in cold water (<50ºF)	Fast-acting herbicide	Kills a wide variety of native plants especially pondweeds, coontail, elodea, naiads Toxic to aquatic invertebrates Ineffective in muddy water – so bottom sediments cannot be disturbed during treatment A trace contaminant in diquateproducts is a carcinogen

Procedural Notes

With many invasive species management techniques it is recommended that pre and post data be collected to understand the effectiveness of a technique. This is useful so that we can determine whys to improve the technique as well as determine whether the cost was worth the benefits.

Winter Water Drawdown

If considering a winter water drawdown, the District should gather more information from experts who have experience with drawdowns. It would be important to also start the process early in order to work with the Village of Palmyra and obtain necessary DNR permits.

Pre and post drawdown plant surveys should be done to document the differences in the plant community. In addition, water quality parameters should be measured

Chemical Management

When chemical applications are made in the lake environment, the following are the steps necessary.

1. Pre-treatment conditions
    - A whole-lake survey of the plant community using the point/intercept survey method is required for whole-lake treatment.
    - Small-scale herbicide treatment should also have a plant survey. Sometimes this can be done with the point/intercept survey. If the area is too small, then other methods for describing the plant community should be undertaken. This could include identifying all species present, estimating the percent coverage of the species, and documenting the height of the species in the water column.
    - When this survey is performed (spring or summer) will depend on the target species and the timing of treatment.
    - Depending on the chemical and timing, it may be important to take temperature readings (at 2 foot depths) in the weeks leading up to treatment.

2. Determine the dosage of chemicals to be used and area to be treated

3. Obtain proper premits

4. Conduct Treatment
    - Some treatments (2,4-D and endotholl) should occur prior to May 31st or before the water temperatures reach 65°F taken 2 feet below the water surface at treatment sites.
    - Follow all other permit requirements.

5. Post treatment water quality sampling – for some treatments
    - For 4 weeks following the treatment, the citizen water quality monitor should measure water clarity and dissolved oxygen concentrations through out the lake.
    - For some chemicals, water samples can be taken after treatment to document amount of chemical in the water.

6. Post treatment plant survey
    - Following whole lake treatment: Point-intercept survey of the entire lake
    - Following small-scale treatment: Point-intercept survey of the area to be treated or other quantitative or qualitative method.
    - Summarize results to evaluate the effectiveness on target plants, evaluate any harm or benefit to native plants, and revisit goals and recommendation of aquatic plant management plan

Other Recommendations

Communication and Education

It is important to keep the public informed about aquatic plant management on Lower Spring Lake. Therefore, it is recommended that the Lower Spring Lake District include time at their Board meetings to inform the public about the goals of the plan and the progress for achieving the plan goals. These meetings are an important opportunity for the public to share their perspectives. In addition, if the goals or plans of aquatic plant management are updated, they should be presented to the public for their input.

District meetings are only one way to educate citizens about the aquatic management plan and other lake issues or concerns. Other possibilities include local and regional newspapers, newsletters, or e-mail newsletters to district members and interested citizens.

Another important area of education is to make sure those directly involved in the various aspects of the aquatic plant control have the information they need to do the best job. It is recommended that the District ensure that those involved in the manual, chemical, and mechanical control of aquatic exotic plants be educated on the following:

- Identification of target plants
- The approved techniques and permits required for manual, mechanical, and chemical control
- The importance of a healthy native plant population

Upper Spring Lake and the Scuppernong River

The Scuppernong River flows into Upper Spring Lake before it flows into Lower Spring Lake. Because of the proximity of Upper Spring Lake, the Lower Spring Lake Protection and Rehabilitation District should pursue opportunities to work cooperatively with the owners of the Upper Spring Lake dam. Topics of concern to both lakes are similar and include nonpoint source runoff, the quality of the Scuppernong River, and aquatic invasive species.

Periodically, the Lower Spring Lake District should determine what exotic species have been documented in the Scuppernong River. The flow of the river is such that species found upstream of the lake will likely make it to Upper and Lower Spring Lake. Therefore, it is good to be prepared and look for the species that are in the Scuppernong River that may soon infest Upper and Lower Spring Lakes. More information on monitoring is contained in the section below.

