Lake Shirley
Lunenburg/Shirley, Massachusetts
2019 Year-End Report

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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. Multiple monitoring events, herbicide/algaecide treatments and reporting are key tasks of the project.

All management activities were consistent with the Order of Conditions [DEP File #284-0388 (Shirley), DEP File #208-1064 (Lunenburg)] and the License to Apply Chemicals issued by MA DEP (#19364)

The bulk of this year's program was conducted under existing Orders of Conditions issued by the Conservation Commissions in the Town of Shirley and the Town of Lunenburg. The LSIC submitted a new Notice of Intent with the Lunenburg Conservation Commission this summer to obtain a new Order of Conditions for this project moving forward. A Lake Management Plan (LMP) was developed in 2016 as dictated by the 2015 OOC, containing approved guidelines for determining treatment activities. Minor revisions to the LMP have been made over the years, but the LMP and now the new OOC issued by the Town of Lunenburg will serve to provide the regulatory basis for conducting management of nuisance aquatic weeds and algae at Lake Shirley. A chronology of the 2019 program's primary milestone activities is as follows:

- Pre-treatment inspection..... June 17th
- Issuance of License to Apply Chemicals permit from MA DEP..... July 23rd
- Reward (diquat)/Nautique (copper) herbicide treatment for tapegrass/naiad..... July 25th
- Monitoring of microscopic algae and Secchi Disk water clarity by LSIC..... May-October
- Post-treatment, late summer plant inspection..... September 13th

Pre-Treatment Survey

In past years, two pre-treatment surveys have sometimes been conducted. The early season survey, usually in May, was designed to evaluate the growth of early emerging species such as curly-leaf pondweed (*Potamogeton crispus*) and Eurasian milfoil (*Myriophyllum spicatum*). Due to the growth cycle of curly-leaf pondweed, it is especially important to manage this plant early, before reproductive structures (turions) are developed and released. Milfoil is also typically an early emerging species, but its frequency of occurrence has been minimal over recent years.

Due to the relatively low amount of curly leaf and milfoil growth over the last few years and also due to budget and permit issues, no early season survey was conducted this year. The objective of the mid-season, pre-treatment plant survey, which served as the only pre-management survey in 2019, is to document the lake-wide density and distribution of plant species throughout the lake. Typically, under the two-treatment approach, the timing and methodology of the mid-season survey is intended to better represent potentially problematic, native species such as tapegrass (*Vallisneria americana*) and European (spiny) naiad (*Najas minor*) among others. The 2019 mid-season survey served to assess the growth of all invasive species [fanwort (*Cabomba caroliniana*), curly-leaf pondweed, Eurasian milfoil and variable milfoil (*Myriophyllum heterophyllum*)] as well as identify any nuisance growth of native plant species.

The survey was conducted using an expanded methodology, which is a combination of SLM's historical qualitative assessment and Geosyntec's more quantitative procedures. In addition to recording data on the general plant assemblage, point data was collected at 66 data points throughout the lake (See **Figure 1**). At each point, data was collected on the species composition (species present), plant growth density and plant biomass. These are the same locations and point #'s used by Geosyntec in past reports.

The mid-season, pre-treatment survey was conducted on June 17th. Bladderwort (*Utricularia spp*.), fanwort and tapegrass were the most commonly observed plants in the lake. Leafy Pondweed (*Potamogeton foliosus*) was also prevalent although this species was not historically recorded in prior surveys of the lake. Curly-leaf pondweed was observed at seven locations, and neither Eurasian nor variable milfoil were observed during the survey. While substantial areas of fanwort were observed, this plant is currently not being actively managed with herbicides due to funding and other constraints. The practice of winter drawdown at the Lake has provided some control of fanwort.

Based on criteria put forth in the LMP, any areas of the lake with non-native species and other areas with either a density or biomass index of 3 or greater, would be potentially targeted for treatment. Due to the presence of non-curlyleaf pondweed and nuisance growth of native plants, approximately 77 acres were designated for treatment. The pre-treatment report, which includes plant survey data and the proposed treatment map, is **attached**. The Commission approved this treatment at their July 17th meeting.

Herbicide Treatment

As previously mentioned, no early-season treatment, targeting curly-leaf pondweed, was performed. A mid-season treatment was conducted on July 25th, for tapegrass, naiad and any remaining curly-leaf pondweed that persisted at the end of the growing cycle. Treatment was conducted with Reward (diquat) and Nautique (copper) herbicides. All proposed areas were treated.

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 an 18-foot Jon boat equipped with tank, pump, and sub-surface injection system. By injecting the diluted herbicide sub-surface, it eliminates the potential for aerial drift. GPS guidance was used to monitor the position of the boat and its relation to the treatment areas. The treatment proceeded smoothly and without difficulty, **Figure 2** shows the GPS recorded treatment tracks. A summary of the treatment specifications is as follows.

