LAKE ST. CATHERINE 2023 AQUATIC MACROPHYTE SURVEY

Report Submitted to the

Lake St. Catherine Association

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ARROWWOOD ENVIRONMENTAL
950 BERT WHITE ROAD
HUNTINGTON,VT 05462
(802 434-7276 FAX: (802) 329-2259

Contents

List of Figures

List of Tables

1. Introduction

Arrowwood Environmental (AE) was retained by the Lake St. Catherine Association (LSCA) to conduct an inventory of aquatic macrophytes in Lake St. Catherine in Poultney and Wells, Vermont. The inventory is part of an ongoing effort to control Eurasian watermilfoil (*Myriophyllum spicatum*, EWM) in the lake.

The Lake St. Catherine system consists of Little Lake (or Little Pond), Lake St. Catherine, and Lily Pond, all collectively referred to as Lake St. Catherine. Little Lake is the southern-most water body and comprises 181 acres. It is a shallow waterbody with an average depth of 4 feet, mucky substrates, and dense aquatic plant growth. It is connected to Lake St. Catherine-proper by a narrow channel. Lake St. Catherine-proper is the largest waterbody in the system; it comprises 885 acres, has a maximum depth of 68 feet, and contains a diverse array of substrates and habitats. At the north end of Lake St. Catherine, a narrow channel connects it to Lily Pond, which is 20 acres in size. Like Little Lake, Lily Pond is a shallow pond characterized by mucky substrates and abundant aquatic plant growth.

Flow in the lake system is from north to south. Along the eastern shore of the channel between Lily Pond and Lake St. Catherine, there is an inlet of an unnamed brook which flows through a large wetland complex. Endless Brook flows into the eastern side of Lake St. Catherine near the northern end. This brook contains most of the flow from the watershed east of the lake, with the exception of two small unnamed tributaries which flow directly into the lake further to the south. The uplands on the western side of Lake St. Catherine drain into the lake via four small unnamed streams. Along the channel separating Lake St. Catherine and Little Lake, there is an inlet on the eastern side which enters in a large wetland. The entire lake system flows out the southern end of Little Lake into Mill Brook, which is a tributary of the Wells River.

The Lake St. Catherine system is underlain by phyllites and limestones from the Bull Mountain Formation. The underlying bedrock can impact the chemistry of the water, in this case resulting in a moderately alkaline lake. Chemistry and nutrient content of the water is also highly influenced by the nature of the surface water inputs.

Landuse in the watershed can also have a large impact of water quality in the lake. Landuse in the Lake St. Catherine watershed is a mixture of forested lands, agricultural fields, and rural residential development. In their analysis of watershed landuse, Vermont Department of Environmental Conservation considers the Lake St. Catherine watershed to be "moderately disturbed." This is based on the amount of landuse under development or agricultural use within the watershed that may have an impact on water quality in the lake (Vermont Lake Scorecard).

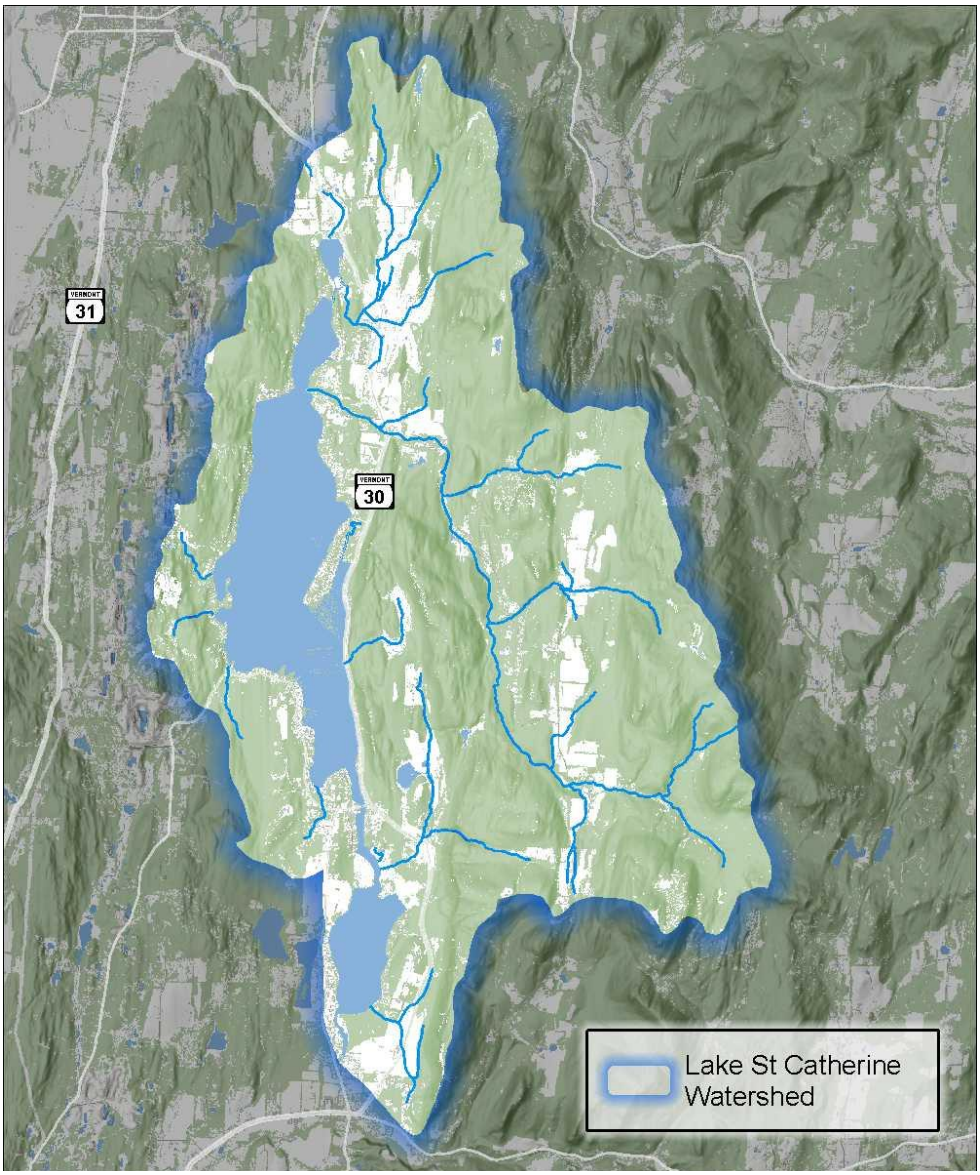

Figure 1. Lake St. Catherine watershed

Lakes are typically classified based on physical parameters such as size, depth, trophic status and alkalinity. Trophic status is a way to categorize different lakes based on the amount of biologically useful nutrients in the water (mainly phosphorus and nitrogen). Oligotrophic lakes are lakes with very low nutrients available for plant (including algae) growth. Because of this low amount of growth, plant and

algae productivity is low and water clarity can be quite high. Mesotrophic lakes have a moderate degree of nutrients available for plant growth and eutrophic lakes are those with a large amount of nutrients. Eutrophic lakes can have low water clarity because of the higher degree of algae growth that is possible when nutrients such as phosphorus are plentiful.

Since phosphorus is typically the limiting nutrient for aquatic plant growth, a common measurement to determine trophic status is to measure the phosphorus content of the lake during spring turn-over. This is the phosphorus that will be available for plant and algae growth during the growing season. Based on these spring phosphorus measurements, the Lake St. Catherine system is considered a mesotrophic lake. Other measures of trophic status such as the measure of algae growth (chlorophyll a) also indicate that the lake is in the mesotrophic category (Vermont Department of Environmental Conservation 2023). Because of their pond-like character, both Lily Pond and Little Lake have lower water clarity than Lake St. Catherine proper, as measured by seechi depth (Vermont Department of Environmental Conservation 2023).

1. Methods

The study area for the inventory consisted of the entire waterbody of the Lake St. Catherine system with the shoreline boundary derived from the Vermont Hydrography Dataset (VHD). Only aquatic species and emergent species that typically occur within aquatic plant communities were included in this inventory. This includes aquatic vascular plants as well as macroalgae, together considered aquatic "macrophytes."

Prior to field work, aerial ortho imagery of the lake was analyzed. This included various imagery from the 1990s to 2019 and included black and white as well as full color and color-infrared. The purpose of this analysis was to create a preliminary base map of floating aquatic vegetation in the lake. The most easily observed vegetation is the Waterlily Aquatic Community because this vegetation is readily visible on the surface of the water. In addition, aerial imagery can sometimes show areas where submerged aquatic vegetation becomes dense and grows to the surface (often

EWM). Though this preliminary map was revised during the field work, it provided a valuable base map as well as insight into the seasonal variations present in some of the aquatic vegetation.

Field work was conducted by Michael Lew-Smith on August 31, September 1, 4 and 21, 2023. During the field work, the lake was circumnavigated with a motorboat. The motorboat was used for the majority of the inventory while a kayak was used to inventory shallow areas. In select areas, snorkeling surveys were also conducted in order to sample aquatic vegetation and obtain more information on aquatic communities.

Two different methods were used to inventory aquatic macrophytes in Lake St. Catherine: Grid Point Sampling and Visual Littoral Surveys. The methodology used for each of these survey types is outlined below.

a. Grid Point Sampling

The Grid Point Sampling method provides a systematic and standardized procedure for sampling aquatic vegetation in lakes and ponds (Hauxwell et al. 2010). Grid point locations were obtained from SOLitude Lake Management to provide consistency with historical data collected on Lake St. Catherine. A total of 199 grid point sampling locations were located throughout the littoral zone of Lake St. Catherine as shown in the map in Appendix 2.

The lake boundary and predetermined grid point locations were uploaded to an iPhone or iPad data collector, running ArcGIS Collector and Survey123 field data collection applications. An ortho-photo basemap project was created on the iPhone/iPad with the grid point locations for use during the fieldwork. This system was used to navigate to each grid point using a boat. All data was recorded using a digital data form on the data collection unit. Tables 1 and 2 list the data and categories of data that were collected at each grid point.

Table 1. Aquatic sampling rake data collected at each grid point

METRIC	*Description and categories*	
RAKE FULLNESS	*Amount of aquatic vegetation on the sampling rake*	
	None	No plants present on rake
	Single	A single plant present on rake
	Low	Sparse vegetation present on rake
	Medium	Moderate amount of vegetation on rake, typically enough to cover center of the rake but not the tines
	High	Large amount of vegetation on rake, typically enough to cover the rake tines, difficult to bring into the boat
SPECIES ABUNDANCE	*Ranking of abundance of each species on sampling rake*	
	Single	A single plant present on rake
	Low	Species was sparse on rake
	Medium	Species was moderately abundant on rake
	High	Species was abundant on rake

An aquatic survey rake was used to gather the vegetation data at each point location. In waters shallower than 8', a rake on a pole was used to sample vegetation. In waters deeper than 8', a survey rake attached to a rope was used to sample vegetation. Rake fullness, as outlined in Table 1, was recorded for each sample to obtain information about vegetation density (Hauxwell et al. 2010; Madsen et al. 1996). Each aquatic plant on the rake was identified to species, if possible. Specimens that were difficult to identify in the field were collected and examined under a dissecting scope. Voucher specimens of many species recorded in the lake were collected and stored at either the Arrowwood Herbarium or at the Pringle Herbarium at the University of Vermont. The abundance of each species on the rake was recorded using the categories outlined in Table 1.

