memo

Project Name	2022 Aquatic Plant Management Services	**Date**	1/4/2022
To / Contact info	BCWD Board of Managers		
Cc / Contact info	Karen Kill, District Administrator		
From / Contact info	Jimmy Marty, Joe Pallardy - EOR		
Regarding	Benz Lake Point Intercept Survey		

Background

Point-intercept aquatic plant surveys of Benz Lake were completed on August 23, 2022. The point-intercept method is considered the standard protocol by MNDNR for sampling macrophytes (aquatic plants) because it offers a methodology that is quantitative (e.g., frequency of occurrence), repeatable (can be used to track trends in aquatic plant communities over time), and georeferenced (can be used to compare plant communities within different areas of a lake). Point spacing of 50 meters was used for the survey and totaled 70 sampling points. At each point, a vegetation sampling rake was used to collect plants and assign a species density rating of 1 (sparse), 2 (common), or 3 (abundant). From this data, a Floristic Quality Index (FQI) was calculated that measures the diversity and health of the aquatic plant community.

The FQI calculation is based on both the quantity of species observed (species richness) as well as the quality of each individual species. Aquatic plants in Minnesota have been assigned a coefficient of conservatism value (c-value) ranging from 0 to 10. The c-value of all aquatic plants sampled from a lake is used to determine the FQI for a given lake. Species with a c-value of 0 include non-native species such as curly-leaf pondweed (*Potamogeton crispus*) that are indicative of a highly disturbed environment. In comparison, the native species Oakes pondweed (*Potamogeton oakesainus*) has a c-value of 10 because this species is extremely rare and only found in undisturbed, pristine waterbodies.

The average FQI score for Minnesota Lakes in the North Central Hardwood Forest (NCHF) ecoregion is 23.7±8 with a median of 22.5 (Radomski and Perleberg, 2012). A study of 41 Minnesota lakes surveyed across the state, as part of the EPA's National Lakes Assessment Project, yielded a maximum FQI score of 30. In 2016, the MNDNR developed a robust geodatabase of aquatic plant surveys and associated FQI scores from more than 3,600 lakes across the state. FQI scores ranged from 0 to 49 with a median of 25.1±9.

Survey Results

The FQI score for Benz Lake (19.6) was just below median and average FQI scores for assessed lakes in the DNR geodatabase and the NCHF ecoregion, but within the standard deviations. Sampling points located in the littoral zone of Benz Lake contained an average of 1.8 species per sample site.

Benz Lake is a shallow lake and is entirely littoral. The lake is in the clear water, aquatic plant dominated state, which is considered the ecologically preferred stable state for shallow lakes. The clear water state provides good fish, invertebrate, and waterfowl habitat compared to the algae-dominated turbid state.

Fern-leaf pondweed (*Potamogeton robbinsii*), coontail (*Ceratophyllum demersum*), and white-water lily (*Nymphaea odorata*) were the most commonly encountered species. All other species had less

1919 University Avenue West, Suite 300 St. Paul, MN 55104 T/ 651.770.8448 F/ 651.770.2552 www.eorinc.com

than 10% frequency of occurrence. Creeping bladderwort, a notably conservative species (c-value = 9), was observed at one location (Figure 1).

The bladders of bladderworts often contain communities of microorganisms (bacteria, algae, and diatoms). The prevailing thought is these bladders help to establish a mutually beneficial relationships between the microorganisms and the plant, possibly helping the plant to obtain nutrients.

Figure 1. Creeping Bladderwort (*Utricularia gibba*) was found on Benz Lake in 2022. Photo courtesy of Minnesota Wildflowers.

One specimen of curly-leaf pondweed (*Potamogeton crispus*) was observed, but the survey was conducted outside the normal growing season for *P. crispus* and its distribution and density could be greater earlier in the season.

The results of the survey for Benz Lake and associated FQI scores are summarized in Table 1. Included in Table 1 is a list of all native aquatic species sampled and their associated c-values, Frequency of Occurrence (FOO) values, and average rake density rank values. Shoreline species associated with wetland habitats that bordered the lake (e.g., reed canary grass) were excluded from the FQI calculation.

The distribution and density ranking for each individual species with a frequency of occurrence ≥ 10% is mapped for Benz Lake within Appendix A. For each data point mapped, a density ranking of

1 indicates only a few individual plants were observed while a ranking of 3 indicates an abundance of plants.

Table 1. Benz Lake species list and frequency of occurrence.

Common Name	Scientific Name	C-Value	Frequency of Occurrence	Average rake density
Coontail	*Ceratophyllum demersum*	2	35.7%	1.2
Lesser duckweed	*Lemna minor*	5	1.4%	1.0
Star duckweed	*Lemna trisulca*	5	4.3%	1.0
Slender naiad	*Najas flexilis*	5	1.4%	1.0
White water lily	*Nymphaea odorata*	6	24.3%	2.2
Leafy pondweed*	*Potamogeton foliosus*	6	0.0%	N/A
Curly-leaf pondweed*	*Potamogeton crispus*	0	0.0%	N/A
Fern-leaf pondweed	*Potamogeton robbinsii*	8	95.7%	2.6
Flat-stemmed pondweed	*Potamogeton zosteriformis*	6	1.4%	1.0
Unknown arrowhead**	*Sagittaria* sp.	7	1.4%	1.0
Giant bur reed	*Sparganium eurycarpum*	5	2.9%	1.0
Large duckweed	*Spirodela polyrrhiza*	5	8.6%	1.0
Creeping bladderwort	*Utricularia gibba*	9	1.4%	1.0
Common bladderwort	*Utricularia macrorhiza*	5	1.4%	1.0

Summary Table FQI = C*√S	**Average C-Value**	5.7
C= Mean coefficient of conservatism value	**Number of species**	12
S= Number of species in sample	**FQI**	**19.6**

*incidental species observation
**likely *S. cristata* or *S. rigida*; lower c-value of *S. rigida* assumed

Conclusions and Management Implications

The results of the point-intercept survey indicate Benz Lake has a plant community of approximately average floristic quality compared to other lakes in the region based on FQI. While not especially diverse, the aquatic plant community is healthy, is home to at least one uncommon species (creeping bladderwort) and is helping maintain the clear water state of the lake. The lake has only recently shifted from a turbid water state (cloudy or muddy water) to a clear water state. Beginning in 2016, water resource professionals with Brown's Creek Watershed District and EOR began noticing a relatively abrupt shift from a turbid water state (cloudy or muddy water) with little aquatic plant growth to a clear water state with abundant aquatic plant growth. Good water clarity is a primary driver of aquatic plant growth and limits competitiveness of curly-leaf pondweed, which was the only aquatic invasive plant observed at Benz Lake. Maintaining good water clarity will support the healthy aquatic plant community of Benz Lake by providing adequate conditions for native plants and limiting existing curly-leaf pondweed. Preventing spread of invasive aquatic plants such as Eurasian watermilfoil and starry stonewort will also protect the aquatic plant community.

Since shifting from the turbid to clear water state, aquatic vegetation has flourished in Benz Lake. During certain times of the year, aquatic plant biomass can become so abundant that it restricts recreational access to certain areas of Benz Lake. This has prompted some concern from landowners and lake users who are interested in evaluating if there is some way to retain aquatic plants but manage them in a way that maximizes the usability of the resource. Further, Benz Lake was identified in the St. Croix River 1W1P document as a "Priority A" lake for internal loading analysis needed. "Priority A" lakes are where internal loading is estimated to *potentially* be a significant contributor to degraded water quality and where not addressing the internal loading could result in sustained degradation. Additional analysis could include the collection and laboratory analysis of lake sediment cores for releasable phosphorus content and phosphorus release rate under oxic and anoxic conditions. EOR limnologists often use this type of information to validate the magnitude of internal loading in comparison with the lake's overall phosphorus budget and to calculate the appropriate alum dosage needed to limit the release of phosphorus from lake sediments. The listing of Benz Lake as a "Priority A" Lake prompted additional evaluation by EOR of how mechanical harvesting of aquatic vegetation might help to control internal loading given its potential to not only remove phosphorus, but also provide a potential recreational benefit to lake users.

Mechanical harvesting has typically been applied as a practice to capture and directly remove phosphorus assimilated into aquatic plant biomass. Additionally, harvesting may also have implications for internal loading dynamics in areas with dense aquatic vegetation. A common misconception is that shallow lakes are homogeneously mixed (not stratified) and that dissolved oxygen concentrations and temperature are similar at the surface in comparison with bottom waters. Recent research ([1, 2]) suggests the opposite, especially in shallow lakes with dense stands of aquatic vegetation. Photosynthesis in surface waters produces oxygen accumulation and CO^2 depletion near the surface whereas respiration in the bottom waters can lead to the formation of anoxic conditions. Further, dense aquatic plant stands restrict light penetration, ultimately leading to the formation of a warmer, oxygen rich surface layer of water on top of cooler, potentially anoxic bottom waters. In addition to large diurnal changes in dissolved oxygen, there are also large changes in pH that are occurring daily in these dense aquatic plant stands that may influence phosphorus release from the sediments. These intermittent (diurnal) periods of stratification can lead to the release of phosphorous from sediments during anoxia, followed by mixing during the nighttime as surface water temperatures begin to cool.

<u>Potential Next Steps:</u>

Key takeaways from this memo are as follows:

- Benz Lake has near-average floristic quality compared to other lakes in the region.
- Benz Lake has remained in the ecologically preferred clear water, aquatic plant dominated state since 2016.
- Since 2016, in-lake phosphorus concentrations are below the MPCA's North Central Hardwood Forest Ecoregion Total Phosphorus Standard of 60 ug/L (Figure 2).
    a. Note: Benz Lake is currently listed as an impaired lake for excess nutrients. It may be possible to de-list Benz Lake from the impaired waters list.

