Aquatic Plant Management Plan Update

Camp and Center Lakes

2/7/2017
Lake and Pond Solutions Co.
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INTRODUCTION

This Aquatic Plant Management (APM) Plan update is presented as an addendum to the previous APM Plan for Camp and Center Lakes from April of 2012. **Its purpose is to report the inventory findings of the aquatic plant communities present, their relative densities and species composition from the summer of 2016.** A review of the past and present aquatic plant community information will be used to formulate an aquatic plant management plan to provide a variety of lake uses, while protecting significant aquatic resources. **This plan outlines a strategy to implement an aquatic harvesting and herbicide management program that will provide for recreational lake uses through nuisance and exotic species control. High quality plant communities which help promote water quality and provide fish and wildlife habitat should be protected from unnecessary negative impacts.**

WATER QUALITY

The Camp and Center Lake Rehabilitation District (CCLRD) contracted with Lake and Pond Solutions Co. to collect turnover samples on each lake starting in 2007. Analyses examined 16 different components of water chemistry including pH, conductivity, alkalinity, total hardness, calcium hardness, reactive phosphorus, total phosphorus, ammonia, nitrite+nitrate, total Kjeldahl nitrogen (TKN), chloride, sulfate, sodium, potassium, turbidity, and color (Figure 1 and Figure 2). Samples were collected at a 1' depth over the deepest portion of each lake during spring and fall turnovers.

Figure 1: Camp Lake Water Quality (2007 - 2016)

CAMP LAKE WATER QUALITY DATABASE																
Sample Date	pH	Cond (uS/cm)	Alk	T Hard	Ca Hard	React P	Total P	NH3 (N)	NO2 + NO3 (N)	TKN	CL	SO4	Na	K	Turb (NTU)	Color
10/15/2007	8.35	561	176	233	99	0.025	0.027	0.08	0.20	1.02	64.7	36.76	29.8	2.6	3.9	26
5/15/2008	8.11	590	200	252	127	0.024	0.052	0.02	0.70	0.99	54.0	30.43	25.7	2.8	6.0	28
10/22/2008	8.52	500	164	201	84	n/a	0.027	0.02	<0.01	0.90	52.5	23.43	25.3	2.8	5.5	36
4/6/2009	8.22	580	184	216	121	n/a	0.028	<0.01	0.58	0.88	51.2	25.10	25.6	2.8	4.2	25.3
10/15/2009	8.41	437	164	180	82	0.031	0.033	0.03	<0.01	0.95	45.9	17.39	23.5	3.2	3.3	21.8
4/13/2010	8.16	492	204	236	126	0.017	0.026	<0.01	0.10	0.77	47.3	20.60	21.7	3.0	3.6	21
10/19/2010	8.11	505	176	208	91	0.018	0.040	0.08	0.10	1.71	50.9	15.2	24.2	3.6	4.9	20.4
4/14/2011	8.26	545	200	232	119	0.009	0.029	0.06	1.54	0.97	50.1	23.3	26.0	3.2	x	7.8
10/19/2011	8.53	452	160	180.4	72	0.025	0.046	0.09	<0.1	1.21	56.5	16.4	26.0	1.8	5.4	23.6
3/28/2012	8.17	620	190	240	120	<0.019	0.038	0.2	0.048	0.83	57	20.0	29.0	2.2	4.4	30
10/11/2012	8.63	560	140	220	74	<0.010	<0.010	0.12	<0.052	0.77	78	20.0	39.0	1.7	3.3	20
4/22/2013	7.84	563	160	202	107	<0.005	0.027	0.056	1.3	0.69	61	29.0	30.6	2.61	7.7	30
10/17/2013	8.24	560	180	209	88.1	<0.005	0.020	0.040	<0.090	0.85	74	21.0	35.3	2.48	1.3	30
4/25/2014	8.44	600	180	212	106	<0.005	0.016	<0.04	0.12	0.55	67	26.0	33.8	2.54	2.7	20
10/13/2014	8.58	582	160	206	83.4	0.023	0.023	<0.04	0.87	1.1	75	24.0	35.6	1.96	2.3	20
4/10/2015	8.21	639	190	217	99.6	<0.004	<0.006	<0.03	<0.07	0.87	80	25.0	34.6	2.11	1.0	15
10/19/2015	7.88	615	190	231	102	<0.004	0.018	<0.03	<0.07	0.56	73	21.0	37.1	2.41	3.1	30
3/29/2016	8.33	565	240	233	119	<0.004	<0.005	<0.03	0.22	0.74	60	23.0	28.7	2.10	2.5	20
10/14/2016	8.04	616	200	228	83.2	<0.004	<0.005	0.048	<0.045	0.98	72	19.0	32.9	2.35	2.1	20
AVG	**8.26**	**557**	**182**	**218**	**100**	**0.010**	**0.024**	**0.044**	**0.294**	**0.91**	**61.6**	**23.0**	**29.7**	**2.54**	**3.5**	**23.4**

Lake and Pond Solutions Co. (2016)

Figure 2: Center Lake Water Quality (2007 - 2016)

CENTER LAKE WATER QUALITY DATABASE															
Sample Date	pH	Cond (umhos)	Alk	T Hard	Ca Hard	React P	Total P	NH3 (N)	NO2 + NO3 (N)	TKN	Cl	SO4	Na	K	Turb (NTU)	Color
10/15/2007	8.00	566	196	245	121	0.021	0.035	0.30	0.30	1.34	51.8	34.67	24.9	3.7	3.4	36
5/15/2008	8.28	657	224	288	154	n/a	0.031	0.02	1.40	0.92	60.4	33.26	28.7	3.1	5.3	35
10/22/2008	8.00	583	205	238	117	0.038	0.042	0.25	<0.01	1.20	52.3	26.42	26.0	3.7	4.1	33
4/6/2009	8.12	654	208	252	146	0.032	0.045	<0.01	1.24	0.92	57.7	29.21	28.0	3.1	4.5	31.5
10/15/2009	8.00	504	208	216	122	0.037	0.049	0.51	<0.01	1.53	42.9	17.61	22.3	4.1	5.5	30.6
4/13/2010	8.31	586	240	287	160	0.018	0.039	<0.01	0.8	0.95	52.9	24.12	24.3	3.2	5.0	33
10/19/2010	7.90	570	212	240	123	0.028	0.048	0.26	0.02	1.39	49.8	17.9	24.0	3.3	4.0	25.5
4/14/2011	8.43	619	232	260	140	0.022	0.060	0.03	0.76	1.23	57.3	26.0	29.0	3.2	x	20.2
10/19/2011	8.01	577	208	234.5	112.5	0.037	0.057	0.56	<0.1	1.67	60.5	20.1	29.0	2.7	4.8	24.2
3/28/2012	8.22	680	210	270	130	<0.019	0.024	0.20	0.77	1.1	65	24	31.0	2.5	1.6	30
10/11/2012	8.18	590	160	240	89	<0.010	0.034	0.29	<0.052	0.9	75	23	37.0	2.5	3.3	20
4/22/2013	7.83	623	180	221	120	<0.005	0.029	0.07	1.9	0.44	70	39	35.0	2.91	8.4	40
10/17/2013	7.88	611	200	237	115	<0.005	0.018	0.14	0.22	0.75	67	30	35.5	2.95	2.6	30
4/25/2014	8.56	670	200	235	124	<0.005	0.025	<0.04	0.22	0.52	77	38	37.9	2.79	11	40
10/13/2014	8.24	672	200	250	120	<0.004	0.022	0.099	0.51	1.4	82	31	38.2	2.75	3.9	35
4/10/2015	8.18	743	230	266	132	<0.004	0.015	<0.03	0.18	1.1	84	33	39.0	2.78	1.9	30
10/19/2015	7.67	668	210	265	129	<0.004	0.028	<0.03	<0.07	0.73	73	23	36.4	3.19	9.3	30
3/29/2016	8.42	608	270	274	145	<0.004	0.009	<0.03	0.74	0.75	73	27	31.5	2.33	3.4	30
10/14/2016	8.19	680	230	257	102	<0.004	<0.005	0.16	<0.045	0.97	73	23	34.5	2.53	2.5	30
AVG	**8.13**	**624**	**212**	**251**	**126**	**0.013**	**0.032**	**0.15**	**0.46**	**1.04**	**64.5**	**27.4**	**31.2**	**3.02**	**4.4**	**30.7**

Lake and Pond Solutions Co. (2016)

pH

pH is an index of lake water's acid level. A pH of 7 is neutral, below 7 is acidic, and above is considered basic. Moderately low pH levels do not usually harm fish, but some metals can become soluble and released into lake water which may harm fish. Lakes dominated by a large amount of plants or algae can experience large fluctuations in pH levels from day to night. pH is measured logarithmically meaning a pH of 6 is ten times more acidic than a pH of 7 and one hundred times more acidic than a pH of 8. From 2007 - 2016, Camp Lake had an average pH of 8.26 while Center Lake was 8.13. Both values fall within typical ranges and there were no statistically significant changes in pH over this time.

Conductivity

Conductivity is a measure of water's ability to conduct electrical current. This number is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans. From 2007 - 2016, Camp Lake had an average conductivity of 557 umhos (2.56 times the hardness) while Center Lake was 624 umohs (2.49 times the hardness). There were no statistically significant changes in conductivity over this time.

Alkalinity and Hardness

A lake's alkalinity and hardness are affected by the type of minerals in the soil, watershed bedrock, and by how much the lake water comes into contact with it. Alkalinity is a measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity (0 – 199 ueq/l) is the main indicator of susceptibility to acid rain. Values from 200 – 499 ueq/l mean a low impact from acid rain. Increasing alkalinity is often related to increased algae productivity. From 2007 - 2016, Camp Lake had an average alkalinity of 182 ueq/l (moderate susceptibility) while Center Lake was 212 ueq/l (low susceptibility).

Total hardness is a measure of the mineral content, typically calcium and magnesium ions. Values over 180 ppm are considered to be "very hard". From 2007 – 2016, Camp Lake had an average total hardness of 218 ppm while Center Lake was 251 ppm. Very hard water is to be expected in the limestone dominated substrate of SE Wisconsin.

Calcium hardness measures the calcium ions in the water. A high value here (related to the total hardness) may indicate groundwater coming from calcite and dolomite. From 2007 – 2016, Camp Lake had an average calcium hardness of 100 ppm while Center Lake was 126 ppm. In this area, it is typical to see calcium hardness comprise about 50% of the total hardness.

Langelier Saturation Index

The Langelier Saturation Index (LSI) is a method of estimating the corrosive and scale-forming properties of water. It takes into account water temperature, pH, conductivity, alkalinity, and calcium hardness. When the LSI is lower than 0, the water causes corrosion of steel. When the LSI equals 0, the water is neutral and stable and causes no corrosion or scaling. When LSI is greater than 0, the water tends to cause scaling. If LSI is greater than 0.5, it can indicate a lake's potential to produce marl ($CaCO_3$) and possibly precipitate phosphorus, thereby controlling algal blooms. Camp and Center Lakes have identical yearly LSI values (Figure 3), and likely are not marl producing lakes.

Figure 3: Average LSI Values (2007 - 2016)

	Avg. Spring LSI	Avg. Fall LSI	Avg. Yearly LSI
CAMP LAKE	0.33	0.48	0.40
CENTER LAKE	0.50	0.33	0.41

Lake and Pond Solutions Co. (2016)

Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of weed and algae growth. The analysis of phosphorus has included soluble reactive phosphorus and total phosphorus. Fertilizers, animal wastes, and septic systems are the main sources of this nutrient. Reactive phosphorus is a measure of readily available phosphorus. This form is in a usable form for aquatic plants and especially algae. Ideally, reactive phosphorus concentrations during the spring should be 0.020 ppm for natural lakes and 0.030 ppm for impoundments to prevent nuisance algal blooms. From 2007 – 2016, Camp Lake had an average spring reactive phosphorus value of 0.006 ppm while Center Lake was 0.009 ppm (Figure 4). Based on the data, this should result in less algal growth during the summer. The increase in fall reactive phosphorus averages is most likely due to phosphorus recycling from the bottom sediments and aquatic plant mortality during fall turnover.

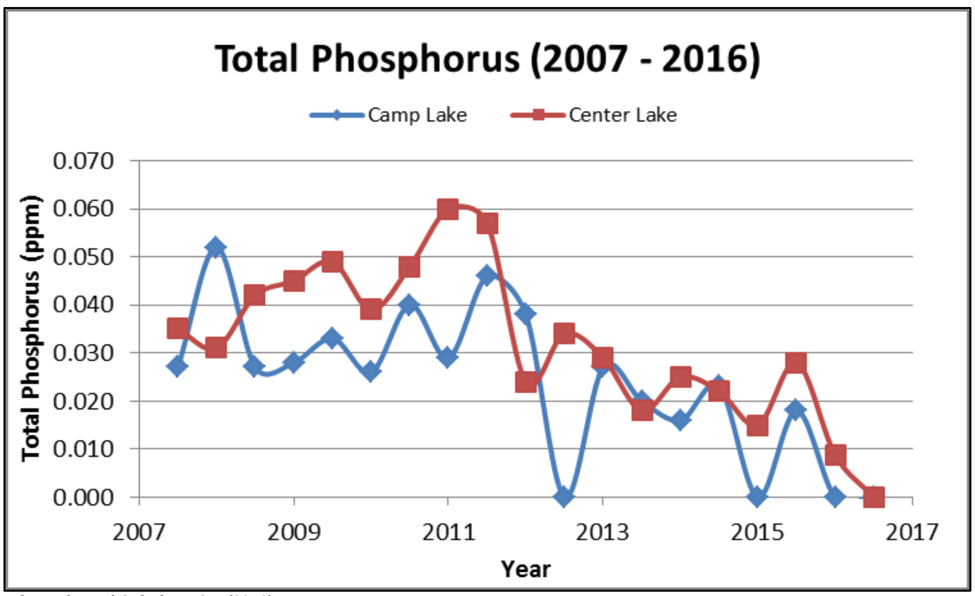
Figure 4: Average Reactive Phosphorus Concentrations (2007 - 2016)

	Avg. Spring RP (ppm)	Avg. Fall RP (ppm)	Avg. Yearly RP (ppm)
CAMP LAKE	0.006	0.014	0.010
CENTER LAKE	0.009	0.016	0.013

Lake and Pond Solutions Co. (2016)

Total phosphorus is usually considered more representative of a lake's nutrient level because it remains more stable than reactive phosphorus. Total phosphorus includes reactive phosphorus plus particulate phosphorus (what is being taken up in growth or contained in suspended sediments). Average concentrations are 0.025 ppm for natural lakes while impoundments may be around 0.065 ppm. From 2007 – 2016, Camp Lake had an average total phosphorus value of 0.024 ppm while Center Lake was 0.032 ppm, both falling within a normal range for many area lakes. Since 2012, average total phosphorus in both lakes has been on the decline (Figure 5). Total phosphorus values taken during the spring turnover can also be used to estimate a lake's trophic state (discussed further in this plan on Page 9). The Town of Salem passed a "No Phosphorus Fertilizer Ordinance" on June 12th, 2006 (Ordinance # 06-06-12B) to reduce phosphorus runoff.

Figure 5: Total Phosphorus Concentrations (2007 – 2016)



Lake and Pond Solutions Co. (2016)

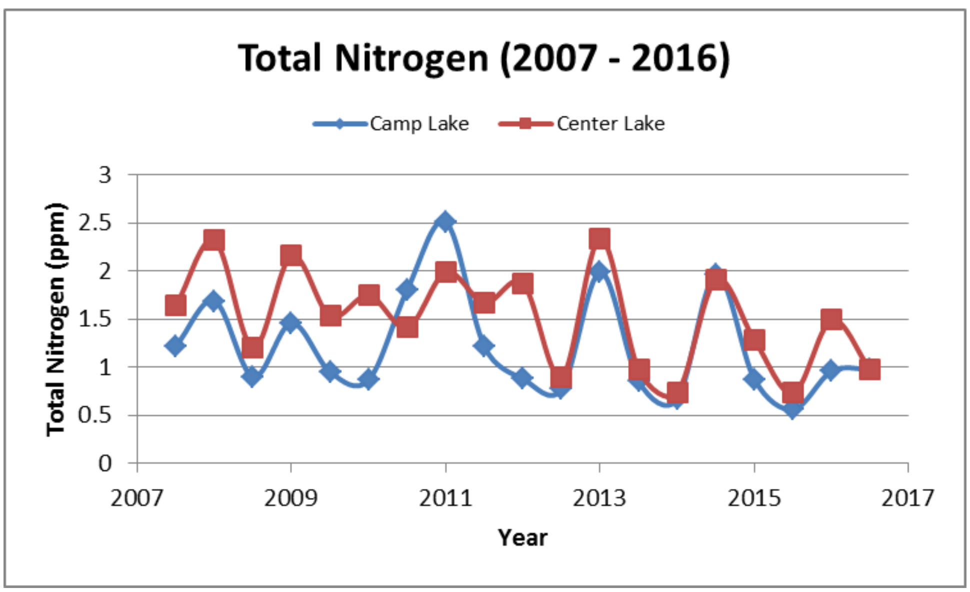
Nitrogen

Nitrogen is second only to phosphorus as an important nutrient for plant and algae growth. In most cases the amount of nitrogen in lake water corresponds to local land use. Sources of nitrogen include agricultural fertilizer, lawn fertilizer, animal wastes and human wastes. Analyses included ammonia (NH_3), nitrite (NO_2) plus nitrate (NO_3), and total Kjeldahl nitrogen (TKN). Ammonia (NH_3) is the first form of nitrogen released when organic material decays which then converts to ammonium. Ammonium is also a waste product of fish and aquatic invertebrates. The ammonium converts rapidly to nitrate if oxygen is present. From 2007 – 2016, Camp Lake had an average ammonium of 0.044 ppm while Center Lake was 0.15 ppm, both normal for SE Wisconsin lakes. The higher value for Center Lake may indicate that organic decay and lack of oxygen may be more prominent than Camp Lake.

Nitrite (NO2) plus nitrate (NO3) nitrogen are the forms important for plant and algae growth. High levels (> 10 ppm) are dangerous to infants and expectant mothers. Typically, if the sum of ammonium and nitrite plus nitrate exceeds 0.30 ppm in the spring, there is sufficient nitrogen to support summer algal blooms. From 2007 – 2016, Camp Lake had an average nitrite plus nitrate value of 0.29 ppm while Center Lake was 0.46 ppm. Both of these levels fall within normal parameters for SE Wisconsin lakes. There were no statistically significant changes over the sampling period.

