Minister & Schoolhouse Ponds

2018 Vegetation Assessment, Water Quality Evaluation, and Phragmites Management Report

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Contents

2018 Vegetation Assessment, Water Quality Evaluation, and Phragmites Management Report

Minister/Schoolhouse Pond
Eastham, Massachusetts

Introduction

SŌLitude Lake Management (SŌLitude) was contracted by the Town of Eastham Health Department to assess the macrophyte growth extent at Minister/Schoolhouse Pond, comparative to the mid-season survey completed in 2017, in addition to investigating potential nutrient impairment by means of water quality and sediment sampling. The common reed (*Phragmites australis*) documented at the pond in 2017 was managed in 2018. The focus of this assessment was not only to better understand the current extent of the native plant assemblage, but also to evaluate the feasibility and long-term success of various restoration techniques.

Site Description

Minister/Schoolhouse Pond is a 22.3-acre waterbody located in Eastham, MA, comprised of two basins commonly referred to as separate ponds – Minister Pond as the northern basin and Schoolhouse Pond as the southern basin. The Minister basin is the larger and shallower of the two, at 16.8 acres with a maximum depth of 15 feet. The Schoolhouse basin is approximately 5.6 acres and reaches 18.5 feet at its deepest. Based on StreamStats and local reports, water primarily flows into the Minister basin and out through the Schoolhouse basin. Nearly the entire watershed is residentially developed, potentially contributing to nutrient deposition into the pond.

The 2009 assessment of the Eastham ponds founded the need for remediation of Minister/Schoolhouse Pond in terms of nutrient impairment. In order to establish an updated state of the pond, SŌLitude performed an assessment of Minister/Schoolhouse Pond, including water chemistry, plankton, and vegetation sampling. Impairment was confirmed by means of the 2017 monitoring, leading to the conception of the 2018 work program.

The following report will discuss: methodology, vegetation assemblage and Phragmites management, water quality & sediment conditions, and management recommendations concentrated on nutrient remediation.

Methodology

Point Intercept Macrophyte Mapping

The Point Intercept Method (PIM) of sampling macrophytes is designed to determine the extent of aquatic growth within an area of concern. The 50 sample sites established in 2017 were created by placing a georeferenced 40-m grid data layer over an orthophoto Minister/Schoolhouse Pond and placing data collection sites at each vertex (Appendix B – Sample Location map). A handheld Garmin GPS unit was used to locate each data point in the field.

The Rake Toss Methodology, developed by the US Army Corps of Engineers and modified by Cornell University was used for this survey (Lord and Johnson 2006). A single rake toss to collect submersed plant specimens was executed at each of the established sample sites. The following data was collected from each rake toss: overall abundance of macrophyte growth, relative abundance of each species, and any other pertinent field notes regarding the sample location (such as notes on bottom substrate and nearby aquatic/emergent plant growth). The abundance scale defined by this methodology was used to categorize the observed macrophyte growth for each rake toss:

Z Zero: no plants on rake
T Trace: Fingerful on rake
S Sparse: Handful on rake
M Medium: Rakeful of plants
D Dense: Difficult to bring into boat

Water depth was also recorded through the use of a hand-held depth finder at each sample location. However, when extensive macrophyte growth in shallow water inhibited the use of the depth finder, a calibrated 6' pole or paddle was used to measure approximate depths.

Macrophyte specimens not readily identifiable in the field were collected and bagged with corresponding sample site information. The collected vegetation samples were then placed in a cooler and transported to SŌLitude for further inspection and positive identification. Regionally appropriate taxonomic keys were used to identify the aquatic macrophytes to the lowest practical taxa – typically to species.

Water Chemistry Sampling

Water quality samples were collected at two locations within the pond – the relative centers of each basin – and at two depths for each location. The Minister basin was sampled at 2 feet and 13 feet, and the Schoolhouse basin was sampled at 2 feet and 15 feet. The samples were analyzed for the following parameters: total phosphorus, orthophosphate, total alkalinity. Additional parameters were analyzed in-situ using a calibrated YSI ProPlus; specific conductance readings were taken at depth and temperature and dissolved oxygen profiles were recorded for each sample location. Clarity at each sample location was recorded using a secchi disk.

Sediment Sampling

The sediment content was tested for available phosphorus to evaluate the design and potential effectiveness of a phosphorus inactivation treatment using Alum or polyaluminum chloride (PAC). Samples were collected using an Ekman dredge or equivalent every 100 feet along a transect for each basin. The samples were composited into Shallow (<10 feet depth) and Deep (>10 feet depth) samples and analyzed for the following parameters: grain size, percent solids, loosely sorbed phosphorus (labile), iron-bound phosphorus (reductant-soluble), organic phosphorus, and other unavailable forms.

Additionally, sediment cores were taken within the littoral zone to estimate the depth extent of the aquatic plant roots. Sample locations were placed along a transect within the littoral zone, extending from the shoreline to approximately 10 feet, where possible.

Herbicide Application

Refer to the Phragmites Management section for a discussion of herbicide application methodologies.

Results & Discussion

Vegetation Inventory

On August 14th, 2018 a two-Biologist crew from SŌLitude conducted the point-intercept survey at Minister/Schoolhouse Pond. As with the 2017 survey, no non-native aquatic species were documented at the time of the survey.

Table 1 (below) lists the macrophytes that have been identified at Minister/Schoolhouse Pond. Raw data and distribution maps for each species are provided in Appendices A and B, respectively.

Table 1. Macrophyte Inventory and Frequency of Occurrence† at Minister/Schoolhouse Pond*

Scientific Name	Common Name	June 21, 2017	August 14, 2018
Brasenia schreberi	Watershield	2%	-
Ceratophyllum sp.	Coontail	4%	24%
Chara/Nitella	Macro-algae	2%	-
Eleocharis sp.	Spikerush	4%	2%
Elodea nuttallii	Western Waterweed	8%	2%
Fontinalis sp.	Aquatic Moss	14%	6%
Myriophyllum farwellii	Farwell's Watermilfoil	-	2%
Najas gracillima	Northern Naiad	-	8%
Nuphar variegata	Yellow Waterlily	20%	32%
Nymphaea odorata	White Waterlily	24%	44%
Nymphoides cordata	Floating Heart	16%	2%
Potamogeton sp.	Thin-leaf Pondweed	-	6%
Potamogeton epihydrus	Ribbon-leaf Pondweed	10%	28%
Potamogeton pusillus	Small Pondweed	4%	-
Utricularia gibba	Humped Bladderwort	8%	18%
Utricularia minor	Lesser Bladderwort	4%	8%
Utricularia purpurea	Whorled Bladderwort	2%	2%
Utricularia radiata	Little Floating Bladderwort	16%	2%
Utricularia vulgaris	Common Bladderwort	2%	6%
Vallisneria americana	Tapegrass	2%	2%

†%Frequency of Occurrence is calculated from the total sample points surveyed (n=50)

The 2018 survey documented seventeen aquatic species – all of which are native to the state of Massachusetts. Of the seventeen (17) native macrophytes, thirteen (13) are submersed, one is classified as a bryophyte, and three (3) are floating-leaf species.

Over half of the points (54%) supported vegetation, where the littoral zone supported an average richness of 3.6 species (vegetated points only). Point 36 in the connecting channel between the two basins supported the maximum richness of seven (7) species (Appendix B).

Overall abundance is categorized as Medium/Dense for 42% (21/50 sites) of the survey area, and nearly all of the 27 vegetated points. Based on the overall abundance of the growth documented during the survey, a high deposition of biovolume in the littoral zone likely occurs when plants die back in the fall. However, the littoral zone is confined to a narrow band of the immediate shoreline and is not wholly captured by the survey points. Comparatively, the 2017 overall abundance was primarily Trace/Sparse, at 38% (19/50 sites). No 2017 sites were categorized as Dense.

White waterlily, the bladderwort genus, and yellow waterlily remained the most common species in Minister/Schoolhouse Pond, in addition to coontail and ribbon-leaf pondweed. Considering the later nature of the 2018 survey when compared to 2017, greater abundance and distribution of these particular species is reasonable. The reduced presence of floating heart is also likely due to the later nature of the survey. The floating heart leaf typically emerges earlier than full leaf-out of the waterlilies, and therefore begins to senesce as the waterlily pads mature. Additional distribution of the floating heart was noted in the Schoolhouse basin, outside of the survey points.

As with the 2017 survey, a greater number of species were documented in the Minister basin. Northern naiad, Farwell's watermilfoil, western waterweed, whorled bladderwort, little floating bladderwort, spikerush, tapegrass, and thin-leaf pondweed were only documented in the Minister basin. Farwell's watermilfoil was documented for the first time in 2018, and only supported in the northwestern corner of the Minister basin.

The emergent and wetland vegetation was still prominent along the less developed shoreline of the pond. A native pennywort population (*Hydrocotyle sp*.) was documented along the shoreline, at a greater distribution than just at the launch location from 2017. Growth was too immature to determine between whorled marsh pennywort (state protected) and many-flowered pennywort (common). The stands of invasive common reed appeared slightly increased from 2017, where additional pioneer growth was observed on the Minister basin shoreline and noted for later management.

Water Chemistry Results & Analysis

Two sampling sessions were conducted throughout the season: June 21st and July 24th (Table 2). A sampling location was visited in each basin at which two depths were sampled: 2ft and 2 feet above the relative bottom (Appendix B).

At the time of each sampling, all locations fell within acceptable ranges for multiple parameters: specific conductance, total alkalinity (for region), and orthophosphate (Table 2.) However, Total Phosphorus, a key parameter that can indicate impairment, was elevated for all sites at all samplings.

Table 2: Water Quality Sampling Results Collected 2018

Parameter	Minister Results				Schoolhouse Results			
	June 21st 2ft	June 21st 13ft	July 24th 2ft	July 24th 13ft	June 21st 2ft	June 21st 15ft	July 24th 2ft	July 24th 15ft
Specific Conductance (umhos/cm)	407.3	400.7	440	440	411.5	430.5	420	440
Total Alkalinity (mg/L)	9.20	16.40	10.70	27.8	9.10	10.80	10.30	9.40
Clarity (ft)	4.92		3.83		4.58		4.17	
Total Phosphorus (mg/L)	0.038	0.041	0.034	0.083	0.027	0.032	0.034	0.031
Orthophosphate (mg/L)	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L	ND at 0.005 mg/L

Total phosphorus is a measure of all forms of phosphorus in the water column (particulate, dissolved, phosphate). Generally, a total phosphorus concentration over 30 parts per billion (ppb, or 0.030 mg/L) is the threshold at which algae blooms or excessive plant growth can be stimulated. Aquatic systems with concentrations 25-96 ppb are considered nutrient rich and eutrophic; >96 ppb contain excessive nutrients and are considered hypereutrophic. Phosphorus concentrations can also vary throughout a water column, depending on factors such as plant growth, aquatic biota, and dissolved oxygen concentration. Waterbodies that stratify (with a low-oxygen hypolimnion) or with low dissolved oxygen in general will release phosphorus from the sediments and contribute to the internal nutrient load of the waterbody.

Overall, both basins are eutrophic at both samplings and were exhibiting evidence of internal phosphorus loading. This is consistent with 2017 phosphorus concentrations, which were also above 30 ppb at the surface. Regarding the Minister basin, the bottom sample increases from 41 ppb to 83 ppb. With an excessive amount of phosphorus in the oxygen-deprived water, the phosphorus typically becomes mixed into the water column in the fall when pond turn-over occurs or when periodic mixing events occur (high winds, storms, etc.), potentially causing algal blooms.

The temperature of a waterbody is one of the limiting factors for algae and plant growth; as temperature increases, biological activity (photosynthesis, respiration, and decomposition) increases to a point. Temperature is directly related to the amount of available dissolved oxygen, where warmer water holds less oxygen. In deeper waterbodies, temperature stratification occurs; a thermocline occurs at depth where the top layer is warmer and actively exchanges gases with the air. The bottom layer is distinctly cooler and isolated from surface impacts. Turn-over, or mixing, typically occurs in spring and late fall; depending on the size and depth of the waterbody, turn-over can occur multiple times throughout a season. The Minister and Schoolhouse basins seem to be weakly stratified at the times of the samplings, if at all (Charts 1-6 on following page).

