An Aquatic Plant Management Plan Update For Delavan Lake Walworth County, WI

2017

Prepared by
Audrey Greene and Charlie Handel
Delavan Lake Sanitary District

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Introduction

Delavan Lake is a 2,072 acre drainage lake, located in the Town and City of Delavan in Walworth County, Wisconsin (Map 1). It lies within in the Turtle Creek watershed, which is a sub-watershed of the Lower Rock River Watershed. Drainage lakes are characterized as having both a defined inlet and outlet. Jackson Creek, lying on the Northeastern end is the lake inlet and Swan Creek, located at a Northwest area of the lake is the outlet. The lake offers recreational and leisure opportunities for residents and visitors and is an important natural resource that provides tremendous economic benefits for Delavan and Walworth County[1].

The Delavan Lake Sanitary District (DLSD), Delavan Lake Improvement Association (DLIA) and the Town of Delavan Lake Commission all work to preserve and protect the lake, however, the DLSD has been the agency responsible for the management of aquatic plants in Delavan Lake since January of 1997. There have been numerous studies and plans conducted over the years concerning Delavan Lake, including several aquatic plant management plans. This plan will provide an update of aquatic plant management history, aquatic plant survey data and aquatic plant management recommendations for 2017 – 2020.

Physical Characteristics

Previous studies of Delavan Lake provide information about the physical characteristics of Delavan Lake and are presented in this plan (Table 1)[2, 3]. Most publications site Delavan Lake as has having a surface area of 2,072 acres, however two Wisconsin Department of Natural Resources (DNR) sources describe the lake as 1,774.8 acres[4] and 1,906 acres[5]. It is believed that these measurements may not have included the Delavan Lake Inlet and/or wetland areas. This publication will use the commonly accepted surface area of 2,072 acres and volume of 44,800 acre-feet.

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[1] Eiswerth, M., Kashian, R., Skidmore, M., University of Wisconsin Whitewater, 2005, What is The Value of a Clean and Healthy Lake to a Local Community

[2] Southeast Wisconsin Regional Planning Commission. 2011, Revised 2012. Memorandum Report Number 190. An Aquatic Plant Management Plan For Delavan Lake, Walworth County, Wisconsin

[3] Wisconsin Conservation Department, 1961, Surface Water Resources of Walworth County

[4] Wisconsin Department of Natural Resources, formerly Wisconsin Conservation Department. 11/22/1954. Lake Survey Map

[5] Wisconsin Department of Natural Resources website: http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=793600, accessed 11/9/2016

Table 1. Hydrology and Morphology of Delavan Lake

Surface Area	2,072 acres	Width of Lake	1.0 miles
Lake Volume	44,800 acre-feet	**General Lake Orientation**	NE-SW
Maximum Depth	56 feet	**Shoreline Development Factor**	2.2
Mean Depth	21 feet	**Drainage Area (Watershed)**	26,180 acres**
Total Shoreline Length	13.0 miles	**Watershed to Lake Ratio**	12.6:1
Length of Lake	3.9 miles	**Trophic Status**	Eutrophic/Mesotrophic

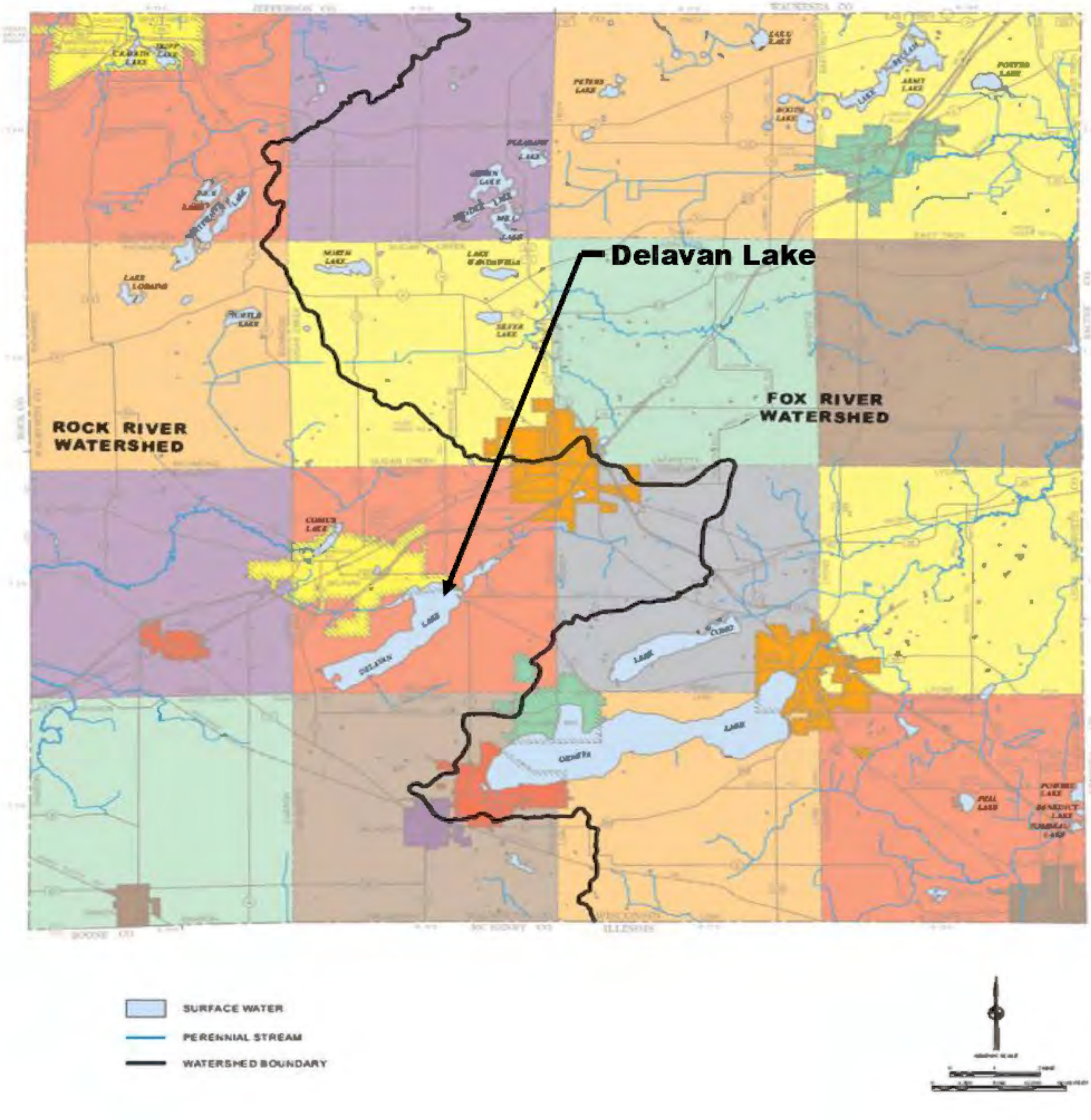
The mean depth of Delavan Lake is 21 feet and the maximum depth is 56 feet. Earlier SEWRPC reports[1] provide data on the percentage of lake depths (map 2, table 2).

Delavan Lake is a thermally stratified lake. Thermal stratification is a trait that many deeper lakes have of separating into layers as a result of different water temperatures and densities. When a lake is stratified, the hypolimnion (denser bottom layer) is cut off from oxygen infusion and will remain so until a sufficient temperature change and wind result in mixing of the water column. The existing dissolved oxygen in the hypolimnion will, over time, be used up by bacteria mediated decomposition and bottom dwelling species. This can cause the bottom layer of the lake to become anoxic (without oxygen) which can cause several problems. When fish are pushed from cooler water to warmer layers due to reduced dissolved oxygen they can become stressed which can lead to fish die off. When the hypolimnion becomes anoxic, phosphorous and nitrogen are released from the sediments into the water column where they can cause algae blooms. During the spring and fall, water column temperatures become uniform. When accompanied by enough wind the water mixes from top to bottom (spring and fall turn-over), which allows the hypolimnion of the lake to receive much needed oxygen.

The shoreline development factor (SDF) is a ratio of the total shoreline measurement of the lake to the circumference of a circle of area equal to that of the lake. A round lake would have a SDF of 0, while a lake with a more irregular shoreline would have a larger SDF. A lake with greater shoreline irregularity and therefore a larger SDF has a larger littoral zone than a round lake. The littoral zone is defined as the near shore area of a lake where the sunlight can penetrate to the bottom. This is an extremely productive part of the lake. Greater productivity in a lake is generally considered a positive attribute. There can however, be negative impacts connected to a larger SDF because more shoreline also means greater potential for disturbance and impact from human development. The shoreline development factor for Delavan Lake is 2.2

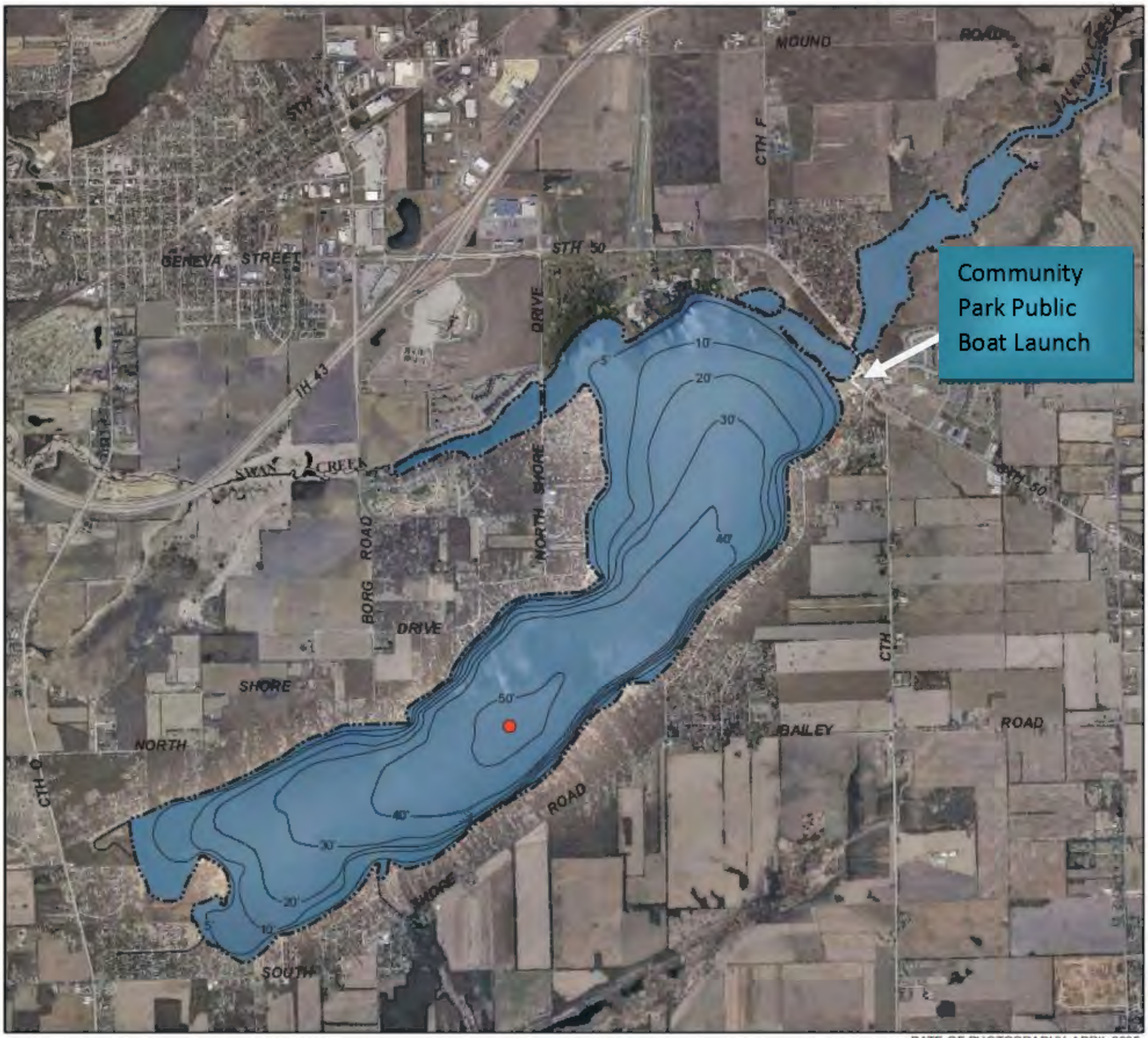
MAP 1

SURFACE WATER RESOURCES AND CIVIL DIVISIONS IN WALWORTH COUNTY



Source: Walworth County Land Conservation Department and SEWRPC.

MAP 2
Delavan Lake Contour Map



DATE OF PHOTOGRAPHY: APRIL 2005

—20— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

Source: U.S. Geological Survey and SEWRPC.

GRAPHIC SCALE 0 1750 3500 FEET

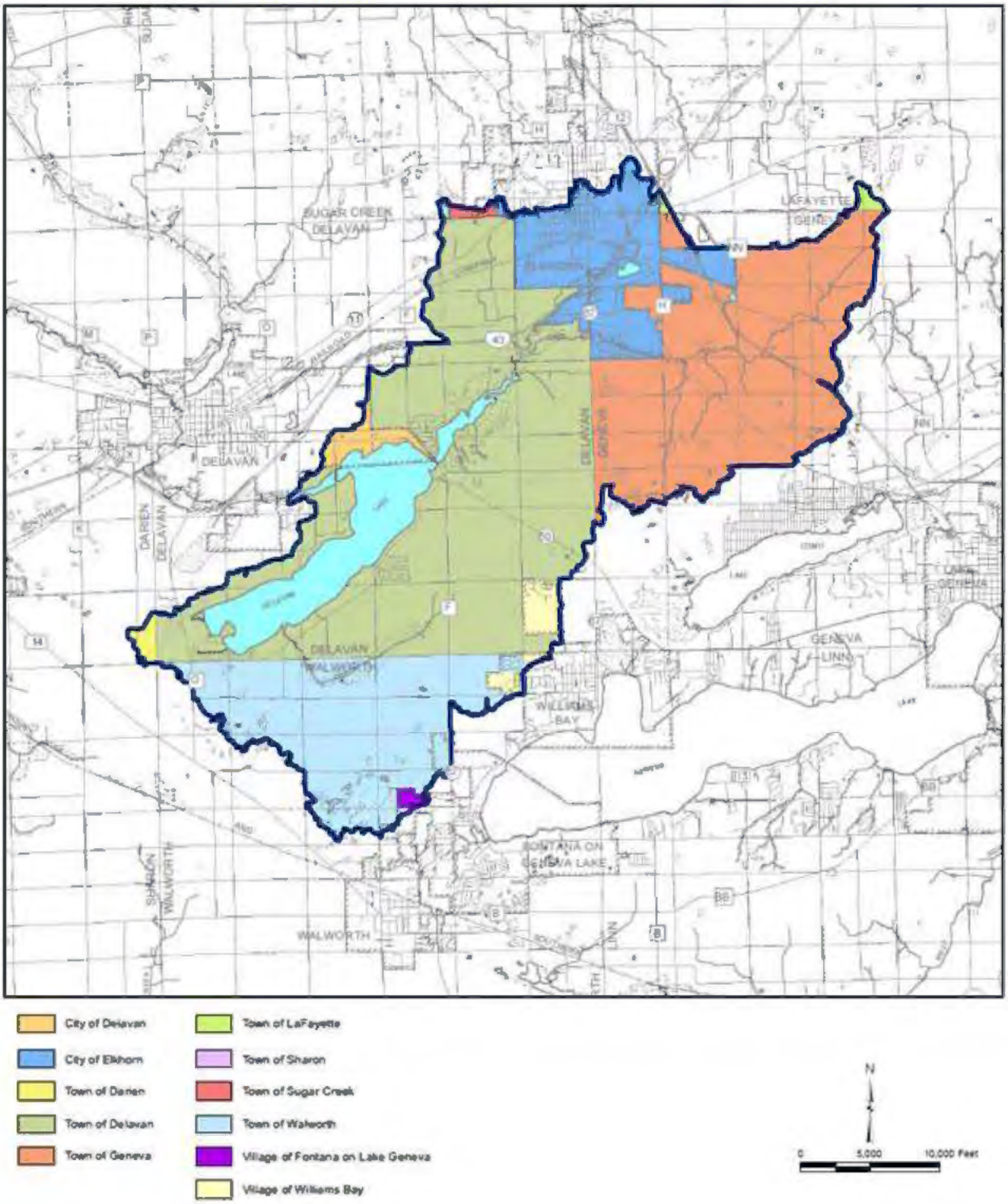
Table 2. Delavan Lake Depths

Max Depth	56 ft.	Percent of Lake 20 – 30 ft.	15%
Mean Depth	21 ft.	Percent of Lake 30 – 40 ft.	17%
Percent of Lake Less than 10 ft.	29%	Percent of Lake 40 – 50 ft.	22%
Percent of Lake 10 – 20 ft.	14%	Percent of Lake Greater than 50 ft.	3%

MAP 3

Delavan Lake Watershed

CIVIL DIVISION BOUNDARIES WITHIN THE AREA TRIBUTARY TO DELAVAN LAKE



Source: SEWRPC.

The Watershed

A watershed or drainage basin is all the area of land surrounding a water body that drains water into that water body. Map 3 shows the watershed area of Delavan Lake. The drainage basin is approximately 26,180 acres and while it is mostly within the Town of Delavan, parts of the tributary are also located in portions of the Cities of Delavan and Elkhorn, the Villages of Fontana-on-Geneva Lake and Williams Bay and the Towns of Darien, Geneva, LaFayette, Sharon, Sugar Creek and Walworth. The watershed size, land use attributes and suggested best management options have been evaluated and discussed in recent publications[6],[7]. These and other publications are excellent sources for a complete analysis of Delavan Lake's watershed and water quality.

Water Quality and Trophic State:

The Trophic State Index (TSI) is a measure of the biologic productivity of a lake. It may be calculated using measurements of chlorophyll-a concentrations, total phosphorus concentrations or Secchi disk depths. Chlorophyll-a, is a molecule found in plant and algae cells that gives them their green color and makes photosynthesis possible. Measuring the concentration of Chlorophyll-a, provides the most accurate measure of algae biomass, and therefore the most accurate TSI for a waterbody. Phosphorus concentrations can also be used to calculate TSI because it is a major nutrient required for plant and algae growth. In Wisconsin it is considered the most influential nutrient, also known as the limiting factor, for plant growth in about 80% of lakes. Nitrogen is the limiting factor for plant growth in the remaining 20% of lakes in Wisconsin. The third factor used to calculate TSI is Secchi disk depths. A Secchi disk is an 8 inch, round, weighted disk that is painted black and white and attached to a rope that has been marked in either feet or meters. The Secchi disk is lowered into the water using specific protocol that will show the depth that the disk disappears from sight. Secchi depths provide a measure of water clarity, or more specifically, how far down into the water light can penetrate. Water clarity can be reduced by particles of algae, silt and organic matter that are suspended in the water but may also be reduced by particles that are dissolved in water, such as tannins.