Aquatic Invasive Species Monitoring

Lower Spring Lake is a lake vulnerable to introductions of new aquatic invasive species. As the District is working on controlling the existing, established invasive species, they should also be monitoring for the presence of new aquatic invasive species. It is much less expensive and more effective to control a new, small infestation of a nuisance species than to try to combat a species that is established throughout the lake.

Training for citizens who are interested monitoring the lake for new species is available through the UW-Extension Lake Program or the LWCD.

If a new invasive species is found in the lake, the LWCD and DNR can assist with steps for controlling the new infestation, including a DNR rapid response grant if expenditures are needed to address the infestation. Control options for new species introductions will vary depending on the species found. It should be noted that DNR permits will likely be necessary for these control options.

Purple loosestrife has been identified along the shoreline of Lower Spring Lake. A purple loosestrife survey is advisable for monitors to document the location and density of purple loosestrife. There is a very effective biological control (a beetle) for large populations of purple loosestrife. Citizens across the state, including school groups, scouts, and lake organizations, have worked to raise the beetles, and place them in infested areas to control the loosestrife populations. For small populations of purple loosestrife, the most effective control is manual and chemical control. Prior to seed production, the stems should be cut and bagged. The remaining stalk is then treated with a chemical such as rodeo that is suitable for near-water application.

Clean Boats, Clean Waters

The Clean Boats, Clean Waters volunteer watercraft inspection program assists Wisconsin residents in stopping the spread of aquatic invasive species. The Wisconsin DNR, UW-Extension, and Wisconsin Association of Lakes have put together a workshop to train volunteers to implement a boater education program in their community. Volunteers then educate boaters at the boat landing on how invasive species can be spread. They also help boats check their boats, trailers, and gear for invasive species, distribute informational pamphlets, and provide boaters with information on infested waters.

The Lower Spring Lake Protection and Rehabilitation District should maintain their Clean Boats, Clean Waters Program. The Jefferson County Land and Water Conservation Department can provide the Clean Boats, Clean Waters training to new volunteers. In addition, it is recommended that existing volunteers should get a refresher training every few years.

Factors Impacting Lake Quality

The quality of a lake is not only related to a balanced aquatic plant community, but also to a variety of factors including agricultural runoff, pollution entering through storm drains, construction site erosion, shoreline erosion, and shoreland habitat. As the Lower Spring Lake Rehabilitation and Protection District moves forward on protecting the lake, they should consider taking steps toward improving these factors also.

Other lake districts, including the Lake Ripley Management District, have budgeted money to help defray the costs of conservation practices for landowners who want to control nonpoint source pollution from agricultural and residential lands. In addition, the Jefferson County Land and Water Conservation Department can assist with addressing nonpoint source pollution through technical expertise and various cost-share programs. The Lower Spring Lake District would certainly benefit from finding out more about these programs.

Construction site erosion can be a major source of sediment and nutrient pollution to the lake. Both the Village and Town of Palmyra have hired building inspectors whose job is to ensure that erosion control is installed prior to land disturbance and maintained until the site is vegetated. It is a good idea for the Lake District to find out more about the laws associated with erosion control and communicate the importance of construction site erosion control and enforcement to the Village and Town of Palmyra.

The land adjacent to our lakes and the shallow water next to the land are important areas for many reasons. These areas are where people use the waters for fishing, bird watching, swimming, getting their boats out on the water, or simply sitting and enjoying the view. The shoreland area is a vital place for many species that are dependent on native habitat during part of their life cycle. In fact as much as 90% of the living things in lakes are found in the shallow waters and shoreland areas.

How we manage our shoreland areas can impact our lakes positively or negatively. The 2007 National Lakes Assessment identified the loss of shoreland habitat as the number one stressor to our lakes in the nation and in Wisconsin. A shoreland area containing a native plant garden can prevent pollutants carried by rainwater from reaching our lakes and also prevent shoreline erosion. In fact, when comparing native shoreland habitat to lawns, areas with lawns contribute 7-9 times more phosphorus and 18 times more sediment to the water. These phosphorus and sediment inputs to the water can reduce water clarity and increase algae blooms which can cause a decrease in property values.

Development of our shorelands and shallow areas can negatively impact lake fish and wildlife. Shorelines that contain seawalls and rock riprap impede the movement of turtles and other animals that need to access the lake and the shoreland area. Increased development (lawns, impervious surfaces, bare ground, piers) has been linked to degraded aquatic plant habitat, decreases in green frog and uncommon bird populations, and a decline in fish species.

