Report For:
Lake Shirley Improvement Corporation
Shirley, MA 01464

Lake Shirley Lake Management Annual Report 2024-2025

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INTRODUCTION

The Lake Shirley Improvement Corporation (LSIC) contracted Aquatic Restoration Consulting, LLC (ARC) to perform the fall aquatic plant survey and summarize the lake management activities that occurred during the prior year (October 15, 2024 through October 14, 2025) in accordance with the Order of Conditions (MassDEP File No. 208-1168 for the Town of Lunenburg and 284-0474 for the Town of Shirley). This report summarizes the LSIC management activities, data evaluation, and recommendations. The report is organized in a semi-chronological order of activities for the 2024-2025 compliance year:

- winter water level drawdown,
- water quality monitoring,
- herbicide/algaecide treatment,
- fall aquatic plant survey and prior year data comparison,
- education and outreach activities; and
- recommended changes (if appropriate) from the management program.

WINTER WATER LEVEL DRAWDOWN

Purpose and Mechanism of Drawdown

Seasonal winter drawdown is an established aquatic plant management strategy at Lake Shirley. Drawdown works by exposing littoral-zone sediments and rooted plant crowns to extended dry and freezing conditions, which desiccate tissues and limit regrowth during the subsequent growing season. Ice formation, ice scour, and mechanical movement across exposed substrates provide additional control.

Effectiveness varies annually because weather and hydrologic conditions influence the degree of sediment exposure. Frequent rain, fluctuating water levels, insulating early snowpack, or groundwater seepage can reduce freeze penetration and limit desiccation. Substrate type is also important; mucky or peaty sediments common in cove areas retain moisture and offer plants greater protection.

Historical Use and Management Context

Winter drawdown has been used at Lake Shirley for many years as a primary tool to control nuisance aquatic vegetation. The Metcalf & Eddy Diagnostic–Feasibility Study originally recommended a drawdown of up to nine feet, but this depth was later limited to six feet due to documented impacts on shallow private wells. Even at the six-foot limit, drawdown has substantially reduced nuisance growth of milfoil (*Myriophyllum heterophyllum* and *M. spicatum*) and fanwort (*Cabomba caroliniana*) within the shallow margins of the lake. Plants that propagate by seed or winter buds (e.g., *Vallisneria*, pondweeds, naiads) are less affected and may rebound during favorable years. As expected, vegetation growing deeper than the drawdown contour (>6 ft) is generally unaffected.

Consistent implementation of the winter drawdown reduces herbicide dependence and provides a non-chemical means of long-term plant suppression.

Annual Drawdown Procedures and Monitoring

The Lake Shirley Improvement Corporation (LSIC) aims to achieve a seasonal drawdown of up to six feet each year. The process begins by opening the two dam gates on or after October 15.

Drawdown is maintained at a rate of approximately two to three inches per day, with a typical target date of December 1 for reaching full depth. Gate adjustments are made as needed to maintain the target depth while balancing downstream flow requirements. LSIC notifies the Conservation Commissions and lake residents prior to initiating the annual drawdown.

The lake generally refills by April 1, driven by snowmelt and seasonal flows from the lake's large watershed (>9,000 acres). The refill process is strongly influenced by precipitation variability. The dam caretaker records lake level and downstream flow observations at least weekly from October through April and adjusts the gates as needed to maintain compliance and safe flow conditions.

2024–2025 Drawdown

Drawdown Performance and Freeze Conditions

The maximum drawdown depth achieved during the 2024–2025 season was 5.8 feet below the spillway, reached on November 28, 2024. While slightly less than the six-foot target, this depth provided meaningful exposure of littoral sediments. The average drawdown depth between November 15 and February 28, the primary period for freeze effectiveness, was 5.2 feet. The average air temperature during this period was 30.1 degrees Fahrenheit (°F), representing a favorable freeze regime supportive of plant control. Overall, the season provided an extended window of cold conditions and substantial sediment exposure, which should result in moderate suppression of susceptible species in 2025.

Water-Level and Downstream Flow Compliance

Water-level monitoring indicates consistent drawdown from mid-October through late November, with typical rates of 2 to 3 inches per day. Several early-winter storm events temporarily increased water levels, but depths generally remained between 55 and 68 inches below the spillway through January and February. These conditions represented a sufficiently long exposure period for effective freeze-induced control. Table 1 provides the complete record of gate settings, water levels, and drawdown rates.

Although the downstream gage was damaged, LSIC and the dam caretaker conducted regular visual inspections of outlet conditions throughout the refill period. Flow was maintained, with observable discharge characteristics consistent with historical flows exceeding the recommended 7.0 cubic feet per second (cfs) threshold. LSIC is in the process of restoring the downstream gage and rating curves and will resume quantitative flow documentation in the next permit cycle.

No fish kills or other adverse effects were observed during the drawdown season. Water was flowing over the spillway on March 25, 2025. Gate operations, recorded water-level data, and general observations demonstrate that the drawdown and refill were managed in accordance with permit conditions and standard Massachusetts DEP drawdown guidance.

Table 1. Water Level Monitoring Data 2024-2025

Date	Mid Valve	Low Valve	Level (in)	Notes	Rate (in/day)
10/1/2024	Open 150	Closed	-2		
10/8/2024	Open 150	Closed	-3		-0.1
10/12/2024	Open 150	Closed	-3		0.0
10/15/2024	Open	Open	-8	Start Drawdown	-1.7
10/17/2024	Open	Open	-14		-3.0
10/19/2024	Open	Open	-20		-3.0
10/21/2024	Open	Open	-27		-3.5
10/23/2024	Open	Open	-33		-3.0
10/25/2024	Open	Open	-40		-3.5
10/27/2024	Open	Open	-46		-3.0
10/28/2024	Open	Open	-47		-1.0
10/30/2024	Open	Open	-51		-2.0
11/1/2024	Open	Open	-53		-1.0
11/4/2024	Open	Open	-61		-2.7
11/6/2024	Open	Open	-64		-1.5
11/8/2024	Open	Open	-67		-1.5
11/9/2024	Open	Open	-68		-1.0
11/11/2024	Open	Closed	-68		0.0
11/18/2024	Open	Closed	-68		0.0
11/23/2024	Open	Open	-64		0.8
11/25/2024	Open	Open	-66		-1.0
11/26/2024	Open	Open	-68		-2.0
11/28/2024	Open	Closed	-69		-0.5
11/30/2024	Open	Closed	-69		0.0
12/1/2024	Closed	Closed	-68		1.0
12/3/2024	Closed	Closed	-67		0.5
12/8/2024	Closed	Closed	-64		0.6
12/12/2024	Closed	Closed	-64	Heavy Rain	0.0
12/18/2024	Closed	Closed	-67		-0.5
12/23/2024	Closed	Closed	-52		3.0
12/27/2024	Closed	Closed	-55		-0.8
1/3/2025	Closed	Closed		Rain 1/1/2025	
1/8/2025	Closed	Closed			
1/14/2025	Closed	Closed	-68		-0.7
1/18/2025	Closed	Closed	-68		0.0
1/22/2025	Open 74	Closed	-65		0.8
1/26/2025	Open 74	Closed	-64		0.3
2/1/2025	Open 75	Closed	-66		-0.3
Date	Mid Valve	Low Valve	Level (in)	Notes	Rate (in/day)

2/5/2025	Open 75	Closed	-61		1.3
2/12/2025	Open 75	Closed	-58		0.4
2/17/2025	Open 75	Closed	-54		0.8
2/22/2025	Open 75	Closed	-51		0.6
3/1/2025	Open 75	Closed	-35		2.3
3/10/2025	Open 75	Closed	-22		1.4
3/11/2025	Open 75	Closed	-20		2.0
3/12/2025	Open 75	Closed	-18		2.0
3/15/2025	Open 75	Closed	-15		1.0
3/18/2025	Open 75	Closed	-7		2.7
3/22/2025	Open 75	Closed	-3		1.0
3/24/2025	Open 75	Closed	-1		1.0
3/25/2025	Open 75	Closed	1	Over spillway	2.0

*Red text indicates the lake level above the spillway

WATER QUALITY MONITORING

The LSIC volunteers performed routine water quality monitoring during the 2025 summer season. Monitoring included measurements of water clarity, in-situ measurements, and collection of nutrient and phytoplankton samples (when water clarity drops below five feet) for analytical analysis. Results of the monitoring program are discussed below.

Secchi Disk Transparency

Secchi disk transparency (SDT) was measured weekly at three long-standing monitoring locations from May through late September 2025 (Figure 1). SDT provides a simple but reliable indication of water clarity and is influenced primarily by suspended sediments and phytoplankton biomass. As a general recreational guideline, water with clarity greater than four feet is considered suitable for swimming.

The Lake Shirley Order of Conditions establishes a minimum SDT of five feet, below which LSIC is required to collect grab samples for phytoplankton analysis to evaluate whether declining clarity is associated with an algal bloom and to evaluate if algaecide treatment may be warranted. SDT fell below the five-foot threshold during late July and early August, with a seasonal minimum of 4.2 ft at both the Upper North and North Basin stations (Figure 2). Overall water clarity in 2025 ranged from 4.2 to 8.0 ft.

Average clarity in 2025 was lower than in the previous five years, continuing the long-standing pattern of highest clarity in the South Basin and lowest clarity in the Upper North Basin (Figure 3). The modest reduction in SDT observed in 2025 is consistent with two factors discussed later in this report: (1) the whole-lake herbicide treatment, which temporarily increases turbidity as vegetation decomposes, and (2) variation in phytoplankton biomass.