Once the measurements for chlorophyll-a, phosphorus concentrations of secchi depth are taken, they are used to calculate the TSI. Robert Carlson wrote and introduced the first TSI calculations in 1977. These calculations are well known and still used today[8]. However, the Wisconsin DNR has developed and uses TSI equations based specifically on Wisconsin lakes. Once calculations are complete, there are three major categories for lake trophic states: oligotrophic, mesotrophic and eutrophic (Table 3). Oligotrophic lakes have the least amount of nutrients and the least productivity. Eutrophic lakes are those with a high

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[6] Southeastern Wisconsin Regional Planning Commission, 2011, rev 2012, An Aquatic Plant Management Plan for Delavan Lake

[7] Berrini & Associates, LLC & North Water Consulting, 2016, The Delavan Lake Watershed Implementation Plan

[8] Carlson, R.E., 1977, A Trophic State Index for Lakes, Limnol. Oceanogr, 22(2): 361-369

amount of nutrients and productivity and are prone to algae blooms and an excess of aquatic plants. Mesotrophic lakes have a moderate amount of nutrients and productivity, but generally do not experience excessive algae and plant growth.

Table 3. Trophic State Index

TSI	Trophic State Index (TSI) Description
TSI<30	Classic oligotrophy: clear water, many alga 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 summer
TSI 40-50	Water moderately clear, but increasing change of low dissolved oxygen in water during the summer
TSI 50-60	Lakes becoming eutrophic; decreased clarity, fewer algal species, oxygen depleted bottom waters during summer, plant overgrowth evident, warm water fisheries (pike, perch bass, etc.) only
TSI 60-70	Blue-green algae becomes 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 limited light penetration limits extent of plant beds
TSI 80	Algae scums, summer fish kills, few plants and rough fish dominate. Very poor water quality

Source: Wisconsin DNR

Photos Courtesy of UW Extension Lakes; Artist: Carol Watkins

Water Quality and Trophic State for Delavan Lake

The first records of water quality data for Delavan Lake date are from 1960. Additional water monitoring data can be found on the DNR website[9], although older water quality data is also available in various publications[10]. The data collected includes secchi depth, chlorophyll and total phosphorous readings. The Trophic State Index has been recorded for most years using chlorophyll (Table 4).

Lake water quality varies with yearly conditions as can be seen on Table 4. The average secchi depth at the deep hole on Delavan Lake in 2016 was 9 feet. The average secchi depth throughout the Southeast Georegion for 2016 was 6.9 feet. The average summer Chlorophyll for Delavan Lake was 5.1µg/l and the total phosphorous concentration for Delavan Lake was 20µg/l. The Southeast Georegion 2016 averages were 23.5 µg/l for Chlorophyll and 30µg/l Total Phosphorous.

The overall TSI was calculated using data for Chlorophyll. Delavan Lake's overall 2016 TSI for the deep hole was calculated to be 47. This reading suggests that Delavan Lake is mesotrophic. The data also shows that in other years the lake is eutrophic.

Table 4. Delavan Lake Historic Water Quality Data – Deep Hole

(Average for July & August Only)

Year	Number of Days Sampled	Avg Secchi Depth (Ft.)	Avg SE Region Secchi Depth (Ft.)	Avg. Chlorophyll µg/l	Avg SE Region Chlorophyll µg/l	Total Phosphorus µg/l	Overall Trophic State
2006	36	7.09	7.8	13.7	43.5	-------	55
2007	21	9.5	5.9	10.3	92.2	-------	52
2008	8	------	------	25.4	16.0	-------	59
2009	39	6.0	6.9	20.5	21.3	-------	59
2010	29	7.08	5.8	12.2	23.9	27.5	54
2011	35	7.2	6.3	8.6	39.8	24.5	51
2012	71	7.7	7.1	8.4	38.6	21.8	51
2013	64	5.79	6.6	36.5	29.0	27.1	62
2014	54	8.4	6.8	8.7	28.2	23.2	51
2015	48	9.25	7.0	23.4	25.7	31.7	59
2016	36	9.4	6.7	5.6	23.4	20	47

Source: http://dnr.wi.gov/lakes/waterquality/Station.aspx?id=653215 accessed 12/12/2016

[9] Wisconsin Department of Natural Resources, http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=793600&page=waterquality, accessed 12/28/2016

[10] Southeastern Wisconsin Regional Planning Commission, 2002, Community Assistance Planning Report No. 253, A Lake Management Plan for Delavan Lake

Aquatic Plants:

Generally, how a person uses the lake will have an impact on whether they view the plants in the lake in a negative or positive light. Many anglers are well versed on the importance of aquatic plants for a successful fishing trip. And, studies have shown that a great deal of people realize that aquatic plants are essential to a balanced lake ecosystem. However, both anglers and pleasure boaters are frequently unhappy about dense floating plant beds that foul propellers and need to be cleaned off boats, trailer and equipment before leaving a launch. Education and communication is a key component of aquatic plant management. It is essential that lake residents understand the value of a healthy aquatic plant population so that they work toward what is truly beneficial for the lake.

Algae

Algae are frequently the most vilified lake organisms, but are in fact, important components of the lake ecosystem. Planktonic algae are microscopic, free-floating species that are found throughout the water column, but may escape notice until high concentrations called 'blooms' change the water color and reduce visibility. These algae form the base of the food chain by producing energy through photosynthesis. This energy is then passed on when algae are consumed by aquatic invertebrates and small fish, which in turn are eaten by larger fish and animals.

Filamentous algae are single celled species which form long chains and appear as mats that resemble wet wool in the water. These mats are usually attached to the lake bed, rocks or plants but will float to the surface when gases are trapped in the mats. Although, filamentous algae are not eaten, they do provide habitat for aquatic invertebrates which are eaten by fish and waterfowl. Delavan Lake has been documented to have high levels of Filamentous algae.

Chara and Nitella, also known as Stoneworts, are complex algae that grow in a fashion that makes them look very much like a vascular plant. The branched structure of Stoneworts provide habitat for invertebrates which are an important food source for young fish like bluegills, bass and trout. Rhizoids, rather than true roots, anchor these algae to the sediments which in turn help to stabilize the lake bottom.

Muskgrass (Chara)
Source: SEWRPC

Macrophytes

Vascular aquatic plants, known as macrophytes provide several important benefits for water bodies. Root systems help to stabilize sediments which reduce erosion near the shoreline and improve water clarity throughout the lake. Leaves growing above or floating on the water surface absorb erosion causing wave energy and provide shade which stabilizes water temperatures. During photosynthesis aquatic plants produce oxygen, which is essential to all lake creatures. Plants in the lake uptake nutrients such as phosphorous and nitrogen, which helps prevent algae blooms. Macrophytes also provide essential habitat and food sources for fish, aquatic invertebrates, and wildlife such as ducks, geese, deer, beaver and muskrats.

Macrophytes are divided into four general categories:

*Emergent plants, such as bulrush, sedges and cattails, are those species that root in the sediments with leaves that extend above the water surface.

* Submersed plants grow almost entirely underwater and can be found growing in shallow and deep areas of the littoral zone. Examples include pondweeds, wild celery, water stargrass and coontail.

* The Floating-leaf group includes species such as Watershield, Spatterdock, White water lily and American lotus. These plants are also rooted but, as their name indicates, their leaves float on the water surface.

*Free-floating are plants that float on the water surface and are not rooted to bottom sediments. This group is represented by duckweeds, slender riccia and watermeal. These are often very small plants that can be mistaken for algae.

Aquatic plants generally grow in the shallower area of lakes, known as the littoral zone, where sunlight can penetrate to provide energy for photosynthesis. Although reference books on aquatic plants do give average depths for each plant, there is no absolute depth because water clarity and other factors which impact sunlight penetration vary within lakes and from lake to lake.

A healthy lake will have a diverse and plentiful native aquatic plant population. There are, however, times when aquatic plant growth is excessive. This can be true even for native species but is most often the case if there are aquatic invasive plants involved. This can cause recreational restrictions, low oxygen levels (due to decaying mats of plants), unbalanced fisheries and other negative results. The key is to determine if there is indeed excessive aquatic plant growth and if there is, what should and can be done to correct the problem. Aquatic plant surveys provide valuable information that will supply answers to many of these questions.

Aquatic Invasive Species (AIS)

An invasive species is defined as a plant, animal or pathogen that is non-native to the area in question, and whose introduction causes or is likely to cause harm to the environment, economy or to human health. There are several aquatic invasive species (AIS) documented as being present in Delavan Lake (Table 5). There are also several AIS that have been tested for and not found in the Lake which are also noted in Table 5. Invasive species cause many different problems. Invasive aquatic plants often create large mats which reduce or eliminate important native plants and impede recreational activities. Dense plant growth can give small fish a place to hide, but if it is too dense, predator fish cannot see to hunt. While all macrophytes take in and use nutrients, which can reduce algae blooms, invasive plants often produce a huge amount of biomass. As these large mats die and decompose they can release significant amounts of nutrients into the water which often cause algae blooms. In addition, the decomposing plants increase bottom sediments. Non-native aquatic animals and invertebrates can endanger native species by reductions in habitat and food sources.

In response to the many problems invasive species can cause for Wisconsin, the Invasive Species Identification, Classification and Control Rule (Wis. Adm. Code Chapter NR 40) was created and became effective on September 1, 2009. This rule classifies invasive species in Wisconsin as Prohibited or Restricted and regulates the transportation, possession, transfer and introduction of those species.

Prohibited species are not yet in Wisconsin, or in very few places, so eradication and prevention are feasible. Prohibited species cannot be transported, possessed, transferred or introduced in Wisconsin without a permit from the DNR. Restricted species are already widely established in Wisconsin and complete eradication is not considered likely. However, in order to prevent spreading restricted species, it is illegal to transport, transfer or introduce Restricted species without a permit. Additional information about the Rule and the list of prohibited and restricted species can be found at http://dnr.wi.gov/topic/invasives/classification.html.

Table 5.	**Aquatic Invasive Species Documentation for Delavan Lake**			
Common Name	**Scientific Name**	**Status**	**Notes**	**NR 40 Classification**
Banded Mystery Snail	Viviparus georgianus	2012 Verified & Vouchered		Restricted
Curly-leaf Pondweed	Potamogeton crispus	1975 Verified & Vouchered		Restricted
Eurasian Water Milfoil	Myriophyllum spicatum	1995 Verified & Vouchered		Restricted
Eurasian water milfoil x Northern water milfoil Hybrid	Myriophyllum spicatum x M. sibiricum	2014 Verified		Restricted
Rusty Crayfish	Orconectes rusticus	2014 – Observed		Restricted
Ornamental waterlilies	Non-native Nymphaea sp.	2010 – Verified		
Phragmites (non-native)	Phragmites australius	2014 – Verified		Restricted
Purple loosestrife	Lythrum salicaria	2014 – Verified & Vouchered		Restricted
Quagga Mussel	Dreissena bugensis	Sampled for Only	Samples are collected and sent to DNR yearly for testing **Not Present in Lake**	Prohibited
Sacred lotus	Nelumbo nucifera	2010 – Verified & Vouchered	Found in Delavan Outlet in front of Geneva Landings. Rapid Response Implemented. Monitoring 2010 to present	Prohibited
Spiny Waterflea	Bythotrephes cederstroemi	Sampled for only	Samples sent to DNR 2008, 2009 & 2010 for testing **Not Present in Lake**	Prohibited
Water Pennywort	Hydrocotyle ranunculoides	Verified & Vouchered - 2010	Found in Delavan Inlet Fall 2010. Rapid Response Implemented. Water Pennywort has been found in other areas of the lake and is treated yearly	Prohibited
Yellow Floating Heart	Nymphoides peltata	2008 Documented in stormwater ponds near Outlet	Rapid Response Implemented – Monitoring continues **Not Present in Lake**	Prohibited
Zebra Mussels	Dreissena polymorpha	Vouchered & verified 1999		Restricted

Source: Wisconsin DNR website: http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=793600&page=facts accessed 12/13/2016

AIS Threats to Delavan Lake

Banded Mystery Snails, *Viviparus georgianus,* are native to areas of the United States, such as Florida and the Gulf of Mexico and the Mississippi River system to Illinois. They are not native to Wisconsin or the Great Lakes but were introduced to the Hudson River around 1867. **Chinese Mystery Snails** arrived in the Great Lakes sometime between 1931 and 1942 from Southeast Asia. The impacts of both of these non-natives are not yet well studied, but they likely compete with native snails for food and habitat. Both species are an intermediate host for trematode parasites which have caused mortality in waterfowl.

Curly-leaf pondweed (CLP), *Potamogeton crispus*, was first documented in Delavan Lake in 1975. CLP is an unusual aquatic plant that begins its life cycle in the fall when the water temperature falls to around 65°F. It grows under the ice and snow during the winter. When the water starts to warm in the spring, CLP grows quickly, producing flowers and vegetative buds called turions. By the end of June, CLP is dying back. Decomposition releases nutrients that were tied up in the living tissue of the plant. These excess nutrients often reduce water quality and cause algae blooms around the 4th of July. Dropped turions remain dormant until fall when they germinate at a 60-80% rate. Seeds are also produced but they contribute to reproduction in a relatively small way.[11]

[11] Borman, S., Korth, Rn Temte J., 1997, Through the Looking Glass, A Field Guide to Aquatic Plants

Eurasian water milfoil (EWM), *Myriophyllum spicatum*, is, unfortunately, all too common in Walworth County lakes, and was documented in Delavan Lake in 1995. EWM is a submersed species that starts to grow when the water warms to about 50°F[12] in the early spring. Plants quickly reach the water surface where they then branch out to create a canopy which shades out native plants. Reproduction is mainly through vegetative means (fragmentation), although there is some seed production as well. Flowers and fruits are produced once plants reach the water surface, followed by stem fragmentation. Fragmentation also occurs during late summer and fall. These fragments are an important part of plant reproduction because fragments are very likely to root.

Hybrid Eurasian/Northern water milfoil, *Myriophyllum spicatum x M. sibiricum*, is listed on the Wisconsin DNR website (WI DNR Invasive Species Locations By Species - http://dnr.wi.gov/lakes/invasives/BySpecies.aspx) was first documented as being present in Delavan Lake in 2014. It is not possible to verify hybrid milfoil visually and therefore any suspected plants must be submitted for DNA analysis. There have been studies which provide evidence that some strains of hybrid milfoil are not as susceptible to commonly used chemicals used to control Eurasian water milfoil.[13,14]

Rusty Crayfish, *Orconectes rusticus*, is listed as a restricted species in Wisconsin rather than a prohibited species because they are already established in several lakes and streams so it is unlikely that they will ever be eradicated. These large and aggressive crayfish are native to Ohio River Basin states of Ohio, Kentucky, Illinois, Indiana, and Tennessee. It is believed that they were introduced as fish bait and either escaped or were released. There are listed as observed in Delavan Lake in 2014.

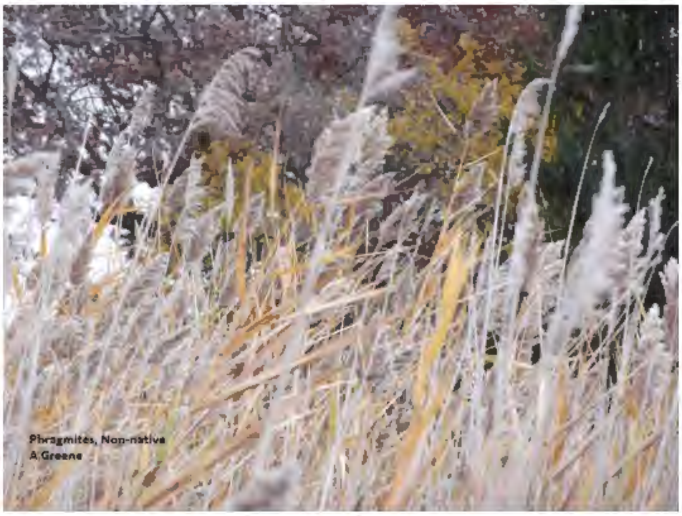
[12] Bode, J. et al. 1992. Eurasian Water Milfoil in Wisconsin: A Report to the Legislature.

[13] LaRue EA, Zuellig M, Netherland MD, Thum RA, 2013, Hybrid Water milfoil lineages are more invasive and less sensitive to a commonly used herbicide thatn their exotic parent. Evolution. 2013, 6(3):462-471

[14] Poovey AG, Slade JG, Netherland MD, 2007, Susceptibility of Eurasian Watermilfoil (Myriophyllum spicatum) and a Milfoil Hybrid (M.spicatum x M. sibiricum) to Triclopyr and 2,4-D Amine. Journal of Aquatic Plant Management. 45:111-115.

Non-native ornamental Waterlilies, non-native *Nymphaea sp.*

Non-native waterlilies can be difficult to distinguish from the native white flowered Nymphaea odorata and native yellow flowered Nuphar variegatum but ornamental waterlilies often have flowers that are pink, purple or red. These exotic non-native aquatic plants have been spread through the water garden trade and while they may cause no problems if they are contained, homeowners have been known to plant them in Wisconsin lakes because they are pretty. This practice is prohibited in Wisconsin as non- native aquatic plants introduced to our lakes can out compete and reduce important native species. They were discovered in the Delavan Lake Outlet in 2010 during AIS monitoring.



Phragmites, *Phragmites australis,* is a non-native grass that can be found in wetlands, along lake and river shorelines, in road ditches and other low lying, wet areas. There is also a Phragmites that is native to Wisconsin (Phragmites americanus) and although there are several characteristics that help with correct identification, the two species are often confused.

Non-native Phragmites form dense monocultures that typically crowd out other plants. Although Phragmites does reproduce by seed, rhizomes are the most common and prolific method of reproduction. The rhizomes also complicate control measures because if the entire rhizome is not removed, it will simply grow back. Chemical control can produce good results but will likely takes several seasons and long term monitoring.