Many of the values lake front property owners appreciate and enjoy about their properties—natural scenic beauty, tranquility, privacy, relaxation—are enhanced and preserved with good shoreland management. And studies have shown that healthy lakes with good water quality translate into healthy lake front property values.

The Lake District should encourage landowners to install native vegetation next to the lake. The Jefferson County Land and Water Conservation Department can assist landowners with technical expertise as well as cost-sharing to defray the costs of implementing a native restoration.

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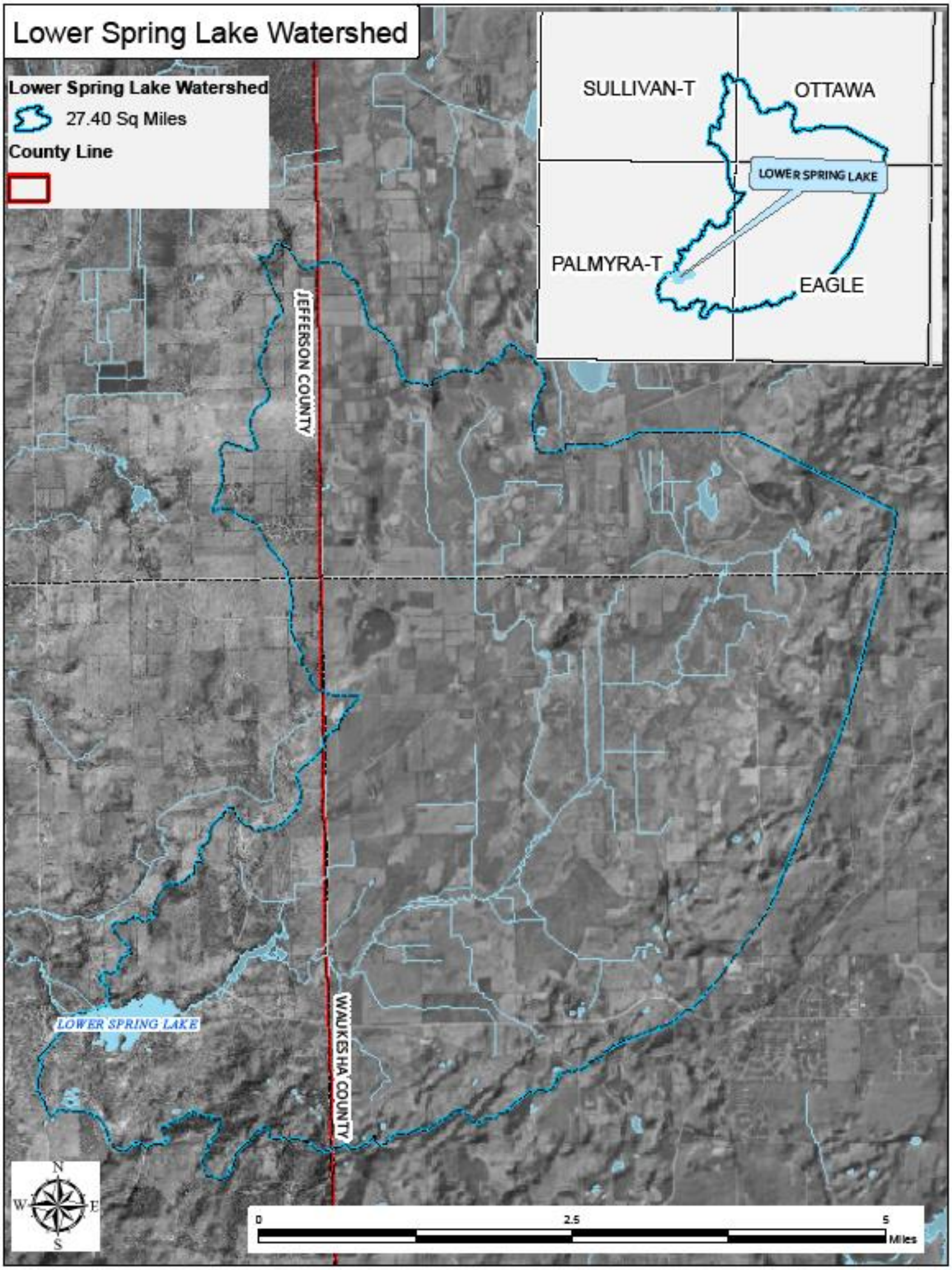
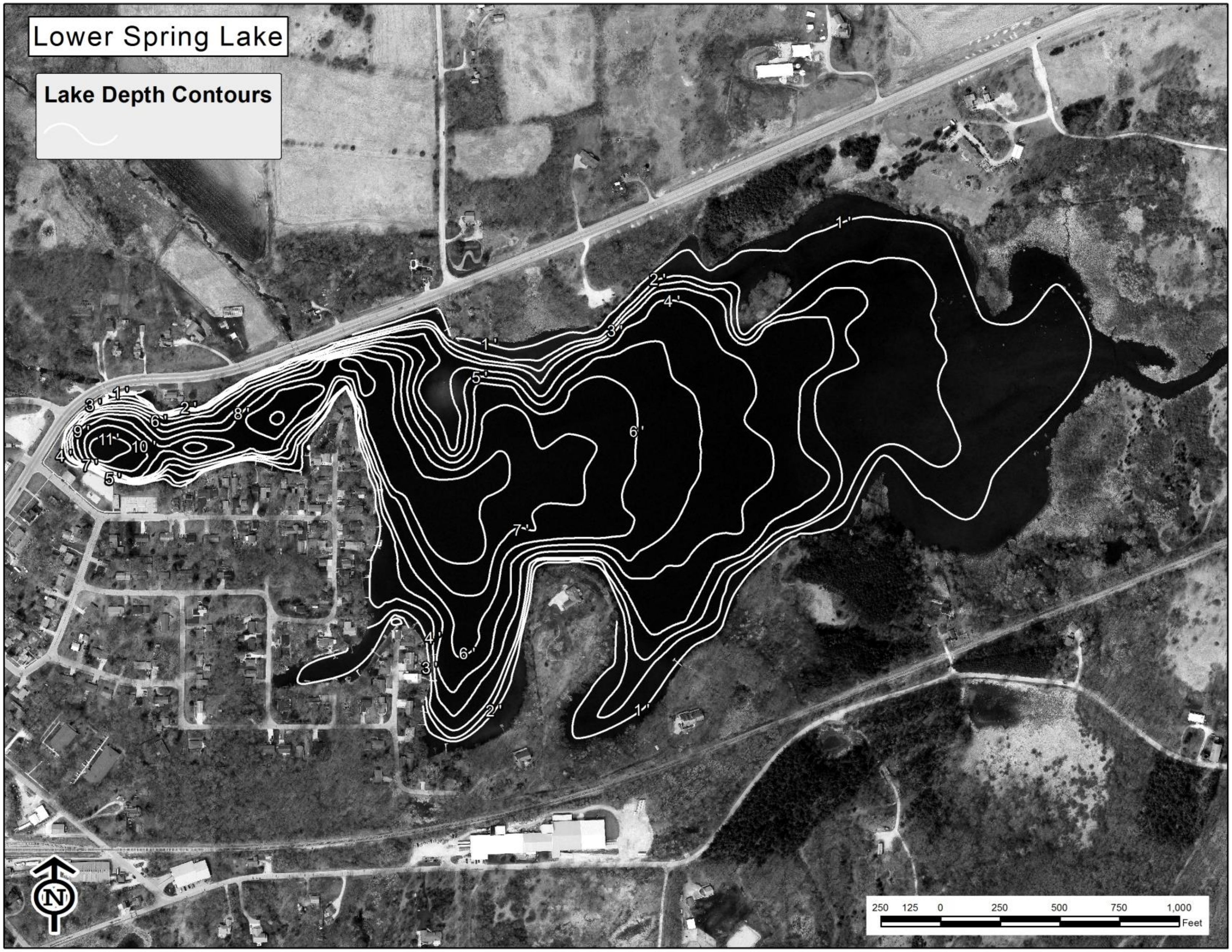
APPENDIX A.