Table 2. Vegetation abundance and site data collected at each grid point

METRIC	*Description and categories*	
BIOMASS	*Amount of plant growth vertically in the water column*	
	None	*No aquatic plants present*
	Low	*Plants growing only as a low layer above the sediment*
	Moderate	*Plants growing well into the water column but generally not reaching the water surface*
	High	*Plants filling the water column and/or surfacing enough to be a possible recreational nuisance*
	Very High	*Plants filling the water column and completely covering the surface; obvious nuisance conditions*
PERCENT COVER SUBMERGED	*A record of the percentage of the lake bottom covered by submerged aquatic plants using the following cover categories: <1%; 1-5%; 5-25%; 25-50%; 50-75%; 75-100%*	
PERCENT COVER FLOATING	*A record of the percentage of the lake surface covered by floating aquatic plants using the following cover categories: 1-5%; 5-25%; 25-50%; 50-75%; 75-100%*	
NONNATIVE INVASIVE SPECIES (NNIS)	*Presence of invasive species with species name and number of plants or percent cover of NNIS plants using the following cover categories: <1%; 1-5%; 5-25%; 25-50%; 50-75%; 75-100%*	
SEDIMENT TYPE	*Type of sediment present using the following categories: Bedrock; Boulder; Cobble; Gravel; Sand; Silt; Clay; Muck*	
WATER DEPTH	*Depth of water taken using sonar (from motorboat) or kayak paddle (from kayak).*	
AQUATIC NATURAL COMMUNITY	*Type of aquatic natural community present at grid point*	

In addition to rake data, vegetation abundance and general site data (described in Table 2) was collected at each grid point.

Overall plant biomass data is used to understand the potential for aquatic plants growing at levels high enough to reach nuisance conditions. The categories for this metric are shown in Table 2. Since this metric measures potential nuisance conditions, it is largely dependent upon water depth in addition to plant growth. Dense plant growth in the water column, for example, does not generally present nuisance conditions if it is well below the surface of the lake. The same amount of growth, however, in very shallow water would potentially create nuisance conditions.

Percent cover of both submerged and floating aquatic plants was recorded at each grid point using the categories shown in Table 2. Recording percent cover of aquatic plants is a similar metric as

the biomass but not dependent on water depth. If submerged vegetation was growing dense enough that it was laying on the surface of the water, it was considered a floating aquatic plant for this metric.

Figure 2. Aquatic sampling rake

Presence or absence of non-native invasive species was evaluated in an approximately 500 square foot area at each grid sampling point. Data on either the number of plants or the percent cover that the plants occupy was recorded as outlined in Table 2. If an NNIS infestation was widespread, "off-grid" sampling points were used to determine the boundaries of the infestation (see Visual Littoral Survey methods below).

Water depth and sediment type data were collected at each grid point as outlined in Table 2. For each grid point where the aquatic natural community was known, data was collected on the presence of this type.

b. Visual Littoral Survey

While the grid point sampling provides a systematic and repeatable method for sampling aquatic vegetation, it does not provide information about the nature of aquatic vegetation in between the grid points. Relying solely on this method, therefore, has the potential to leave significant gaps in the knowledge of aquatic vegetation in the overall lake. The visual littoral survey method was employed to fill in these gaps and provide a more complete picture of aquatic vegetation. This survey methodology is based on methods from the Vermont Agency of Natural Resources Department of Environmental Conservation (2006) field manual.

When navigating in between grid point locations, aquatic vegetation was viewed from the boat. An "off-grid" data point was taken to document invasive species, record information about aquatic natural communities, record areas of high biomass, document rare species or record other features of interest. Data was recorded on the digital data collection form at these "off-grid" points. Only a subset of the data presented in Tables 1 and 2 was collected at these points related to the specific feature being documented. In some cases, a field sketch map of a particular feature (typically an

EWM infestation or natural community) was used to document the extent of the feature. This was conducted on the iPhone/iPad using a line feature class.

Mapping the distribution and abundance of NNIS was a major focus of the visual littoral survey data collection effort. When NNIS were discovered outside of the grid points, an "off-grid" point was taken and an estimate of percent cover of the NNIS was used to document the abundance. For infestations with a smaller extent, an estimate of the area covered by the NNIS was recorded. For areas with a larger extent, GPS points were taken on the margins of the population to establish infestation boundaries.

c. Creating maps of aquatic natural communities and EWM

Once field work was complete, the spatial data was analyzed in ArcGIS. In order to create a complete map of aquatic vegetation in the lake, the grid points and off-grid points were used to create a polygon layer of vegetation. Using ortho-photo interpretation, bathymetric maps of the lake and the field data, a polygon feature class was created of the different aquatic natural communities. This map provides the extent of the aquatic vegetation in the lake at the time of the survey.

Table 3. Cover categories for EWM

Percent Cover	Density Description
0-5%	None-Trace
5-25%	Sparse
25-50%	Moderate
50-75%	Moderate-Dense
75-100%	Dense

Using the above method along with the NNIS point data, a polygon map of EWM was created. Different polygons of EWM were created for each of the different density categories shown in Table 3. In some cases, the transition between the different density categories in the lake was gradual; the boundaries shown on the final map are therefore considered approximate.

The map of EWM in the lake should be viewed in conjunction with ongoing EWM control activities. The presence and density of EWM shown on the maps in this report are, in many cases, dependent on and determined by EWM control efforts. If, for example, Diver-Assisted Suction Harvesting (DASH) occurred on a dense infestation of EWM before the inventory was undertaken,

no EWM would be recorded at that location. Conversely, an infestation of EWM may be included on the maps that has since been removed by DASH or other control methods.

d. Macrophyte Species List

A list of all aquatic plant species encountered during the inventory is included in the results section. This list was compiled from the grid point and off-grid point samples and the visual littoral surveys. Grid point rake sampling generally favors larger species and species that are dominant in the lake. This sampling method tends to miss species that are uncommon in the lake, species that occur in isolated habitats, or species that are small or grow along the sediment surface. For this reason, other species that were noted during the visual littoral surveys were also recorded. It was not within the scope of this project to conduct a comprehensive survey of all aquatic vegetation in the lake. There may be additional species occurring in the lake (either sparse in number or located in limited or specialized habitats) that were undetected by these survey methods.

Table 4. Plant rarity ranking

S-rank	Description
S1	Very Rare
S2	Rare
S3	Uncommon
S4	Common
S5	Common and widespread

The Vermont Natural Heritage Inventory (NHI) maintains a list of species that are rare, threatened and endangered in the state. Determination of how rare or common a particular species is in the state is based on rarity rankings (Table 4) assigned to each species by Vermont NHI. This methodology was used in Lake St. Catherine to determine if any of the species documented in the lake were considered rare or uncommon. A discussion of state-listed rare or uncommon species encountered during the inventory is included in the results.

2. Results

The results of the inventory are presented below in four sections: a) Macrophyte Species; b) Native Aquatic Natural Communities; c) Non-Native Invasive Species; and d) Macrophyte Biomass.

a. Macrophyte Species

The aquatic plant species documented during the inventory are presented in Table 5, this includes eight species that are considered rare or uncommon in the state. The rarest of these is the S1-ranked Tuckerman's quillwort. This is a cryptic species that grows as a short rosette of quill-shaped leaves. In Lake St. Catherine it prefers the rocky substrate of the Water Naiad Cobble Shoal Community. It is quite rare in Lake St. Catherine; located in one location along the western shore just south of the narrows. Given the limitations of the survey methodology outlined above, there are likely other locations of this species in the lake.

Slender naiad (S2-ranked) is also considered a rare species in Vermont. This species is rare in Lake St. Catherine, being documented in one location, on the western shore of Cones Point. It was found mixed with the similar looking common naiad in the Robbins-Illinois Pondweed Assemblage. It is likely that more occurrences of slender naiad are found scattered throughout the lake mixed with the more common species.

Two species considered uncommon-rare (S2S3-ranked) were documented in the lake: wire-stemmed pondweed and hornwort. Wire-stemmed pondweed is fairly common in the lake, being found at low abundance in all three vegetation types. Hornwort is found mixed in with the dense aquatic vegetation of the Water Lily Aquatic Community and the Robbins/Illinois Pondweed Assemblage, though overall seems uncommon in the lake.

There are three uncommon (S3-ranked) species documented in the lake. White water crowfoot is a small aquatic member of the buttercup family. It is uncommon in Lake St. Catherine, where it grows in shallow waters of the Water Naiad Cobble Shoal and the Water Lily Aquatic Communities. The other two S3-ranked species are both species of bladderwort. These are small,

Table 5. List of plant species documented during the inventory

Latin Name	Common Name	S-Rank*	Plant Family
Alisma gramineum	grass-leaved water-plantain		Alismataceae
Sagittaria cuneata	northern arum-leaved arrowhead		Alismataceae
Sagittaria graminea	grass-leaved arrowhead		Alismataceae
Lemna minor	duckweed		Araceae
Ceratophyllum demersum	coontail		Ceratophyllaceae
Ceratophyllum echinatum	hornwort	S2S3	Ceratophyllaceae
Nitella spp.	stonewort		Characeae
Eleocharis acicularis	needle spike-rush		Cyperaceae
Myriophyllum spicatum	Eurasian water-milfoil		Haloragaceae
Myriophyllum tenellum	leafless water-milfoil		Haloragaceae
Elodea canadensis	water-weed		Hydrocharitaceae
Najas flexilis	common naiad		Hydrocharitaceae
Najas gracillima	slender naiad	S2	Hydrocharitaceae
Vallisneria americana	eel-grass		Hydrocharitaceae
Isoetes tuckermanii	tuckerman's quillwort	S1	Isoetaceae
Juncus pelocarpus	mud-rush		Juncaceae
Utricularia gibba	humped bladderwort	S3	Lentibulariaceae
Utricularia macrorrhiza	common bladderwort		Lentibulariaceae
Utricularia minor	lesser bladderwort	S3	Lentibulariaceae
Decodon verticillatus	water willow		Lythraceae
Brasenia schreberi	water shield		Nymphaeaceae
Nuphar variegata	common yellow pond-lily		Nymphaeaceae
Nymphaea odorata	waterlily		Nymphaeaceae
Heteranthera dubia	water star-grass		Pontederiaceae
Pontederia cordata	pickerelweed		Pontederiaceae
Potamogeton amplifolius	broad-leaved pondweed		Potamogetonaceae
Potamogeton berchtoldii	Berchtold's pondweed		Potamogetonaceae
Potamogeton epihydrus	ribbon-leaved pondweed		Potamogetonaceae
Potamogeton gramineus	grass-leaved pondweed		Potamogetonaceae
Potamogeton illinoensis	Illinois pondweed		Potamogetonaceae
Potamogeton oakesianus	Oakes' pondweed		Potamogetonaceae
Potamogeton praelongus	white-stemmed pondweed		Potamogetonaceae
Potamogeton robbinsii	Robbins' pondweed		Potamogetonaceae
Potamogeton spirillus	common snailseed pondweed		Potamogetonaceae
Potamogeton strictifolius	wire-stemmed pondweed	S2S3	Potamogetonaceae
Potamogeton zosteriformis	zigzag pondweed		Potamogetonaceae
Ranunculus aquatilis	white water-crowfoot	S3	Ranunculaceae

floating, carnivorous plants with thread-like leaves. They are found in the shallow waters of the Water Lily Aquatic Communities in Lily Pond, Little Lake and (less commonly) along the shores of Lake St. Catherine.