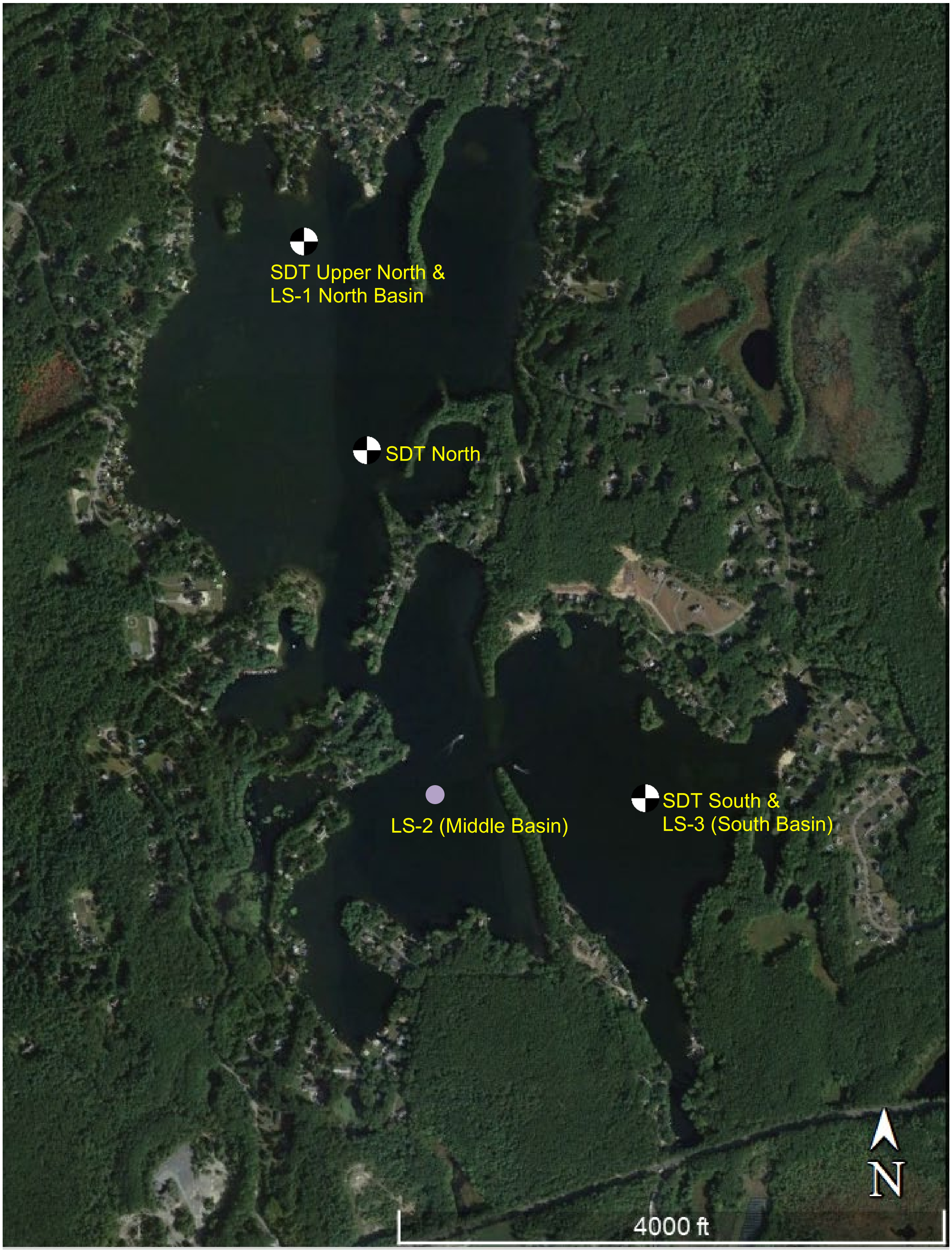

Figure 1. Water Quality and Secchi Disk Transparency Locations

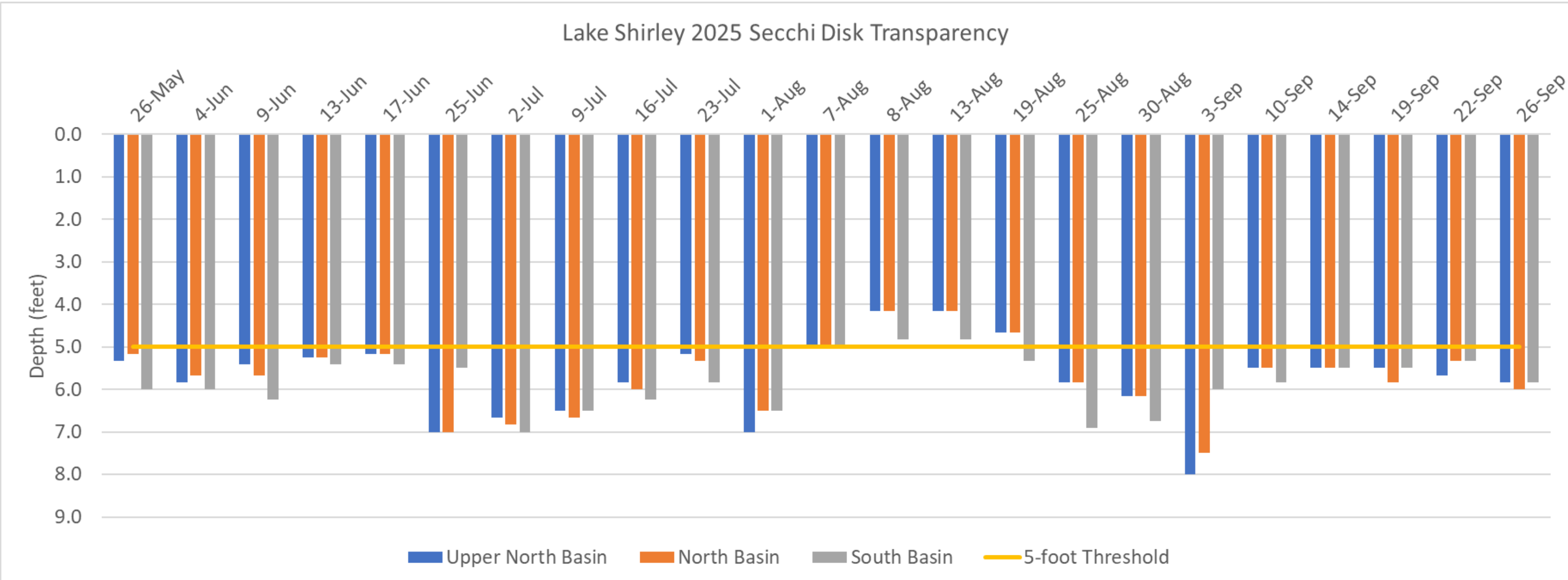

Figure 2. Lake Shirley 2025 Secchi Disk Transparency

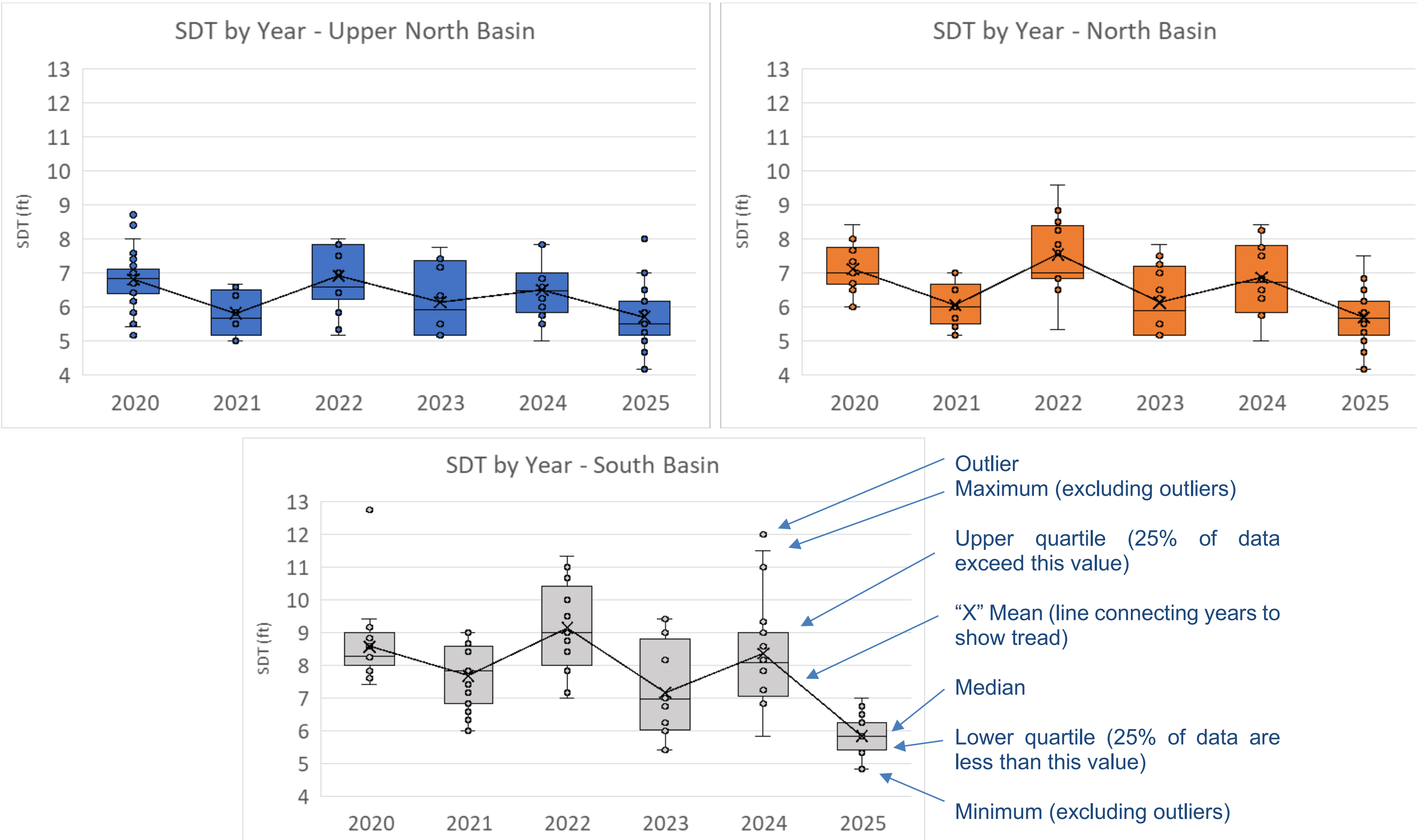

Figure 3. Box & Whiskers Plot SDT by Year

In-situ Measurements

LSIC volunteers collected in-situ measurements of temperature, dissolved oxygen (DO), specific conductivity, pH, and turbidity at the three monitoring stations (Figure 1) on June 22, July 16, and August 21, 2025. Summary data are provided in Table 2. pH and turbidity results are not included in the table because values were uncharacteristically high and likely represented sensor malfunction; the meter will be returned to the manufacturer for inspection and service.

Temperature and Dissolved Oxygen

Lake Shirley is classified as a Class B warm water body under the Massachusetts Surface Water Quality Standards (WQS). For warmwater fisheries, surface water temperatures are not expected to exceed 28.3°C. Temperatures at all three monitoring stations exceeded this threshold in July, with a maximum recorded value of 31.2°C (Table 2).

Dissolved oxygen concentrations were generally within desirable ranges throughout the season and remained above the 5.0 milligrams per liter (mg/L) minimum WQS at most depths. As expected, lower DO values were observed near the bottom at each station, reflecting sediment oxygen demand typical of shallow systems during the summer. Temperature and DO profiles illustrate that the three monitored stations did not exhibit thermal stratification during any of the sampling events (Figure 4). This is consistent with the relatively shallow depths of the Upper North, North, and Middle Basin stations. The deeper hole in the South Basin was not profiled but is expected to show periodic thermal layering and hypolimnetic oxygen depletion, as observed in previous years.

pH

pH is a measure of how acidic or basic water is, expressed on a logarithmic scale based on hydrogen ion concentration. Lower values indicate acidity; higher values indicate alkalinity. The Massachusetts Class B standard for pH is 6.5 to 8.3 standard units (SU). Field pH values exceeded this range at all stations during all three sampling events, similar to the previous year's results. While intense photosynthetic activity can elevate pH in productive lakes, the recorded values were unusually high and not consistent with other indicators of lake productivity. These results suggest a possible instrument calibration or sensor failure. The pH probe was not refurbished prior to the 2025 season, despite earlier recommendations, and will be sent for evaluation and servicing before 2026 monitoring begins.

Specific Conductivity

Conductivity reflects the concentration of dissolved ions and tends to be stable within a given system. Changes over time may indicate shifts in watershed inputs or internal cycling. There are no numerical conductivity standards for Class B waters; however, general threshold ranges are commonly used to indicate when water quality impairment may be present. Conductivity in Lake Shirley averaged 288 μS (microsiemens) in 2025, slightly higher than the 2024 average. Values typically ranged from 260–308 μS, with the highest conductivity consistently measured in the South Basin. These values fall within the moderate range for Massachusetts lakes and do not indicate any known water-quality concern.

Turbidity

Turbidity values below 3 nephelometric turbidity units (NTU) are generally considered desirable for lakes. Like pH, the 2025 turbidity measurements were uncharacteristically elevated and inconsistent with field observations and Secchi disk transparency data. These results appear to reflect a sensor issue, and the turbidity probe will be inspected and serviced, along with the pH probe, during winter maintenance.

Table 2. Lake Shirley 2025 In-Situ Data.

22-Jun-25							16-Jul-25							21-Aug-25						
Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)	Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)	Station	Depth (ft)	Temp (DegC)	DO (mg/L)	Spec. Cond. (uS)	pH (su)	Turb (NTU)
1	0	25.0	8.18	271			1	0	30.7	7.87	290			1	0	23.2	7.58	307		
1	1	25.0	7.98	269			1	1	30.7	7.64	290			1	1	23.2	7.52	308		
1	2	25.0	7.95	272			1	2	30.7	7.64	290			1	2	23.2	7.51	308		
1	3	25.0	7.85	271			1	3	30.6	7.76	284			1	3	23.2	7.44	307		
1	4	25.0	7.77	279			1	4	30.4	7.77	287			1	4	23.2	7.44	308		
1	5	25.0	7.79	272			1	5	29.7	7.74	290			1	5	23.2	7.46	308		
1	6	25.0	7.81	270			1	6	29.1	7.76	276			1	6	23.2	7.42	308		
1	7	23.3	7.44	274			1	7	27.9	6.25	285			1	7	23.2	7.38	308		
1	8						1	8	27.6	5.33	287			1	8	23.2	7.31	308		
1	9						1	9						1	9					
2	0	25.7	10.23	272			2	0	30.8	7.84	288			2	0	23.6	6.85	306		
2	1	25.4	7.49	272			2	1	30.8	7.51	290			2	1	23.6	6.84	306		
2	2	25.2	7.46	274			2	2	30.6	7.68	289			2	2	23.6	6.71	306		
2	3	25.2	7.49	274			2	3	30.2	7.77	291			2	3	23.6	6.64	306		
2	4	24.7	7.51	274			2	4	29.1	7.86	288			2	4	23.6	6.61	305		
2	5	24.0	7.52	272			2	5	28.6	7.89	284			2	5	23.6	6.6	304		
2	6	23.2	7.21	274			2	6	28.3	7.92	288			2	6	23.5	6.84	303		
2	7	22.2	6.37	273			2	7	26.7	6.34	284			2	7	23.3	6.83	306		
2	8	22.6	4.54	277			2	8	26.6	2.97	285			2	8					
2	9						2	9						2	9					
3	0	25.4	12.48	272			3	0	30.9	7.51	296			3	0	23.6	13.73	301		
3	1	25.3	7.70	272			3	1	31.2	7.39	289			3	1	23.6	6.62	304		
3	2	25.2	7.61	270			3	2	31.1	7.51	286			3	2	23.6	6.35	305		
3	3	25.2	7.62	273			3	3	31.2	7.45	289			3	3	23.6	6.3	301		
3	4	25.2	7.49	272			3	4	30.4	7.52	285			3	4	23.6	6.2	302		
3	5	24.7	7.03	272			3	5	30.5	7.54	284			3	5	23.6	6.19	304		
3	6	23.1	6.99	270			3	6	29.4	7.67	285			3	6	23.6	6.09	302		
3	7	21.5	4.18	276			3	7	27.9	7.64	284			3	7	23.5	5.95	301		
3	8	19.1	2.45	286			3	8	27.2	7.09	284			3	8					
3	9						3	9						3	9					

pH & turbidity data excluded. Reported numbers appeared erroneously high. Recommend sending the meter in for service.

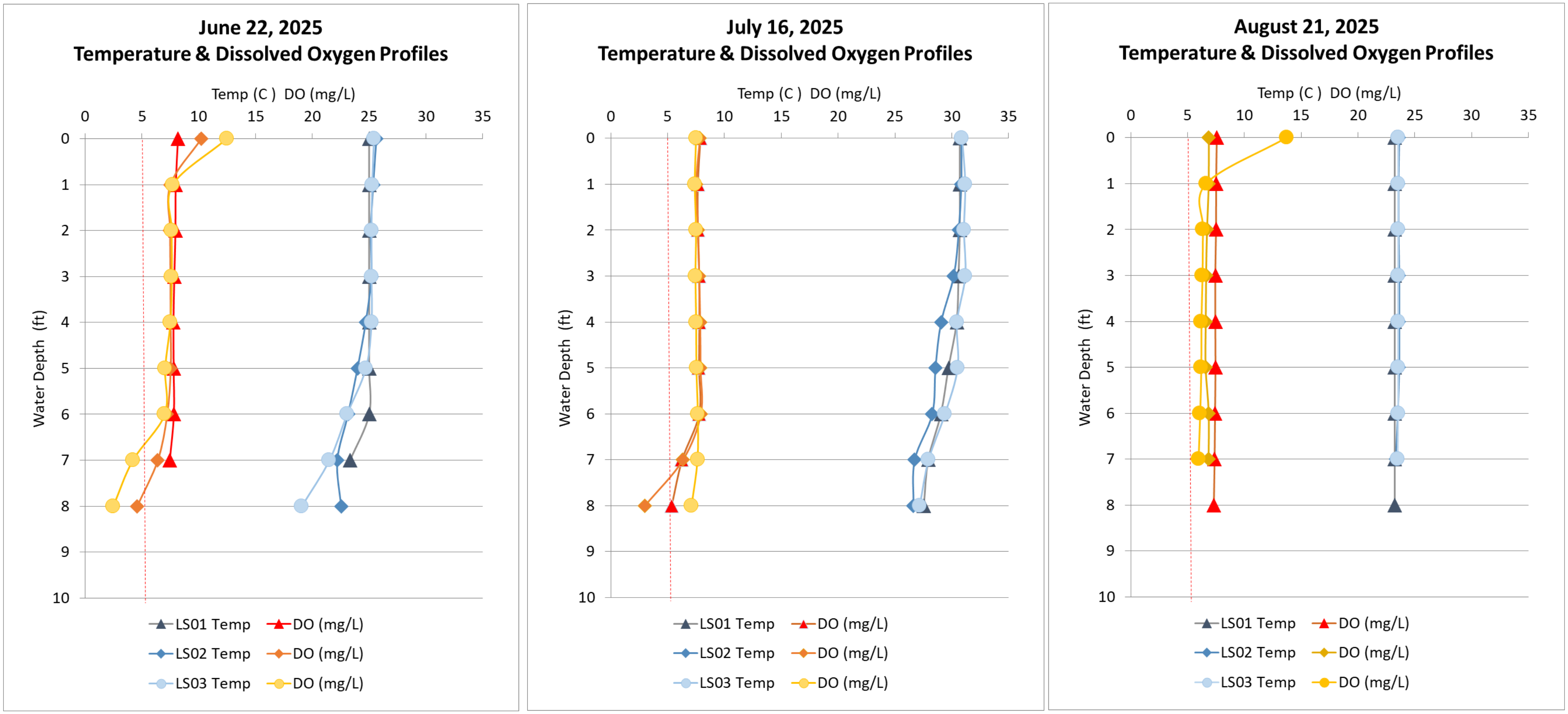

Figure 4. Lake Shirley 2025 Temperature and Dissolved Oxygen Profiles

Nutrient Concentrations

LSIC volunteers collected surface and bottom grab samples from three lake stations on three dates during the 2025 monitoring season. Samples were analyzed for total phosphorus (TP) and total nitrogen (TN), the two nutrients most responsible for stimulating algal growth. Phosphorus is typically the limiting nutrient in freshwater systems, meaning that algal and aquatic plant productivity is primarily controlled by phosphorus availability.