TKN is a measure of the amount of ammonia (NH3), ammonium (NH4), and other organic nitrogen in the water. Typically the organic-N in TKN is the largest portion and found in proteins, amino acids, urea, living or dead organisms, decaying plant material, and organic based sediments like muck. When TKN is added to nitrite plus nitrate, the resulting value is the total nitrogen of a water body () which can be used to calculate nitrogen to phosphorus ratios. For our area, TKN values range between 0.7 and 1.7 ppm. Although the organic portion is usually not available for growth, plants and algae do convert other forms of nitrogen back to the organic form. Ultimately high TKN values can indicate potential growth impacts, runoff issues or organic sediment accumulation. From 2007 – 2016, Camp Lake had an average TKN of 0.91 ppm while Center Lake was 1.04 ppm, both typical values for SE Wisconsin lakes.

Figure 6: Total Nitrogen (2007 - 2016)



Lake and Pond Solutions Co. (2016)

N:P Ratio

In most of Wisconsin's lakes, phosphorus is the limiting factor affecting algae growth. Examining the nitrogen to phosphorus (N:P) ratio can highlight which is the limiting nutrient. If the N:P ratio is less than 10:1, nitrogen is the limiting nutrient. If values are between 10:1 and 15:1, the lake is considered transitional. Lakes with values greater than 15:1 are considered phosphorus limited, meaning algae growth is controlled by the amount of phosphorus cycled into the system. From 2007 – 2016, Camp Lake had an average N:P ratio of 45:1 while Center Lake was 55:1. Ultimately, small increases in phosphorus can have an impact on growth.

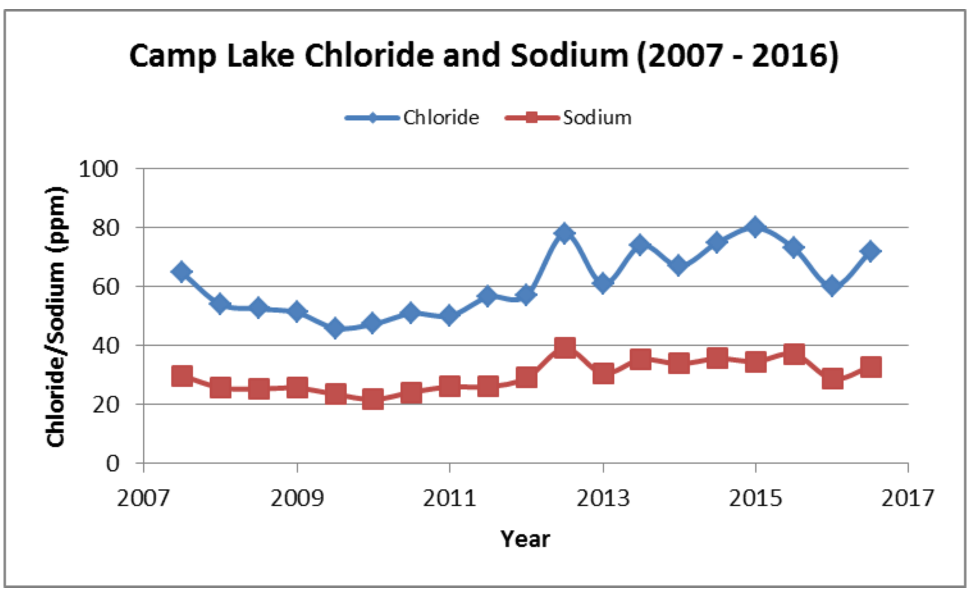
Chloride

The presence of chloride (Cl) where it does not occur naturally indicates possible water pollution, commonly from human activity. Septic systems, animal waste, and road salts are major chloride sources. Research shows at levels greater than 230 ppm, aquatic life may be impacted. Typically, an increase in chloride is found during the spring turnover due to runoff from roads that have been salted over the winter. From 2007 – 2016, Camp Lake had an average chloride of 61.6 ppm while Center Lake was 64.5 ppm. Normal levels range from 10 – 50 ppm though it is not uncommon to see 100 – 250 ppm in water bodies receiving large amounts of spring runoff. Over the past 10 years, chloride levels have been steadily increasing (Figure 7 and Figure 8).

Sodium

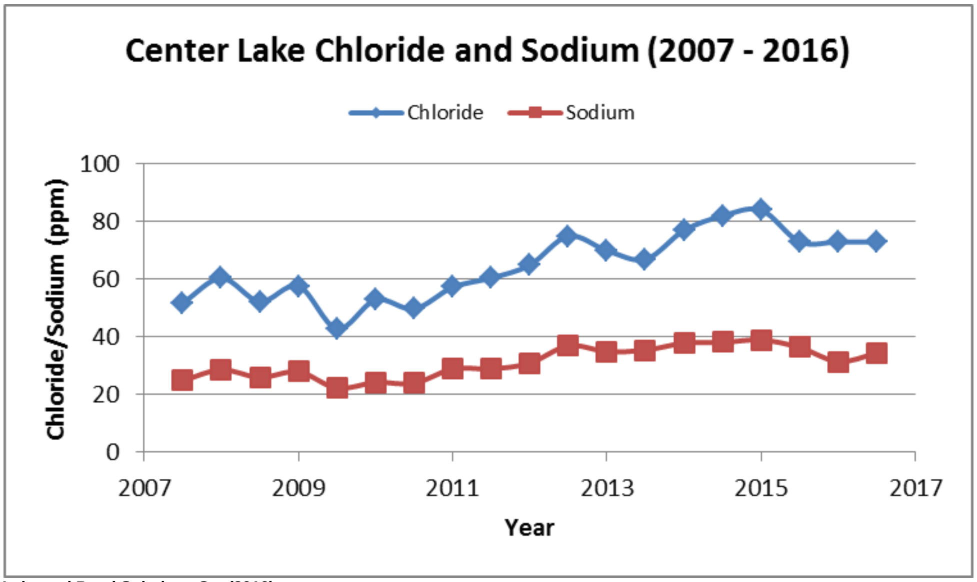
Natural levels of sodium (Na) in soil and water are very low so its presence may indicate pollution caused by human activities. Commonly found in road salt, fertilizers, and animal waste, increasing values over time can mean a long-term effect caused by pollution. Often, sodium when in conjunction with other factors can influence large algal blooms. From 2007 – 2016, Camp Lake had an average sodium concentration of 29.7 ppm while Center Lake was 31.2 ppm. Normal levels range from 5 – 40 ppm though it is not uncommon to see up to 150 ppm in water bodies receiving large amounts of spring runoff (usually correlates with chloride). Like chloride, sodium levels have been slowly increasing over time (Figure 7 and Figure 8).

Figure 7: Camp Lake Sodium and Chloride (2007 - 2016)



Lake and Pond Solutions Co. (2016)

Figure 8: Center Lake Sodium and Chloride (2007 - 2016)



Lake and Pond Solutions Co. (2016)

Sulfate

Sulfate (SO4) is the most common form of sulfur in natural waters. The amounts relate primarily to soil minerals in the watershed. Sulfate may also be an indicator of acid rain. In water depleted of oxygen, sulfate can be reduced to hydrogen sulfide which smells like rotten eggs and is toxic to aquatic organisms. Commonly, background concentrations in SE Wisconsin are 20 – 40 ppm. From 2007 – 2016, Camp Lake had an average sulfate value of 23.0 ppm while Center Lake was 27.4 ppm.

Potassium

Like sodium, natural levels of potassium (K) in soil and water are very low so its presence may indicate pollution caused by human activities. It is commonly found in fertilizer and abundant in animal waste. Increasing values over time can mean a long-term effect caused by pollution. High potassium levels have also been associated with large algae populations. From 2007 – 2016, Camp Lake had an average potassium value of 2.54 ppm while Center Lake was 3.02 ppm, both within normal ranges. There were no statistically significant changes over the sampling period.

Turbidity

Turbidity is one component to water clarity. It measures the materials suspended in the water such as algae and silt and ultimately affects the depth at which plants can grow. Suspended particulates are an indicator of overland flow (runoff) and disturbances within the water body itself (bottom-feeding fish, crayfish, muskrat activity…). From 2007 – 2016, Camp Lake had an average turbidity of 3.5 NTU while Center Lakes had an average turbidity of 4.4 NTU. This is a typical value as many area lakes may range from 2 – 10. There were no statistically significant changes over the sampling period.

Color

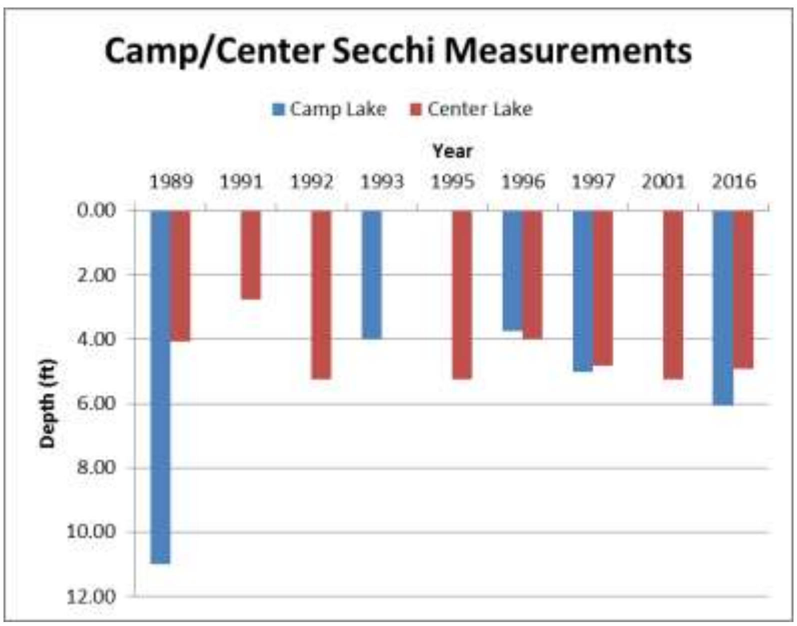
Color is the other component to water clarity. It measures the materials dissolved in the water. The main significance of this component is aesthetic. High color values may also reduce light penetration, ultimately affecting weed and algae growth. From 2007 – 2016, Camp Lake had an average color of 23.4 while Center Lake was 30.7. Typical values are 0 – 40 while higher color values may reach 40 – 100. There were no statistically significant changes over the sampling period.

Secchi Disk Readings

Clarity can also be measured with a Secchi disk, which is a black and white eight-inch disk that is lowered into the water until a depth is reached at which the disk is no longer visible. The depth is known as the Secchi disk reading.

The average yearly Secchi disk readings from 1989 – 2016 are illustrated in Figure 9. The length of the bar illustrates the depth that the Secchi disk was visible. The Secchi reading averages for both lakes fall into the "poor" water clarity zone in comparison to other Wisconsin lakes. There has, however, been an absence of Secchi data since 2001. It would be beneficial to take measurements again since management has been refined on the lakes. This can easily be accomplished through a volunteer taking a few minutes each week.

Figure 9: Average Secchi Measurements (1989 – 2016)



Lake and Pond Solutions Co. (2016)

Chlorophyll-*a*

Chlorophyll-*a* is a major photosynthetic pigment in algae. The amount of Chlorophyll-*a* present is an indicator of the biomass of live algae in the water. Concentrations are usually lowest in the winter and reach their peak in the summer, when algae populations reach their maximum. Average annual chlorophyll-*a* concentrations in Camp and Center Lakes from 1993 – 2016 are summarized in Figure 10. The concentrations indicate moderate levels of algae growth, which in part, explains the lower water clarity values discussed previously.

Figure 10: Average Chlorophyll *a* (1993 - 2016)

Year	Camp Lake Chlorophyll a	Center Lake Chlorophyll a
1993	10.7	45.9
1994	9.9	7.8
1995	16.4	24.7
1996	18.0	22.2
1997	7.4	9.4
1998	7.1	15.7
2000	6.6	n/a
2001	n/a	9.0
2016	7.6	9.5

Lake and Pond Solutions Co. / WDNR (2016)

Trophic State Index

The Carlson trophic state index (TSI) assigns a trophic condition rating based on Secchi disk, total phosphorus, and Chlorophyll-*a* which can be used to summarize the quality of a lake. The trophic state index was developed by Dr. Robert Carlson in 1977 to compare the three water quality values on a scale from 0 to 100. Values from 0 to 35 describe lakes defined as oligotrophic—lakes that are generally clear, deep, and free of rooted aquatic plants and algae blooms. Values above 50 define eutrophic lakes—lakes that are high in nutrients and tend to support large biomass of rooted aquatic plants and algae. Mesotrophic lakes, with values from 35 to 50, lie between oligotrophic and eutrophic lakes. Discretion is advised as the Carlson Trophic State Index was developed for use with lakes that have few rooted aquatic plants and little non-algae related turbidity (EPA, 2010).

There has been a tendency to average the three variables rather than to prioritize their use (Osgood, 1982; Kratzer and Brezonic, 1981). According to Carlson (1982), there is no logic in combining them since chlorophyll is a better predictor. Figure 11 shows the chlorophyll *a* TSI and related classification. Camp Lake is in a transitional phase between mesotrophic and eutrophic while Center Lake is classified as eutrophic.

Figure 11: Trophic Status Based On Chlorophyll a

	CAMP LAKE		CENTER LAKE	
YEAR	TSI (CHL)	CLASS	TSI (CHL)	CLASS
1993	54	Eutrophic	64	Eutrophic
1994	52	Eutrophic	52	Eutrophic
1996	57	Eutrophic	57	Eutrophic
1997	50	Mesotrophic	52	Eutrophic
1998	49	Mesotrophic	n/a	n/a
2000	n/a	n/a	n/a	n/a
2001	49	Mesotrophic	51	Eutrophic
2016	47	Mesotrophic	51	Eutrophic

Lake and Pond Solutions Co. / WDNR (2016)

RESULTS OF THE 2016 AQUATIC PLANT SURVEY

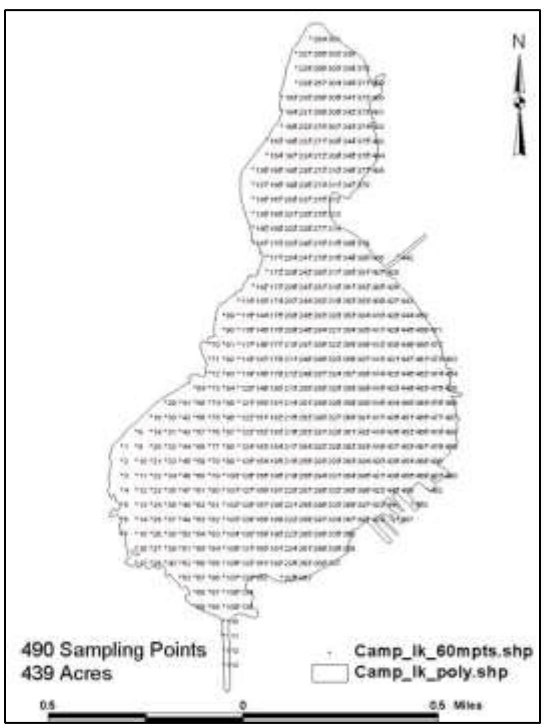
The 2016 aquatic plant survey was conducted using the guidelines adopted by the WDNR for point-intercept survey methods. This method utilizes a grid system that takes into account the size and morphology of the lake. The WDNR established points are transferred to a GPS unit before sampling. For the 2016 survey, Camp Lake had 490 points while Center Lake had 576 points.

At each established point, a plant sampling rake on a 10' graduated pole was lowered down. An underwater camera was used for sites with depths greater than 10'. Data collection included depth, substrate, species present, species specific densities, and visuals of species not collected. Ultimately, calculations can be performed to figure out a frequency of occurrence, average rake fullness, total sites with vegetation, Simpson diversity index, maximum depth of plants, average native species per site, and species richness.

Camp Lake

Plants were surveyed on August 4th, 5th, and 8th, 2016 using the 490 pre-determined WDNR points (Figure 12). Thirty-four different species of plants were found and they are outlined in Figure 13 from most to least frequent based on the number of sites they were found. The C-value for each species is also recorded. The C-value is the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unaltered from pre-settlement conditions. The C-value ranges from 0 – 10 with 10 being assigned to species most sensitive to disturbance.

