KIESER & ASSOCIATES
ENVIRONMENTAL SCIENCE & ENGINEERING

A Summary of Findings from LakeScan™
Guided Surveys and Analysis of:

Cedar Lake South

Iosco County

2022 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

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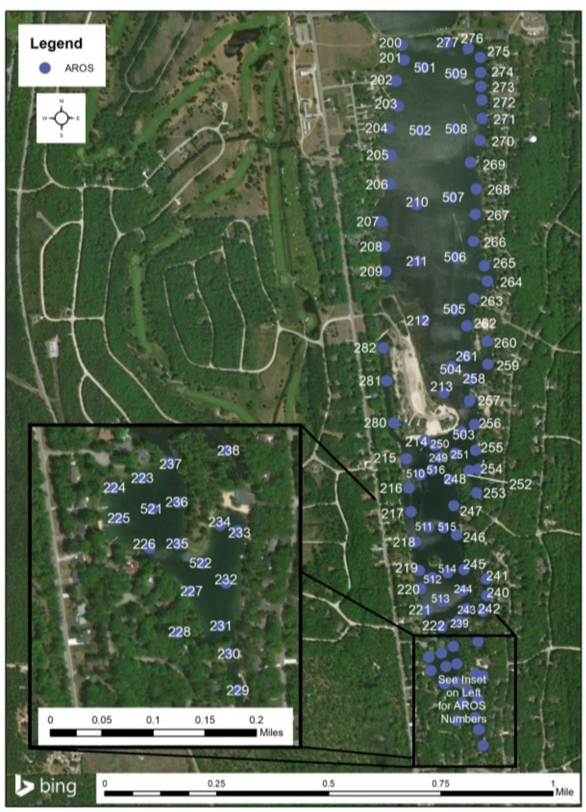

LakeScan™

Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on Cedar Lake South (Iosco County, MI) during the summer of 2022 using LakeScan™ assessment methods with the support of Doug Pullman of Aquest. The purpose of these efforts was to assess aquatic vegetation during the summer recreational season in the context of nuisance conditions and management needs/outcomes. LakeScan™ methods combine detailed field data collection with mapping capabilities and whole-lake analyses based on established scientific metrics to score various lake conditions. This approach allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical planning information necessary for improving the lake's ecological and recreational conditions.

Cedar Lake South averaged scores from early-season and late-season LakeScan™ 2022 surveys are summarized in Table ES - 1.[1] Results indicate scores meeting management goals set for all LakeScan™ analysis metrics. These scores indicate a diverse plant community harboring good habitat for fish and macroinvertebrates. The high Floristic Quality Index score indicates a higher distribution of desirable, native plant species and a lower distribution of undesirable species, such as Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM). Recreational Nuisance Presence also met management goals, suggesting that in 2022 very few problematic aquatic plant conditions were present in this southern portion of Cedar Lake. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the low proportion of agricultural and urban land use draining to the lake.

Table ES-1 – Summary of lake analysis metrics.

LakeScan™ Metrics	2022 Average	Management Goal
Species Richness	23.0	n/a
Shannon Biodiversity Index	10.2	> 8.4
Shannon Morphology Index	7.3	> 6.0
Floristic Quality Index	27.3	> 20
Recreational Nuisance Presence	1%	< 10%
Algal Bloom Risk	Low	Low

The Cedar Lake South early-season LakeScan™ vegetation survey was conducted over the course of two days; the afternoon of Wednesday, July 13, 2022 and the morning of Thursday, July 14, 2022. The most common native species observed during the early-season survey include variable pondweed, Illinois pondweed (*Potamogeton Illinoensis*), Richardson's pondweed (*Potamogeton richardsonii*), sago

[1] See LakeScan™ Metrics section for a more detailed explanation of these management indices.

pondweed (*Stuckenia pectinata*), and *Chara* (*Chara sp.*) Eurasian watermilfoil was the only aquatic invasive species observed during the survey. In the past, a small population of starry stonewort (*Nitellopsis obtusa*; SSW) has occasionally been observed in South Cedar Lake; however, no observations of this species were made during the early-season survey.

The late-season LakeScan™ vegetation survey on Cedar Lake South was conducted over the course of two days; Tuesday, September 20, 2022 and Wednesday, September 21, 2022. *Chara*, naiad (*Najas sp.*), Illinois pondweed, Richardson's pondweed, and variable pondweed were the most dominant native species observed during the late-season survey. Aquatic invasive species (AIS) observed during this survey included Eurasian watermilfoil and starry stonewort. The latter AIS was not observed in 2021.

For this report, K&A also analyzed the past 5 years of LakeScan™ data for invasive species coverage (Figure ES -1). Cedar Lake South's coverage of Eurasian watermilfoil has exhibited a slight increasing trend and starry stonewort has exhibited a slightly decreasing trend over the last five years. In 2022, starry stonewort was only observed during the late-season survey at low abundances. Despite the increasing trend of EWM, coverage in 2022 was the lowest observed since 2019. Variable-leaf (native) watermilfoil (*Myriophyllum heterophyllum*; VWM) coverage has decreased over the last five years, suggesting that management activities have suppressed growth for this particular species.

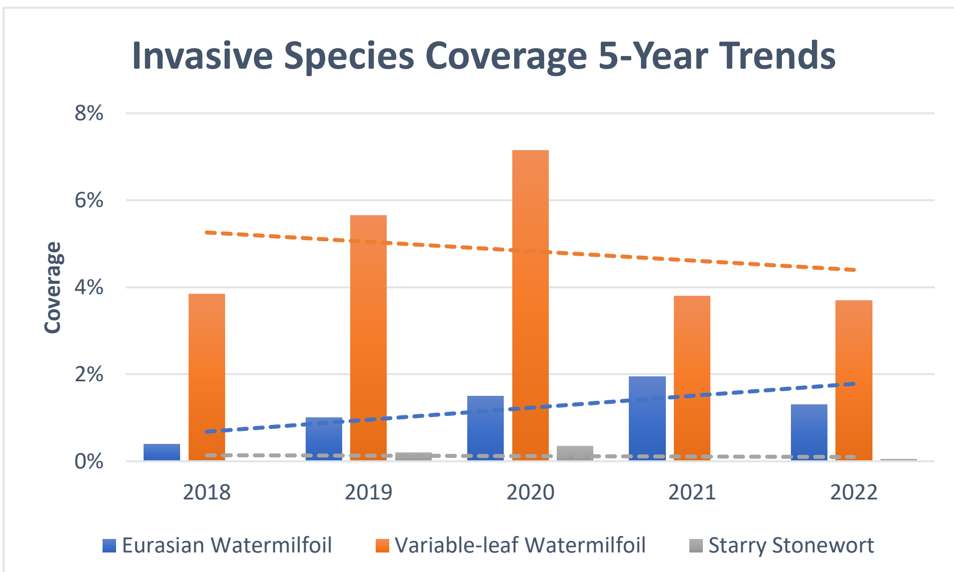

Figure ES-1 – Invasive and nuissance species coverage 5-year trends.

Based on 2022 findings, K&A recommends the following management considerations for 2023:

- **Continued Eurasian watermilfoil management is recommended**. The trend in percent coverage of Eurasian watermilfoil over the past 5-year has slightly increased, though current management activities still appear to be suppressing its growth.
- **K&A suggests considering a combined mananagement approrach of physical and chemical** management techniques to reach even lower populaions of Eurasian watermilfoil and other target species. Due to EGLE's restrictions on chemical usage within Cedar Lake, it may be beneficial to utilize diver assisted suction harvesting (DASH) to remove nuisance species. DASH management has shown positive results for controlling and reducing aquatic invasive species

populations. Utilizing DASH in targetted areas could allow for management during times when chemical applications are restricted, potentially further reducing Eurasian watermilfoil populations. Manual physical removal of the limited starry stonewort observation in late summer could provide a reasonable alternative for control as EGLE copper-based algaecide restrictions become more imposing, particularly with the 2022 confirmed presence of the endangered Eastern pondmussel, *Sagittunio nasutus* (originally referred to as, *Ligumia nasuta*).

- **K&A recommends consideration of harvesting be explored to control native plant nuisance conditions.** Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake South. Locations that received the September 2020 treatment did, however, still appear to have suppressed variable watermilfoil growth. These observations suggest that the chemical treatment of variable-leaf watermilfoil was successful. Because EGLE restricts chemical applications to treat native aquatic plant nuisance conditions, chemical treatment of natives may continue to become more difficult. Management strategies such as aquatic weed harvesting could help to alleviate native plant nuisance conditions as chemical usage becomes more restricted.
- **Continued LakeScan™ vegetation monitoring twice a year** (once during the spring-early summer and another during the late summer) to assess aquatic vegetation during the growing season is recommended. Information collected during these surveys allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical information necessary to improve the lake's ecological and recreational conditions.

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1.0. Introduction

Inland lakes are complex systems, and managing them for both ecological health and recreational enjoyment involves balancing goals that are sometimes at odds with one another. Successful lake management requires a solid understanding of a lake's current ecological and recreational conditions, as well as how those conditions are changing over time. The LakeScan™ program combines a detailed data collection methodology with mapping capabilities and whole-lake analysis metrics backed by scientific literature. This analysis allows lake managers to identify successful lake management activities, as well as highlight potential issues requiring intervention. Appropriately targeted aquatic plant suppression can minimize weedy and nuisance species while allowing beneficial species to flourish at ecologically balanced levels supporting healthy lake conditions. This kind of adaptive management system provides a scientifically sound and consistent methodology to better manage a lake's ecological and recreational conditions.

The LakeScan™ analysis involves collecting data over two vegetation surveys during the critical summer recreational season. These surveys are based on a system where the lake is first divided into biological tiers (see Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS; see Figure 1). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species in each AROS, as well as noting any nuisance conditions. Dissolved oxygen profiles and temperature profiles as well as Secchi depth are additionally recorded. Other water quality sampling can be included with surveys when requested.

Aquatic plant communities change over the course of a year, so the surveys are split into early and late season observations. Early season surveys are scheduled with the goal of taking place within 10 days of early summer treatments to best observe treatment-targeted and non-targeted vegetation. However, this scheduling is subject to weather and times of increased boat activity.

Table 1 – Biological Tier Descriptions.

Tier*	Description
2	Emergent Wetland
3	Near Shore
4	Off Shore
5	Off Shore, Drop-Off
6	Canals
7	Around Islands and Sandbars
9	Off Shore Island Drop-Off

*Tiers 1 and 8 are reserved for future use.