Analysis of the grid sampling survey data is presented in summary form in Table 6. The dataset allows for analysis on the most abundant species that occur on the rake samples shown as the Frequency of Occurrence (FOO). Full results of the rake samples are included in the table in Appendix 1.

The list of species in Table 6 are arranged from most abundant to least abundant species encountered during the 2023 rake sampling. The final column includes FOO data from 2022 sampling at the same grid point locations (SOLitude Lake Management 2022).

Absent any significant change in ecological conditions, it is difficult to attach any ecological significance to the variations in the annual FOO data for rake samples. It is likely that the perceived changes are the results of "noise" in the data related to the grid point sampling technique. This methodology takes samples from small, discreet points in the lake, so the overall area that is sampled in the lake is minor. In addition, while the coordinates of the grid points can be the same from year to year, the actual sampling locations are not the same. Due to limited GPS accuracy (and other factors such as wind) the actual sampling locations are generally within 10-15' of each other from year to year. Given the high degree of horizontal diversity in many aquatic communities (i.e., change in plant species in different areas), it would be common to find different plant species on sampling rakes sampled 10-15' apart. The changes seen from 2022 to 2023 may therefore be more reflective of the horizontal diversity in the lake than of potential changes over time.

Another way to analyze the rake sample data is to stratify it based on aquatic natural community type. This data is presented in the Native Aquatic Natural Communities section below.

Table 6. Frequency of occurrence (FOO) data for aquatic plant species in all rake samples

Latin Name	Common Name	# Occurrences (2023)	2023 FOO	2022 FOO*
Potamogeton robbinsii	Robbins' pondweed	118	62.8%	60%
Elodea canadensis	water-weed	86	45.7%	17%
Potamogeton illinoensis	Illinois pondweed	66	35.1%	42%
Vallisneria americana	eel-grass	42	22.3%	7%
Myriophyllum spicatum	Eurasian water-milfoil	36	19.1%	17%
Heteranthera dubia	water star-grass	31	16.5%	10%
Najas flexilis	common naiad	31	16.5%	15%
None	NA	16	8.5%	NA
Potamogeton strictifolius	wire-stemmed pondweed	14	7.4%	0
Nitella spp.	stonewort	13	6.9%	5%
Utricularia macrorrhiza	common bladderwort	13	6.9%	45%
Nymphaea odorata	waterlily	12	6.4%	10%
Potamogeton amplifolius	broad-leaved pondweed	11	5.9%	42%
Ceratophyllum demersum	coontail	9	4.8%	3%
Potamogeton berchtoldii	Berchtold's pondweed	9	4.8%	3%
Utricularia minor	lesser bladderwort	8	4.3%	0
Potamogeton gramineus	grass-leaved pondweed	6	3.2%	5%
Potamogeton zosteriformis	zigzag pondweed	5	2.7%	2%
Potamogeton praelongus	white-stemmed pondweed	3	1.6%	0
Ranunculus aquatilis	white water-crowfoot	3	1.6%	0
Ceratophyllum echinatum	hornwort	2	1.1%	0
Eleocharis acicularis	needle spike-rush	2	1.1%	0
Nuphar variegata	common yellow pond-lily	2	1.1%	19%
Utricularia geminiscapa	hidden-flowered bladderwort	2	1.1%	0
Eleocharis palustris	marsh spike-rush	1	0.5%	0
Eriocaulon aquaticum	pipewort	1	0.5%	0
Juncus pelocarpus	mud-rush	1	0.5%	0
Lemna minor	duckweed	1	0.5%	0
Najas gracillima	slender naiad	1	0.5%	0
Pontederia cordata	pickerelweed	1	0.5%	0
Sagittaria graminea	grass-leaved arrowhead	1	0.5%	0

*Data from 2022 SOLitude Lake Management Report (2022). Data on # of occurrences in 2022 not available

b. Native Aquatic Natural Communities

A natural community is an interacting assemblage of organisms, their physical environment, and the natural processes that affect them. Terrestrial natural communities have been well-described in the state (Thompson, Sorenson, and Zaino 2019) but much work still needs to be done on classifying groups of aquatic plants into natural communities. There are a few groups, such as the Waterlily Aquatic Community, that appear to be well-understood, common components of aquatic systems throughout the region. Other groupings of plants are referred to as "assemblages" or "types" because more studies are needed to determine if they are established groupings that warrant the "natural community" designation. Arrowwood Environmental scientists are working on a classification from lakes across the state. Such a classification is useful for documenting the diversity of types, ranging from sparsely vegetated rocky shoals to densely vegetated mucky bays. These community types not only provide different habitats for aquatic organisms but vary in their susceptibility to NNIS invasion.

Table 7. Natural community types in Lake St. Catherine

Natural Community Type	#	Acres	Biomass
Water Naiad Cobble Shoal Assemblage	10	46.29	None-Low
Robbins-Illinois Pondweed Assemblage	7	280.85	Moderate-High
Water Lily Aquatic Community	13	63.79	Moderate-High
Total	30	390.93	

The littoral zone of Lake St. Catherine contains three different aquatic community types as summarized in Table 7. The near-shore areas of the lake are largely composed of the sparsely vegetated cobble shallows of the Water Naiad Cobble Shoal Assemblage. The deeper areas in the lake are occupied by the Robbins-Illinois Pondweed Assemblage and the shallow mucky bays provide habitat for the Water Lily Aquatic Community.

Each of these vegetation types are shown on the map in Appendix 2 and described below.

Water Naiad Rocky Shoal Assemblage

This vegetation type is found in shallow depths (generally less than 6' deep) with rocky cobble and gravel substrates. The shallower areas of this type may freeze in the winter and are subject to wave action in the summer. This, combined with the relatively nutrient-poor substrates, result in vegetation that is low-growing, rarely exceeding 6" height. The vegetation of this type is dominated by common naiad, water stargrass, eelgrass and waterweed. Table 8 lists the frequency of occurrence data from grid sample points in this vegetation type. Percent cover of vegetation in this type is highly variable. There are a few localized areas where vegetation can reach 50-75% cover, but most areas exhibit much lower percent cover (5-25%). There are also many areas where vegetation is absent or present as scattered individual plants; this is illustrated in Table 8, where 27% of the sampling points lacked vegetation ("None" in column 1). The short stature of most plants in the assemblage, combined with low percent cover results in a vegetation type with low overall aquatic plant biomass.

Figure 3. Stonewort Rocky Shoal Assemblage

In Lake St. Catherine, this vegetation type is found in shallow areas such as Sunken Island as well as along the shores of most of the lake. In some cases, there is only a narrow band of this assemblage before the vegetation transitions into the Robbins-Illinois Pondweed Assemblage. In other areas (such as Atwater Bay) the Stonewort Rocky Shoal Assemblage includes an area hundreds of feet from the shore and makes up most of the vegetation type in the bay. The distribution of this type is shown on the maps in Appendix 2.

Table 8. Frequency of occurrence (FOO) data for Water Naiad Cobble Shoal Community

Latin Name	Common Name	# Occurrences (2023)	2023 FOO
Najas flexilis	common naiad	8	31%
None	NA	7	27%
Heteranthera dubia	water star-grass	7	27%
Vallisneria americana	eel-grass	7	27%
Elodea canadensis	water-weed	6	23%
Potamogeton illinoensis	Illinois pondweed	6	23%
Potamogeton robbinsii	Robbins' pondweed	5	19%
Potamogeton strictifolius	wire-stemmed pondweed	4	15%
Myriophyllum spicatum	Eurasian water-milfoil	3	12%
Nitella spp.	stonewort	2	8%
Potamogeton gramineus	grass-leaved pondweed	2	8%
Eriocaulon aquaticum	pipewort	1	4%
Nymphaea odorata	waterlily	1	4%
Potamogeton amplifolius	broad-leaved pondweed	1	4%
Potamogeton berchtoldii	Berchtold's pondweed	1	4%
Ranunculus aquatilis	white water-crowfoot	1	4%
Sagittaria graminea	grass-leaved arrowhead	1	4%

In general, EWM does not favor the disturbance regime associated with the habitat of this assemblage. For this reason, EWM is generally absent or found only at low cover in these areas. Most of the areas mapped with only trace amounts of EWM (see Sub-Section C below) are comprised of this vegetation type.

Robbins-Illinois Pondweed Assemblage

This aquatic vegetation type is the most widespread and abundant type in the lake, comprising over 70% of the vegetated littoral zone. On more exposed shores, the Stonewort Rocky Shoal Assemblage occupies the shallow rocky areas, and the Robbins-Illinois Pondweed type is found in adjacent areas of deeper water. However, in bays and other shallow, protected areas this pondweed type grows right to the shore. It can range in depth from 1 to 13' deep, and the sediments are silts or silt over gravel and cobble. Overall cover of submerged vegetation is typically 75-100%, though can be less in more exposed sites or along the deeper margins of the community where vegetation fades out.

Figure 5. Robbins-Illinois Pondweed Assemblage

As the name suggests, the two most common and visible species in this assemblage are Robbins pondweed and Illinois pondweed. Robbins pondweed generally forms the "understory" species and can grow in dense colonies that completely cover the lake bottom. This species, however, rarely grows taller than 12" and rarely reaches the water surface. Illinois pondweed, however, grows very tall (3-8') and often surfaces late in the growing season. Waterweed is also a common component of this aquatic community and can sometimes form dense colonies like Robbins pondweed. Other species found in this community include eelgrass, water stargrass, and common naiad. In Lake St. Catherine, Eurasian watermilfoil is also a common species found in this community. The Frequency of Occurrence data in Table 9 shows species that were documented in this community. As can be seen from this data, this is the most diverse aquatic vegetation type in the lake, with 31 species being recorded from the grid point sampling data.

Figure 4. Dense growth of Robbins pondweed

This vegetation type provides the most suitable habitat for EWM in the Lake. These areas, therefore, are where the densest infestations of EWM are likely to occur. In addition, most of the vegetative biomass of the lake occurs in this (and the Water Lily) type. Because these areas are where

most of the aquatic vegetation exists, these are the areas that provide most of the habitat for aquatic life, including a wide array of benthic organisms and fish in most stages of their life cycles.