Figure 12: Overview of 2016 Plant Sampling Points - Camp Lake



WDNR (2007)

 Lake and Pond Solutions Co. (2016)

Figure 13: 2016 Plant Sampling Species Summary - Camp Lake

Common Name	Scientific Name	Percent Frequency***	# of Sites (incl visuals)	Avg. Rake Fullness	C-value
Widgeon Grass	*Ruppia cirrhosa*	46.19	200	1.53	8
Eurasian Water Milfoil**	*Myriophyllum spicatum*	45.96	199	1.14	-
Muskgrass	*Chara spp.*	42.26	183	1.54	7
Bushy Pondweed	*Najas flexilis*	40.42	175	1.42	6
*Wild Celery**	*Vallisneria americana*	34.64	150	1.06	6
Variable Pondweed	*Potamogeton gramineus*	33.49	145	1.08	7
*Sago Pondweed**	*Stuckenia pectinata*	32.56	141	1.09	3
White Water Lily	*Nymphaea odorata*	27.94	121	1.12	6
*Illinois Pondweed**	*Potamogeton illinoensis*	24.25	105	1.07	6
Common Bladderwort	*Utricularia vulgaris*	16.86	73	1.06	7
Narrow-leaved Cattail	*Typha angustifolia*	15.01	65	n/a	1
Floating-leaf Pondweed	*Potamogeton natans*	13.63	59	1.05	5
Common Waterweed	*Elodea canadensis*	12.47	54	1.53	3
Coontail	*Ceratophyllum demersum*	11.09	48	1.28	3
Flat-stem Pondweed	*Potamogeton zosteriformis*	10.85	47	1.29	6
*Soft-stem Bulrush**	*Schoenoplectus tabernaemontani*	10.39	45	1.00	4
Purple Loosestrife**	*Lythrum salicaria*	10.16	44	n/a	-
Long-leaf Pondweed	*Potamogeton nodosus*	9.70	42	1.05	7
Spatterdock	*Nuphar variegate*	7.62	33	1.00	6
Common Watermeal	*Wolffia columbiana*	6.24	27	1.00	5
Hybrid Pondweed	*n/a*	5.31	23	1.44	-
Water Star-grass	*Heteranthera dubia*	4.85	21	1.25	6
*White-stem Pondweed**	*Potamogeton praelongis*	4.39	19	1.14	8
Small Duckweed	*Lemna minor*	2.54	11	1.00	5
Northern Water Milfoil	*Myriophyllum sibiricum*	2.54	11	1.00	6
Small Bladderwort	*Utricularia minor*	2.31	10	1.00	10
Pickerelweed	*Pontederia cordata*	1.15	5	n/a	9
Spiny Naiad	*Najas marina*	0.46	2	1.00	-
Forked Duckweed	*Lemna trisulca*	0.46	2	1.00	6
Common Reed**	*Phragmites australis*	0.46	2	n/a	-
Leafy Pondweed	*Potamogeton foliosus*	0.46	2	1.00	6
Curly-leaf Pondweed**	*Potamogeton crispus*	0.23	1	1.00	-
Filamentous Algae	*n/a*	0.23	1	1.00	-
Fries Pondweed	*Potamogeton friesii*	0.23	1	1.00	8
Common Arrowhead	*Sagittaria latifolia*	0.23	1	1.00	3

Lake and Pond Solutions Co. (2016)

* Italicized species are considered "high value" plant species under Wisconsin Administrative Code NR 107

** Bolded species are non-native (exotic) species

*** Percent frequency is shown as a percentage of occurrence within vegetated areas including visuals

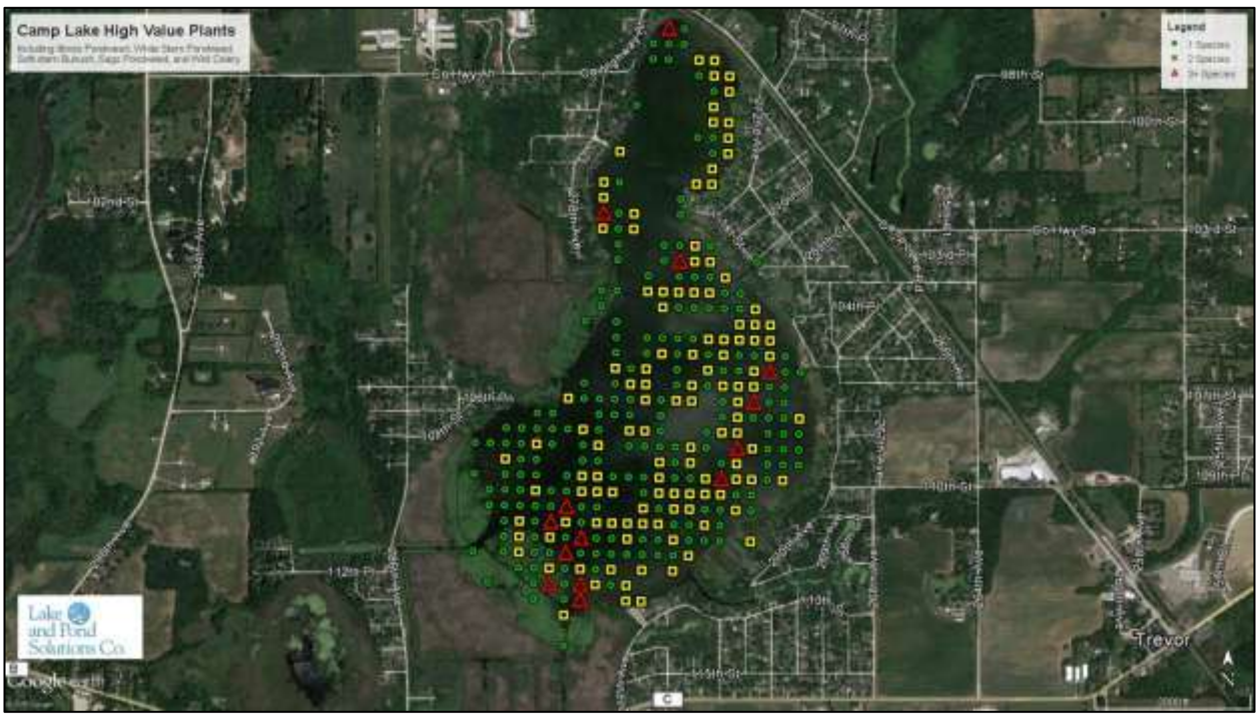
Figure 14: 2016 Plant Sampling Data Summary - Camp Lake

Total number of sites with vegetation	433 / 490 (88%)
Maximum depth of plants	10.5 feet
Species Richness (including visuals)	34
Average number of all species per site (vegetated sites only)	3.08
Average number of native species per site (vegetated sites only)	2.76

Lake and Pond Solutions Co. (2016)

Lake-wide, there was an average of 2.76 native species found per site (down slightly from 3.02 in 2011). Populations of non-native plants like Eurasian water-milfoil have remained, especially on the south end of the lake where treatment typically does not occur. There is, however, a good distribution of native plants throughout the lake including five species listed as “high value” by the WDNR. These include Illinois pondweed, white-stem pondweed, soft-stem bulrush, sago pondweed, and wild celery. Below, Figure 15 shows if a site contained one high value species (green), two high value species (yellow), or three or more high value species (red).

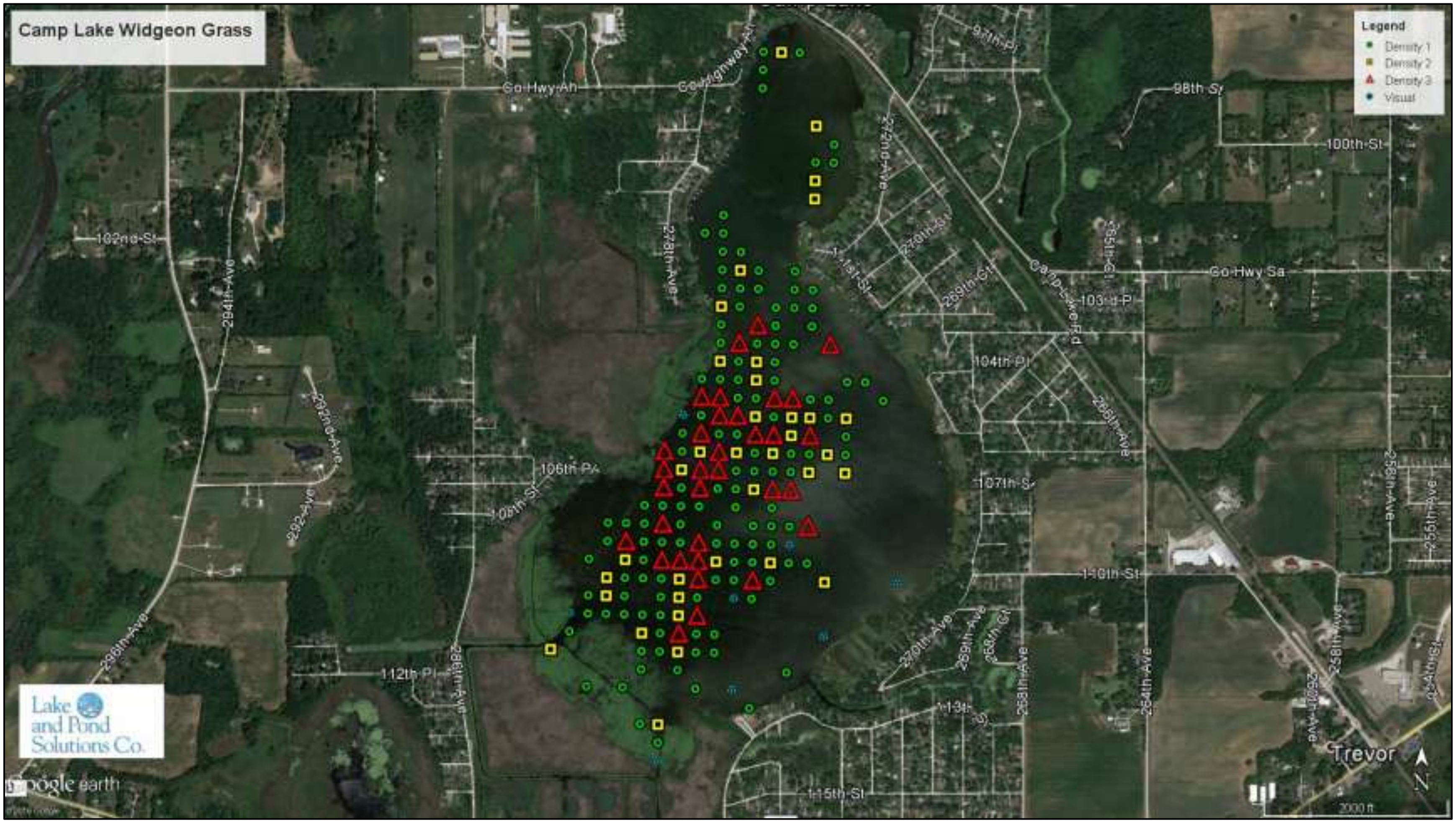
Figure 15: Camp Lake "High Value" Plants (2016)



Lake and Pond Solutions Co. (2016)

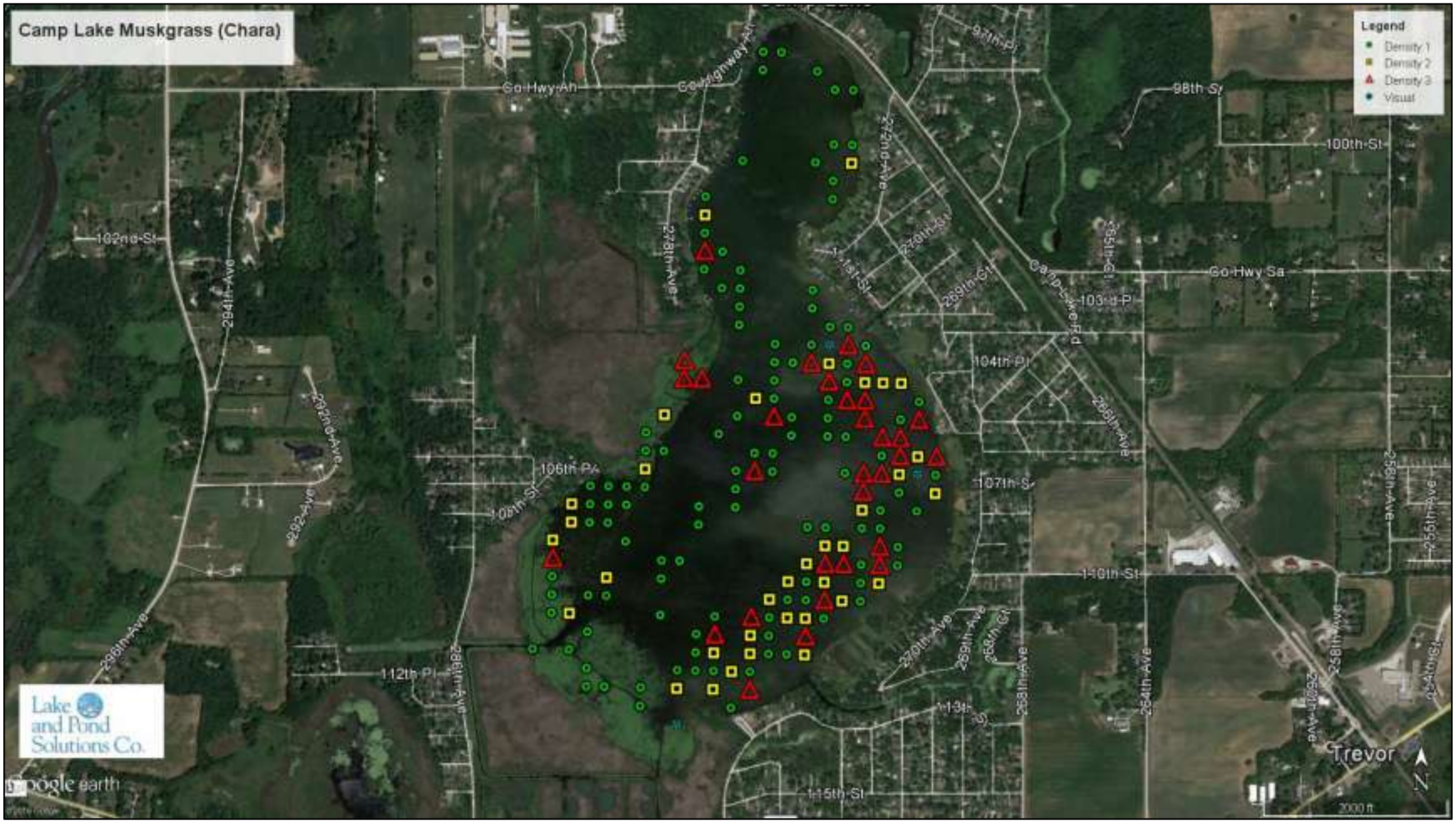
The five most common aquatic plant species (including visuals) within Camp Lake are widgeon grass (46.19%), Eurasian water-milfoil (45.96%), muskgrass (42.26%), bushy pondweed (40.42%), and wild celery (34.64%). Figure 16 through Figure 20 show locations of the top five most common native plants while Figure 21 and Figure 22 show locations of the non-native plants. Curly-leaf pondweed and Phragmites (non-native plants) were not depicted in a map since only one or two sites were found throughout the lake. Species from the 2016 survey are compared with previous surveys on Page 31 in Figure 35.

Figure 16: Camp Lake Widgeon Grass (2016)



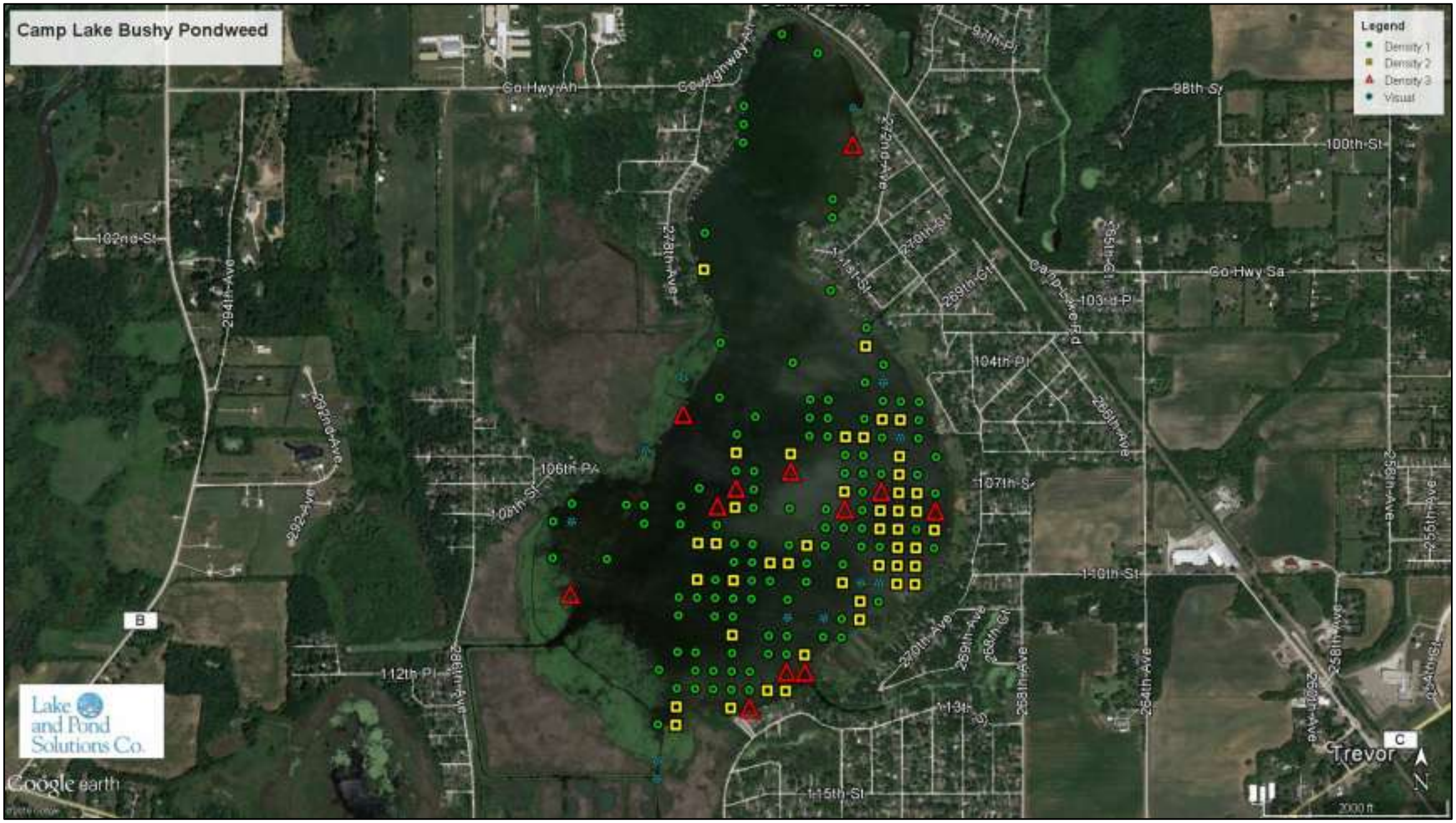
Lake and Pond Solutions Co. (2016)

Figure 17: Camp Lake Muskgrass (2016)



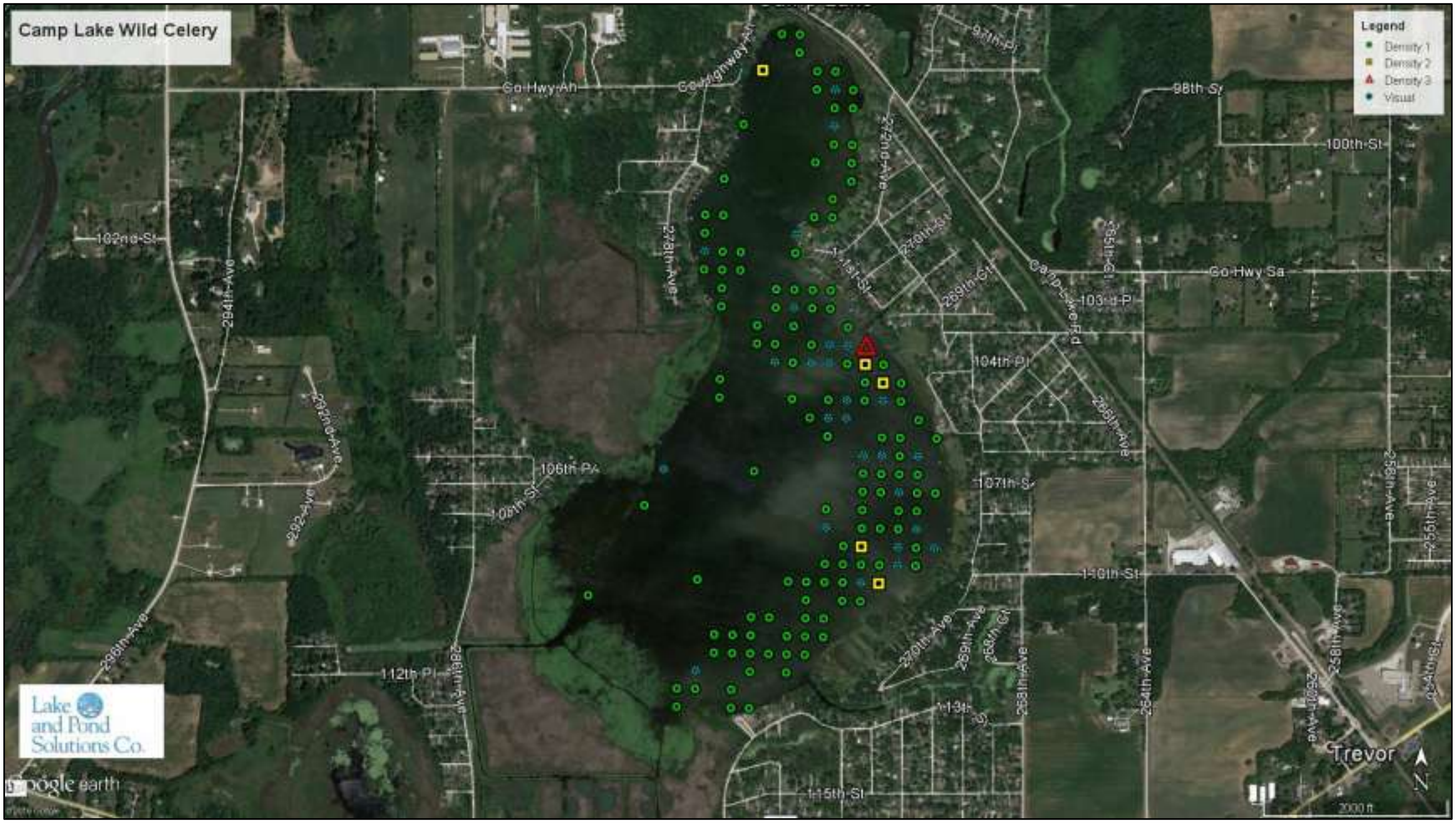
Lake and Pond Solutions Co. (2016)