Purple Loosestrife, *Lythrum salicaria,* is an intensely invasive wetland species that was introduced to Wisconsin as a garden perennial. Once seeds find their way to a wetland, lakeshore, stormwater pond or wet road ditch, these large, multi-stemmed plants take over quickly.

Luckily, Wisconsin has a very successful biocontrol program to help control (not eradicate) purple loosestrife. The biocontrol agents include 2 species of insects that feed on the shoots and leaves of the purple loosestrife plants. Over time the plants are weakened to the point that they produce smaller plants with fewer stems and many eventually die. While we are seeing significant control of this species it is still extremely important that no new plants are introduced and that existing populations are carefully monitored.

Quagga Mussel
UW-Extension Lakes

Quagga Mussel, *Dreissena bugensis,* are a relative of Zebra Mussels. Like their cousins, Quagga mussels are also filter feeders that disrupt the food chain and reduce food supplies for young fish. Quagga mussels cause many of the same problems as zebra mussels, such as clogging water intake pipes.

Delavan Lake sends samples to the WI DNR every year to be analyzed. **To date NO Quagga Mussels have been documented in Delavan Lake.**

Sacred Lotus, *Nelumbo nucifera*, also known as Asian lotus is a non-native aquatic perennial that was introduced through the water garden trade. This species is extremely invasive due to fast growth and reproductive methods that include seeds and rhizomes. Seeds of the Sacred Lotus have been shown to germinate after hundreds of years.

Asian lotus
Before Rapid Response
July 2010

Sacred Lotus Seed Pod
Photo by Charlie Handel

Sacred lotus was discovered in the Delavan Lake outlet in 2010. The DLSD worked with DNR to develop and conduct a Rapid Response Plan to eradicate the Sacred lotus. The plants were chemically treated in 2010. Monitoring of the site has been conducted yearly by DLSD and County staff throughout the growing season from 2010 through 2016 and is planned for 2017. The DLSD has also been educating the public about this and other aquatic invasive species in order to protect the lake from invasive species.

Spiny waterflea, *Bythrotrephes longimanus*, is a relatively large (1/4-1/2 inch long) non-native zooplankton that was introduced to the Great Lakes in the 1980s via ballast water. Native zooplankton is normally food for young fish, however, spiny waterflea prey on our native zooplankton and have caused major changes in the zooplankton population. Spiny waterflea are known to be transported to new lakes by boaters and anglers, on boats, fishing equipment and in water. Lake water samples were taken by Delavan Lake Sanitary District staff in 2008, 2009 and 2010 to test for the presence of Spiny waterflea. **No Spiny waterflea** were found in any of these samples.

Water Pennywort, *Hydrocotyle ranunculoides,* were found in the Delavan Lake Inlet in the fall of 2010. Due to its extremely aggressive nature, a rapid response plan was quickly implemented. Unfortunately, this plant has not been eradicated from the Lake. Water Pennywort has been found in several additional areas of the Lake and the DLSD continues to treat and monitor all populations.

This non-native aquatic perennial can be found in shallow, slow moving water and on the wet edges and mudflats of lakes and ponds. It prefers full sun but can also flourish in part shade. This plant reproduces by runner stems and roots, seed and stem fragments and can produce large colonies

Yellow Floating Heart, *Nymphoides peltata,* is an extremely aggressive plant that was originally introduced to Wisconsin as an ornamental pond plant. Although it does reproduce by seed and adventitious roots, rhizomes are the most common and prolific method of reproduction. The rhizomes also complicate control measures because if the entire rhizome is not removed, it will simply grow back.

In 2008, Yellow Floating Heart was discovered in two stormwater ponds that empty into the Delavan Lake outlet. Working with the DNR, the pond management company attempted eradication with every chemical combination that was available in Wisconsin. However the plants were not eradicated. In order to eliminate this aggressive invasive, the ponds were drained and all material (including the plants and plant parts) were removed by dredging. The removed material was buried to stop any possibility of spread. The ponds were then relined so that no escaped seeds could germinate. Monitoring of the ponds and the Outlet shoreline has been conducted during the growing season since the rapid response was conducted in 2009. **No Yellow Floating Heart has ever been found in the Delavan Lake**.

Zebra mussels, *Dreissena polymorpha,* small exotic mussels, were first discovered in Delavan Lake in 1999. They are prolific filter feeders that reduce phytoplankton, which is an important food source for young fish. Zebra mussels are well known for colonizing pipes that supply water for public use and industrial facilities. The engine systems of boats can also be damaged when small mussels get into the cooling systems. In addition, because of bioaccumulation, there have been waterfowl die-off events after Loons consumed zebra mussels. Although there is on going scientific research, at this time there is no control or eradication method for zebra mussels once they have been introduced to a new water body.

Aquatic Plant Management Options for Wisconsin Lakes:

Prevention, Education, Monitoring

Most aquatic plant management issues are caused by non-native, invasive plants that are introduced to a water body. Preventing the spread of invasive species to the lake is an important first management option. Wisconsin law requires that before leaving a boat launch or shoreline area, boaters and anglers must inspect and remove all aquatic plants and animals from their boat, trailer and equipment. It is also illegal to launch any watercraft or equipment into any waters of the State if there are any aquatic plants or animals attached to them. Boaters and anglers are also required to drain all water from their boat, equipment, fish and livewell. One important protection measure lake protection groups can take is to implement their own Clean Boats, Clean Waters watercraft inspection program. Inspectors work at the local boat launch to inspect incoming and outgoing boats and to educate boaters so they know, and perform, the steps that are required by law.

While boaters and anglers are certainly a known pathway for the movement of AIS, there are also other ways that invasive species are moved. Water gardeners and aquarium owners may also present a risk for the introduction of non-native invasive plants and animals. Educating the entire lake community is an excellent first step to protecting the lake from new AIS.

A second useful program is the Citizen Lake Monitoring Network. This program will train citizen volunteers to look for a new invasive species or monitor existing invasive species for population changes. Regular monitoring by volunteers to find any new invasive species before they become established so that rapid response plans can be organized and implemented is also an excellent protection method.

Delavan Lake has had the Delavan Lake Sanitary District, Delavan Lake Improvement Association, the Town of Delavan, USGS and the DNR working to monitor the lake for water quality and for AIS for over 125 years.

Managing Invasive Aquatic Plant Growth Through Watershed Best Management Practices

Phosphorous and nitrogen are the two major nutrients required for aquatic plant and algae growth. In Wisconsin, phosphorous is the key nutrient, or limiting factor, for aquatic plant growth in most lakes but the lakes in SE Wisconsin are generally not lacking in either nutrient. Nutrients from historic land use practices that have washed into the lake are likely still in the sediments. These nutrients can cycle back into the water column and contribute to algae blooms and excessive plant growth. Reducing or eliminating nutrient contributions to water bodies through watershed best management practices (BMPs) can, over time, improve water quality and reduce excess plant and algae issues.

The Delavan Lake Watershed Implementation Plan (http://townofdelavan.com/lake/watershed-plan/) which is a concerted effort protect and improve Delavan Lake and its water quality through the positive use of BMPs. Watershed BMPs can be as simple as not using lawn treatments that contain phosphorous unless soil testing shows a definite need. Maintaining a properly working septic system is a BMP that will protect the lake, human health and property values. Adding a native shoreline buffer at the lake edge instead of mowing the grass up to the waters edge not only helps protect the lake from nutrient laden stormwater runoff, it also deters geese from the property. Additional information about watershed BMPs can be found on the DNR website at http://dnr.wi.gov/topic/watersheds/.

Manual Control

Hand pulling, cutting and raking of invasive plants has been successful in some Wisconsin lakes with small populations or for rapid response operations. For lakes with large, established populations of Eurasian water milfoil, Curly-leaf pondweed or on of the other AIS, hand pulling may not be practical.

Per Wisconsin Administrative Code, Chapter NR 109, riparian owners may manually remove aquatic plants in a 30 foot wide, single area along their shoreline provided their pier, boatlifts, swim rafts and other recreational and water used devices are located within that 30 foot wide zone, and provided it is not within a documented sensitive area. Caution to protect native aquatic plants should always be used.

Eurasian water milfoil and curly-leaf pondweed, like many invasive aquatic plants are capable of spreading into new areas when fragments, cut by boats or during manual and mechanical harvesting. Removal of these floating fragments will help prevent new populations in Delavan Lake.

DASH – Diver Assisted Suction Harvesting

DASH, or diver assisted suction harvesting works with a barge on the lake surface and a diver in the water. Target plants are identified, pulled from the sediments with the roots attached and fed into a suction hose that carries the plants up to the barge where they are put into a storage container for later disposal.

Diver Assisted Suction Harvesting - DASH
Photo: Greg Jablonowski

As with every management method, there are advantages and disadvantages associated with suction harvesting. Because a diver hand pulls each plant to be removed, selective control can be largely achieved, although there may be some removal of non-target plants and sediments. This method will be slower than conventional harvesting, but with the root system eliminated, those plants will not regrow and therefore longer term control may be possible.

DASH - Diver Assisted Suction Harvesting
Photo: Greg Jablonowski

Mechanical Control

Harvesting in the Delavan Lake Outlet

Mechanical harvesters are often described as underwater lawn mowers. They come in a large array of sizes to fit different situations. Moving along predetermined and permitted paths, harvesters cut, collect and remove aquatic vegetation.   Mechanical harvesting removes the top layer of plant growth to allow for boat traffic while the remaining plant and root system provide habitat and sediment stabilization. Removing the top growth also removes some of the nutrients tied up in the plant biomass. Depending on the type of plant and the conditions, harvesting may need to be conducted more than one time each year to maintain boating paths.

The Delavan Lake Sanitary District mechanical harvesting equipment includes three harvesters, one high-speed transport barge, three off-loading shore conveyors, one dump truck and three other support vehicles. The maximum cutting width ranges from 7 feet for the two larger harvesters to five feet for the smallest harvester. Each of the three harvesters is capable of harvesting plants up to a maximum depth of five feet.

Biological Control

Biological control of aquatic plants is the use of a living organism, such as insects, fungi or a pathogen to reduce the plant in question by eating or causing infection. An example is *Euhrychiopsis lecontei,* which is a weevil, native to Wisconsin that eats native milfoils and Eurasian water milfoil. In 1996, twelve Wisconsin lakes were chosen to participate in a study conducted to examine existing weevil populations in Wisconsin and experimental weevil stocking for Eurasian water milfoil control[15]. While some interesting information did result from the study it was found that weevil stocking was not cost effective for EWM control. However, biological control for Purple loosestrife has been extremely successful in Wisconsin.

Figure 1.

Aquatic Plant Management Rules

- NR 107 Chemical
- NR 109 Manual/Mechanical
- NR 40 Invasive Species
- Chapter 30/31 Waterways
- Wisconsin Pollutant Discharge Elimination System (WPDES)

(http://dnr.wi.gov/lakes/plants/)

Chemical Control

Herbicides to control aquatic plants and algae must be registered by the U.S. Environmental Protection Agency, (EPA) and the Department of Agriculture, Trade and Consumer Protection (DATCP), and permitted by the Wisconsin DNR. Generally aquatic herbicides must be applied by a DATCP certified and licensed applicator. There are several aquatic herbicides registered for use in Wisconsin.

During the permitting process, the DNR Water Resources Management Specialist will work with the applicant and the licensed applicator to choose the best herbicide, correct dose and best treatment timing for the aquatic plants being treated. When chosen carefully and used correctly, herbicides can be very helpful to reduce the abundance of invasive and nuisance aquatic plants, especially in areas that are too shallow for mechanical harvesters. It is possible that more than one treatment will be needed per year to achieve the desired control. It is likely that treatment will be needed in succeeding years because most herbicides do not kill seeds or underground structures that lie dormant. As plants die and decompose after herbicide treatment, the nutrients in the plant body are released back into the water column, which can cause algae blooms. This can also contribute to the sediment layer and if too large of an area of plants is treated can cause oxygen levels to decline to such a level that fish may die.

Aquatic herbicide *Clipper* will no longer be used in the Highlands channel to manage water meal and duckweed. Instead, the Delavan Lake Sanitary District will be testing the use of Diver Assisted Suction Harvesting (DASH) to remove plant material from the water's surface. The purpose of this change is to reduce harvest impact on native plant species and fish habitat.

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[15] Jester, Laura L., Bozek, Michael A, Helsel, Daniel R., 1999, Wisconsin Milfoil Weevil Project, Wisconsin Cooperative Fishery Research Unit

A lack of water movement in the Viewcrest channel has created water quality issues. Assorted algae, duckweed, water meal and other aquatic plants often build up and impede navigation and reduce aesthetic appeal. To resolve this, the Delavan Lake Sanitary District plans to create an artificial flow through the channel. This would stop the plants and debris from accumulating.

Table 6. Aquatic Plant Management Method Comparison Chart

Method	Advantages	Disadvantages
Manual Control – Hand pulling & Raking	* No residual effects from chemicals * Highly selective removal of targeted species * Low or no cost	* Labor intensive * Generally for small areas
Diver Assisted Suction Harvesting	* Highly selective removal of targeted species * No residual effects from chemicals * Root system is also removed so there is likely longer control * Plant biomass and associated nutrients are removed from the waterbody	* Labor intensive * Cost may be higher than other methods * Generally for smaller areas * Disturbed substrate may hinder visibility (short term) for plant identification
Mechanical Harvesting	* No residual effects from chemicals * Immediate results * Plant biomass and associated nutrients are removed * The lower portion of the plants remain to provide habitat and sediment stabilization * Removing the upper portion of plants allows sunlight to penetrate and may benefit native plants * Site specific based on plant inventory	* Repeated harvesting needed to maintain boating paths *Equipment is expensive to purchase, maintain and store * By-catch (fish, crayfish, snails, frogs) may be a concern * Uncollected plant fragments of some plants (Eurasian water milfoil) will produce new growth
Chemical Control	* Different chemicals for different plants and situations * Results generally in 10 days * Good documentation of use and results available * Relatively low cost	* Unknown toxicity to aquatic animals and humans * Non-target plants may also be killed * May be water use restrictions * May result in drop in dissolved oxygen resulting in fish kills * dead plants contribute to sediments and nutrients in water column *Pesticide resistance can result if precautions are not taken

Note: The choice or choices for aquatic plant management will often be based on which plants need to be managed, available funding and desired results. Conditions that may impact aquatic plant management methods can change from year to year. The DNR, using the best scientific evidence available, regulates control of aquatic invasive species within all waterbodies of the State (Figure 1). Please contact the local DNR aquatic plant coordinator (http://dnr.wi.gov/lakes/plants/)before planning and implementing any aquatic plant management program.

History of Aquatic Plant Management in Delavan Lake:

In 1903 aquatic plant management for Delavan Lake consisted of pulling plants from the bottom of the lake by chains attached to boats[16]. Although it may have satisfied lake residents to begin with, it most likely removed so many aquatic plants that there were not enough left in the lake to use the excess nutrients in the water column, which likely resulted in large algae blooms.

Aquatic plant management evolved by 1924 when the first weed cutter was purchased, and again by the 1930's when chemical applications took the place of harvesting. Over the years, various chemicals have been used to control nuisance macrophytes and algae[17].

Since 1997 the Delavan Lake Sanitary District has been responsible for aquatic plant management of the lake. There has been considerable effort to use a careful balance of aquatic plant harvesting and chemical treatments. The District and the Town of Delavan developed the initial goals and objectives for lake management which included controlling the quantity and density of aquatic plant growth in portions of Delavan Lake to maintain and improve water related recreation while improving the aesthetic value of the lake and enhancing the over-all resource value of Delavan Lake[14].

The recommendations listed in The Aquatic Plant Management Plan and the conditions listed in the mechanical harvesting permit granted by DNR, which expired December 31, 2016, specified that mechanical harvesting be used as the primary control for aquatic plants, with chemical control measures to be limited to control of nuisance growths of exotic species and filamentous algae . The permit also stated that the harvesting of aquatic plants should not mean removing 100% of the plants in the lake, but should only remove nuisance plants in order to facilitate recreational use of the lake. In addition, prior to June 15 of each year, in order to protect newly spawned fish, harvesting was limited to cutting channels only where they are needed to provide boating access to channels and piers. After June 15, harvesting can be expanded as needed.

The harvesting season generally runs from mid-May to mid-October, depending upon weather and plant growth. The lake is divided into 12 harvesting areas (Map 4, Table 7) and has approximately 349 management acres. The Delavan Lake Sanitary District mechanical harvesting equipment includes three harvesters, one high-speed transport barge, three off-loading shore conveyors, one dump truck and three other support vehicles. The maximum cutting width ranges from 7 feet for the two larger harvesters to five feet for the smallest harvester. Each of the three harvesters is capable of harvesting plants up to a maximum depth of five feet. Table 8 provides the harvesting history from 2011 through 2016.