LAKE CHARACTERISTICS MAPS

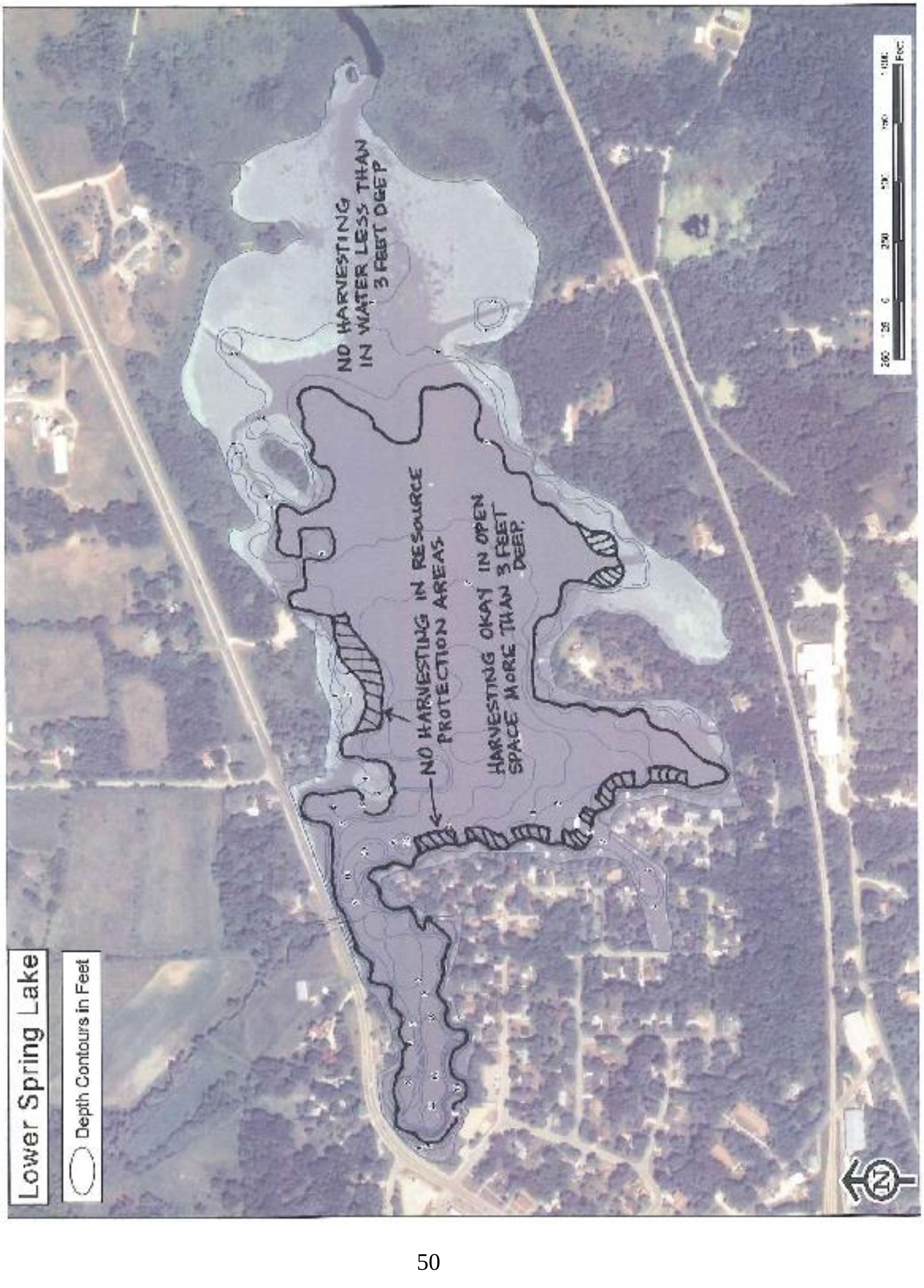

Lower Spring Lake Watershed
Lower Spring Lake Watershed
27.40 Sq Miles
County Line
SULLIVAN-T
OTTAWA
LOWER SPRING LAKE
PALMYRA-T
EAGLE
JEFFERSON COUNTY
WAUKESHA COUNTY
LOWER SPRING LAKE
N
W
E
S
0
2.5
5
Miles



Lower Spring Lake
Lake Depth Contours
1'
2'
3'
4'
5'
6'
7'
8'
9'
10'
11'
250 125 0 250 500 750 1,000
Feet
N

