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

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.

Potential Next Steps:

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.

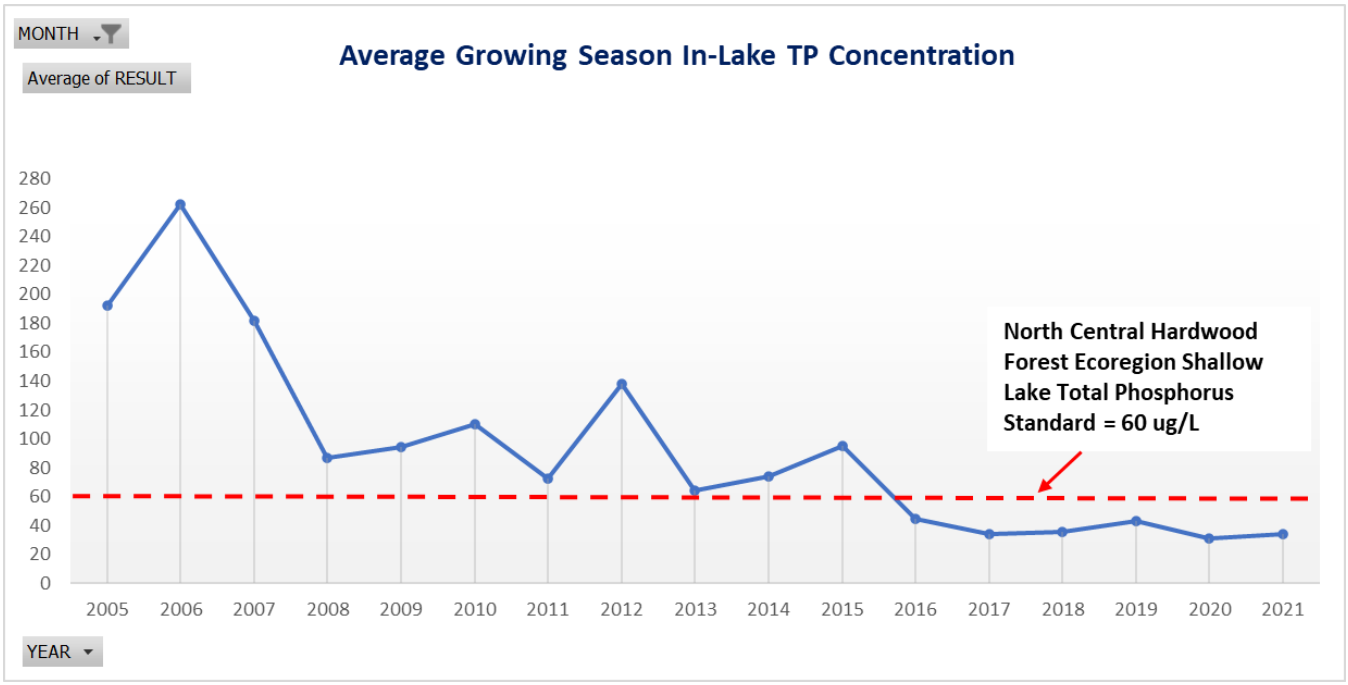

Figure 2. Pivot chart of growing season (June-September) average in-lake total phosphorus (TP) concentrations show a reduction in lake phosphorus concentrations that corresponds to the 2016 transition to a clear water, aquatic plant dominated state.