The most sensible step for Benz Lake seems to be to focus on measures that enhance and/or protect the existing aquatic plant community given the clear correlation between the 2016 shift to a clear water aquatic plant dominated state and in-lake TP concentrations while simultaneously looking for ways to improve recreational access through selective mechanical harvesting.

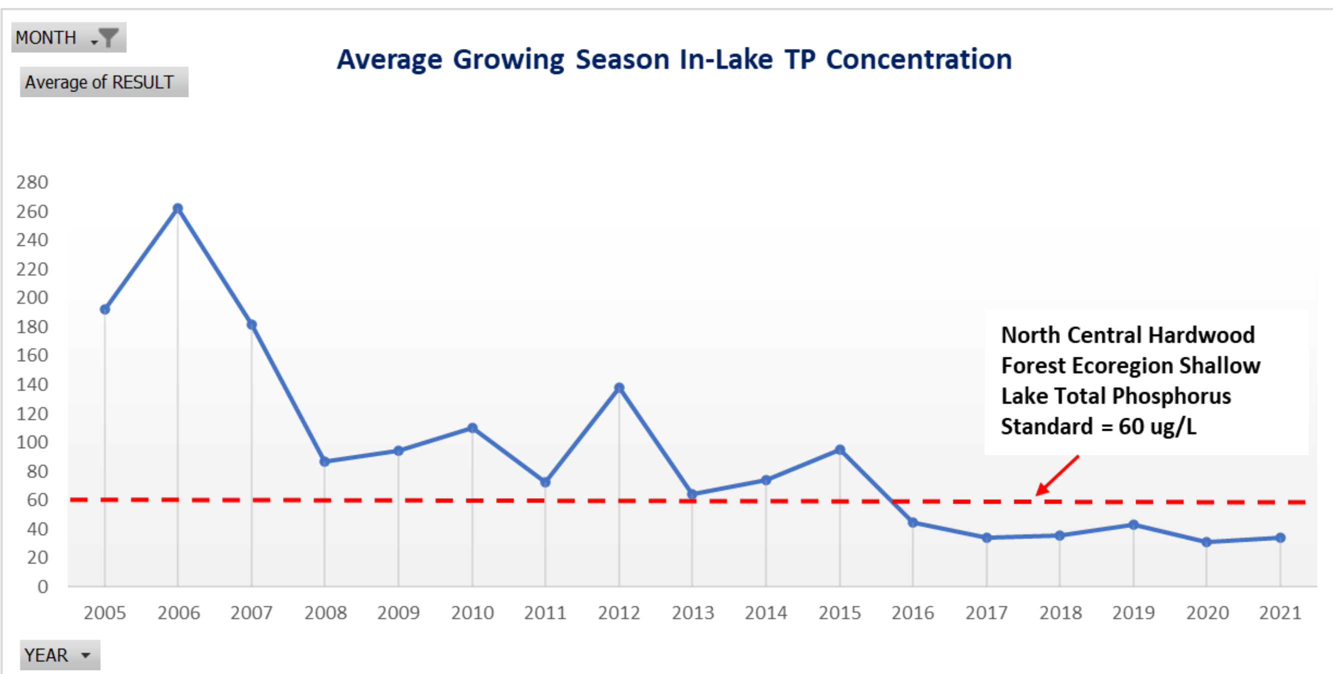

Figure 2. Pivot chart of growing season (June-September) average in-lake total phosphorus (TP) concentrations show a reduction in lake phosphorus concentrations that corresponds to the 2016 transition to a clear water, aquatic plant dominated state.

EOR would like the District to consider the following two options:

Option A

Conduct a microcosm study to evaluate the potential benefits of a strategically and thoughtfully designed mechanical harvesting program to help answer the following questions:

- Is it feasible to use mechanical harvesting to improve recreational usability on Benz Lake
- Does mechanical harvesting help to mitigate phosphorus release from lake sediments?
- Can we quantify the potential benefits to in-lake water quality via removal of phosphorus assimilated into aquatic plant biomass?
- Does harvesting aquatic vegetation help to moderate large diurnal fluxes in dissolved oxygen in shallow lakes, thereby potentially reducing internal loading while also providing a recreation benefit?
- Can harvesting be done sustainably to avoid detrimental impacts to the native aquatic plant community and water quality?
    - Note: Recent research ([3]) conducted on the Phalen Chain of Lakes in the Twin Cities, suggests strategic aquatic plant harvesting can be an effective in-lake management tool.

Option B:

Continue to work with Washington Conservation District and Met Council to review water quality data collected on Benz Lake. Conduct lake-wide point intercept surveys every 3-5 years and compare water quality data with aquatic plant data to evaluate trends.

References:

1) https://royalsocietypublishing.org/doi/10.1098/rspb.2017.1427
2) https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2020JG006065
3) https://rwmwd.org/wp-content/uploads/2022/06/Strategic-Aquatic-Plant-Harvesting-as-a-Multi-Faceted-In-Lake-Management-Tool-Lakeline-V40-No.4-Winter-2020.pdf

1919 University Avenue West, Suite 300 St. Paul, MN 55104 T/ 651.770.8448 F/ 651.770.2552 www.eorinc.com

Appendix A

Benz Lake Aquatic Plant Species Distribution

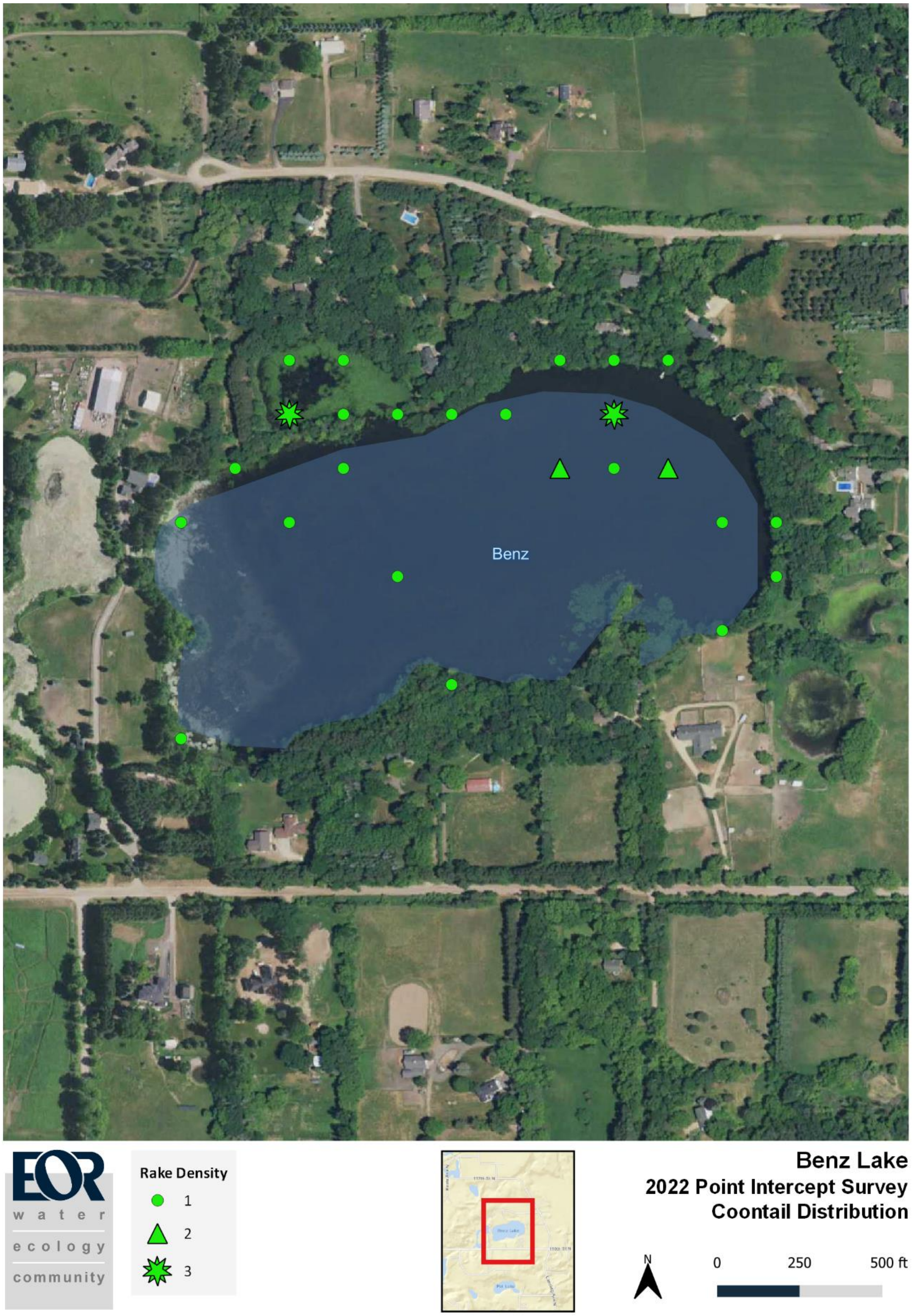

Figure 3. Benz Lake coontail distribution – August 2022.