Table 9. Frequency of occurrence (FOO) data for Robbins-Illinois Pondweed Assemblage

Latin Name	Common Name	# Occurrences (2023)	2023 FOO
Potamogeton robbinsii	Robbins' pondweed	118	89.4%
Elodea canadensis	water-weed	86	65.2%
Potamogeton illinoensis	Illinois pondweed	66	50.0%
Vallisneria americana	eel-grass	42	31.8%
Myriophyllum spicatum	Eurasian water-milfoil	36	27.3%
Heteranthera dubia	water star-grass	31	23.5%
Najas flexilis	common naiad	31	23.5%
None	N/A	16	12.1%
Potamogeton strictifolius	wire-stemmed pondweed	14	10.6%
Nitella spp.	stonewort	13	9.8%
Utricularia macrorrhiza	common bladderwort	13	9.8%
Nymphaea odorata	waterlily	12	9.1%
Potamogeton amplifolius	broad-leaved pondweed	11	8.3%
Ceratophyllum demersum	coontail	9	6.8%
Potamogeton berchtoldii	Berchtold's pondweed	9	6.8%
Utricularia minor	lesser bladderwort	8	6.1%
Potamogeton gramineus	grass-leaved pondweed	6	4.5%
Potamogeton zosteriformis	zigzag pondweed	5	3.8%
Potamogeton praelongus	white-stemmed pondweed	3	2.3%
Ranunculus aquatilis	white water-crowfoot	3	2.3%
Ceratophyllum echinatum	hornwort	2	1.5%
Eleocharis acicularis	needle spike-rush	2	1.5%
Nuphar variegata	common yellow pond-lily	2	1.5%
Utricularia geminiscapa	hidden-flowered bladderwort	2	1.5%
Eleocharis palustris	marsh spike-rush	1	0.8%
Eriocaulon aquaticum	pipewort	1	0.8%
Juncus pelocarpus	mud-rush	1	0.8%
Lemna minor	duckweed	1	0.8%
Najas gracillima	slender naiad	1	0.8%
Pontederia cordata	pickerelweed	1	0.8%
Sagittaria graminea	grass-leaved arrowhead	1	0.8%

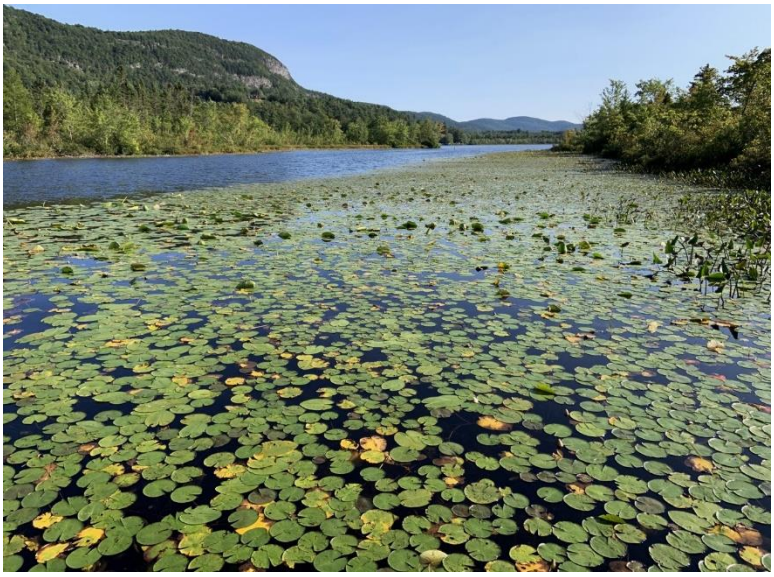

Figure 6. Water Lily Aquatic Community

Water Lily Aquatic Community

This community is dominated by the presence of floating-leaved aquatic species such as water lily. This is a well-documented community found throughout the region (Gawler and Cutko 2010; Hunt, Anderson, and Sorenson 2002). This community is typically found where the water is shallow and there is a significant layer of organic muck substrates. This can occur in the sheltered bays of large lakes or throughout the littoral zones of lakes and ponds that are small or shallow. In these areas, the cover of the floating-leaved species can be very high and completely cover the water surface. Table 10 shows the frequency of occurrence data for grid point samples in this community. Water lily is the most common floating leaved species in Lake St. Catherine, though yellow pond lily is also present in some areas. Submerged vegetation cover is very high, typically 75-100% cover. Dominant submerged species include Robbins pondweed, waterweed, Eurasian watermilfoil, coontail, and bladderwort species.

In the Lake St. Catherine system, this community is most common in Little Lake and Lily Pond. In both of these shallow water bodies, the Water Lily Aquatic Community occupies the margins of the ponds where disturbance is minimal. Elsewhere in the lake system, this community can be found along the margins of the Channel, in Halls Bay and along the shore north of the state park beach. In all cases the boundaries of this community can vary from year to year as the abundance of water lily naturally varies.

Table 10. Frequency of occurrence (FOO) data for Water Lilly Aquatic Community

Latin Name	Common Name	# Occurrences (2023)	2023 FOO
Potamogeton robbinsii	Robbins' pondweed	17	89%
Nymphaea odorata	waterlily	10	53%
Elodea canadensis	water-weed	7	37%
Myriophyllum spicatum	Eurasian water-milfoil	7	37%
Ceratophyllum demersum	coontail	4	21%
Utricularia macrorrhiza	common bladderwort	4	21%
Utricularia minor	lesser bladderwort	4	21%
Heteranthera dubia	water star-grass	3	16%
Potamogeton amplifolius	broad-leaved pondweed	3	16%
Potamogeton illinoensis	Illinois pondweed	3	16%
Vallisneria americana	eel-grass	3	16%
Nitella spp.	stonewort	2	11%
Nuphar variegata	common yellow pond-lily	2	11%
Ranunculus aquatilis	white water-crowfoot	2	11%
Utricularia geminiscapa	hidden-flowered bladderwort	2	11%
None	NA	1	5%
Ceratophyllum echinatum	hornwort	1	5%
Eleocharis acicularis	needle spike-rush	1	5%
Eleocharis palustris	marsh spike-rush	1	5%
Lemna minor	duckweed	1	5%
Najas flexilis	common naiad	1	5%
Pontederia cordata	pickerelweed	1	5%
Potamogeton berchtoldii	Berchtold's pondweed	1	5%

c. Non-Native Aquatic Species

Eurasian watermilfoil was the only non-native aquatic species documented in the lake. Both brittle naiad (*Najas minor*) and curly pondweed (*Potamogeton crispus*) have been reported in the lake in the past but were not documented during the current inventory. Brittle naiad has never been abundant in St. Catherine, being found at only 2% FOO in the last inventory (SOLitude Lake Management 2022). Its absence in the current inventory may be an artifact of the sampling methodology and not indicative of its absence. Earlier in the summer of 2023, curly pondweed was found in abundance at the north end of Little Lake and in The Channel (LSCA members, personal communication). Such a dense infestation should have shown up to some degree in the

current survey. However, curly pondweed is generally an earlier-season species and may have died back by the time the present survey was conducted, which may explain its absence.

The maps in Appendix 2 show the distribution and abundance of EWM in the lake. As discussed above, EWM is generally less abundant in areas of the Water Naiad Cobble Shoal Community. These areas have coarser sediments and, in the shallow areas, are more prone to winter-time disturbance. While EWM is found in these areas, it is much less common and does not establish dense infestations. EWM is also found in only trace or sparse amounts along the shores where the steep drop-off limits the amount of suitable habitat. EWM is most common and reaches highest abundance in the Robbins-Illinois Pondweed Community. The finer sediments and less disturbed nature of this community are more suitable for the growth of EWM.

A summary of EWM infestations in the lake is shown in Table 11.

Table 11. EWM Infestations Summary

EWM Category	# Sites	Total Acres
Trace	9	258.58
Sparse	20	100.17
Moderate	11	19.65
Moderate-Dense	9	3.93
Dense	4	1.35
Total	**53**	**383.69**

Field notes about EWM in specific areas throughout the lake are presented below, arranged by site, from north to south. Each EWM infestation area is shown on the maps in Appendix 2. Summary data on the acreage of the infestation at each site is presented in Table 12. Trace infestations occur throughout the lake and are excluded from the data in Table 12.

Lily Pond. This shallow, mucky pond has very high aquatic biomass, but EWM is largely absent. A few small areas of low cover result in a trace abundance.

North Bay. North Bay is a shallow, well-vegetated bay with moderate-high biomass of submerged vegetation. Most of the vegetation in this bay is native, likely due to frequent EWM management. EWM is found scattered throughout the bay but never reaches more than sparse abundance.

Table 12. EWM Infestations by Site

Site Name	EWM Categories and Acreage*			
	Sparse	Moderate	Moderate-Dense	Dense
Atwater Bay	4.8		1.0	
Cones Point		0.02		
Forest House Bay	0.4			
Halls Bay	10.5	3.5		
Idlewild Bay	1.8	1.8		
Little Lake	28.4	5.4		
North Bay	13.5		0.02	
Northeastern Shore	2.5	0.1		0.03
Oxbow Bay	3.3	0.2	0.6	
Pine Point	0.4		0.5	1.0
Sandy Bay		0.3	1.3	0.1
Sandy Bay and Cones Point	13.2			
State Park Beach			0.6	
Stonehenge	6.2	6.2		0.2
The Channel	15.0	2.1		
Total Acreage	100.17	19.65	3.93	1.35

** Areas with trace EWM are not shown*

Stonehenge. A fairly large EWM infestation with moderate density is mapped in this bay. The density within this mapped area, however, is quite variable with some patches of EWM reaching moderate-dense abundance and some areas with only sparse abundance.

Pine Point. An infestation of dense EWM is found off the southern end of this point in the deeper water, about 50 feet offshore. This infestation continues around the eastern end of the point, though is much less dense in this area.

Sandy Bay. Along the shores of this bay, EWM is found only in trace abundance within the Water Naiad Cobble Shoal community. In the deeper areas of the Robbins-Illinois Pondweed community, EWM is found at a background level of sparse abundance. There is a moderate-dense patch of EWM in the bay as well as three patches of higher abundance south of the bay.

Halls Bay. The biomass of submerged aquatic vegetation in this bay is moderate to high and composed of a mix of native vegetation and EWM. EWM in most of the bay is sparse but density increases to moderate in the northern part of the bay.

Oxbow Bay. Active management has resulted in mostly trace and sparse EWM abundance in this bay. There are two small areas of higher abundance along the eastern shore of the bay as well as a moderate-dense patch off the northern end of the Island.

Horseshoe Bay. This bay received DASH harvesting in 2023. What remains of EWM here are only scattered individual plants-yielding a "Trace" designation. There are a few small patches of sparse EWM within this area mapped as trace, but these are generally too small to map and mostly in deeper water.

Atwater Bay. Much of the shallower parts of this bay are occupied by the Water Naiad Cobble Shoal community, where EWM is generally present in trace amounts, though some small local patches of sparse cover do exist. The deeper areas of Robbins-Illinois Pondweed community have some larger areas of sparse EWM present. The shallow area north of the bay has patches of Moderate-Dense EWM, especially in the northern end of that vegetated area.

Idlewild Bay. Along the shores of this bay in the Water Naiad Cobble Shoal Community, EWM exists in trace amounts. Away from shore, the Robbins-Illinois Pondweed assemblage consists of a dense mixture of native vegetation and EWM in moderate density. EWM density is sparse along the northern shores of the bay.

Forest House Bay. Overall, EWM was documented in trace abundance in this bay. One area of sparse EWM abundance was mapped near the shore. Other small patches of sparse EWM are scattered throughout the bay, but these are limited in extent and too small to map separately.

The Channel. Habitat for EWM is very good in the channel, and the potential for spread from boat traffic is high. One area of Moderate EWM density was mapped and the rest of the channel was mapped as Sparse. Active management of EWM in this area largely determined the density of EWM mapped at the time of the survey.

Little Lake. Aquatic vegetation in Little Lake is actively managed with a mechanical harvester. Abundance of EWM mapped is largely determined by this management. Most of this area showed only trace abundance of EWM with only a few areas in the northern end of the lake showed moderate EWM abundance. Sparse EWM abundance was mapped along the northeastern and northwestern edges of the lake, as well as a small area in the southeast corner. This EWM abundance is in sharp contrast with observations of dense EWM in the northern part of Little Lake earlier in the season (LSCA, personal communication). The reason for the decline of EWM abundance here is not known.