Dissolved oxygen is a crucial component of systems supporting aquatic fauna; organisms such as fish and zooplankton breath the water containing dissolved oxygen for survival. Oxygen enters the water through flow, atmosphere, and photosynthesizers (plants and algae). And, fluctuations

Chart 1. Schoolhouse Pond Temp/DO 6/21/18

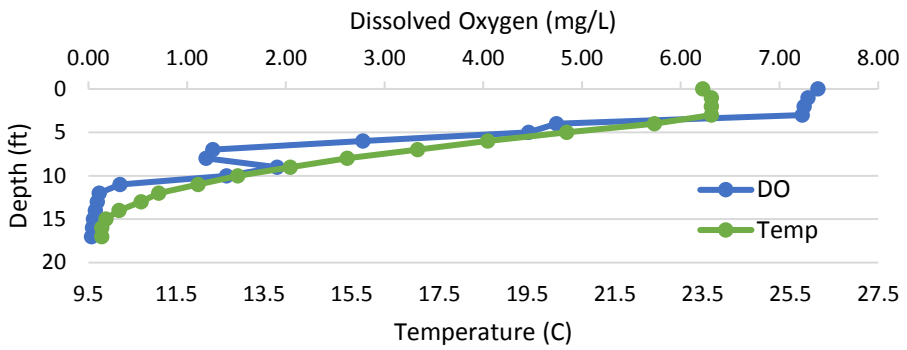


Chart 2. Minister Pond Temp/DO 6/21/18

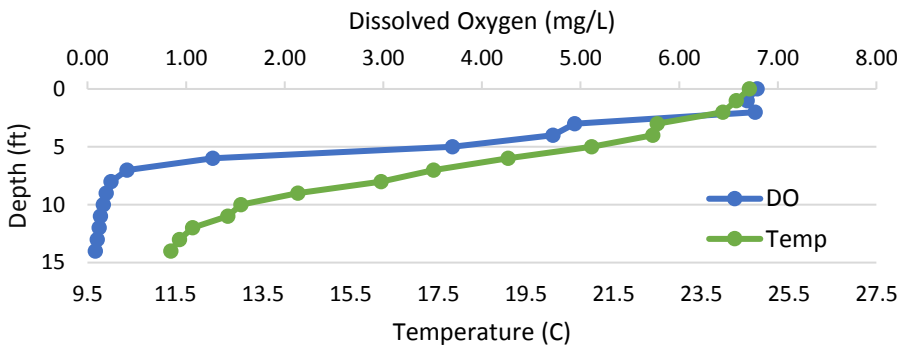


Chart 3. Schoolhouse Pond Temp/DO 7/24/18

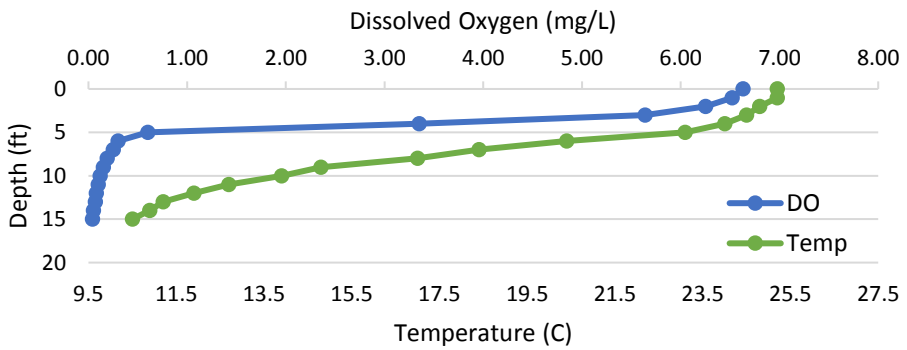


Chart 4. Minister Pond Temp/DO 7/24/18

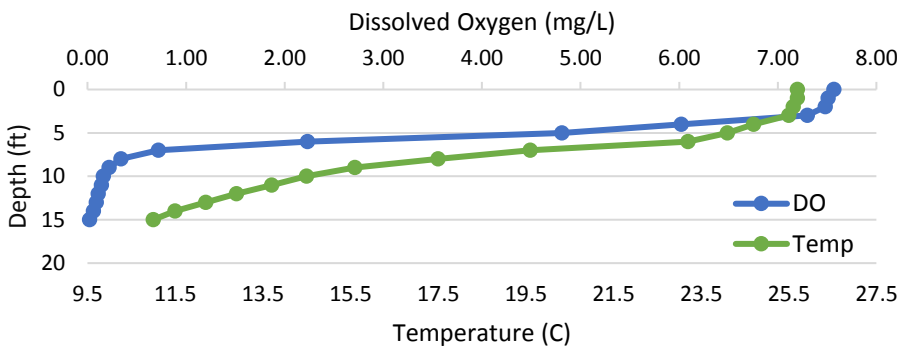


Chart 5. Schoolhouse Pond Temp/DO 8/14/18

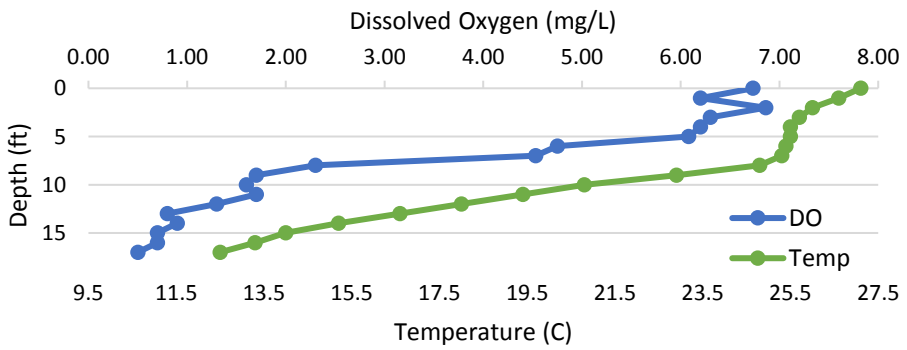
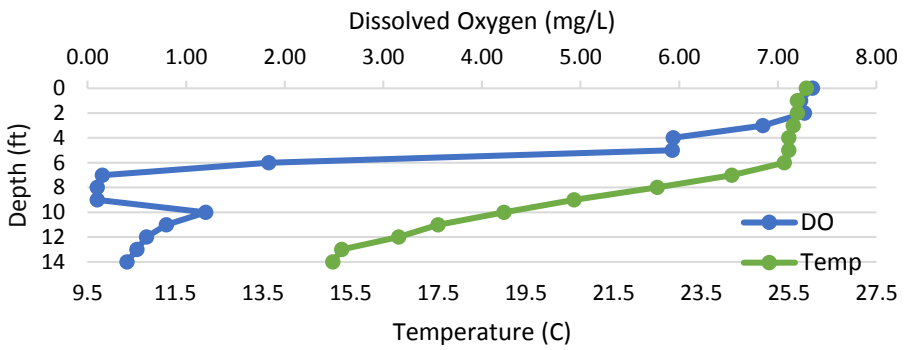


Chart 6. Minister Pond Temp/DO 8/14/18



in oxygen will occur based on the amount of photosynthesizers present in the water (more sunlight = more oxygen). However, with high volumes of plant and algae decay, dissolved oxygen is consumed and causes oxygen deficient environments (eutrophy, anoxia, etc). Dissolved oxygen is also inversely related to temperature, where high temperatures coincide with low dissolved oxygen.

Somewhat predictable levels of oxygen are available throughout the water column, where the dissolved oxygen can be measured vertically from surface to bottom for a profile. This profile can identify waterbody stratification and habitat availability for fish. Values above 5.0 mg/L are desirable for most aquatic life, including most fish species, however lower values commonly occur near the sediment layer where oxygen exchange is at a minimum. Both basins experience low oxygen levels after the first 3-5 feet of the water column, which confines the majority of potential fish habitat to the upper, warmer water layers.

The clarity of both basins ranges from 3-5 feet, congruent with the depth of oxygen production, which makes sense for plant and algae growth reports at the pond.

Sediment Sampling Results

Layers of grain size were present in both basins, ranging from silt to course sand. The Shallow samples typically contained a greater quantity of larger grain size, considering the small layer of organics over hard sand bottom. The Deep samples were generally comprised of smaller grain sizes, such as levels of silt, with some sand present.

As expected, available phosphorus increased in areas of deeper water, where more organic sediment was present (Table 3).

Table 3. Available Phosphorus at Minister/Schoolhouse Pond 6/21/18

	Total Overall Phosphorus (mg/kg)	Total Available (mg/kg)	Labile (mg/kg)	Reductant-soluble (mg/kg)	Organic (mg/kg)
Minister Shallow	1620	226	14	95	117
Minister Deep	989	358	19	185	154
Schoolhouse Shallow	1182	271	14	222	35
Schoolhouse Deep	2202	858	25	408	425

Both shallow samples revealed available phosphorus content that is considered low. The deep sample in the Minister Pond basin is within the low end of what is considered moderate levels of available phosphorus (300-800 mg/kg), while the deep sample in Schoolhouse basin showed moderate to high levels of available phosphorus.

Potentially available organic, or biogenic phosphorus, can be released through decomposition under any aerobic conditions although the release rates would be higher during periods of warmer water. Reductant soluble phosphorus would only be released when dissolved oxygen levels at the sediment were anoxic (<1 mg/L), which typically occurs only during the summer. Given the levels of available phosphorus observed in the samples, along with evidence of higher phosphorus in the hypolimnion, it is likely that internal loading is an issue for both of the Minister and Schoolhouse basins.

Given the shallow water depths in the ponds, there is a relatively small volume of water in which to incorporate the internal loading of phosphorus from the sediments. Additionally, poor oxygenation in the ponds increases the extent of bottom that is subject to anoxic conditions and resultant release of iron-bound phosphorus. Both of these conditions increase the potential adverse effects of internal loading. Additional study would be needed to gain further understanding of the nutrient loading and dynamics in these ponds.

To analyze for root depth, sediment cores were taken within the littoral zone, from the shoreline out to approximately 10 feet deep; cores were primarily taken along the same transect utilized for the sediment samples. However, additional cores were attempted outside of the transect due to variation in pond bottom and plant growth. Achieving whole cores was a challenge due the hard, sandy bottom. In areas of very little organic deposition or lily root mat, an adequate sediment core for measurement could not be obtained. Any cores that were retrieved were loose and non-compact, which did not maintain shape during extraction.

Based on the sediment cores and general field assessment, root depths in both Minister and Schoolhouse basins were confined to any organic space available above the sandy bottom, of which there was very little present. In areas of organic deposition, such as the northern cove of the Schoolhouse basin, root depth was greatly dependent on the density of the lily root mat and the solidity of the organic material. In general, the species present in Minister/Schoolhouse Pond are shallow-thriving, and do not require a great deal of sediment space for growth.

Phragmites Management

On October 18, 2018 a SŌLitude Biologist performed an herbicide application of the Phragmites stands present around the shoreline of the Minister basin. The stands encompassed approximately 0.25-acres of the perimeter of the basin. Aquapro (Glyphosate) was applied via backpack sprayer as a foliar application.

The chosen date was mostly sunny with a slight breezy. Appropriate weather is important for success of Phragmites management. As such, day of treatment had been postponed numerous times due to unfavorable conditions.

Summary of Findings

- 17 species were documented during the vegetation survey, all of which are native.
- Littoral zone is confined to the immediate shoreline, especially in the Schoolhouse basin.
- At the vegetated points, nearly all sites are considered at nuisance levels.
- Waterlilies and bladderwort are the most common macrophytes, in addition to coontail and ribbon-leaf pondweed.
- More abundant growth is expected when compared with the 2017 survey considering the later nature of the 2018 survey.
- The reduced distribution of floating heart is also likely due to the later nature of the survey.

- Based on the water chemistry samplings, internal phosphorus loading is occurring, especially in the Minister basin. Otherwise, the phosphorus concentration in both basins is just generally high.
- The abundance of plant growth suggests a high deposition of biovolume in the littoral zone during fall die-back.
- Sediment sampling shows that a moderate to high amount of available phosphorus is present in the deeper areas of both pond basins, which is likely contributing to nutrient loading and the potential for nuisance algal blooms.
- Plant root depth appeared confined to the small (1-4 inches) organic layer above the hard, sandy bottom. In areas of organic deposition, the dense waterlily root mat became the support for other plant growth.
- Retrieving sediment cores to assess root depth was a challenge due to the unconsolidated organics above a hard, sandy bottom. When a core was obtained, the organic material was too thin for intact extraction.
- Vegetation root depth appears to be largely dependent on the dense waterlily root mats that cover much of the pond bottom, especially the areas with greater organic deposition.
- Phragmites management was performed on October 18, 2018.

Management Recommendations

Management Program

The data collected during the point-intercept mapping and sampling efforts at Minister/Schoolhouse Pond suggest that ecosystem balance would benefit from in-lake management and continued monitoring.

Foremost, water chemistry sampling detailed a severe oxygen deprivation within the water column of both basins, paired with a high-abundance, but limited, littoral zone, and an overall high phosphorus concentration. Potential internal nutrient loading is also occurring. Oxygenation of the water column and nutrient inactivation can be combined as two techniques that help reduce the internal loading of phosphorus in addition to creating an adequate water column to support aquatic biota, especially various fish species.

We recommend the implementation of an aeration system for both basins in 2019. Traditional aeration (diffusers) and nanobubblers are two technologies that could provide the suggested level of oxygenation to Minister/Schoolhouse Pond. Generally, diffusers are placed throughout the pond based on pond characteristics such as depth and acreage. Traditional diffusers push air into the water column to assist the uptake of oxygen which in-turn also mixes the water column. The nanobubbler system is a new technology used for super saturation oxygenation; pond water is pulled into the system which is then super saturated and dispersed back into the pond. The set-up and energy source are similar to that of a traditional aeration system.

Phosphorus inactivation can be achieved through different Alum dosage programs. Lower dose applications can be completed on an annual basis to reduce the overall concentration of phosphorus within the water column, and can be performed even during winter months (assuming ice-out) as a preventative for the upcoming growing season. Paired with aeration, potential internal loading from bottom sediments may also be reduced. A higher dose application can be implemented to reduce (if not prevent) internal loading from bottom sediments of the waterbody, while also binding to phosphorus within the water column upon application. High dose Alum is likely applicable for Minister/Schoolhouse Pond based on the phosphorus concentration in both water and sediment samples. To determine dosage, a nutrient loading assessment should be completed, in addition to further sediment sampling and alum assays before actual application.

Considering that the vegetation is generally confined to the immediate shoreline, it likely acts as a refuge for aquatic biota such as fish, especially with the low oxygen below a water depth of 4-5 feet. The overall extent of waterlilies is not readily concerning with regard to ecosystem balance. However, specific over-abundant areas could be targeted, such as the connector channel between the two basins or around the primarily inlet into the Minister basin. While the management of vegetation extent falls second to water column remediation and nutrient inactivation, a hydro-raking program could be instituted at Minister/Schoolhouse Pond to target specific areas of higher macrophyte abundance.