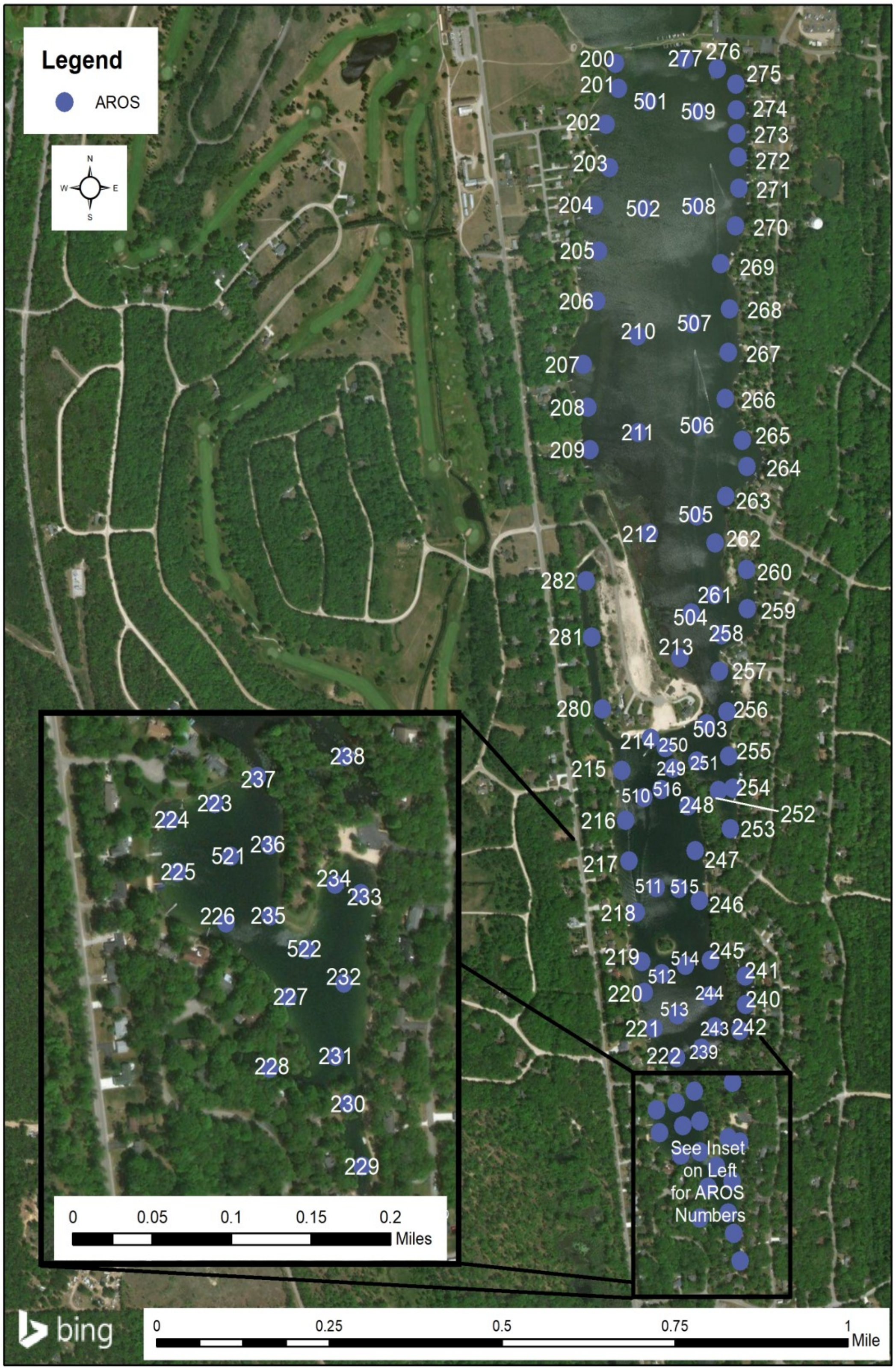

Figure 1 - Map of Aquatic Resource Observation Sites (AROS).

The following sections describe the lake and watershed characteristics, field water quality measurements, results of the aquatic vegetation surveys, and aquatic vegetation management activities and recommendations for Cedar Lake South using LakeScan™ methods.

2.0. Lake and Watershed Characteristics

This section provides a brief overview of physical and geopolitical characteristics of the lake and its watershed.

Location

County: Iosco

Township: Oscoda

Township/Range/Section(s): T25N, R9E Sections: 3 & 10

GPS Coordinates: N 44°29.79996' W 83°20.04684

Morphometry

Total Area: 78 acres

Shoreline Length: 20,583 feet

Maximum Depth: 12 feet

Watershed Factors

Tributaries: None: Limited to no residential property runoff

Outlet type: Channel at northern end of Cedar Lake South connecting it to Cedar Lake North

Administrative Management

Management Authority: Cedar Lake Improvement Board

Years in LakeScan™ Program: 2003 to Present

2.1. Algal Bloom Risk Level

K&A calculates an algal bloom risk level for each LakeScan™ lake based on the characteristics of its watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grasslands or forested land uses; phosphorus being the limiting nutrient that drives algal blooms. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms. Not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs). It is important to note that the risk factor reported here is based on a limited watershed analysis. Lakes at high risk of algal blooms should consider more in-depth studies that can identify possible watershed or in-lake improvements to mitigate the risk of HABs.

The algal bloom risk for Cedar Lake South is: **Low**

3.0. Water Quality

Secchi depth, dissolved oxygen and temperature data were collected during each vegetation survey. Data are shown in Figures 2 and 3 for early and late season surveys, respectively. Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[2] Secchi depths in 2022 were to the lake bottom.

A sufficient supply of dissolved oxygen (DO) in lake water is necessary for most forms of desirable aquatic life. Colder waters contain more dissolved oxygen than warmer waters. Oxygen depletion can occur in deeper, unmixed bottom waters during warmer summer months in highly productive lakes. Increased algal growth associated with additional nutrients in the lake can lead to severe decreases in DO in lake bottom waters. This decrease in oxygen is due in part to dead algae and other organic matter, such as leaves, grass and other plant debris washed in from shoreline lawns and storm drains settling to the bottom of the lake. This organic matter is then consumed along with oxygen by organisms in the sediment. DO depletion is most often observed in lake bottom waters during periods of temperature stratification in warmer summer months and, to a lesser degree, under winter ice cover conditions. In Cedar Lake South, temperatures and dissolved oxygen levels were generally uniform from surface to bottom.

Dissolved oxygen levels and temperature were measured by K&A using a YSI ProODO dissolved oxygen meter, calibrated prior to use. Michigan water quality standards for surface waters designated for warm water fish and aquatic life call for a DO of at least 5 mg/L.[3] Temperature and DO concentrations stayed relatively uniform through the water column during both the early and late-season surveys (Figures 2 and 3). Both parameter concentrations were optimal conditions to support desirable fish populations and aquatic life.

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[2] US Geological Survey. 2012. "Water Quality Characteristics of Michigan's Inland Lakes, 2001-10." Scientific Investigations Report 2011–5233. Available online at: https://pubs.usgs.gov/sir/2011/5233/.

[3] Michigan Department of Environmental Quality. 2006. "Part 4-Water Quality Standards." Water Bureau, Water Resources Protection. Available online at: https://www.michigan.gov/documents/deq/wrd-rules-part4_521508_7.pdf.

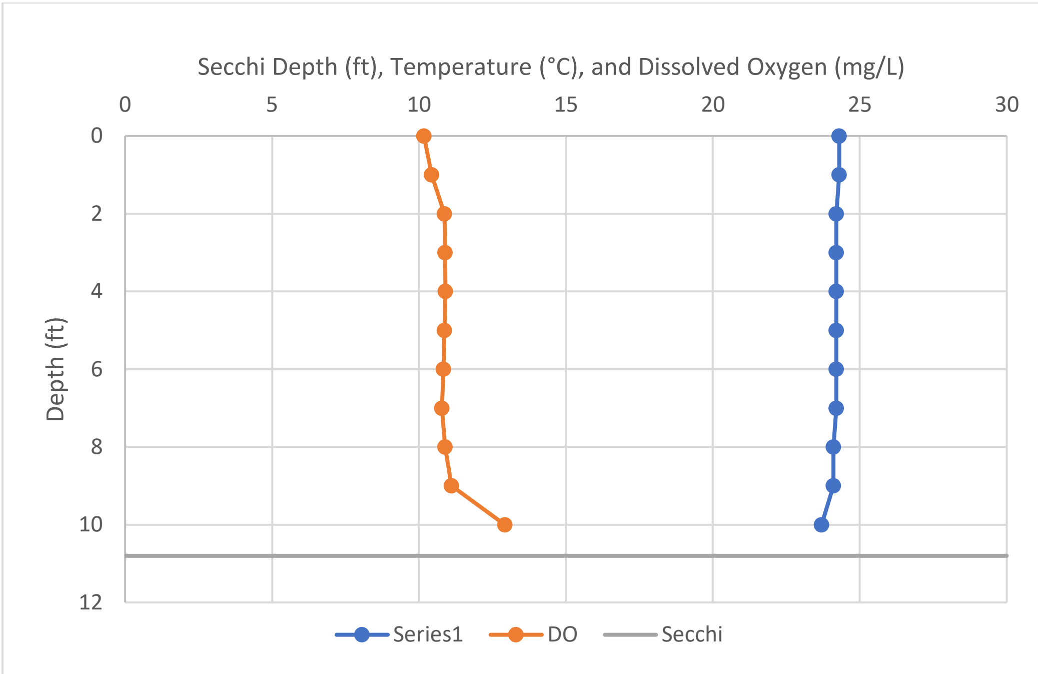

Figure 2 - Early season survey (July 13-14, 2022) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake.

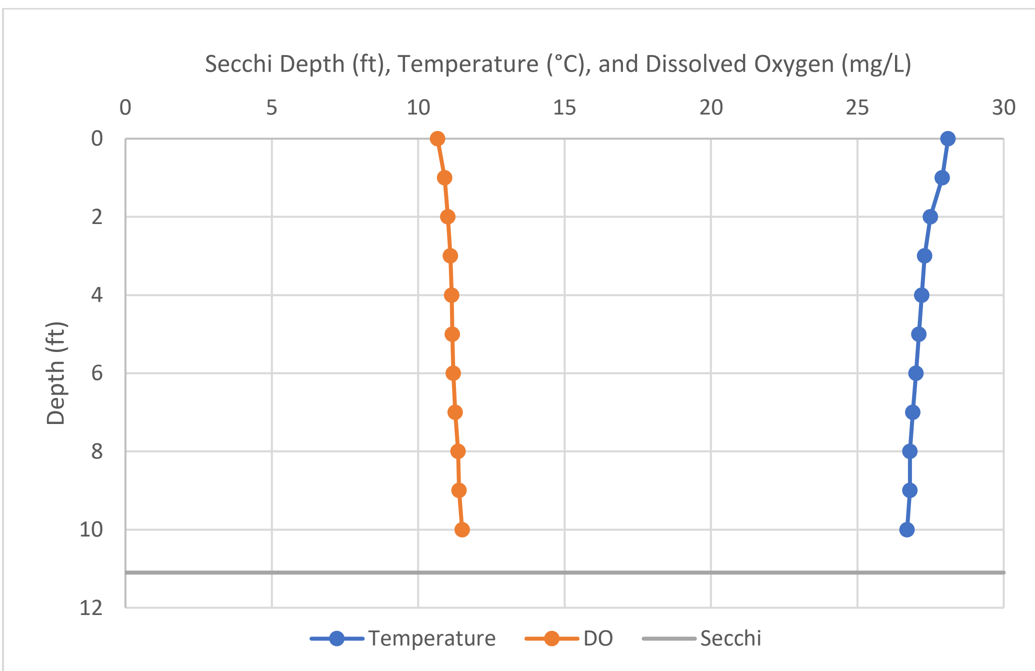

Figure 3 - Late season survey (September 20-21, 2022) dissolved oxygen and temperature profiles with Secchi depth, taken at the deepest point in the lake.

4.0. Aquatic Vegetation

This section details findings from the two vegetation surveys that were conducted on the lake in 2022. This includes observations, aquatic vegetation mapping, and LakeScan™ analysis metrics.

4.1. Early-Season Survey

The Cedar Lake South early-season LakeScan™ vegetation survey was conducted on the afternoon of Wednesday, July 13 and the morning of Thursday, July 14, 2022. Wednesday afternoon was partly cloudy and sunny with a high of 75°F and 10mph northeast winds. Thursday morning had sunny weather conditions with temperatures reaching 76°F and low north winds at 5mph. Visibility through the water column was excellent with a Secchi disk depth reading of 11.2ft. Figure 4 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations of all species observed on Cedar Lake South during the early-season survey. Color-coding is provided for each AROS that helps to spatially depict observed vegetation data. The colors range from dark blue which depicts no vegetation observed, to yellow depicting medium density and distribution of plant species, to red which depicts high density and distribution of vegetation within the AROS.

The most common native species observed in Cedar Lake South were similar to those found in Cedar Lake North. Variable pondweed (*Potamogeton gramineus)*, Illinois pondweed (*Potamogeton Illinoensis*), Richardson's pondweed (*Potamogeton richardsonii*), sago pondweed (*Stuckenia pectinanta*), and *Chara* (*Chara sp.*) were the most common native species observed at the time of the survey. Variable milfoil (*Myiophyllum heterophyllum;* VWM) was also present, but less abundant in South Cedar compared to North Cedar. Variable-leaf watermilfoil was observed at low densities and only a total of ten observations were made (Figure 5; AROS 206-209, 269, 273-277, & 502). Emergent species were much more dominant in South Cedar compared to North Cedar. White water-lily (*Nymphaea odorata*) and spadderdock (*Nuphar advena*) were often observed exhibiting high densities in the canals and nearshore, but did not appear to be recreational or navigational nuisances. Variable and Illinois pondweed did occasionally reach the surface of the water along the north eastern shoreline, which could be perceived as a nuisance (AROS 251-277).

Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM) was the only aquatic invasive species observed during the survey. EWM was primarily found within the southernmost half of South Cedar (Figure 6). Most areas with EWM exhibited low to moderate growth. However, one area did exhibit high densities and nuisance growth of EWM (AROS 217, 510, 511, 515, & 516). Herbicide treatments on June 22, 2022 did target this location (Appendix C; Figure C1). K&A staff noted that EWM in this area appeared to show signs of wilting at the time of the survey. However, abundances and densities of EWM at this location were still substantial and growing high into the water column (<2-feet below the surface).

Seasonal presence of starry stonewort (*Nitellopsis obtusa*; SSW) has been observed sporadically in South Cedar since 2018; a small patch was found during the pre-season survey in May (AROS 254-256). However, the species was not observed during the early-season (July) survey. *Chara* and native pondweed growth in this area had increased since the pre-season survey in May, likely outcompeting starry in previously observed areas.

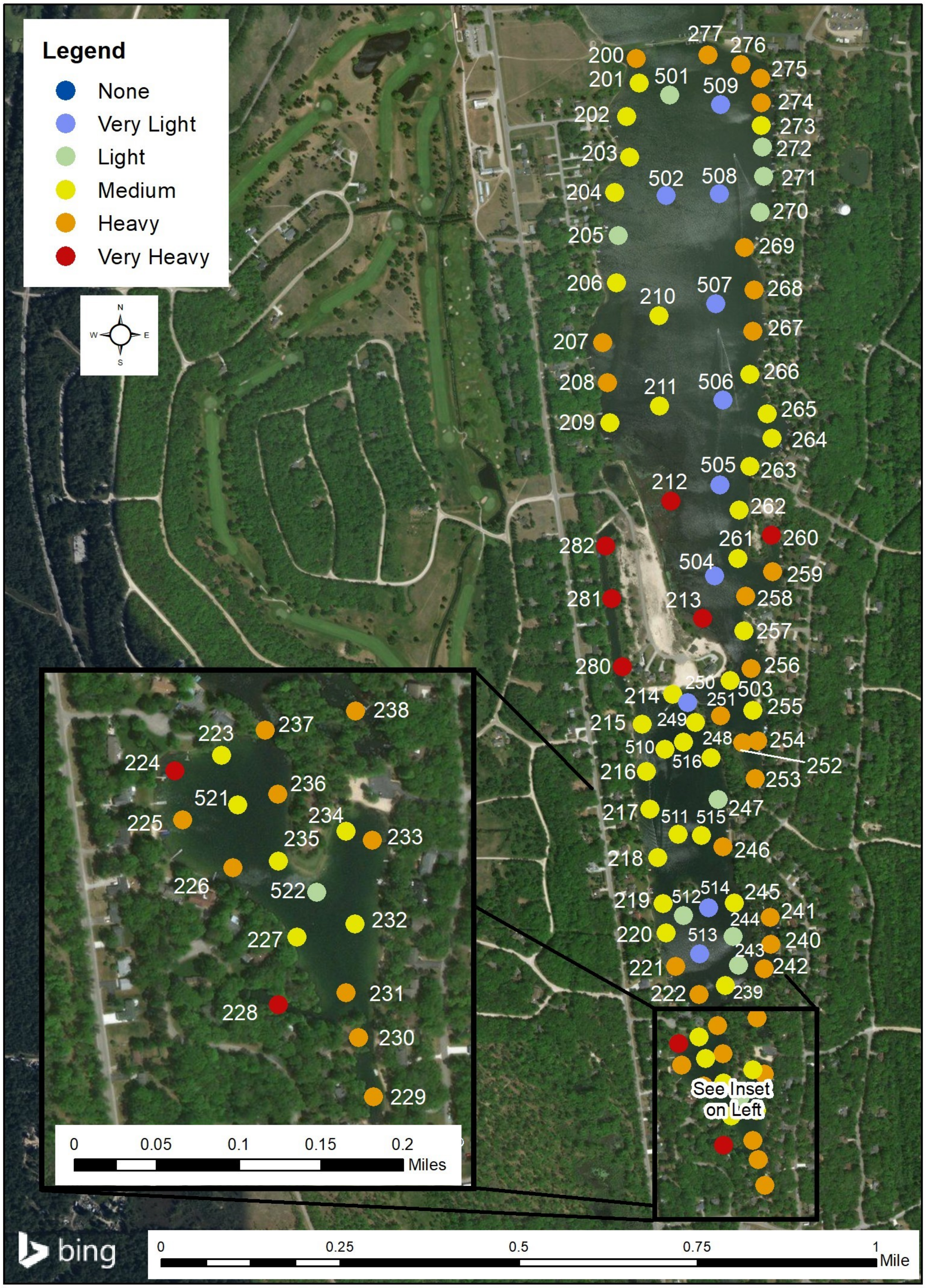

Figure 4 - Early season survey (July 13-14, 2022) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

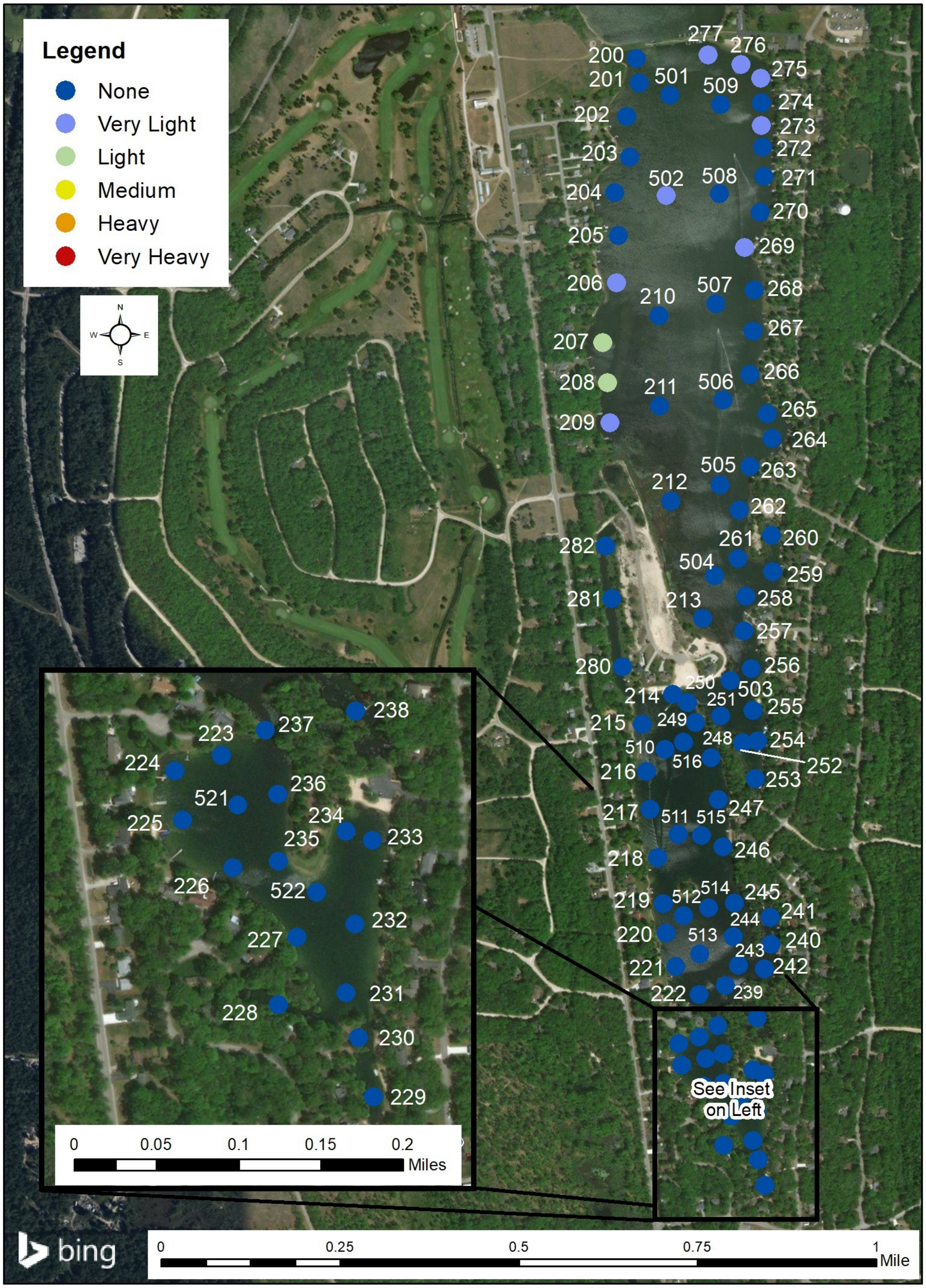

Figure 5 - Early season (July 13-14, 2022) Variable-leaf pondweed coverage.

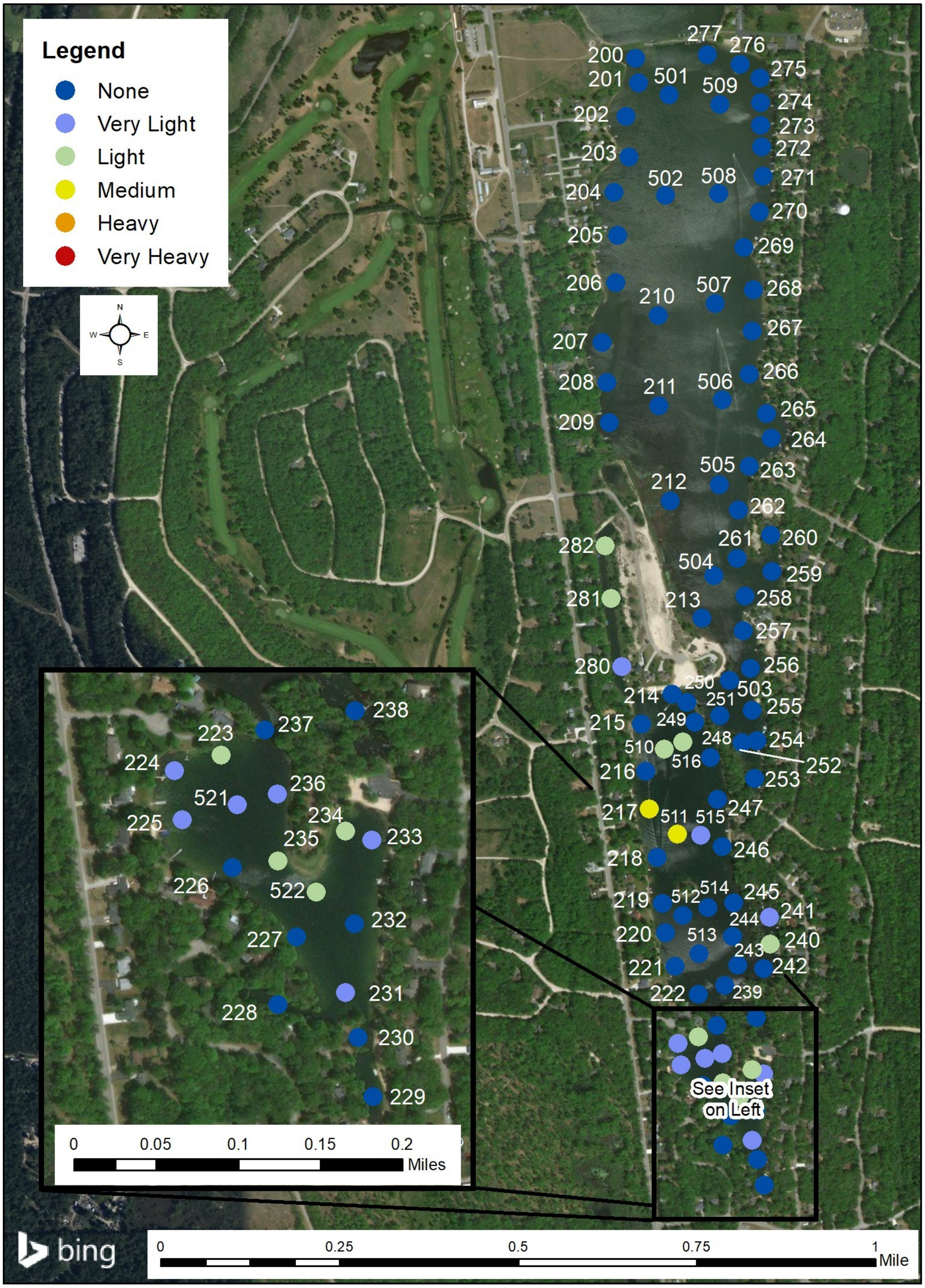

Figure 6 - Early season (July 13-14, 2022) Eurasian Watermilfoil and Hybrids coverage.