Figure 18: Camp Lake Bushy Pondweed (2016)



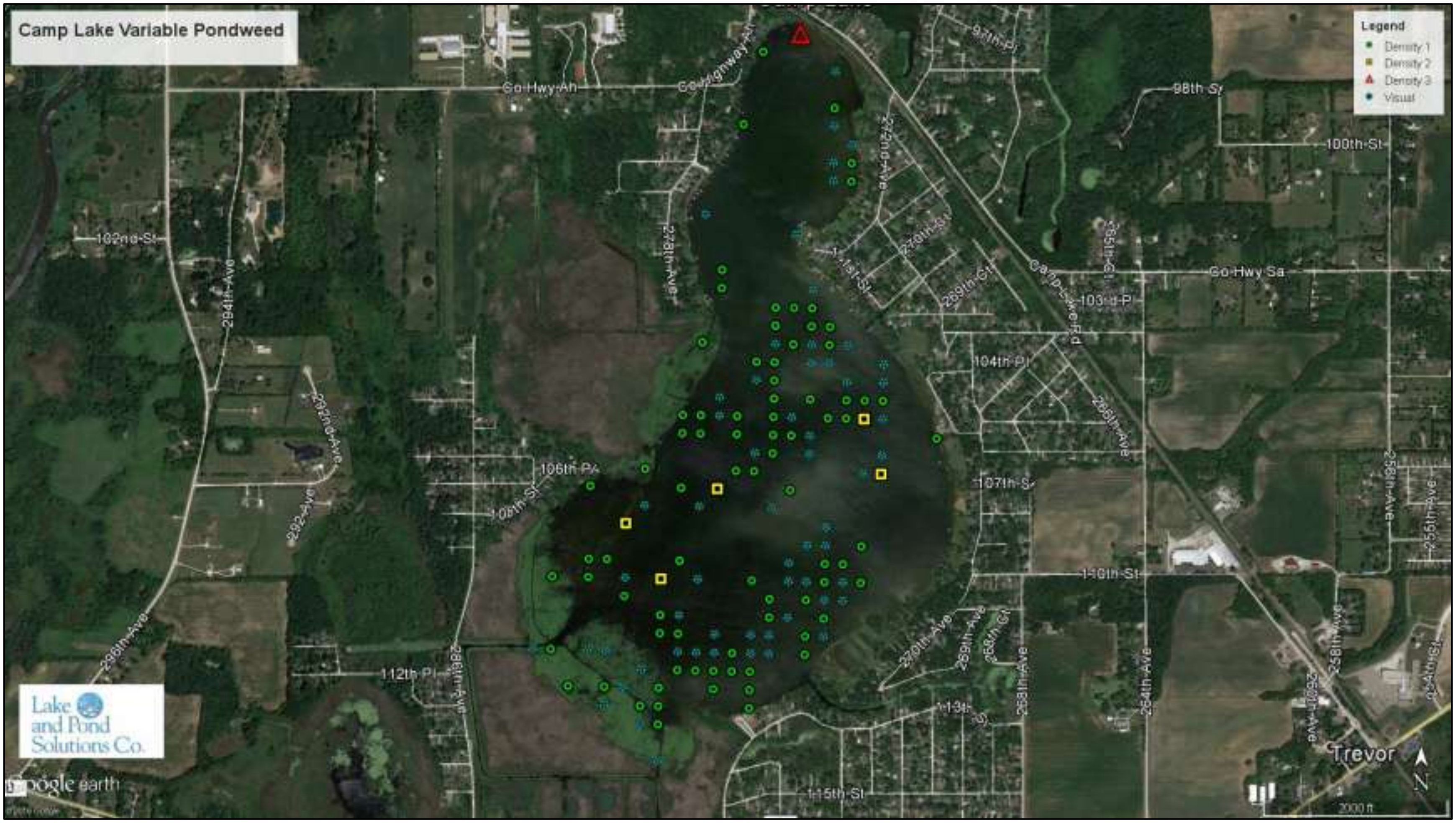
Lake and Pond Solutions Co. (2016)

Figure 19: Camp Lake Wild Celery (2016)



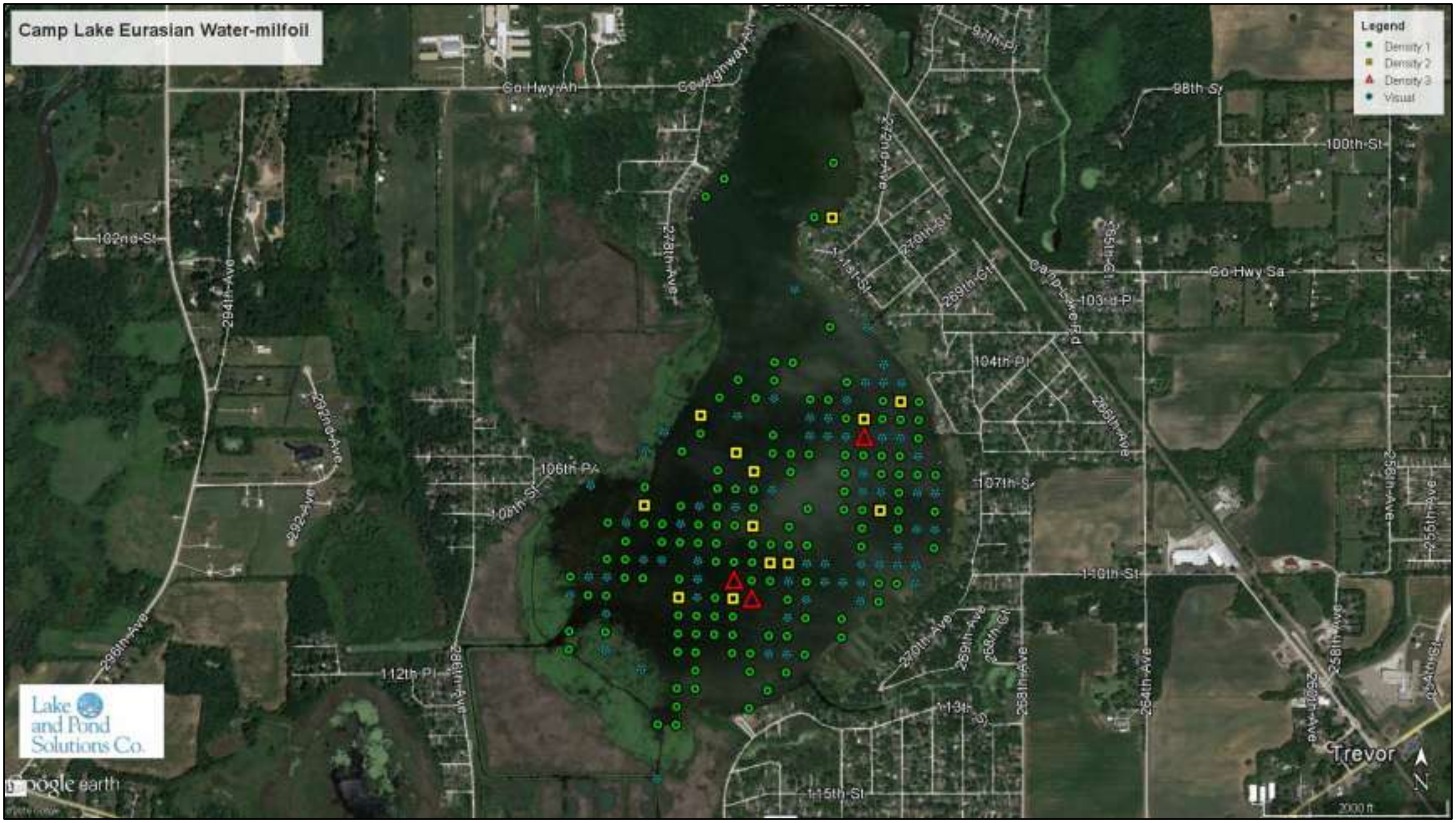
Lake and Pond Solutions Co. (2016)

Figure 20: Camp Lake Variable Pondweed (2016)



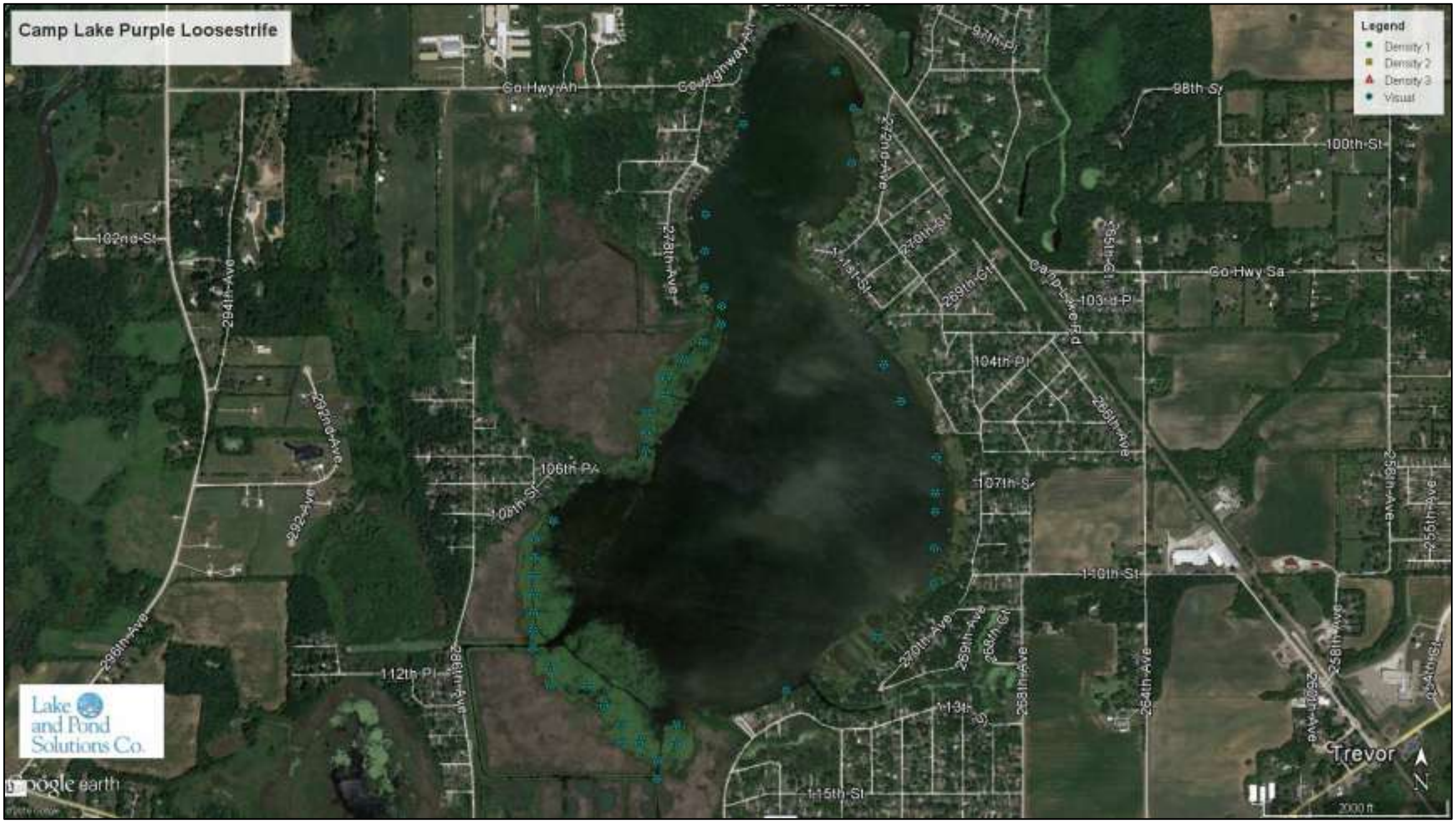
Lake and Pond Solutions Co. (2016)

Figure 21: Camp Lake Eurasian Water-milfoil (2016)



Lake and Pond Solutions Co. (2016)

Figure 22: Camp Lake Purple Loosestrife (2016)

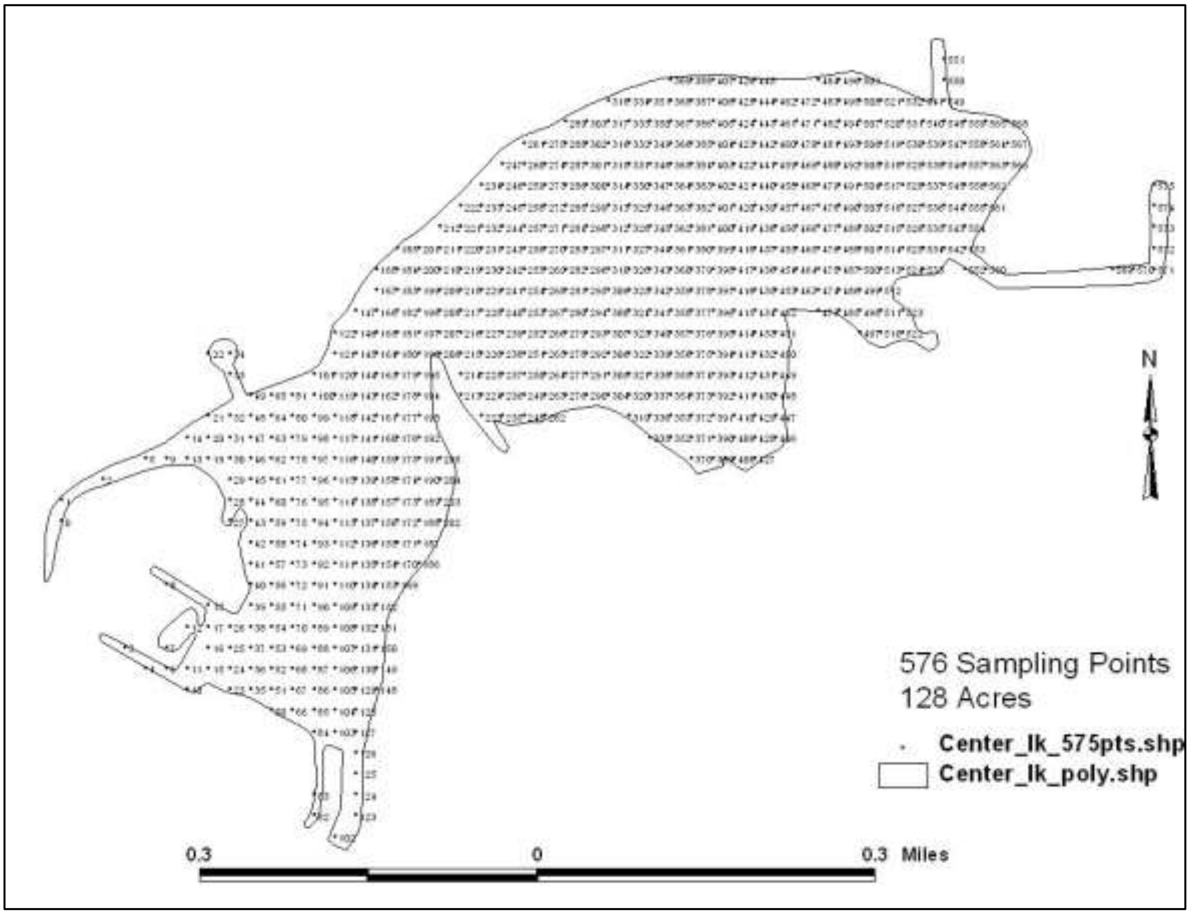


Lake and Pond Solutions Co. (2016)

Center Lake

Plants were surveyed on August 4th and 5th, 2016 using the 576 pre-determined WDNR points (Figure 23). Twenty-six different species of plants were found and they are outlined in Figure 24 from most to least frequent based on the number of sites they were found. The C-value for each species is also recorded. The C-value is the estimated probability that a plant is likely to occur in a landscape that is believed to be relatively unaltered from pre-settlement conditions. The C-value ranges from 0 – 10 with 10 being assigned to species most sensitive to disturbance.