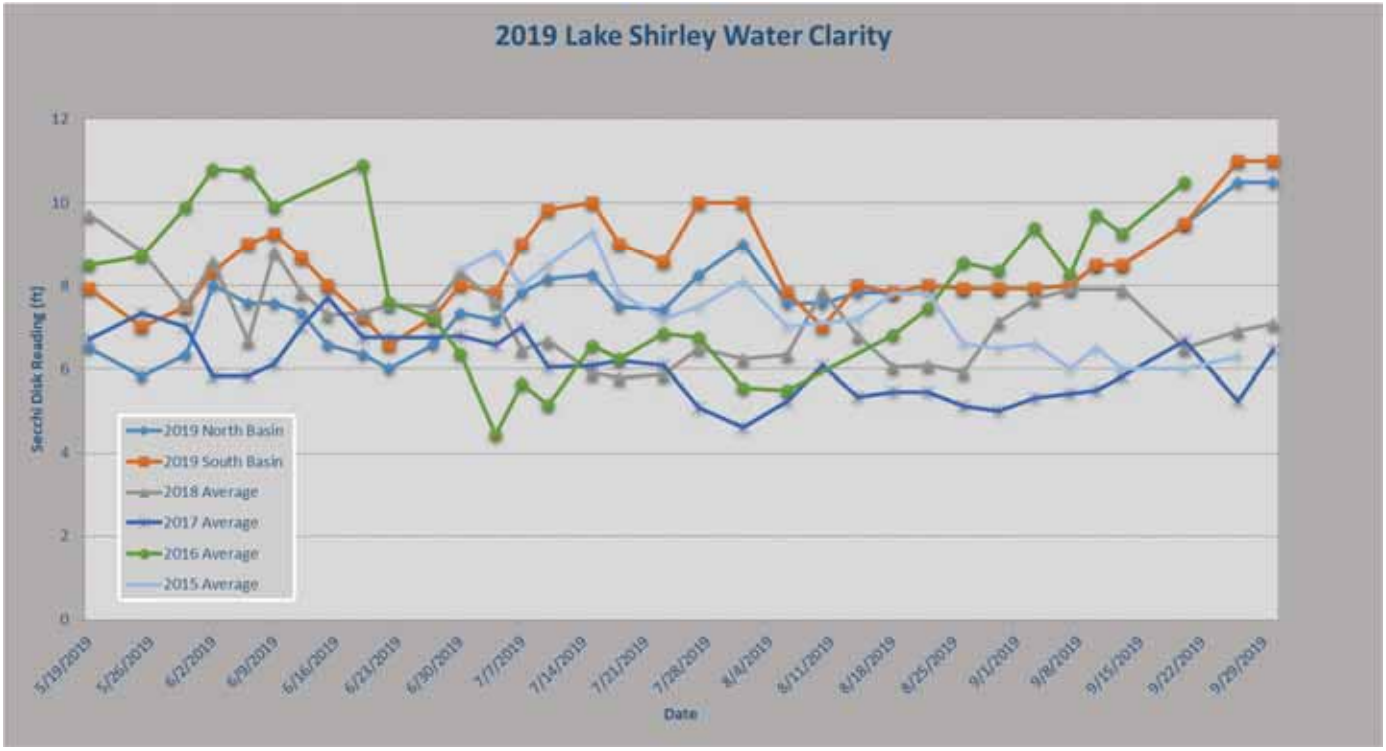
Table 1 – Mid-Season Treatment Specifications

Treatment Date	July 25th
Product	Reward (diquat) & Nautique (copper)
Treatment Area	77 acres
Quantity	86 gallons – Reward 99 gallons – Nautique
GPS Tracks	See Figure 2
Applicator name	Colin Gosselin, MA Certification #24004
Site Conditions	Weather: Partly to Mostly Cloudy, light winds 5-8 MPH NW, 77^{o}F Water Temp: 26.4^{o}C at surface, 24.1^{o}C near bottom Dissolved Oxygen: 7.7 mg/l at surface; 3.7 mg/l near bottom (9-feet) Water clarity: 5’9”

Algae & Water Clarity Monitoring

Water clarity was monitored closely again this year and readings were taken starting in the beginning of May and continuing through the end of September. The following graph shows the water clarity in the North and South Basins over the course of the season along with the 2015-2018 lake-wide averages for comparison.

Graph 1 – Water Clarity



Water clarity was excellent this year and never fell below the 5-foot sampling trigger at any point during the monitoring period. In fact, on only one occasion did the clarity drop below 6 feet (May 25th in the North Basin). As expected, there is some variation over the course of the summer with "lower" clarity periods observed in May, late June and mid-August, but readings were generally near or above 8-feet for most of the period after July. Clarity in both basins went from 8-feet to over 10-feet in September, which is usually a critical time for potential algae blooms.