TP concentrations in 2025 were generally moderate to elevated, ranging from 0.013 to 0.065 mg/L and averaging 0.024 mg/L, nearly twice the 2024 average. Surface TP exceeded the 0.020 mg/L threshold, above which nuisance and harmful algal blooms become more likely at:

- The North Basin in June and July
- The Middle Basin in July

Bottom TP frequently exceeded the 0.020 mg/L threshold at all stations, particularly in July. TP concentrations were lowest during the August sampling event (Table 3). As in past years, the North Basin exhibited the highest surface TP concentrations, reflecting its position as the receiving basin for Catacoonamug Brook and other watershed inputs.

TN ranged from <0.30 to 0.93 mg/L, which is considered moderate for Massachusetts lakes. Values above 1.0 mg/L often indicate strong nitrogen loading and heightened algal bloom potential. However, the laboratory's quality control (QC) sample failed the nitrogen acceptance criteria during this analytical batch, a recurring issue from last year. Because QC standards exceeded allowable limits, the TN data lack the accuracy and precision necessary for interpretation. As a result, no conclusions can be drawn from the 2025 TN dataset.

In most years, TP and TN concentrations follow a consistent spatial pattern: highest in the North Basin and declining through the Middle and South Basins. This gradient suggests nutrient inputs from Catacoonamug Brook and/or internal or shoreline sources within the North Basin. This pattern is most evident during dry summers when lower watershed flushing amplifies concentration differences. For comparison, 2024 was 27% drier than normal and 2.4°F warmer, based on Worcester climate data from the Northeast Regional Climate Center.[1]

Table 3. Lake Shirley 2025 Nutrient Concentrations

	SURFACE TP mg/L				BOTTOM TP mg/L		
	LS-1	LS-2	LS-3		LS-1	LS-2	LS-3
6/22/2025	0.023	0.017	0.020		0.023	0.021	0.020
7/16/2025	0.024	0.022	0.020		0.031	0.045	0.065
8/21/2025	0.014	0.019	0.013		0.016	0.018	0.016
	SURFACE TN mg/L				BOTTOM TN mg/L		
	LS-1	LS-2	LS-3		LS-1	LS-2	LS-3
6/22/2025	0.50	0.43	0.48		0.60	0.52	0.53
7/16/2025	<0.30	0.43	0.32		0.88	0.69	0.72
8/21/2025	0.93	0.51	0.48		0.46	0.75	0.50
Exceed TP desirable threhold concentration							
Laboratory QC exceeded acceptance thresholds; had issue last year as well							

[1] https://www.nrcc.cornell.edu/services/blog/2024/09/01/index.html

Phytoplankton

Phytoplankton were sampled in the Upper, Middle, and Lower Basins between May and September 2025 and analyzed for total density and major algal groups (Figure 5). Densities remained well below the Massachusetts DPH recreational advisory of 70,000 cells/mL, with the highest value (~15,000 cells/mL) occurring in late September in the Upper Basin, only 20% of the advisory level and below the threshold at which algaecides are typically considered (<20,000 cells/mL). No bloom-level conditions were observed in these samples during the 2025 sampling period.

A notable anomaly occurred on August 21, when two samplers and two laboratories (WRS and NE Labs) analyzed samples from the same basins. NE Labs reported substantially higher total densities and cyanobacteria proportions than WRS, likely reflecting methodological differences in subsampling, homogenization, preservation, and taxonomic interpretation. These results should be interpreted cautiously and not used for trend evaluation. Interpretation herein relies primarily on WRS results for consistency with the long-term dataset.

Seasonal patterns were otherwise consistent: densities were lowest in the Lower Basin, highest in the Upper Basin, and cyanobacteria increased gradually through late summer, reflecting spatial nutrient gradients and typical seasonal succession.

Phytoplankton biomass (Figure 6), estimated by WRS, followed similar trends. Biomass peaked on June 22 at ~13,700 micrograms per liter (µg/L) (Upper Basin), ~8,900 µg/L (Middle Basin), and ~6,000 µg/L (Lower Basin), dominated by large-bodied chrysophytes. By July 16, biomass declined sharply across all basins (<2,500 µg/L), and August values were the lowest of the season.

Lake-wide conditions influenced these seasonal patterns. Above-average May rainfall (7.63") likely increased nutrient loading, contributing to elevated June biomass. The whole-lake fluridone treatment, which exceeded its intended exposure duration, led to greater-than-expected macrophyte die-off, temporarily increasing light levels and potentially releasing nutrients during decomposition, factors that can enhance early-season phytoplankton growth.

As the treatment progressed, rainfall dropped sharply (2.08" in June; 1.55" in July), reducing watershed inputs and likely contributing to the mid- and late-summer decline in phytoplankton density and biomass. Overall, 2025 phytoplankton conditions indicate low to moderate productivity, no harmful algal bloom activity, and patterns that correspond closely to nutrient availability, weather conditions, and the timing of lake management actions.

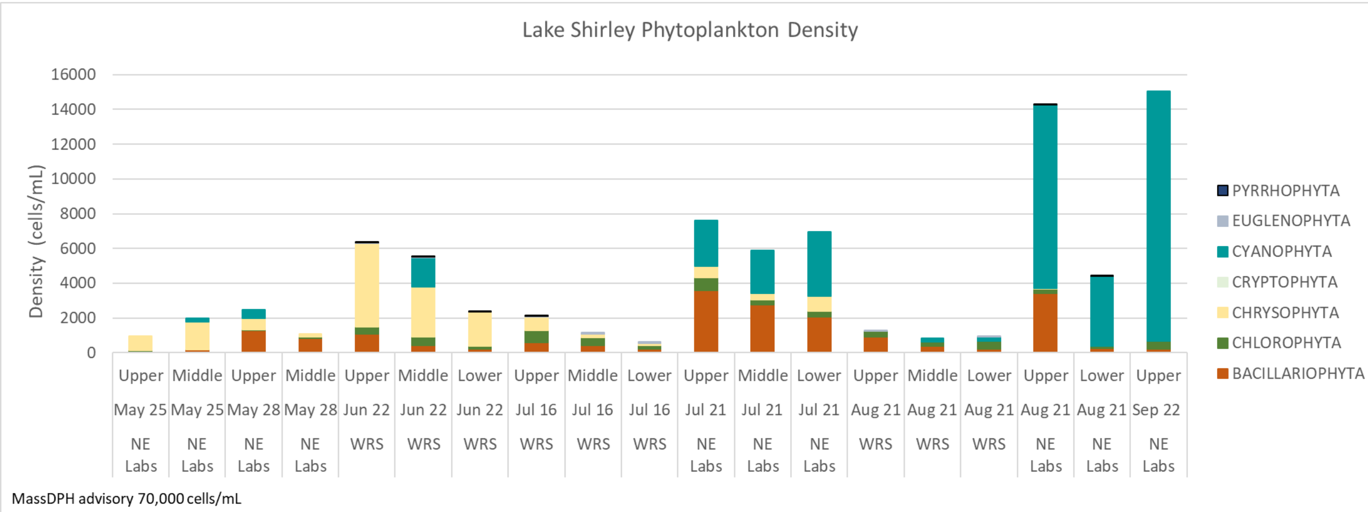

Figure 5. Phytoplankton Density 2025

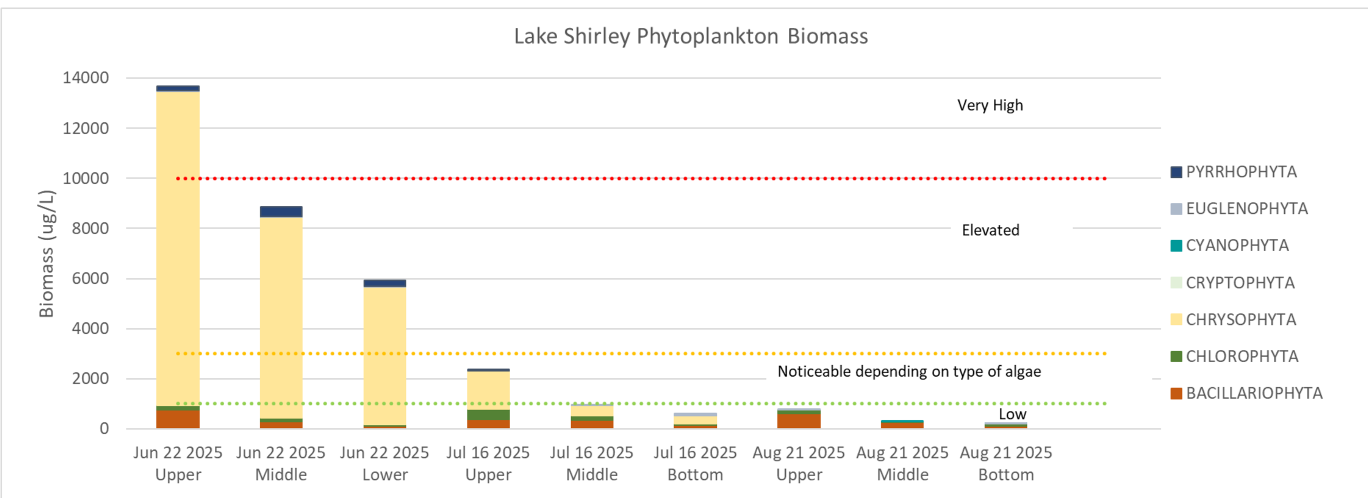

Figure 6. Phytoplankton Biomass 2025

2025 HERBICIDE AND ALGAECIDE TREATMENTS

In 2025, SŌLitude Lake Management implemented a fluridone treatment, marking a departure from the targeted herbicide approach used in previous years. The decision was based on several years of vegetation data, particularly ARC's September 2024 survey, which documented a continued expansion of non-native fanwort (*Cabomba caroliniana*) throughout Lake Shirley and its increasing competitive pressure on native plant communities. No formal pre-treatment survey was conducted in spring 2025 because the fluridone program was designed using these prior multi-year datasets.

The treatment objective was to maintain a lake-wide fluridone concentration of 5–8 parts per billion (ppb) for at least 90 days, with a targeted peak concentration of 10–12 ppb to achieve long-term suppression of fanwort while reducing the density of other nuisance vegetation. To accomplish this, SŌLitude conducted a sequence of three applications: an initial Sonar ONE pellet application on April 29, followed by booster applications on May 28 and June 19 using pellet and liquid fluridone formulations. These were applied primarily to the ~150-acre littoral zone, although dosage was calculated based on the full lake volume.

Early season conditions strongly influenced treatment behavior. Above-average rainfall in May (7.63") diluted the herbicide after the first application, causing fluridone concentrations to fall short of expectations (1.7–1.9 ppb by May 28). Booster applications were adjusted accordingly. Once rainfall subsided, only 2.08" in June and 1.55" in July, fluridone concentrations rose and remained elevated for longer than planned. Lake-wide concentrations exceeded 5 ppb from mid-June through late September (90+ days) and peaked between 10.5 and 11.5 ppb, meeting the criteria for multi-year fanwort control.

The applicator reported no algaecide treatments, no fish kills, and no operational issues during the herbicide applications. Plant inspections following the June 19 application indicated that no additional treatments were needed. SŌLitude anticipates excellent multi-year suppression of fanwort but also acknowledges that the unexpectedly prolonged exposure resulted in more substantial impacts on native vegetation than anticipated. According to their report, many native species are expected to rebound in 2026, particularly seed-producing pondweeds, though full recovery may extend into 2027.

SŌLitude recommends limited management in 2026 aside from monitoring water clarity and algal conditions, conducting a summer vegetation survey, and applying contingency treatments only if nuisance growth reappears. They emphasize maintaining an integrated, long-term management strategy that includes watershed actions, regular monitoring, and adaptive lake management planning. Their full report is provided in Appendix A.

END OF SEASON PLANT SURVEY

Aquatic Restoration Consulting, LLC performed a late summer plant survey. The purpose of the survey was to document conditions at the end of the growing season and compare these results to prior annual surveys. ARC used the same 66 survey locations (Figure 7) as prior surveys and observed plants at these locations using both a rake-toss and underwater video. Both plant cover (estimated percent area containing plants in two dimensions) and biovolume (estimated percent volume containing plants in three dimensions)[2] were estimated using a semi-quantitative (0-4) ranking system as follows:

0 = 0% 1 = 1–25% 2 = 26–50% 3 = 51–75% 4 = 76–100%

The presence of species and their relative densities were recorded. Relative densities were categorized as trace (only one or two plants present), sparse (multiple plants but not abundant, about a handful), moderate (multiple plants but not dominant, about a rake full), and dense (dominant component of assemblage, more than one rake full). Results of the survey are provided in Table 4.

Of the 66 observation locations, 28 contained plants (42%), much lower than the 92% in 2024. Fanwort was observed at 87% of the sites containing plants in 2024, the most abundant since 2002 (the earliest comprehensive survey), which necessitated the whole lake fluridone treatment with a goal of extreme reduction to allow beneficial natives to recover from the fanwort invasion. Fanwort was observed at only two sites (62 & 63), at trace densities in the middle of the North Basin. The other target nuisance species, non-native Naiad (*Najas minor*) and water celery (*Vallisneria americana*), were not observed at this sample location. The most commonly observed aquatic vegetation included macroscopic algae, stonewort (Nitella sp.), musk grass (Chara sp.), and filamentous green algae. Also observed, but infrequent, were yellow waterlily (*Nuphar variegatum*), bladderwort (*Utricularia* sp.), and Robbins' pondweed (*Potamogeton robbinsii*), one of two target conservation species. Robbins' pondweed was observed at two sites (18 and 21). Robbins' pondweed is consistently observed at site 18, a designated non-treatment area and one of two areas designated as a habitat preservation zone, during partial lake treatments.