Figure 23: Overview of 2016 Plant Sampling Points - Center Lake



WDNR (2007)

Figure 24: 2016 Plant Sampling Species Summary - Center Lake

Common Name	Scientific Name	Percent Frequency***	# of Sites (incl visuals)	Avg Rake Fullness	C-value
Coontail	*Ceratophyllum demersum*	74.25	222	1.95	3
Common Watermeal	*Wolffia columbiana*	49.83	149	1.37	5
*Sago Pondweed**	*Stuckenia pectinata*	37.79	113	1.34	3
Muskgrass	*Chara spp.*	27.76	83	1.88	7
*Wild Celery**	*Vallisneria americana*	27.42	82	1.18	6
White Water Lily	*Nymphaea odorata*	26.42	79	2.00	6
Small Duckweed	*Lemna minor*	23.06	69	1.32	5
Eurasian Water Milfoil**	*Myriophyllum spicatum*	19.73	59	1.32	-
Filamentous Algae	*n/a*	16.39	49	1.19	-
Common Waterweed	*Elodea canadensis*	15.38	46	1.30	3
Water Star-grass	*Heteranthera dubia*	14.72	44	1.43	6
*Illinois Pondweed**	*Potamogeton illinoensis*	10.70	32	1.00	6
Flat-stem Pondweed	*Potamogeton zosteriformis*	9.70	29	1.21	6
Narrow-leaved Cattail	*Typha angustifolia*	9.36	28	n/a	1
Spatterdock	*Nuphar variegate*	9.03	27	1.84	6
Widgeon Grass	*Ruppia cirrhosa*	9.03	27	1.46	8
Bushy Pondweed	*Najas flexilis*	8.70	26	1.31	6
Forked Duckweed	*Lemna trisulca*	6.69	20	1.33	6
Common Bladderwort	*Utricularia vulgaris*	3.68	11	1.00	7
*White-stem Pondweed**	*Potamogeton praelongis*	3.34	10	1.33	8
Spiny Naiad	*Najas marina*	1.67	5	1.50	-
Curly-leaf Pondweed**	*Potamogeton crispus*	1.34	4	1.00	-
Purple Loosestrife**	*Lythrum salicaria*	0.67	2	n/a	-
Common Reed**	*Phragmites australis*	0.67	2	n/a	-
Small Pondweed	*Potamogeton pusillus*	0.67	2	1.00	5
Northern Water Milfoil	*Myriophyllum sibiricum*	0.33	1	2.00	6
*Soft-stem Bulrush**	*Schoenoplectus tabernaemontani*	0.33	1	n/a	4

Lake and Pond Solutions Co. (2016)

* Italicized species are considered "high value" plant species under Wisconsin Administrative Code NR 107

** Bolded species are non-native (exotic) species

*** Percent frequency is shown as a percentage of occurrence within vegetated areas including visuals

Figure 25: 2016 Plant Sampling Data Summary - Center Lake

Total number of sites with vegetation	536 / 576 (93%)
Maximum depth of plants	17.0 feet
Species Richness (including visuals)	26
Average number of all species per site (vegetated sites only)	2.88
Average number of native species per site (vegetated sites only)	2.69

Lake and Pond Solutions Co. (2016)

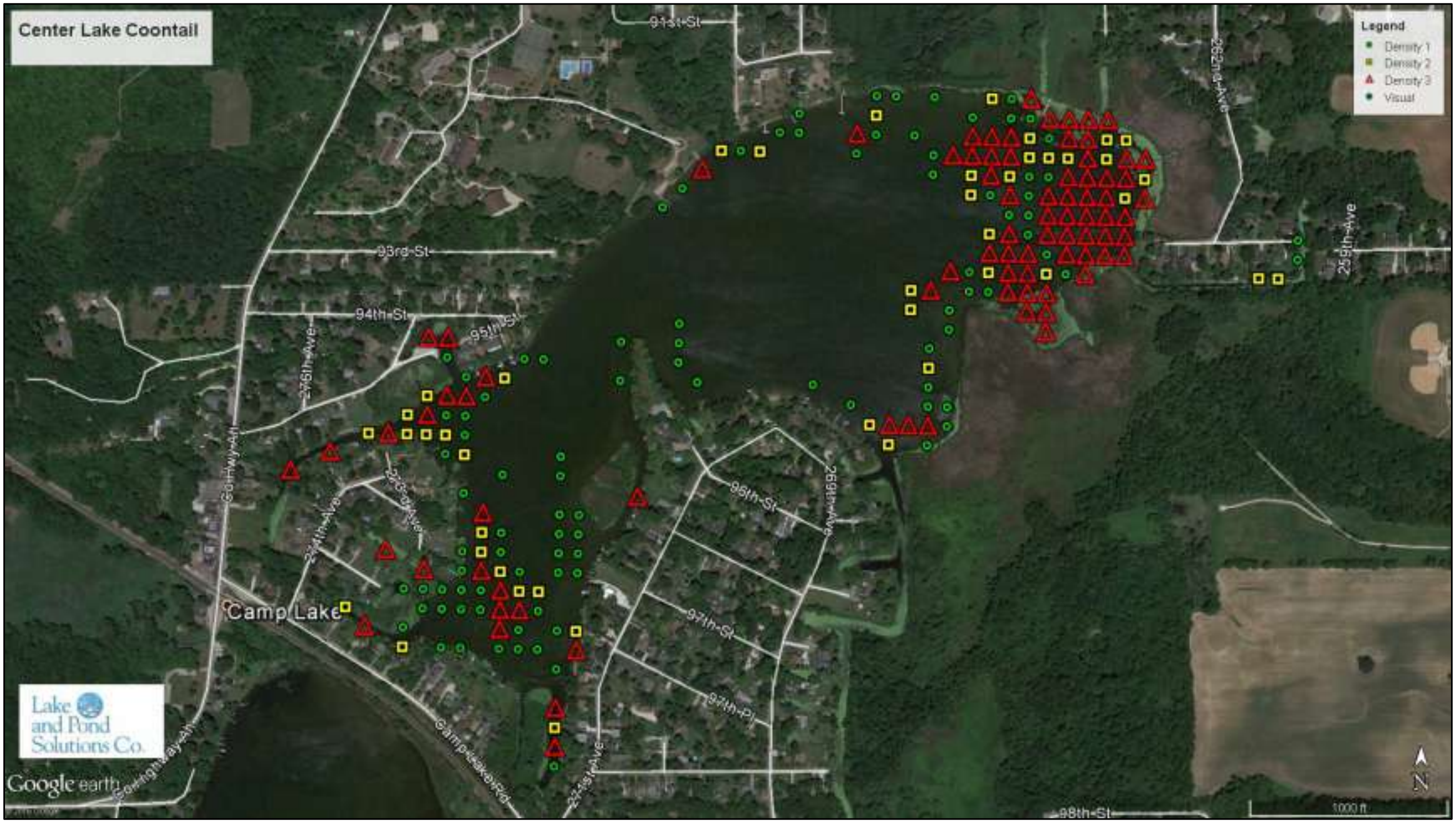
Lake-wide, there was an average of 2.69 native species found per site (up from 1.56 in 2011). Populations of non-native plants like Eurasian water-milfoil have remained scattered around the shoreline since not all known populations are treated in the spring. There is, however, a good distribution of native plants throughout the lake including five species listed as “high value” by the WDNR. These include Illinois pondweed, white-stem pondweed, soft-stem bulrush, sago pondweed, and wild celery. Below, Figure 26 shows if a site contained one high value species (green), two high value species (yellow), or three high value species (red).

Figure 26: Center Lake “High Value” Plants (2016)

Lake and Pond Solutions Co. (2016)

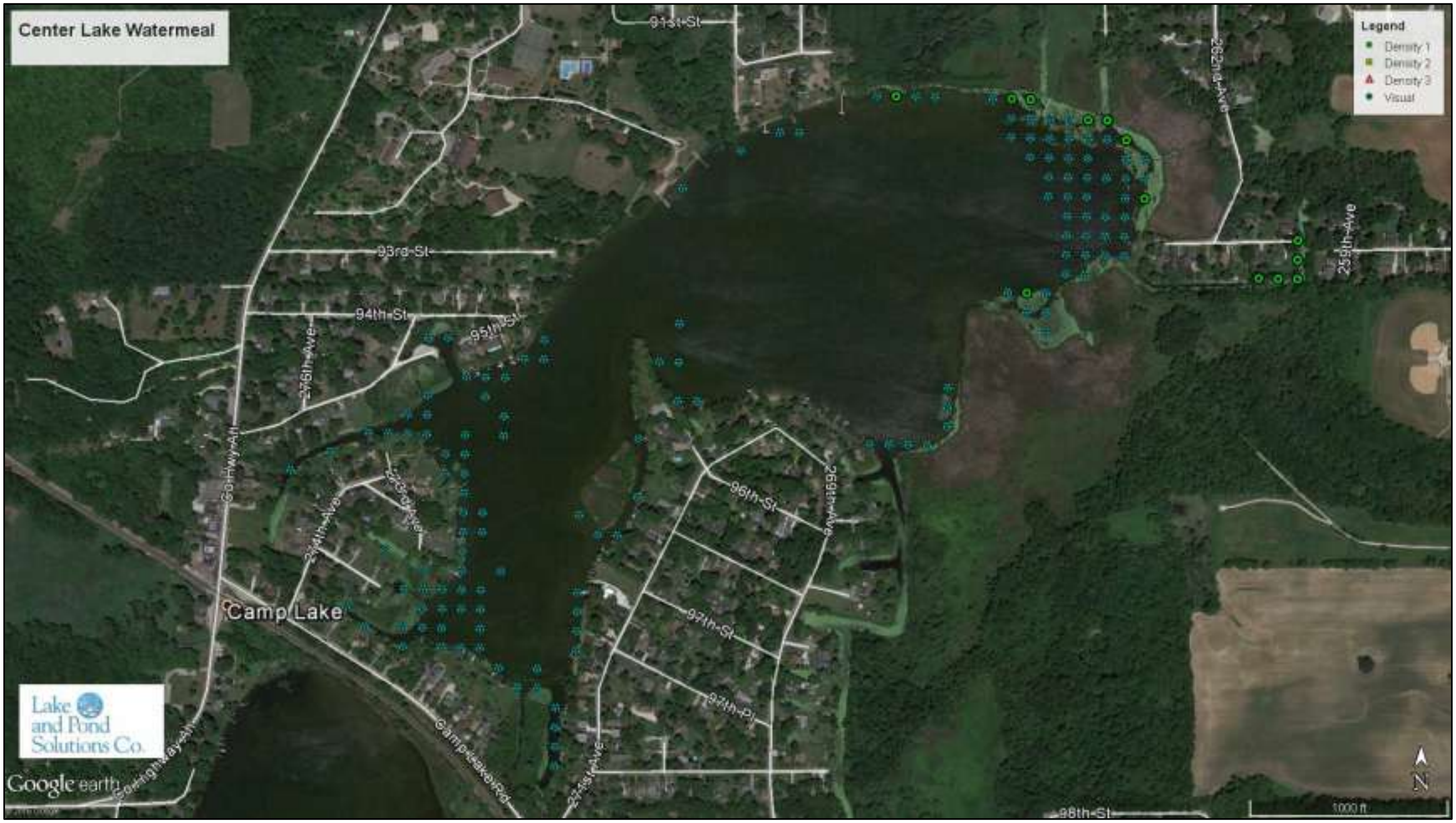
The five most common aquatic plant species (including visuals) within Center Lake are coontail (74.25%), watermeal (49.83%), sago pondweed (37.79%), muskgrass (27.76%), and wild celery (27.42%). Figure 27 through Figure 31 show locations of the top five most common native plants while Figure 32 and Figure 33 show locations of the non-native plants. Purple Loosestrife and Phragmites (non-native plants) were not depicted in a map since only two sites were found throughout the lake. Species from the 2016 survey are compared with previous surveys on Page 33 in Figure 36.

Figure 27: Center Lake Coontail (2016)



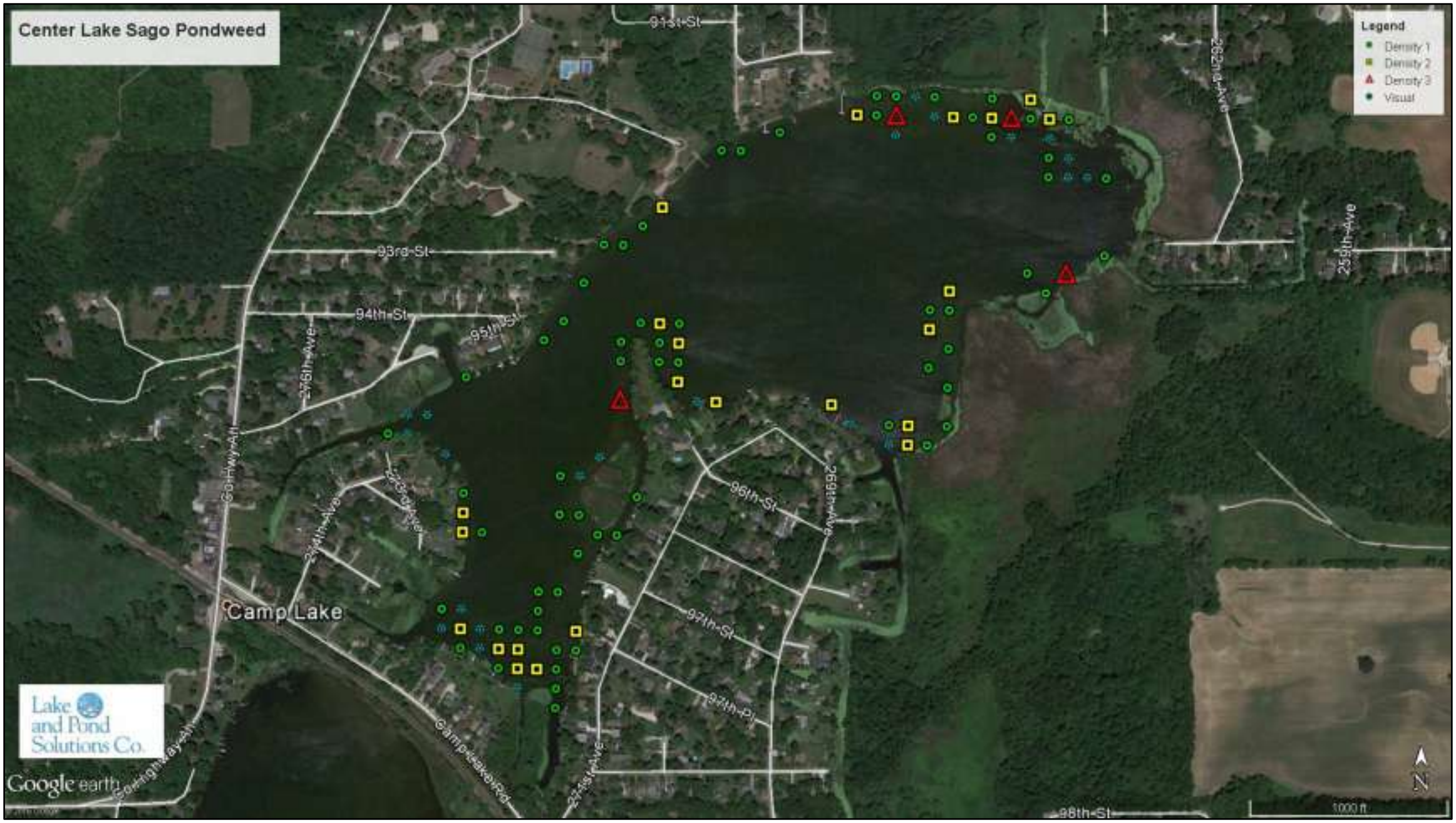
Lake and Pond Solutions Co. (2016)

Figure 28: Center Lake Watermeal (2016)



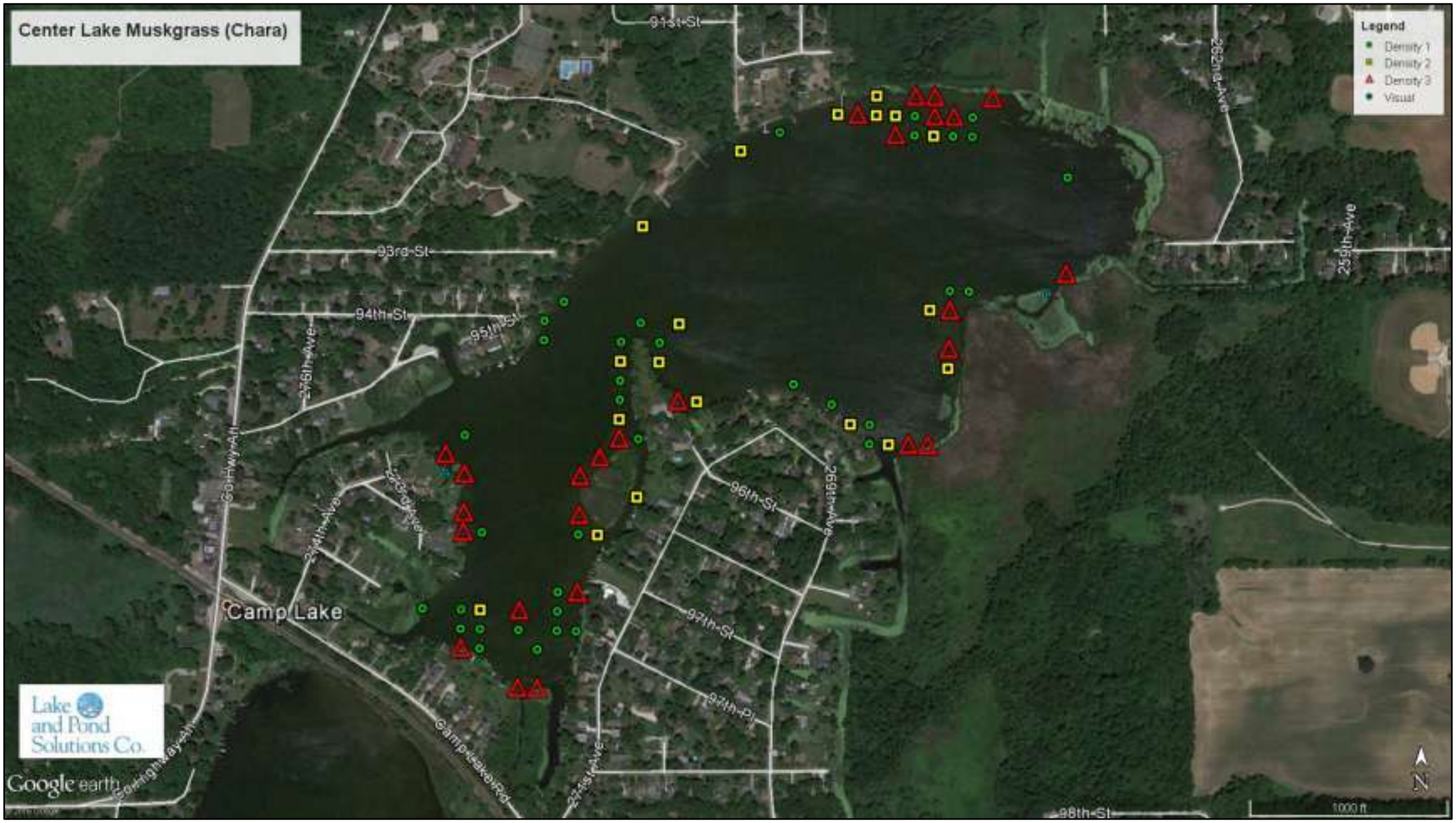
Lake and Pond Solutions Co. (2016)

Figure 29: Center Lake Sago Pondweed (2016)