Figure 7. Flowering EWM

d. Biomass

Data on the overall biomass of macrophytes was taken at each grid point. From that data, a heat map of biomass was created to show areas in the lake that exhibit abundant aquatic vegetation. This biomass map in Appendix 2 is based on software generated interpolation between grid point locations and includes both EWM and native vegetation.

Not surprisingly, the areas of highest biomass are Lily Pond and Little Lake. These shallow waterbodies naturally provide habitat for dense growth of aquatic vegetation. The southwestern area of Little Lake that exhibits lower biomass is a direct result of vegetation management

(mechanical harvesting and potentially 2022 herbicide treatment). The North Bay and Stonehenge area exhibit high biomass. In the case of the Stonehenge area, this is partly comprised of EWM. Elsewhere, biomass consists mostly of native vegetation. Areas such as Halls Bay, Forest House Bay and The Channel also exhibit higher biomass, with moderate biomass recorded in smaller bays such as Oxbow and Horseshoe.

3. Conclusion

Through grid point sampling and visual littoral surveys, the native and non-native aquatic vegetation in the Lake St. Catherine system was mapped in August and September 2023. The aquatic vegetation in the lake consists of three different natural community types. The cobble shores and shoals around the margins of the lake consist of the Water Naiad Cobble Shoal Community. Deeper areas with finer sediments consist of the Robbins-Illinois Pondweed assemblage. This is the most abundant and diverse aquatic vegetation type in the lake. Finally, the shallow bays with mucky substrates provide habitat for the Water Lily Aquatic Community. The abundance and distribution of EWM throughout the lake was mapped. This non-native invasive species was found in trace amounts throughout the lake system. In addition, 1.35 acres of dense infestation, 3.93 acres of moderate-dense infestation, and nearly 20 acres of moderate infestation were recorded. Most of the denser EWM infestations occur within the Robbins-Illinois Pondweed vegetation type. Data on the distribution and abundance of EWM throughout the St. Catherine Lake system will help to guide management of EWM in 2024.

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Appendix 1: Aquatic Sampling Rake Data

Appendix 1a. Plant data at each grid point

Grid Point Sample Number	Ceratophyllum demersum	Ceratophyllum echinatum	Eleocharis acicularis	Eleocharis palustris	Elodea canadensis	Eriocaulon aquaticum	Heteranthera dubia	Juncus pelocarpus	Lemna minor	Myriophyllum spicatum	Najas flexilis	Najas gracillima	Nitella spp.	Nuphar variegata	Nymphaea odorata	Pontederia cordata	Potamogeton amplifolius	Potamogeton berchtoldii	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton robbinsii	Potamogeton strictifolius	Potamogeton zosteriformis	Ranunculus aquatilis	Sagittaria graminea	Utricularia macrorrhiza	Utricularia minor	Vallisneria americana
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Grid Point Sample Number	Ceratophyllum demersum	Ceratophyllum echinatum	Eleocharis acicularis	Eleocharis palustris	Elodea canadensis	Eriocaulon aquaticum	Heteranthera dubia	Juncus pelocarpus	Lemna minor	Myriophyllum spicatum	Najas flexilis	Najas gracillima	Nitella spp.	Nuphar variegata	Nymphaea odorata	Pontederia cordata	Potamogeton amplifolius	Potamogeton berchtoldii	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton robbinsii	Potamogeton strictifolius	Potamogeton zosteriformis	Ranunculus aquatilis	Sagittaria graminea	Utricularia macrorrhiza	Utricularia minor	Vallisneria americana
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Grid Point Sample Number	Ceratophyllum demersum	Ceratophyllum echinatum	Eleocharis acicularis	Eleocharis palustris	Elodea canadensis	Eriocaulon aquaticum	Heteranthera dubia	Juncus pelocarpus	Lemna minor	Myriophyllum spicatum	Najas flexilis	Najas gracillima	Nitella spp.	Nuphar variegata	Nymphaea odorata	Pontederia cordata	Potamogeton amplifolius	Potamogeton berchtoldii	Potamogeton gramineus	Potamogeton illinoensis	Potamogeton praelongus	Potamogeton robbinsii	Potamogeton strictifolius	Potamogeton zosteriformis	Ranunculus aquatilis	Sagittaria graminea	Utricularia macrorrhiza	Utricularia minor	Vallisneria americana
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174					H						L							L				L							L
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206					M		L															H							
207																						L							
208																				L		M							L
209					L					M										H									L
210					M																	H							
211					M												L					H							L
212																						L							
213																						M							L
214					M																	H							
215					M										M														
216																				M								S	
17A					L																	M		L					

Appendix 1b. Site data at each grid point

Survey Point	Depth (ft)	% Cover Floating	% Cover Submerged	Biomass	Sediment
<Null>	15				
20	9	0%	75%	Moderate	Silt
21	5	0%	1%	Low	Cobble
22	0				
23	6	0%	100%	Moderate	Silt
24	8	0%	100%	High	Silt
25	3	0%	75%	Moderate	Cobble
26	3.5	50%	100%	High	Silt
27	6	25%	100%	High	Silt
28	3	50%	100%		Silt
29	11	0%	75%		Silt
30	8	0%	75%	Moderate	Cobble
31	6	0%	75%	Moderate	Cobble
32	2.5	75%	50%	High	Muck
33	4	25%	100%	High	Silt
34	3	100%	75%	Extremely High	Muck
35	8	0%	100%	Moderate	Silt
36	6	0%	100%	Moderate	Silt
37	8		100%	Moderate	Silt
38	4	5%	100%	Extremely High	Silt
39	9	0%	100%	Moderate	Silt
40	10	0%	75%	Moderate	Silt
41	3	0%	50%		Cobble
42	9.6	0%	100%	Moderate	Silt
43	5	5%	100%	High	Muck
44	3	5%	100%	Moderate	Muck
45	3	25%	100%	Extremely High	Muck
46	3	5%	100%	Extremely High	Muck
47	2		100%	Extremely High	Muck
48	2	5%	75%	Moderate	Muck
50	2	100%	50%	High	Muck
51	6	0%	100%	Moderate	Muck
52	6	0%	100%	High	Muck

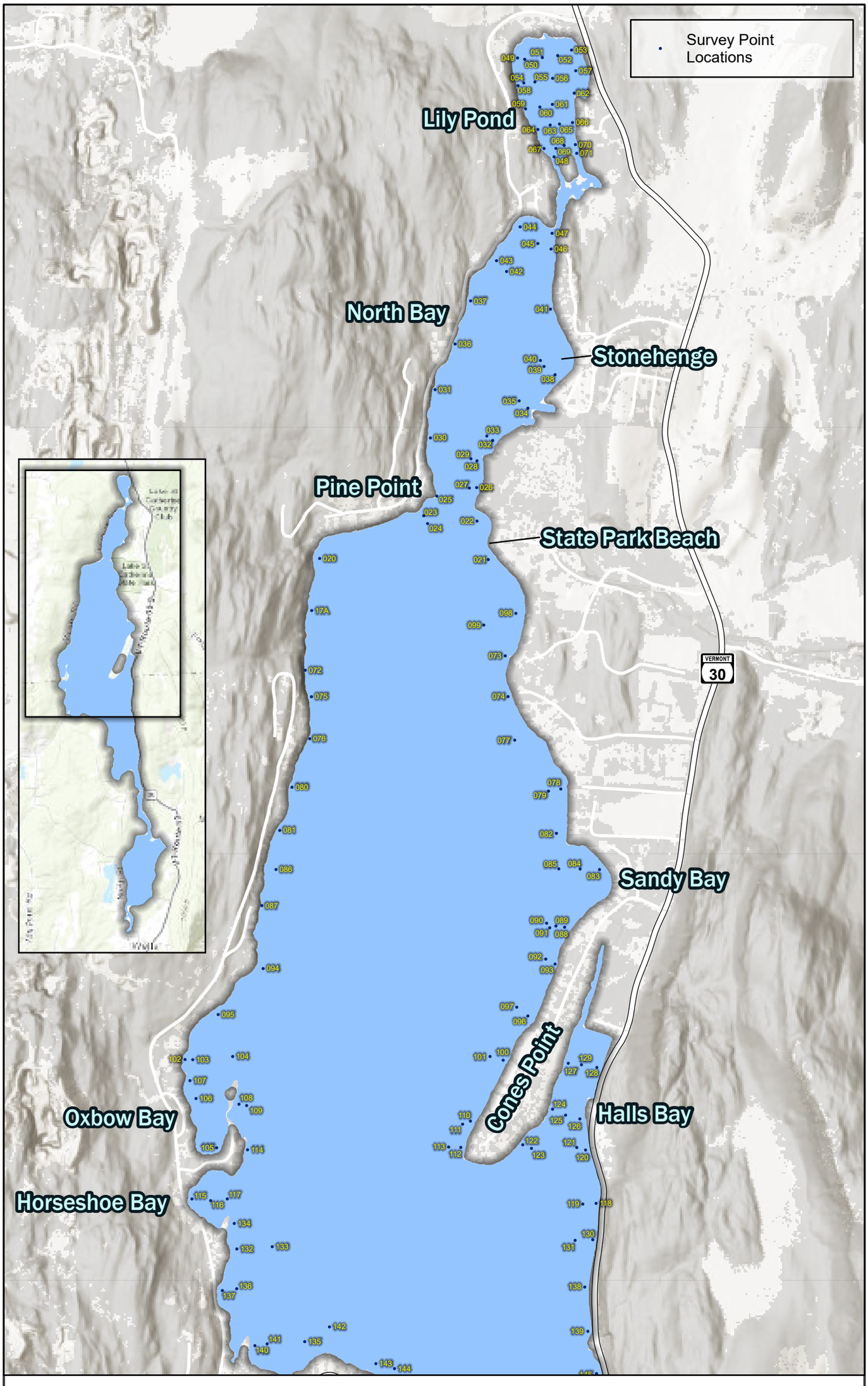
Survey Point	Depth (ft)	% Cover Floating	% Cover Submerged	Biomass	Sediment
54	2	25%	100%	Extremely High	Muck
55	5	0%	100%	High	Muck
56	6	0%	100%	Moderate	Muck
57	3	100%	100%	Extremely High	Muck
58	5	0%	100%	High	Muck
59	3	25%	100%	Extremely High	Muck
60	5	5%	100%	High	Muck
61	6	0%	100%	Moderate	Muck
62	2	100%	50%	Moderate	Muck
63	4	50%	100%		Muck
64	6	0%	100%	Moderate	Muck
65	5	25%	100%	Extremely High	Muck
66	6	75%	100%	High	Muck
67	2	25%	100%	Extremely High	Muck
68	2.7	75%	100%	Extremely High	Muck
69	5	50%	100%	Extremely High	Muck
70	2	75%	100%	Extremely High	Muck
71	1.5	100%	100%	Extremely High	Muck
72	3	0%	0%	No	Cobble
73	4	0%	100%	Low	Silt
74	3	0%	50%	Low	Cobble
75	16	0%	0%	No	Boulder
76	3	0%	5%	Low	Cobble
77	5	0%	25%	Low	Cobble
78	3	0%	50%	Low	Cobble
79	7	5%	100%	Moderate	Silt
80	8	0%	50%	Low	Cobble
81	7	0%	75%	Moderate	Cobble
82	7	0%	50%	Low	Cobble
83	3	0%	75%	Low	Cobble
84	5	0%	100%	Moderate	Silt
85	11	0%	75%	Moderate	Cobble
86	14	0%	25%	Low	Silt
87	1	0%	0%	No	Cobble
88	3	0%	5%	Low	Cobble
89	10		100%	Moderate	Silt
90	14	0%	25%	Low	Silt
91	9	0%	75%	Moderate	Silt
92	9	0%	75%	Moderate	Silt