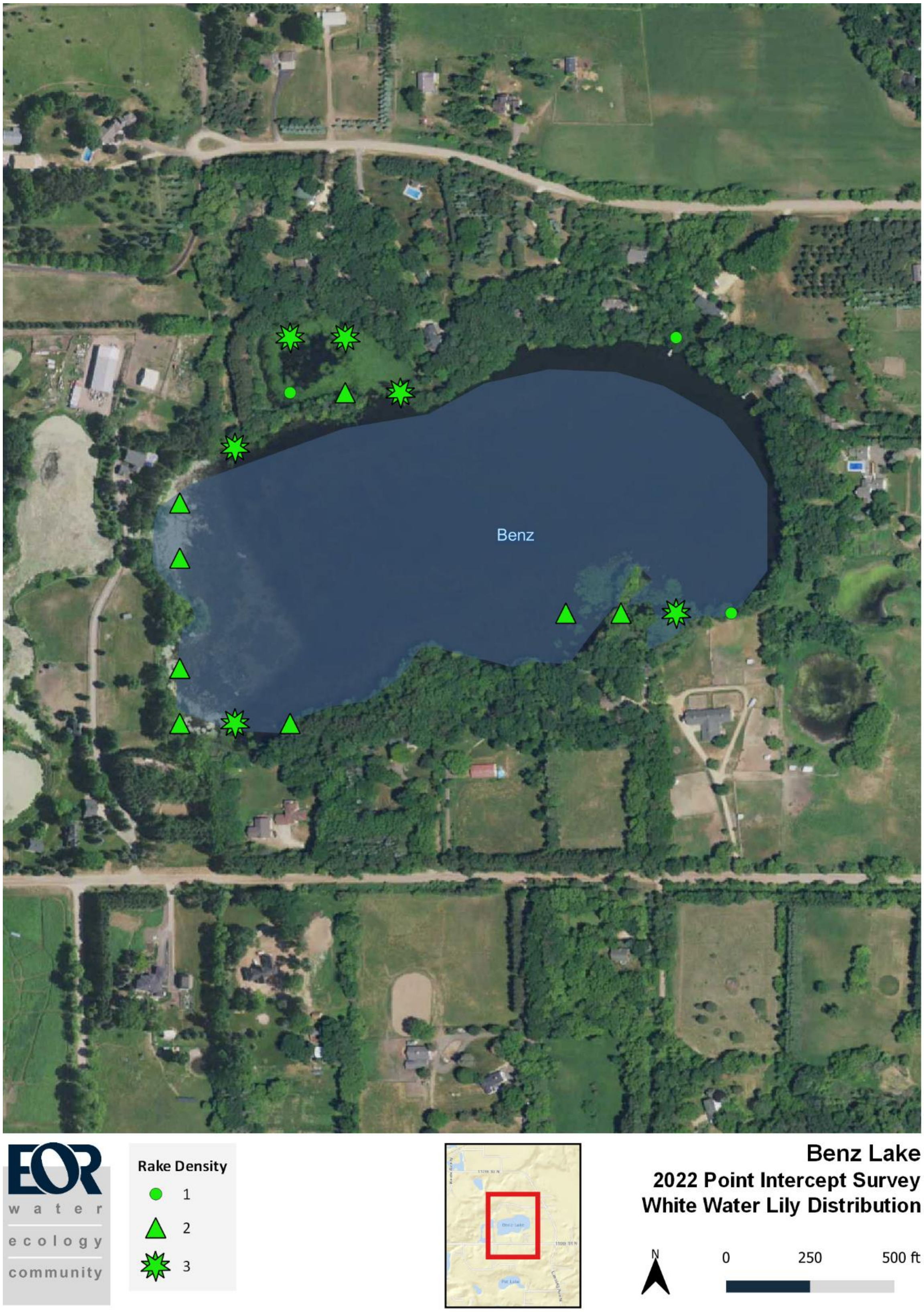

Figure 4. Benz Lake white water lily distribution – August 2022.

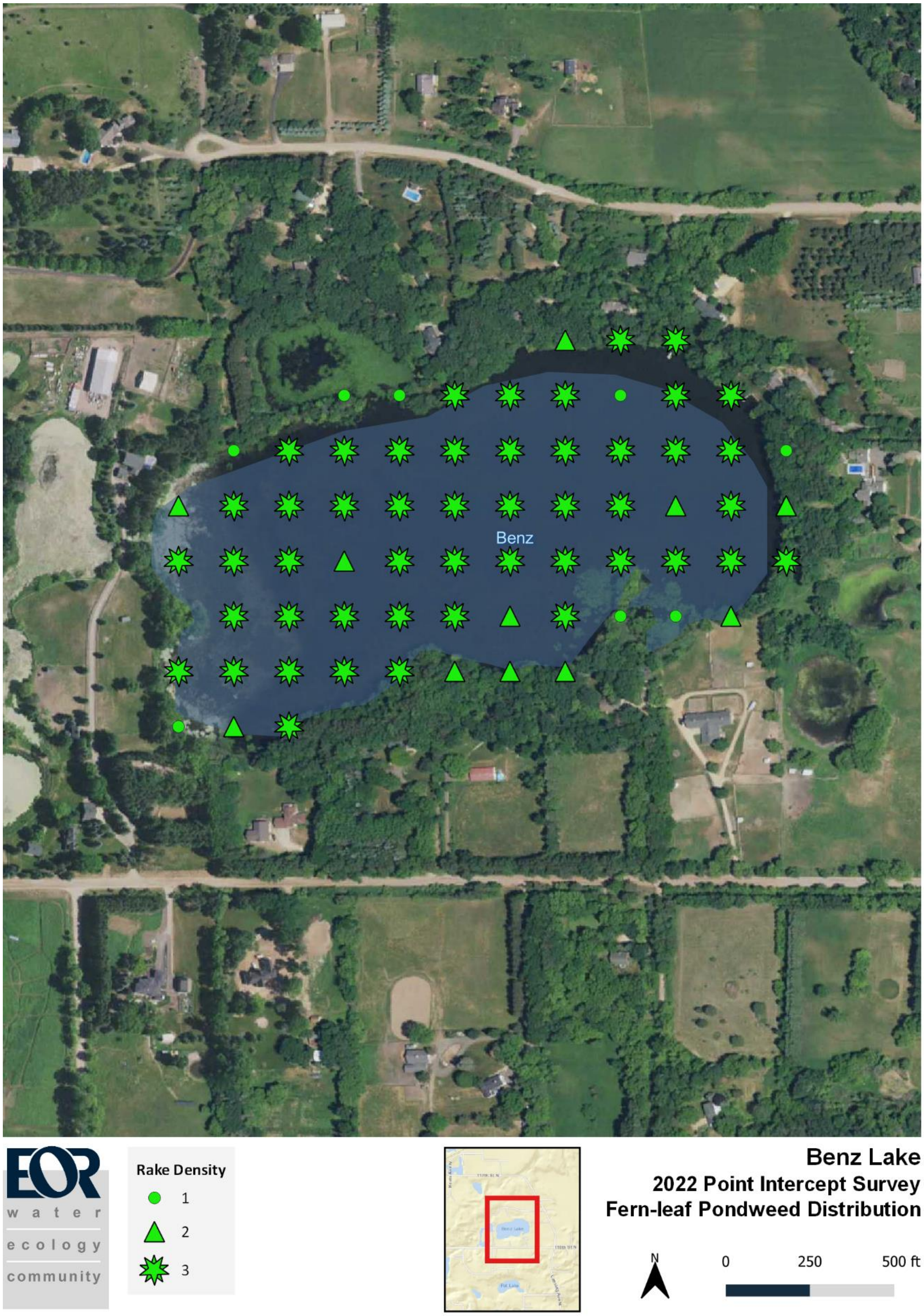

Figure 5. Benz Lake Fern-leaf pondweed distribution – August 2022.

memo

Project Name	2022 Aquatic Plant Management Services	**Date**	1/4/2022
To / Contact info	BCWD Board of Managers		
Cc / Contact info	–Karen Kill, District Administrator		
From / Contact info	Jimmy Marty, Chris Long, Joe Pallardy - EOR		
Regarding	South School Section Lake and Goggins Lake Point Intercept Survey		

Background

Point-intercept aquatic plant surveys of South School Section Lake (SSSL) and Goggins Lake were completed on August 26, 2022. The point-intercept method is considered the standard protocol by MNDNR for sampling macrophytes (aquatic plants) because it offers a methodology that is quantitative (e.g., frequency of occurrence), repeatable (can be used to track trends in aquatic plant communities over time), and georeferenced (can be used to compare plant communities within different areas of a lake). Point spacing of 50-meters was used for the survey and totaled 130 sampling points on South School Section Lake and 75 sampling points on Goggins Lake. At each point, a vegetation sampling rake was used to collect plants and assign a species density rating of 1 (sparse), 2 (common), or 3 (abundant). From this data, a Floristic Quality Index (FQI) was calculated that measures the diversity and health of the aquatic plant community.

The FQI calculation is based on both the quantity of species observed (species richness) as well as the quality of each individual species. Aquatic plants in Minnesota have been assigned a coefficient of conservatism value (c-value) ranging from 0 to 10. The c-value of all aquatic plants sampled from a lake is used to determine the FQI for a given lake. Species with a c-value of 0 include non-native species such as curly-leaf pondweed (*Potamogeton crispus*) that are indicative of a highly disturbed environment. In comparison, the native species Oakes pondweed (*Potamogeton oakesainus*) has a c-value of 10 because this species is extremely rare and only found in undisturbed, pristine waterbodies.

The average FQI score for Minnesota Lakes in the North Central Hardwood Forest (NCHF) ecoregion is 23.7±8 with a median of 22.5 (Radomski and Perleberg, 2012). A study of 41 Minnesota lakes surveyed across the state, as part of the EPA's National Lakes Assessment Project, yielded a maximum FQI score of 30. In 2016, the MNDNR developed a robust geodatabase of aquatic plant surveys and associated FQI scores from more than 3,600 lakes across the state. FQI scores ranged from 0 to 49 with a median of 25.1±9.

Survey Results

Floristic Quality Index (FQI) Comparison

The FQI scores for SSSL and Goggins Lake were similar: 15.6 and 15.5 respectively, which is below the median FQI score for assessed lakes in the DNR geodatabase (Table 3 and Table 4).