Ongoing monitoring (vegetation, water quality, sediment sampling, algae, etc.) is the life-blood of successful lake management and should therefore be a part of any responsible long-term management plan. The Town of Eastham should consider annual monitoring on some level in order to identify changing conditions in response to management, but also for the early detection of possible new management concerns/issues. As such, we recommend replicating the point-intercept macrophyte mapping conducted in August. Monitoring becomes further important if nutrient management/inactivation becomes a direction that the Town of Eastham would like to pursue; understanding direct inputs into the lake (inlet streams, runoff, and watershed pollution) and indirectly from the lake bottom (sediments) supports the ability to manage the health and preservation of Minister/Schoolhouse Pond.

Regardless of management technique, we recommend continued water quality monitoring and sediment sampling, congruent with the 2018 program.

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We hope you find this information helpful in making your lake management decisions. If you have any questions or need anything further, please contact our office.

Appendix A: Raw Data Tables

Appendix A: Raw Data

Point	Overall Density	Coontail	Farwell's Watermilfoil	Tapegrass	Nuttall's Waterweed	Spikerush	Humped Bladderwort	Lesser Bladderwort	Common Bladderwort	Whorled Bladderwort	Little Floating Bladderwort	Northern Naiad	Thin-leaf Pondweed	Ribbonleaf Pondweed	Yellow Waterlily	White Waterlily	Floating Heart	Aquatic Moss
1							S							S	T	D		
2							S	T		T					S	M		
3							T								S	M		
4							T	T						S		M		
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6																		
7																		T
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9												S			S	M		
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38		T												M	S	S		
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45														S		D		
46		T					S	T						S		D		
47																		
48																		
49																		
50																		

Appendix B: Distribution Maps

Water Chemistry Sample Locations
June 21 & July 24, 2018

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Minister Pond
Eastham, MA
Barnstable County
41.84143°, -69.97718°

Minister/Schoolhouse Pond

0 100 200 300 400 Feet

1:3,000

N

Map Date: 12/13/18
Prepared by: BNA
Office: SHREWSBURY, MA

Sediment Sample Locations
June 21, 2018

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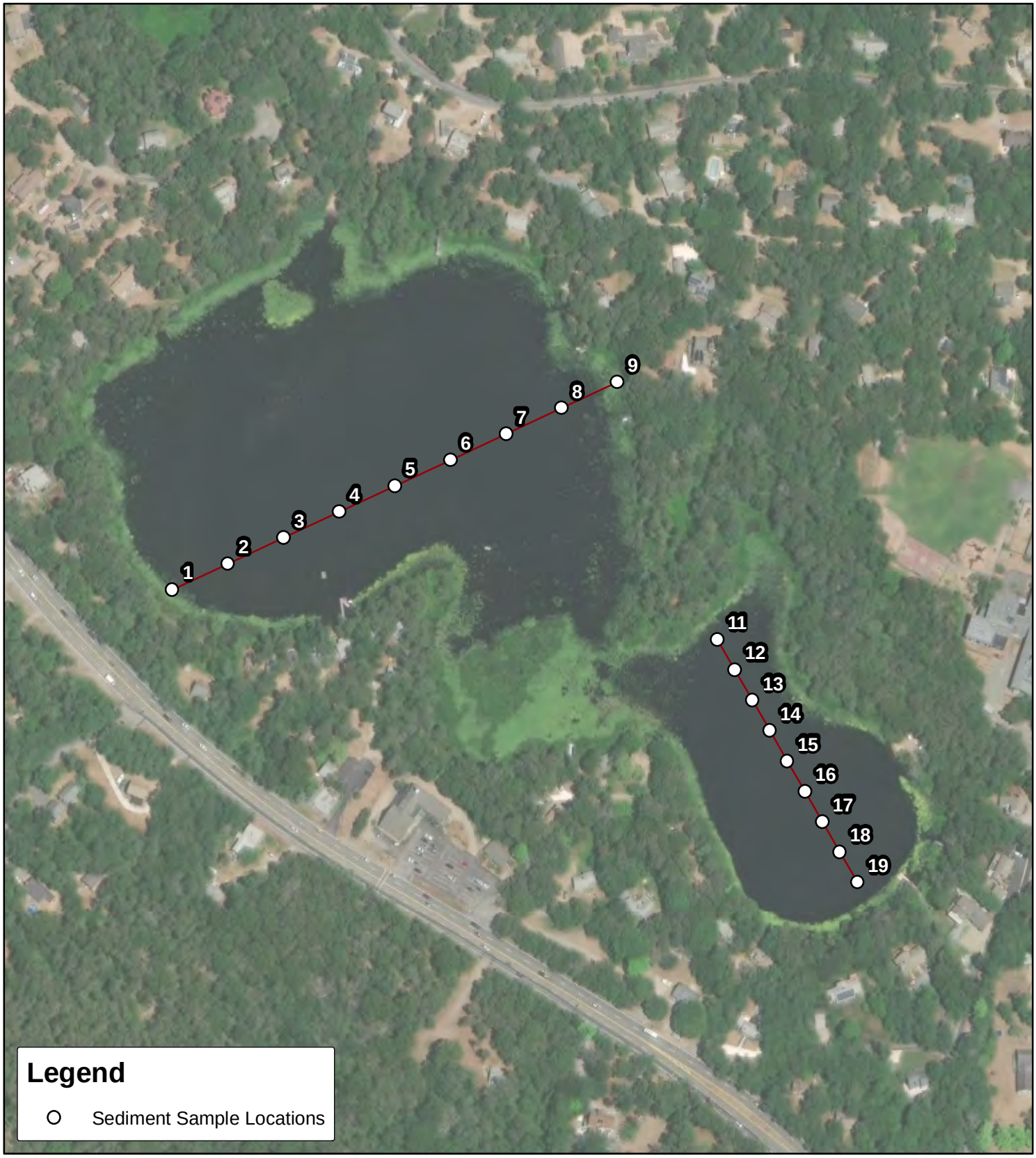

Minister Pond
Eastham, MA
Barnstable County
41.84143°, -69.97718°

Minister Pond

0 100 200 300 400 Feet

1:3,000

N

Map Date: 12/13/18
Prepared by: BNA
Office: SHREWSBURY, MA

Survey Point Locations
August 14, 2018

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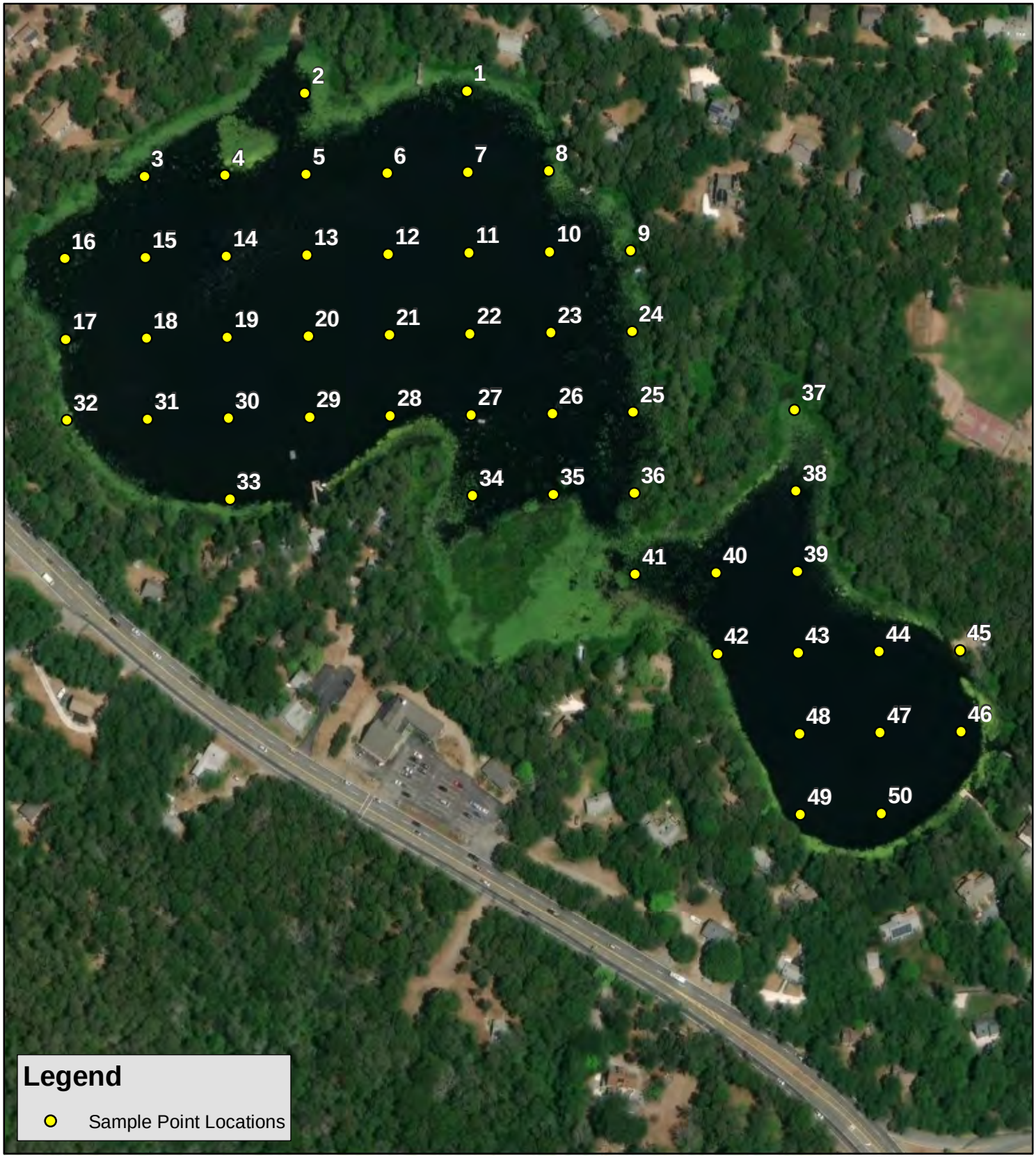

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

Map Date: 12/5/18
Prepared by: BNA
Office: SHREWSBURY, MA

Overall Vegetation Abundance
August 14, 2018

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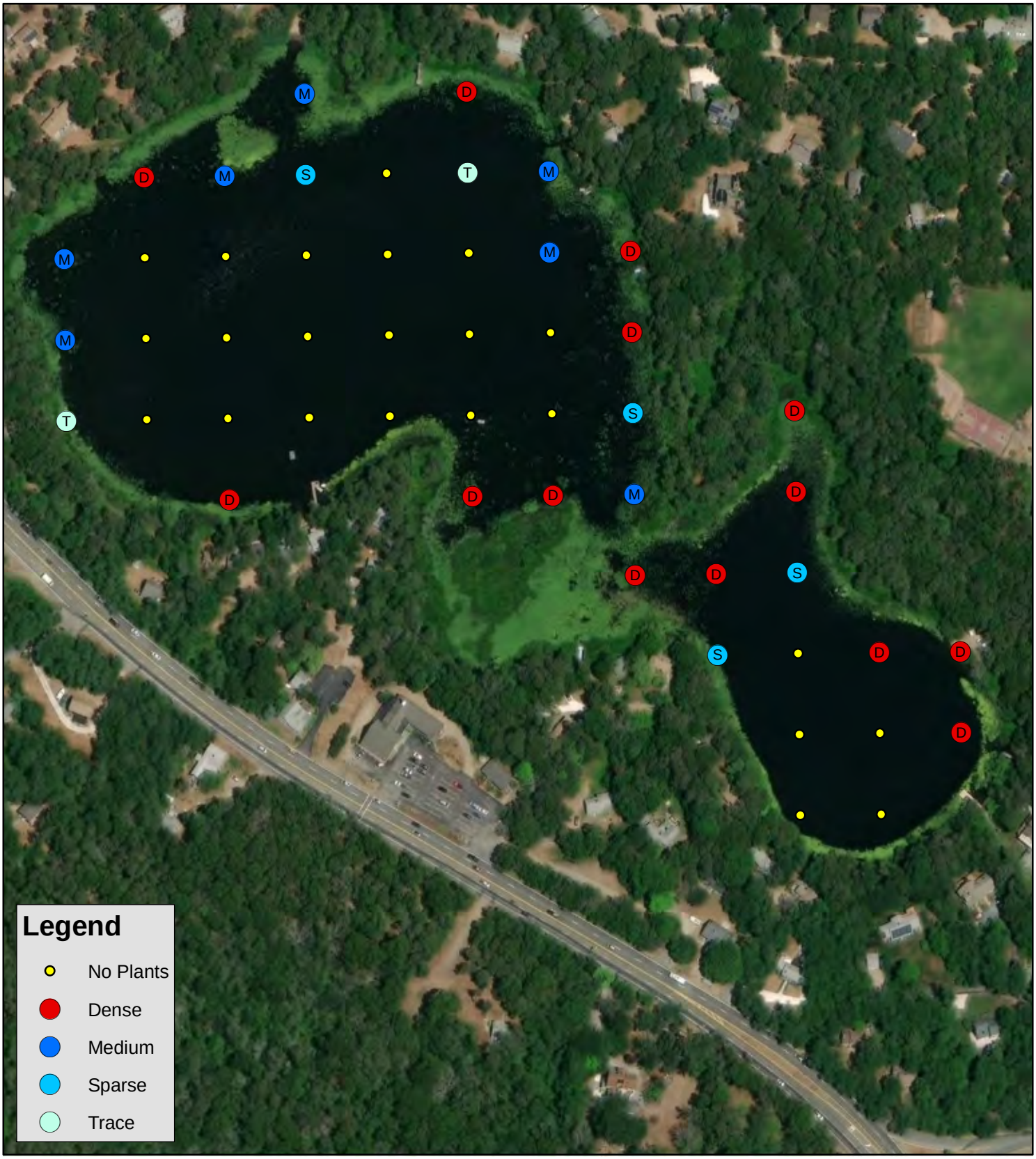