4.2. Late-Season Survey

The Cedar Lake South late-season LakeScan™ survey was partially conducted on Tuesday, September 20, 2022 and completed the following morning of Wednesday, September 21. Weather throughout the survey was sunny with a light south wind. Visibility through the water column was good with a Secchi disk depth of 11.2 feet. Figure 7 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution and height observations of all species observed on Cedar Lake South during the late-season survey.

Chara, naiad (*Najas sp.*), Illinois pondweed, Richardson's pondweed, and variable pondweed were the most dominant native species observed during the late-season survey. South Cedar Lake showed improved conditions relative to those observed during the early-season survey. Native nuisance conditions exhibited by variable pondweed, Illinois pondweed, and wild celery (*Vallisneria americana*) had greatly improved and variable-leaf watermilfoil populations decreased substantially (Figure 8). The most notable areas of improvement included the channel near Shoreview Dr (AROS 280-282) and AROS 259-260 which had previously been topped-out with a variety of native and invasive plant species. Moderately dense and topped-out native pondweed growth was observed along the northeast shoreline (AROS 268-277), although it was deemed unlikely that recreational or navigational activity will be hindered.

Invasive species observed in Cedar Lake South during the late season LakeScan™ survey included starry stonewort (*Nitellopsis obtusa*) and Eurasian watermilfoil (*Myriophyllum spicatum*). During the late-season survey, starry stonewort was observed for the first time since 2020. Starry stonewort was detected in the same location it had been found previously, AROS 256 (Figure 9). The small patch of starry stonewort was mixed with a variety of other native species such that it is not causing any ecological or recreational harm to the native plant community. However, this area of Cedar Lake South should continue to be monitored closely for any observations of starry stonewort gaining an advantage over the native species present.

The presence of Eurasian watermilfoil has improved in Cedar Lake South. EWM was only observed at low densities within six AROS following the treatment in early September (Figure 10; AROS 281-282, 216-217, and 510-511). Compared to the early-survey, EWM densities had diminished, suggesting that late-season herbicide treatments successfully controlled the Eurasian watermilfoil population (Appendix C; Figure C2).

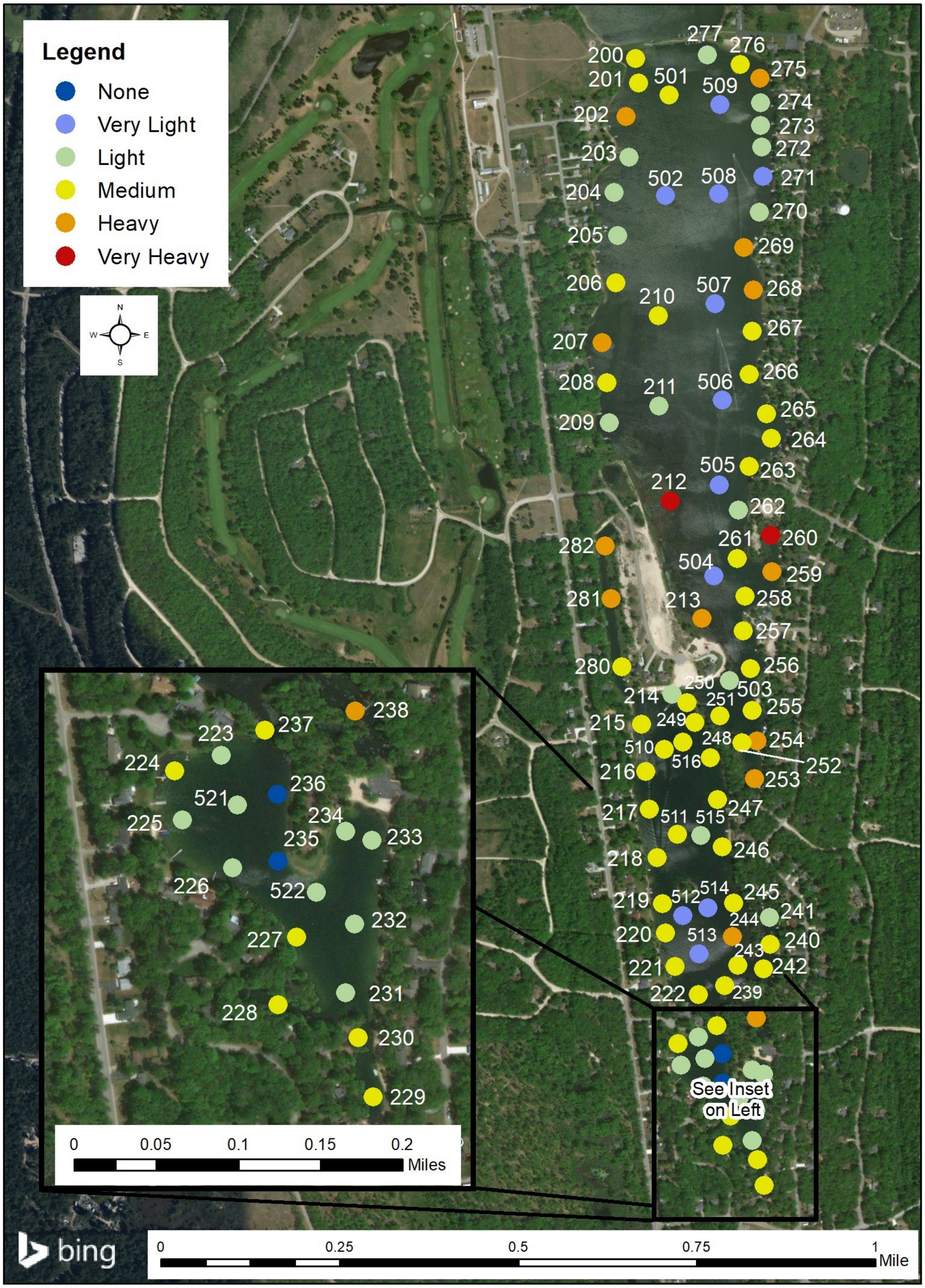

Figure 7 - Late season survey (September 20-21, 2022) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

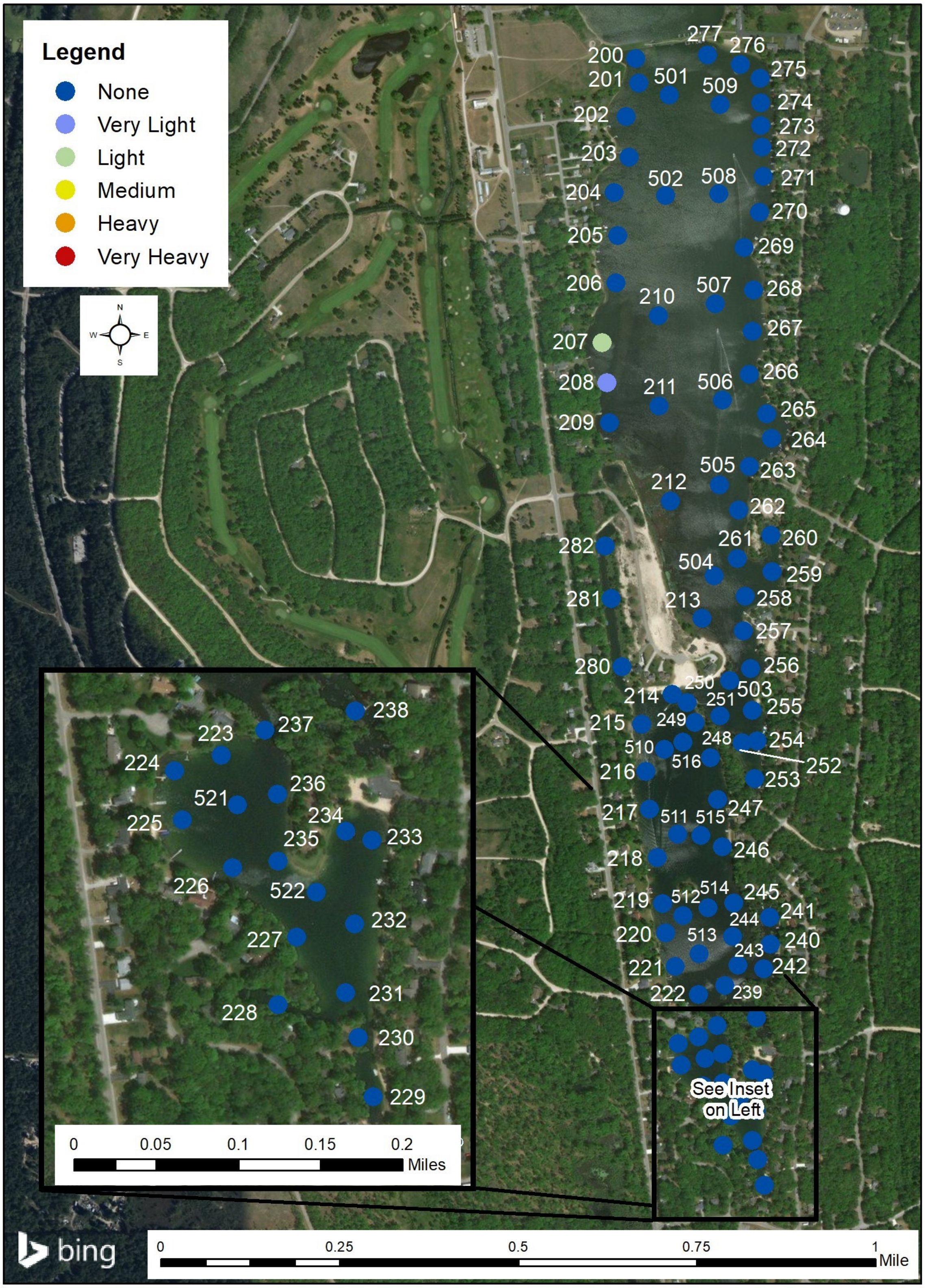

Figure 8 – Late season (September 20-21, 2022) Variable-leaf Watermilfoil coverage.