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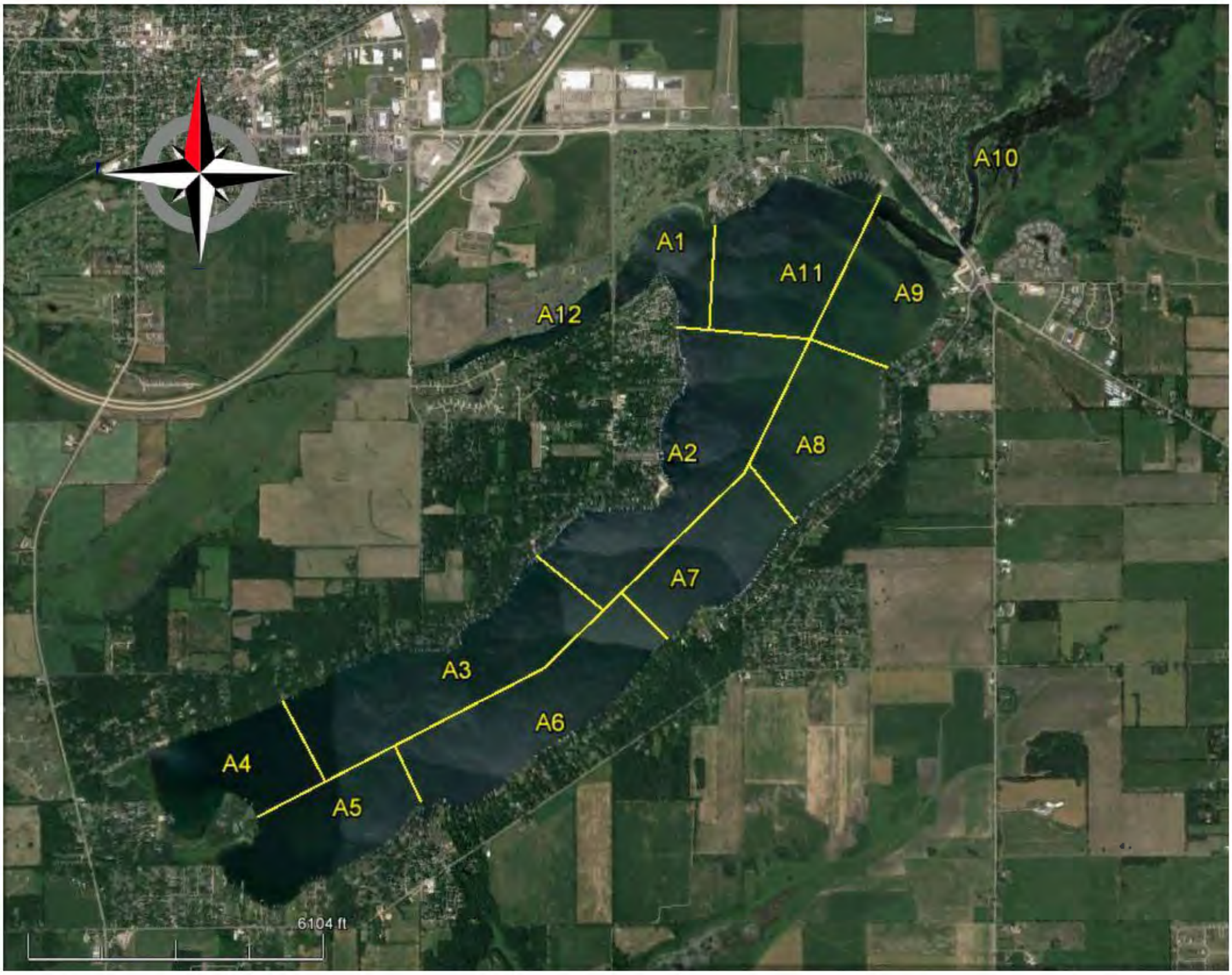
[16] 100 Years of Aquatic Plant Management on Delavan Lake, NALMS, 2005, Kevin MacKinnon, Charlies Handel

[17] Southeastern Wisconsin Regional Planning Commission, 2011, rev. 2012, Memorandum Report No, 190, An Aquatic Plant Management Plan for Delavan Lake, Walworth County, WI

MAP 4

Delavan Lake Harvesting Areas



Source: Google Earth

Table 7. Aquatic Plant Management Harvesting Areas for Delavan Lake

Aquatic Plant Management Area	Lake Shore Location Description	Estimated Length of Shoreline (Ft.)	Estimated Distance Out From Shore (Ft.)	Estimated Potential Management Acres	Avg. Depth (Ft.)
1	**North Shore Drive to Windtree Condos**	**2640**	**167**	**10**	**4**
2	**Windtree Condos to Delavan Boat Co.**	**6859**	**352**	**34**	**5**
3	**Delavan Boat Co. to Chicago Club**	**6516**	**150**	**17**	**5**
4.	**Chicago Club to Point on Island**	**4545**	**843**	**47**	**4**
5	**Point on Island to S Shore Manor Point**	**4900**	**490**	**36**	**6**
6	**S Shore Manor Point to Del Oaks**	**6465**	**208**	**27**	**5**
7	**Delavan Oaks to Belvidere Park**	**3310**	**176**	**11**	**5**
8	**Belvidere Park to Silver Sands Point**	**4005**	**173**	**11**	**5**
9	**Silver Sands Point to Town Park**	**6125**	**280**	**41**	**5**
10	**Inlet Upstream to SR 50**	**2885**	**146**	**11**	**3**
11*	**Lake Lawn Resort**	**2715**	**195**	**12**	**4**
12	**Outlet – North Shore Dr to Dam**	**3728**	**357**	**24**	**3**
Estimated Total Aquatic Plant Management Area				**289 Acres**	

*** Lake Lawn Resort runs their own weed harvesting operation**

Table 8. Mechanical Harvesting Record for Delavan Lake 2011 - 2016

Year	Number of Days Harvesting Occurred	Total Harvester Loads	Estimated Cubic Yards Removed	Estimated Phosphorous Removed from Lake (lbs)
2011	**55**	**188**	**1,864**	**310**
2012	**72**	**306**	**4,230**	**705**
2013	**71**	**218**	**2,717**	**452**
2014	**82**	**185**	**2,875**	**479**
2015	**85**	**372**	**4,891**	**815**
2016	**86**	**233**	**3,278**	**546**
Average	**75**	**250**	**3,309**	**551**

Note: Additional history (1997-2010) for Mechanical Harvesting can be found in SEWRPC, 2011, revised 2012, An Aquatic Plant Management Plan for Delavan Lake.

Before 1997 chemicals were a primary means of aquatic plant management for Delavan Lake. While current plans prescribe mechanical harvesting for the majority of aquatic plant management, there are still conditions when chemical control is the best option. Table 9 provides documentation of the chemical treatments that have been conducted on the Lake from 2009 – 2016.

Chemical Treatment of Pennywort

Chemical Treatment of Shallow Areas

Table 9. Delavan Lake Chemical Treatments 2009-2016

Date	Treatment Area	Acres Treated	Product	Amount
05/05/09	Outlet	16.45	DMA-4	96.75 gal
			Cutrine Plus	33 gal
06/04/09	Inlet	10.46	Aquathol-K	22 gal
			Cutrine Plus	22 gal
			Reward	10.5 gal
06/29/09	East shoreline	8.67	Cutrine Plus	21.75 gal
07/20/09	Inlet	6.4	Aquathol-K	13 gal
	Inlet		Cutrine Plus	13.75 gal
	Inlet		Reward	6.4 gal
	Total for 2009	41.98 acres		
05/05/10	Outlet	26.67	Cutrine Plus	50.75 gal
			Weedestroy	103.75 gal
6/10/10	Inlet	8.59	Aquathol-K	39.5 gal
			Cutine Plus	40.5 gal
			Reward	8.25 gal
6/29/10	South Channel	0.65	Cutrine Plus	3.0 gal
			Reward	.75 gal
8/11/10	Inlet	8.59	Aquathol-K	39.5 gal
			Cutrine Plus	40.5 gal
			Reward	8.25 gal
09/13/10	Outlet	0.61	Touchdown Pro	32 oz
			Habitat	32 oz
	Total Acres 2010	45.11		
06/01/11	Outlet	41.68	Aquathol-K	36.5 gal
			Cutrine Plus	39.5 gal
			Weedestroy	83.5 gal
06/28/11	Highlands Channel	2	Cutrine Plus	6 gal
10/03/11	Inlet	1	DMA-4	.44 gal
	Total Acres 2011	44.68		
04/30/12	Outlet	25.566	Aquathol-K	44.25 gal
			Cutrine Plus	44.25 gal
			DMA-4	96.5 gal
5/14/12	Inlet	4	Aquathol-K	8.5 gal
			Cutrine Plus	7.75 gal
			Reward	4 gal
5/26/12	Highlands Channel	1.75	Clipper	14.75 gal
7/31/12	Various	7	Weedestroy	.563 gal

Date	Treatment Area	Acres Treated	Product	Amount
8/13/12	Inlet	7	Aquathol-K	8.5 gal
			Cutrine Plus	1 gal
9/12/12	Various	1.5	Weedestroy	1 gal
	Total Acres 2012	39.816		
5/29/13	Outlet	53.132	Weeddestroy	96.5 gal
			Aquathol-K	44.25 gal
			Cutrine Plus	44.25 gal
6/5/13	Highlands/Viewcrest Channel	3.75	Clipper	30.62 gal
8/01/13	Inlet	4	Aquathol-K	8.25 gal
			Cutrine Plus	9.75 gal
	Total Acres 2013	60.882		
05/29/14	Outlet/Viewcrest/Assembly Park	22.51	Cutrine Plus	72.75 gal
6/03/14	Outlet/Viewcrest/Assembly Park	25.68	AM-40	95.5
7/01/14	Outlet/Viewcrest/Assembly Park	19.63	Cutrine Plus Ultra	71.25 gal
7/16/14	Highland/Viewcrest/Browns	5.8	Clipper	3.75 lbs
			Captain XTR	29.25 gal
			Reward	1.65 gal
			SeClear	13.5 gal
09/03/14	Highway 50 Shoreline	<1	AM-40 Amine	0.813 gal
9/11/14	Inlet Shoreline	1.5	Aquathol-K	9.5 gal
			Cutrine Plus	4 gal
			Reward	1.5 gal
10/24/14	Various for Pennywort	<1	AM-40 Amine	1.0 gal
	Total Acres 2014	77.12		
5/14/2015	Northshore	26.63	AM-40	99.75 gal
			Cutrine Ultra	9.5 gal
6/24/15	Inlet – West Shoreline	2.07	AM-40	3.5 gal
			Aquathol K	3.5 gal
			Cutrine Ultra	11 gal
			Reward	1.5 gal
8/17/15	Various for Pennywort	<1	AM-40	12oz
10/12/15			AM-40	48 oz
	Total Acres 2015	29.7		

Date	Treatment Area	Acres Treated	Product	Amount
5/17/16	Beach Street Bridge	1.74	Clipper	7.41 lbs
8/18/16	Various for Pennywort	Spot treatments	AM-40	0.5 gal
9/15/16	Single Pennywort Patch	Spot treatment	AM-40	8 oz
	Total Acres 2016	55.28		

Note: Additional history (1950-2008) for chemical treatment of aquatic plants can be found in SEWRPC, 2011, revised 2012, An Aquatic Plant Management Plan for Delavan Lake.

Wisconsin's Aquatic Plant Survey Protocol:

Aquatic Plant Surveys that are funded by Wisconsin DNR grant funds are required to follow a specific protocol that was developed by DNR staff. This protocol, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, field and Laboratory Procedures, Data Entry and Analysis, and Applications,(Rev. March 2010), is also used by DNR staff during all aquatic plant surveys that they conduct. The protocol is designed to quantitatively assess the distribution and abundance of macrophytes in all types of lakes, which makes it possible to statistically evaluate the change in the aquatic plant population of a lake over time and to compare lakes across the State.

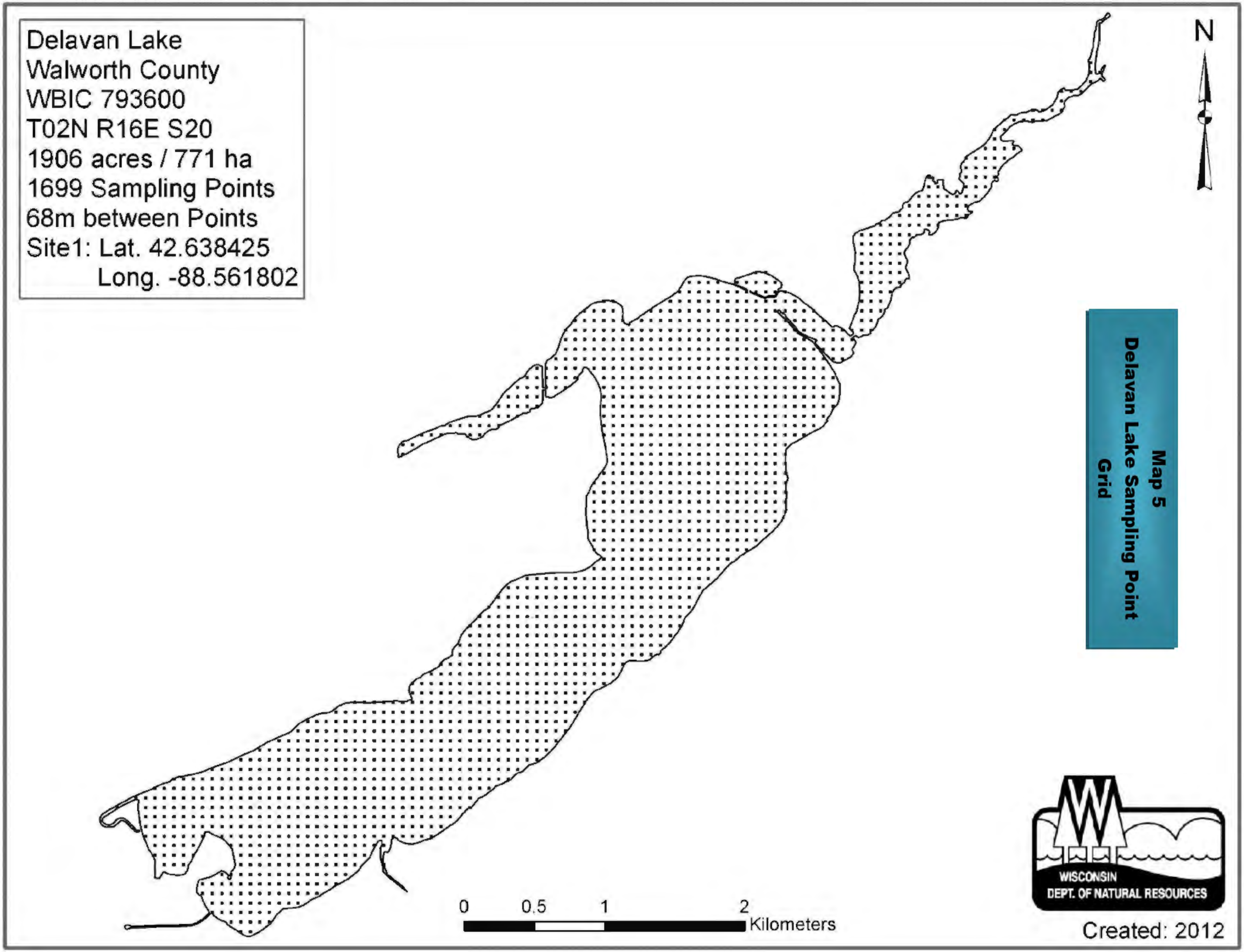
Per protocol, for every lake surveyed, DNR staff generates a sampling grid of equally spaced points specifically for the lake to be sampled. Map 5 shows Delavan Lake sampling points. An electronic file containing a map of the lake with the sampling points overlain on it and a GPS text file with the latitude and longitude of each site is provided by DNR to the company or individuals that will be sampling the lake. These coordinates are then downloaded into the sampling teams own GPS unit. Every sampling site will be visited unless the site is inaccessible. At each site, a rake on either a pole or rope, depending on the depth, will be lowered to the lake bottom. Once on the lake bottom, the pole rake is rotated twice, or if the rope rake is used it is dragged for one foot. The sampling rake is then pulled straight out of the water.

Figure 2 **Illustration of Sample Rake Fullness**

Source: DNR

Fullness Rating	Coverage	Description
1		Only a few plants. There are not enough plants to entirely cover the length of the rake head in a single layer
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines
3		The rake is completely covered and tines are not visible.

At each site, depth and substrate type is recorded. All plants that are on the sampling rake are identified and given a fullness rating of 1, 2 or 3 (Figure 2). Voucher specimens of undocumented plant species may be collected, unless the population is so small it is not possible or desirable. Once field work is complete, all data is entered into the Aquatic Plant survey Data Workbook. This is an Excel spreadsheet, created with the DNR protocol, with formulas embedded in it that allow the workbook to automatically calculate statistics which provide an accurate picture of the aquatic plant population at the time of survey. Summary statistics are calculated based on all data (Table 10). Some of these statistics are self-explanatory, such as number of sites visited and number of sites where a species was found, others are explained below. Individual statistics (Table 14) are calculated for each species sampled.


Delavan Lake
Walworth County
WBIC 793600
T02N R16E S20
1906 acres / 771 ha
1699 Sampling Points
68m between Points
Site1: Lat. 42.638425
Long. -88.561802
N
Map 5
Delavan Lake Sampling Point Grid
0
0.5
1
2
Kilometers
WISCONSIN
DEPT. OF NATURAL RESOURCES
Created: 2012

Delavan Lake Aquatic Plant Survey Results

There has been many aquatic plant surveys conducted on Delavan Lake yearly since 1992 by trained aquatic plant specialists. These surveys followed the accepted methodology of that time and many of the full reports of these surveys can be found on the DLSD website (http://www.dlsd.org/lake-operations/aquatic-plant-harvesting) as well as in previous aquatic plant management plans for Delavan Lake. The 2015 aquatic plant survey which was conducted by trained DLSD and DNR staff, followed methodology that was designed by Wisconsin DNR Science Services in 2009 and updated in 2010. This methodology provides data that can be compared between years and lakes throughout Wisconsin, which makes it an extremely valuable tool for lake management and protection.

Although previous aquatic plant survey results provide valuable results, it is not possible to compare those results against the data collected in 2015 using the protocol outlined in Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, field and Laboratory Procedures, Data Entry and Analysis, and Applications,(Rev. March 2010).

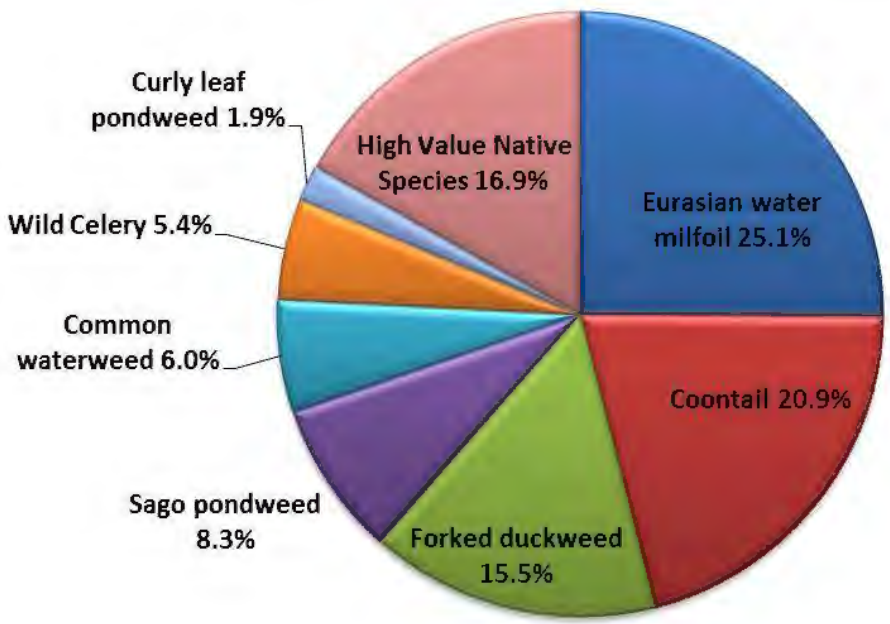
The Delavan Lakes Sanitary District staff working with DNR staff conducted the 2015 aquatic plant survey on Delavan Lake between July 22 and July 29. The data presented as part of this plan are the results from that survey. Of the 1699 sampling points on the grid map (map 5) that was created for Delavan Lake, only 866 were visited, either because the survey boat was unable to navigate to certain points or because points were beyond the maximum depth of plants (Figure 3). Of the 866 points that were sampled, 549 points were vegetated. Eighteen species of aquatic plants were documented during the point-intercept survey (Table 12). There was also one species, Potamogeton natans, Floating – leaf pondweed that was "visually observed" but that was not collected on the rake during the survey and as a result is not included in the 2015 survey results but is considered a "visual" species. Although not included in the statistical analysis, Filamentous algae were collected at 301 sites and Nostoc sp., a genus of cynobacteria were collected at 63 sites.