Survey Point	Depth (ft)	% Cover Floating	% Cover Submerged	Biomass	Sediment
93	3	0%	5%	Low	Cobble
94	11	0%	75%	Moderate	Cobble
95	4	0%	0%	No	Cobble
96	4	0%	5%	Low	Cobble
97	11	0%	100%	Moderate	Silt
98	6	0%	100%	Moderate	Silt
99	0				
100	6	0%	100%	Moderate	Silt
101	7	0%	75%	Moderate	Cobble
102	3	50%	75%	Moderate	Cobble
103	3	0%	50%	Low	Cobble
104	17	0%	0%	No	Silt
105	7	5%	100%	Moderate	Muck
106	12	0%	50%	Low	Silt
107	4	0%	25%	Low	Cobble
108	9	0%	100%	Moderate	Cobble
110	4	0%	0%	No	Cobble
111	9	0%	100%	Moderate	Silt
112	3	0%	25%	Low	Cobble
113	8	0%	100%		Silt
114	12	0%	0%	No	Boulder
115	4	50%	100%	High	Muck
116	8		100%	Moderate	Silt
117	1.3	0%	25%	Low	Silt
118	6	5%	100%	Moderate	Cobble
119	6	0%	75%	Moderate	Cobble
120	4	0%	5%	Low	Cobble
121	10	0%	75%	Moderate	
122	5	0%	50%	Low	Cobble
123	9	1%	100%	High	Silt
124	5	0%	75%	Moderate	Cobble
125	8.6	0%	100%	Moderate	Silt
126	4	0%	25%	Low	Cobble
127	5		100%	Moderate	Silt
128	3	75%	100%	Extremely High	Muck
129	5	5%	100%	Moderate	Silt
130	6	5%	100%	Moderate	Silt
131	9	0%	100%	Moderate	Silt
132	12	0%	0%	No	Boulder

Survey Point	Depth (ft)	% Cover Floating	% Cover Submerged	Biomass	Sediment
133	8	0%	100%	Moderate	Silt
134	8	0%	5%	Low	Boulder
135	9	0%	25%	Low	Cobble
136	12	0%	100%	Moderate	Silt
137	6	0%	100%	Moderate	Boulder
138	10	0%	0%	No	Cobble
139	7	1%	25%	Low	Cobble
140	3	0%	5%	No	Boulder
141	6	0%	25%	Low	Cobble
142	4	0%	5%	Low	Cobble
143	4	0%	5%	No	Cobble
144	7	5%	100%	Moderate	Silt
145	8	0%	25%	Low	Cobble
146	11	0%	1%	Low	Cobble
147	10	5%	100%	Moderate	Silt
148	4		100%	Moderate	Silt
149	14	0%	5%	Low	Silt
150	10	0%	1%	Low	Boulder
151	8	0%	0%	No	Boulder
152	8	1%	100%	High	Silt
153	4	0%	100%	High	Silt
154	8	0%	5%	Low	Boulder
155	7	0%	100%	Moderate	Silt
157	6	0%	75%	Moderate	Cobble
158	8	0%	75%	Moderate	Silt
159	16	0%	0%	No	
160	6	0%	5%	Low	Cobble
161	5	0%	100%	Moderate	Silt
162	10	0%	100%	Moderate	Silt
163	4	0%	75%	Moderate	Sand
164	10	0%	75%	Moderate	
165	6	5%	100%	Extremely High	Silt
166	4	5%	100%	High	Silt
168	7	0%	100%	Moderate	Silt
169	5	0%	5%	Low	Cobble
170	4	0%	25%	Low	Cobble
171	7	0%	100%	Moderate	Muck
174	6	0%	100%	Moderate	Muck
175	5	0%	100%	Moderate	Silt

Survey Point	Depth (ft)	% Cover Floating	% Cover Submerged	Biomass	Sediment
176	6	0%	75%	Moderate	Muck
177	3	0%	75%	Moderate	
178	5	0%	1%	Low	Silt
179	3	25%	100%	High	Muck
17A	10	0%	75%	Moderate	Cobble
180	2	100%	75%	Extremely High	Muck
181	4	0%	0%	No	Muck
182	1.7	100%	75%	Extremely High	Muck
183	1.8	100%	75%	Extremely High	Muck
184	4		75%	Moderate	Muck
185	0				
188	3	75%	75%	Extremely High	Muck
189	3	100%	75%	Extremely High	Muck
191	3	5%	100%	High	Muck
192	4	5%	100%		Muck
193	3	0%	100%	Extremely High	Muck
194	3	5%	100%	Extremely High	Muck
195	4		100%	High	Muck
196	4	0%	100%	Extremely High	Muck
197	4	0%	100%	Extremely High	Muck
198	2.7	0%	100%	Extremely High	Muck
199	3	25%	100%	High	Muck
200	4	25%	100%	Extremely High	Muck
201	4	0%	100%	Extremely High	Muck
202	6	0%	100%	High	Muck
203	3.8	1%	100%	High	Muck
204	3.7	0%	100%	Extremely High	Muck
205	4	0%	100%	Extremely High	Muck
206	5		100%	High	Muck
207	3	0%	25%	Low	Muck
208	3.7	0%	25%	Low	Muck
209	3.6	0%	100%	Extremely High	Muck
210	4	0%	100%	High	Muck
211	3	25%	100%	Extremely High	Muck
212	5	0%	25%	Moderate	Muck
213	3	0%	50%	Low	Muck
214	3.7	0%	75%	Low	Muck
215	3	50%	50%	Moderate	Muck
216	4	25%	75%	Moderate	Muck

Appendix 2: Aquatic Vegetation Maps



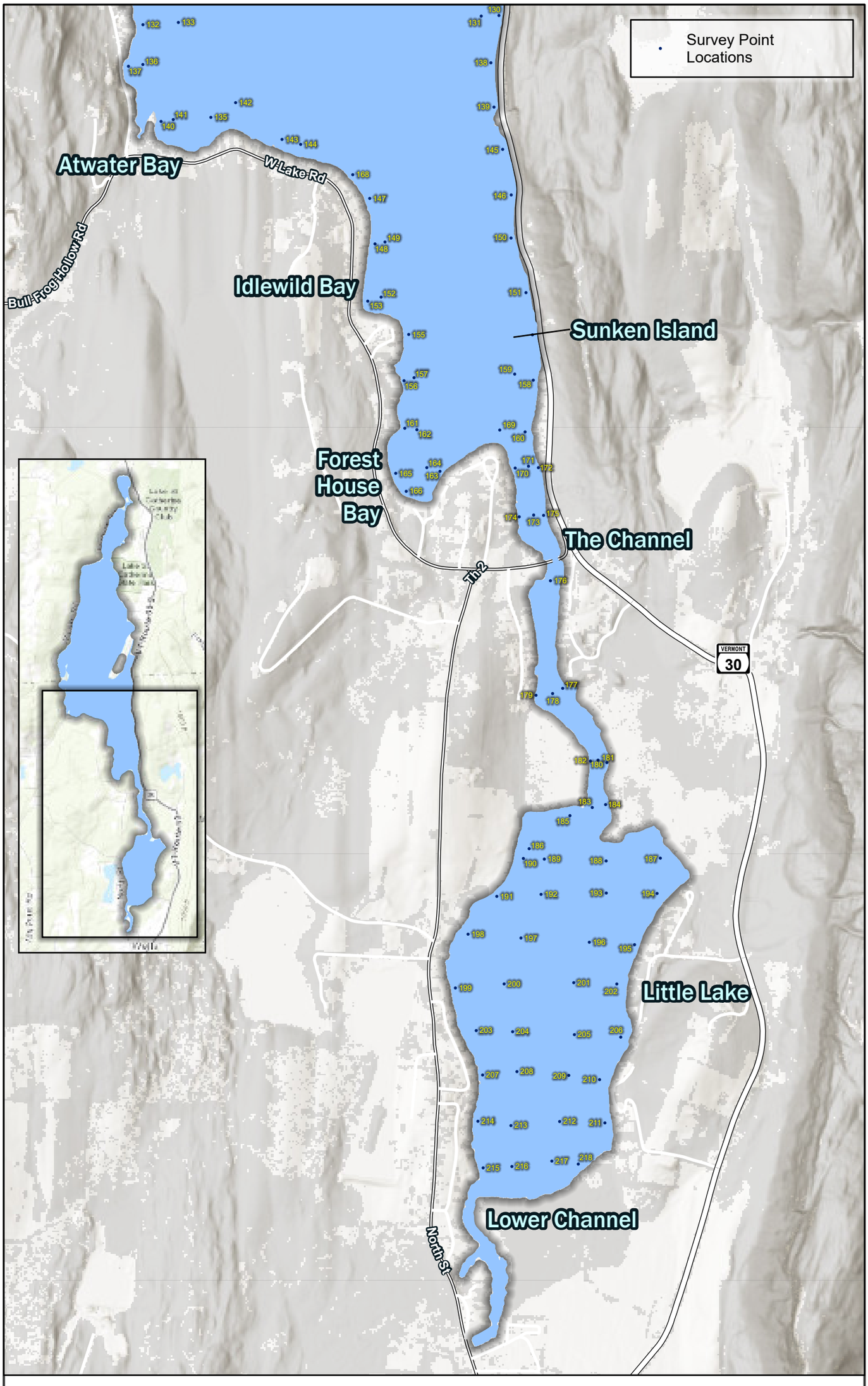
Lake St. Catherine North, Poultney & Wells, Vt.