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

Map Date: 12/5/18
Prepared by: BNA
Office: SHREWSBURY, MA

Coontail (*Ceratophyllum echinatum*) Distribution

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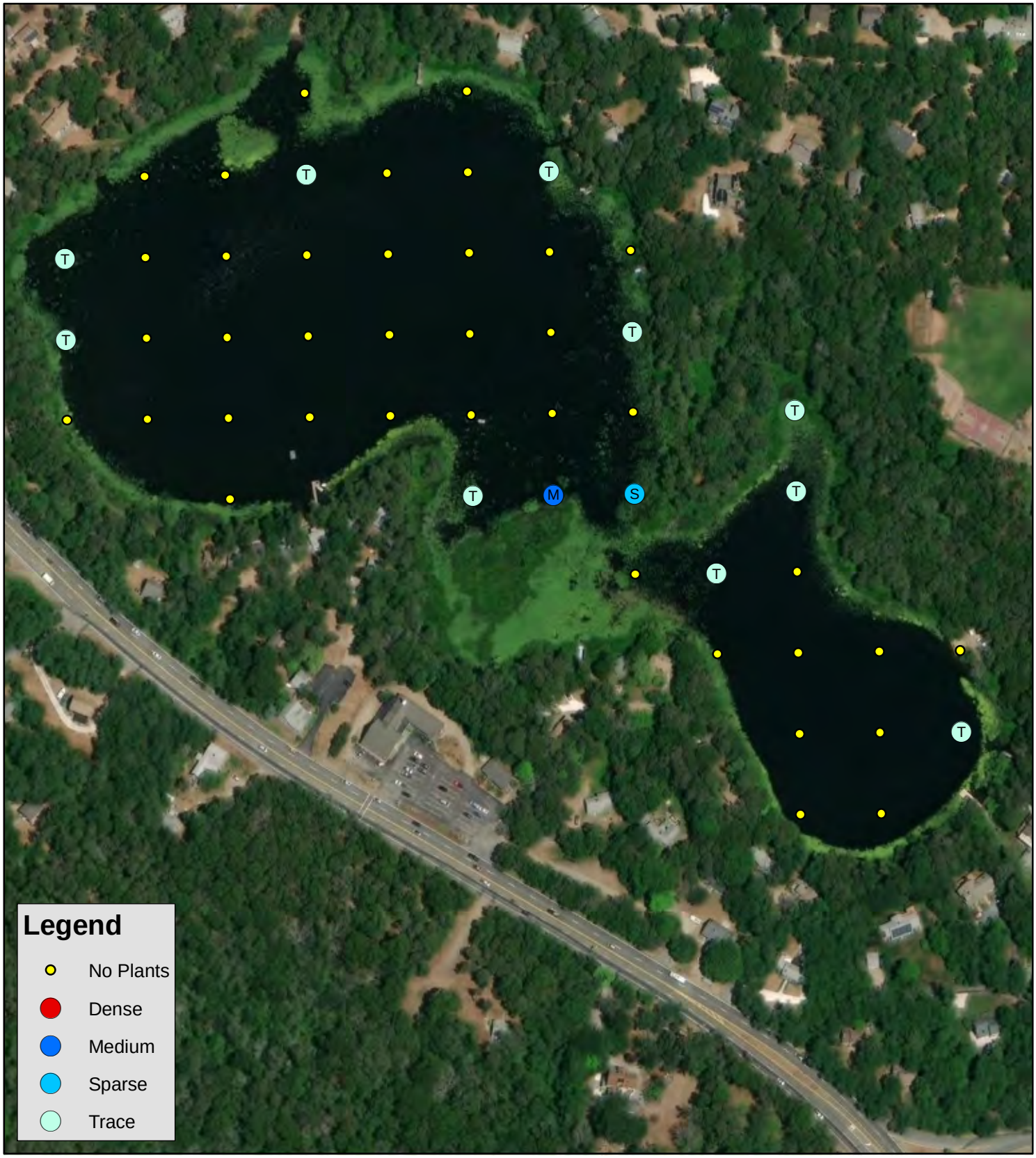

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

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Spikerush (*Eleocharis acicularis*) Distribution

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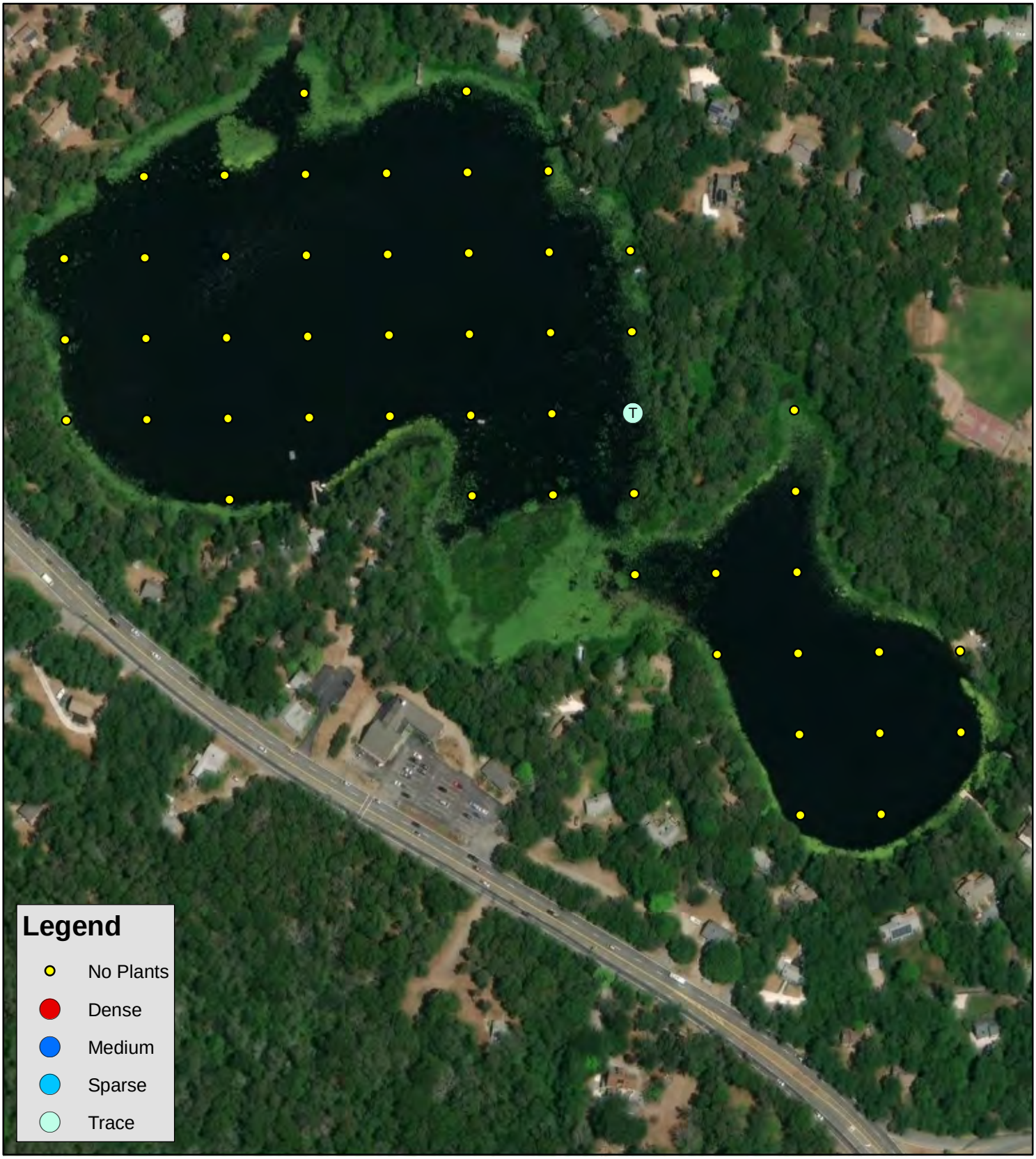

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

Map Date: 12/5/18
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Nuttall's Waterweed (*Elodea nuttallii*) Distribution

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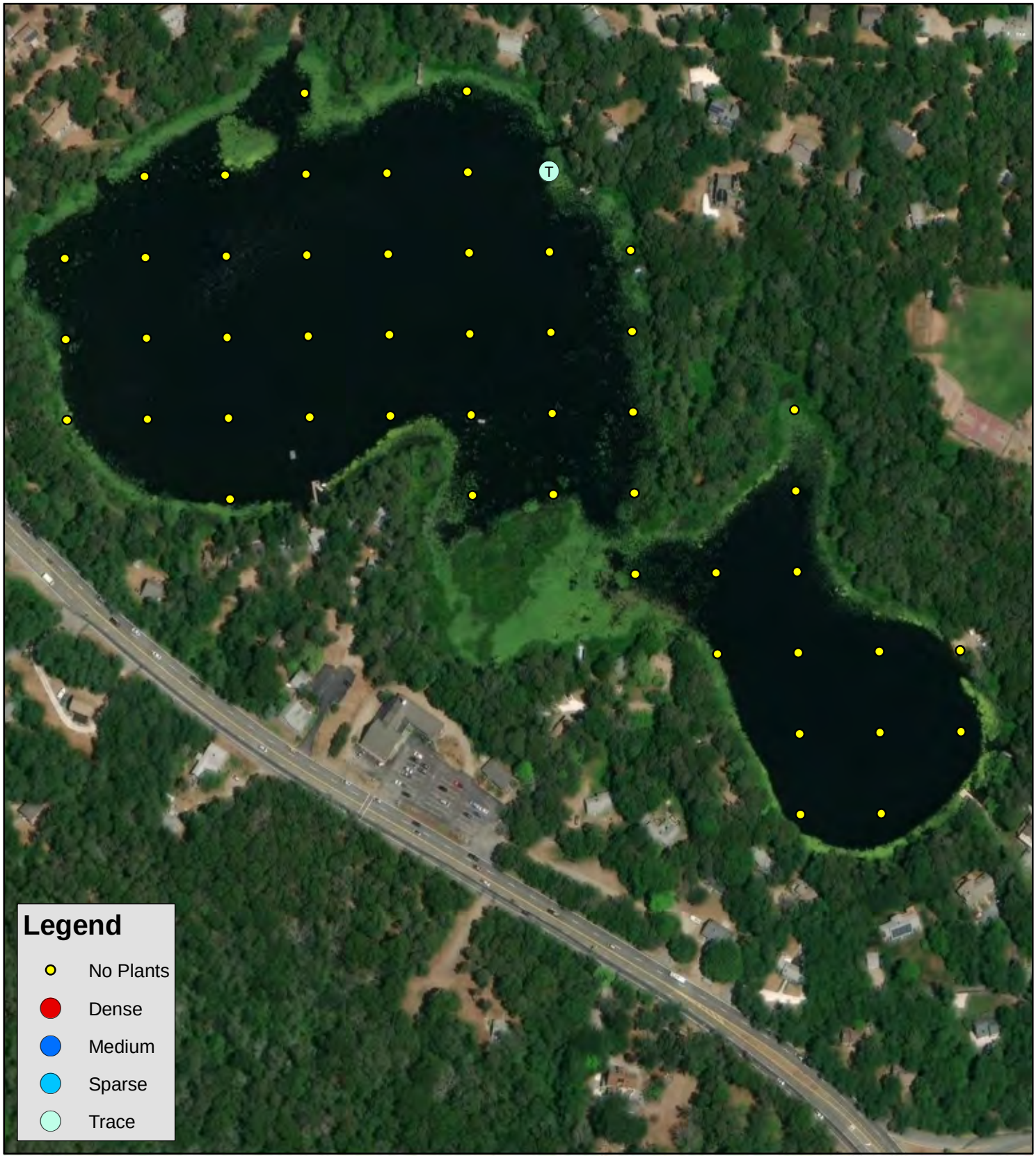

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

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Aquatic Moss (*Fontinalis sp.*) Distribution