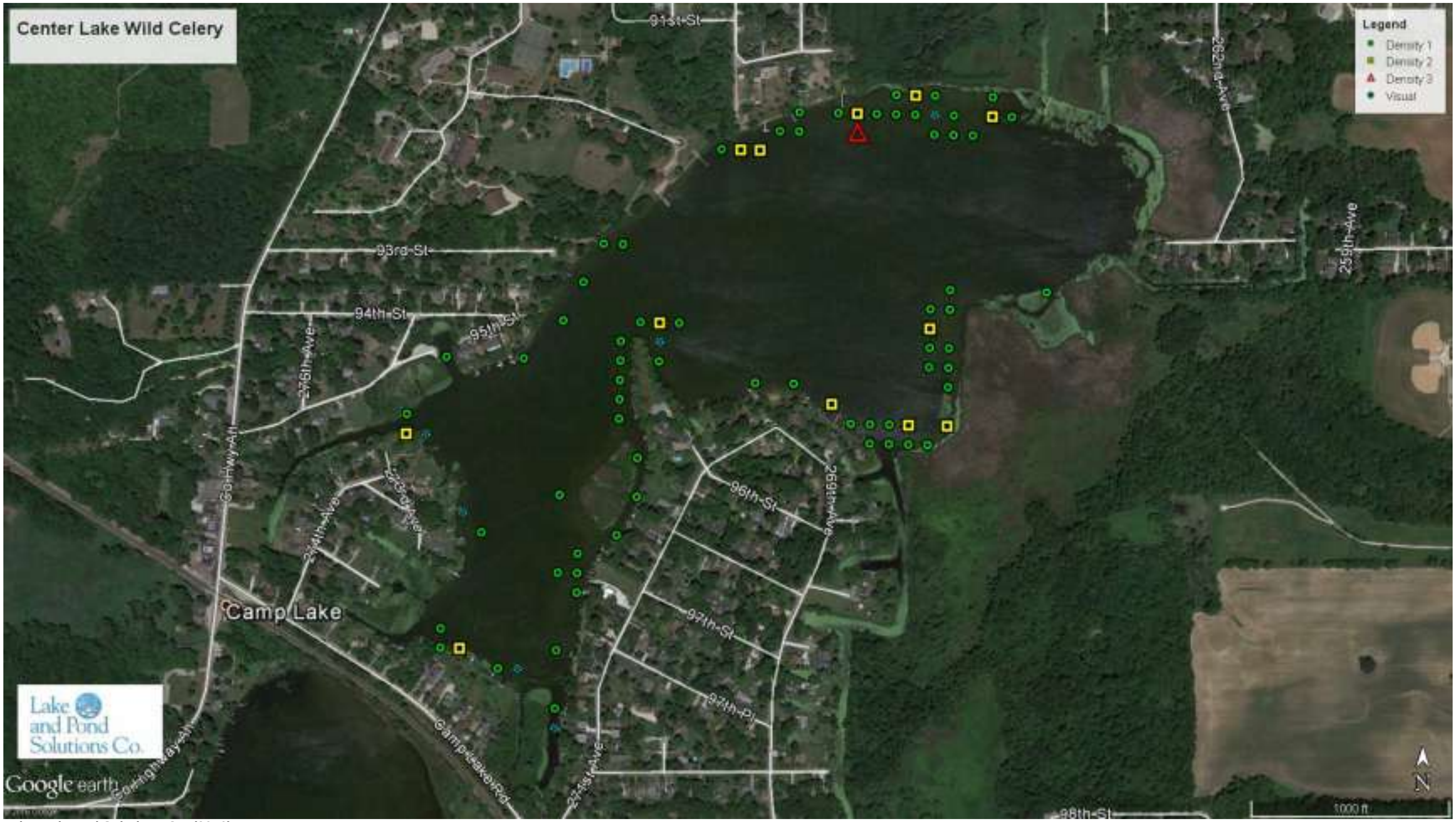
Lake and Pond Solutions Co. (2016)

Figure 30: Center Lake Muskgrass (2016)



Lake and Pond Solutions Co. (2016)

Figure 31: Center Lake Wild Celery (2016)

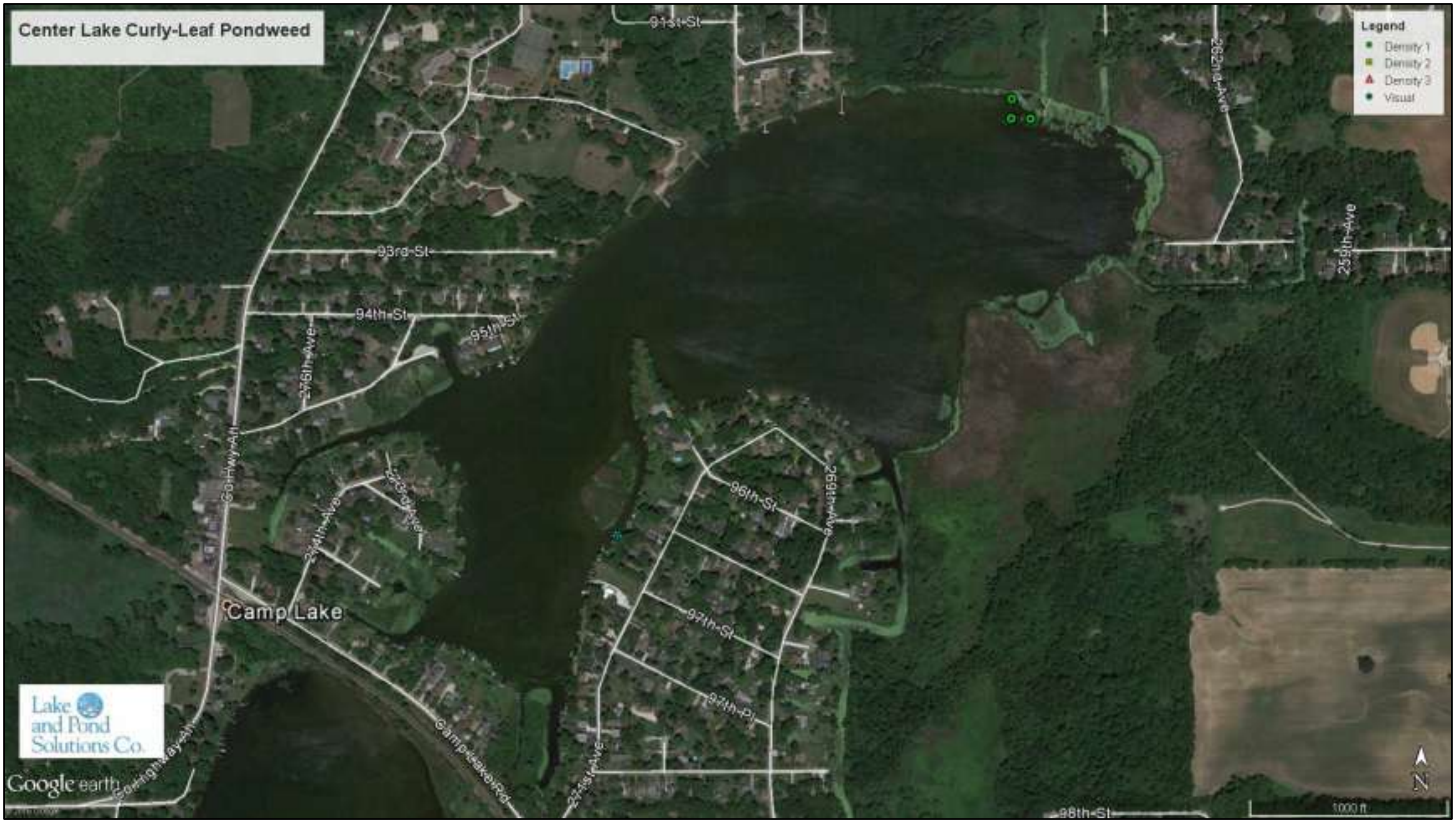


Lake and Pond Solutions Co. (2016)

Figure 32: Center Lake Eurasian Water-Milfoil (2016)

Lake and Pond Solutions Co. (2016)

Figure 33: Center Lake Curly-Leaf Pondweed (2016)



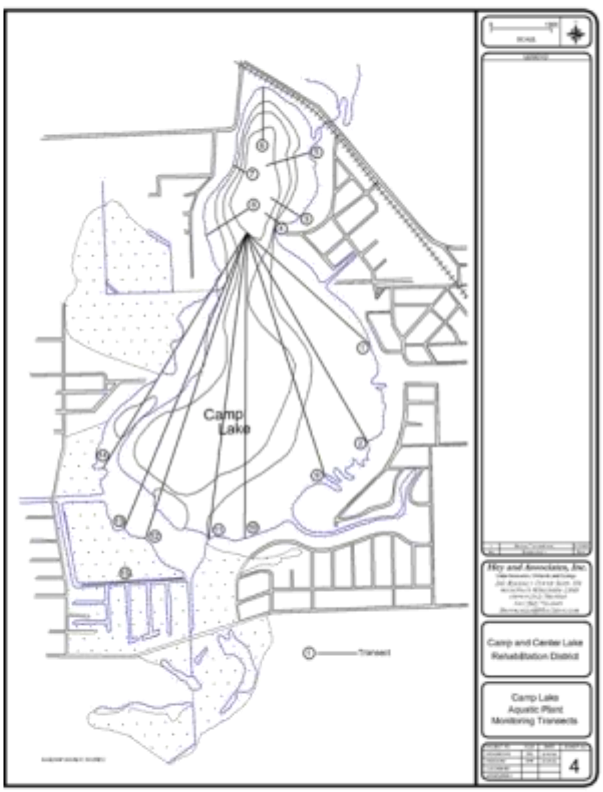
Lake and Pond Solutions Co. (2016)

Comparison of Aquatic Plant Surveys (2004 – 2016)

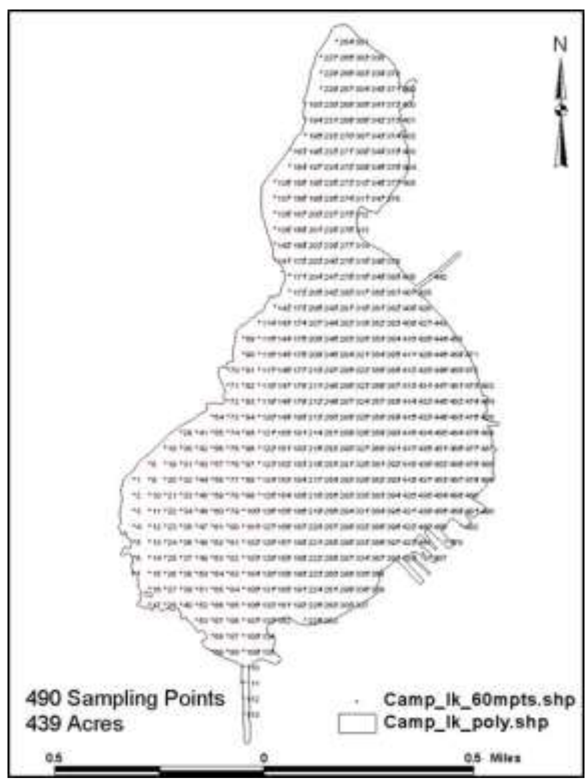
A comparison of past plant surveys can serve as a valuable resource indicating how the lake may be changing from a variety of factors. It is important to take into account the methods by which those surveys were performed. The past surveys from 1995 and 2004 (transect surveys) were compiled using the grid sampling method of Jessen and Lound (1962) and modified by Deppe and Lathrop (1992). The method utilized a grid system determined by the size and morphology of the lake and developed transects to survey all major aquatic plant communities and specific areas of interest. No attempts were made to catalog riparian wetland areas in the 2004 survey. Transects were established on both lakes beginning in the shallow water and continuing to deep water devoid of vegetation. Plants are then sampled along the transect lines at different depths. The limiting factor of this type of survey is the lower number of points sampled and higher probability to omit pertinent vegetation. There is also the potential to skew the percent frequency numbers if sampling took place in a large bed of one plant species.

The surveys from 2005 – 2016 (point-intercept surveys) were compiled using a modified grid sampling method determined by the size and morphology of the lake. Instead of developing transects, the WDNR generated grids lay points throughout the entire lake. Sampling takes place at each point and the survey allows for the ability to catalog "visual" sightings of species not directly sampled. These surveys are much more comprehensive and the same GPS points are used year after year.

Figure 34: Example of Different Plant Sampling Methods



Transect Survey



Point-Intercept Survey

Camp Lake

Camp Lake had a transect survey performed in July of 2004 while point-intercept surveys were performed in August of 2011 and 2016. Figure 35 shows the species summary from the last three surveys.

Figure 35: Plant Species Summary for Camp Lake (2004 - 2016)

Plant Species		Frequency of Occurrence within Vegetated Areas (%)		
Common Name	**Scientific Name**	**July 2004**	**Aug 2011**	**Aug 2016**
Widgeon Grass	*Ruppia cirrhosa*	53.1	53.7	46.19
Eurasian Water-Milfoil**	*Myriophyllum spicatum*	77.6	7.7	45.96
Muskgrass	*Chara spp.*	26.5	55.1	42.26
Bushy Pondweed	*Najas flexilis*	22.4	49.0	40.42
Wild Celery*	*Vallisneria americana*	12.2	19.7	34.64
Variable Pondweed	*Potamogeton gramineus*	2.0	n/a	33.49
Sago Pondweed*	*Stuckenia pectinata*	24.5	7.0	32.56
White Water Lily	*Nymphaea odorata*	n/a	14.1	27.94
Illinois Pondweed*	*Potamogeton illinoensis*	n/a	27.7	24.25
Common Bladderwort	*Utricularia vulgaris*	n/a	20.9	16.86
Narrow-leaved Cattail	*Typha angustifolia*	n/a	6.8	15.01
Floating-leaf Pondweed	*Potamogeton natans*	6.1	4.8	13.63
Common Waterweed	*Elodea canadensis*	2.0	23.1	12.47
Coontail	*Ceratophyllum demersum*	44.9	19.3	11.09
Flat-stem Pondweed	*Potamogeton zosteriformis*	6.1	5.2	10.85
Soft-stem bulrush*	*Schoenoplectus tabernaemontani*	n/a	7.0	10.39
Purple Loosestrife**	*Lythrum salicaria*	n/a	6.8	10.16
Long-leaf Pondweed	*Potamogeton nodosus*	n/a	3.9	9.70
Spatterdock	*Nuphar variegatum*	n/a	3.4	7.62
Common Watermeal	*Wolffia Columbiana*	n/a	n/a	6.24
Unknown Pondweed	*Potamogeton spp.*	2.0	n/a	5.31
Water Star-grass	*Heteranthera dubia*	8.2	0.9	4.85
White-stem Pondweed*	*Potamogeton praelongis*	n/a	5.9	4.39
Northern Water-Milfoil	*Myriophyllum sibiricum*	n/a	n/a	2.54
Small Duckweed	*Lemna minor*	n/a	0.2	2.54
Small Bladderwort	*Utricularia minor*	n/a	n/a	2.31
Pickerelweed	*Pontedaria cordata*	n/a	0.2	1.15
Common Reed**	*Phragmites australis*	n/a	n/a	0.46
Forked Duckweed	*Lemna trisulca*	n/a	n/a	0.46
Leafy Pondweed	*Potamogeton foliosus*	n/a	n/a	0.46
Spiny Naiad	*Najas marina*	n/a	1.4	0.46
Common Arrowhead	*Sagittaria latifolia*	n/a	n/a	0.23
Curly-leaf Pondweed**	*Potamogeton crispus*	4.1	0.5	0.23
Fries Pondweed	*Potamogeton friesii*	n/a	n/a	0.23
Various-leaved Milfoil	*Myriophyllum heterophyllum*	n/a	0.5	n/a
Water-Milfoil species	*Myriophyllum spp.*	24.5	n/a	n/a

Lake and Pond Solutions Co. (2016)

*Species are considered “high value” plant species under Wisconsin Administrative Code NR 107

**Denotes non-native species

When comparing the past three surveys, it is important to point out that a transect survey was performed in July of 2004 versus point-intercept in August of 2011 and 2016. Additionally, the 2004 survey did not catalog emergent and floating species.

- Eight native species were added (common arrowhead, common watermeal, forked duckweed, Fries pondweed, leafy pondweed, northern water-milfoil, small bladderwort, and variable pondweed) while only one species was lost (various-leaved milfoil). This nets a +7 in total native species over the last survey.

- EWM was in 45.96% of vegetated sites in 2016 compared to only 7.7% in 2011. Much of this is likely due to the resurgence of EWM on the south end of the lake where no large treatment typically occurs.

- Two native species (common waterweed and muskgrass) saw double digit decreases (10.63% and 12.84% respectively) while four native species (sago pondweed, variable pondweed, white water lily, and wild celery) saw double digit increases (25.56%, 33.49%, 13.84%, and 14.94% respectively).

- Maximum depth of plant growth dropped from 13.0’ in 2011 to 10.5’ in 2016 likely due to seasonal changes in clarity.

- Species richness increased from 15 in 2004 and 26 in 2011 to 34 in 2016.

- There were 2.76 native species per vegetated site in 2016 which was down slightly from 3.20 species in 2011.

- In 2016, there were six native species found at a frequency of occurrence great than 30% compared to three in 2011. This demonstrates that the plant community is becoming more diverse and widespread throughout the lake.

Center Lake

Center Lake had transect surveys performed in 1995 and 2004 while point-intercept surveys were performed in September of 2005 and August of 2011 and 2016. Figure 36 shows the species summary from the last three point-intercept surveys.