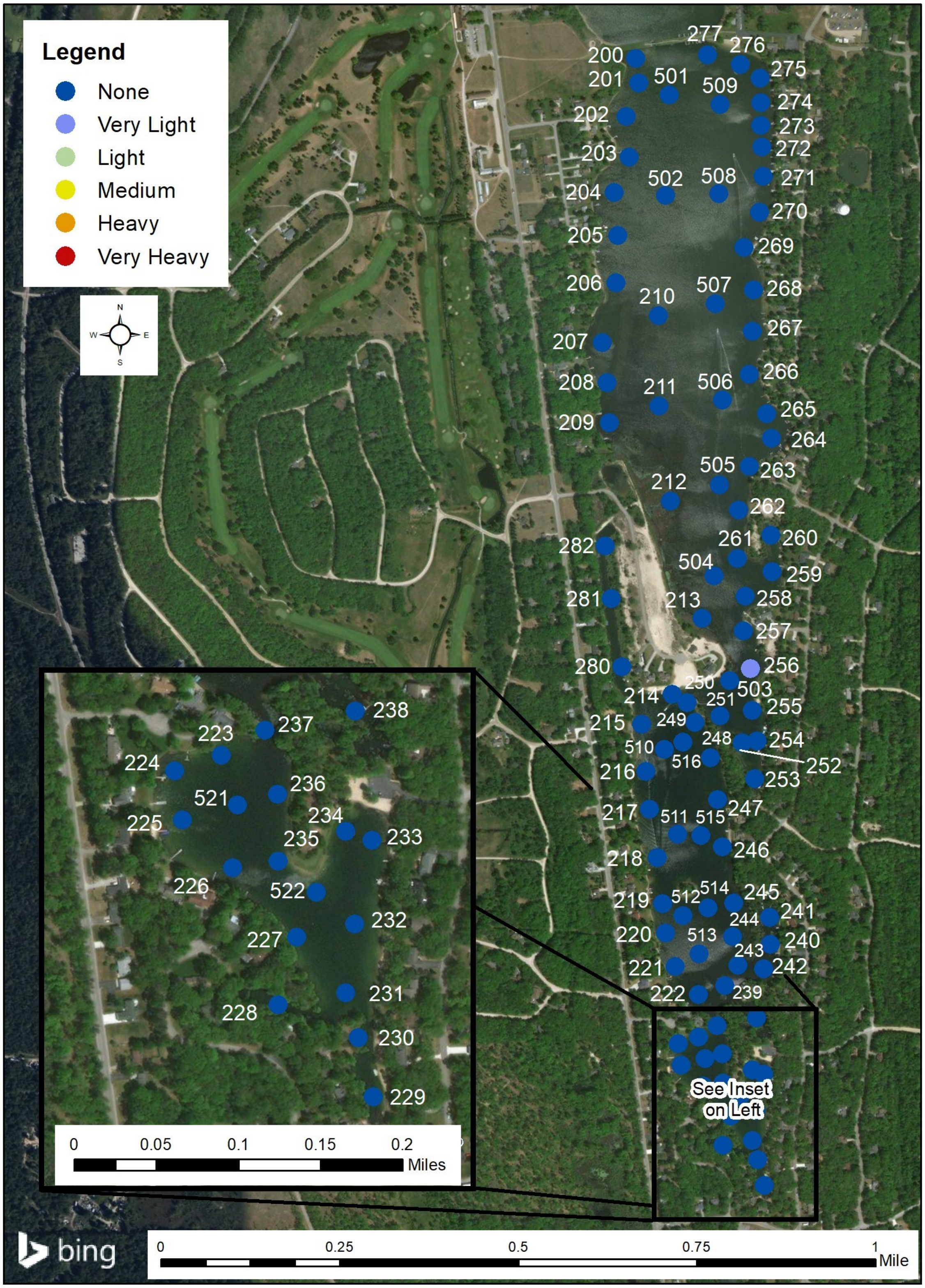

Figure 9 - Late season (September 20-21, 2022) Starry Stonewort coverage.

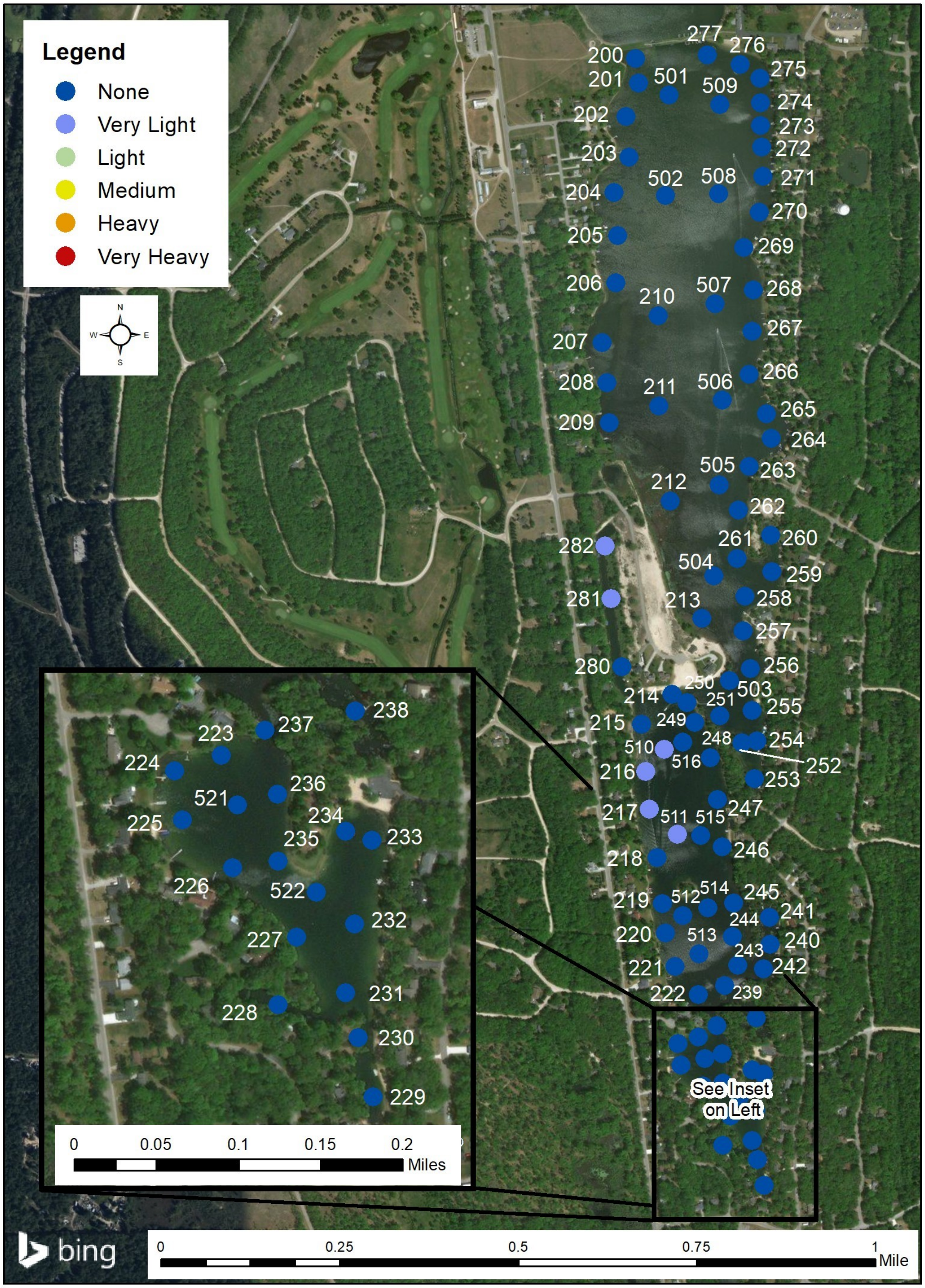

Figure 10 - Late season (September 20-21, 2022) Eurasian Watermilfoil coverage.

4.3. Summary Observations for Early & Late Surveys

Aquatic plant species observed during the 2022 vegetation surveys are identified in Table 2. The 'T Value' in this table is a qualitative value ranging from 1 to 4 that is assigned to each species, where 1 represents an undesirable species highly likely to require treatment and 4 represents a desirable species highly unlikely to require treatment (thus, 1 is 'bad'; 4 is 'good'). 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Coverage' represents the lake bottom spatial cover observed for each species, represented as a percentage of available area. 'Dominance' represents the degree to which a species is more numerous than its competitors. Figure 11 illustrates dominance by T Value categories for early and late season surveys over the last few years.

Table 2- Aquatic Plant Species Observed in 2022.

Common Name	T Value	Frequency		Coverage		Dominance	
		Early '22	Late '22	Early '22	Late '22	Early '22	Late '22
American Pondweed	3	5.1%	0.0%	0.5%	0.0%	0.6%	0.0%
Cattail	3	14.1%	10.1%	1.1%	1.0%	1.4%	1.6%
Chara	4	96.0%	93.9%	15.8%	16.2%	19.7%	25.3%
Clasping-leaf Pondweed	3	8.1%	7.1%	0.7%	0.7%	0.9%	1.1%
Common Bladderwort	3	6.1%	1.0%	0.4%	0.1%	0.5%	0.1%
Elodea	3	3.0%	0.0%	0.2%	0.0%	0.2%	0.0%
Eurasian Watermilfoil Hybrid	1	20.2%	6.1%	2.2%	0.4%	2.8%	0.6%
Flat Stem Pondweed	3	9.1%	0.0%	1.8%	0.0%	2.2%	0.0%
Floating Leaf Pondweed	3	2.0%	0.0%	0.1%	0.0%	0.2%	0.0%
Green/Variable Watermilfoil	2	10.1%	2.0%	0.8%	0.2%	0.9%	0.3%
Illinois Pondweed	3	79.8%	46.5%	17.7%	3.7%	22.1%	5.8%
Naiad	2	48.5%	74.7%	4.2%	7.2%	5.3%	11.3%
Pickerelweed	3	4.0%	3.0%	0.7%	0.3%	0.9%	0.4%
Purple Loosestrife (sub)	1	2.0%	0.0%	0.1%	0.0%	0.2%	0.0%
Richardson's Pondweed	2	52.5%	39.4%	7.7%	2.7%	9.6%	4.2%
Rush	4	41.4%	28.3%	3.3%	2.3%	4.2%	3.7%
Sago Pondweed	2	18.2%	12.1%	3.5%	0.9%	4.4%	1.4%
Small Pondweed	4	2.0%	0.0%	0.1%	0.0%	0.2%	0.0%
Spadderdock	2	6.1%	8.1%	1.1%	0.6%	1.4%	1.0%
Starry Stonewort	1	0.0%	1.0%	0.0%	0.1%	0.0%	0.1%
Thin-leaf Pondweed	4	14.1%	0.0%	1.8%	0.0%	2.3%	0.0%
Variable Pondweed	2	43.4%	85.9%	4.0%	16.0%	5.0%	25.0%
Watershield	3	3.0%	2.0%	0.4%	0.1%	0.5%	0.2%
Water Stargrass	2	3.0%	2.0%	0.2%	0.3%	0.2%	0.4%
White Water-lily	2	50.5%	46.5%	9.7%	6.4%	12.0%	10.1%
White-stem Pondweed	3	11.1%	1.0%	0.8%	0.1%	0.9%	0.1%
Wild Celery	2	17.2%	43.4%	1.2%	4.8%	1.5%	7.5%

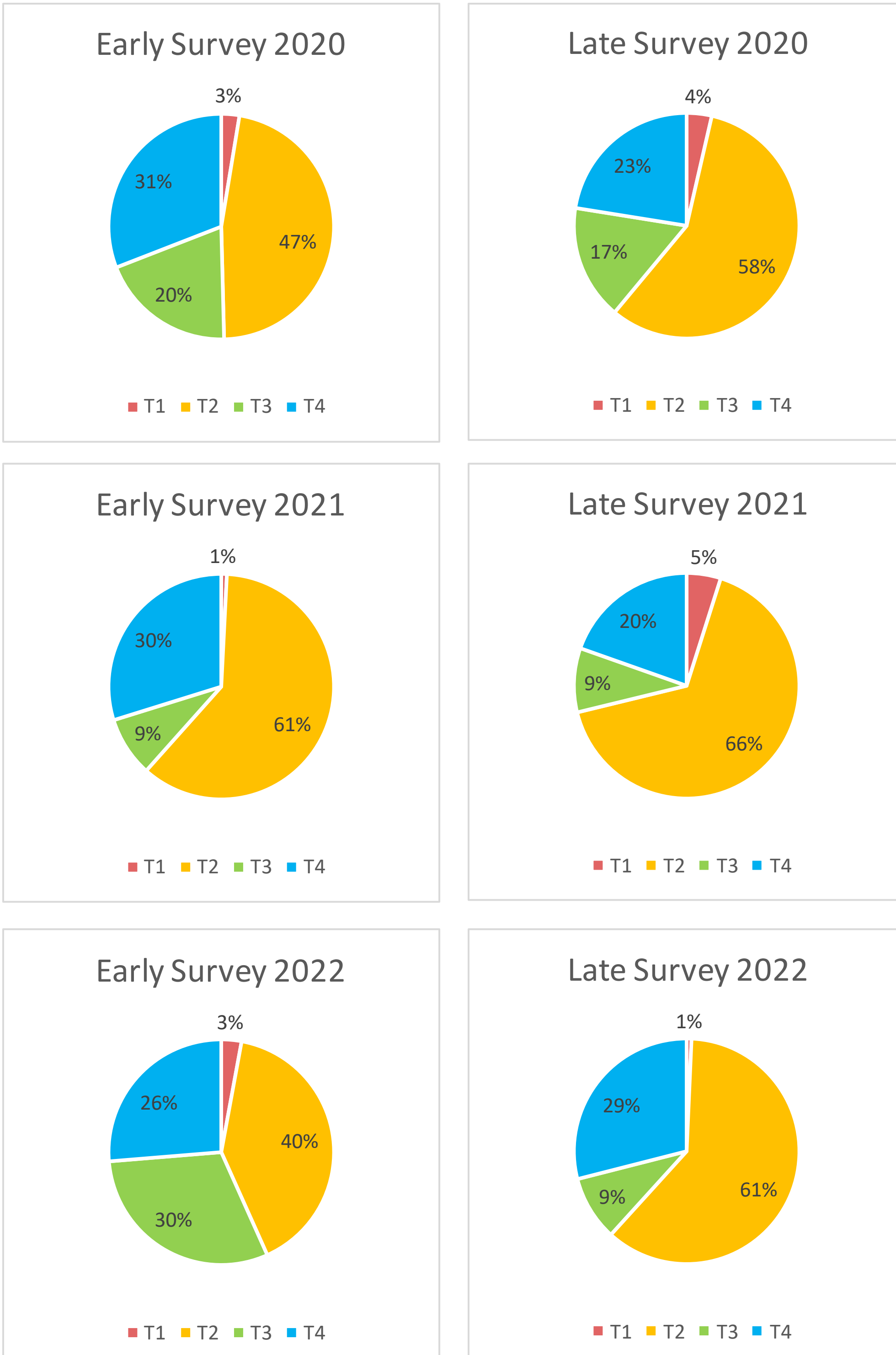

Figure 11 - Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2020 – 2022.