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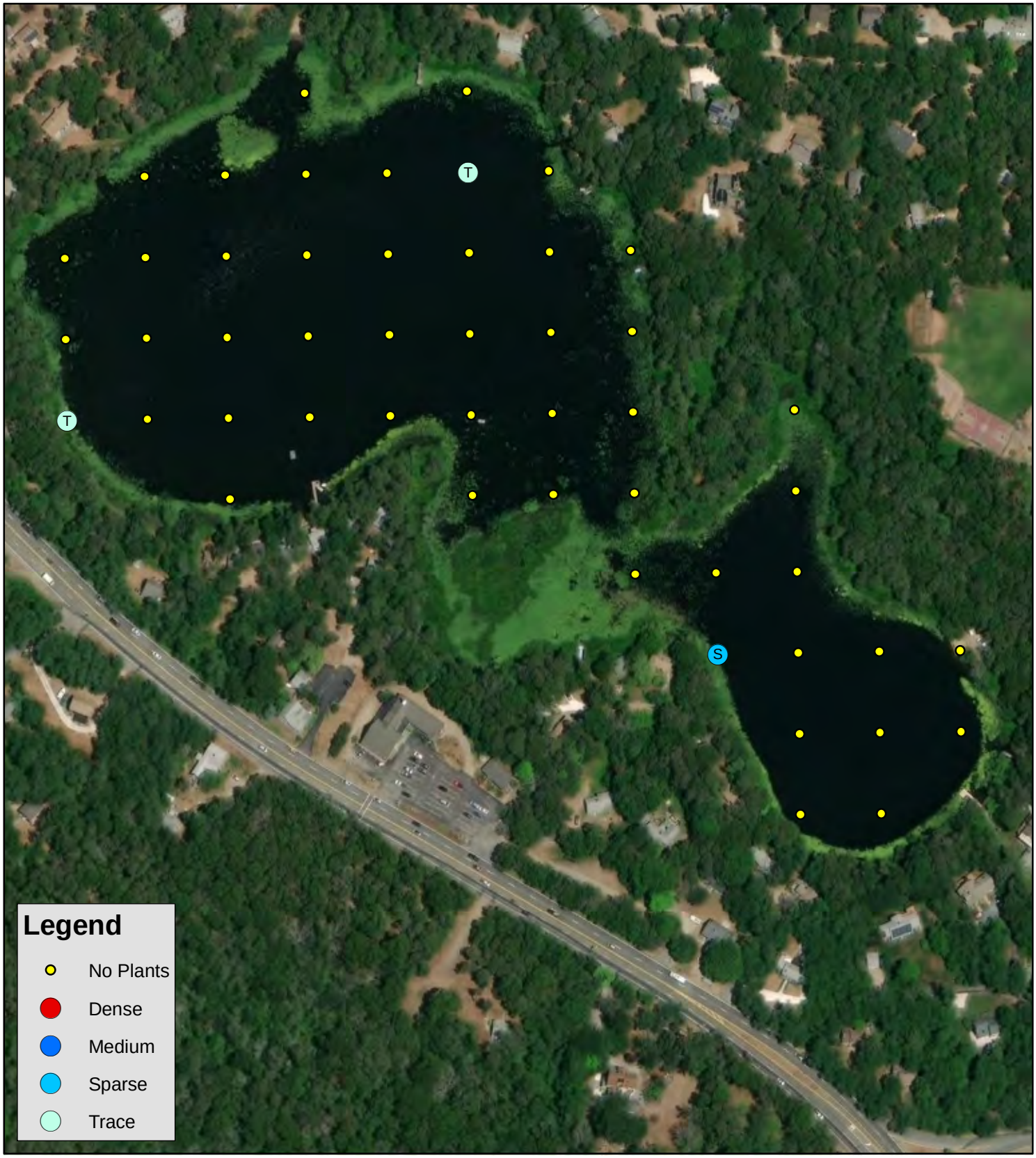

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

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0 180 360 Feet

N

Map Date: 12/5/18
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Farwell's Watermilfoil (*Myriophyllum farwellii*) Distribution

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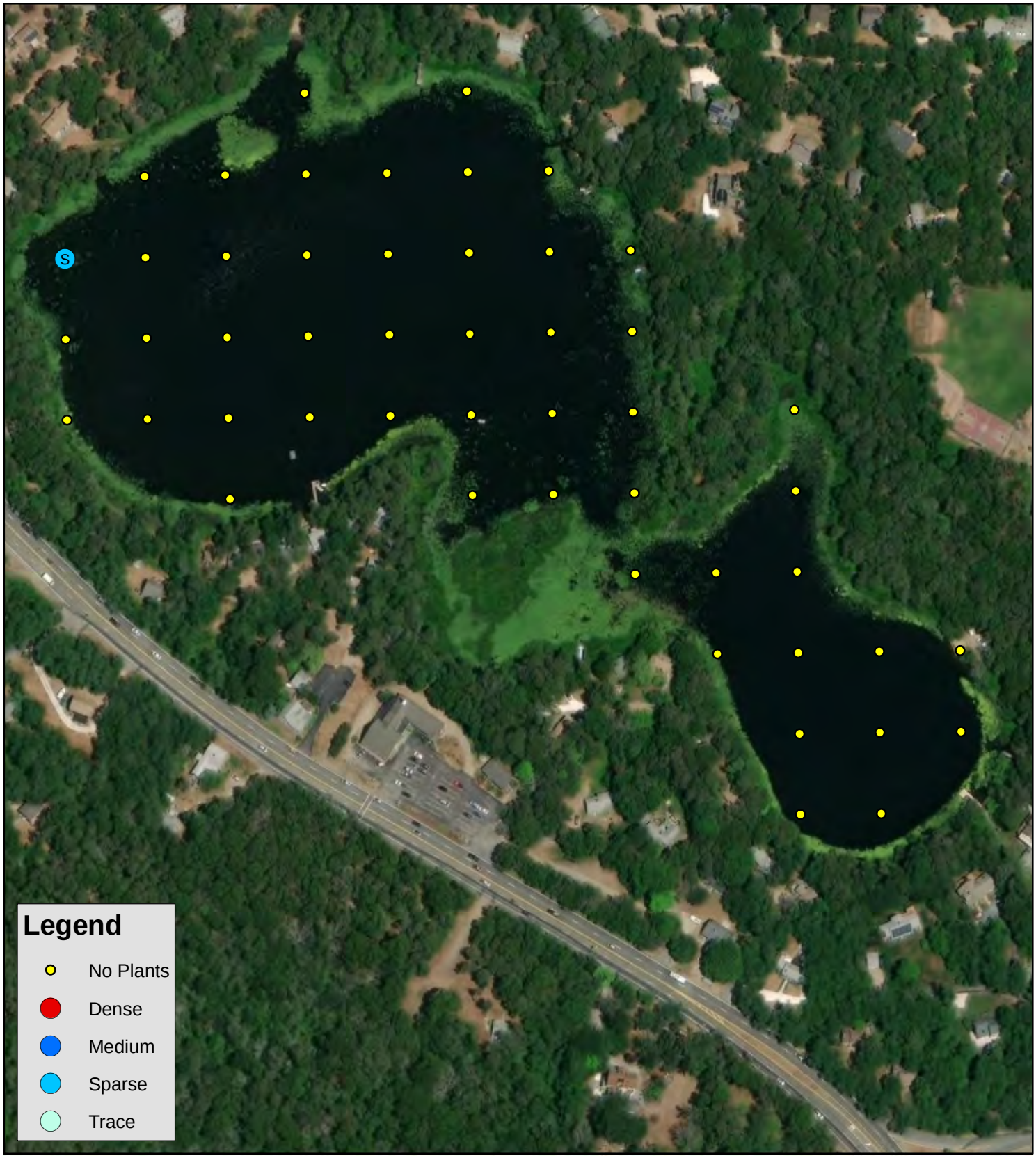

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

1:2,600

0 180 360 Feet

N

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Northern Naiad (*Najas gracillima*) Distribution

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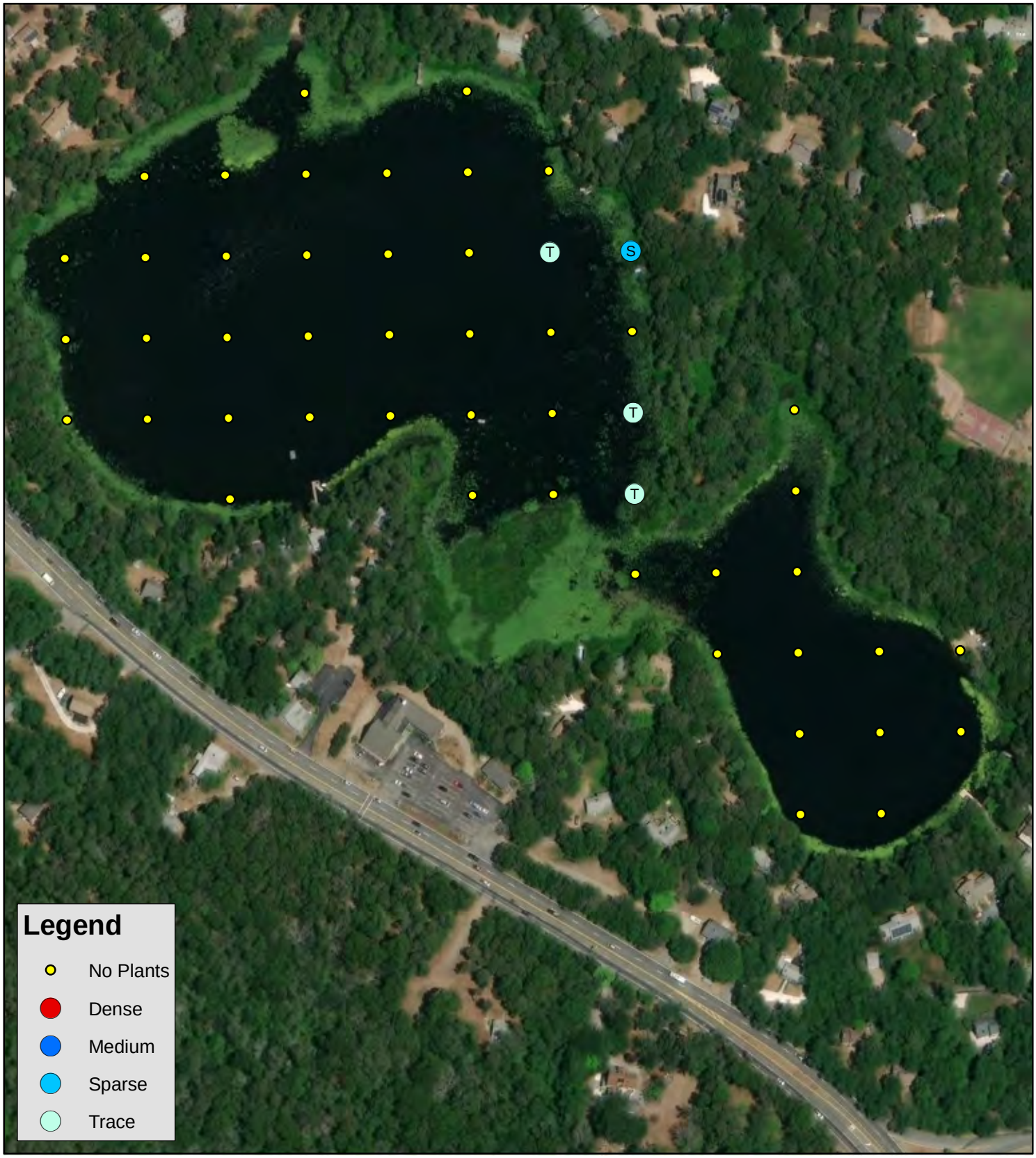

Minister & Schoolhouse Ponds
Eastham, MA

Minister/Schoolhouse Pond

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0 180 360 Feet

N

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Yellow Waterlily (*Nuphar variegata*) Distribution

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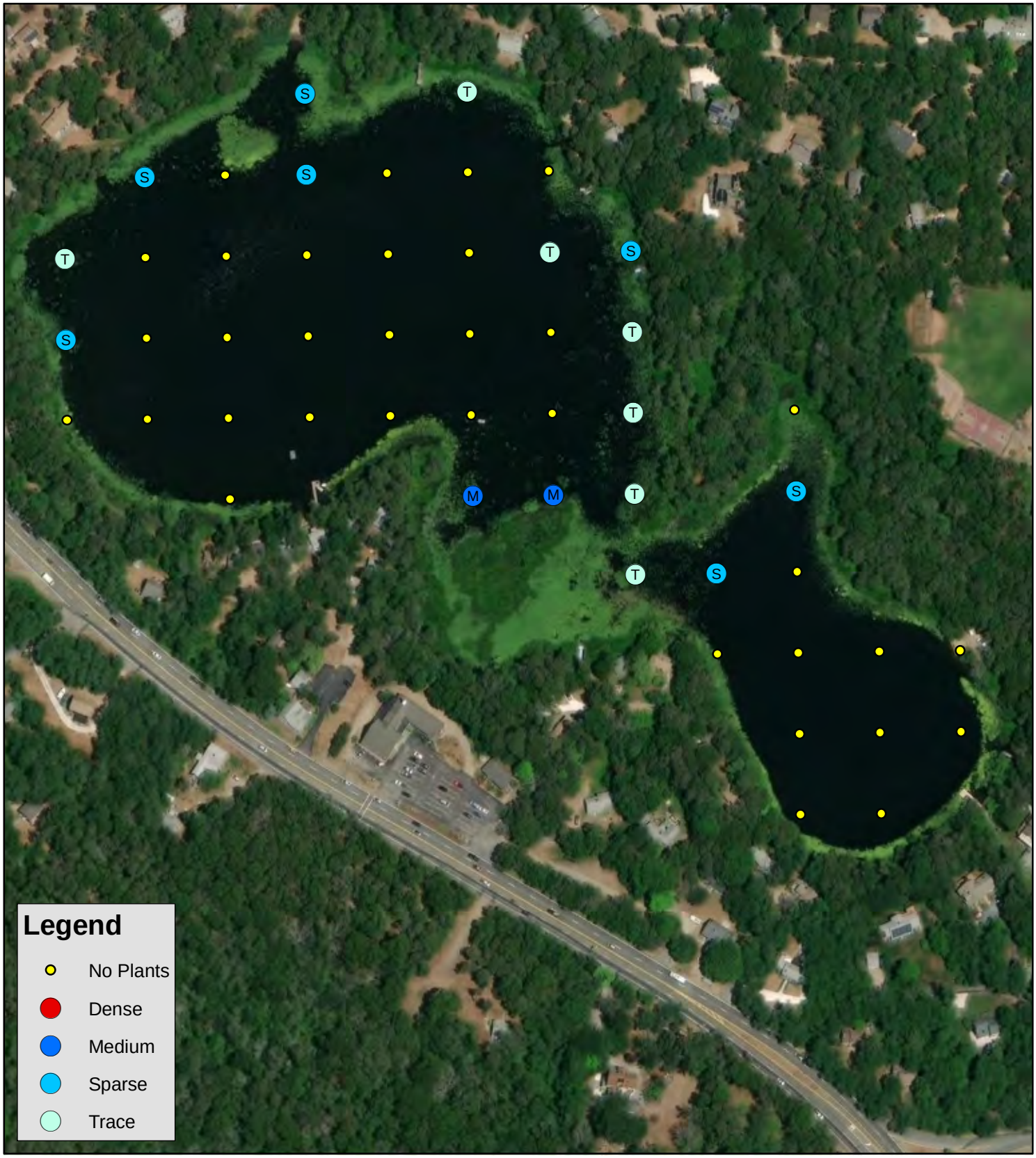