Coontail, the second conservation species, was not observed during the September 2025 survey, nor was it in 2024. These two species have become significantly less abundant since 2007. It is unclear whether these species are responding to herbicide treatments or are being outcompeted for habitat by aggressive non-native species. Coontail and Robbins' pondweed are generally more tolerant of herbicides than other species. Coontail lacks true roots and obtains nutrients directly from the water column, which reduces herbicide uptake. Robbins' pondweed is more tolerant than many other pondweeds.

[2] Note that "cover" is interchangeable with "density" in prior consultant reports, and "biovolume" is interchangeable with "biomass". ARC believes cover and biovolume are more precise descriptions of what is observed. For coverage, the scientist estimates the areal coverage of the survey point with plants, and biovolume estimates the percent of the water volume occupied by plants.

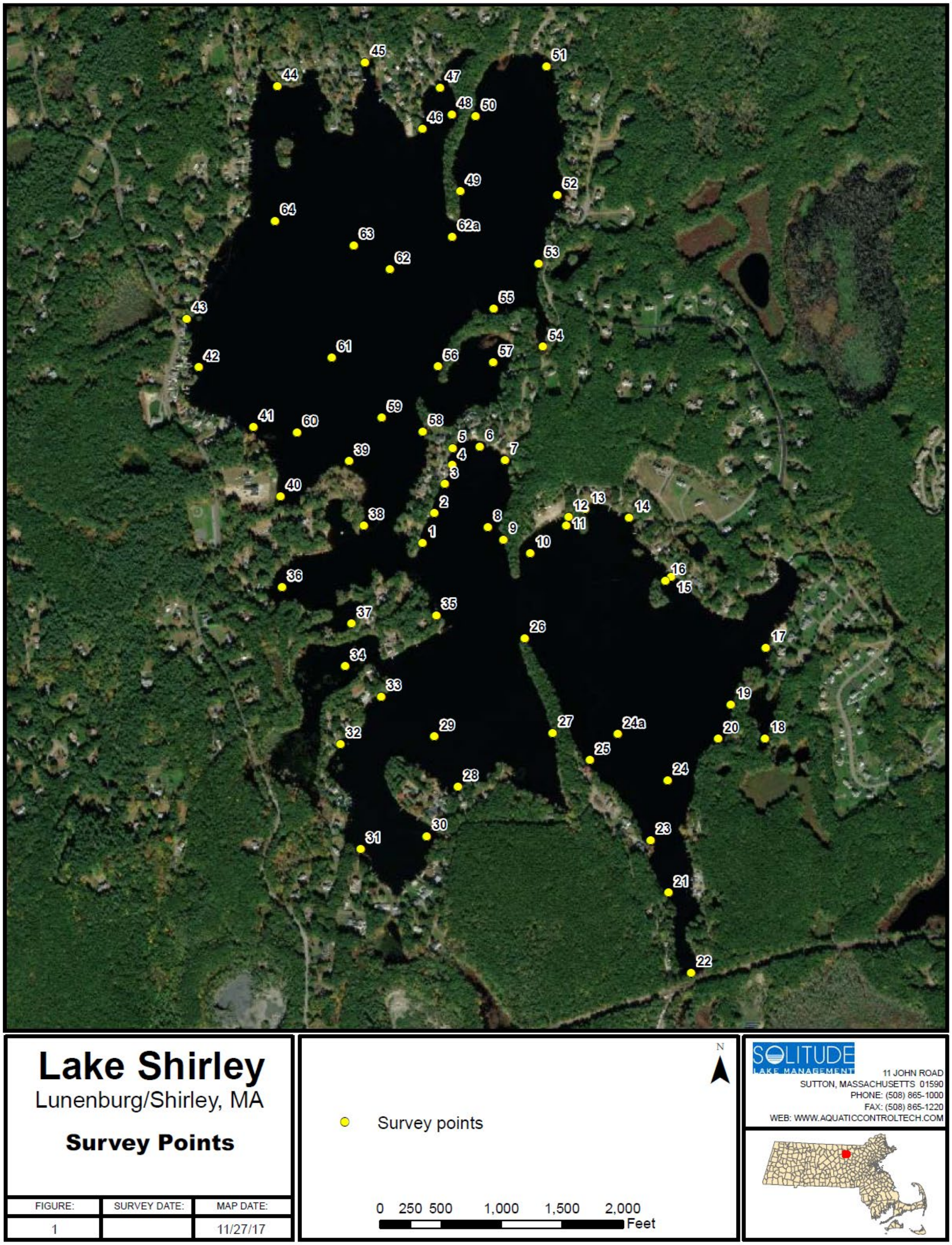

Figure 7. Lake Shirley Plant Survey Points

Aquatic Restoration Consulting, LLC

Table 4. Lake Shirley Plant Survey Data September 6, 2025

Point	Water Depth (ft)	Cover	Bio-volume	Cc	Nm	Va	Mh	Pc	Bb	Bs	BG	Chara	Cd	Eleo	FG	Moss	Nf	N grac	Nit	No	Nv	Pa	Pf	Pg	Pp	Ppus	Pr	Pz	Spar.	Usp	Species Richness	Richness w/o Target Sp[2]
1	8	0	0																												0	0
2	7.7	0	0																												0	0
3	7	0	0																												0	0
4	6.6	0	0																												0	0
5	3.6	0	0																												0	0
6	7	1	1									T																			1	1
7	3	4	1									D																			1	1
8	8	0	0																												0	0
9	7.3	0	0																												0	0
10	8	1	1																T												1	1
11	5	1	1																T												1	1
12	3	0	0																												0	0
13	4.3	1	1																S												1	1
14	3.6	3	1									D							D												2	2
15	5.3	0	0																												0	0
16	4	4	1																D												1	1
17	3.3	0	0																												0	0
18	4.6	4	1																								D			T	2	2
19	6.3	0	0																												0	0
20	2.5	0	0																												0	0
21	5	1	1																								T				1	1
22	3.6	1	1																T												1	1
23	7.7	1	1									T			S																2	2
24	8.3	1	1																												0	0
24a	9.8	0	0																												0	0
25	4.2	0	0																												0	0
26	6.8	0	0																												0	0
27	6.8	0	0																												0	0
28	4.3	0	0																												0	0
29	8.2	1	1												S				S												2	2
30	4.2	0	0												S																1	1
31	4.3	0	0												S																1	1
32	5.8	0	0																												0	0
33	7.1	0	0																												0	0
34	5.6	4	1									D																		S	2	2
35	6.2	0	0																												0	0
36	8.1	0	0												S																1	1
37	5.4	0	0												S																1	1
38	8.7	0	0												S																1	1
39	3.3	0	0																												0	0
40	2.6	0	0												M																1	1
41	7	1	1									T																			1	1
42	6.2	0	0																												0	0
43	3.8	4	1												D																1	1
44	3.6	0	0												T																1	1

Table 4 (continued). Lake Shirley Plant Survey Data September 6, 2025

Point	Water Depth (ft)	Cover	Bio-volume	Cc	Nm	Va	Mh	Pc	Bb	Bs	BG	Chara	Cd	Eleo	FG	Moss	Nf	N grac	Nit	No	Nv	Pa	Pf	Pg	Pp	Ppus	Pr	Pz	Spar.	Usp	Species Richness	Richness w/o Target Sp[2]
45	3.2	0	0												S																1	1
46	4.3	1	1									S			S																2	2
47	3.6	2	1									S																			1	1
48	5	1	1												S				S												2	2
49	4.6	1	1									T																			1	1
50	5.6	1	1									T			S																2	2
51	4	1	1									T			S																2	2
52	5	1	1									S			S																2	2
53	4.6	0	0																												0	0
54	1.6	1	1																S		S										2	2
55	6.5	0	0												S																1	1
56	4	0	0																												0	0
57	5.3	0	0												S																1	1
58	4.3	0	0																												0	0
59	9	0	0																												0	0
60	6.9	0	0																												0	0
61	8	4	1												S				D												2	2
62	8.3	3	1	T											S				M												3	2
62a	7.3	0	0									S																			1	1
63	8	2	1	T											S				M												3	2
64	8.3	4	1												D																1	1
Frequency of Occurrence				2	0	0	0	0	0	0	0	13	0	0	22	0	0	0	12	0	1	0	0	0	0	0	2	0	0	2	7	
Frequency of Occurrence (%)[1]				7%	0%	0%	0%	0%	0%	0%	0%	46%	0%	0%	79%	0%	0%	0%	43%	0%	4%	0%	0%	0%	0%	0%	7%	0%	0%	7%		
Density When Present (%)																																
			Dense	0%	0%	0%	0%	0%	0%	0%	0%	23%	0%	0%	9%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	0%		
			Moderate	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	0%	0%	0%	17%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%		
			Sparse	0%	0%	0%	0%	0%	0%	0%	0%	31%	0%	0%	82%	0%	0%	0%	33%	0%	100%	0%	0%	0%	0%	0%	0%	0%	0%	50%		
			Trace	100%	0%	0%	0%	0%	0%	0%	0%	46%	0%	0%	5%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	50%		

[1] – Frequency of occurrence (%) is the number of observations where plants are present (# observed/61 total observations with plants)
[2] – Richness w/o Target Species is richness at the sample location, not including fanwort (Cc), European naiad (Nm), wild celery (Va), and curly-leaf pondweed (Pc).

See the next page for the key to species.

Key to plant species in Table 4.

Bb - *Bidens beckii* [water marigold]	Nv - *Nuphar variegatum* (yellow waterlily)
BG - Bluegreen algae	Pa - *Potamogeton amplifolius* (big leaf pondweed)
Cc - *Cabomba caroliniana* (fanwort)	Pg - *Potamogeton gramineus* (grassy pondweed)
Cd - *Ceratophyllum demersum* (coontail)	Pf - *Potamogeton foliosus* (leafy pondweed)
Eleo - *Eleocharis* sp. (spikerush)	Pp - *Potamogeton perfoliatus* (clasping pondweed)
FG - Filamentous green algae	Ppus - *Potamogeton pusillus* (thin-leaf [Small] pondweed)
Nf - *Najas flexilis* (bushy pondweed)	Pr - *Potamogeton robbinsii* (Robbins' pondweed)
Mh - *Myriophyllum heterophyllum* (variable milfoil)	Pz - *Potamogeton zosterformis* (flatstem pondweed)
Ngrac - *Najas gracillima* (northern [thread-like] naiad)	Spar - *Sparganium sp.* (bur-reed)
Nm - *Najas minor* (European Naiad)	Usp - *Utricularia sp.* (bladderwort)
Nit - *Nitella sp.* (stonewort)	Va - *Vallisneria americana* (wild celery)
No - *Nymphaea odorata* (white waterlily)	

Species richness (number of different species observed) at each observation location in 2024 ranged from one to seven (Table 4), with an average of 2.7. In 2025, this declined to a maximum of three at any single site. After removing richness data for the managed target species (fanwort, European naiad, curly-leaf pondweed, and wild celery), the maximum species richness at any site declines to two. Overall richness in 2024 was 15, the same as 2023, and the lowest since 2018 as shown in Figure 8. This pattern was true with and without target species suggesting that non-native species may be outcompeting natives. In 2025, richness markedly declined, but not because of competition with increased invasive species density; rather, it was the response to the herbicide treatment. This resulted in a loss of three target species and five other species in 2025 compared to 2024.

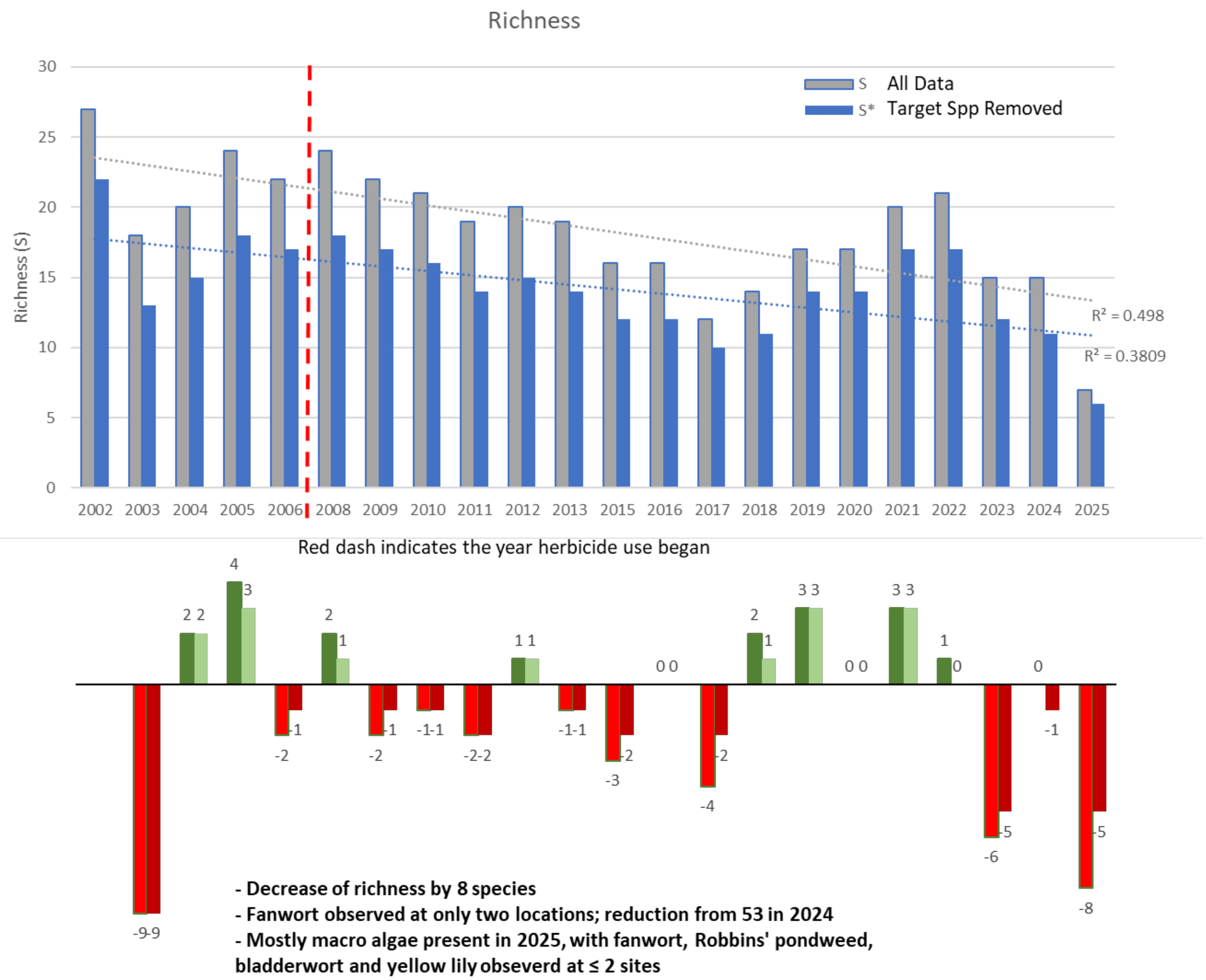

Figure 8. Lake Shirley Plant Species Richness
The sharp decline in 2025 reflects treatment-related suppression of both target and non-target species rather than competitive displacement by invasive plants. Overall plant cover and biovolume were the lowest of the 20 years of data

(Figure 9). Years 2019 and 2023 were the highest. Plant cover averaged less than 25 percent. Biovolume was also low lake-wide at less than 25%.