Monday, December 18, 2023 File: LakeStCatherine:8.5x14 Report Appendix
Prepared By: A Worthley *NAD 1983 StatePlane Vermont FIPS 4400 Feet*

0 155310 620 930 1,240 Feet

N W E S

ARROWWOOD ENVIRONMENTAL
950 BERT WHITE ROAD
HUNTINGTON,VT 05462
(802 434-7276 FAX: (802) 329-2259



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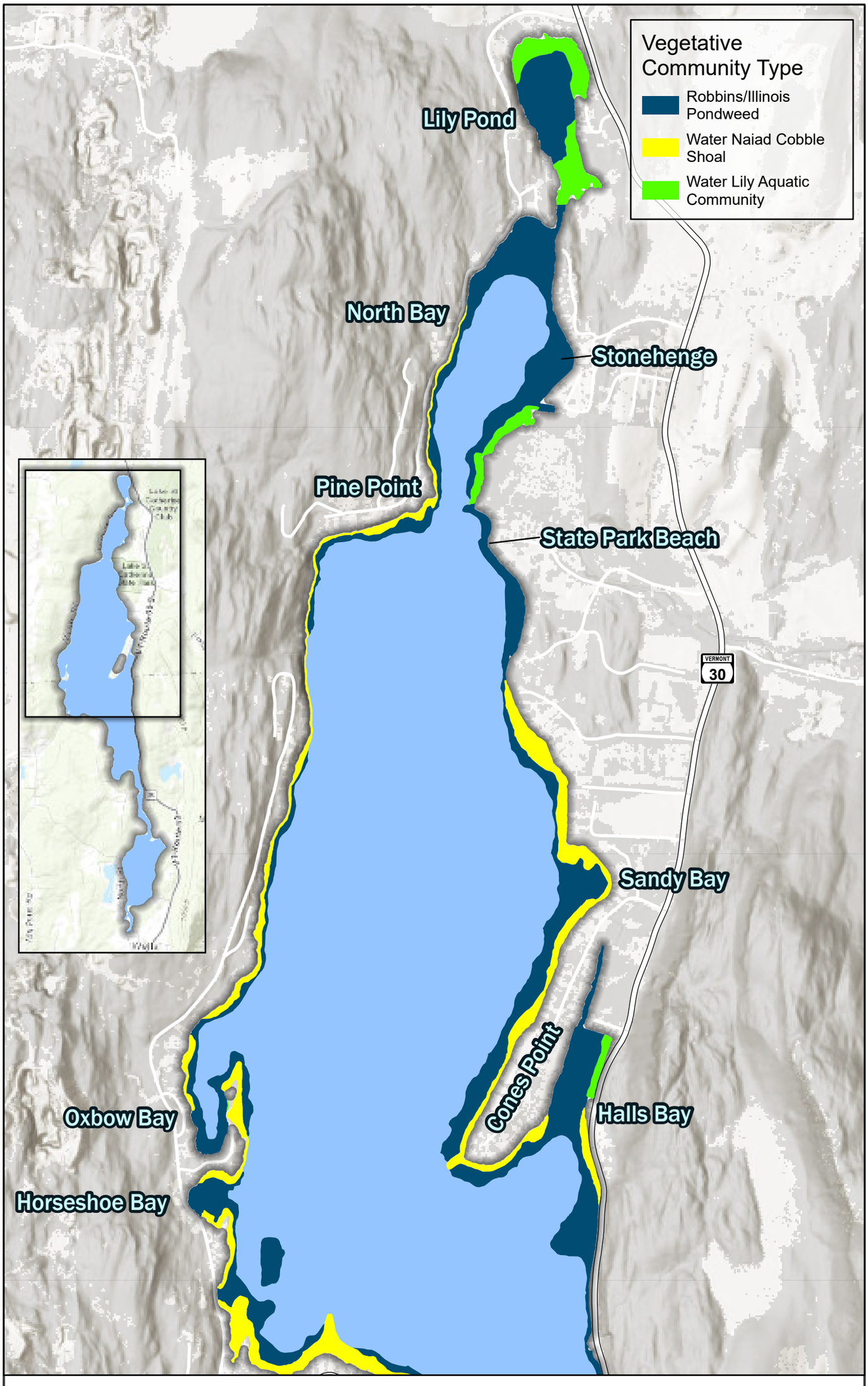

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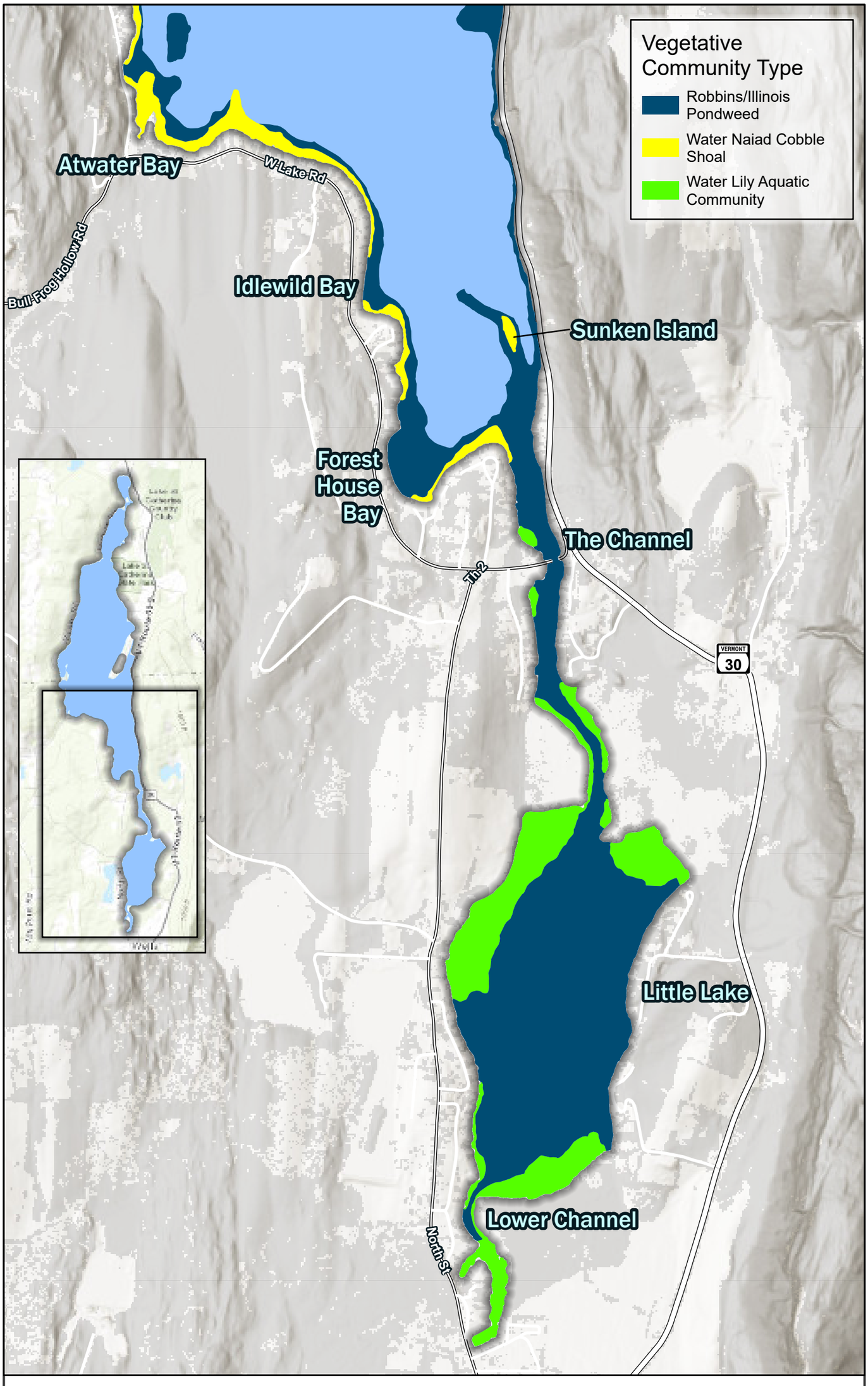

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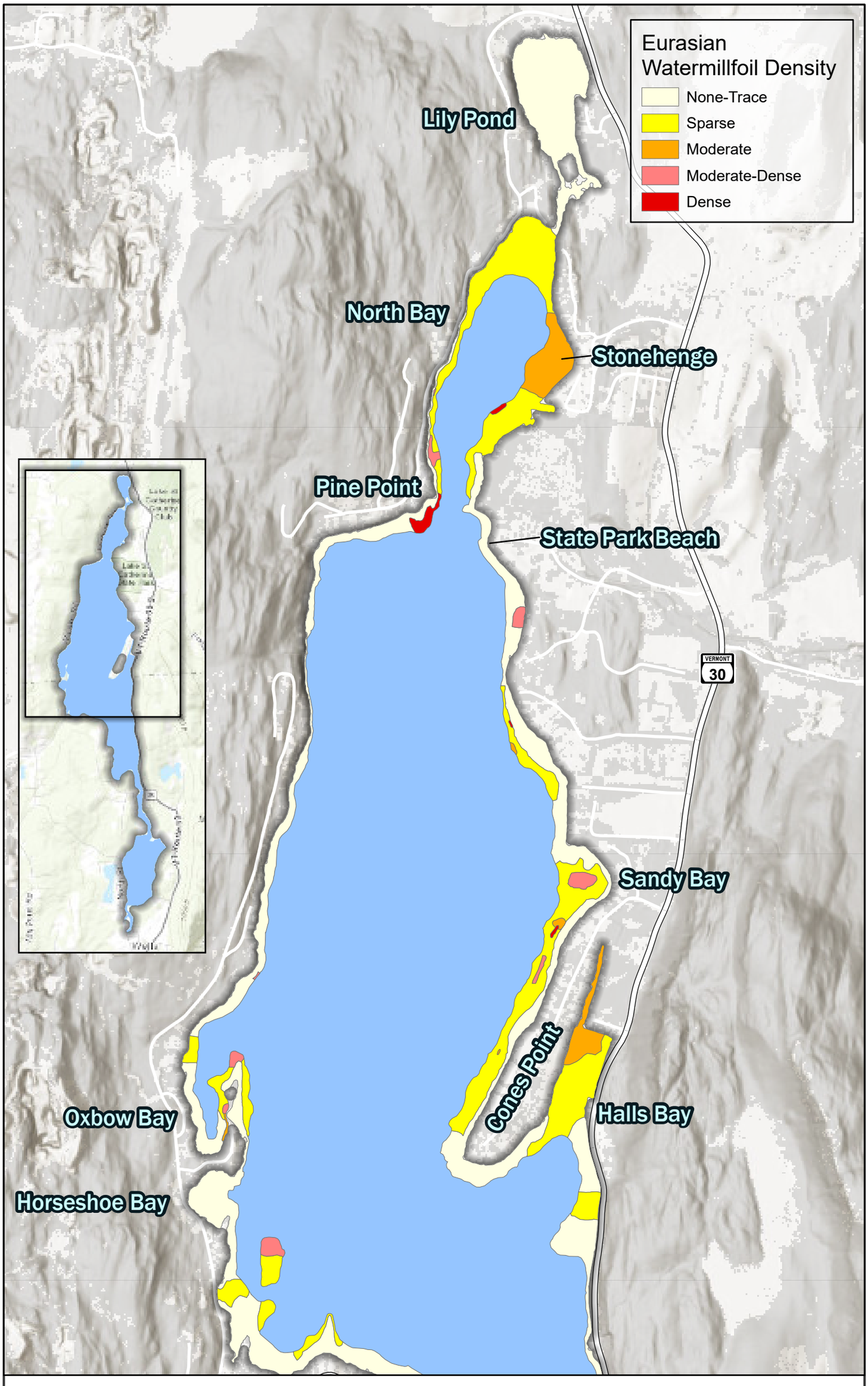

Lake St. Catherine North, Poultney & Wells, Vt.