Minister & Schoolhouse Ponds
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0 180 360 Feet

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White Waterlily (*Nymphaea odorata*) Distribution

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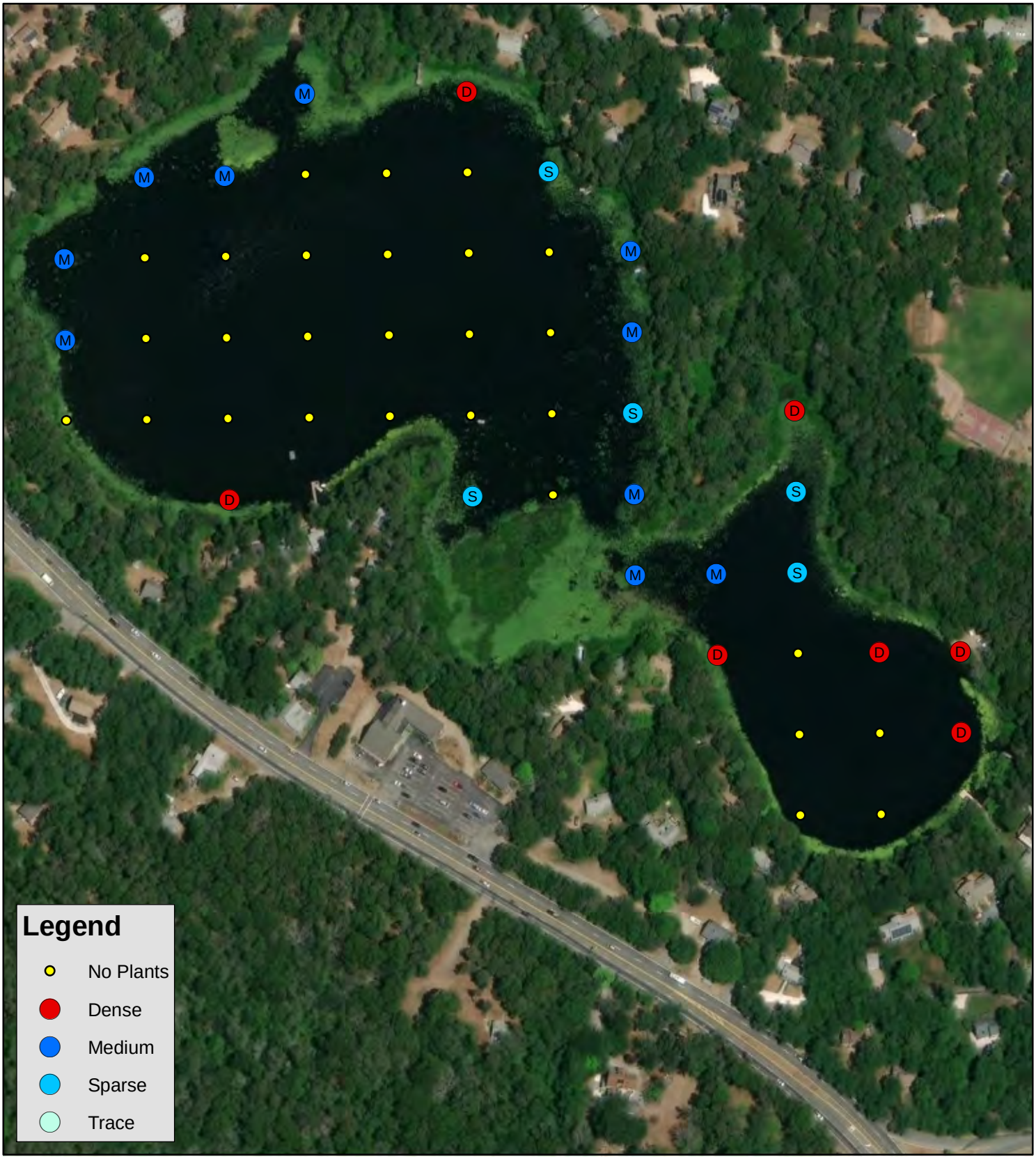

Minister & Schoolhouse Ponds
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0 180 360 Feet

N

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Floating Heart (*Nymphoides cordata*) Distribution

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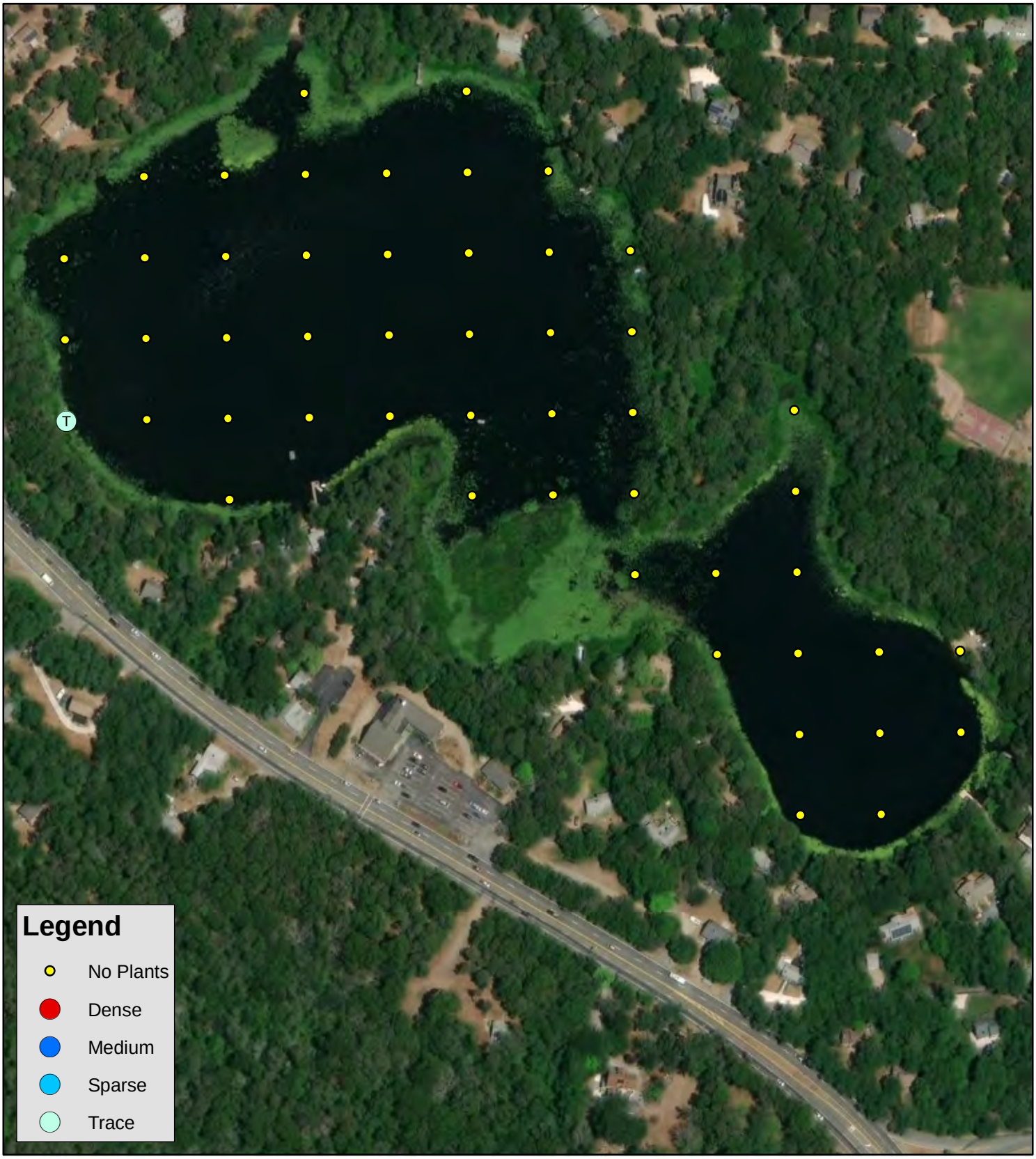

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Thin-leaf Pondweed (*Potamogeton sp.*) Distribution

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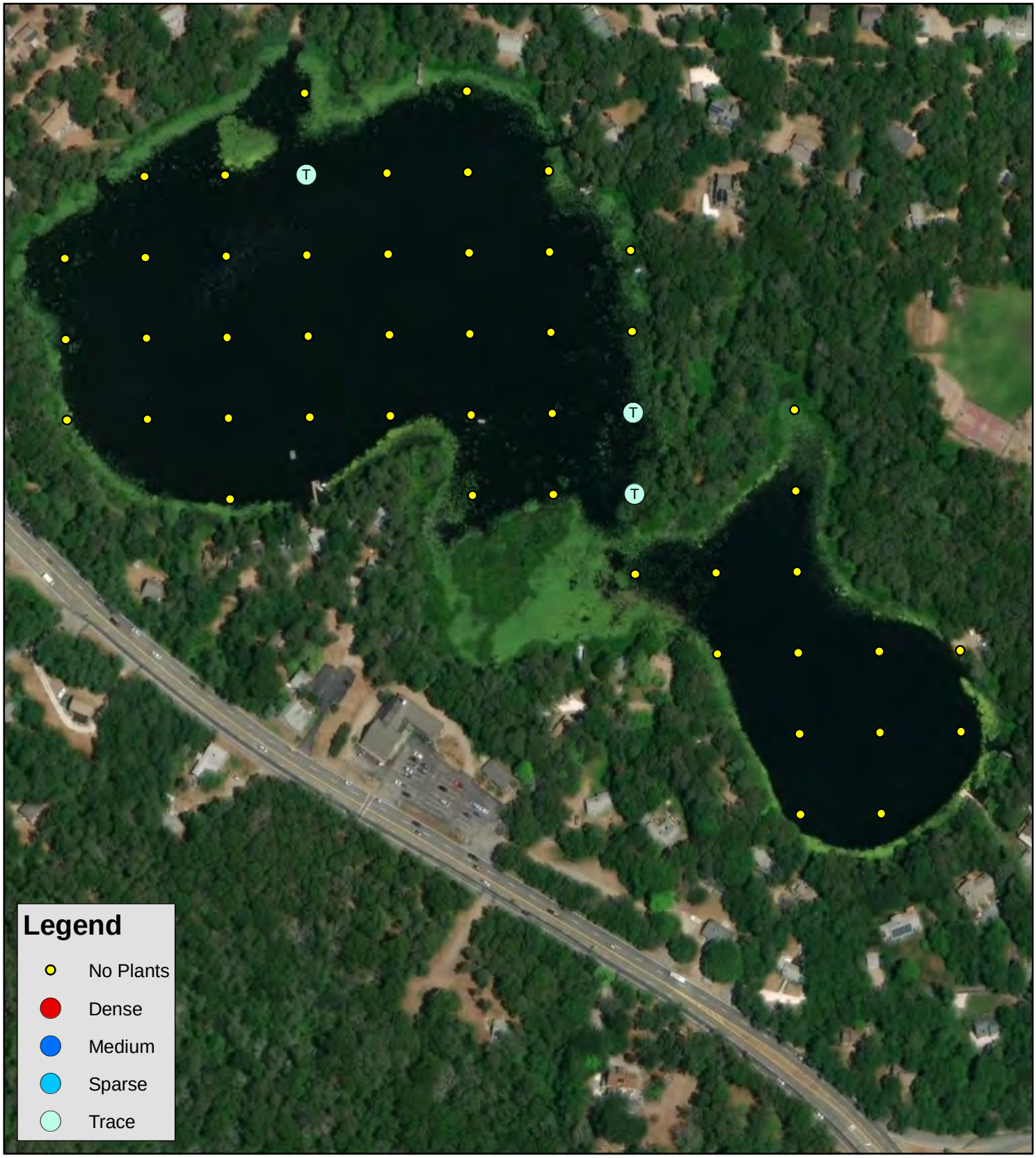

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Eastham, MA

Minister/Schoolhouse Pond

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Ribbon-leaf Pondweed (*Potamogeton epihydrus*) Distribution