4.4. LakeScan^{TM} Metrics

Six important metrics for defining lake conditions are presented here for the 2022 vegetation surveys (Table 3). Early and late season scores are averaged for a yearly score and compared against a management goal for each metric. Management goals are based on median Michigan lake values (Shannon Biodiversity Index and Shannon Morphology Index), scientific literature (Floristic Quality Index), and professional judgement (Recreational Nuisance Presence and Algal Bloom Risk). Green shading in Table 3 highlights scores meeting management goals, while yellow and red highlights represent scores needing improvement. A total lake score[4] is presented with 1 being poor and 10 being excellent. Descriptions of each metric are as follows:

- **Species Richness** – the number of aquatic plant species present in the lake. (More species are generally indicative of a healthier ecosystem, but not all species are desirable.)
- **Shannon Biodiversity Index** – a measure of aquatic plant species diversity and distribution evenness, indicative of the plant community's stability and diversity. (Also known as the Shannon Expected Number of Species[5].)
- **Shannon Morphology Index** – a measure of aquatic plant morphology type diversity and distribution evenness, indicative of fish and macroinvertebrate habitat quality. (This is calculated using morphology types instead of species.)
- **Floristic Quality Index[6]** – a measure of the distribution of desirable aquatic plants. (This index is used by Midwestern states for aquatic habitats, with higher scores indicative of increased biodiversity and a positive ratio of desirable versus undesirable aquatic plant species.)
- **Recreational Nuisance Presence** – the percentage of survey sites that identified aquatic plants inhibiting recreational activities. (Areas where any vegetation is growing densely enough to inhibit boating and/or swimming.)
- **Algal Bloom Risk** – a calculated algal bloom risk level based on the characteristics of the lake's watershed. (Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms because these land uses contribute more phosphorus to receiving waters than grasslands or forests.)

[4] A total lake score is a summary of the category scores where: "red" scores receive 0 points, "yellow" scores receive 1 point, and "green" scores receive 2 points. The Floristic Quality Index is double-weighted, and the total is then refit to a 1 to 10 scale for more simplified scaling and interpretation of the overall lake condition.

[5] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.

[6] Nichols, S. A. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Lake and Reservoir Management*, 15(2), 133-141.

Table 3 – 2022 LakeScan™ Metric Results.

LakeScan™ Metrics	Score Range	2022 Early Season	2022 Late Season	2022 Average	Management Goal
Species Richness	5 - 30	26	20	23	n/a
Shannon Biodiversity Index	1 -15	11.9	8.4	10.2	> 8.4
Shannon Morphology Index	1 - 10	8.1	6.4	7.3	> 6.0
Floristic Quality Index	1 - 40	28.2	26.4	27.3	> 20
Recreational Nuisance Presence	0 - 100%	0%	1%	1%	< 10%
Algal Bloom Risk	Low - High	n/a	n/a	Low	Low
Total Lake Score	1 - 10	n/a	n/a	10.0	n/a

*n/a = not applicable

Cedar Lake South scores met management goals set for all LakeScan™ analysis metrics. The Shannon scores indicate a diverse plant community harboring good habitat for fish and macroinvertebrates. The consistently high Floristic Quality Index results indicate a higher distribution of desirable, native plant species and a lower distribution of undesirable species, such as Eurasian watermilfoil. Recreational Nuisance Presence met optimal management goals of less than 10% during both the early and late-season surveys, and was considerably lower than previous years. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the low proportion of agricultural and urban land use draining to the lake. The overall total lake score for Cedar Lake South is 10 out of 10.

The 5-year historical trends for Floristic Quality Index (FQI) scores and invasive species coverage values are presented in Figures 12 and 13, respectively. Trendlines shown are calculated using Microsoft Excel's linear trendline function. Positive trends for the FQI scores indicate increases in desirable plant species and/or decreases in undesirable plant species. Negative trends for the invasive species coverage values indicate that herbicide treatment and other lake management activities are showing success.

Over the last five years, the FQI score for Cedar Lake South has exhibited a positive trend, which indicates an increase in desirable, native plant species and a decrease in undesirable, non-native plant species (Figure 12). For the last five years, Cedar Lake South's FQI score exceeded the management goal of 20. Furthermore, Cedar Lake South's invasive species coverage of Eurasian watermilfoil has only exhibited a slight increasing trend while starry stonewort has exhibited a generally decreasing 5-year trend, with no starry stonewort observed during the 2022 early-season survey and very low densities observed during the late-season survey. This suggests that management activities are suppressing invasive species populations and negating population expansion, since no significant increases have been observed. Additionally, the native species, variable-leaf watermilfoil, has had decreasing coverage over the last five years (Figure 13), suggesting that management activities have also suppressed the growth for this particular species as well. However, prior to 2020, variable-leaf watermilfoil coverage was increasing year-over-year, prompting treatment during September of 2020 to relieve nuisance conditions. Since treatment, variable-leaf watermilfoil coverage for the past two years has been the lowest observed over the last five years. This suggests that management actions for this species have successfully controlled the growth of this species over multiple years.

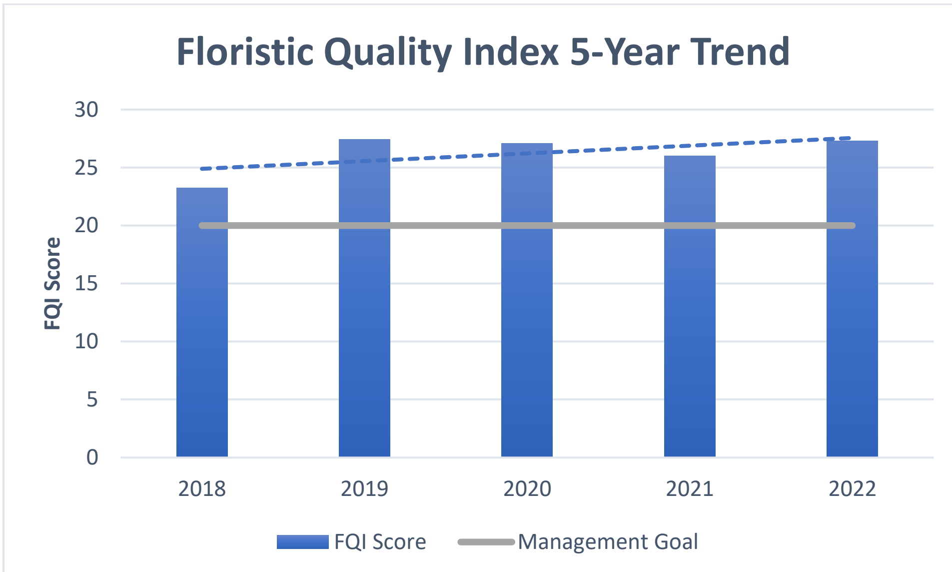

Figure 12 – Floristic Quality Index 5-Year Trend.

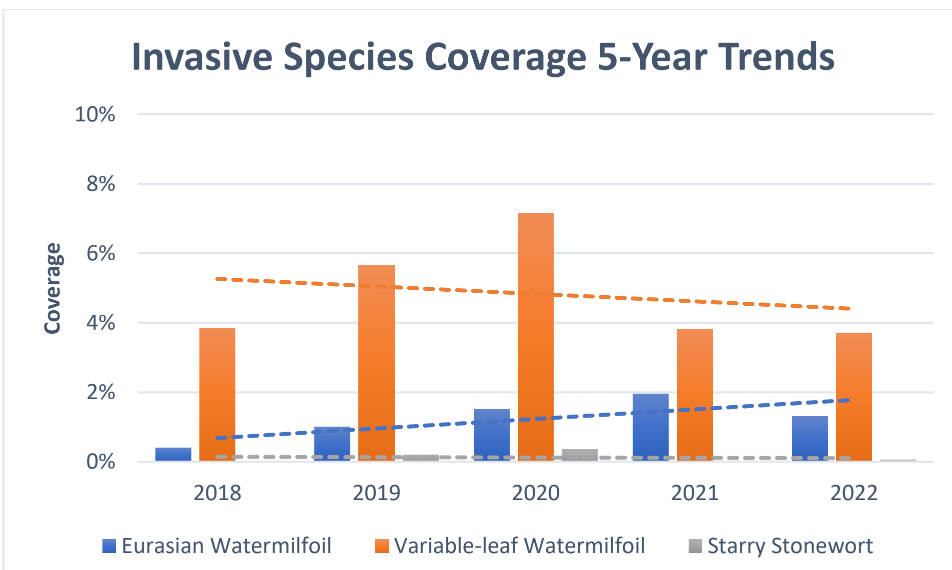

Figure 13 – Invasive and Nuisance Native Species Coverage 5-Year Trends.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes (see Appendix C). These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of healthy lake ecosystems. This section includes an analysis on nuisance conditions in the lake, as well as a description of any management actions that were taken in 2022. Figure 14 shows the coverage changes of targeted species over both surveys. (Copies of the herbicide applicator treatment maps are included in Appendix C.)

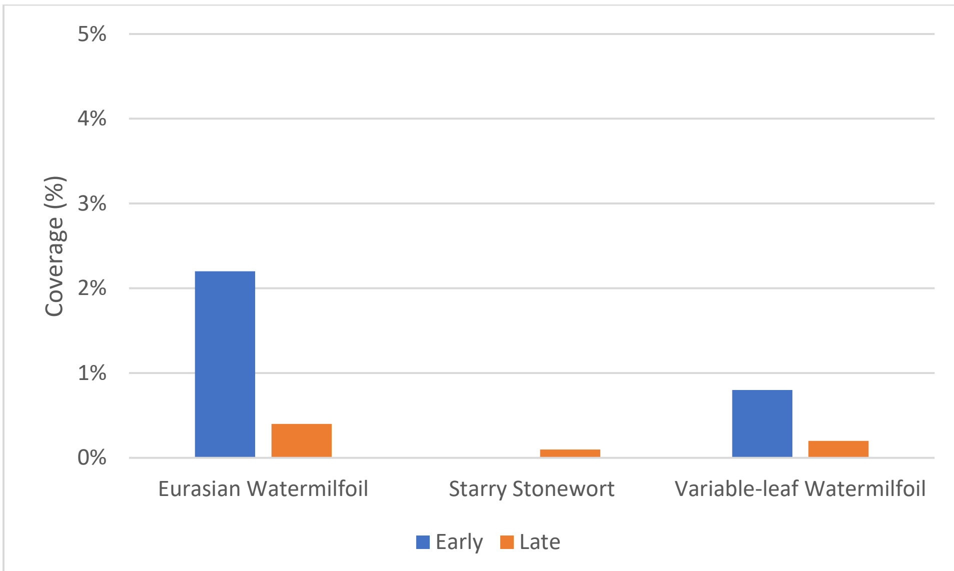

Figure 14 – Changes in coverage across both surveys for targeted species.