Figure 36: Plant Species Summary for Center Lake (2005 - 2016)

Plant Species		Frequency of Occurrence within Vegetated Areas (%)		
Common Name	**Scientific Name**	**Sept 2005**	**Aug 2011**	**Aug 2016**
Coontail	*Ceratophyllum demersum*	42.3	83.3	74.25
Common Watermeal	*Wolffia columbiana*	9.0	0.4	49.83
Sago Pondweed*	*Stuckenia pectinata*	11.7	4.8	37.79
Muskgrass	*Chara spp.*	15.0	3.1	27.76
Wild Celery*	*Vallisneria americana*	13.0	12.7	27.42
White Water Lily	*Nymphaea odorata*	1.7	13.2	26.42
Small Duckweed	*Lemna minor*	2.7	16.7	23.08
Eurasian Water-Milfoil**	*Myriophyllum spicatum*	88.0	6.6	19.73
Common Waterweed	*Elodea canadensis*	n/a	0.4	15.38
Water Star-grass	*Heteranthera dubia*	0.7	1.8	14.72
Illinois Pondweed*	*Potamogeton illinoensis*	1.7	0.9	10.70
Flat-stem Pondweed	*Potamogeton zosteriformis*	n/a	1.8	9.70
Narrow-leaved Cattail	*Typha angustifolia*	n/a	22.8	9.36***
Spatterdock	*Nuphar variegatum*	1.3	3.5	9.03
Widgeon Grass	*Ruppia cirrhosa*	24.7	7.0	9.03
Bushy Pondweed	*Najas flexilis*	8.0	0.9	8.70
Forked Duckweed	*Lemna trisulca*	2.3	6.1	6.69
Common Bladderwort	*Utricularia vulgaris*	n/a	n/a	3.68
White-stem Pondweed*	*Potamogeton praelongis*	n/a	0.4	3.34
Spiny Naiad	*Najas marina*	2.7	0.9	1.67
Curly-leaf Pondweed**	*Potamogeton crispus*	n/a	4.0	1.34
Common Reed**	*Phragmites australis*	n/a	n/a	0.67
Small Pondweed	*Potamogeton pusillus*	n/a	0.9	0.67
Purple Loosestrife**	*Lythrum salicaria*	n/a	11.8	0.67***
Northern Water-Milfoil	*Myriophyllum sibiricum*	13.7	n/a	0.33
Sotft-stem bulrush*	*Schoenoplectus tabernaemontani*	n/a	0.4	0.33
Bottle Brush Sedge	*Carex comosa*	n/a	0.9	n/a***
Common Arrowhead	*Sagittaria latifolia*	n/a	0.4	n/a***
Swamp Loosestrife	*Decodon verticillatus*	0.3	n/a	n/a***
Large Duckweed	*Spirodela polyrhiza*	0.3	n/a	n/a
Variable Pondweed	*Potamogeton gramineus*	2.3	n/a	n/a

Lake and Pond Solutions Co. (2016)

*Species are considered “high value” plant species under Wisconsin Administrative Code NR 107

**Denotes non-native (exotic) species

***Survey crew catalogued emergent species differently than previous surveys

Comparing the past three surveys should provide a good source for comparison since they were all performed using the point-intercept method and utilized the same points.

- Two native species were added (common bladderwort and northern water milfoil) while two species were lost likely due to a reduced emergent identification effort (bottle brush sedge and common arrowhead). This nets a +0 in total native species over the last survey.

- EWM was in 19.73% of vegetated sites in 2016 compared to 6.6% in 2011 and 88.0% in 2005. Recently, CCLRD has taken efforts to target larger beds of EWM which looks to have increased native diversity.

- Seven native species saw double digit increases (common watermeal – 49.43%, common waterweed – 14.98%, muskgrass – 24.66%, sago pondweed – 32.99%, water star-grass – 12.92%, white water lily – 13.22%, and wild celery – 14.72%). There were no species with double digit decreases.

- Maximum depth of plant growth dropped from 19.5' in 2011 to 17.0' in 2016 likely due to seasonal changes in clarity.

- Species richness remained the same (26) when compared to 2011.

- There were 2.69 native species per vegetated site in 2016 which was significantly up from 1.56 native species in 2011. Additionally, 93% of the sites contained vegetation compared to only 40% in 2011.

- In 2016, there were six native species found at a frequency of occurrence greater than 25% compared to two in 2011. This again demonstrates that the plant community is becoming more diverse and widespread throughout the lake.

Floristic Quality Assessment

Floristic quality (Swink and Wilhelm, 1994) is a rapid assessment metric designed to evaluate the closeness that the flora of an area is to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts.

For any area (lake in this case), floristic quality (I) equals the average coefficient of conservatism (C-value) times the square root of the number of native species ($\sqrt{N}$).

The coefficient of conservatism (C-value) was assigned to 128 aquatic plants, compared to regional studies, and reviewed by a number of biologists familiar with Wisconsin lake plants. They range from 0 to 10 with 10 being assigned to species most sensitive to disturbance. These final C-values were used in calculating the Floristic quality for Camp and Center Lakes.

Camp Lake

Figure 37 shows the floristic quality from 2011 and 2016 for Camp Lake compared to the Southeastern Till Plain (STP) average, Wisconsin average, and the Wisconsin 75th percentile average. The STP average categorizes the lakes in the southeast corner of the state. The plant community within Camp Lake would rank above 75% of all other Wisconsin lakes for its closeness to what it would be like under undisturbed conditions!

Figure 37: Floristic Quality Comparison for Camp Lake

	CAMP LAKE 2011	CAMP LAKE 2016	STP AVERAGE	WI AVERAGE	WI 75th PERCENTILE
Avg. C-value	6.0	5.75	5.6	6.0	6.9
# of natives (N)	21	28	14	13	20
Floristic Quality	27.5	30.4	20.9	22.2	27.5

Lake and Pond Solutions Co. (2016)

Additionally, Figure 38 shows the five most common plant species from the last three surveys including an average C-Value and Floristic Quality. The average C-Value and Floristic Quality have dropped since 2011 although this is due to EWM making resurgence in the untreated south end of the lake. If EWM was replaced with the next most common native species (variable pondweed), the average C-Value (6.8) and Floristic Quality (15.2) would be higher.

Figure 38: Five Most Common Plant Species in Camp Lake

2004 Plant Survey			2011 Plant Survey			2016 Plant Survey		
Species	**Percent Frequency**	**C-Value**	**Species**	**Percent Frequency**	**C-Value**	**Species**	**Percent Frequency**	**C-Value**
Eurasian Water Milfoil	77.60	0	Muskgrass	55.10	7	Widgeon Grass	46.19	8
Widgeon Grass	53.10	8	Widgeon Grass	53.74	8	Eurasian Water Milfoil	45.96	0
Coontail	44.90	3	Bushy Pondweed	48.98	6	Muskgrass	42.26	7
Muskgrass	26.50	7	*Illinois Pondweed*	27.66	6	Bushy Pondweed	40.42	6
Sago Pondweed	24.50	3	Common Waterweed	26.08	3	*Wild Celery*	34.64	6
Avg. C-Value of Top 5 = 3.6			**Avg. C-Value of Top 5 = 6.4**			**Avg. C-Value of Top 5 = 5.4**		
Floristic Quality of Top 5 = 7.2			**Floristic Quality of Top 5 = 14.3**			**Floristic Quality of Top 5 = 10.8**		

Lake and Pond Solutions Co. (2016)

Both of the above figures show the lake is reacting nicely to the CCLRD restoration efforts. In fact, there has been improvement lake-wide in the last five years with an increased number of native species and floristic quality. Larger treatments of Eurasian water-milfoil have allowed native vegetation to flourish while the use of harvesting to "top" native vegetation has allowed for recreation while ensuring a balanced plant community (see topping explanation on Page 37).

Center Lake

Figure 39 shows the floristic quality from 2011 and 2016 for Center Lake compared to the Southeastern Till Plain (STP) average, Wisconsin average, and the Wisconsin 75th percentile average. The plant community within Center Lake now ranks above the STP and WI average for its closeness to what it would be like under undisturbed conditions. Much of this is due to the quality of species now inhabiting the lake.

Figure 39: Floristic Quality Comparison for Center Lake

	CENTER LAKE 2011	CENTER LAKE 2016	STP AVERAGE	WI AVERAGE	WI 75th PERCENTILE
Avg. C-value	4.3	5.4	5.6	6.0	6.9
# of natives (N)	21	21	14	13	20
Floristic Quality	19.7	24.9	20.9	22.2	27.5

Lake and Pond Solutions Co. (2016)

Figure 40 shows the five most common plant species from the last three surveys including an average C-Value and Floristic Quality. The average C-Value and Floristic Quality have steadily been increasing since 2005 indicating that more sensitive species are growing in the lake.

Figure 40: Five Most Common Plant Species in Center Lake

2005 Plant Survey			2011 Plant Survey			2016 Plant Survey		
Species	**Percent Frequency**	**C-Value**	**Species**	**Percent Frequency**	**C-Value**	**Species**	**Percent Frequency**	**C-Value**
Eurasian Water-Milfoil	88.00	0	Coontail	83.33	3	Coontail	74.25	3
Coontail	42.3	3	White Water Lily	13.16	6	Watermeal	49.83	5
Widgeon Grass	24.67	8	*Wild Celery*	12.72	6	*Sago Pondweed*	37.79	3
Muskgrass	15.00	7	Widgeon Grass	7.02	8	Muskgrass	27.76	7
Northern Water-Milfoil	13.67	7	Eurasian Water-Milfoil	6.58	0	Wild Celery	27.42	6
Avg. C-Value of Top 5 = 2.9			**Avg. C-Value of Top 5 = 3.8**			**Avg. C-Value of Top 5 = 4.8**		
Floristic Quality of Top 5 = 5.8			**Floristic Quality of Top 5 = 7.6**			**Floristic Quality of Top 5 = 10.73**		

Lake and Pond Solutions Co. (2016)

Like Camp Lake, both of the above figures show the lake is reacting nicely to the CCLRD restoration efforts. More emphasis was put on wide-spread early season treatments for EWM and the natives have responded favorably. These larger treatments of Eurasian water-milfoil have allowed native vegetation to flourish while the use of harvesting to “top” native vegetation has allowed for recreation while ensuring a balanced plant community (see topping explanation on Page 37).

RECOMMENDATIONS

For the purpose of these recommendations, nuisance species shall be defined as those native species which can produce excessive biomass as to hinder realistic lake uses and may include plants such as coontail, widgeon grass and common waterweed (elodea). *It should be explicitly noted that the aforementioned species are beneficial natives and comments about their nuisance behavior is limited to excessive growth that limits lake use*. Exotic species include Eurasian Water-milfoil, Curly-leaf pondweed and Purple loosestrife. **Limiting disruption of**

non-nuisance, native aquatic plant beds should be a priority to meet long-term management goals. The protection of the desirable species will provide natural "seedbanks" or "plantbanks" for re-establishment into other areas of the lake.

Aquatic Plant Harvesting

As of 2016, the Lake District owns and operates two Aquarius Systems HM-420 7-foot aquatic plant harvesters, one transporter, two shore conveyors, and two International DT466 long box dump trucks. The purpose of each harvester is to accomplish harvesting in recreational boating use areas and cut boating accessing channels and fishing lanes in water three feet and deeper. Due to the favorable results shown in the 2016 plant survey, no deviation from the previous plan is recommended at this time.

"**Topping**" is a harvesting practice employed on Camp and Center Lakes, where harvesters essentially cut up to ¼ of the plant tops off. This process allows the cut plants to survive but also allows other native plants to establish thus increasing diversity. The harvesters are also used to transport and re-populate high quality native vegetation, such as muskgrass, to areas of the lakes where it can compete with invasive species. In 2016, harvesting didn't begin until the 3rd week of June and was limited to 2-3 days per week.

Specific areas on both lakes will continue to need harvesting repeatedly each year, concentrating on removing nuisance levels of aquatic plants to provide navigation along with recreational boating and fishing activities. The key goal of the harvesting program must be adequate control of aquatic plants <u>in common use areas</u> of the lakes, while protecting ecologically important aquatic resources. Prior to the implementation of the annual harvesting program, it would be highly desirable to dispatch a "weed scout" to determine area-specific management strategies for that harvesting period. The weed scout could be any reasonably trained person familiar with overall aquatic plant management strategies and basic plant identification. For CCLRD, this person is currently the Operations Manager. By executing spot monitoring of the aquatic plant communities within specific areas, priority harvesting zones, cutting depths and intensities can be formulated.

Camp Lake

The primary goals of the aquatic plant management program are to increase recreational boating and fishing opportunities by clearing a wide navigation area in the central portion of lake, along with channel cutting in the access channels and fishing channels. By far the largest management hurdle is the extensive and dense aquatic plant beds, which occupy much of the southern two thirds of this lake. Water depths generally range from three to six feet. The northern end of the lake is deeper and water depth tends to control plant growth in that area though the shallow shoreline areas also contain dense macrophyte beds.

Figure 41 shows the proposed harvesting plan and priorities for Camp Lake. Figure 42 shows the planned harvesting areas and access lanes on Camp Lake. Access to and from all boat landings and private piers should be prioritized. A wide navigation area within the lake proper will be necessary to allow multiple recreational uses. The main navigation areas should be harvested at least five cutter widths wide (wider if time permits). When dealing with beds of native, non-nuisance species, it is important to harvest only as much vegetation as needed to increase recreational opportunities. This will allow the “topped” species of plants to thrive underneath the water surface and protect plant diversity.

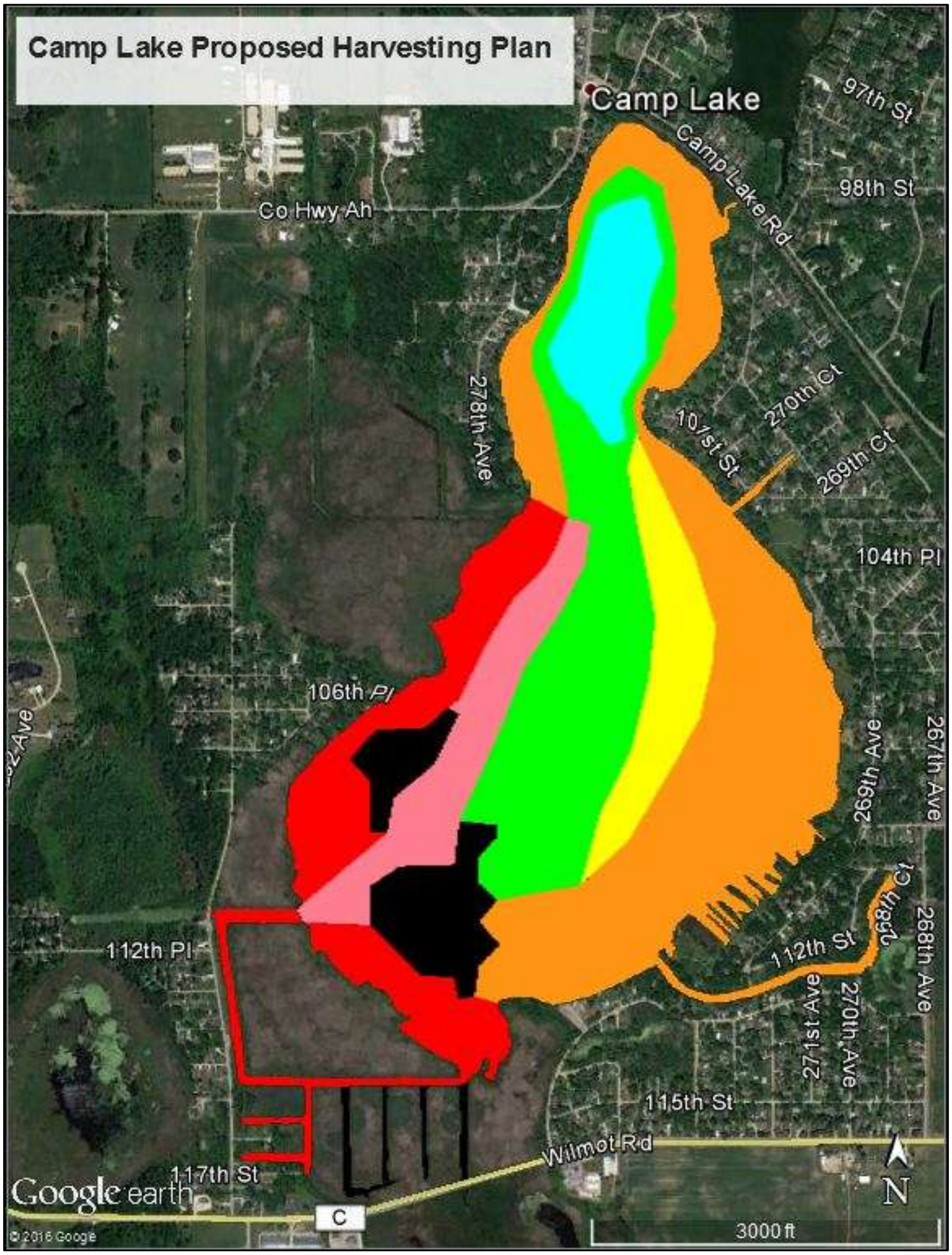
Cutting needs to be limited in the southern and southwestern ends of the lake, roughly corresponding with the water lily and soft-stem bulrush beds. Some of these areas contain high numbers of desirable native species and are not suitable or safe for intense recreational uses because of their shallow depth. To increase fishing opportunities, spot harvesting of nuisance species to create “Fishing Channels” three cutter widths wide in strategic areas for fishing boat access is acceptable as well as, “Fish” channels two cutter widths wide so predatory fish can gain access to the prey fish that live in the dense vegetation, as long as the harvesting does not promote the expansion of undesirable species. Motorboat intrusions into these areas should be kept to a minimum to prevent fragmentation of species such as Eurasian water-milfoil, which may then invade the beds of native species. Also, boat traffic and harvesting should be limited in near shore areas along developed shorelines, which are found to contain low densities of the aforementioned nuisance species.

It is generally recommended that harvesting activities avoid fish spawning periods. The WDNR will not approve any harvesting that promotes large scale cutting during the time of fish spawning. However, realizing that weed growth already can be excessive by late May, harvesting can begin in areas that do not support fish spawn such as creating a channel from the DNR boat landing to the deep water in center of the North Bay. Early harvesting should avoid natural shorelines and larger plant beds away from shore to allow for spawning fish to complete their breeding and disperse from the nesting grounds.

To increase fishery opportunities, lanes can be cut in plant beds to open up access for fishing. Research conducted in Wisconsin has shown that areas at the edge of aquatic plant beds generally have the highest usage by bluegill and other prey species (Storlie, et al, 1995). This is likely due to the increased macroinvertebrate production along the ecotonal edge between plant beds and open water. By harvesting lanes in the previously dense plant beds, greater edge habitat could be created. This would provide greater food success for smaller fish and better access for larger fish to prey upon them. Also, fisherman access would be greater, allowing for more of the lake to be successfully fished.

A summary of overall recommendations can be found at the end of this plan in Figure 51.