We recommend maintaining the current trigger criteria and continuing to collect samples as a composite of the top three feet of the water column, when clarity drops below 5-feet. Additionally, during critical periods, SOLitude Biologists can also examine samples for a preliminary assessment. The lab has made available an expedited turnaround process (for a higher cost) that the LSIC will consider budgeting for next summer in order to get more timely results.

Late Season Survey

The late season survey was performed on September 13th. The survey followed the same methodology as the spring and prior year's surveys. At each point, data was collected on the species composition (species present), plant growth density and plant biomass. **Figure 1** (attached) shows the location of data points in Lake Shirley.

Table 2 (below) shows the percentage of points exhibiting each category of plant density along with the average density index for each year of the survey (2002-2019).

Table 2: Plant Growth Density Estimates, Fall 2002-2019

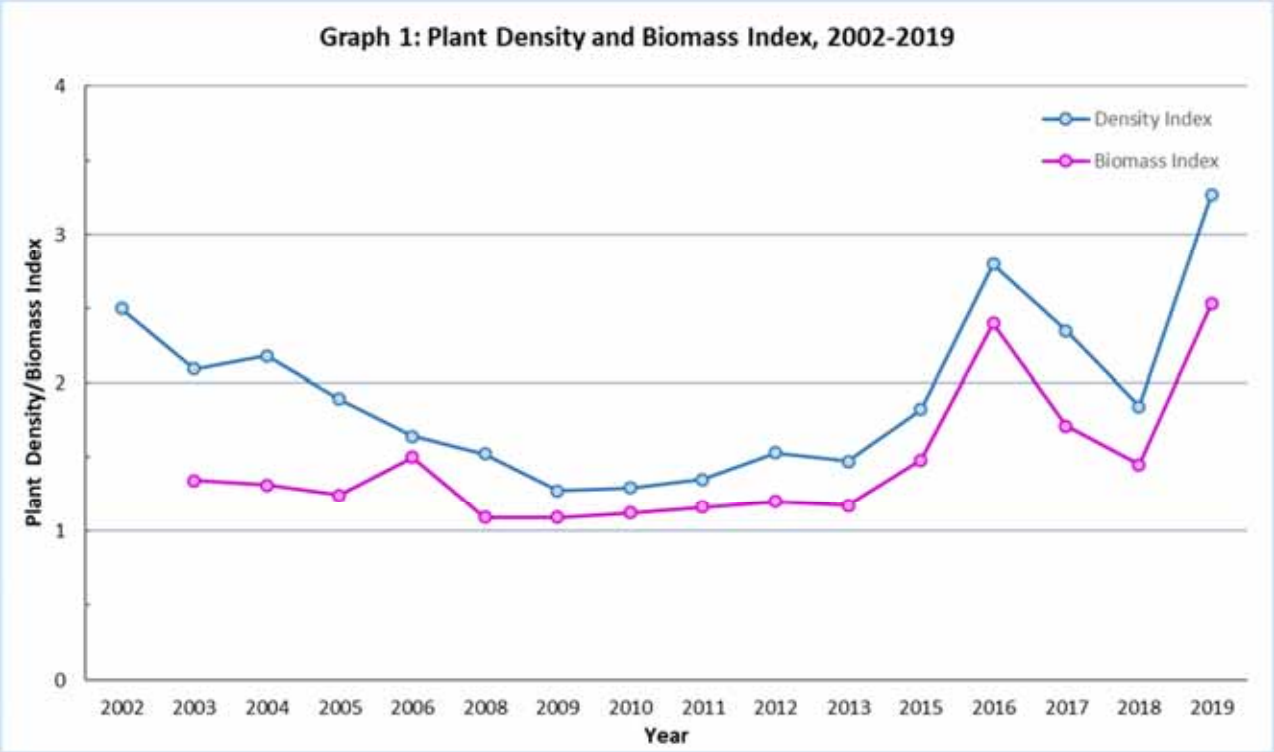
Density Rating	% of stations															
	2002 (n=64)	2003 (n=65)	2004 (n=66)	2005 (n=66)	2006 (n=66)	2008 (n=66)	2009 (n=66)	2010 (n=66)	2011 (n=66)	2012 (n=66)	2013 (n=66)	2015 (n=66)	2016 (n=66)	2017 (n=66)	2018 (n=66)	2019 (n=66)
1: Sparse 0-25%	14	11	17	27	45	59	79	77	77	65	65	32	12	17	38	5
2: Moderate 26-50%	36	72	58	61	42	33	17	17	14	20	23	50	24	38	39	11
3: Dense 51-75%	36	15	17	8	9	5	3	6	6	12	9	17	37	30	15	36
4: Very Dense 76-100%	14	3	9	5	2	3	2	0	3	3	3	2	27	15	8	48
Density Index	**2.50**	**2.09**	**2.18**	**1.89**	**1.64**	**1.52**	**1.27**	**1.29**	**1.35**	**1.53**	**1.47**	**1.82**	**2.80**	**2.35**	**1.84**	**3.27**

Table 3 (below) shows the number of points exhibiting each category of plant biomass, along with the average biomass index for each year of the survey.