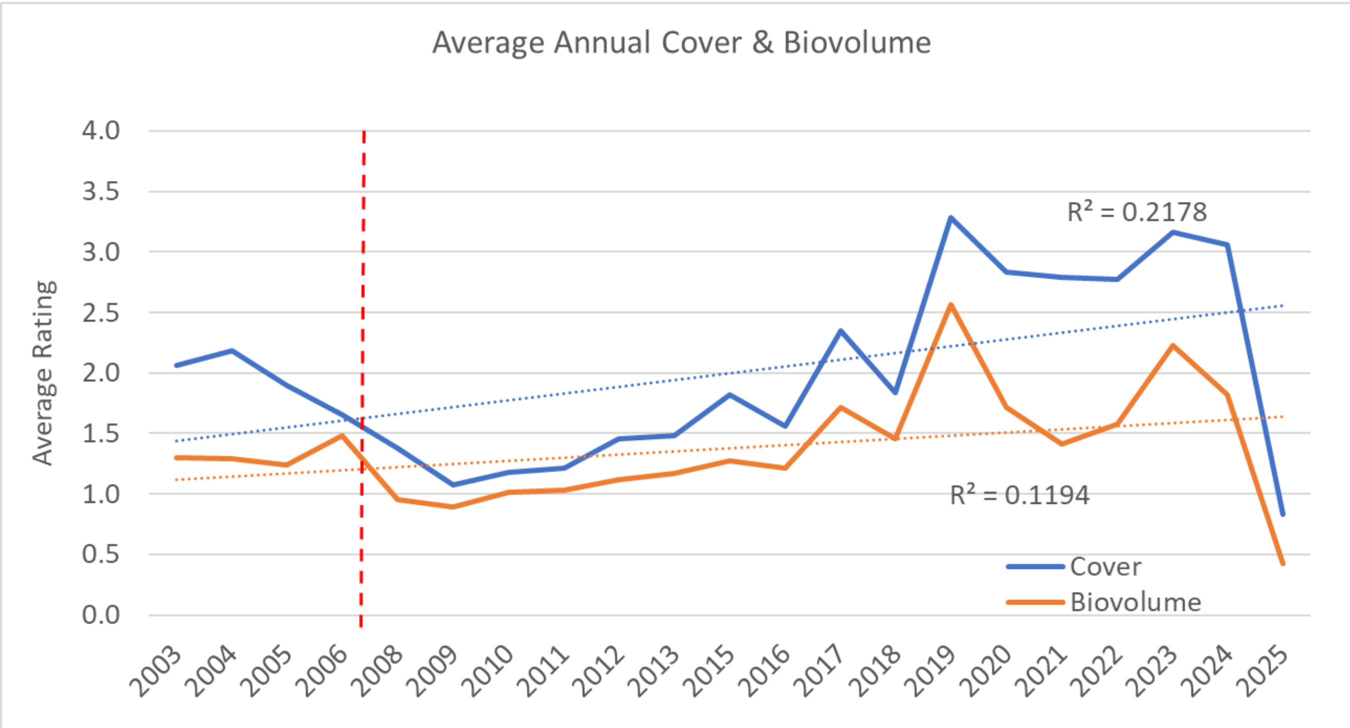

Figure 9. Lake Shirley Plant Cover & Biovolume Trends
The pronounced decline in 2025 reflects the whole-lake fluridone treatment and represents the lowest recorded plant abundance in the long-term dataset.

Looking at the overall plant density and biovolume together, it is interesting that the cover and volume of plant matter increased in 2023, but there's been a reduction in species richness (Figure 10). This suggests that a few species comprise the biomass (i.e., community domination by fewer species). This also coincides with the frequency and density of increased fanwort, European naiad, and wild celery observations reported in 2023. While species richness was the same in 2023, density and biomass were slightly reduced. There was a slight reduction in 2024 in density and biovolume, but richness was consistent.

In 2025, there was a sharp decrease in all community metrics. Undoubtedly a result of the herbicide treatment.

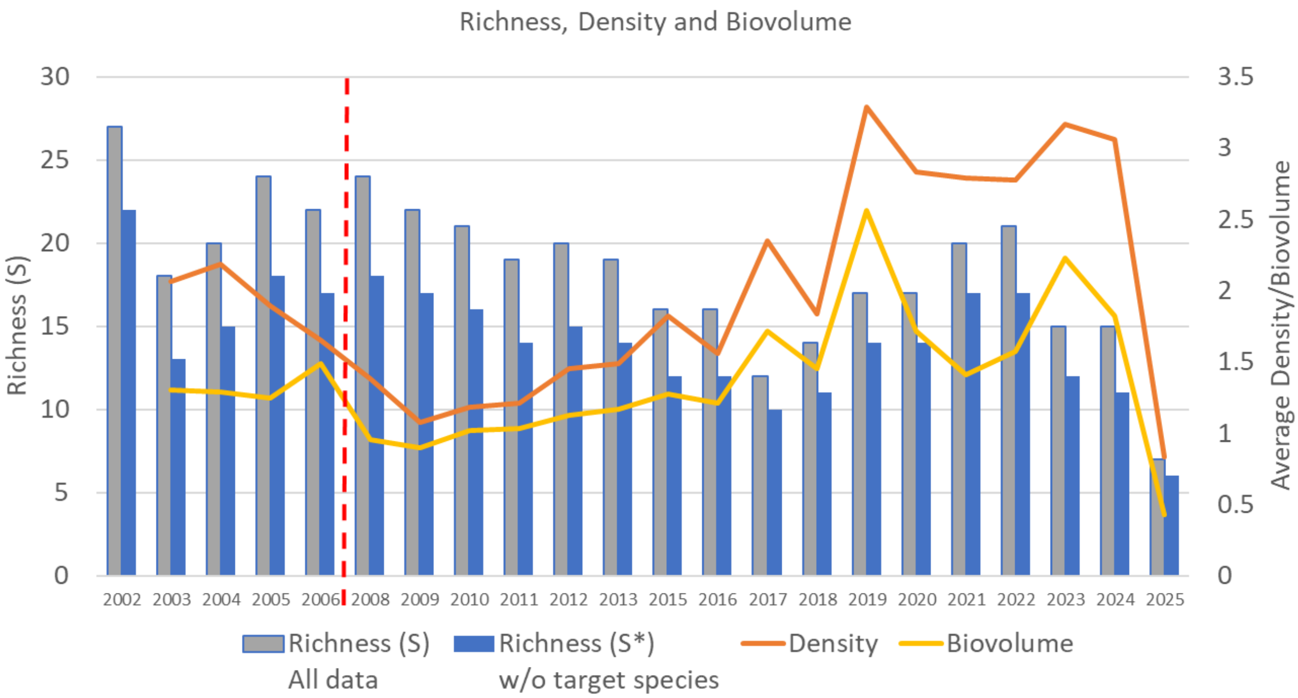

Figure 10. Species Richness, Density, and Biovolume
Divergence among these metrics highlights periods of community dominance by fewer species (e.g., 2023–2024) and the system-wide suppression observed following the 2025 herbicide treatment.

The diversity index, Shannon Index (H), considers both species richness and abundance (i.e., dominance). The higher the H value, the greater the diversity and evenness, or lack of dominance by a few species. Values closer to zero indicate that richness is low and the community is dominated by only a few species. The Shannon Index is often discussed along with an equitability (or evenness) index. Evenness is expressed on a scale of 0 to 1, where values closer to 1 indicate that species are evenly represented in the community. Evenness value (E) near 0 indicates dominance by only a few species. These two indices are described in detail, including formulas, in the Lake Shirley Long Term Macrophyte Monitoring Assessment Report – 2002-2019, prepared by ARC in April 2020 (available at www.lakeshirley.com/resources.html).

Plant diversity and evenness have gradually increased since 2017, with and without the managed species, until 2022. There was a marked decline in 2023, which remained consistent with 2024. 2023 and 2024 metrics are still above the lowest values calculated for 2016 & 2017, but are concerning. (Figure 11). Diversity (H) in 2023 and 2024 was 2.06 and 2.04, respectively down from 2.42 in 2022. Removing the target management species from the population, diversity (H*) still shows a decrease in 2023 and 2024 from 2022. Evenness (E*) slightly improved when the target species were removed, suggesting that the plant community was more evenly represented (less dominance by a few species). In other words, when only the desirable plants were assessed, the community was dominated by only a few species. This is common when aggressive non-native species invade waterbodies. These data provided additional lines of evidence that a more aggressive strategy to manage the target species, primarily fanwort, was needed.

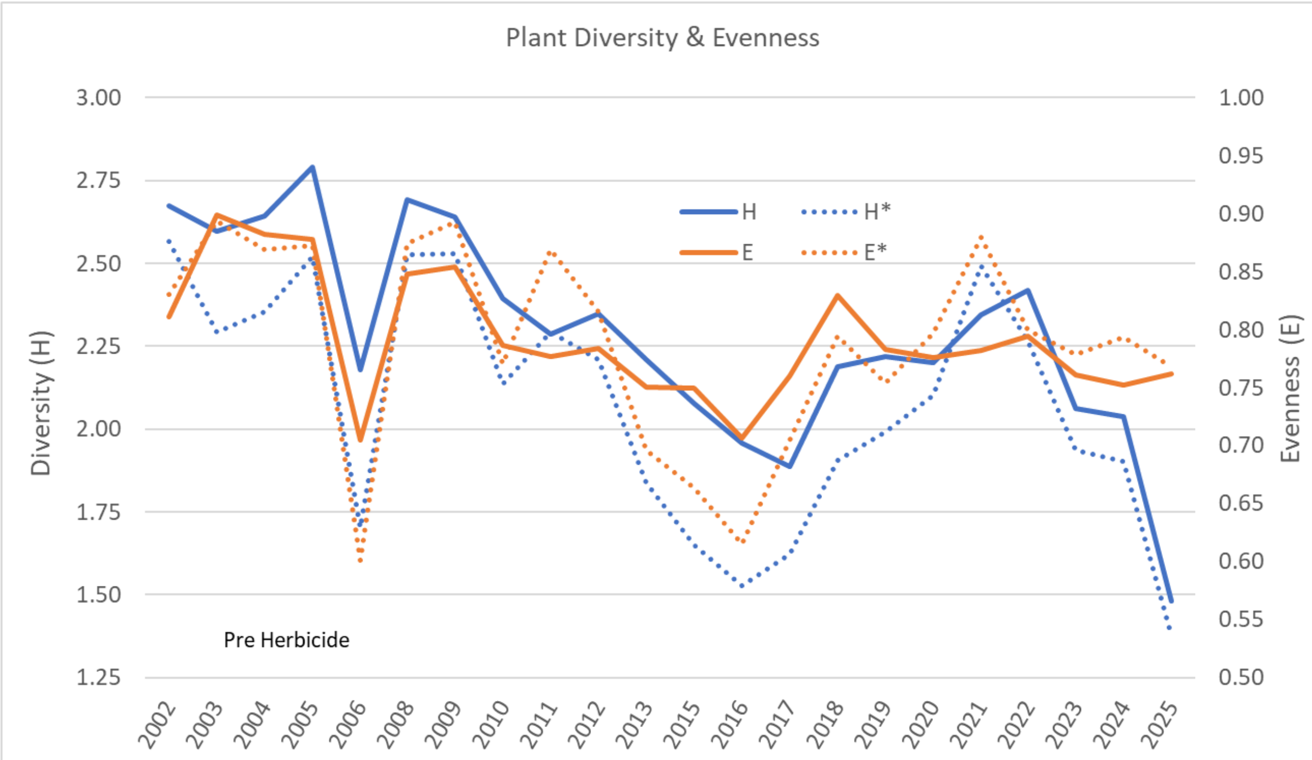

Figure 11. Lake Shirley Plant Diversity and Evenness
Shannon diversity (H) and evenness (E) indices decline after 2022, reflecting increasing dominance by invasive species, followed by whole-community suppression in 2025.

The reduction in diversity and evenness from 2022 is likely due to the absence of native pondweed, coontail, and naiad observations that were present in 2022. Recall that native pondweeds reached nuisance levels in the summer of 2022, which were treated with herbicides on August 23, 2022, just after the end-of-year survey by ARC was conducted (August 21, 2022). It is likely these plants were still present but impaired during the survey.

The non-native invasive plant species abundance was much greater in 2024, with an increase of fanwort frequency from 32 sites in 2022 to 44 sites in 2023 and 53 sites in 2024 (Table 5). There was no flumioxazin treatment in 2022 or 2023. Even though several areas were treated with flumioxazin in 2024, many of these areas still contained dense fanwort in September. Of the 16 survey points in the treated area, 11 were dense with fanwort. These data suggest that the flumioxazin treatment is no longer providing effective fanwort control, nor is diquat effective. Again, more data suggesting that more aggressive management is needed to restore an ecological balance.