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

Appendix A

Benz Lake Aquatic Plant Species Distribution

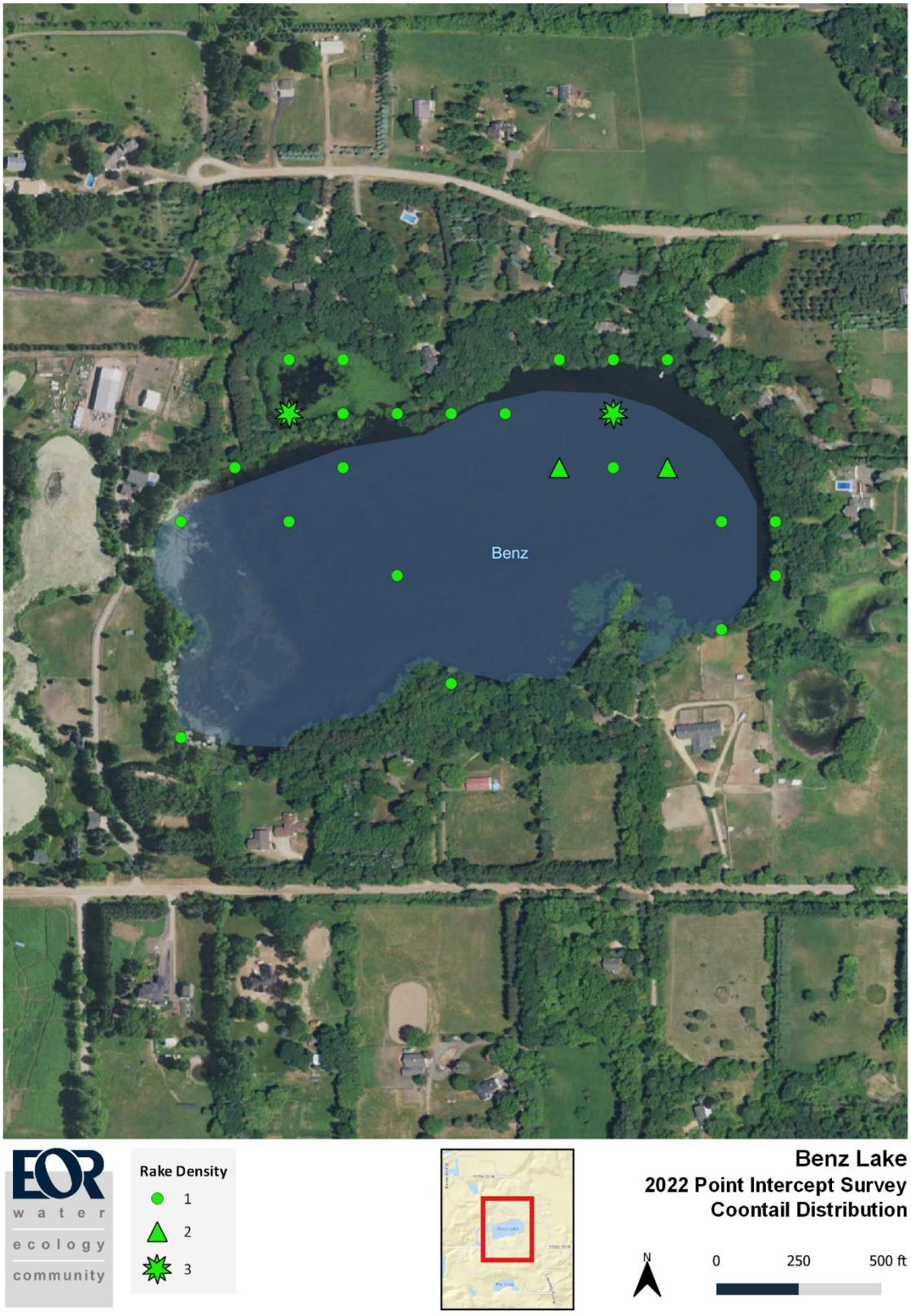

Figure 3. Benz Lake coontail distribution – August 2022.