Native aquatic plants, such as variable-leaf watermilfoil, tend to create recreational nuisances on Cedar Lake South. Variable-leaf watermilfoil was observed creating late-season recreational nuisances prompting treatment in September 2020 targeting select areas. According to survey results, locations that received treatment have shown successful suppression of this targeted species. With variable-leaf watermilfoil nuisance conditions currently under control, it may be beneficial to explore other options for controlling native aquatic plant species as EGLE restricts the use of herbicides for controlling native species. Alternative options can be utilized if native populations rebound in the future, or can be used yearly as a maintenance option in order to prevent nuisance conditions from occurring in the future. For example, mechanical harvesting can help limit nuisance conditions of native species without requiring a permit. Small scale, diver-assisted physical harvesting is may be useful in managing small populations.

Starry stonewort was not observed during the early-season survey but a low density was observed within one AROS during the late-season survey. Increased native plant growth may be outcompeting and suppressing the growth of starry stonewort at this location. At this time, treatment for starry stonewort is not necessary if it continues to stay contained. It will be important to monitor starry stonewort at this location and surrounding areas closely to quickly respond should SSW begin to spread as the 5-year trend of cumulative coverage has been declining. Limited physical removal by divers may be warranted for the isolated patches noted.

The 2022 early-season survey found very limited locations with Eurasian watermilfoil nuisance conditions. Unfortunately, the early-season treatments were not as effective as anticipated. This led to a large population of Eurasian watermilfoil remaining in the southern canal (AROS 280-282) and the deep trench (AROS 510-511). Late-season treatments showed more success with density observations of EWM having decreased during the late-season survey.

Of relevant consideration going forward, are EGLE restrictions with timing of herbicide applications for copper products on Cedar Lake, limiting applications to after June 10th in order to limit any negative impacts to fish spawning. Also, herbicide treatments cannot be conducted on Cedar Lake when water temperatures exceed 75°F; unless dissolved oxygen concentrations exceed 5 mg/L. Early-season survey data of DO and temperature monitoring remain important for discerning such potential restrictions.

Additionally, a historic mussel survey conducted in 1953, indicated the presence of an endangered mussel, the Eastern pondmussel (originally referred to as, *Ligumia nasuta* but now as, *Sagittunio nasutus*), in the southern portion of Cedar Lake. Though more recent surveys conducted between 1998 and 2015 did not observe this species presence,[7] a Central Michigan University (CMU) mussel assessment in 2022 confirmed its presence in Cedar Lake.[8] Of the six CMU sampling locations examined on Cedar Lake (with one in Cedar Lake South), it was found at three of these in Cedar Lake North. As such, EGLE will likely include expanded exclusion zones as a permit restriction for Cedar Lake North and South in 2023. The exclusion zone would prohibit the use of Hydrothol and other copper-based products within the southern half of Cedar Lake South. It might be necessary to submit a permit in the future if the starry stonewort population begins to increase. However, at this time there does not appear to be an imminent need since the population has been decreasing over the last five years and has expanded to other areas of the lake. This again, points to the potential for manual removal, something that K&A has successfully implemented in another Michigan lake with small, early outbreaks of starry stonewort.

EGLE restrictions will also limit native emergent and floating leaf aquatic plant control to a 40-foot x 40-foot area for swimming and boat launching, and a 20-foot-wide boat lane to reach open water per residentially developed parcel. EGLE restricts treatment of native algae and submersed aquatic plants to 100 feet of frontage per residential property. Herbicides may be applied to native vegetation up to 100 feet from shore or to the 5-foot depth contour (whichever is closer to shore). Thus, a resurgence of variable-leaf watermilfoil may portend alternative treatments in Cedar Lake South if in areas covered by such EGLE restrictions.

5.1. Future Management Recommendations

Continued LakeScan™ vegetation monitoring twice a year (once during the spring-early summer and another during the late summer) is recommended to assess aquatic vegetation during the growing season. Information collected during these surveys allows lake managers to readily and consistently

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[7] Badra, P. J. (2017). Status Assessment of Unionid Mussel Species in the Huron-Manistee National Forest. *Michigan Natural Features Inventory.*

[8] Vlasak, A. L, Barczewski, A. J., Laszlo, A. M., Vellequette, N. M., and D. A. Woolnough. 2022. "Unionids of Cedar Lake, Michigan, USA: Community, Abundances, and Invasive Mollusk Risks." Department of Biology and Institute for Great Lakes Research, Central Michigan University, Mt. Pleasant, MI – Poster Presentation for CMU Biology Undergraduate Research Symposium; provided by R. Vaughn, CLIB to K&A on February 20, 2023.

identify successful lake management activities, highlight potential issues requiring intervention, and gather critical information necessary to improve the lake's ecological and recreational conditions.

Continued Eurasian watermilfoil management is recommended. Eurasian watermilfoil's 5-year trend shows coverage has slightly increased. However, Eurasian watermilfoil coverage (lower in 2022 than 2021) has not substantially or rapidly expanded either. This suggests that current management activities are likely suppressing the growth and coverage of Eurasian watermilfoil.

Due to EGLE's restrictions of chemical applications on Cedar Lake, K&A suggests future exploration of a combination of management strategies to reach even lower populations of target species. Diver assisted suction harvesting (DASH) management could be combined with targetted herbicide applications. DASH management has shown positive results for controlling and reducing aquatic invasive species populations, especially in combination with herbicide applications.[9] Utilizing DASH in targetted areas throughout the summer will allow for management during times when chemical applications are restricted, potentially further reducing Eurasian watermilfoil populations.

Native aquatic plants, such as variable watermilfoil, tend to create recreational nuisances on Cedar Lake South. Locations that received the September 2020 treatment did appear to have suppressed variable watermilfoil growth. These observations suggest that the treatment of variable-leaf watermilfoil was successful. Because EGLE restricts chemical applications to treat native aquatic plant nuisance conditions, it is recommended that other options also be considered to control native plant nuisance conditions. This could include management such as aquatic weed harvesters alleviate nuisance variable watermilfoil conditions in the future.

[9] Kelting, D. L., & Laxson, C. L. (2010). Cost and effectiveness of hand harvesting to control the Eurasian watermilfoil population in Upper Saranac Lake, New York. *Journal of Aquatic Plant Management (JAPM)*, *48*, 1.

6.0. Appendices

Appendix A: Blue-green Algae

Blue-green algal blooms are becoming increasingly common in Michigan. Blooms can appear as though green latex paint has been spilled on the water, or resemble an oil slick in enclosed bays or along leeward shores. Blue-green algal blooms are usually temporal events and may disappear as rapidly as they appear. Such blooms have become more common for a variety of potential reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue-green algae.

Figure A1: Example blue-green algae images from the 2019 LakeScan™ field crew.

Blue-green algae are really a form of bacteria known as cyanobacteria. They are becoming an important issue for lake managers, riparian property owners and lake users because studies have revealed that substances made and released into the water by some of these nuisance algae can be toxic. They are known to have negative impacts on aquatic ecosystems and can potentially poison and sicken pets, livestock, and wildlife. Blue-green algae can have both direct and indirect negative impacts on fisheries. Persons can be exposed to the phytotoxins by ingestion or dermal absorption (through the skin). They can also be exposed to toxins by inhalation of aerosols created by overhead irrigation, strong winds, and boating activity.

Approximately one-half of blue-green algae blooms contain phytotoxins, and this is determined through lab testing. It is recommended that persons not swim in waters where blue-green algal blooms are conspicuously present. Specifically, persons should avoid contact with water where blooms appear as though green latex paint has been spilled on the water, or where the water in enclosed bays appears to be covered by an "oil slick". Pets should be prevented from drinking from tainted water. Since blue-green algal toxins can enter the human body through the lungs as aerosols, it is suggested that water containing obvious blue-green algae blooms not be used for irrigation in areas where persons may be exposed to it.

Blue-green algae typically bloom and become a nuisance when resources are limiting to other plant and algae or when biotic conditions reach certain extremes, particularly warm water conditions. Some of the reasons that blue-green algae can bloom and become noxious are listed below:

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants). Very small amounts of phosphorus may result in large algal blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue-green algae may dominate a system because they are able to "fix" their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject cyanobacteria and feed selectively on other more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in "good" algae and a gain in "bad" blue-green algae as the "good" algae are consumed and the "bad" algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussel.

Management: Treatment methods for blue-green algae are generally preventative rather than reactionary. One of the most common forms of algae treatment is limiting nutrients, namely phosphorus, from entering the lake ecosystem through several sources. Phosphorus mainly enters lake systems through surface water inputs such as rivers, creeks, or overland runoff. In some inland lakes that experience late-summer stratification, sediment-bound phosphorus at the lake bottom becomes mobilized due to low-oxygen conditions which, under high sustained wind conditions, can mix surface and bottom waters. This is particularly problematic in the late summer. Phosphorus-reducing practices include: implementing Best Management Practices (BMPs) in upstream agricultural and urban areas, limiting nutrient (fertilizer) applications on lawns, planting vegetative buffer strips between nutrient-producing areas and surface water, reducing septic system leaching (if riparian homes are not sewered), binding lake-bottom phosphorus using alum or other adsorbent materials (e.g., Phoslock®), and treating/infiltrating stormwater prior discharge into upstream surface waters of the lake.

Research has shown that water circulation devices such as bubblers or aeration systems may limit the viability of blue-green algae over native algae species.[10] Blue-green algae are more buoyant than native algae species and often float to the water's surface during quiescent conditions to increase the amount of sunlight needed for photosynthesis. Circulation systems disturb the water column and eliminate this evolutionary advantage portrayed by blue-green algae. The intended result is a shift from a blue-green algae dominated community to a mix of green algae species. When nuisance conditions occur, contact algaecides or hydrogen peroxide may be used as a reactionary treatment to destroy algae cells present in the water column. However, chemicals should be applied with caution due to concerns of bioaccumulation and toxicity to other forms of aquatic life. Moreover, chemical applications will often need to 'chase' blooms that can be pushed to different areas of the lake with prevailing winds.

[10] Pastorok, R., T. Ginn, AND M. Lorenzen. Evaluation of Aeration/Circulation as a Lake Restoration Technique. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/3-81/014 (NTIS PB81191884), 1981.

Appendix B: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids:

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as Eurasian watermilfoil hybrids. Eurasian watermilfoil hybrids are a very common nuisance in many Michigan inland lakes.

Management: Lake disturbance, such as weed control, unusual weather, and heavy lake use can destabilize the lake ecosystem and encourage the sudden nuisance bloom of weeds, like Eurasian watermilfoil. Eurasian watermilfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to suppress the nuisance production of Eurasian watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatments. Herbicide resistant Eurasian watermilfoil and hybrid watermilfoil have been observed in many lakes throughout the Midwest.[11,12] Continued chemical applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[13] Some research suggests this resistance can be defeated with the use of microbiological system treatments. Eurasian watermilfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in the dominance of distinct Eurasian watermilfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.

Figure B1: Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

[11] Berger, S. T., Netherland, M. D., & MacDonald, G. E. (2015). Laboratory documentation of multiple-herbicide tolerance to fluridone, norflurazon, and topramazone in a hybrid watermilfoil (*Myriophyllum spicatum× M. sibiricum)* population. Weed Science, 63(1), 235-241.
[12] Netherland, M. D., & Willey, L. (2017). Mesocosm evaluation of three herbicides on Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum x Myriophyllum sibiricum*): Developing a predictive assay. J. Aquat. Plant Manage, 55, 39-41.
[13] Netherland and Wiley, 2017.

Starry Stonewort:

Background: Starry stonewort, a macroalgae native to northern Eurasia, invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. Though not positively identified in a Michigan inland lake until 2006, by Aquest Corporation in Lobdell Lake, Genesee County, starry stonewort has likely been present in Michigan's inland lakes since the late 1990's. Since then, this invasive species has spread throughout Michigan. Able to spread by both fragmentation and asexual reproduction, starry stonewort has thrived in Michigan's high-quality oligotrophic and mesotrophic lakes, particularly those with marl sediments. Once established, this opportunistic species will bloom and crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. In some years starry stonewort can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.