Aquatic Restoration Consulting, LLC

Table 5. Lake Shirley Species Frequency over the Last 12 Years

	Common Name	Aug-13	Oct-15	Oct-16	Oct-17	Sep-18	Sep-19	Sep-20	Sep-21	Aug-22	Sep-23	Sep-24	Sep-25
Target Non-native Invasives	Eurasian milfoil												
	Variable milfoil	1	1									1	
	European Naiad	36	13	40		39	60	35	29	23	37	21	
	Fanwort	25	19	18	7	19	50	33	37	32	44	53	2
	Curlyleaf pondweed	1		2						1			
Target Native	Wild celery	38	38	52	32	30	50	42	40	41	38	37	
Emergent Wetland	Arrow arum												
	Arrowhead												
	Bur-reed							2	2				
	Pickerel weed												
	Spike rush		2	2								1	
	Wool grass												
Macro Algae	Stonewort						3	1	6	13	5	2	12
	Musk grass	20	12	1	11					1			13
	Stonewort/Musk grass					29							
	Bluegreen algae								2		3		
	Filamentous green algae			5	6		16	8	6	8	3	5	22
Similar Bladderworts	Bladderwort	5	10	6	22	16	50	27	14	24	25	24	2
	Eastern purple bladderwort	3											
	Little floating bladderwort												
Free floating	Watermeal												
	Giant duckweed												
	Duckweed												
Similar floating leaves	Watershield	1				2				1	1		
	White waterlily	2	2	3			4	2	2	3	6	4	
	Yellow waterlily	6	2				6	2	1	4	2	5	1
Similar naiad	Bushy pondweed	51	48	50	40	10	30	9	6	24	15	13	
	Northern (Thread-like) naiad					20		7	10	12			
Similar pondweeds	Clapsing pondweed	1	4	8	3	7	12	12	11	9	6	7	
	Richardson's pondweed												
Other Pondweeds	Grassy pondweed	3							3	1			
	Flatstem pondweed					1	2	1	3	2		2	
	Big leaf (Large leaf) pondweed									1		1	
	Floating (broad-leaf) pondweed												
	Leafy pondweed						1	6		1	1		
	Thin-leaf (Small) pondweed	7	9	2	1		17	1	3	4			
	Ribbonleaf pondweed	2	1	1	1	2	1						
	Robbins' pondweed	1	1	2	1	1		2	1	1	1	1	2
	Sago pondweed			2									
	Coontail	4	1	1	1	3	5	1	2		1		
	Waterweed						1						
	Hedge hyssop												
	Quilwort						1						
	Small waterwort	3											
	Water marigold								1	1			
	Water purslane												
	Water starwort												
	Bog moss		1		6	3			1				

Darkness of red shading indicates higher relative abundance.

HERBICIDE TREATMENT AND ECOLOGICAL IMPACT DISCUSSION

Macrophytes

While the treatment achieved excellent suppression of fanwort, exposure conditions exceeded typical fluridone selectivity thresholds during June–August due to a combination of hydrologic dilution early in the season and prolonged pellet release during a period of unusually low inflow. This resulted in broader-than-anticipated suppression of native vascular macrophytes.

This outcome is documented in other whole-lake fanwort programs when concentrations remain above 6–8 ppb for extended periods. Importantly, the lake's seedbank and the persistence of occurrences of *Nitella*, *Chara*, Robbins' pondweed, bladderwort, and lilies indicate high potential for recovery. There is a seedbank of other native pondweeds left behind from plants that have proliferated in the past but have been found in lower frequency of occurrence due to suppression by fanwort and other aggressive target species. Native species richness is expected to rebound over 1–3 years, consistent with regional and national case experience.

Phytoplankton

The near–whole-lake loss of submerged macrophytes in 2025 may also influence phytoplankton structure and productivity over the next one to two years. In plant-dominated systems, macrophytes compete with phytoplankton for nutrients, stabilize sediments, and enhance water clarity through uptake and physical baffling. When vegetation is abruptly reduced, the system may temporarily shift toward a phytoplankton-dominated state, particularly during the first full growing season after treatment.

Several mechanisms support this shift:

- **Reduced nutrient uptake by plants**, leaving more nitrogen and phosphorus available in the water column.
- **Increased light availability** due to the absence of canopy shading, enhancing phytoplankton growth potential.
- **Greater sediment resuspension** in shallow areas without plant roots and stems to stabilize the substrate.
- **Altered grazer dynamics**, as zooplankton communities adjust to changes in fish predation and habitat structure.

These conditions occasionally lead to short-term increases in algal biomass, or shifts in phytoplankton composition (e.g., toward fast-growing chlorophytes or cyanobacteria in warm, nutrient-rich periods). This is not guaranteed, but it is a commonly observed transitional phase in lakes that undergo large reductions in macrophyte abundance. As native macrophytes recover and reoccupy the littoral zone, nutrient competition, substrate stabilization, and habitat structuring return, generally allowing the system to migrate back toward a more balanced macrophyte–phytoplankton equilibrium.

Fish

The temporary loss of submerged macrophytes in 2025 likely influenced predator–prey dynamics within the fish community. Vegetation typically provides critical refuge habitat for juvenile bluegill, perch, young-of-year bass, and other forage species. With this structural cover largely absent, predatory species such as largemouth bass, pickerel, and larger sunfish experience increased foraging efficiency, which often leads to short-term improvements in angling success, particularly for larger individuals.

However, the same conditions that improved foraging also increased vulnerability of both predators and prey to angling harvest, potentially reducing overwinter survival of multiple age classes.

From an ecological perspective, a year with greatly reduced refuge for juvenile fish often leads to:

- Lower recruitment of young-of-year forage species,
- Reduced prey availability in subsequent years, and
- A shift in predator size structure, whereby the current cohort of large fish performs well initially but declines over the next 1–3 years as prey becomes limited.

This is not necessarily a “population crash,” but instead a temporary restructuring of age-class distribution and a likely reduction in the proportion of larger predatory fish until vegetative cover returns and recruitment stabilizes.

As native macrophytes re-establish over the next one to two growing seasons, refuge habitat and prey recruitment should recover, allowing the fish community to gradually return to a more balanced structure.

Hydrologic Conditions and Exposure Dynamics

It should be noted that the outcome was not caused by herbicide misuse. Rather, it resulted from a combination of:

- Unusual hydrology (heavy May rain diluting early doses).
- The need to increase booster applications to reach minimum effective fanwort concentrations.
- A sharp decline in flow thereafter, allowing fluridone to persist longer and build higher than anticipated.
- Three pellet treatments + a liquid bump, creating sustained inputs even after weather normalized

All of this is documented in the applicator report, which helps demonstrate that the treatment sequence remained within permitted dosage parameters, but hydrologic conditions drove the system into a non-selective exposure regime. What happened at Lake Shirley is not unique and aligns with known deviations from selectivity when dose/exposure exceeds intended levels.

Implications for Future Management

The current absence of fanwort creates a rare opportunity to promote a more diverse and balanced native plant assemblage through careful monitoring and a comprehensive, targeted approach to remove fanwort regrowth using multiple methods, including hand-pulling small areas and aggressive spot treatment with herbicides during the recovery window.

EDUCATION AND OUTREACH

While the Lake Shirley Improvement Committee (LSIC) does not own the lake or dam, this volunteer-based lake association is dedicated to the protection and long-term management of Lake Shirley. LSIC works continually to further education and outreach efforts directed toward association members, the general public, and municipal representatives. Monthly association meetings are held and are open to the public, during which topics such as nutrient loading, responsible lakefront ownership, and lake and watershed best management practices are presented and discussed. LSIC openly communicates management goals, objectives, and funding priorities related to the stewardship of Lake Shirley.

The most significant limitation to LSIC's ability to implement lake and watershed management measures continues to be limited funding and a lack of direct control over watershed land use, much of which is privately owned or under the jurisdiction of the Towns of Lunenburg and Shirley.

Historically, LSIC partnered with the Town of Lunenburg on a Low Impact Development (LID) project funded through a three-year Section 319 Nonpoint Source Pollution grant. This project focused on reducing sediment and nutrient loading to the lake while addressing in-lake nuisance vegetation. As part of this effort, the Town adopted MassDEP requirements for 80% removal of total suspended solids from new development and implemented five LID demonstration projects within the Lake Shirley watershed. These projects included constructed wetlands, rain gardens, vegetated buffer strips, and sediment capture forebays. Additional details are provided in the Section 319 Nonpoint Source Pollution Project Report available at: https://www.lakeshirley.com/assets/2009-low-impact-development-project.pdf. LSIC continues to seek grant opportunities and municipal partnerships to support watershed protection and lake management efforts.

During the past year, LSIC accomplished the following outreach and education activities:

- Updated the Lake Shirley website (https://www.lakeshirley.com/).
- Held monthly association meetings via Zoom and in person; meetings are open to the public and regularly address lake management activities, watershed best management practices, water quality conditions, and volunteer opportunities.
- Continued use of the Lake Shirley website and Facebook page to communicate with residents and the public regarding lake stewardship practices and management activities.
- Distributed signage and posted notices around the lake to inform residents of upcoming herbicide treatments.
- Published treatment notices in the Sentinel and the Lunenburg Ledger.

LAKE MANAGEMENT PROGRAM 2025-2026

LSIC continues to implement a comprehensive lake management program focused on measures that are within its physical control and consistent with available funding. For the 2025–2026 management year, LSIC plans to continue the winter water-level drawdown, conduct algaecide treatments if warranted, support volunteer-based water quality and water clarity monitoring, and contract for an independent end-of-season aquatic plant survey.

LSIC intends to implement the winter water-level drawdown to a target depth of approximately six feet during the winter of 2025–2026. The drawdown was initiated in October, and weather conditions to date have been favorable, with below-average temperatures.

Following the 2025 fluridone treatment, which resulted in a substantial reduction of fanwort but also caused widespread loss of rooted aquatic vegetation, LSIC anticipates limiting future herbicide use. Increased frequency of aquatic plant monitoring is recommended, including observations at locations beyond the 66 routinely sampled survey sites. This enhanced monitoring does not require contractor involvement and may be conducted by lake residents and other trained volunteers. The objective is to detect early regrowth of fanwort so that small infestations in shallow water can be hand-pulled, and larger or deeper-water infestations can be delineated and addressed with targeted treatment before nuisance growth levels are reached. Early detection and spot management are intended to delay the need for broader-scale herbicide applications, recognizing that herbicide intervention may be needed more often as vegetation recolonizes over time.

Given the current condition of the aquatic plant community, algaecide use may be required more frequently in the near term than in previous years.

LSIC will continue education and outreach efforts emphasizing nutrient reduction, boat inspection, and removal of aquatic plants before launching and following boat removal, including outreach to the campground, homeowners, and their guests.

SŌLitude Lake Management has provided monitoring and management recommendations in their annual report (Appendix A), including recommendations for contingency herbicide and algaecide treatments. ARC recommends more frequent monitoring than outlined in that report to support early detection and targeted response. If needed, SŌLitude will present any proposed treatment plans to the Conservation Commissions before implementation and will proceed with treatments in accordance with the approved Orders of Conditions. No herbicides or algaecides are proposed beyond those currently authorized under the existing permits.

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Appendix A

Lake Shirley 2025 Year End Treatment Report

(Prepared by SŌLitude Lake Management)

Lake Shirley
Lunenburg/Shirley, Massachusetts
2025 Year-End Treatment Report

November 26, 2025

Report Prepared by: SOLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Report Prepared for: Ms. Joanna Bilotta, President
Lake Shirley Improvement Corporation (LSIC)
PO Box 567
Shirley, MA 01464
jobilotta@comcast.net

Dear Joanna:

In accordance with the aquatic plant management contract between SŌLitude Lake Management (SOLitude) and the Lake Shirley Improvement Corporation (LSIC) for Lake Shirley, the following document serves to provide this year's treatment and survey results, as well as management recommendations for next season. The continued objective of the program is to manage non-native and nuisance aquatic vegetation as well as potentially harmful cyanobacteria (blue-green algae) blooms. Monitoring events, herbicide/algaecide treatments and reporting are key tasks of the project.

Based on recent conditions of the lake, a decision was made to implement a whole-lake treatment using fluridone herbicide in 2025. This represents a substantial change in the historical management approach in response to an increase in the extent of fanwort (*Cabomba caroliniana*) growth throughout the lake. The whole lake treatment is intended to be a "one-time" effort to reduce the lake's fanwort infestation before returning to a more typical approach of monitoring and localized treatments.

All management activities were consistent with the Order of Conditions [DEP File #284-0474 (Shirley), DEP File #208-1168 (Lunenburg)] and the License to Apply Chemicals issued by MA DEP (#WM04-0001866). The following is a chronology of this year's management events.

2025 Management Program Summary

Program Task	Date Completed
Received Approved License to Apply Chemicals	April 14, 2025
Initial Fluridone Herbicide Treatment	April 29, 2025
Inspection and herbicide testing	May 12 & May 28, 2025
1st Follow-Up Fluridone Treatment	May 28, 2025
Inspection and herbicide testing	June 11, 2025
2nd (Final) Fluridone Treatment	June 19, 2025
Inspection and herbicide testing	June 25, July 21, August 21, September 22, 2025

Pre-Treatment Survey

Given that the fluridone treatments were planned to start early in the season, no formal pre-treatment survey was conducted this year. The treatment plan for 2025 was based on vegetation data from the last several years, especially the September 2024 survey conducted by Aquatic Restoration Consulting (ARC).

Herbicide Treatment

The goal of the 2025 treatment program was to maintain a target dose of 5-8 parts per billion (ppb) of fluridone throughout the lake for at least 90 days while reaching a peak concentration of 10-12 ppb somewhere between the 30 and 60 day point. This concentration regime is required to provide effective, multiple year control of fanwort and help to reduce or "regulate" the abundance of native vegetation. In order to achieve this, a series of applications using both pellet and liquid formulations of Sonar (fluridone) herbicide was proposed.

The initial herbicide application was conducted using the Sonar ONE herbicide on April 19th. The timing of the initial treatment was proposed to coincide with the start of active fanwort growth as this is the time when plants are most sensitive. While the dose for this treatment was calculated over the entire volume of the lake, the product was applied only to the ~150-acre littoral zone. The lakewide dose applied was 12 ppb which was anticipated to be released over a 4-6 week period.

As with all treatments, the lake community and the two towns were notified prior to treatment by LSIC. Several means of notification were utilized: placement of a written notice in the newspaper(s); placement of large, printed signs at major road intersections/locations around the lake and posting of numerous 8.5 inch by 11-inch orange colored, printed signs around the lake shoreline and other means of communication/notification.

The treatment was performed with a 20-foot airboat equipped with an electric spreader to distribute the pellets to the pre-determined treatment areas. GPS guidance was used to monitor the position of the boat and its relation to the treatment areas. The treatment proceeded smoothly and without any issues. **Figure 1** shows the actual application areas and GPS recorded treatment tracks. A summary of the treatment specifications is shown below in **Table 1**.