The overall dominant species in 2015 were Eurasian water milfoil, Coontail, Forked duckweed, Sago pondweed, Common waterweed and Wild celery (Figure 4). Eurasian water milfoil and Coontail are shown to be the top dominate plant species in reports from 2008, 2011, 2012 and 2013[18]. Eurasian water milfoil is also recorded as the most harvested aquatic plant for 2015 and 2016[19]. Other species with high dominance include Forked duckweed, Sago pondweed Common waterweed and Wild celery. Curly leaf pondweed is not shown to have a high relative frequency of occurrence (1.9%). This may be because the survey was conducted in late July which is well after the end of the growing season for Curly leaf.

[18] Aron & Associates, 2008, 2011, 2012, 2013, Delavan Lake Aquatic Plant Survey

[19] Delavan Lake Sanitary District, 2015 & 2016 Aquatic Plant Harvesting Report

Figure 3. Delavan Lake 2015 Plant Dominance



Summary Statistics

Table 10. Summary Statistics	
Total number of sites visited	866
Total number of sites with vegetation	549
Total number of sites shallower than maximum depth of plants	623
Frequency of occurrence at sites shallower than maximum depth of plants	88.12
Simpson Diversity Index	0.86
Maximum depth of plants (ft.) See Figure 4	20.20
Number of sites sampled using rake on Rope (R)	110
Number of sites sampled using rake on Pole (P)	558
Average number of all species per site (shallower than max depth)	2.71
Average number of all species per site (veg. sites only)	3.07
Average number of native species per site (shallower than max depth)	2.00
Average number of native species per site (veg. sites only)	2.42
Species Richness	18
Species Richness (including visuals)	19

As per protocol, statistics were automatically calculated when data was entered into the excel spreadsheet following survey field work.

Species Richness: This is the total number of species collected on the sampling rake during an aquatic plant survey, including exotic species. Eighteen (18) species were found on Delavan Lake in 2015. Species richness with visuals included is calculated separately.

Frequency of Occurrence at Sites Shallower than the Maximum Depth of Plants (Littoral Zone): This is the percentage of sites in the littoral zone where plants were sampled. For Delavan Lake, there were 623 sites shallower than the maximum plant depth and 548 of those sites had vegetation. [{548/623} x 100 = 87.96%].

Simpson's Diversity Index: This is a measure of how diverse the aquatic plant community is. The calculation is based on relative density and therefore is not sensitive to the number of sites sampled. The Simpson Diversity Index ranges from 0 to 1. The higher the number, the more diverse the plant community is. There were 18 species documented during the 2015 survey. Delavan Lake's Simpson's Diversity Index (Table 11) was 0.86. Comparing Delavan Lake data to data available from other lakes throughout Wisconsin and data from the Southeast Wisconsin Till Plain (SWTP) region shows that Delavan Lake had a diversity index level that is just slightly lower than the State and just slightly higher that the Regional average.

Table 11. 2015 Simpson's Diversity Index Comparison

	Simpson's Diversity Index Comparison		
	Minimum	**Median**	**Maximum**
Wisconsin Lakes	**0.65**	**0.86**	**0.95**
Southeast Wisconsin Till Plains	**0.44**	**0.82**	**0.93**
Delavan Lake	**0.85**		

Floristic Quality Index (FQI): This measure assesses the native plant community to determine how close to a pre-settlement (undisturbed) condition the aquatic plant population is and therefore the lake. This assessment is possible because most native plants in Wisconsin have been assigned a Coefficient of Conservatism (C), which is an estimated value based on how sensitive that species is to disturbance. C uses a scale of 0 to 10, with 0 being not sensitive to disturbance and 10 being very sensitive to disturbance. The FQI is calculated by finding the mean C of all native aquatic plants sampled and multiplying it by the square root of the total number of native species inventoried (FQI= mean c x $\sqrt{N}$).

Sixteen native species were sampled during the 2015 aquatic plant survey, with a mean C of 5.5625 (Table 12). This calculated to a FQI for Delavan Lake of 22.25 (Table 12). Comparing Delavan Lake with the State and Regional FQI (Table 13) shows that Delavan Lake ranks equal to the mean quartile of the State and slightly higher than the upper quartile of the Southern Till Plains.

Table 12. Aquatic Plants Detected During the 2015 Aquatic Plant Survey			
Scientific Name	**Common Name**	**Growth Form**	**Coefficient of Conservatism (C)**
Ceratophyllum demersum	Coontail	Submersed	**3**
Chara spp.	Muskgrass; Stonewort	Submersed	**7**
Elodea Canadensis	Common waterweed	Submersed	**3**
Heteranthera dubia	Water stargrass	Submersed	**6**
Lemna minor	Small duckweed	Floating leaf	**4**
Lemna trisulca	Forked duckweed	Floating leaf	**6**
Myriophyllum sibiricum	Northern water milfoil	Submersed	**6**
Myriophyllum spicatum	Eurasian water milfoil	Submersed	**Exotic**
Nymphaea odorata	White water lily	Floating leaf	6
Potamogeton crispus	Curly-leaf pondweed	Submersed	**Exotic**
Potamogeton friesii	Fries pondweed	Submersed	8
Potamogeton illinoensis	Illinois pondweed	Submersed	6
Potamogeton nodosus	Long-leaf pondweed	Submersed	7
Potamogeton pusillus	Small pondweed	Submersed	7
Potamogeton zosteriformis	Flat-stem pondweed	Submersed	6
Stuckenia pectinate	Sago pondweed	Submersed	3
Valisneria americana	Wild celery	Submersed	6
Wolffia columbiana	Common watermeal	Floating leaf	5
Floristic Quality Index (FQI) = mean C x √N			
		Mean C	**FQI**
Total Native Species	**16**	**5.5625**	**22.25**

Table 13. 2015 Average Coefficient of Conservatism (C) & Floristic Quality Index (FQI) Comparison

	Average Coefficient of Conservatism			**Floristic Quality Index**		
Quartile	**Lower**	**Mean**	**Upper**	**Lower**	**Mean**	**Upper**
Wisconsin Lakes	**5.5**	**6.0**	**6.9**	**16.9**	**22.2**	**27.5**
Southeastern Till Plains	**5.2**	**5.6**	**5.8**	**17**	**20.9**	**24.4**
Delavan Lake	**5.5625**			**22.25**		

Table 14.	Individual Statistics for 2015 Aquatic Plant Survey – Delavan Lake					
Scientific Name	**Common Name**	**Frequency of Occurrence Within Vegetated Areas**	**Frequency of Occurrence at Sites Shallower Than Max Depth of Plants**	**Relative Frequency of Occurrence (Dominance)**	**Number of Intercept Points Where Sampled**	**Average Density**
Ceratophyllum demersum	Coontail*	61.86	54.41	20.9	339	1.32
Chara spp.	Muskgrass; Stonewort	11.86	10.43	4.0	65	1.35
Elodea Canadensis	Common waterweed*	17.70	15.57	6.0	97	1.19
Heteranthera dubia	Water stargrass	13.32	11.72	4.5	73	1.03
Lemna minor	Small duckweed	7.85	6.90	2.6	43	1.02
Lemna trisulca	Forked duckweed*	45.80	40.29	15.5	251	1.02
Myriophyllum sibiricum	Northern water milfoil	0.91	0.80	0.3	5	1.00
Myriophyllum spicatum	Eurasian water milfoil*	74.27	65.33	25.1	407	1.39
Nymphaea odorata	White water lily	1.09	0.96	0.4	6	1.50
Potamogeton crispus	Curly-leaf pondweed*	5.66	4.98	1.9	31	1.00
Potamogeton friesii	Fries pondweed	1.46	1.28	0.5	8	1.00
Potamogeton illinoensis	Illinois pondweed	0.18	0.16	0.1	1	1.00
Potamogeton nodosus	Long-leaf pondweed	1.28	1.12	0.4	7	1.00
Potamogeton pusillus	Small pondweed	4.56	4.01	1.5	25	1.00
Potamogeton zosteriformis	Flat-stem pondweed	0.36	0.32	0.1	2	1.00
Stuckenia pectinate	Sago pondweed*	24.45	21.51	8.3	134	1.11
Valisneria americana	Wild celery*	16.06	14.13	5.4	88	1.20
Wolffia columbiana	Common watermeal	7.48	6.58	2.5	41	1.02

***See 2015 location maps 6 - 13**

Individual Species Statistics (Table 14):

Frequency of Occurrence for Each Species (%). The number of sites a species was recorded divided by the total number of vegetated sites sampled. This statistic is sensitive to the number of sites sampled.

Frequency of Occurrence at Sites Shallower Than the Maximum Depth of Plants (Littoral Zone): Calculated by dividing the number of sits a species was collected by the total number of sites shallower than the maximum depth of plants.

Relative Frequency of Occurrence (%) for each species is found by dividing the frequency of occurrence of a species by the total frequency of occurrence of all species found during the survey. Relative frequency of occurrence is a percentage that is used in other calculations and can also stand alone to show the amount of one plant species in the lake in relation to the entire plant population of the lake, also known as plant dominance. The sum relative frequency of occurrence for all plants will equal 100% also used in other calculations.

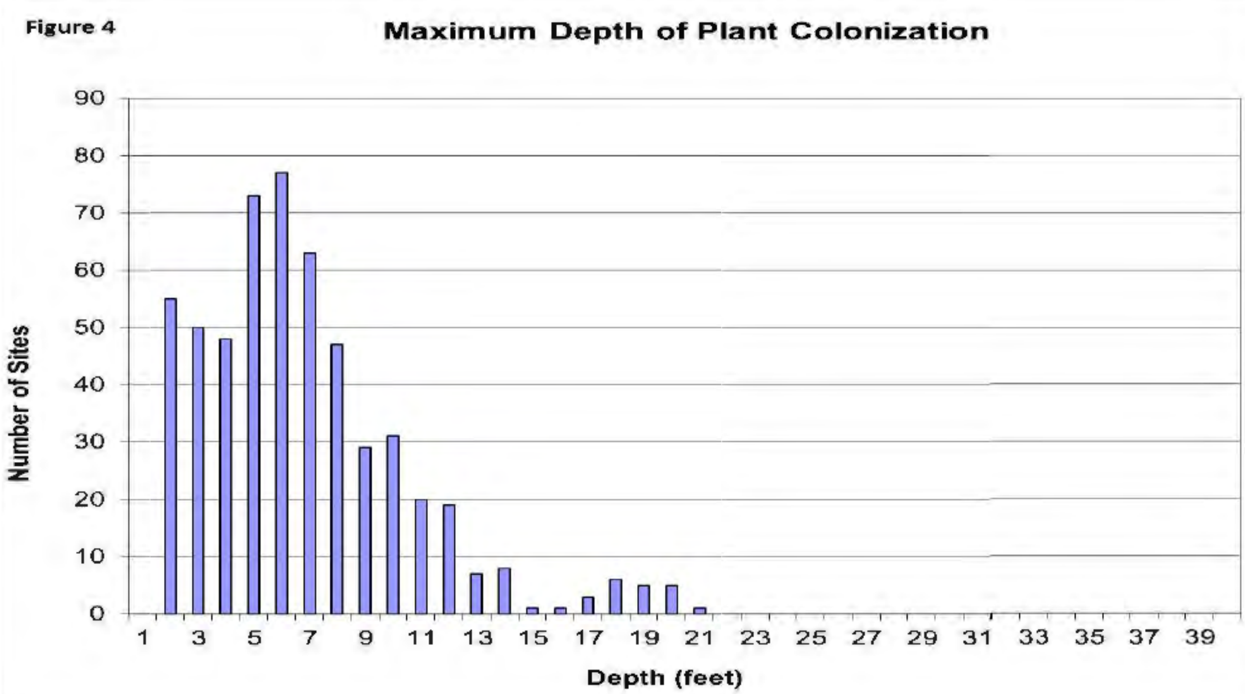
Relative Frequency (squared): Simpson's Diversity Index = 1- the sum of the RF^2 for all species surveyed.

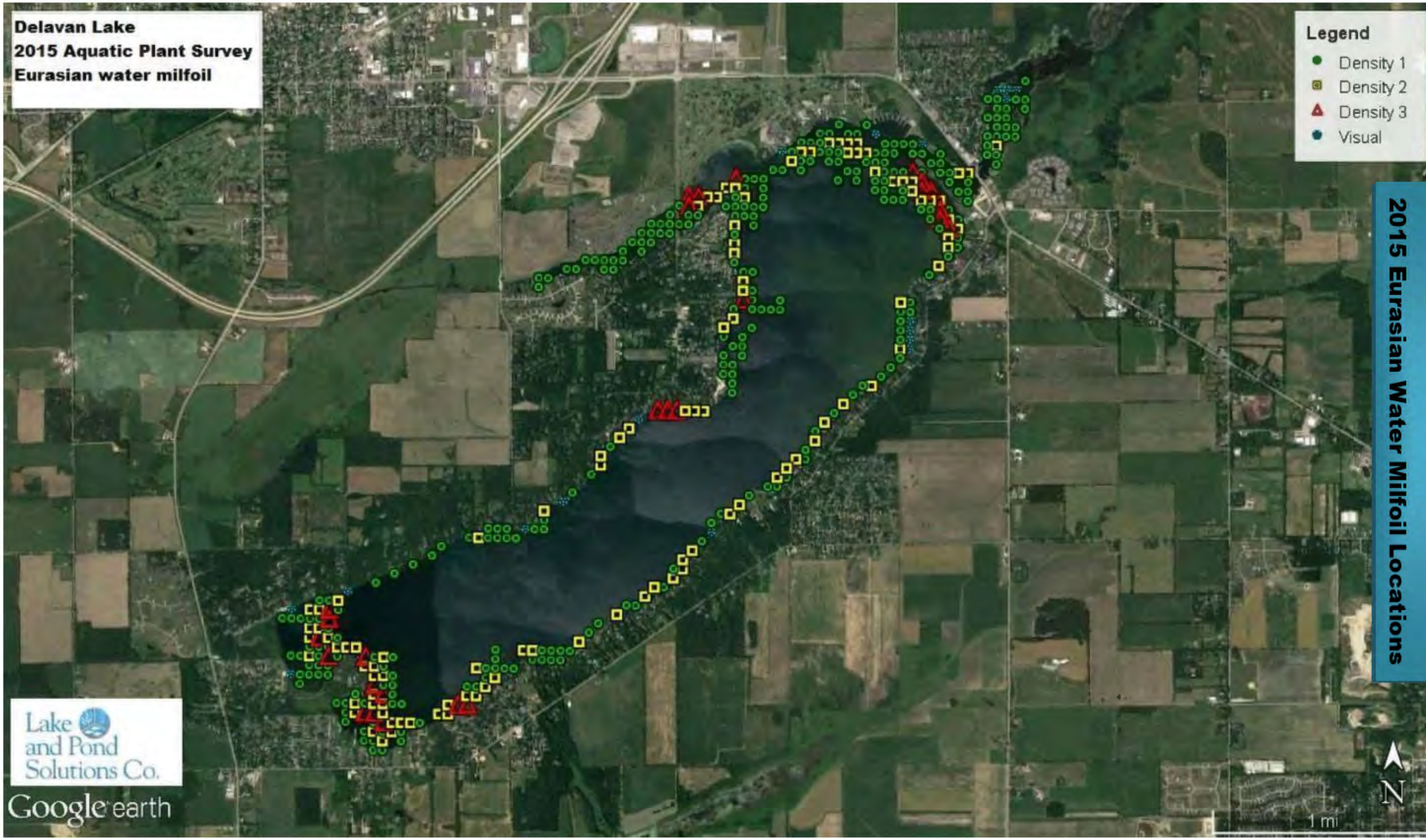
Number of visual sightings: The number of times a species was seen within 6ft of the boat but not collected on the rake.

Average Rake Fullness: The sum of all the rake fullness ratings (1-3) for each species, divided by the number of sites a species was recorded (Figure 3).

Maximum Depth of Plants: (Figure 4) Shows plant occurrences by water depth. This can be an especially important parameter to use when comparing surveys from different years because if water quality and clarity decrease, without a change in overall water depths, it may indicate a decline in water quality.