Wednesday, December 20, 2023 File: LakeStCatherine:8.5x14 Report Appendix
Prepared By: A Worthley *NAD 1983 StatePlane Vermont FIPS 4400 Feet*

0 155310 620 930 1,240 Feet

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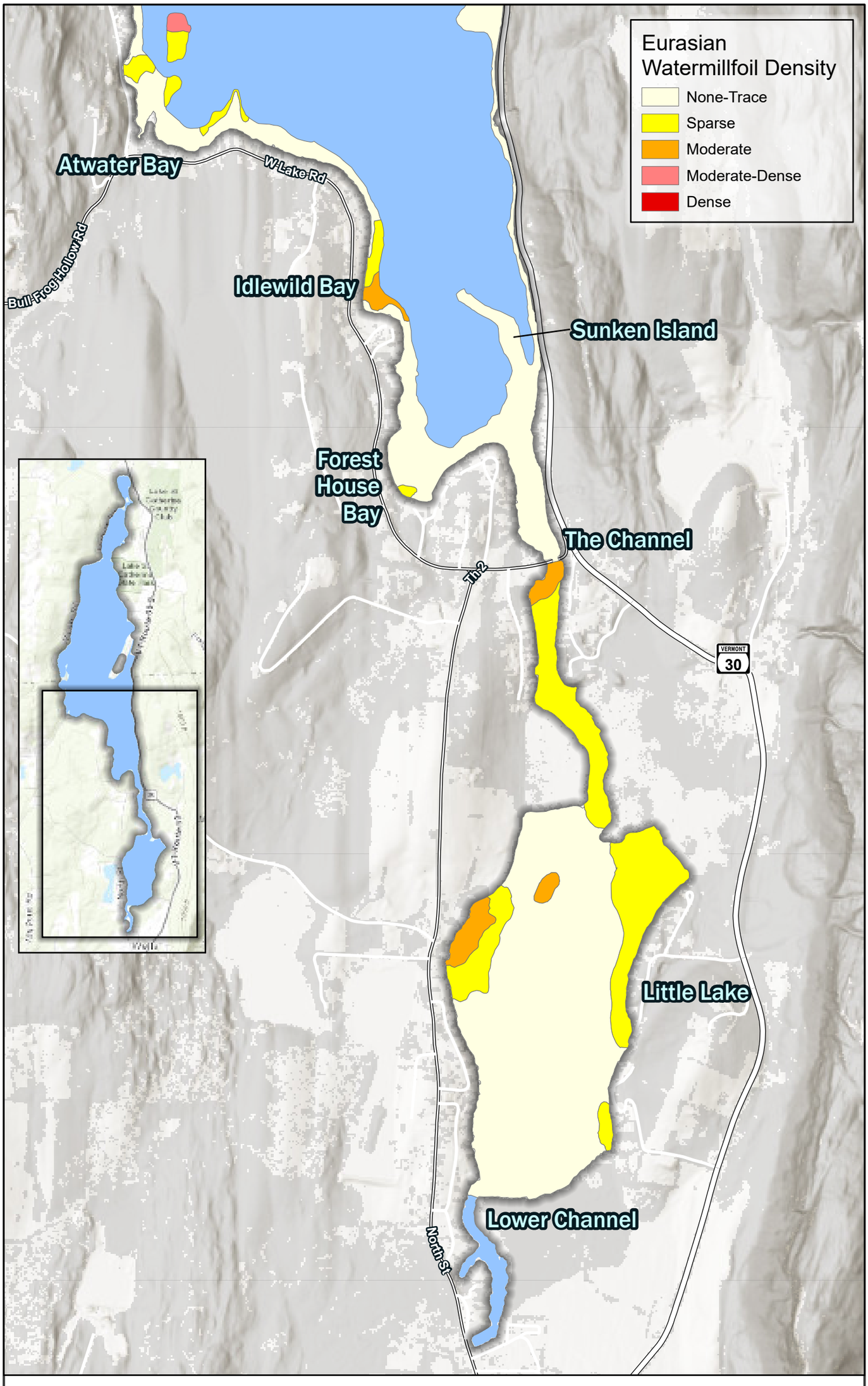

Lake St. Catherine South, Poultney & Wells, Vt.

Wednesday, December 20, 2023 File: LakeStCatherine:8.5x14 Report Appendix

Prepared By: A Worthley *NAD 1983 StatePlane Vermont FIPS 4400 Feet*

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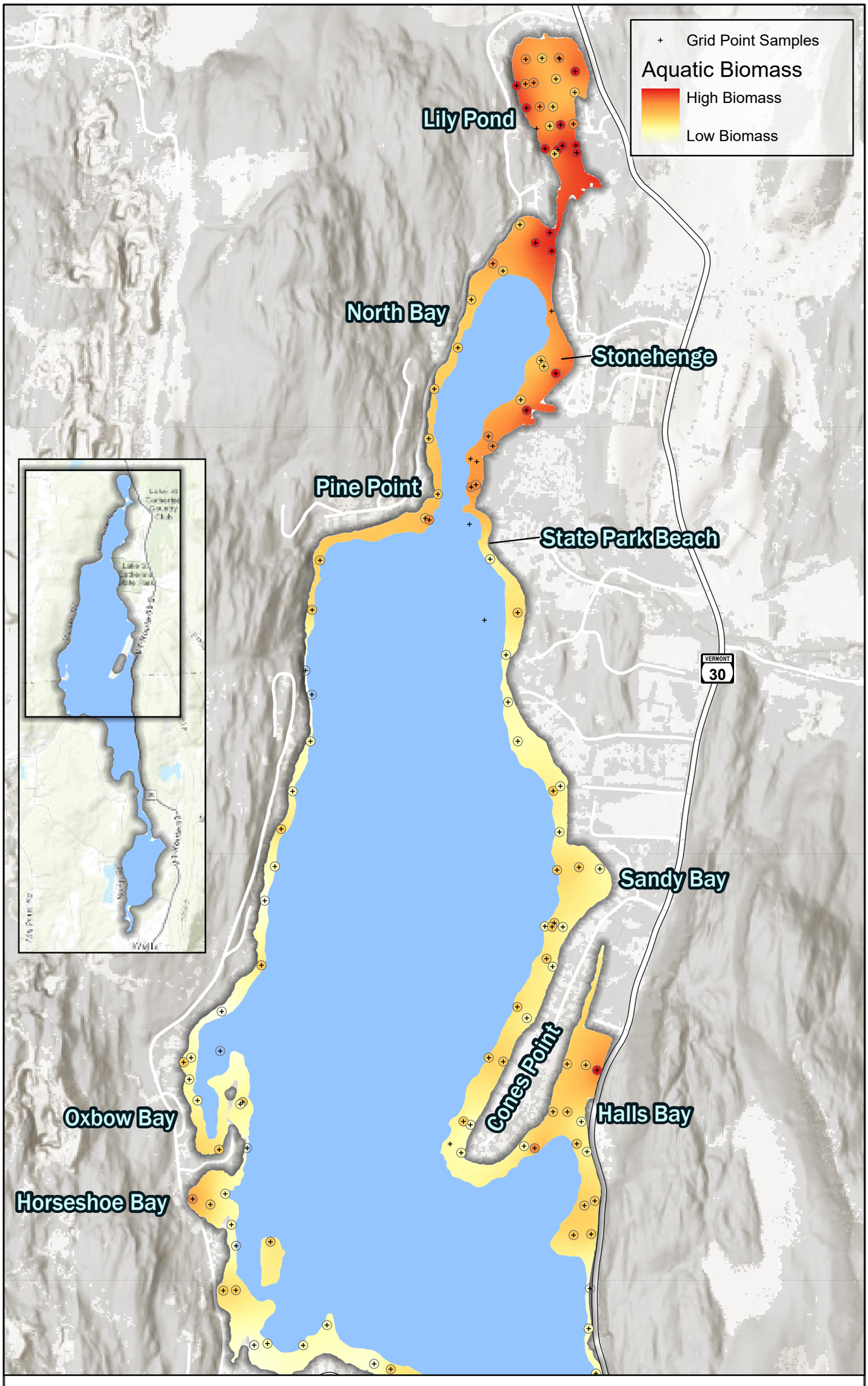

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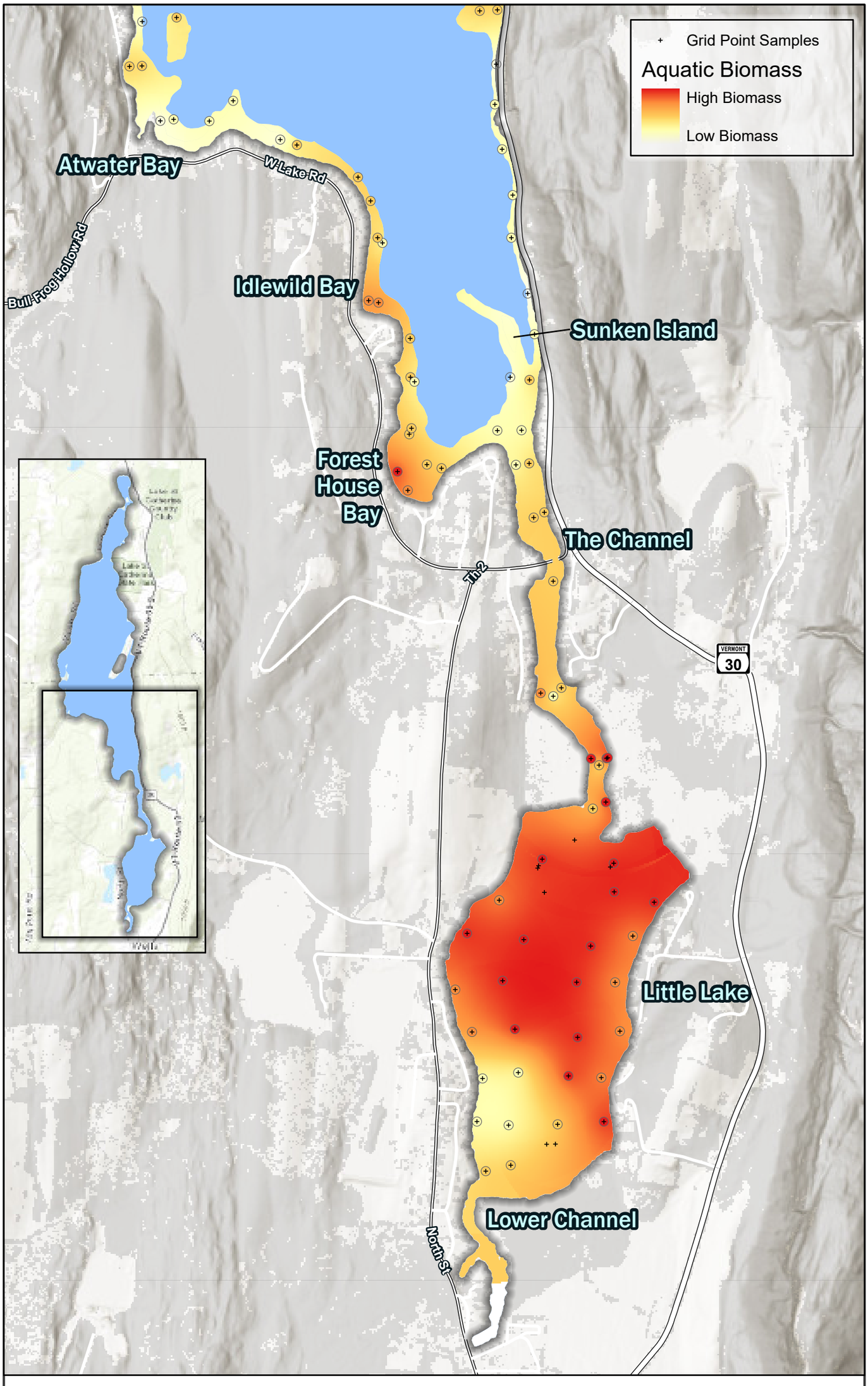

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