Management: Starry stonewort is capable of growing to extreme nuisance levels and can significantly impact important ecosystem functions. This species is difficult to control due to its asexual reproductive structures (bulbils) which embed in lake sediments.[14] While many strategies have been employed to manage starry stonewort, no single strategy has emerged as a panacea for controlling infestations.

Diver-assisted suction harvesting (DASH) or diver-assisted hand-pulling of small starry stonewort infestations could reduce populations over time.[15] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[16] These strategies may not be viable for large-scale infestations, however, due to their labor-intensive nature and their potential for increasing distribution of the target plant species through fragmentation during removal.

Starry stonewort chemical treatments using copper-, diquat- and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[17] While starry stonewort is susceptible to most selective algaecides, the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

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[14] Glisson, W. J., Wagner, C. K., McComas, S. R., Farnum, K., Verhoeven, M. R., Muthukrishnan, R., & Larkin, D. J. (2018). Response of the invasive alga starry stonewort (*Nitellopsis obtusa*) to control efforts in a Minnesota lake. Lake and Reservoir Management, 34(3), 283-295.

[15] Glisson et al., 2018.

[16] Larkin, D.J., Monfils, A.K., Boissezon, A., Sleithd, R.S., Skawinski, P.M., Welling, C.H., Cahill, B.C., and Karold, K.G. 2018. Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; Characeae): A Red-listed Eurasian green alga invasive in North America. https://doi.org/10.1016/j.aquabot.2018.04.003

[17] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).

Figure B2: Example starry stonewort images from the 2019 LakeScanTM field crew.

Curly-leaf Pondweed:

Background: Curly-leaf pondweed (CLP) is one of the world's most widespread aquatic plant species. Although it is found worldwide, CLP is native to only Eurasia. The earliest verifiable records of the plant are from Pennsylvania in the 1840s, and has been found in Michigan since 1910. Curly-leaf pondweed is currently found in inland lakes of 34 counties in Michigan, distributed both in the upper and lower peninsulas.[18] Scientific literature suggests that curly-leaf pondweed is an aggressively growing species that often expands to nuisance levels when native plants are damaged.

Curly-leaf pondweed can create problems such as recreational nuisances, ecological nuisances (by outcompeting native species and reducing light availability to other plants), and degraded fish spawning habitat. Curly-leaf pondweed is easily detectable in early spring as it will be one of the few plants readily growing and the first submersed plant to reach the surface. This gives it a competitive advantage and can grow 4 to 5 feet tall before other plants begin germinating from the bottom sediments. As water temperatures rise in late June and early July, curly-leaf pondweed stems begin to die, break down, and can be completely gone by mid-July.[19]

Management: Like other invasive species, CLP is difficult to control once established and is considered widespread in Michigan. Therefore, prevention of new populations in uninfected waters is the most economical management approach. Several herbicides have been shown to be effective at long-term control of CLP, but eradication is difficult after establishment. Bottom barriers have shown effectiveness at combating CLP in small areas, and mechanical harvesting of CLP can be effective if timed and managed correctly.[20]

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[18] MDEQ. (2018). "State of Michigan's Status and Strategy for Curly-leafed Pondweed (*Potamogeton crispus L.*)." Accessed online: <https://www.michigan.gov/documents/invasives/egle-ais-potamogeton-crispus_708948_7.pdf>.

[19] Hart, Steven, M. Klepinger, H. Wandell, D. Garling, L. Wolfson. (2000). "Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes." Accessed online: <https://www.michigan.gov/documents/invasives/egle-great-lakes-aquatics-IPM-manual_708904_7.pdf>.

[20] MDEQ, 2018.

The most viable ways to control CLP is through chemical and physical means after developing an integrated pest management plan. Early infestations may best be controlled by manual removal, diver-assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and imazamox are the most effective for general applications. Aquatic herbicides including flumioxazin and imazamox are effective for specific types of application and in specific environments. Chemical treatments are a part of a long-term integrated management plan as the turions are viable for at least 5 years and only diquat, fluridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[21]

Figure B3: Example curly-leaf pondweed image from the 2021 LakeScan™ field crew.

[21] MDEQ, 2018.

Appendix C: Herbicide Applicator Maps

Copies of the herbicide treatment maps obtained by the herbicide applicators are included below.

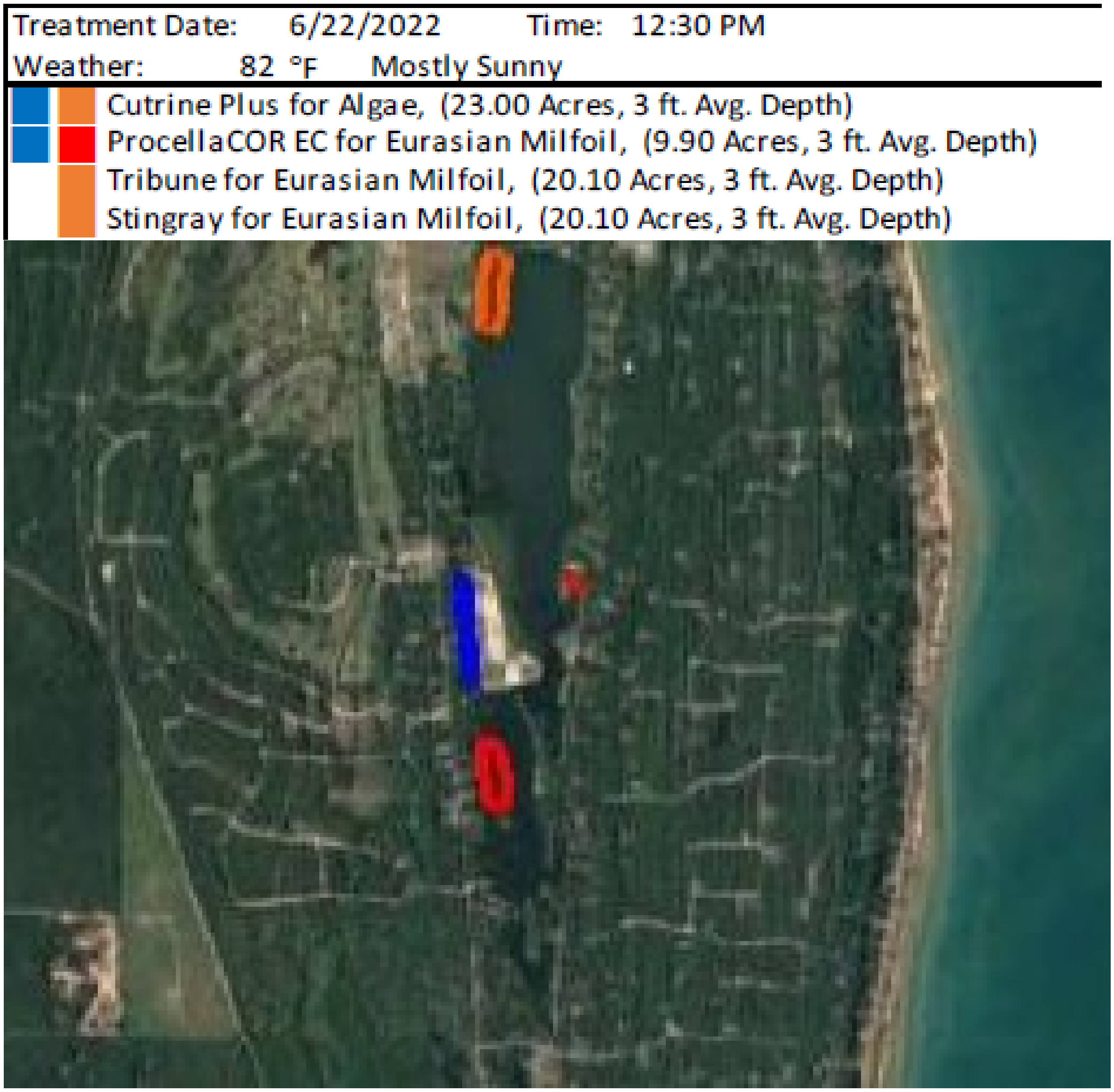

Figure C1. – Herbicide applicator treatment maps from June 22, 2022 chemical treatments targeting Eurasian watermilfoil and filamentous algae

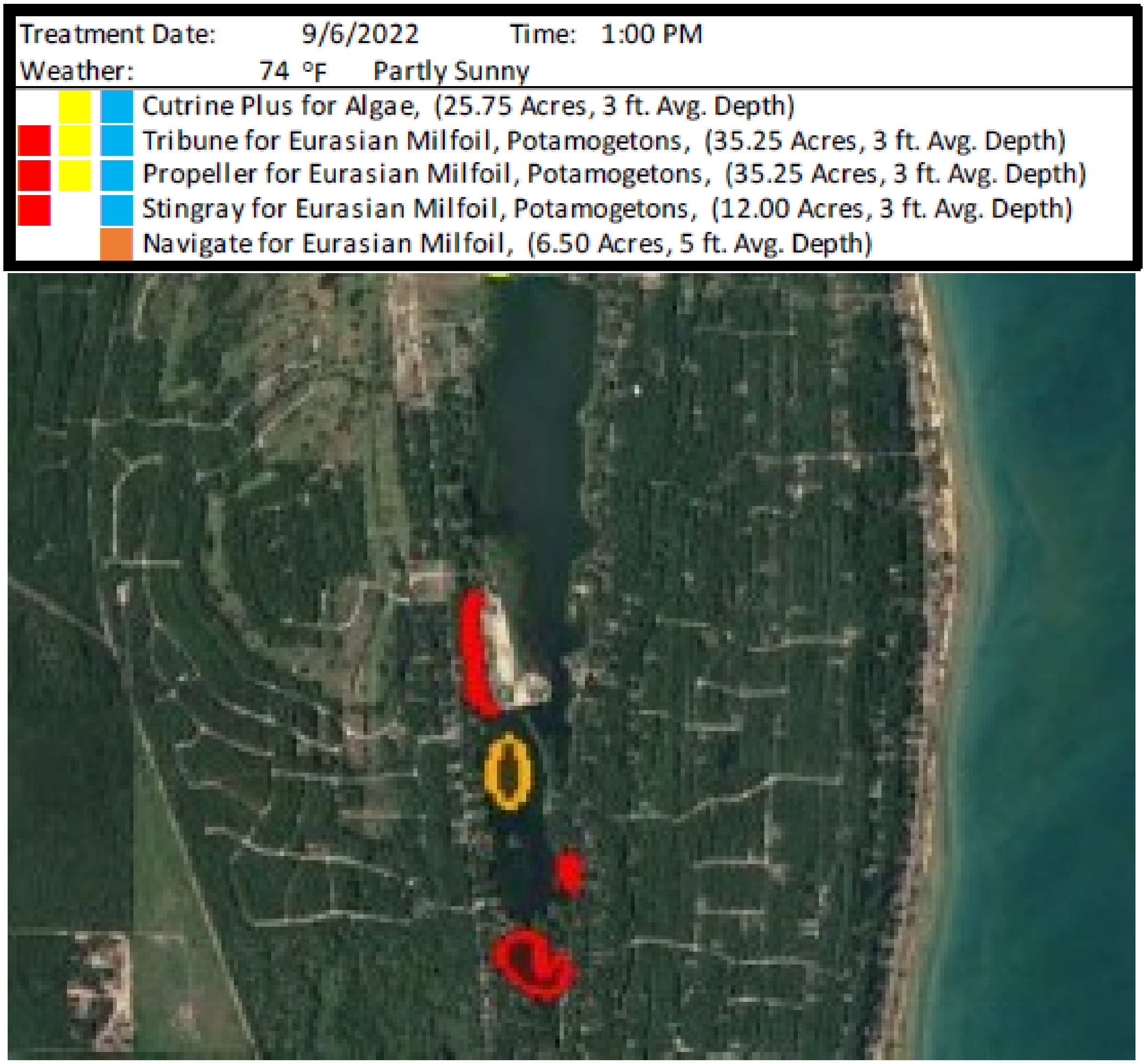

Figure C2 – Herbicide applicator treatment maps from September 9, 2022 chemical treatments targeting Eurasian watermilfoil