South School Section Lake

Sampling points located in the littoral zone of SSSL (87 of 130 total points) contained an average of 1.5 species per sample site. In total, 12 aquatic or emergent species were observed in SSSL. Coontail (*Ceratophyllum demersum*), Canada waterweed (*Elodea canadensis*), and Eurasian watermilfoil (*Myriophyllum spicatum*) were by far the most encountered species, with white water lily (*Nymphaea odorata*) the next most common species. All other species had less than 10% frequency of occurrence.

Goggins Lake

Goggins Lake, which was 100% littoral (less than 15 feet deep), displayed a slightly better distribution of species. Although only 11 aquatic or emergent species were observed in Goggins, it contained an average of 1.8 species per sample site. Despite the near ubiquity of coontail (91% of points), fern leaf pondweed was widely encountered (40% of points). Four (4) other species had a frequency of occurrence (FOO) greater than 10%, including flat-stemmed pondweed (*Potamogeton zosteriformis*), Canada waterweed, and Eurasian watermilfoil. Notably, a single, immature individual of a floating-leaved pondweed (*Potamogeton* spp.) was observed that resembled several state-listed species, but sufficient features were not present to make a species identification.

Invasive Species

The plant community in both lakes was generally dominated by native species, although two invasive species were observed during the surveys: Eurasian watermilfoil and curly-leaf pondweed (*Potamogeton crispus*).

Eurasian Watermilfoil

Eurasian watermilfoil (EWM) was observed at 44% of the sample points in SSSL and 12.2% of sample points in Goggins Lake. Eurasian watermilfoil was generally observed growing in patches with tall prominent stalks intermixed with native species. Heavy growth was observed on SSSL in the northern portion of the lake, and it is widely distributed throughout the entire shoreline (Photograph 1). EWM density on Goggins Lake is low and more sparsely distributed throughout the lake.

Curly-leaf pondweed

Very little curly-leaf pondweed (CLP) was observed during the surveys. CLP dies back in mid-summer and peak growth was not captured by this survey. CLP was found at only 1 sample point of 130 on SSSL (0.8% of points). On Goggins, a single turion (a wintering bud that becomes detached and remains dormant at the bottom of the water) was recovered during the survey, but no live plants were observed. During a focused meander survey conducted in May 2022, CLP was observed at 2.7% of sample points on SSSL and it was not found at all on Goggins Lake.

Comparison to Past Point-Intercept Surveys

Point-intercept surveys were conducted at both SSSL and Goggins Lakes in 2014. A comparison of survey results shows a slight improvement in both the number of native species recorded and the overall quality of the aquatic plant community as demonstrated by a slight increase in FQI scores (Table 1 and Table 2). However, Eurasian watermilfoil (EWM) was observed at 44% of sampling locations in SSSL and 12% of sampling locations in Goggins Lake. EWM was not found in either lake during the 2014 survey. A comparison of species detected is provided in Appendix B.

Table 1. South School Section Lake 2014 vs. 2022 P.I. Survey Comparison.

Metric	2014	2022
Total # of Native Plants	9	10
% of Sites with Aquatic Plants	67%	72%
FQI Score	12.9	15.6
Max Depth of Growth (ft)	N/A	17
% of sites w/ EWM	0	44%
Average growing season water level (ft)[1]	964.29	967.88

[1]Based on available water level data from DNR Lakefinder. Datum: NGVD 29 (ft)

Table 2. Goggins Lake 2014 vs. 2022 P.I. Survey Comparison.

Metric	2014	2022
Total # of Native Plants	11	9
% of Sites with Aquatic Plants	39%	75%
FQI Score	13.3	15.5
Max Depth of Growth (ft)	N/A	14
% of sites w/ EWM	0	12.2%
Average growing season water level (ft)[1]	961.70	967.42

[1]Based on available water level data from DNR Lakefinder. Datum: NGVD 29 (ft)

Conclusions and Assessment of Curly-Leaf Pondweed Treatments

The FQI scores from both lakes indicate that the floristic quality of the plant communities increased since last surveys in 2014. The reason for the improvements is not immediately clear and could be due to several factors and their interactions such as water level fluctuations, water quality, aquatic plant management, or simply natural variability. Additionally, though FQI scores improved, the invasive EWM was observed at both SSSL and Goggins for the first time, with relatively high frequency of occurrence (44% of sites) at SSSL.

Water levels at both lakes have fluctuated over this time, with average water levels being deeper in 2022 by just under 3 feet at Goggins and over 6 feet at SSSL compared to 2014 (Table 1 and Table 2). Both lakes exceeded highs of 970 feet in 2019-2021, over 3 feet higher than average levels in 2022. Water level increases could have shifted the littoral zone (area of aquatic plant growth). For example, newly inundated areas represent a new opportunity for aquatic plant growth, while areas with deeper water become limiting due to less light penetration. A potential mechanism for increased plant abundance and FQI scores driven by water level changes would be when newly inundated areas host unique species while existing vegetation in deeper areas persists at decreased density. Another mechanism driven by fluctuations could be wet-drying cycles that stimulate the aquatic seed bank and provide suitable conditions for germination.

Water quality could also factor into the slightly increased FQI scores. Water clarity is a primary driver of aquatic plant growth and diversity. Based on the 2021 BCWD water monitoring summary, statistically significant improving trends for water quality parameters have been recorded at Goggins Lake, while no statistically significant trends are present for SSSL. Improving water clarity while also increasing water depth could lead to expansion of the littoral zone where newly inundated areas provide new habitat while deeper areas of the lake also become habitat due to increasing clarity. This may have occurred at Goggins, where water clarity has both improved and lake levels have increased since 2014.

Finally, aquatic plant management conducted by BCWD at SSSL and Goggins could have contributed to slightly increased FQI scores. Chemical treatments for CLP were conducted at SSSL in 2017 and 2021 and at Goggins in 2021. In general, CLP does not compete directly with native vegetation and is more limited by environmental factors like good water clarity (that allows native plants to compete), deep winter snow cover (that limits light availability beneath the ice), spring water temperatures, or deeper water levels (that shift the littoral zone toward areas not yet colonized by CLP). That said, management may have limited CLP and reduced establishment in newly inundated areas, creating more open niches for native vegetation and thereby improved FQI scores. At the very least, the improved FQI scores suggest that management has not harmed the native plant community.

EWM was documented at both SSSL and Goggins for the first time, with relatively high frequency of occurrence at SSSL (44% of sites). It is not known when EWM colonized the lakes between 2014 and 2022. High density and frequency of EWM was concentrated along the shoreline in many areas that were likely above the lake elevation in 2014. Higher water levels may have facilitated EWM colonization before native plants (or CLP) could establish in newly inundated areas. Unlike CLP, EWM competes directly with native vegetation and aggressive growth forms mats that shade out competitors (Photograph 1). Continued expansion of EWM could negatively impact FQI scores in the future.

Recommendation: While every lake and lake user is different, most experts agree that CLP treatments, which almost exclusively involve the use of contact herbicides, are not warranted unless CLP occupies 15% or more of the littoral zone due to the potential for damage to non-target species. Intermittent treatments of CLP conducted over the past 5 years have helped to keep CLP below this threshold. The efficacy of these treatments has likely been aided by above average lake levels which likely reduced the area in which CLP could germinate or sprout from turions in deeper areas while expanding the littoral zone into shallower areas where little or no CLP seed/turion bank existed.

EOR recommends spring CLP surveys every three years, which likely will be sufficient to identify problematic CLP growth greater than 15% or more of the littoral zone that warrants treatment. Additionally, research shows that long-term CLP control is best achieved via improvements to water

1919 University Avenue West, Suite 300 St. Paul, MN 55104 T/ 651.770.8448 F/ 651.770.2552 www.eorinc.com

clarity. Continued watershed or in-lake practices to improve and maintain clarity will likely be the most cost-effective means of CLP management at SSSL and Goggins and should be prioritized as part of a comprehensive AIS management strategy. Improved clarity also supports native vegetation and could increase FQI scores.

Further, given that the quality of the aquatic plant community appears to be at least stable and possibly increasing, EOR is not recommending treatments to target EWM. However, the increase in the abundance of EWM should be monitored via early summer point-intercept aquatic plant surveys conducted every three years (e.g., 2025). If the frequency of EWM continues to increase to the detriment of the native plant community, EOR would likely recommend that BCWD explore herbicide treatments using ProcellaCOR. EOR has had outstanding success with ProcellaCOR treatments on lakes in Wisconsin and Minnesota both in terms of control of the target species (EWM) and avoidance of impacts to the native plant community. Progress towards achieving control of these target species is subject to change based on feedback from lake users and methods of control.

Photograph 1. Surface matting of EWM at SSSL.

Mapping

The distribution for each individual species with a frequency of occurrence ≥ 10% is mapped within Appendix A.

Table 3. South School Section Lake species list and frequency of occurrence.

Common Name	Scientific Name	C-Value	Frequency of Occurrence
Coontail	*Ceratophyllum demersum*	2	63.8%
Muskgrass/stonewort	*Chara* cf. *globularis*	7	0.8%
Needle spikerush	*Eleocharis acicularis*	4	1.5%
Canada waterweed	*Elodea canadensis*	4	35.4%
Northern watermilfoil	*Myriophyllum sibiricum*	7	0.8%
Eurasian watermilfoil	*Myriophyllum spicatum*	0	44.6%
White water lily	*Nymphaea odorata*	6	10.8%
Water smartweed	*Persicaria amphibium*	4	6.2%
Curly-leaf pondweed	*Potamogeton crispus*	0	0.8%
White-stem pondweed	*Potamogeton praelongus*	7	0.8%
Small pondweed	*Potamogeton pusillus*	7	1.5%
Flat-stemmed pondweed	*Potamogeton zosteriformis*	6	1.5%
Summary Table FQI = C*√S	**Average C-Value**	4.5	
C= Mean coefficient of conservatism value	**Number of species**	12	
S= Number of species in sample	**FQI**	**15.6**	

Table 4. Goggins Lake species list and frequency of occurrence.