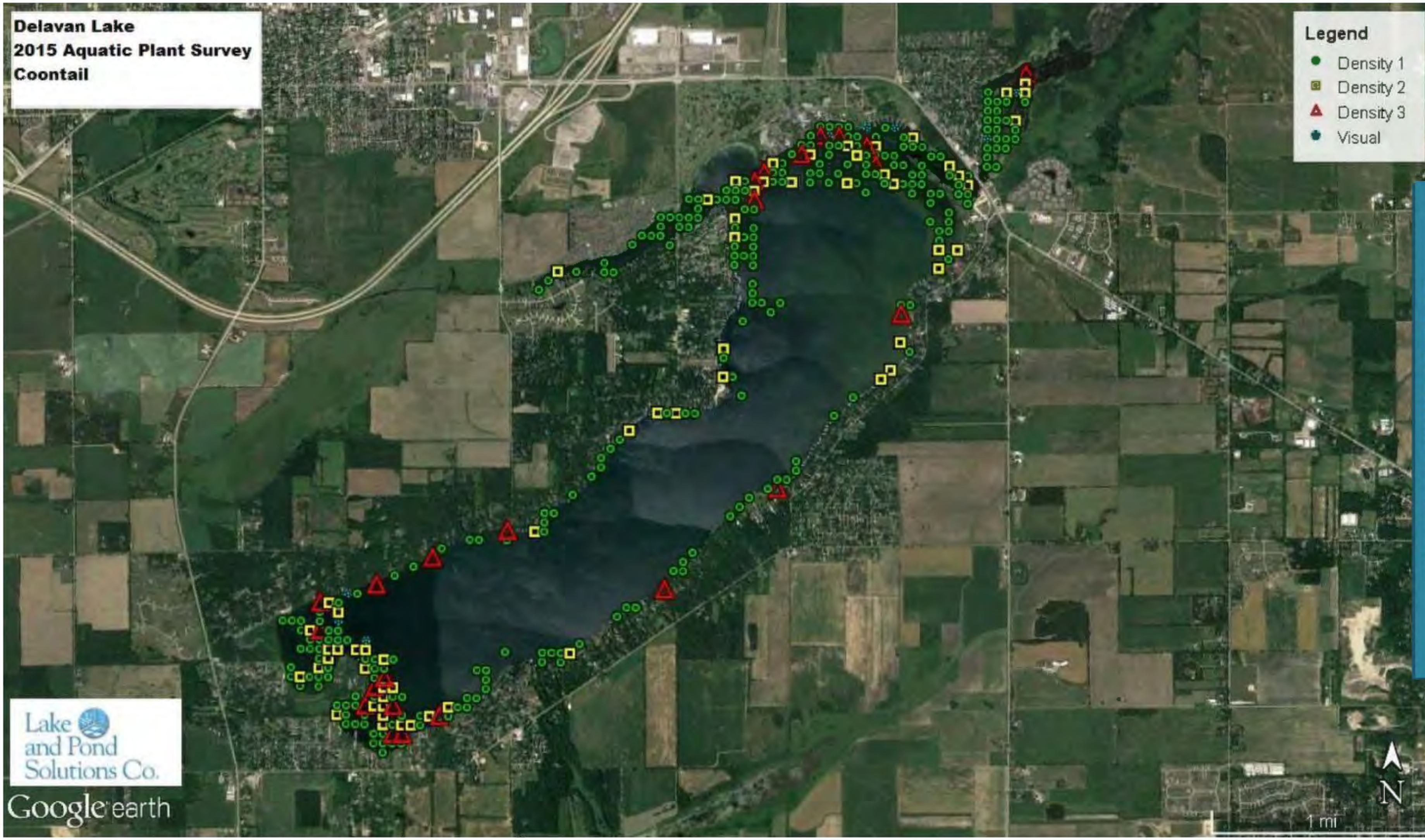
Figure 4





MAP 6
2015 Eurasian Water Milfoil Locations

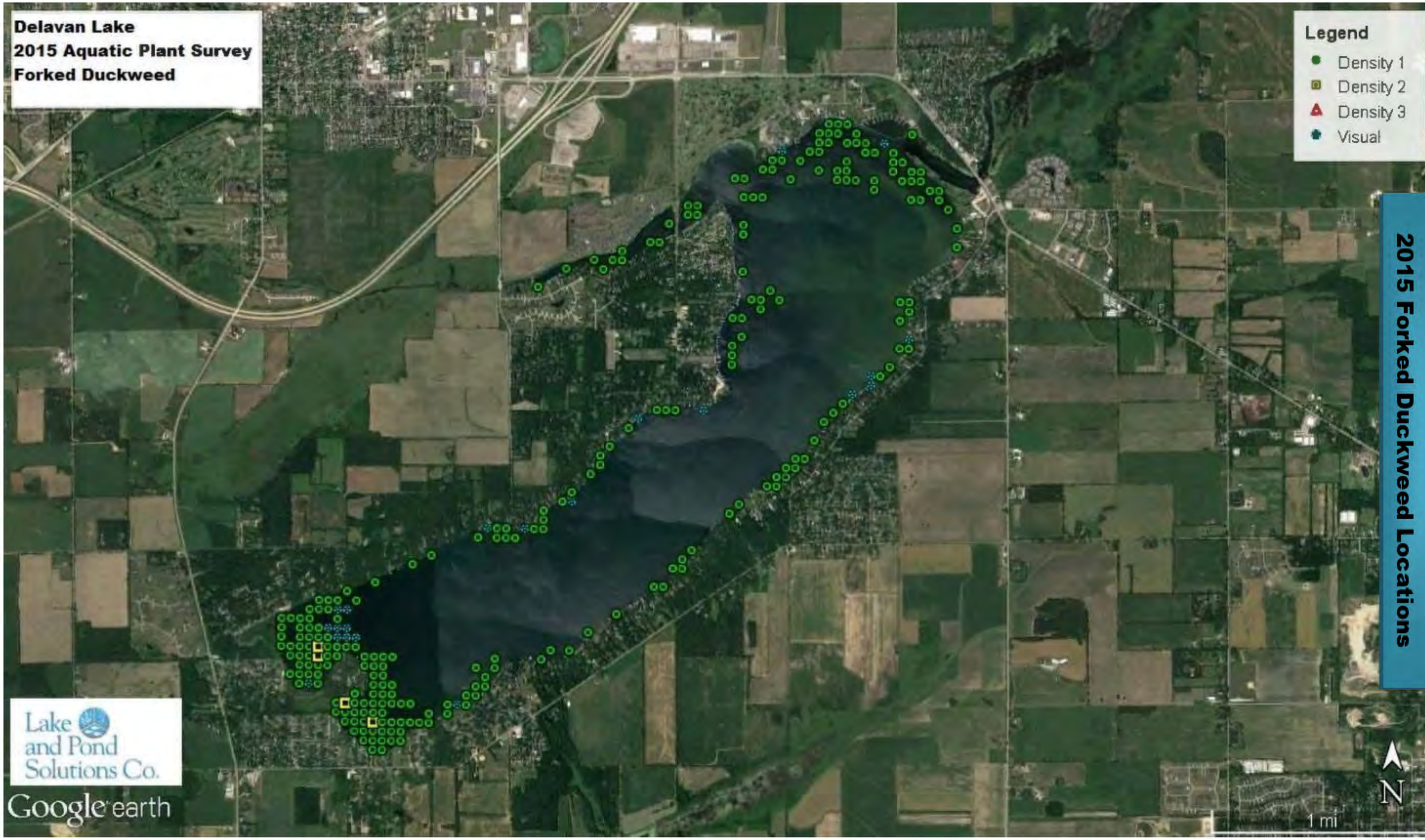
Eurasian Water Milfoil
Source: SEWRPC



MAP 7
2015 Coontail Locations


Coontail (Ceratophyllum demersum)

Source: SEWRPC



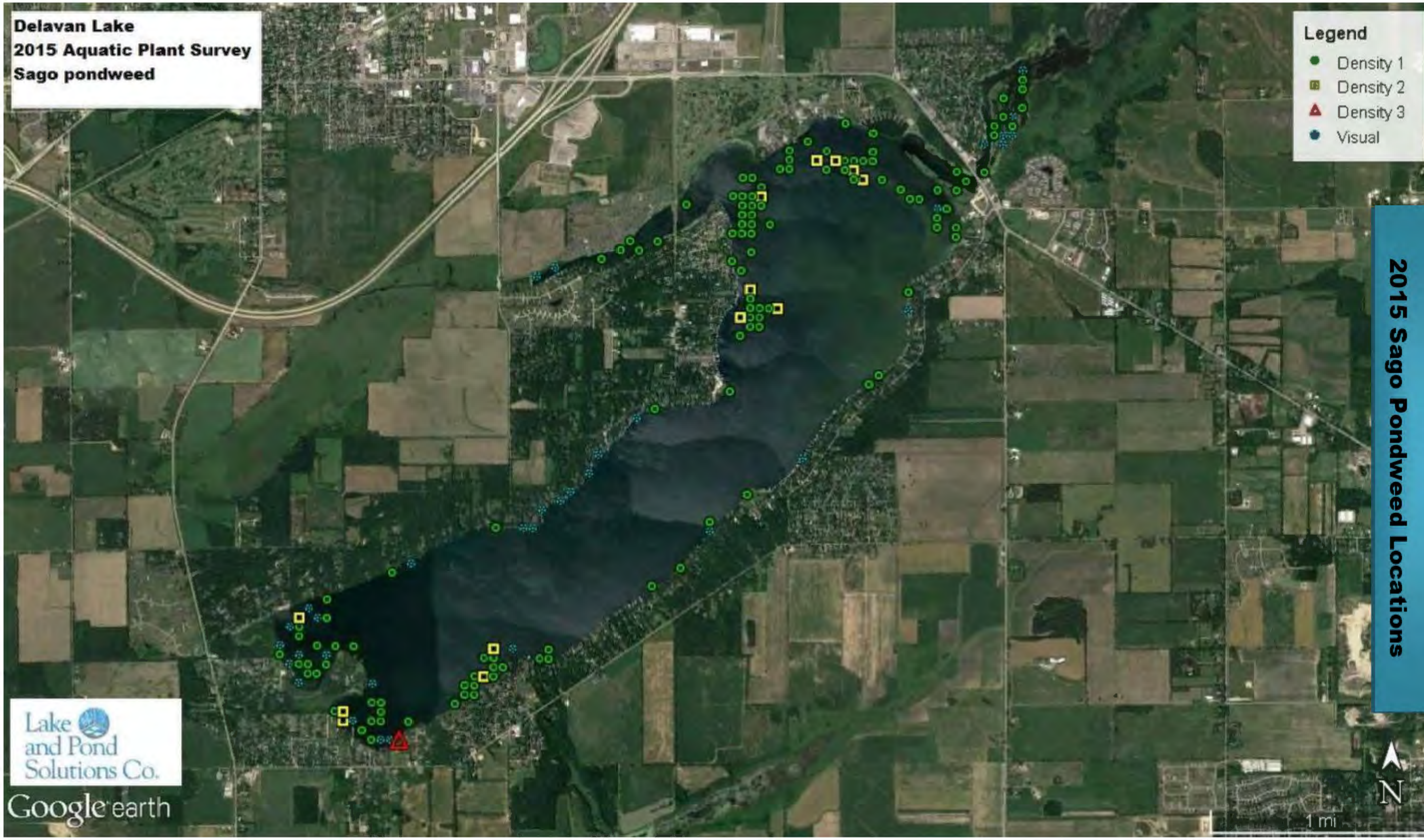
MAP 8

2015 Forked Duckweed Locations

Source: **Aquatic Plants of Wisconsin : A photographic field guide to submerged and floating-leaf aquatic plants**

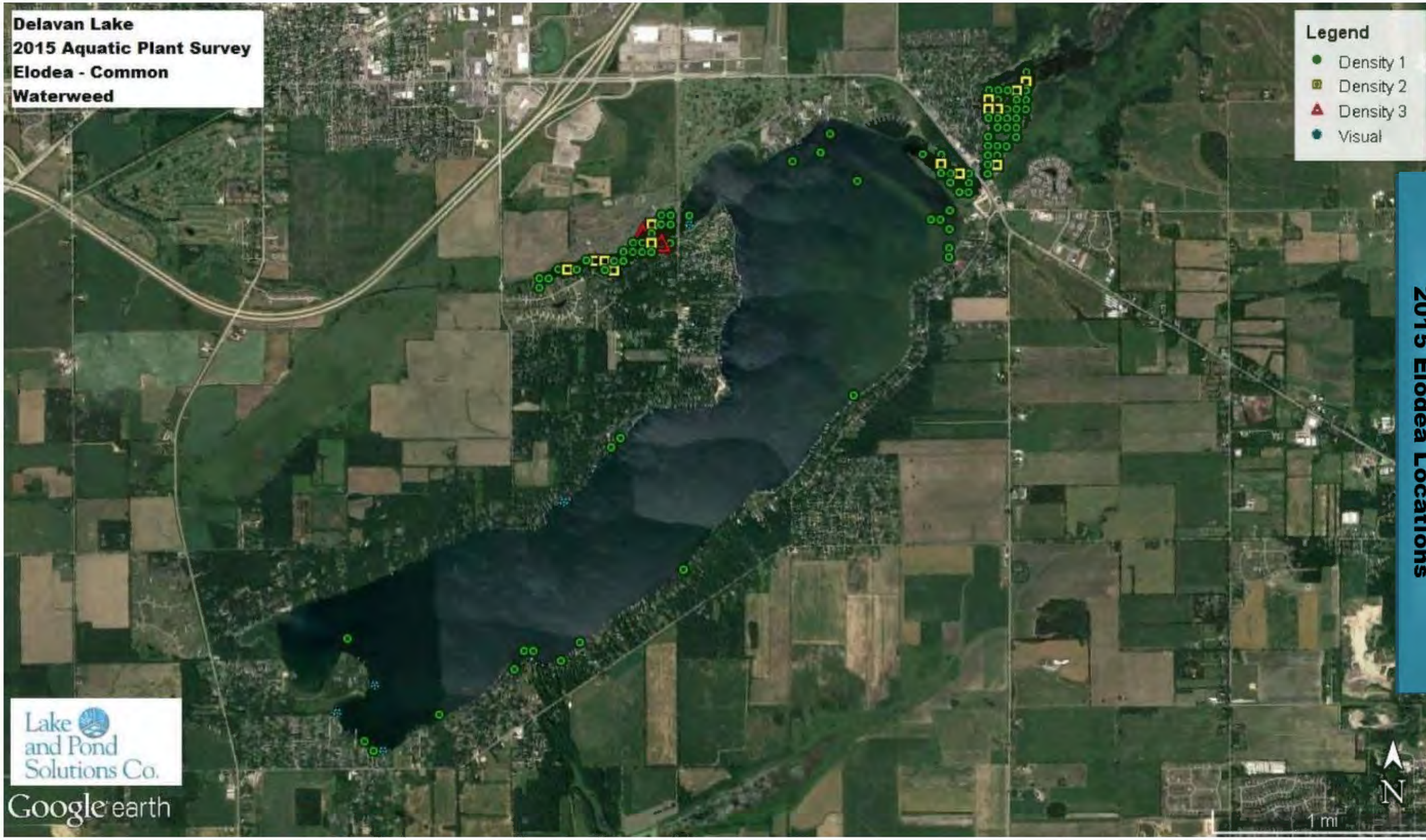
MAP 9

2015 Sago Pondweed Locations



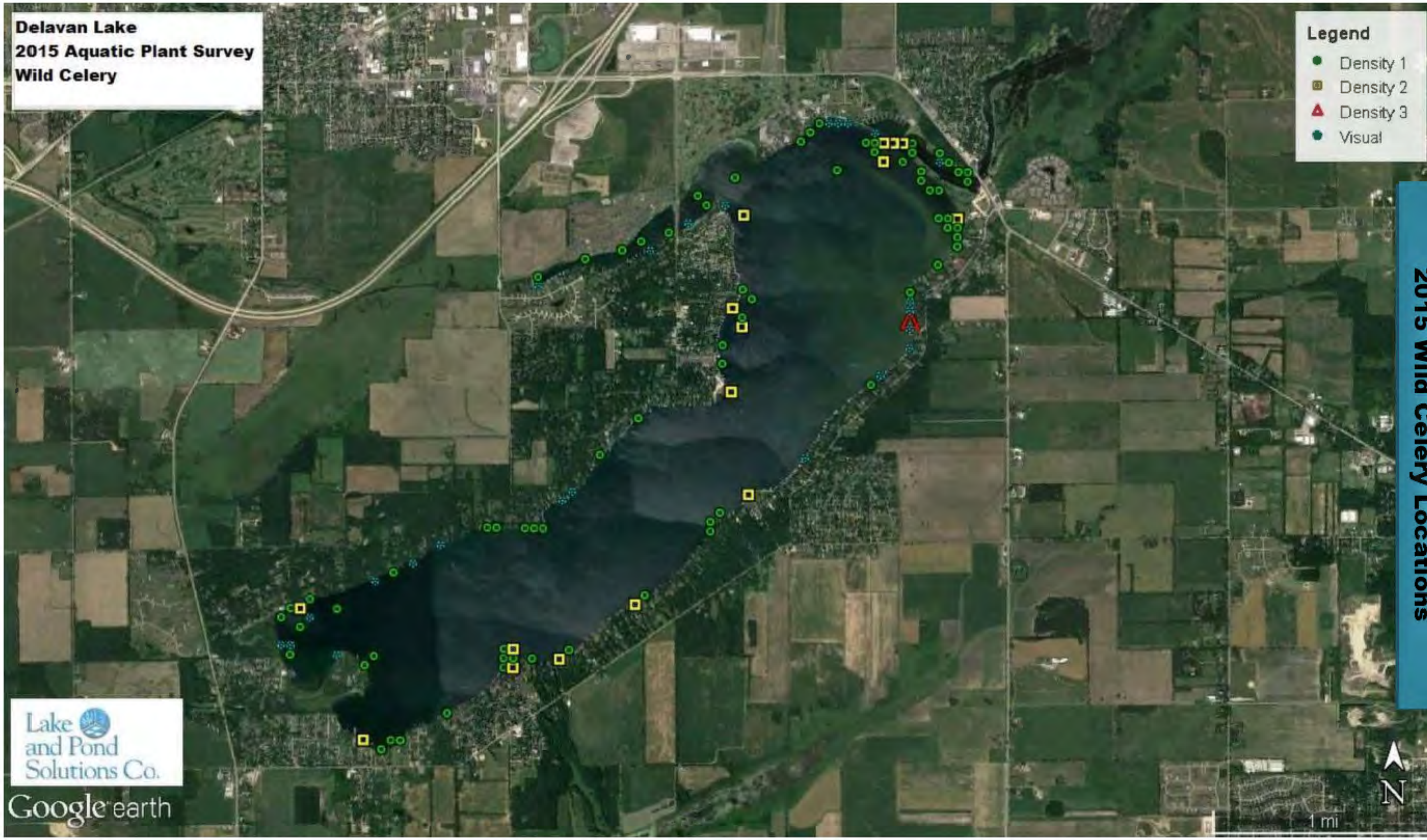
Sago Pondweed (Potamogeton pectinatus)