Table 1 – Initial Herbicide Treatment Specifications

Treatment Date	April 29th
Product	Sonar ONE (fluridone)
Treatment Area	354 acres (Herbicide applied to 150 acre littoral zone)
Quantity	1,600 lbs
GPS Tracks	See Figure 1
Applicator name	Rocco Notaro, MA Certification #AL-0053966
Site Conditions	Weather: Fair, winds 10-15 MPH SW, mid 70's°F Water Temp: 16.1°C at surface, 15.8°C near bottom Dissolved Oxygen: 10.27 mg/l at surface; 10.16 mg/l near bottom (9-feet) Water clarity: 7'

A follow-up, booster treatment was conducted on May 28th using the same areas and herbicide formulation (see **Figure 2 & Table 2**). For this treatment a total lakewide dose of 7 ppb was applied to the littoral zone. Herbicide sampling conducted after the initial application on May 12th showed lower than desirable concentrations in the lake, averaging <2 ppb (see next section), so the dose for this booster treatment was adjusted upward to hopefully reach the concentration target level of >5 ppb. An above average amount of rainfall occurred in May (7.63") which caused increased dilution of fluridone following the initial application.

Table 2 – 1st Follow-Up Herbicide Treatment Specifications

Treatment Date	May 28th, 2025
Product	Sonar ONE (fluridone)
Treatment Area	354 acres (Herbicide applied to 150 acre littoral zone)
Quantity	940 lbs
GPS Tracks	See Figure 2
Applicator name	Rocco Notaro, MA Certification #AL-0053966
Site Conditions	Weather: Fair, winds 5-8 MPH S, High 70's°F Water Temp: 19.2°C at surface, 17.5°C near bottom Dissolved Oxygen: 8.5 mg/l at surface; 3.5 mg/l near bottom (9-feet) Water clarity: 7'2"

A final booster application was applied to the lake on June 19th (see **Figure 3**). Again with higher than average rainfall in May, fluridone levels were still a bit lower than desired (4.9 ppb average), so this application entailed using 7 ppb of Sonar ONE and 4 ppb of liquid Sonar Genesis to provide a rapid increase in concentration while adding to the previous pellet applications to support longer term support of target concentrations.

Table 3 – 2nd Follow-Up Herbicide Treatment Specifications

Treatment Date	June 19th, 2025
Product	Sonar ONE (fluridone) & Sonar Genesis (fluridone)
Treatment Area	354 acres (Herbicide applied to 150 acre littoral zone)
Quantity	940 lbs Sonar ONE, 53.5 gallons Sonar Genesis
GPS Tracks	See Figure 3
Applicator name	Rocco Notaro, MA Certification #AL-0053966
Site Conditions	Weather: Fair, winds 8-12 MPH variable, Mid 80’s^{o}F Water Temp: 23.4^{o}C at surface, 21.2^{o}C near bottom Dissolved Oxygen: 8.1 mg/l at surface; 2.3mg/l near bottom (9-feet) Water clarity: 6’4”

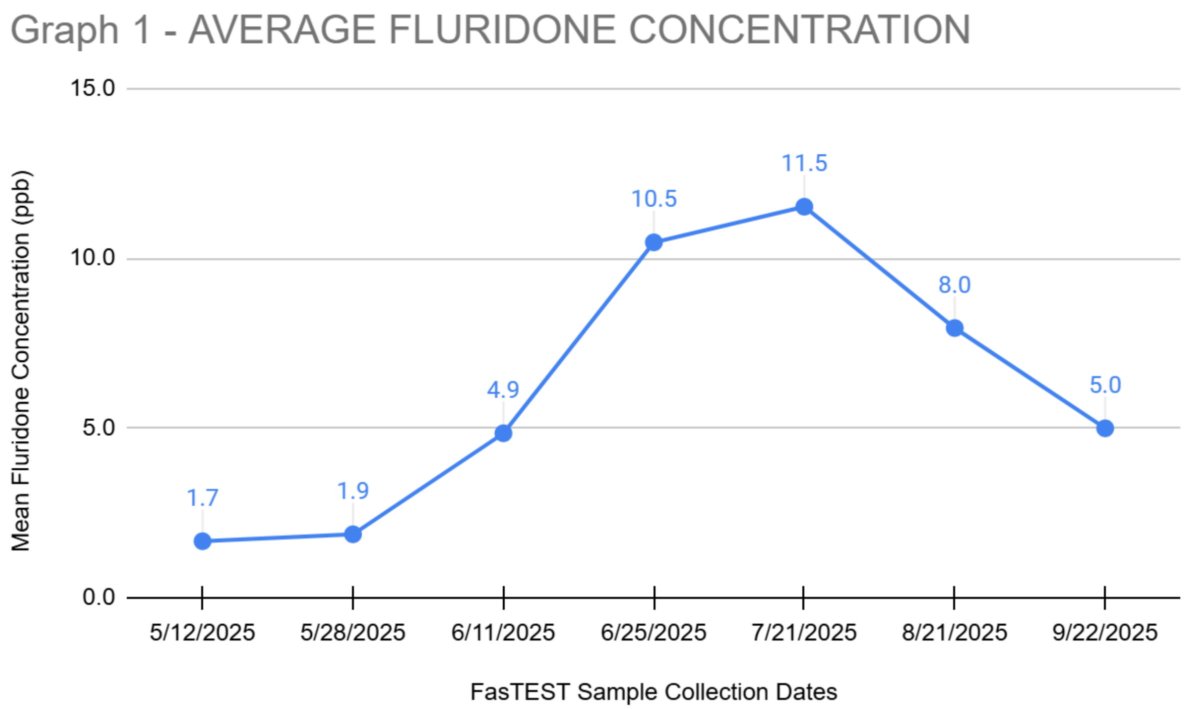
Based on plant inspections and monitoring following the June 19th application, no further herbicide treatments were required to meet the goals of the project. Given the adjustments made to the follow-up applications due to heavy rain in May, the liquid fluridone and the three pellet applications still releasing product sustained a desirable concentration of fluridone well into September.

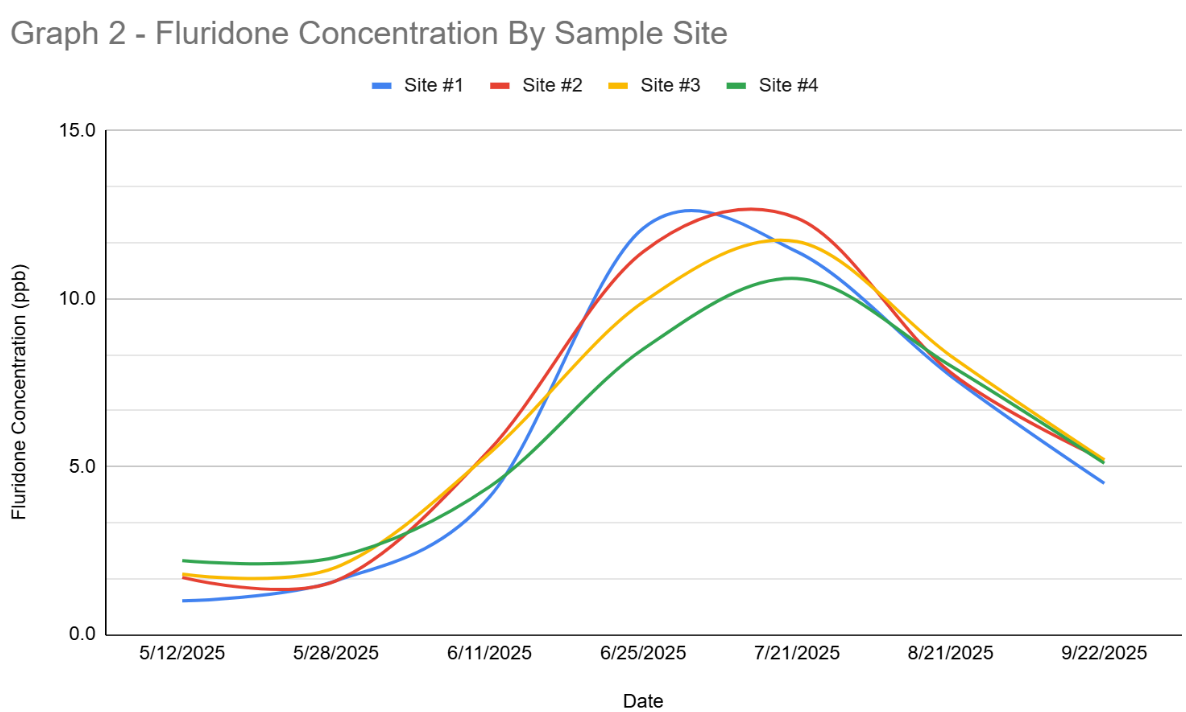
Algaecide Treatments

No algaecide treatments were required this year.

Herbicide Monitoring

To monitor herbicide concentrations in the lake and help guide the timing and dose of the follow-up applications, seven sampling rounds at four different lake stations were collected. The sampling round occurred on May 12th, May 28th, June 11th, June 25th, July 21st, August 21st and September 22nd. Figure 4 shows the locations of the FasTEST sampling. Graph 1 shows the average fluridone concentration in the lake over time and Graph 2 shows the results at each sampling station over time.


Graph 1 - AVERAGE FLURIDONE CONCENTRATION
15.0
10.0
5.0
0.0
Mean Fluridone Concentration (ppb)
1.7
1.9
4.9
10.5
11.5
8.0
5.0
5/12/2025
5/28/2025
6/11/2025
6/25/2025
7/21/2025
8/21/2025
9/22/2025
FasTEST Sample Collection Dates


Graph 2 - Fluridone Concentration By Sample Site
Site #1
Site #2
Site #3
Site #4
15.0
10.0
5.0
0.0
Fluridone Concentration (ppb)
5/12/2025
5/28/2025
6/11/2025
6/25/2025
7/21/2025
8/21/2025
9/22/2025
Date

Herbicide monitoring shows that concentrations took longer to build than expected given the above average rainfall in May, but a concentration of >5 ppb was maintained between mid June and late September (90+ days). The peak was also delayed, but reached 10.5 ppb in late June and 11.5 in late July. Concerns over dilution during the early stages of the treatment prompted us to accelerate the timing and dosing of the applications. Following May, rainfall amounts fell off sharply (2.08" in June, 1.55" in July) while the pellets were still releasing, so concentrations remained on the higher end of the desired range for longer than anticipated. In fact, the average lake concentration did not drop below 8 ppb until the later half of August.

Due to these circumstances, we expect excellent muli-year control of fanwort, however the year of treatment effects on native plant growth were more pronounced than anticipated. While we fully expect the native plant populations to rebound rapidly in 2026, it will likely be a longer period of time and desirable recovery could extend into the next year as well. Seed bearing plants are likely to rebound more quickly in the new year

Anticipated Management in 2026

With the successful fluridone treatment this past summer, we expect there to be minimal need for management of invasive species in 2026. In fact, the prolonged levels of fluridone due to higher than normal rain in May followed by lower than normal precipitation in June and July should also limit any treatment needs for native plants as well. Little or no treatment in 2026 will help to allow desirable plants to return more rapidly and robustly. The following table presents the proposed schedule of efforts in 2026.

Table 4 – Proposed Plan for 2026

	Schedule	Notes/Criteria
Contingency DEP Permitting	March	Permit for contingency herbicide & algaecide treatments
Summer Survey	June/July	Full data point survey, survey and document plant populations, identify any areas of invasive or nuisance growth (unlikely)
Contingency Herbicide & Algaeci treatment (as needed)	July-September	Conduct any needed herbicide treatment based on summer survey and algaecide treatment based on water clarity monitoring and algae testing
Late Season Survey (conducted by ARC)	Late September/early October	Full data point survey

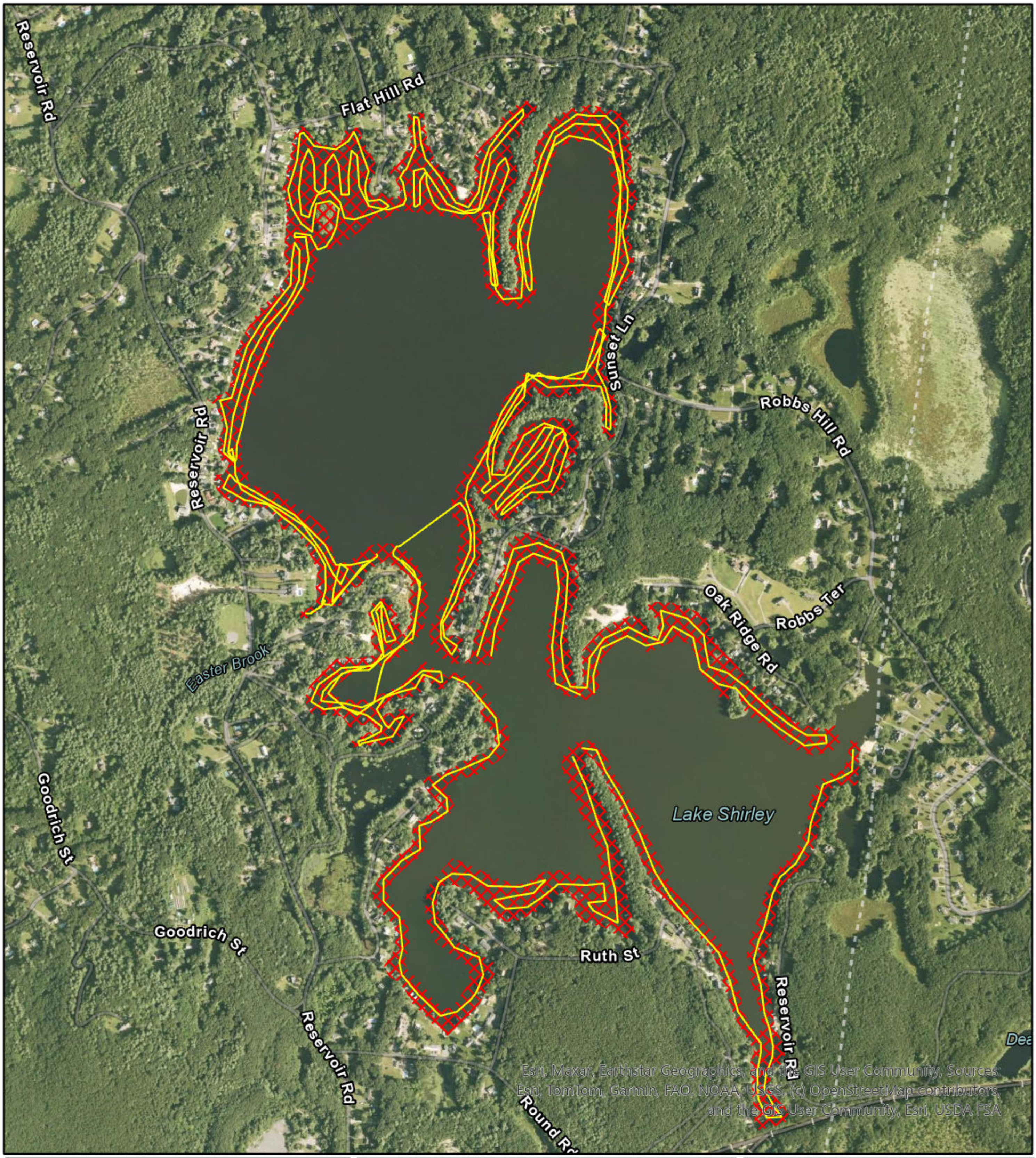
Monitoring of water clarity and algal populations (as necessary) provides timely information to guide algaecide treatments should such treatments be warranted. It continues to be of paramount importance to ensure that the water clarity monitoring is conducted on a regular basis (weekly or bi-weekly depending on general observation) from May-October and that results are provided to SOlitude and other project partners so that algaecide treatments are scheduled in a timely manner. Should treatment of cyanobacteria be required in 2026, copper sulfate is again proposed for use.