Figure 41: Camp Lake Proposed Harvesting Plan

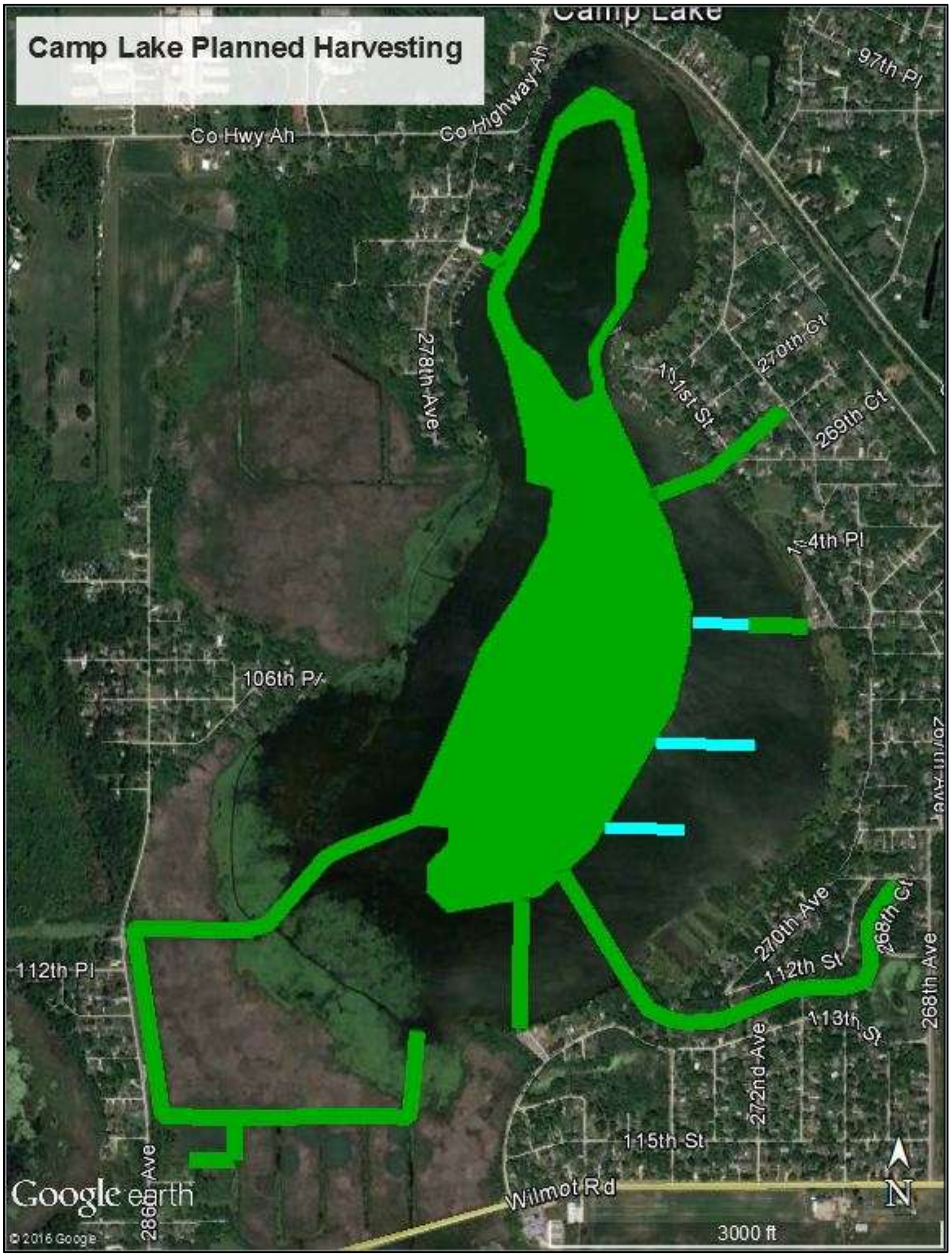


Lake and Pond Solutions Co. (2012

MAP KEY

- No restriction on harvesting after fish spawn – 1st Priority
- Harvesting prioritized for access channels and access points – 2nd Priority
- No restriction on harvesting after fish spawn – 3rd Priority
- Limit harvesting for channel clearing only (Ecologically Significant Area) – 4th Priority
- Limit harvesting for channel clearing only (Ecologically Significant Area)
- Avoid harvesting (Ecologically Significant Area)
- Open Water

Figure 42: Camp Lake Planned Harvesting Areas



Lake and Pond Solutions Co. (2012)

MAP KEY

- Approximate harvesting areas
- Approximate access channels
- Fish or fishing access lanes

Access for unloading harvested plants onto shore conveyors is located at the NW public boat launch (Figure 43) which is 1.23 miles from the DNR approved dumping site (Figure 44). It is the most economical for fuel consumption and allows for the fastest turnaround or cycle time. Any dump site farther away would result in a reduction in productivity while harvesters sit idle waiting for the transport to return.

Figure 43: Camp Lake Harvesting Off-Load and Disposal Sites

Lake and Pond Solutions Co. (2016)

Figure 44: Harvesting Disposal Site

Lake and Pond Solutions Co. (2016)

Center Lake

Like Camp Lake, the primary goals of the aquatic plant management program are to increase recreational boating and fishing opportunities by clearing a wide navigation area into the central portion of lake, along with channel cutting in the access channels and fishing channels. By far the largest management hurdle is the extensive and dense aquatic plant beds, occupying the northern and southern portions of the lake. Water depths generally range from three to six feet.

Figure 45 shows the proposed harvesting plan and priorities for Center Lake. Figure 46 shows the planned harvesting areas and access lanes. To provide lake access, aquatic plant harvesting in the channels adjoining residential properties is permitted. It is, however, limited to harvesting in the center of a channel in less than 3-foot depths or where high percentages of native aquatic plants exist. Once out of the channels, harvesting locations depend on the specific locations of plant beds.

Harvesting on the south and northeast ends should be optimized to "top" the nuisance coontail growth and allow more beneficial natives a chance to compete. Access to and from all boat landings and private piers should be prioritized. A wide navigation area within the lake proper will be necessary to allow multiple recreational uses. The main navigation areas should be harvested at least five cutter widths wide (wider if time permits). When dealing with beds of native, non-nuisance species, it is important to harvest only as much vegetation as needed to increase recreational opportunities. This will allow the "topped" species of plants to thrive underneath the water surface and protect plant diversity.

Cutting depths should be raised where high concentrations of wild celery and widgeon grass exist. Harvesting in the lily beds along the northeastern shore should be conducted for fishing and access channels only. To increase fishing opportunities, spot harvesting of nuisance species to create "Fishing Channels" three cutter widths wide in strategic areas for fishing boat access is acceptable as well as, "Fish" channels two cutter widths wide so predatory fish can gain access to the prey fish that live in the dense vegetation, as long as the harvesting does not promote the expansion of undesirable species. Motorboat intrusions into these areas should be kept to a minimum to prevent fragmentation of species such as Eurasian water-milfoil, which may then invade the beds of native species.

It is generally recommended that harvesting activities avoid fish spawning periods. The WDNR will not approve any harvesting that promotes large scale cutting during the time of fish spawning. However, realizing that weed growth already can be excessive by late May, harvesting can begin in areas that do not support fish spawn such as creating a channel from the DNR boat landing to the deep water in center of the North Bay. Early harvesting should avoid natural shorelines and larger plant beds away from shore to allow for spawning fish to complete their breeding and disperse from the nesting grounds.

A summary of overall recommendations can be found at the end of this plan in Figure 51.

Figure 45: Center Lake Proposed Harvesting Plan

Lake and Pond Solutions Co. (2016)

<u>MAP KEY</u>

- No restriction on harvesting after fish spawn – 1st Priority
- Harvesting prioritized for access channels and access points – 2nd Priority
- No restriction on harvesting after fish spawn – 3rd Priority
- Limit harvesting for channel clearing only (Ecologically Significant Area)
- Avoid harvesting (Ecologically Significant Area)
- Open Water

Figure 46: Center Lake Planned Harvesting Areas

Lake and Pond Solutions Co. (2016)

MAP KEY

- Approximate harvesting areas
- Approximate access channels
- Fish or fishing access lanes

Access for unloading harvested plants onto shore conveyors is located at the SW public boat launch (Figure 47) which is 1.67 miles from the DNR approved dumping site (Figure 44).

Figure 47: Center Lake Harvesting Off-Load and Disposal Sites

Lake and Pond Solutions Co. (2016)

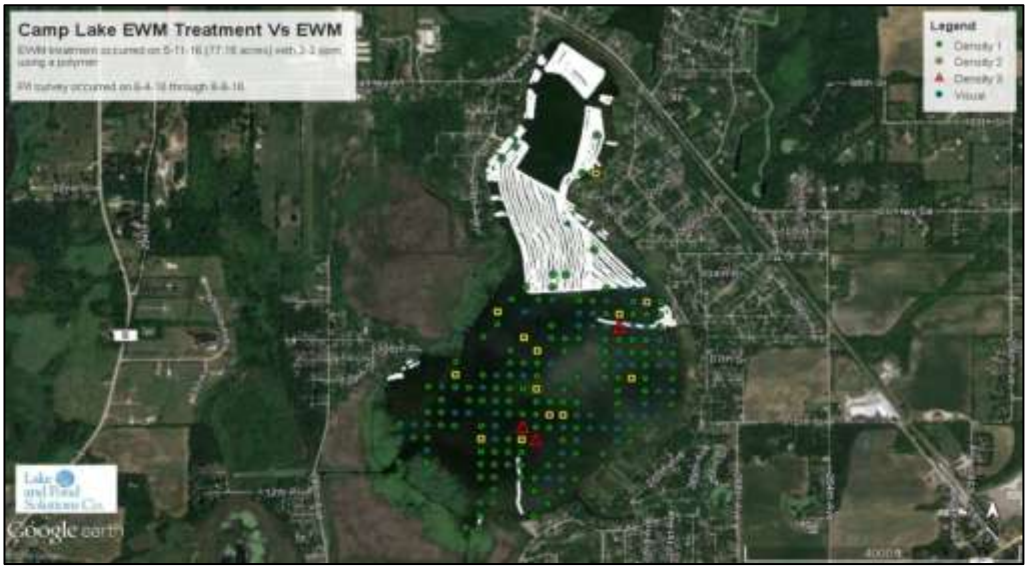
Herbicides

In the past, lake residents "opt in" to EWM treatment via a spring mailer sent by the CCLRD. Larger herbicide treatment areas for exotic plants are determined on an annual basis by the operations manager in conjunction with the contracted consultant. For Camp Lake, larger areas on the north and middle portions of the lake have been selected for EWM treatment to aid in navigation. However, large expanses of EWM have not been treated on the south end of the lake mainly due to cost. For Center Lake, in-lake treatments for EWM have slowly increased in recent years with positive results.

An early season treatment for Eurasian Water-Milfoil and Curly-leaf Pondweed is strongly encouraged as many native aquatic plant species have yet to begin growing and plant biomass is limited. Purple Loosestrife treatments are typically most effective when performed after mid-July. Currently, no treatments are performed for native plants (nuisance or non-nuisance).

Figure 48 shows the August EWM densities overlaid on May treatment areas for Camp Lake. Eighty-nine percent of the EWM points were located outside of the treatment areas indicating that the targeted strategy using a polymer has been successful. This is also confirmed by looking at the top five native species: widgeon grass, muskgrass, bushy pondweed, wild celery, and variable pondweed. The aforementioned species are found at 16% - 40% of the sites in the treatment area showing the larger scale treatments are not affecting the dominant and high quality beneficial natives. Due to the expanding EWM outside of the treatment, it is recommended that CCLRD consider a whole lake treatment on Camp Lake in the future.

Figure 48: Camp Lake May 2016 Treatment vs August 2016 EWM



Lake and Pond Solutions Co. (2016)

Figure 49 shows the August EWM densities overlaid on May treatment areas for Center Lake. Fifty-three percent of the EWM points were located outside of the treatment areas indicating less seasonal success versus Camp Lake. This may be due, in part, to smaller treatment areas and lower rates (2 ppm). On a positive note, the top five native species: coontail, sago pondweed, muskgrass, wild celery, and white water lily were found at 27% - 43% of the sites <u>in</u> the treatment area. This demonstrates the treatments are not affecting the dominant and high quality beneficial natives (four of the five increase significantly since the last P/I survey in 2011). Since the EWM is mainly confined to the shoreline and the average depth is much greater than Camp Lake, a whole lake treatment on Center Lake is not recommended at this time. It could however be considered if budget allows.

Figure 49: Center Lake May 2016 Treatment vs August 2016 EWM

Lake and Pond Solutions Co. (2016)

Diver Assisted Suction Harvesting (DASH)

DASH is a process where a certified diver maintains control of a hydraulic pump and pulls selected plants by the root and feeds them into the vacuum of the pump. The plant is transferred to a collection station that can range from an onion sack to large on-shore drainage bags. The advantage of DASH includes the ability to select the target plant for removal. The disadvantage of this is the slow nature of this process and the high cost due to specially trained staff (see Figure 50 below). Also, as operations begin in a DASH location, visibility rapidly diminishes, further reducing the speed of removal. Low visibility and human error also contribute to missed plants or improper removal (not removing the roots). There is a chance for damage to non-target species when native plants get tangled with aquatic plants being removed or the hydraulic hose flattens areas as the diver(s) are searching for target plants. Mussels, snails, other mollusks, crustaceans and other species that live in and around the lake bottom, on or within the plants are also inevitable bycatch.

Figure 50: DASH Cost and Time Comparison

Acreage	DASH*	Chemical (2,4-D)	Harvesting**
1 acre	$12,000 - 4-7 days	$800 – 1.5 hours	$1,000 – 45 min.
5 acres	$60,000 – 1 month	$3,000 – 3 hours	$5,000 – 1.5 hours
20 acres	$240,000 – 1 season	$10,000 – 6 hours	$20,000 – 1 day
100 acres	$1,200,000 – years	$44,000 – 3 days	$100,000 – 1+ weeks

*Based on www.aquaticinvasivecontrol.com and local contractors
**Based on www.ecy.wa.gove and www.lakesaquaticweedremoval.com

DASH would be best used in instances of very small and relatively dense patches of invasive plant species that are ideally located on a hard bottom. For Camp and Center Lake, DASH would not be a recommended option.

Public Information and Education

It is extremely important to provide information to lake property owners and lake users on the benefits of a healthy aquatic plant community including the management issues involved in controlling nuisance and exotic aquatic plants. Annual meetings, newsletters and informational materials provided by the Department of Natural Resources and the University of Wisconsin-Extension can assist lake users in understanding the many areas of aquatic plant management and ways to protect lakes from other invasive species. Currently, annual meetings and newsletters are the main form of communication between the district and lake residents.

The CCLRD should encourage and support one or two volunteers from each lake to participate in the DNR-Self Help Lake Monitoring Program which assists in monitoring overall health of the lakes. Additionally, Wisconsin Lakes (www.wisconsinlakes.org) provides some valuable resources including workshops and conferences geared towards lake owners and users.

Another potential educational inclusion could be the Clean Boats, Clean Waters Program. This program includes teams of volunteers, as well as some paid staff from other organizations that perform boat and trailer checks at launches. The volunteers also help to disseminate informational brochures and educate boaters on how to prevent the spread of aquatic invasive species. The UW Extension conducts trainings for new boat inspectors and coordinates the volunteer effort. Visit http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/cbcw/default.aspx for more information.

Lastly, it is always important to evaluate current signage at the public launches. Invasive signs should contain all known species found in the lake. Additionally, posting information about new invasives in the area may help play a role in educating the public and protecting the resource.

SUMMARY

Camp and Center Lakes continue to provide diverse aquatic plant communities and a multitude of recreational opportunities. Over the last ten years EWM densities have remained lower than pre-treatment levels while beneficial native plant densities have increased. During the last plan revision we wrote that, “Center Lake looks to be turning a corner although the challenge is increasing the beneficial native species”. As of this revision, Center Lake has especially benefited from the combination approach of expanding exotic plant treatments early in the spring and responsible harvesting throughout the year. Minimizing impacts to non-nuisance natives in both treatments and harvesting have led to increased plant frequency throughout the lake. Camp Lake had seen this dynamic by the last plan revision and is maintaining that during this current revision. Native plant densities remain healthy while many new species were found.

With the increasing demand for recreational opportunities by lake users, the CCLRD has demonstrated an ongoing effort to effectively manage the aquatic resources while providing for multiple use recreation on both lakes. In fact, the recreation on both lakes is no longer dictated by the growth of Eurasian water-milfoil and the ecosystems of each are continually moving toward a rehabilitated state. Moving forward, it is important to continue to educate land owners and lake users about the benefits of native plants and the detriments posed by non-natives. Figure 51 highlights overall management recommendations outlined in this plan revision.

Figure 51: Aquatic Plant Management Summary for Camp and Center Lakes

1. **Continue with Mechanical Harvesting Plan**
    - Limit excessive harvesting of EWM to prevent fragmentation
    - Cut excessive aquatic plant growth as determined by the "Weed Scout" (Operations Manager) through the use of "topping" (the practice of only cutting the top ¼ of the plant).
    - It is generally recommended that harvesting activities avoid fish spawning periods
    - For Camp Lake, avoid or limit cutting in the southern and southwestern ends of the lake corresponding with the water lily and soft stem bulrush beds (Figure 41).
    - For Center Lake, harvesting on the south and northeast ends should be optimized to "top" the nuisance coontail growth. Harvesting in lily beds along the northeastern shore should only be conducted for fishing and access channels. Avoid cutting the ecologically significant areas on the south end of the lake (Figure 45).
    - Harvesting should not be needed in water depths over 12' and should also not be performed in water less than three feet deep unless critical to channel navigation. Boating lanes should be approximately 50 – 70 feet wide while fishing channels should be 20 – 30 feet wide (Figure 42 and Figure 46).
    - Figure 43, Figure 44, and Figure 47 show the harvesting plant off-load sites, disposal site, and routes.
    - Manual raking can be continued for "floaters" along with a 30 foot area around private piers.
    - The "Harvesting Administrator" is responsible for satisfying the harvesting requirements of the APM Plan as well as fulfilling all the DNR permit requirements. This administrator will also submit copies of what is required by the DNR to the CCLRD Board for their annual meeting.

2. **Herbicide Treatment Recommendations**
    - Early season (May) treatment of EWM should be continued. See Figure 48 and Figure 49 for past treatment maps.
    - Small scale private shoreline treatments of EWM should target 3.5 ppm 2,4-D while larger scale mid-lake EWM treatments should target 2 ppm 2,4-D.
    - Whole lake 2,4-D treatment at 350 – 500 ppb or fluridone at 2 – 5 ppb should be explored on both lakes.
    - Purple loosestrife could be treated in August or September with glyphosate (hasn't been treated since 2011).
    - Monitor and collect data on effectiveness of the aquatic plant control measures each year via informal invasive species surveys. Present data at the CCLRD Annual Meeting.

3. **Lake Monitoring**
    - The Camp and Center Lake Rehabilitation District (CCLRD) should recruit citizen volunteers to implement Citizen Lake Monitoring for water quality and Aquatic Invasive Species (AIS) monitoring on each lake.
    - Continue with current turnover water sampling via private consultant.
    - Follow the Rapid Response Plan in previous APM Plan for any new aquatic species not previously found on the waterbody.
    - Continue with P/I Surveys every 5 years (or sooner if needed) to evaluate efficacy and environmental impact of aquatic plant management activities.

4. **Watershed Practices**
    - The CCLRD should continue to educate property owners about watershed best management practices to reduce nutrient inputs to the lakes.
    - Muskgrass (Chara spp.) should continue to be transplanted in areas of the lake with high non-native species densities under the direction of the Operations Manager, Harvesting Administrator, Lake Consultant, and the WDNR.

Lake and Pond Solutions Co. (2016)

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