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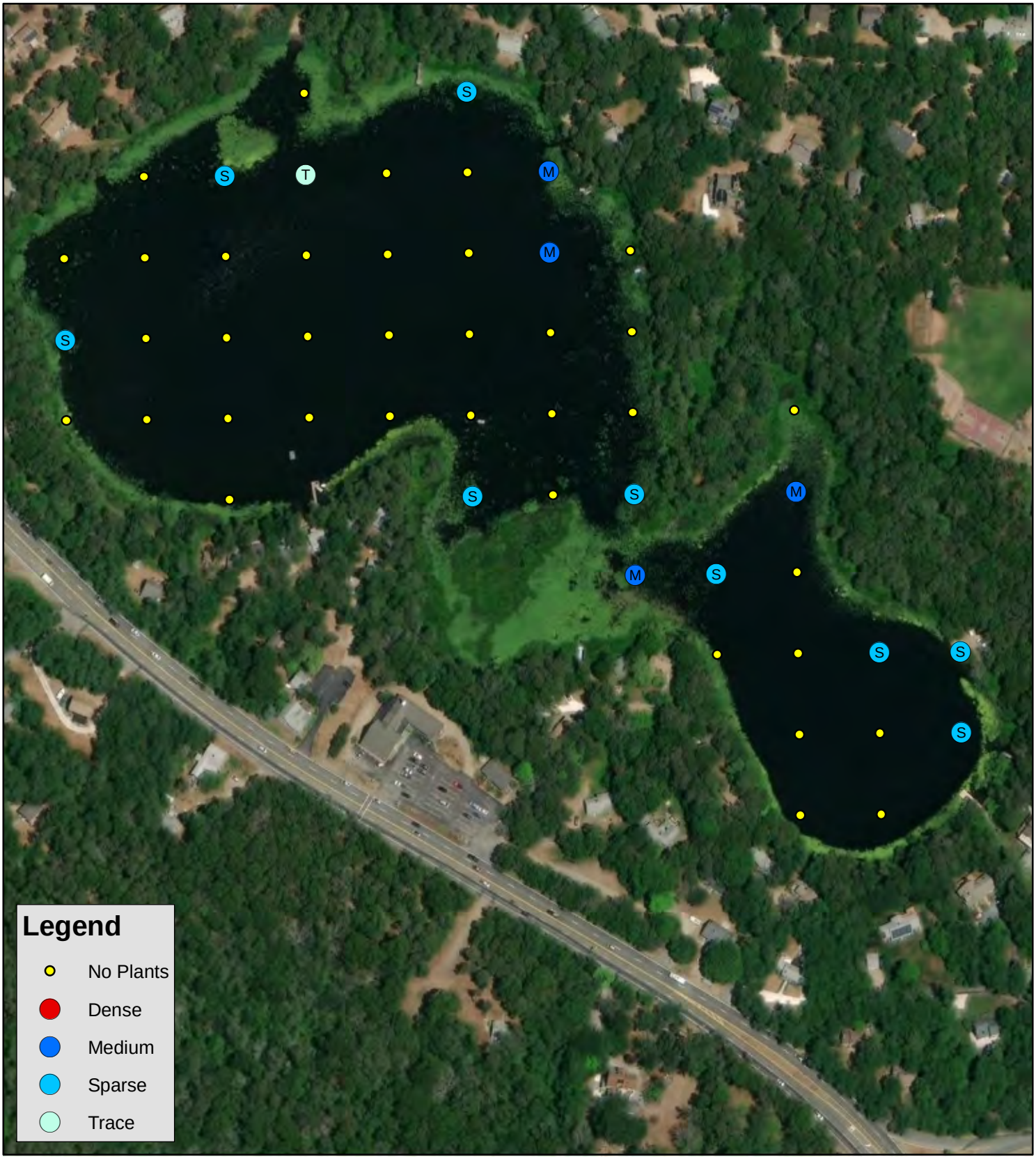

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0 180 360 Feet

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Humped Bladderwort (*Utricularia gibba*) Distribution

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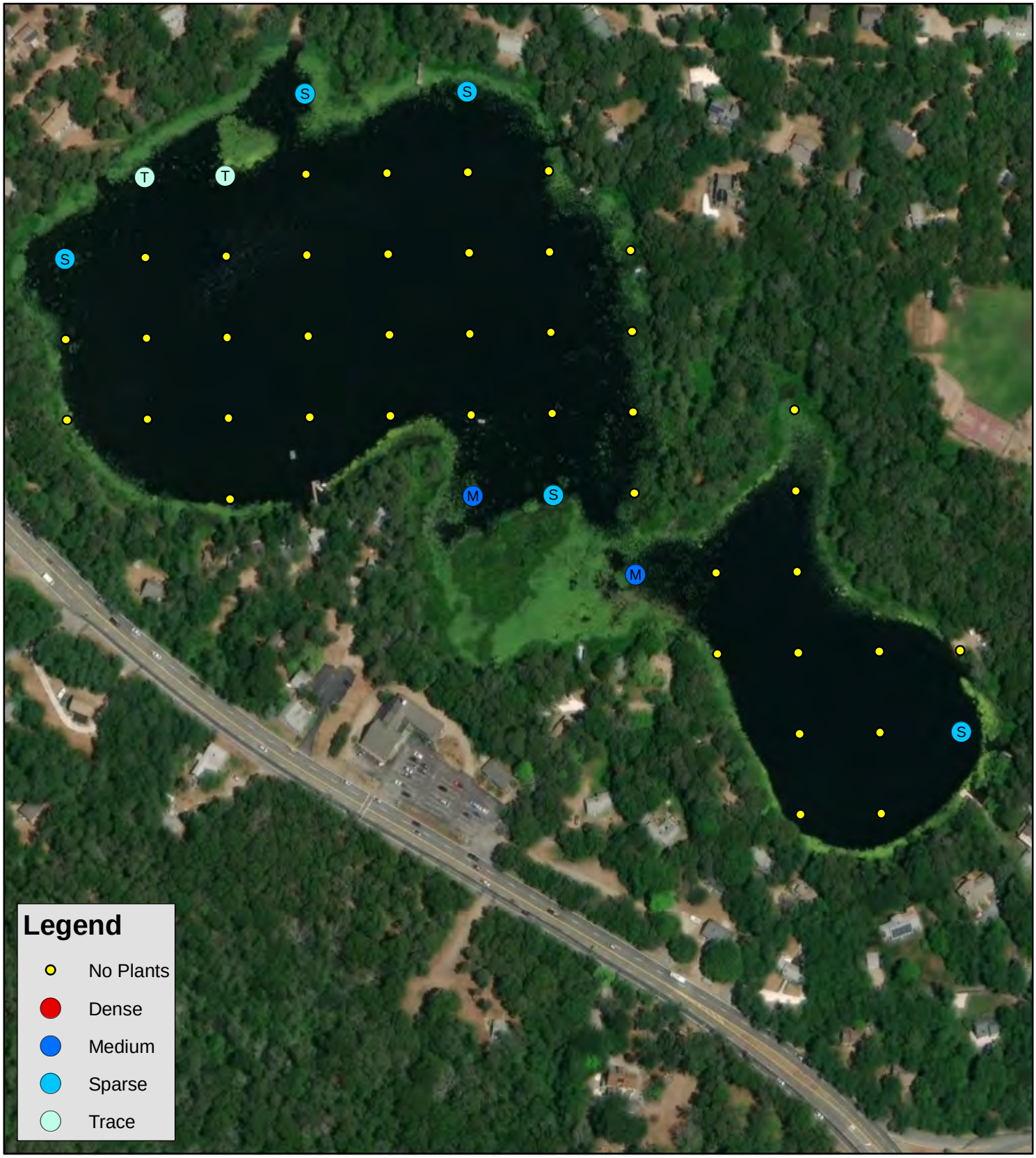

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0 180 360 Feet

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Lesser Bladderwort (*Utricularia minor*) Distribution

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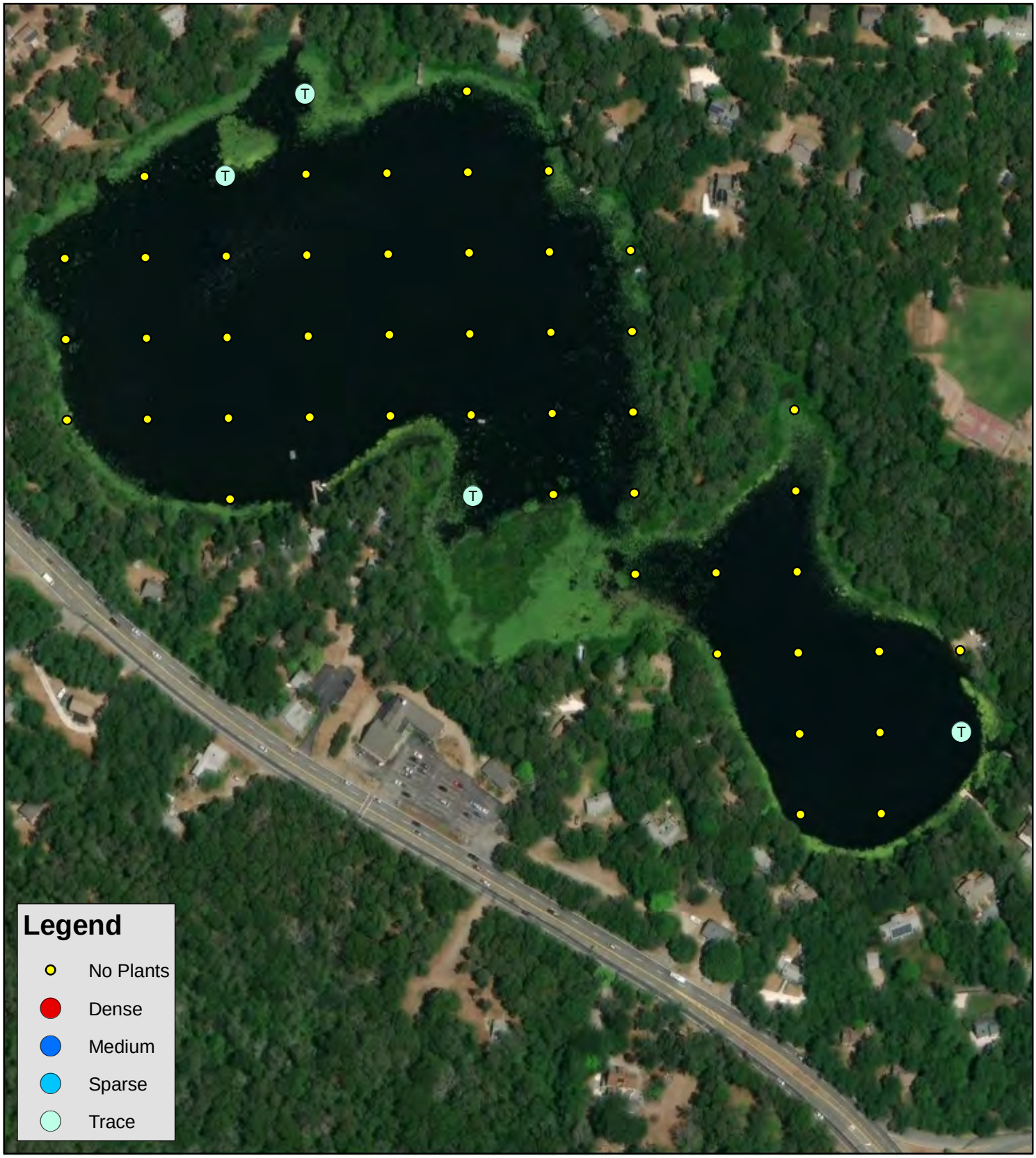

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0 180 360 Feet

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Whorled Bladderwort (*Utricularia purpurea*) Distribution

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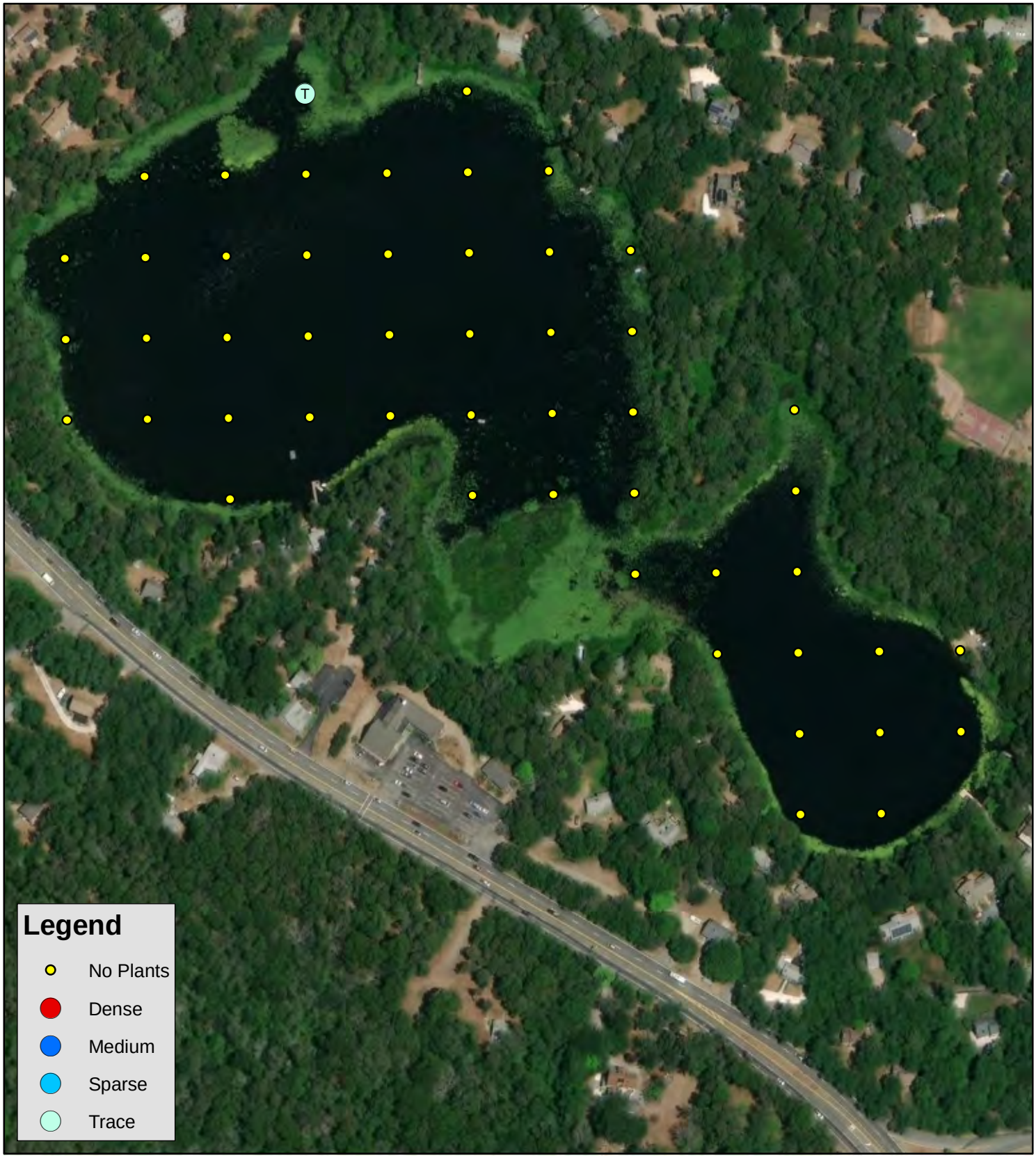