Source: SEWRPC



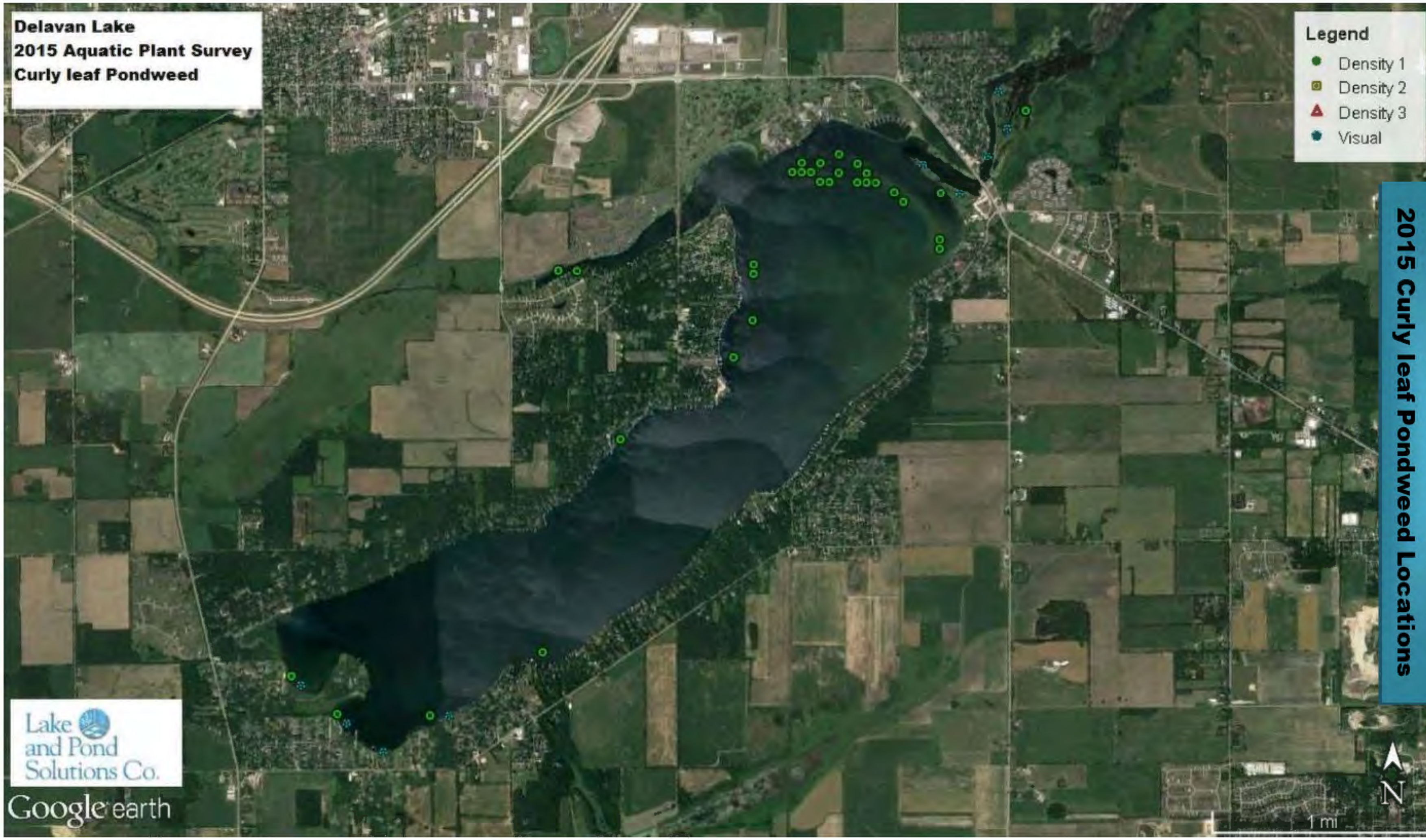
MAP 10
2015 Elodea Locations

Elodea (Common Waterweed)
Source: SEWRPC



MAP 11
2015 Wild Celery Locations

Wild Celery
Source: SEWRPC

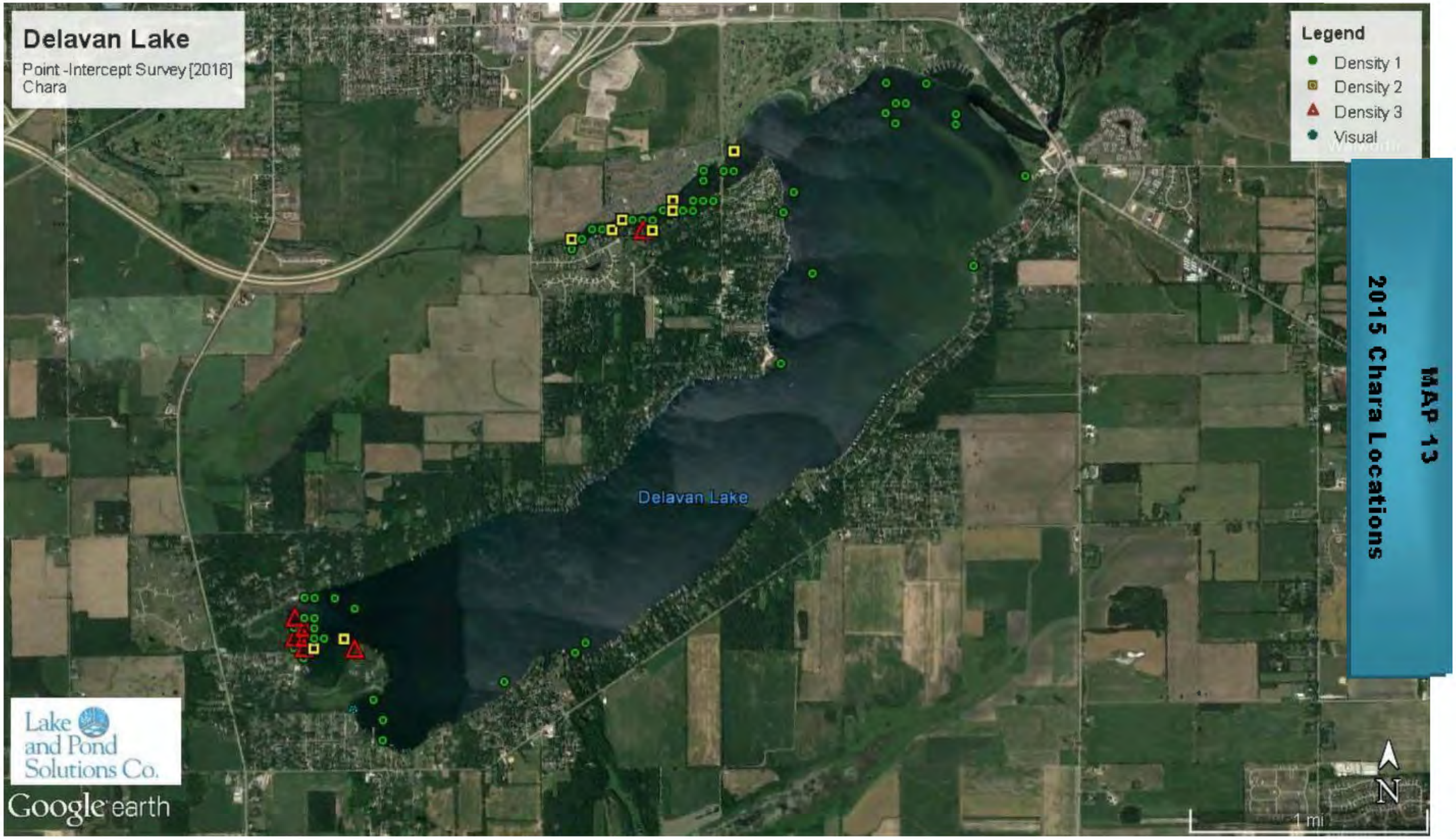


MAP 12

2015 Curly leaf Pondweed Locations

Curly-Leaf Pondweed (Potamogeton crispus)

Source: SEWRPC


Delavan Lake
Point -Intercept Survey [2016]
Chara
Legend
Density 1
Density 2
Density 3
Visual
Delavan Lake
Lake and Pond Solutions Co.
Google earth
N
1 mi
MAP 13
2015 Chara Locations


Source: Roberta Hill, VLMP © 2007

Discussion & Recommendations for Delavan Lake

The Delavan Lake Sanitary District has been responsible for aquatic plant management of Delavan Lake since 1997. There has been considerable effort to use a careful balance of aquatic plant harvesting and chemical treatments to manage nuisance growth of non-native invasive plants and filamentous algae in the lake. Management of aquatic plants has been used to preserve water quality, lake aesthetics and recreational opportunities for Delavan Lake.

Although statistics can not be compared between the 2015 and earlier surveys, Eurasian water milfoil and Coontail were considered the dominate aquatic plants found in Delavan Lake during those earlier surveys and the 2015 aquatic plant survey shows that they are still dominate species. Survey reports from 2008 through 2013 also state that the Chara population was declining. The 2015 survey results show that Chara was only found in 65 sites in the lake with the majority found in the outlet and in the North lobe of the South end of the lake. The 2008 survey report suggests that the high levels of filamentous algae may be at least partially responsible for the decline in Chara[20]. It is recommended that Delavan Lake be sampled every 3-5 year intervals and using the same sampling protocol Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, field and Laboratory Procedures, Data Entry and Analysis, and Applications,(Rev. March 2010).

An evaluation of the 2015 survey statistics show that 18 species total and 16 native species were sampled in 2015. This is an increase from the 2011, 2012 and 2013 aquatic plant surveys, although the increase could be a reflection of a different, more intense, sampling protocol. The 2015 aquatic plant survey results show that Delavan Lake has a diversity (Simpson's Diversity Index) of 0.85, which is approximately the same as the average for the SWTP Region and the entire state. The Floristic Quality Index (FQI), which gives a level of how close to pre-settlement the plant population is 22.25 for Delavan Lake. This measure is equal to the FQI for the State and slightly about the average of the SWTP Region. These data indicate that Delavan Lake has a relatively robust aquatic plant population. However, Delavan Lake like most lakes must manage the nuisance aquatic plants that have been introduced.

Eurasian water milfoil and Curly leaf pondweed were the only non-native invasive species that were sampled. Curly leaf pondweed (Map 12) was only sampled at 31 sites and all in the Northern portion of the lake. However, the survey was conducted in late July which is after the average Curly leaf pondweed growing cycle. It may be necessary to conduct an aquatic plant survey earlier in the season on some years in order to achieve a good Curly leaf pondweed population assessment. There are also several other AIS that have been found in or near Delavan Lake. Water Pennywort was likely not sampled because it is generally not seen until late August and September. It is recommended that monitoring for AIS be continued. It is also recommended that public education concerning AIS and AIS monitoring be continued. It is also recommended that DLSD staff continue to work with volunteers who wish to assist with AIS monitoring. In addition, it is recommended that the Town of Delavan work with the Delavan Community Park to continue the Clean Boats, Clean Waters watercraft inspection program to education boaters and anglers about the steps that are required by law to prevent the spread of AIS.

[20] Aron & Associates, 2008, Delavan Lake Aquatic Plant Survey

Mechanical harvesting provides several benefits for the lake. Harvesting opens boating and fish swimming channels and removes biomass and nutrients from the lake. Delavan Lake has an extensive and successful harvesting program. It is recommended that the Delavan Lake Sanitary District continue to use mechanical harvesting to control nuisance aquatic plants in areas of the lake where conditions (water depth and sediments) are conducive. In areas where mechanical harvesting can not be used safely or effectively it is recommended that manual harvesting and herbicide treatment be used to control nuisance aquatic plants. It is recommended that the Delavan Lake Sanitary District obtain a dedicated aquatic plant harvester for use in the Aquatic Plant Management Area 12 (Outlet – North Shore Drive to Dam).

Manual harvesting is recommended around piers and docks by riparian owners to control non-native nuisance plants. Many riparian owners do not need a permit to control nuisance aquatic plants in a 30 foot wide (including pier) area perpendicular from their shoreline. Those riparian owners with lake frontage in designated sensitive areas will require a permit from the Wisconsin DNR before they can conduct any aquatic plant management including plant removal. Harvested material could be left on piers and picked up by the Delavan Lake Sanitary District pier pick-up program.

Chemical treatment of non-native nuisance aquatic plants is recommended for areas that are too shallow for mechanical harvesting. Chemical treatment should be limited to controlling nuisance growths of AIS, especially Eurasian water milfoil, Curly leaf pondweed and Water pennywort. Chemicals that offer some selectivity such as 2,4-D and Endothall should be considered for control of Eurasian water milfoil and Curly leaf pondweed. Early spring and late fall applications may provide good control while protecting native species. Chemical treatment may also be considered for any newly discovered AIS.

Algicides may be considered in order to provide control of filamentous algae when there is a severe navigational obstruction. For example, when boating through filamentous algae causes the boat motor prop to become filled. The 2015 aquatic plant survey showed that Chara populations (Map 13) were healthy in the View Crest area, the Outlet and along portions of the frontage of Lake Lawn Resort. Chara is an important species that provides shelter and habitat for many species of fish and aquatic invertebrates. The local fisheries biologist recommends that algicide be limited to protect Chara populations.

Blue green algae should not be treated with an algicide as toxins could result. It is recommended that watershed best management practices which are discussed in the Delavan Lake Watershed Implementation Plan[21] be implemented to reduce nutrients and improve the water quality of Delavan Lake. It is also recommended that public education concerning watershed and water quality best management practices be conducted by the Delavan Lake Sanitary District and Town of Delavan and The Delavan Lake Improvement Association.

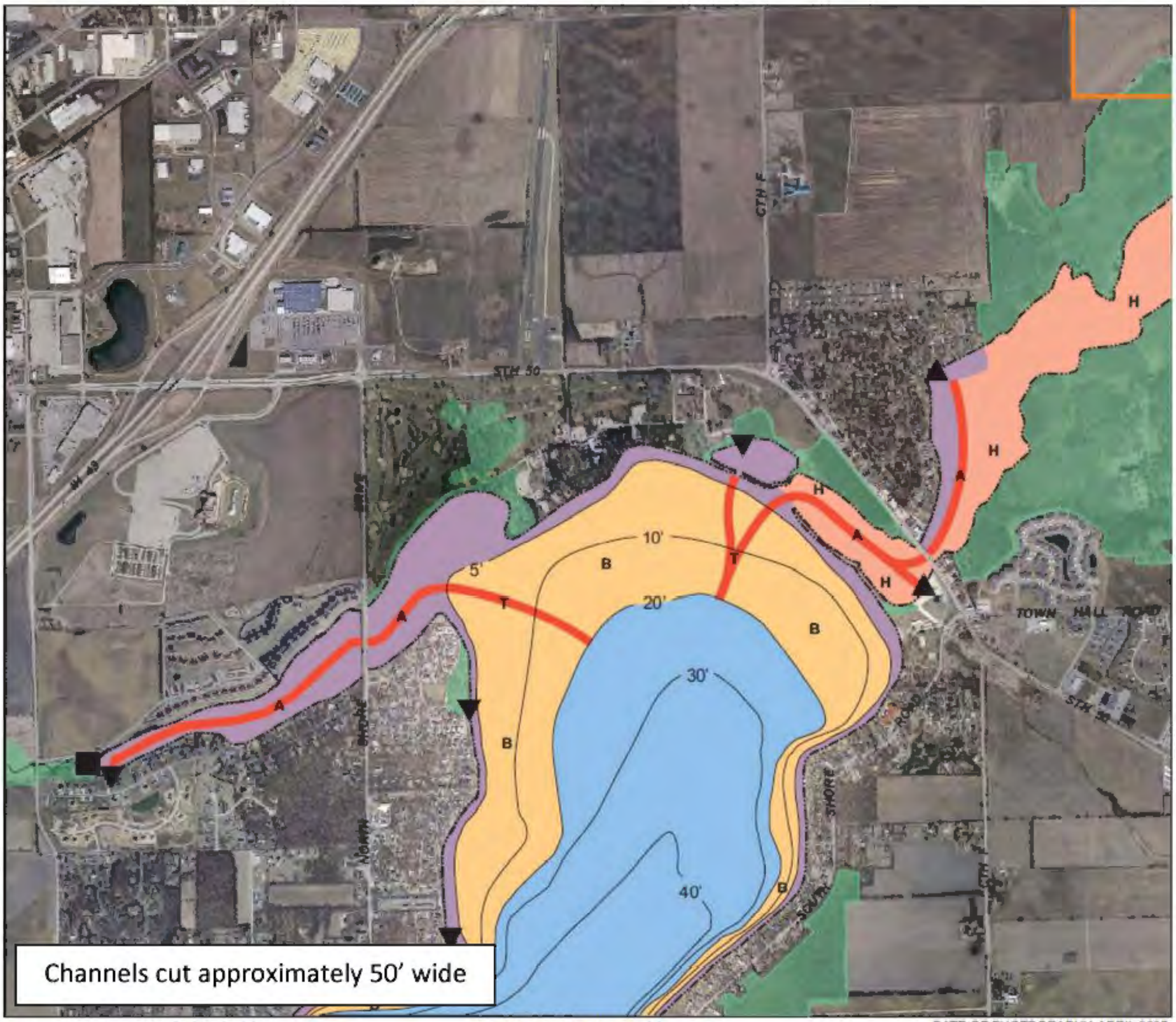
[21] Berrinin & Associates, LLC and Northwater Consulting, 2016, Delavan Lake Watershed Implementation Plan, Final Report

Table 15.	Aquatic Plant Management Options for Delavan Lake 2017 - 2021
1.	**Mechanical Harvesting** • Use mechanical harvesting to control nuisance aquatic plants in areas of the lake where conditions (water depth and sediments) are conducive to mechanical harvesting • Mechanical harvesting should not "clear-cut" but should remove nuisance species to maintain or improve boating access lanes, cut fish swimming channels, promote public safety • Mechanical harvesting should be used to "top" the first 3ft of Eurasian water milfoil in Viewcrest Bay and Highlands Bay (Maps 13 & 14) to give native plant species greater sun penetration • It is recommended that in order to minimize the loss of newly spawned fish, aquatic plant harvesting prior to June 15 of each year should be limited to cutting access channels only in those areas necessary to facilitate boating to piers and channels • Harvested material will be removed from the lake and transported to one of the accepted disposal sites (Map 16) • Channels are cut through some sensitive areas to allow for boat navigability. These channels have a width of 50 feet.
2.	**Chemical Treatment** • Chemical treatment to be limited to treatment of nuisance plants such as Eurasian water milfoil, Curly leaf pondweed, Water pennywort and other AIS • Chemicals with some selectivity for the nuisance species such as 2,4-D and Endothall should be considered • Chemical treatment is recommended for areas that are too shallow for mechanical harvesting • In order to protect the existing native species it is recommended that the DNR Aquatic Plant Management Coordinator be consulted when choosing chemical options and timing • Algicides may be considered in order to provide control of filamentous algae when there is a severe navigational obstruction
3.	**AIS Prevention Recommendations** • It is recommended that the Delavan Lake Sanitary District staff continue to monitor for water quality and aquatic invasive species in Delavan Lake and along the lake shore • It is recommended that the Delavan Lake Sanitary District work with the Town of Delavan to continue to implement a Clean Boats, Clean Waters program so that watercraft inspectors can educate boaters that visit the Community Park boat launch