Common Name	Scientific Name	C-Value	Frequency of Occurrence
Coontail	*Ceratophyllum demersum*	2	91.5%
Canada waterweed	*Elodea canadensis*	4	12.2%
Eurasian watermilfoil	*Myriophyllum spicatum*	0	12.2%
Water smartweed	*Persicaria amphibium*	4	4.9%
Curly-leaf pondweed (turion)	*Potamogeton crispus*	0	1.2%
Small pondweed	*Potamogeton pusillus*	7	2.4%
Fern-leaf pondweed	*Potamogeton robbinsii*	8	40.2%
Unknown floating-leaved pondweed	*Potamogeton sp.*	7	1.2%
Flat-stemmed pondweed	*Potamogeton zosteriformis*	6	12.2%
Unknown arrowhead	*Sagittaria* sp.	7	1.2%
River bulrush	*Schoenoplectus fluviatilis*	4	2.4%
Summary Table FQI = C*√S	**Average C-Value**	4.9	
C= Mean coefficient of conservatism value	**Number of species**	10	
S= Number of species in sample	**FQI**	**15.5**	

Appendix A

South School Section Lake and Goggins Lake Aquatic Plant Species Distribution

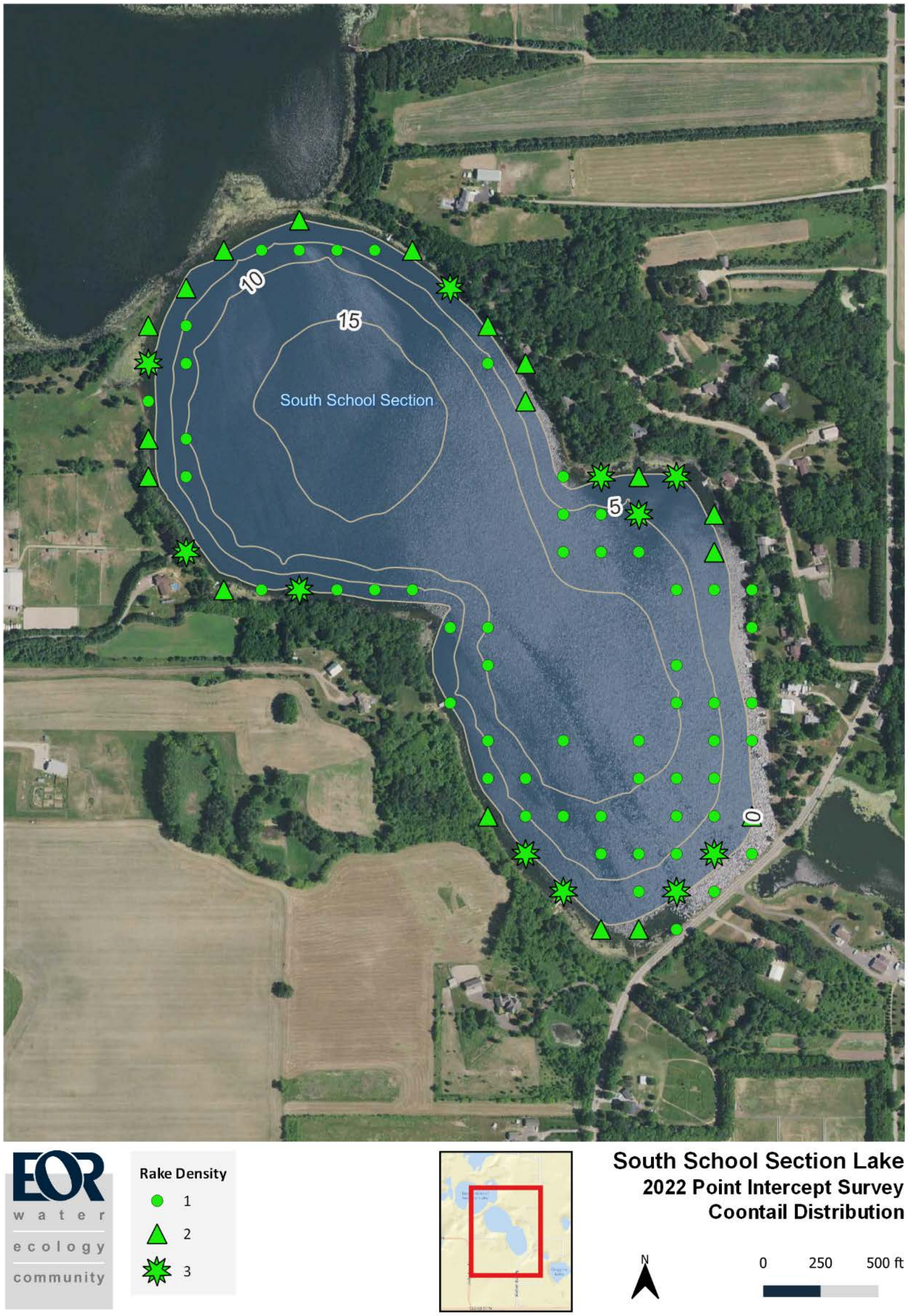

Figure 1. South School Section Lake coontail distribution – August 2022.

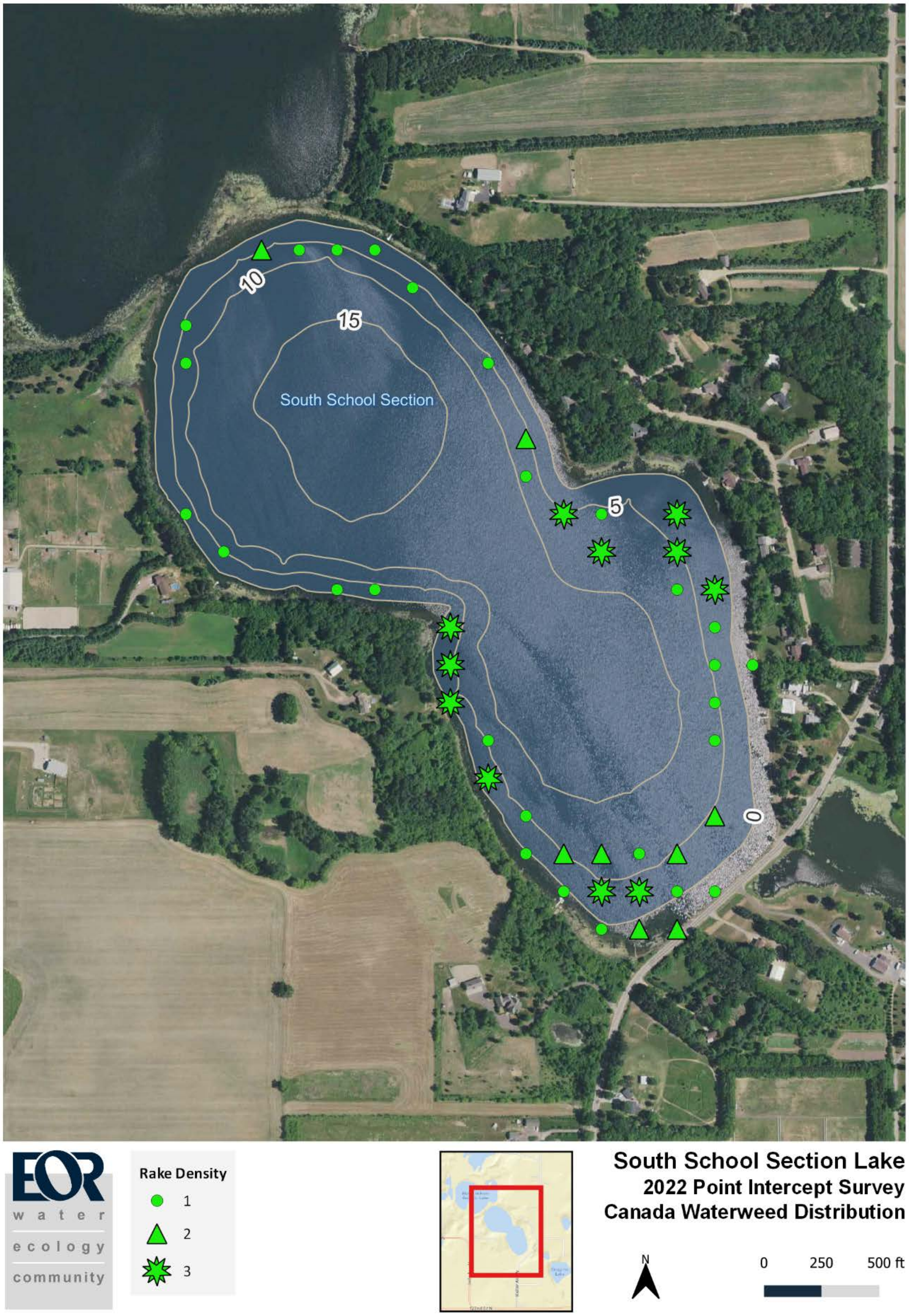

Figure 2. South School Section Lake Canada waterweed distribution– August 2022.