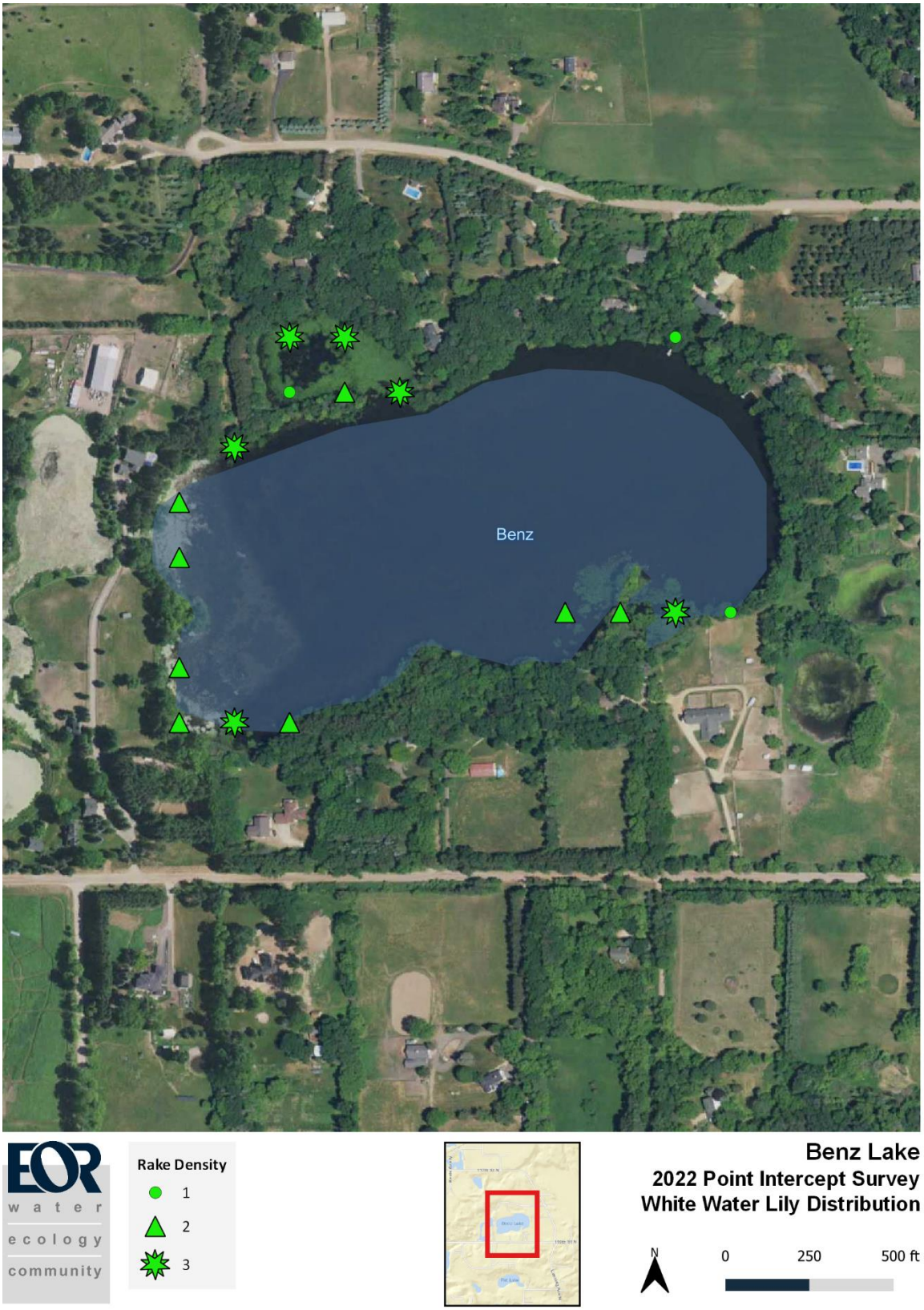

Figure 4. Benz Lake white water lily distribution – August 2022.

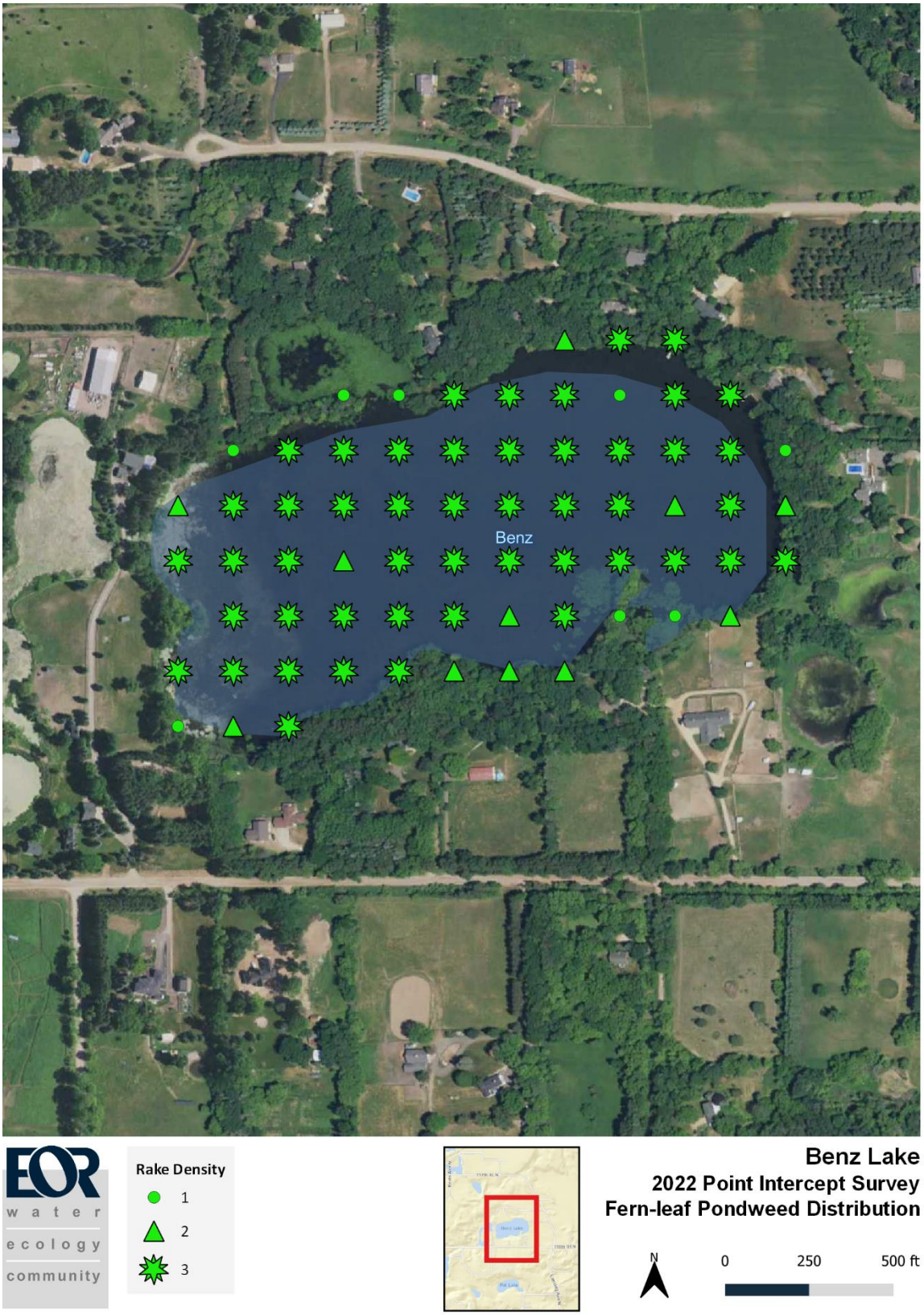

Figure 5. Benz Lake Fern-leaf pondweed distribution – August 2022.