Table 15. Aquatic Plant Management Options for Delavan Lake 2017 – 2021 con't	
3. con't.	• It is recommended that the Delavan Lake Sanitary District continue to work with the Delavan Lake Improvement Association to recruit and train volunteers to implement AIS and Native Aquatic Plant and water quality monitoring on their lake
4.	**Watershed Best Management Practices to Manage Aquatic Plant and Algae Growth** • It is recommended that watershed best management practices which are discussed in the Delavan Lake Watershed Implementation Plan be implemented to reduce nutrients in the lake in order to reduce nuisance levels of filamentous algae and blue-green algae • It is recommended that the Delavan Lake Sanitary District and Town of Delavan educate property owners about watershed and lake water quality best management practices to reduce nutrient flow into the lake
5.	**Lake Best Management Practice Education** • It is recommended that the Delavan Lake Sanitary District work with the Town of Delavan, the Delavan Lake Improvement Association and the Walworth County Lake Association to conduct lake best management practice education including pontoon classroom days, lake festivals and lake days to help educate adults and children • It is recommended that the Delavan Lake Sanitary District work with the Town of Delavan and the Delavan Lake Improvement Association to engage local, County and State policy makers to help protect and improve Delavan Lake and all Wisconsin lakes
5.	**Apply for Grants** • It is recommended that the Delavan Lake Sanitary District continue to monitor and survey the aquatic plant community of the lake a minimum of every 3 - 5 years • It is recommended that the Delavan Lake Sanitary District consider applying for a WI DNR Lake Management Planning Grant to help fund a 2020 Point Intercept Aquatic Plant Survey (67% cost-share). See http://www.dnr.wi.gov for grant application information

Map 14

DETAIL OF RECOMMENDED AQUATIC PLANT MANAGEMENT PLAN FOR THE NORTHERN PORTION OF DELAVAN LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

- —20'— WATER DEPTH CONTOUR IN FEET
- ■ WATER LEVEL CONTROL STRUCTURE
- ▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA
- ▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

- A — ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE
- T — TRANSIT LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE
- B — BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE PRIORITY
- H — HABITAT: ECOLOGICALLY-VALUABLE AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON
- LITTORAL ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY, INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS
- OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

LAND USE MANAGEMENT

- PROTECT ENVIRONMENTAL CORRIDOR LANDS
- OBSERVE GUIDELINES SET FORTH IN THE REGIONAL LAND USE PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS
- BOUNDARY OF SANITARY SEWER SERVICE AREA: WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT - PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

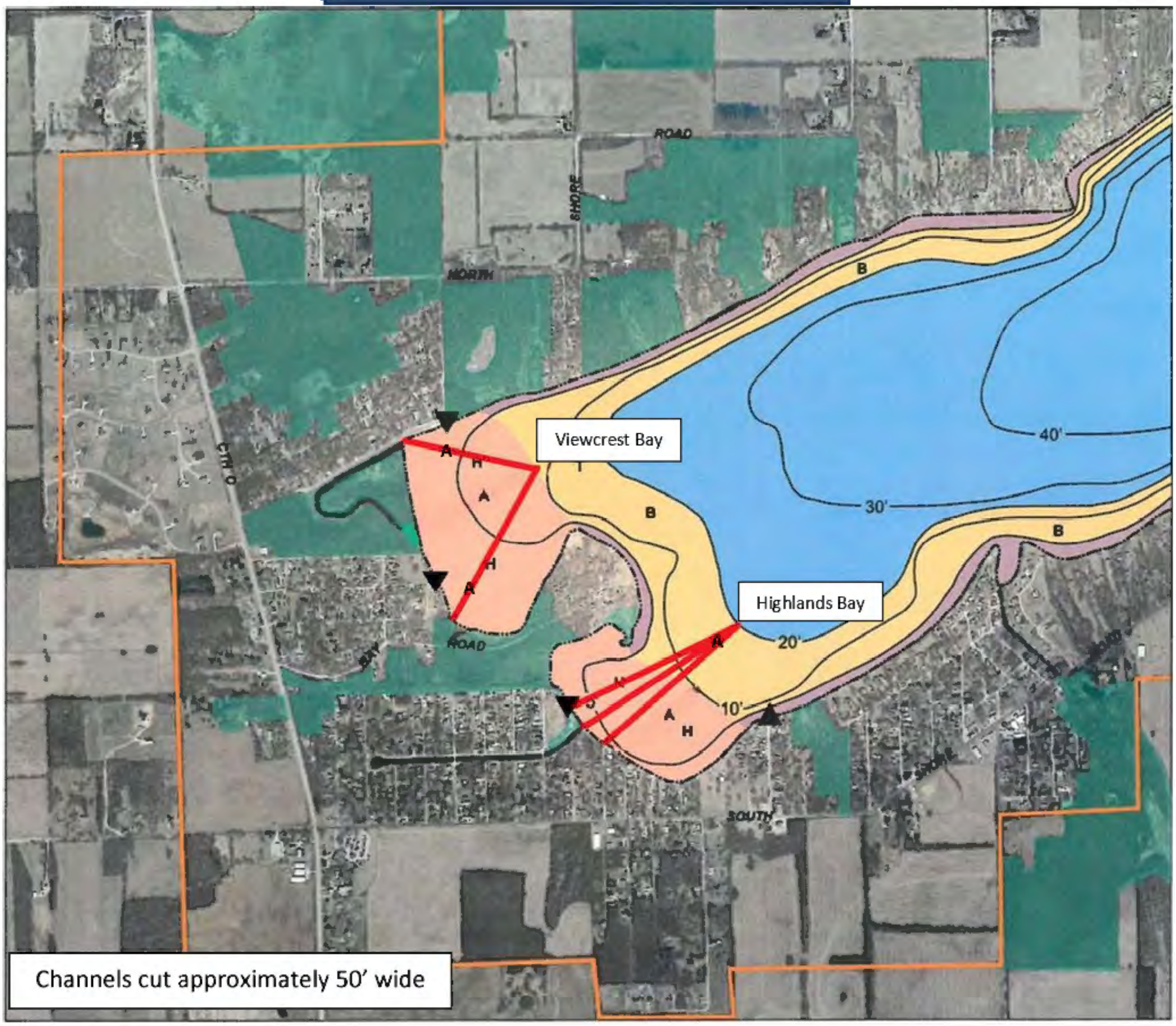
- CONTINUE PUBLIC AWARENESS PROGRAM

GRAPHIC SCALE

0 1000 2000 FEET

Source: SEWRPC.

Map 15



—20'— WATER DEPTH CONTOUR IN FEET

■ WATER LEVEL CONTROL STRUCTURE

▲ PUBLIC ACCESS SITE AND HARVESTER OFF-LOAD AREA

▼ PRIVATE ACCESS SITE

AQUATIC PLANT MANAGEMENT

A ACCESS: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

T TRANSIT LANES: HARVEST RECREATIONAL BOATING ACCESS CHANNELS APPROXIMATELY 50 FEET WIDE

B BOATING / RECREATION: SURFACE CUT OF EURASIAN WATER MILFOIL, HARVESTING MODERATE PRIORITY

H HABITAT: ECOLOGICALLY-VALUABLE AREAS - NO AQUATIC PLANT MANAGEMENT MEASURES RECOMMENDED DURING FISH BREEDING SEASON

LITTORAL ZONE: MAINTAIN SHORELINE PROTECTION STRUCTURES AS NECESSARY, INSTALL VEGETATIVE BUFFERS, MANUALLY HARVEST AQUATIC PLANTS AROUND PIERS AND DOCKS

OPEN WATER: DEPTH GREATER THAN 20 FEET - NO AQUATIC MANAGEMENT MEASURES RECOMMENDED

Source: SEWRPC.

LAND USE MANAGEMENT

PROTECT ENVIRONMENTAL CORRIDOR LANDS

- OBSERVE GUIDELINES SET FORTH IN THE REGIONAL LAND USE PLAN, MAINTAIN HISTORIC LAKEFRONT RESIDENTIAL DWELLING DENSITIES
- PROMOTE GOOD HOUSEKEEPING PRACTICES IN URBAN AREAS

BOUNDARY OF SANITARY SEWER SERVICE AREA: WALWORTH COUNTY METROPOLITAN SEWERAGE DISTRICT - PROVIDE PUBLIC SANITARY SEWERAGE SERVICES, REFINE AS NECESSARY

WATER QUALITY MANAGEMENT

- CONTINUE PARTICIPATION IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES SELF-HELP MONITORING PROGRAM

FISHERIES MANAGEMENT

- CONTINUE TO MONITOR FISH POPULATIONS, MODIFY STOCKING/ HARVESTING PROGRAM AND REGULATIONS, AS NECESSARY

PUBLIC INFORMATION AND EDUCATION

- CONTINUE PUBLIC AWARENESS PROGRAM

DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE

0 750 1500 FEET

Map 16
Mechanical Harvesting Disposal Sites 2017 - 2021

Table 16. Mechanical Harvesting Disposal Sites 2017 - 2021

Disposal Site #	Parcel Number	Legal Description	Owner
1	J G 2000001	W1/2 NE1/4 NE1/4 & S1/2 of NE1/4, EXC. 66' ALG E LN SD PAR. & NW ½ SE ¼, SEC 20 T2N R17E 138A	Charles G. Palmer & Connie Palmer
2	E W 600007	N1/2 SE ¼ SEC 6 T1N R16E. EXC HWY Land. EXC CSM 1968. 74.89 A. M/L	CST Holding LLC
3	E W 2400004	W1/2 W1/2 NW1/4 & .6A IN SW COR E 1/2 W 1/2NW ¼ BEING 2.88 ¼ CHS E & W BY 3.31 CHS N & S Sec 24 T1N R16E. 40.6A.	William J Henry Trust

APPENDIX A –
2015 POINT-INTERCEPT AQUATIC PLANT SURVEY WORKBOOK RESULTS

	STATS	Total vegetation	*Myriophyllum spicatum* ,Eurasian water milfoil	*crispus* ,Curly-leaf pondweed	Ceratophyllum demersum, Coontail	Chara sp., Muskgrasses	Elodea canadensis, Common waterweed	Heteranthera dubia, Water star-grass	Lemna minor, Small duckweed	Lemna trisulca, Forked duckweed	Myriophyllum sibiricum, Northern water-milfoil	Nymphaea odorata, White water lily	Potamogeton friesii, Fries' pondweed	Potamogeton illinoensis, Illinois pondweed	Potamogeton natans, Floating-leaf pondweed	Potamogeton nodosus, Long-leaf pondweed	Potamogeton pusillus, Small pondweed	Potamogeton zosteriformis, Flat-stem pondweed	Stuckenia pectinata, Sago pondweed	Vallisneria americana, Wild celery	Wolffia columbiana, Common watermeal
Lake	Delavan Lake																				
County	Walworth																				
WBIC	793600																				
Survey Date	7/22 - 7/29																				
	INDIVIDUAL SPECIES STATS:																				
	Frequency of occurrence within vegetated areas (%)		74.27	5.66	61.86	11.86	17.70	13.32	7.85	45.80	0.91	1.09	1.46	0.18		1.28	4.56	0.36	24.45	16.06	7.48
	Frequency of occurrence at sites shallower than maximum depth of plants		65.33	4.98	54.41	10.43	15.57	11.72	6.90	40.29	0.80	0.96	1.28	0.16		1.12	4.01	0.32	21.51	14.13	6.58
	Relative Frequency (%)		25.1	1.9	20.9	4.0	6.0	4.5	2.6	15.5	0.3	0.4	0.5	0.1		0.4	1.5	0.1	8.3	5.4	2.5
	Relative Frequency (squared)	0.15	0.06	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.01	0.00	0.00
	Number of sites where species found		407	31	339	65	97	73	43	251	5	6	8	1		7	25	2	134	88	41
	Average Rake Fullness	1.83	1.39	1.00	1.32	1.35	1.19	1.03	1.02	1.02	1.00	1.50	1.00	1.00		1.00	1.00	1.00	1.11	1.20	1.02
	#visual sightings		18	9	8	1	5	13	34	21		39	1	2	1	9	3		34	24	108
	present (visual or collected)		present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present	present
	SUMMARY STATS:																				
	Total number of sites visited	866																			
	Total number of sites with vegetation	548																			
	Total number of sites shallower than maximum depth of plants	623																			
	Frequency of occurrence at sites shallower than maximum depth of plants	87.96																			
	Simpson Diversity Index	0.85																			
	Maximum depth of plants (ft)**	20.20																			
	Number of sites sampled using rake on Rope (R)	110																			
	Number of sites sampled using rake on Pole (P)	558																			
	Average number of all species per site (shallower than max depth)	2.61																			
	Average number of all species per site (veg. sites only)	2.96																			
	Average number of native species per site (shallower than max depth)	1.90																			
	Average number of native species per site (veg. sites only)	2.31																			
	Species Richness	18																			
	Species Richness (including visuals)	19																			
	****SEE "MAX DEPTH GRAPH" WORKSHEET TO CONFIRM**																				

APPENDIX B – AIS PREVENTION CONTINGENCY PLAN:

AIS Prevention Contingency Plan:

Educating residents and visitors is an essential AIS prevention measure. Most often, new AIS are introduced by people, so it makes sense to educate the people that will be using the water body to make sure they are aware of their role in prevention. DNR signs that explain the AIS prevention steps should be placed in a visible location. AIS education is necessary for all residents however, because AIS are not moved by boaters and anglers alone. Gardeners, especially water gardeners, pond owners and aquarium enthusiasts, are also potential AIS transporters. Walworth County, like many Wisconsin counties have an AIS Coordinator that is available to provide education and for residents free of charge. For more information about invasive species visit the DNR website http://dnr.wi.gov/.

Lake Monitoring For Early Detection & Rapid Response

Unfortunately, every lake, stream, pond and creek has some level of susceptibility to aquatic invasive species. Putting an early detection and rapid response contingency plan in place is another way to protect your lake.

One part of an AIS contingency plan should be to create and build an emergency fund that can be used for a rapid response project in the event that a pioneer AIS is found in your lake. There are grants available from the DNR to help pay for a rapid response project but these grants only pay 75% cost-share up to a maximum of $20,000 and rapid response projects can be expensive. This means that additional funds will be needed. Being prepared by investing in an emergency fund will help.

Scheduled monitoring of the lake for AIS is a critical part of an early detection and rapid response for AIS. Rather than asking one person to take on this large task, it is an excellent idea to form a volunteer monitoring team with several resident volunteers. Volunteers need not be lake experts or have any experience at all. The Wisconsin Lakes Partnership sponsors a great program called the Citizen Lake Monitoring Network (CLMN) that provides training and equipment to assist lake volunteers to monitor their lakes for AIS and water quality parameters such as water clarity, temperature, dissolved oxygen and native plants. To find dates and locations for scheduled training workshops, contact Citizen Lake Monitoring Network Education Specialist, Paul Skawinski at (715) 346-4853, email him at paulskawwinski@uwsp.edu, or go to The Wisconsin Department of Natural Resources site at http://dnr.wi.gov/lakes/CLMN/. Volunteers do need to be willing and able to contribute some time to be trained and to spend a few hours a month on the lake doing the actual monitoring work. Monitoring teams can split up areas of the lake and even which species to monitor for. It is recommended that a team leader and possibly an assistant team leader be recruited. Team leaders would be responsible for keeping track of what, where and when volunteers are monitoring. Team leaders would also be the person responsible for delivering any suspicious samples (possible AIS) to the DNR AIS contact person.

With routine monitoring for AIS, it is very possible that a volunteer monitor could find a suspect plant or animal. Each volunteer monitor should have contact numbers for the team leader and assistant team leader. They should have attended a CLMN training workshop to learn the correct monitoring protocols. This training will also teach the following steps for volunteers to take should they encounter an unknown species that they suspect may be a new AIS.

If a possible AIS is encountered it is very important to get a sample to the DNR Regional CLMN Coordinator for positive identification.

A. Take a photo of the specimen where it was found (if possible)

B. Collect intact samples
   a. For plants: try to get (5 -10) samples. Include the root system, leaves, flowers, and seed heads when possible. Place in a ziplock bag with NO water. Place on ice until sample can be refrigerated
   b. For animals: Take up to (5) samples. Place samples in a jar with water. Place on ice until sample can be refrigerated. Transfer to a jar filled with rubbing alcohol.

C. Document location on the lake where samples were taken

D. Fill out Aquatic Invasive Incident Report form which will be included in the CLMN monitoring manual and can be downloaded from http://dnr.wi.gov/topic/Invasives/

E. Immediately contact the Team Leader and deliver samples.

F. The Team Leader will immediately contact the DNR Regional CLMN Coordinator (http://www4.uwsp.edu/cnr/uwexlakes/clmn/CLMN-Statewide-contacts.pdf) and deliver specimens with report and photo within no more than 4 days.

The DNR CLMN coordinator will contact and deliver the samples to the correct State expert who will provide positive identification. For example, a suspect plant would be sent to the Freckmann Herbarium for identification. As soon as positive identification is made, the DNR CLMN Coordinator will let the team leader know. If the suspect species is positively identified to be an AIS, the DNR CLMN Coordinator will work with the lake group leaders, or other responsible parties to begin steps for a rapid response. The DNR has existing rapid response protocol for some AIS that have previously been found in Wisconsin waters. Where no rapid response protocol exists, the DNR CLMN Coordinator will work to find the best possible method of eradication or control if eradication is deemed unfeasible.

If a new AIS is found in the lake alerting lake residents and lake users will increase the chances of finding additional populations. A handout can be created that gives information to residents about the new AIS, including photos, where the species is known to be located and what is known about the impacts caused by the species. Ask your residents to keep an eye out and report any other sightings so that each population can be addressed. Another sign should be placed at the boat launch so that visiting boaters are aware they need to take extra precautions so they do not carry the AIS to another lake. DNR staff are often able to assist with the creation of handouts and signs.