1919 University Avenue West, Suite 300 St. Paul, MN 55104 T/ 651.770.8448 F/ 651.770.2552 www.eorinc.com

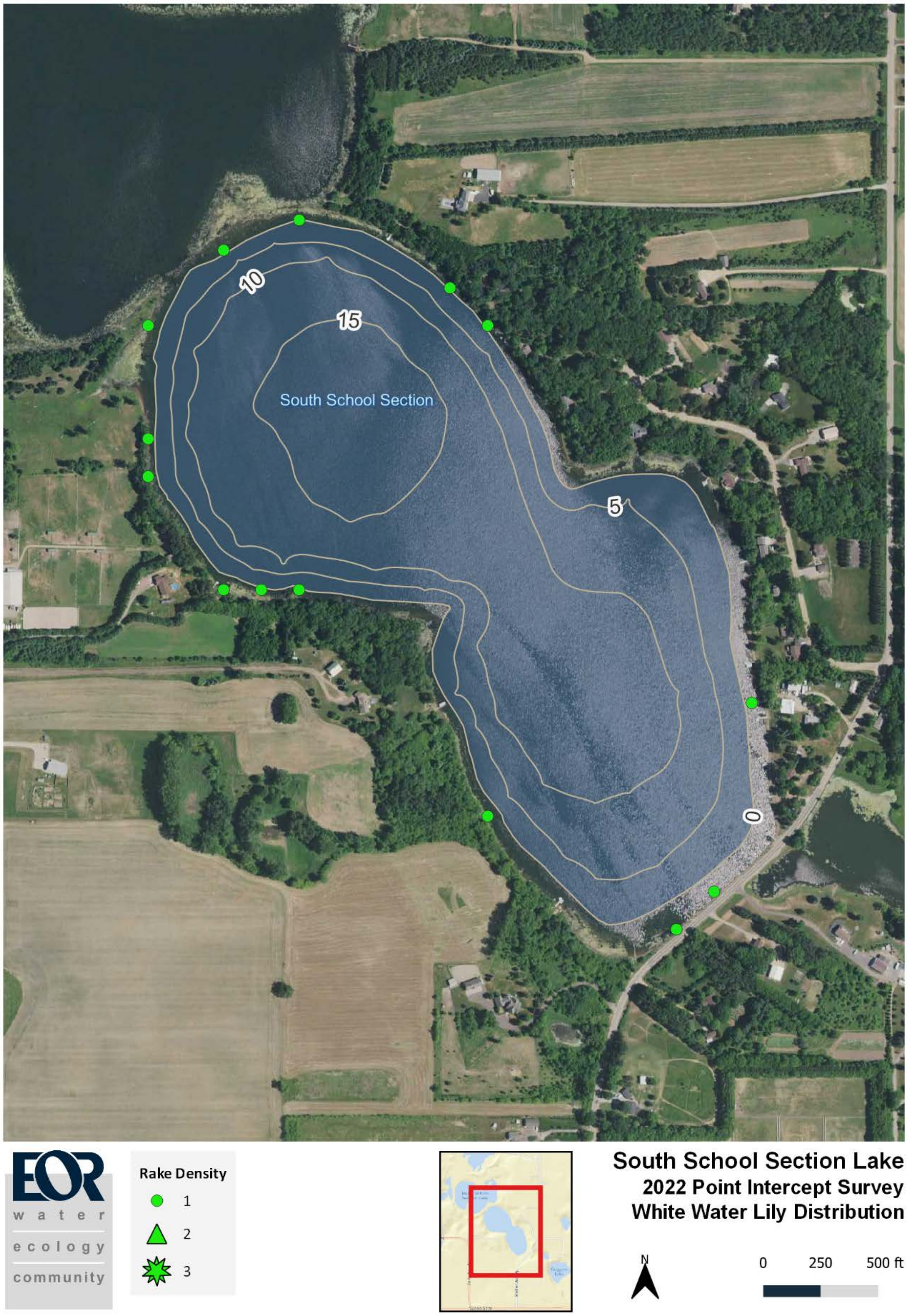

Figure 3. South School Section Lake white water lily distribution – August 2022.

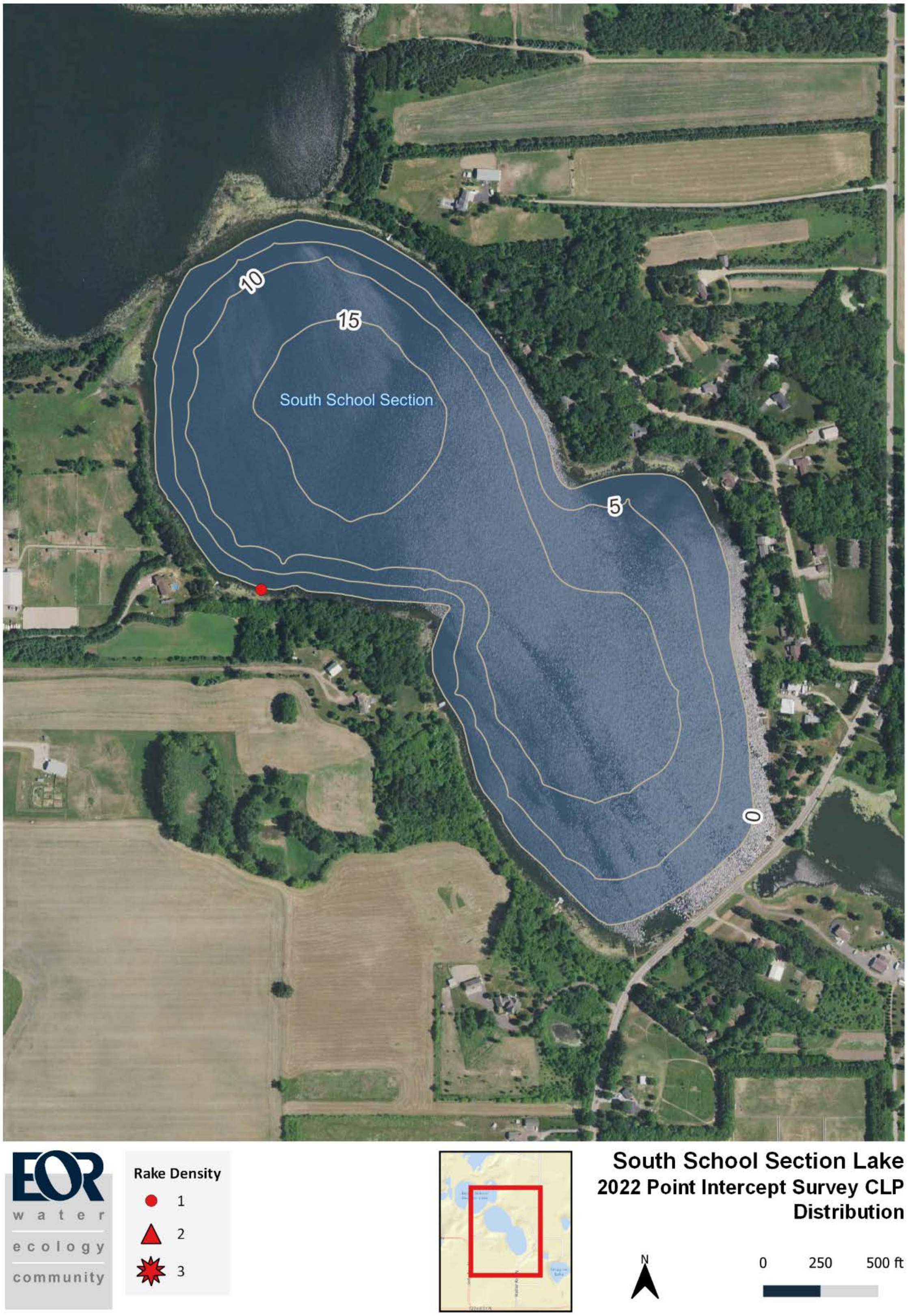

Figure 4. South School Section Lake curly-leaf pondweed distribution – August 2022.