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0 180 360 Feet

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Little Floating Bladderwort (*Utricularia radiata*) Distribution

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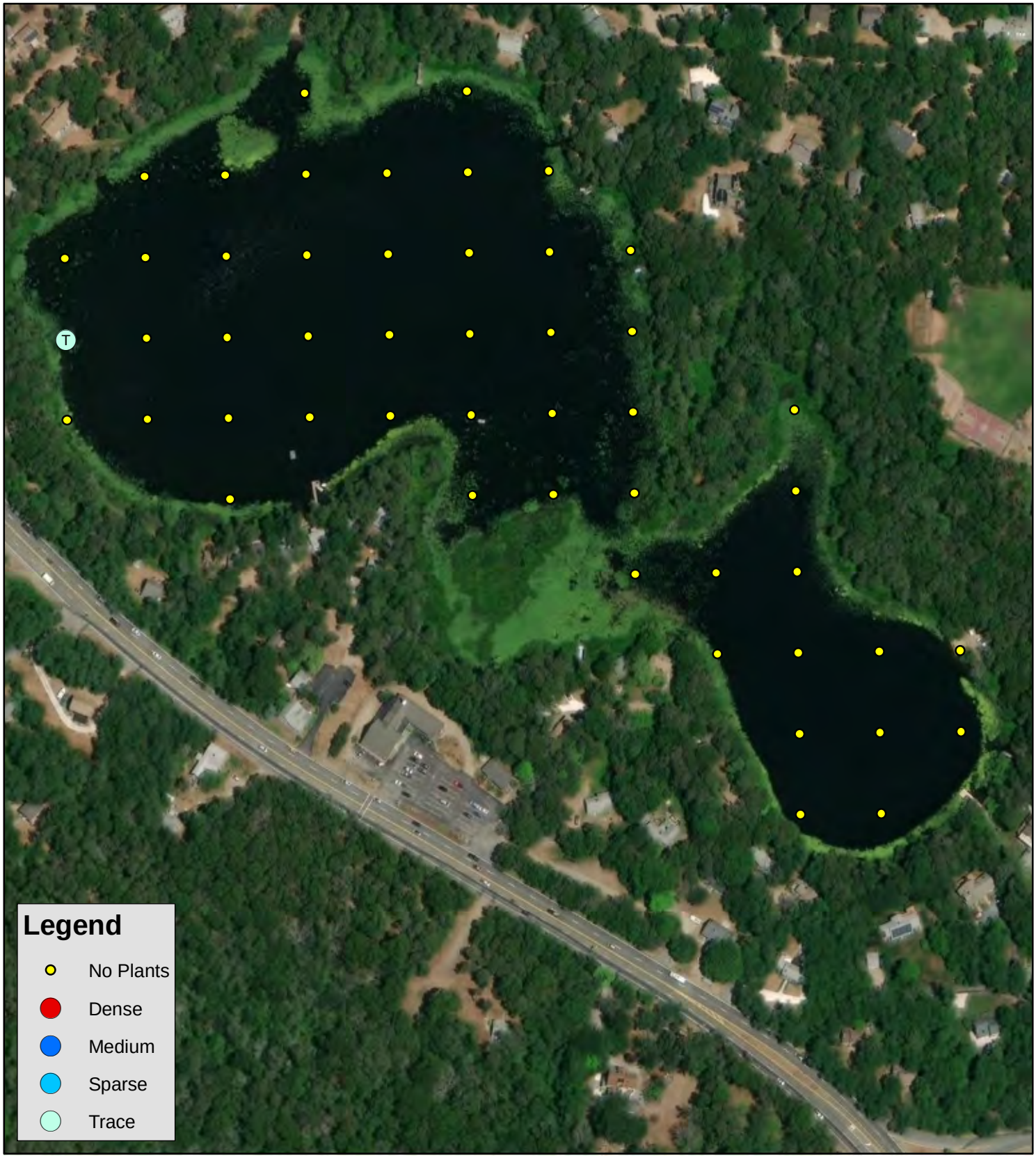

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1:2,600
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Common Bladderwort (*Utricularia vulgaris*) Distribution

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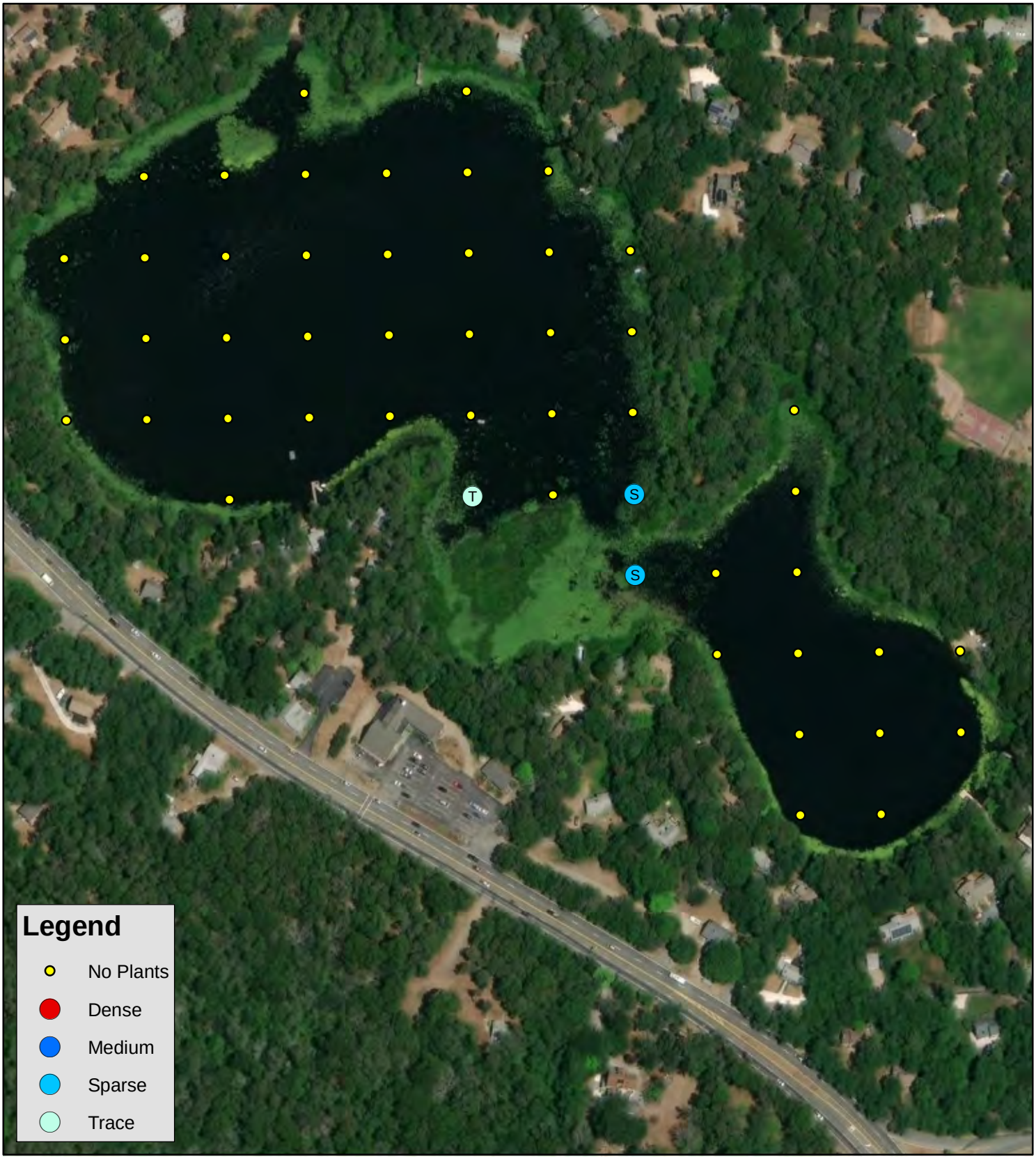

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Tapegrass (*Vallisneria sp.*) Distribution

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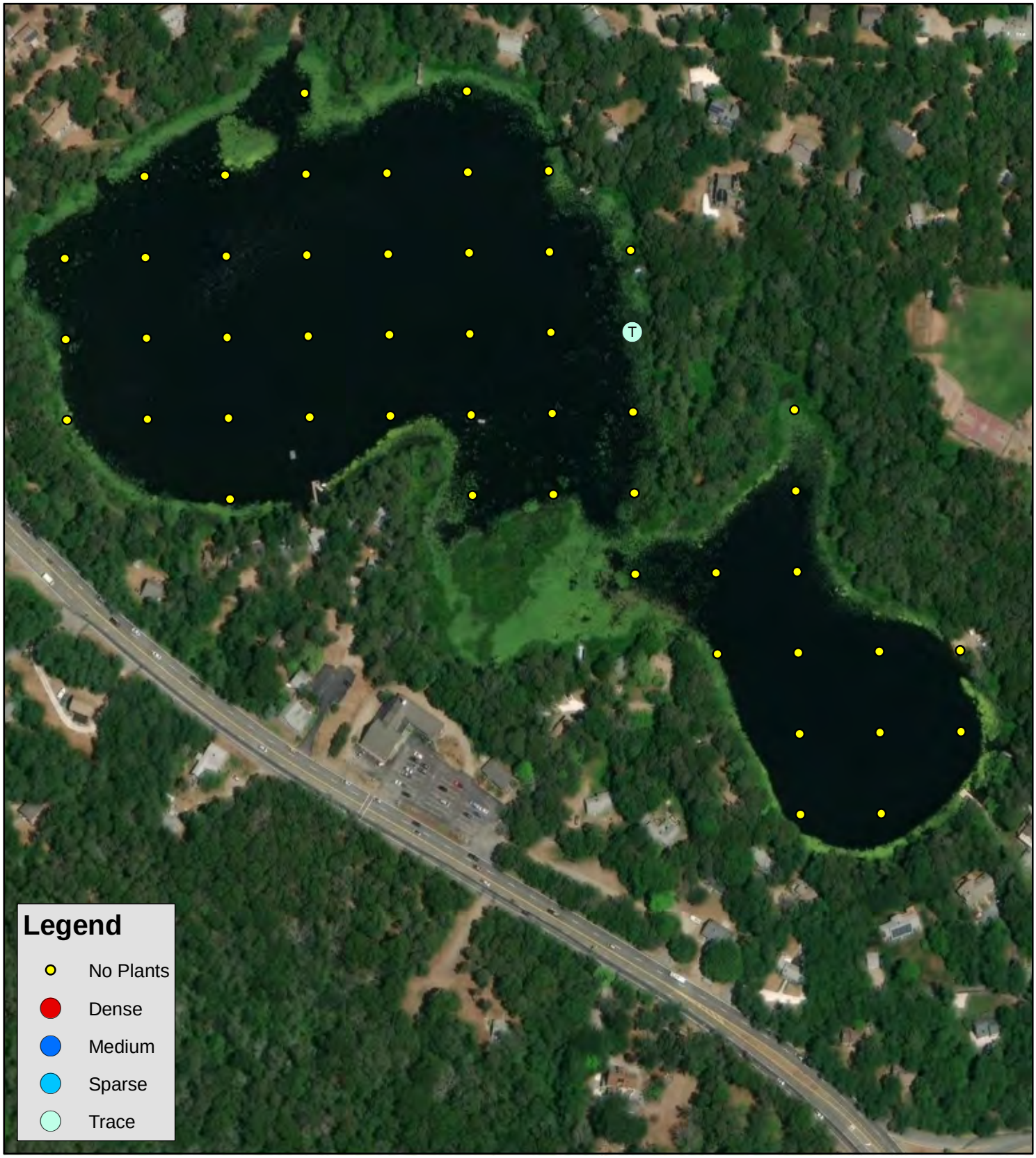

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