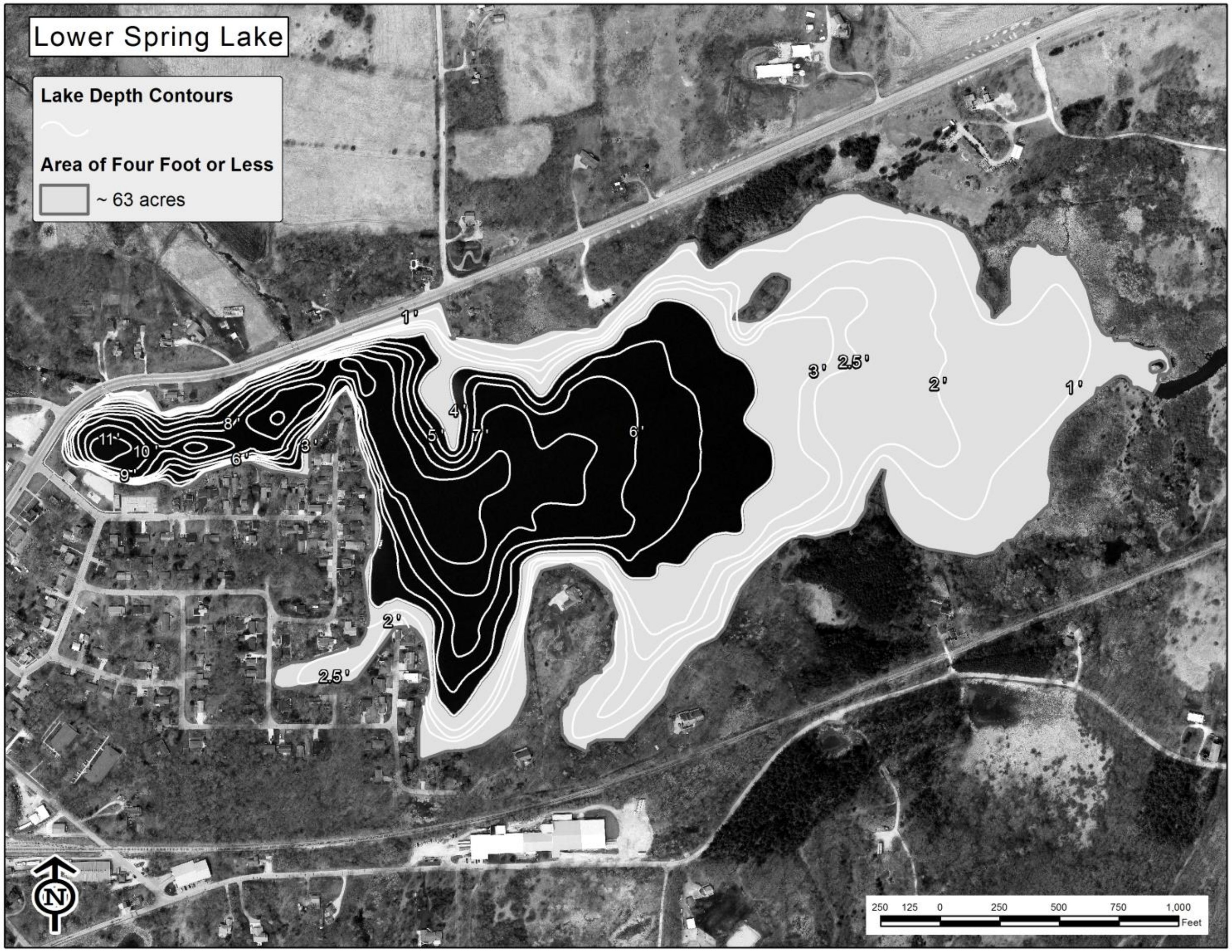
APPENDIX B.

HARVESTING PERMIT MAP


Lower Spring Lake
Depth Contours in Feet
NO HARVESTING IN WATER LESS THAN 3 FEET DEEP
NO HARVESTING IN RESOURCE PROTECTION AREAS
HARVESTING OKAY IN OPEN SPACE MORE THAN 3 FEET DEEP
Feet
N

APPENDIX C.

4 FOOT DRAWDOWN MAP


Lower Spring Lake
Lake Depth Contours
Area of Four Foot or Less
~ 63 acres
1'
11'
10'
9'
8'
6'
8'
4'
5'
7'
6'
3'
2.5'
2'
1'
2'
2.5'
N
250 125 0 250 500 750 1,000
Feet