We recommend LSIC continue to pursue an integrated approach to manage nuisance plants and algae utilizing drawdown and herbicide/algaecide as required. To address overall lake management and long-term goals, the LSIC should continue the investigation and implementation of alternative in-lake methods, watershed management, public education and diagnostic assessments.

We hope this report will be of help to LSIC in planning for 2026 and beyond. If you have any questions regarding this report, please feel free to contact me. We look forward to working with you again in the future.

Figure 1: Lake Shirley - April Treatment Areas & Tracks

SŌLITUDE
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Lake Shirley
Lunenburg/Shirley, MA
WORCESTER COUNTY

N

0 1,100 2,200 Feet

1:12,000

Map Date: 11/26/2025
Prepared by: D. Meringolo
Office: SHREWSBURY, MA

Figure 2: Lake Shirley - May Treatment Areas & Tracks

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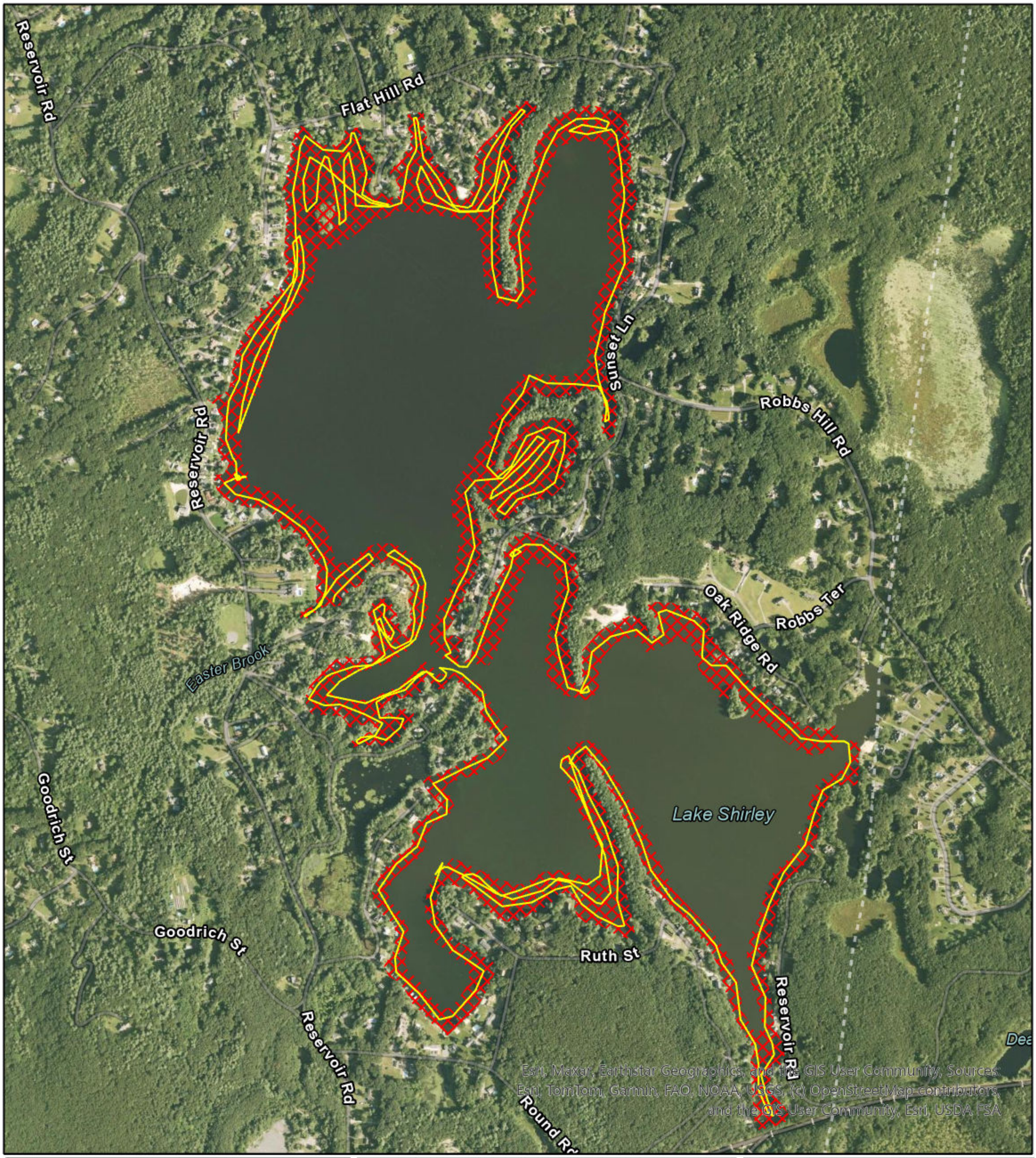
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Lake Shirley
Lunenburg/Shirley, MA
WORCESTER COUNTY

N

0 1,100 2,200 Feet
1:12,000

Map Date: 11/26/2025
Prepared by: D. Meringolo
Office: SHREWSBURY, MA

Figure 3: Lake Shirley - June Treatment Areas & Tracks

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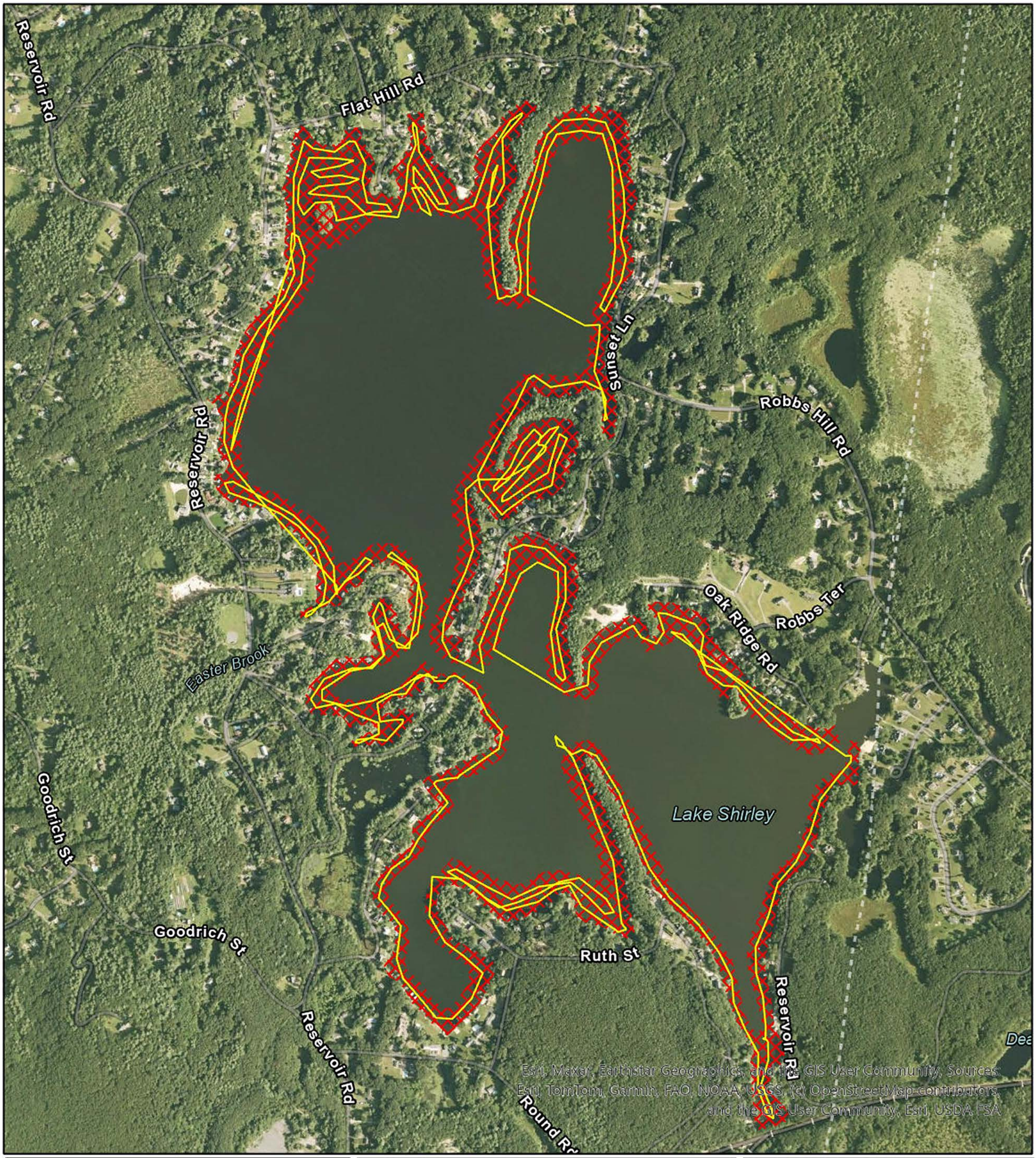

Lake Shirley
Lunenburg/Shirley, MA
WORCESTER COUNTY

N

0 1,100 2,200 Feet
1:12,000

Map Date: 11/26/2025
Prepared by: D. Meringolo
Office: SHREWSBURY, MA

Figure 4 - FasTEST Sample Sites

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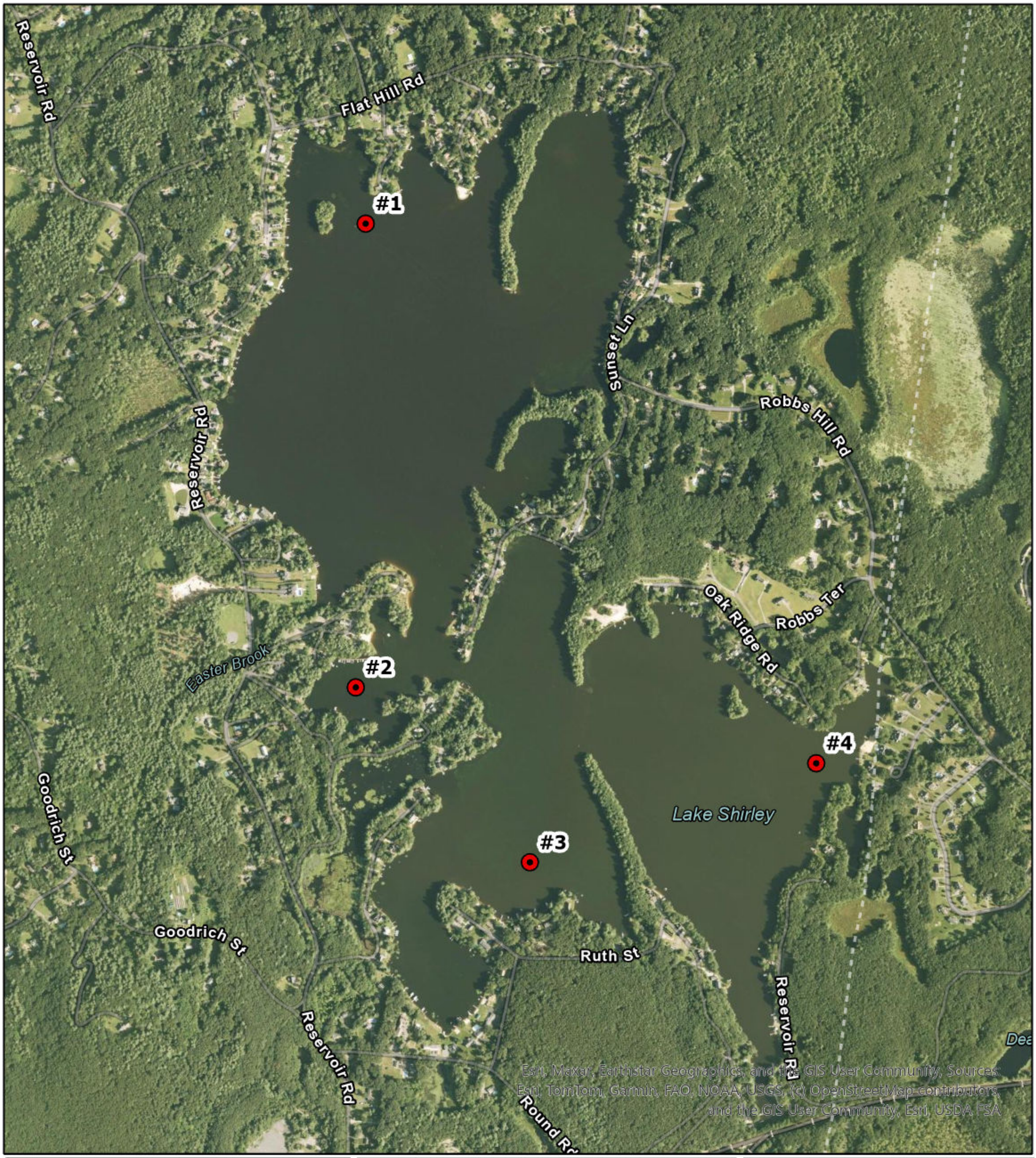

Lake Shirley
Lunenburg/Shirley, MA
WORCESTER COUNTY

N

0 1,100 2,200 Feet
1:12,000

Map Date: 6/10/25
Prepared by: D. Meringolo
Office: SHREWSBURY, MA