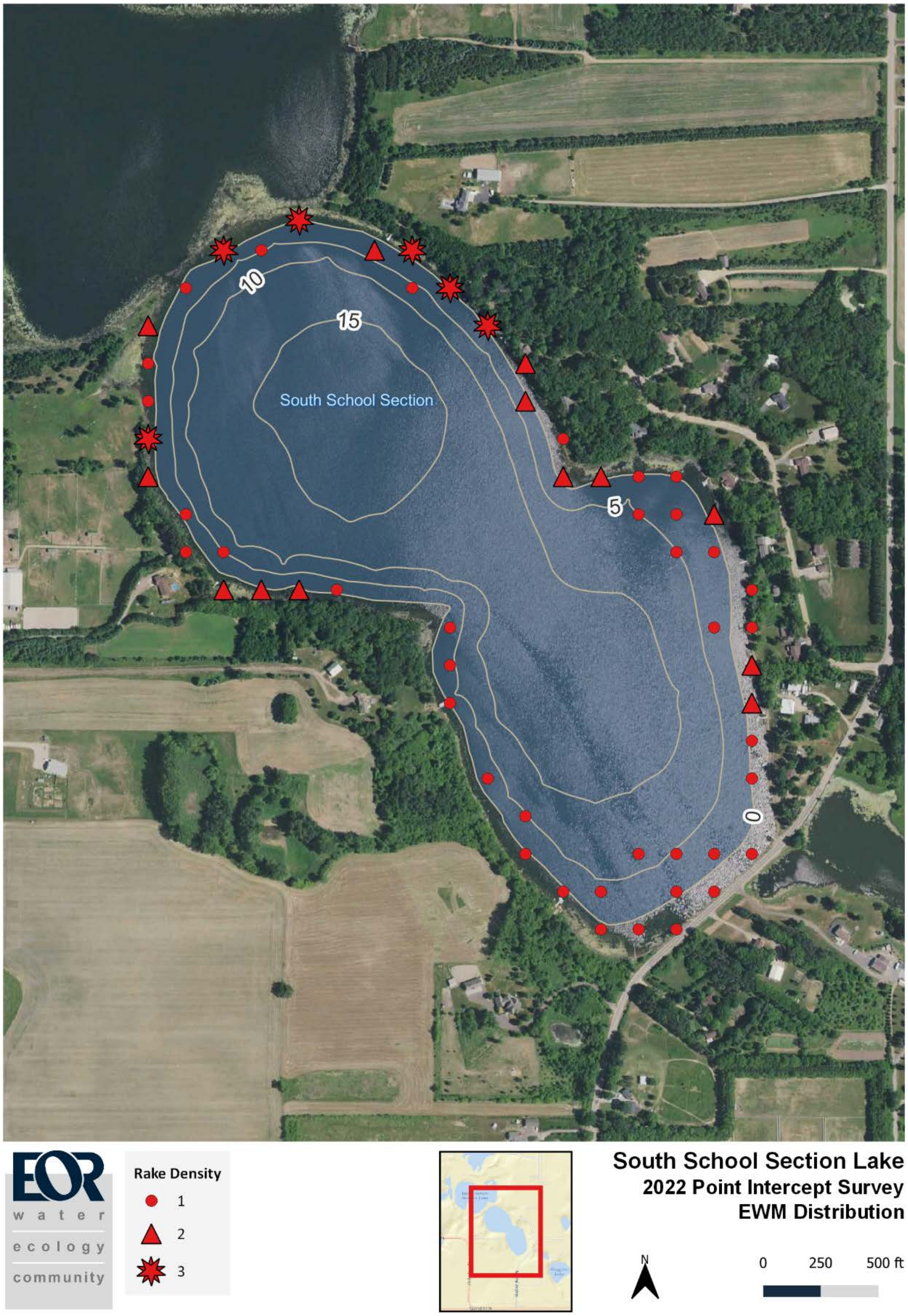

Figure 5. South School Section Lake Eurasian watermilfoil distribution – August 2022.

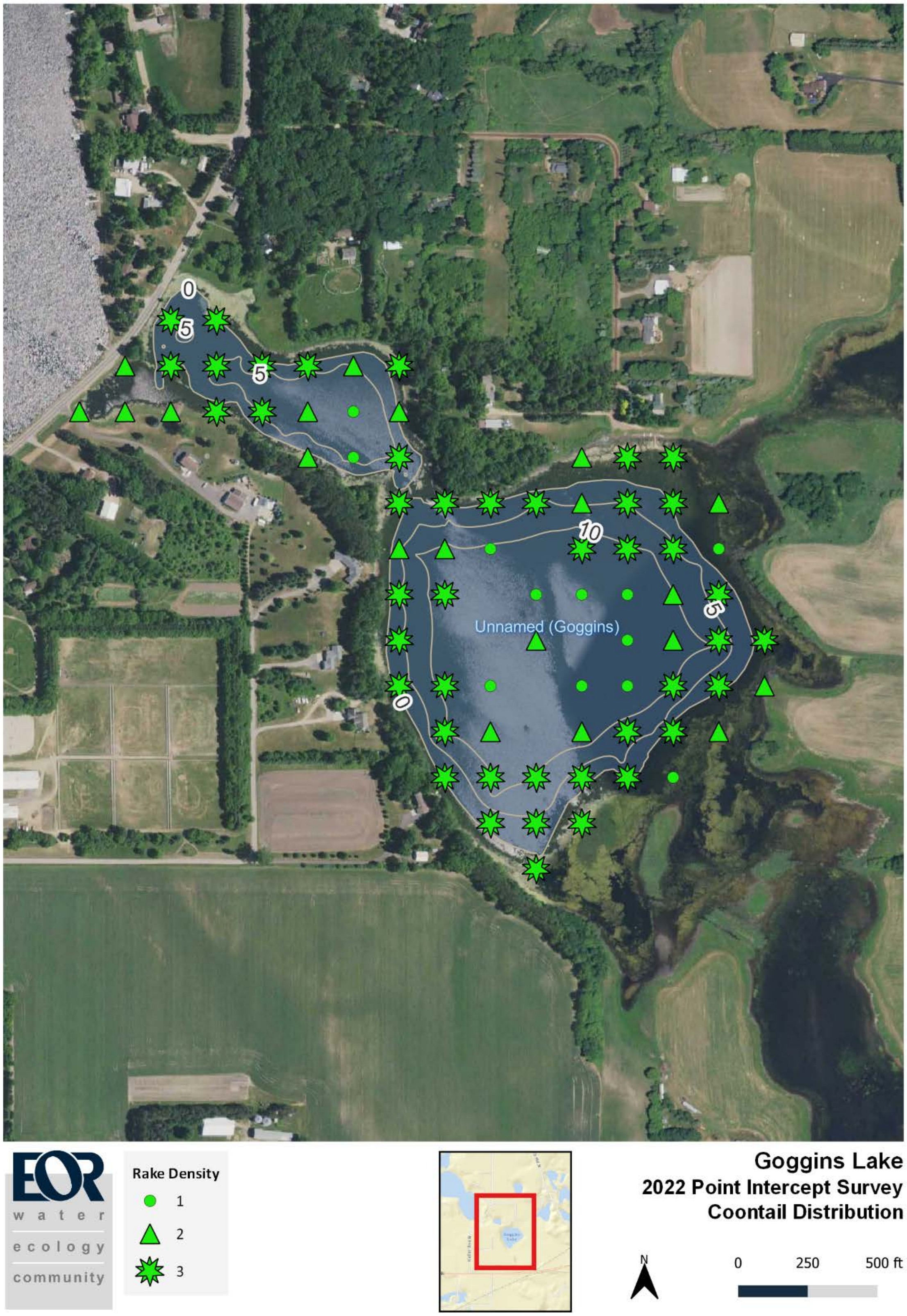

Figure 6. Goggins Lake coontail distribution – August 2022.

Figure 7. Goggins Lake Canada waterweed distribution – August 2022.

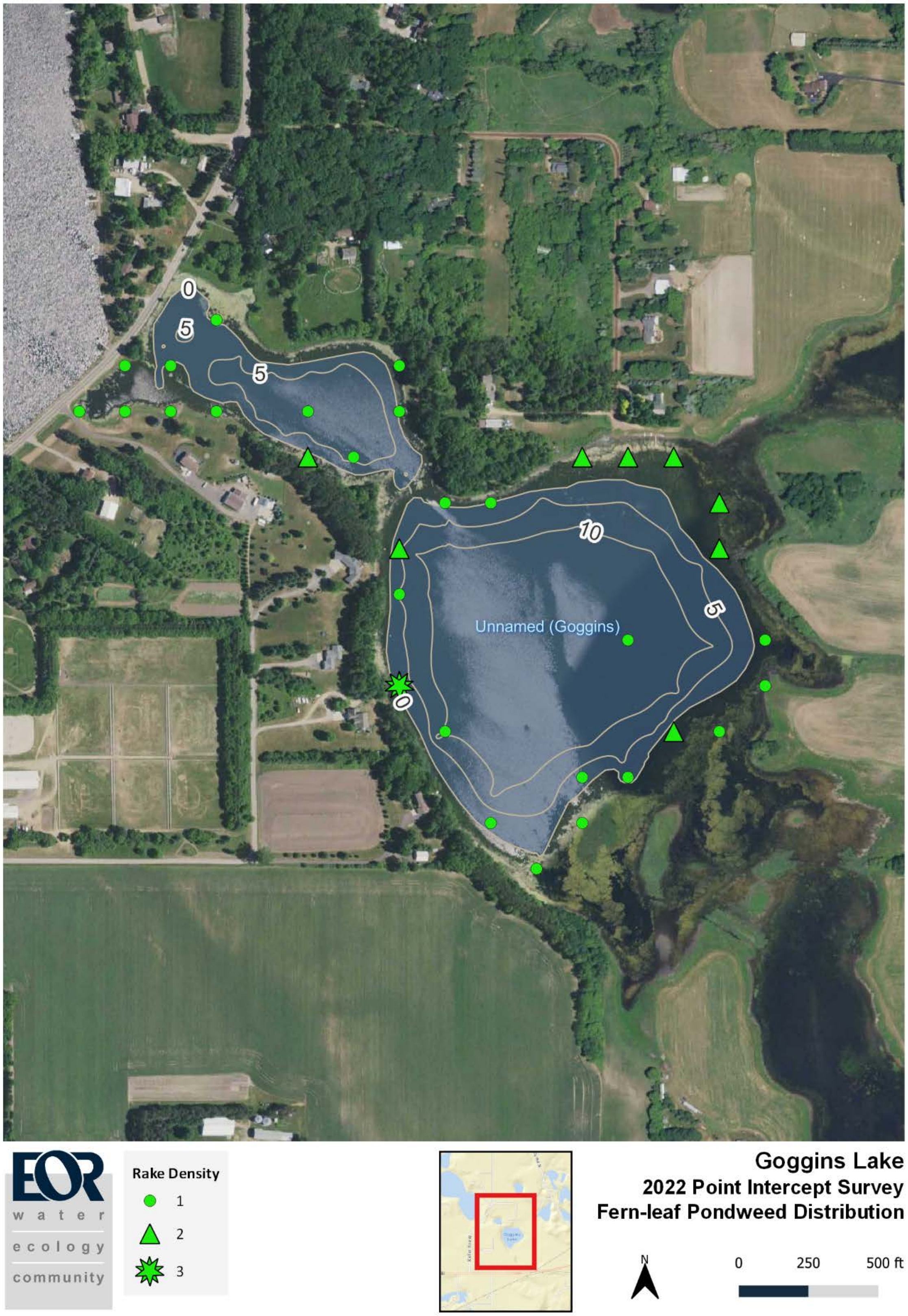

Figure 8. Goggins Lake fern-leaf pondweed distribution – August 2022.

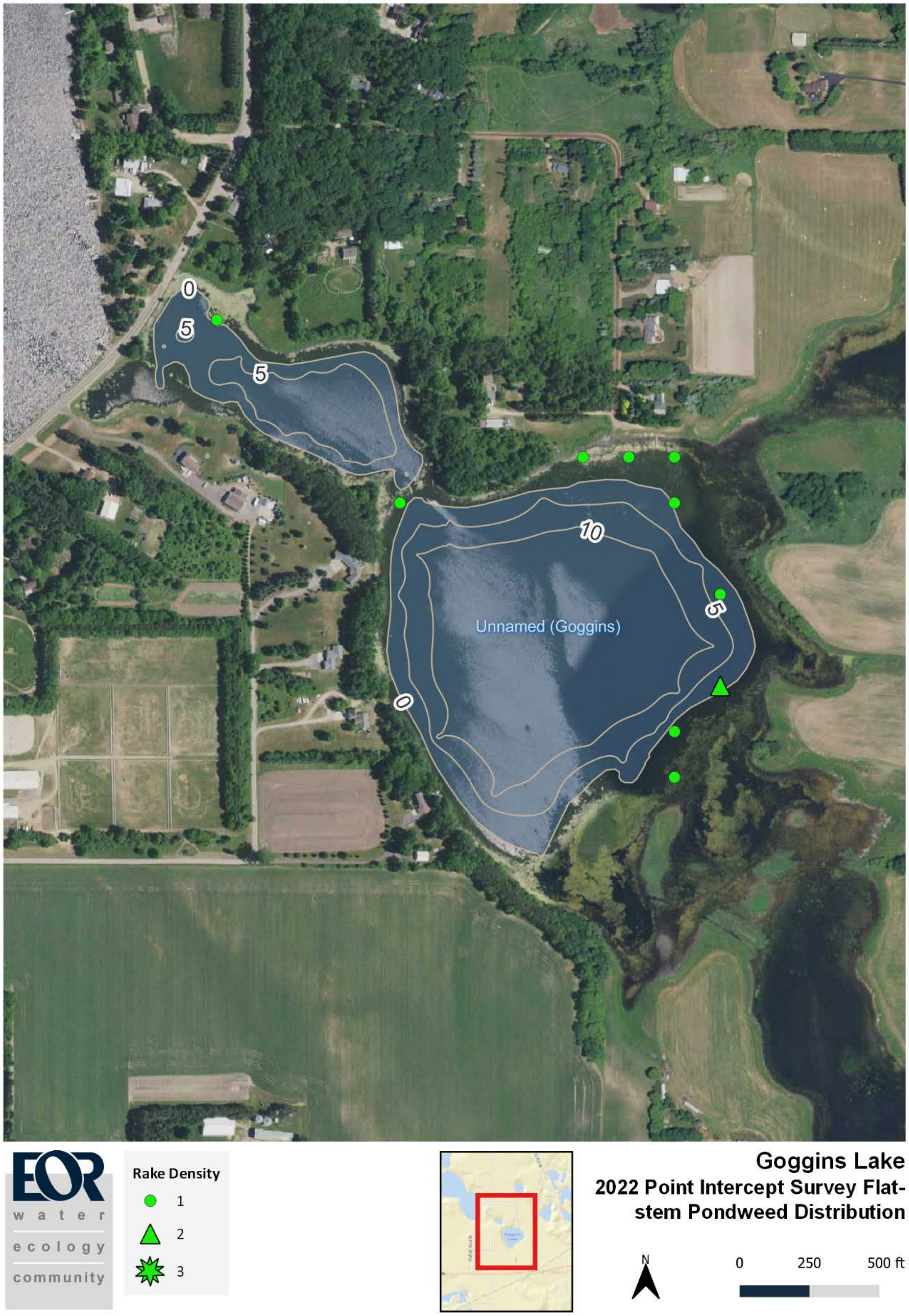

Figure 9. Goggins Lake flat-stem pondweed distribution – August 2022.

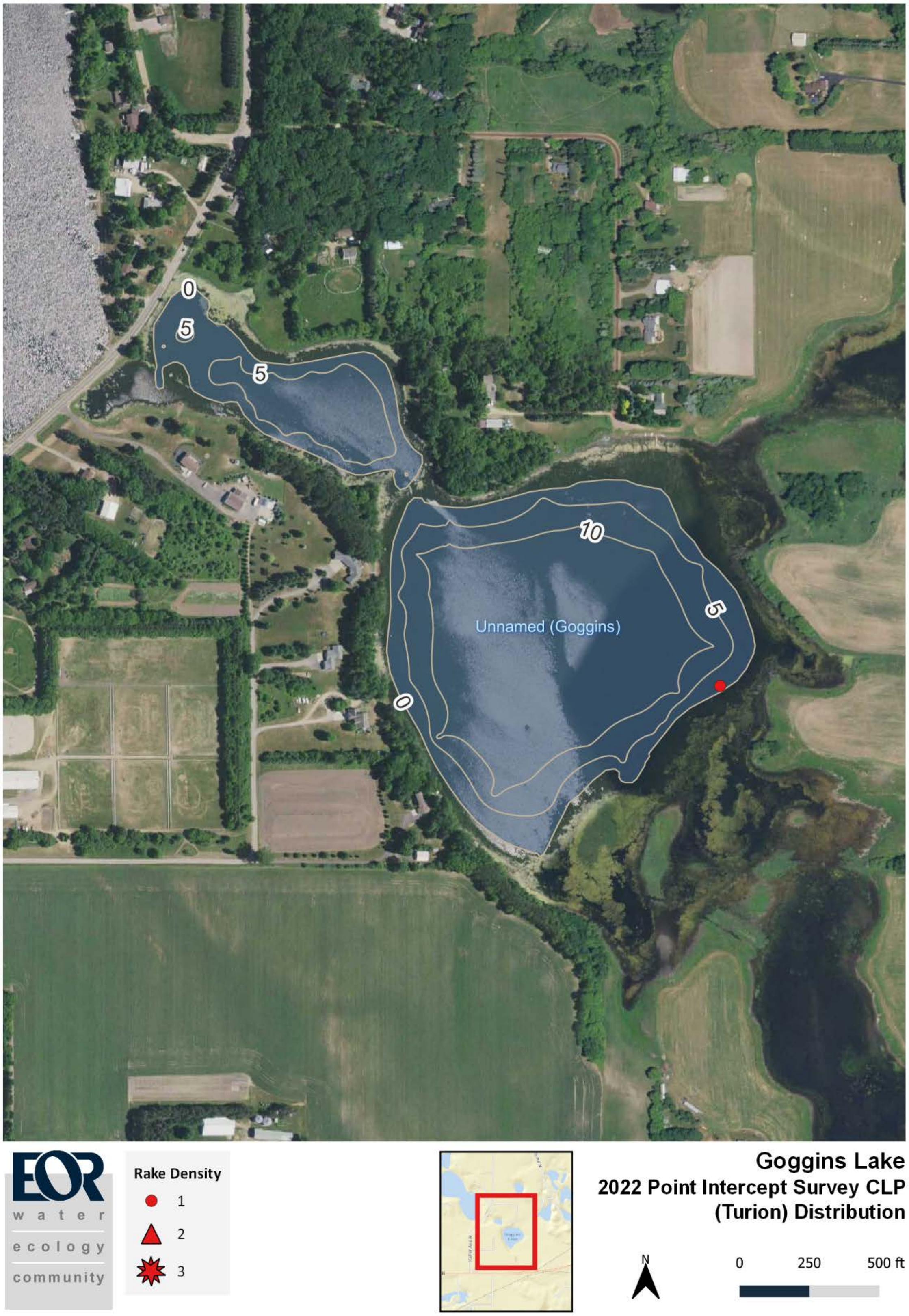

Figure 10. Goggins Lake CLP (turion) distribution – August 2022.

Figure 11. Goggins Lake EWM distribution – August 2022.

Appendix B

Historical Macrophyte Data

Table 5. Historical Aquatic Plant Survey Results

Lake Name		Goggins		South School Section (2014)		South School Section (2017)*	
Scientific Name	**Common Name**	**Avg. Density**	**% of Sites**	**Avg. Density**	**% of Sites**	**Avg. Density**	**% of Sites**
Elodea canadensis	Canada waterweed	2.4	22%				60%
Brasenia schreberi	Watershield			1	2%		
Ceratophyllum demersum	Coontail	1.4	27%	1.97	41%		45%
Lemna Minor	Lesser Duckweed	1	10%				
Najas guadalupensis	Southern waternymph			1.7	13%		
Nitella spp.	Stonewort (algae)	1	1%	1.3	21%		
Nuphar lutea	Yellow pond lily						
Nymphaea odorata	American white waterlily	1	1%	1.2	3%		
Potamogeton crispus	Curlyleaf pondweed			1.3	55%		48%
Potamogeton foliosus	Leafy pondweed			1.2	3%		
Potamogeton natans	Floating-leaf pondweed	1	1%				
Potamogeton pectinatus	Sago pondweed	1.2	18%	1	4%		
Potamogeton robbinsii	Robbins' pondweed						
Potamogeton spp.	Unidentified pondweed			1	1%		
Potamogeton zosteriformis	Flatstem pondweed	1	1%	1.5	19%		
Typha spp.	Cattail/possible hybrid	1.5	1%	1.2	6%		
Utricularia macrorhiza	Common Bladderwort	1	3%				
Vallisneria americana	Wild celery	1	1%				

* The 2017 survey was conducted early in the growing season with an emphasis on delineating the extent of CLP growth. Many native species had not