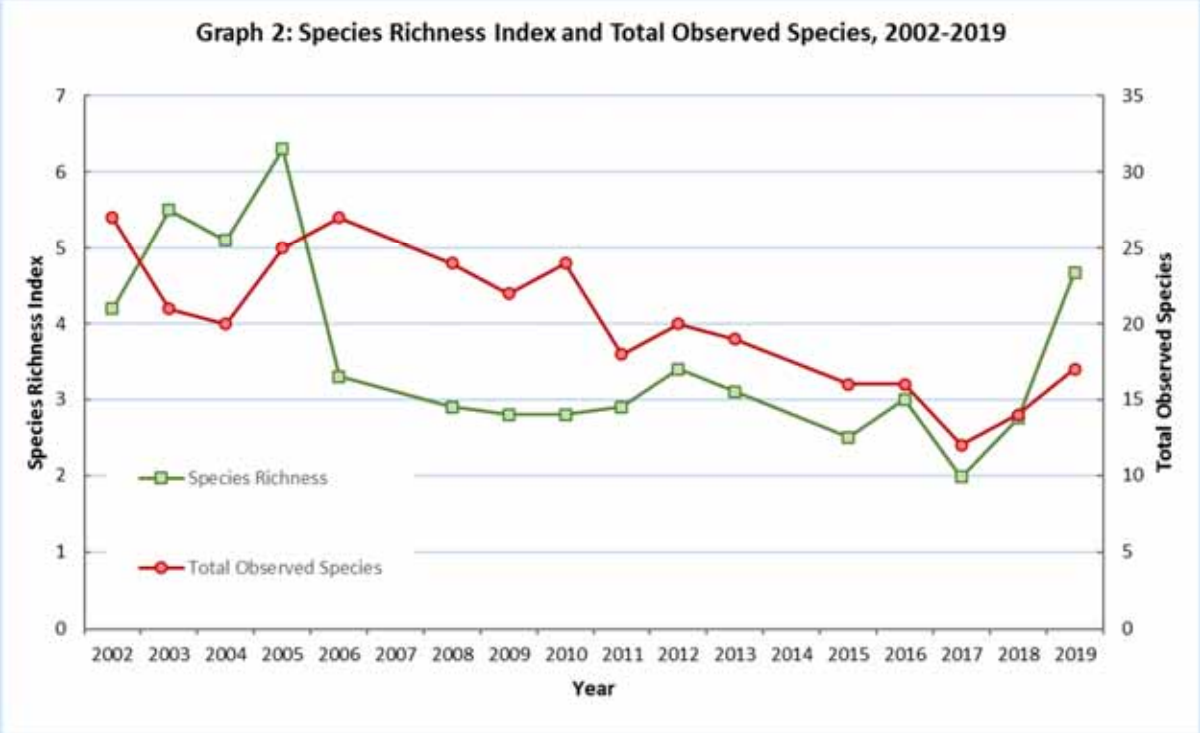
Table 3: Plant Biomass Estimates, Fall 2003-2019

Biomass Rating	% of stations														
	2003 (n=65)	2004 (n=66)	2005 (n=66)	2006 (n=66)	2008 (n=66)	2009 (n=66)	2010 (n=66)	2011 (n=66)	2012 (n=66)	2013 (n=66)	2015 (n=66)	2016 (n=66)	2017 (n=66)	2018 (n=66)	2019 (n=66)
1: Scattered plant growth; or primarily at lake bottom	69	80	77	59	91	92	91	88	82	88	73	21	33	61	8
2: Less abundant growth, or in less than half of water column	29	12	21	33	9	6	6	8	17	5	21	35	56	26	24
3: Substantial growth through majority of water column	2	6	2	6	0	2	3	5	2	8	6	30	8	12	24
4: Abundant growth throughout water column to surface	0	2	0	2	0	0	0	0	0	0	0	14	3	1	10
Biomass Index	**1.34**	**1.31**	**1.24**	**1.50**	**1.09**	**1.09**	**1.12**	**1.16**	**1.20**	**1.17**	**1.48**	**2.40**	**1.71**	**1.45**	**2.53**

This year both plant density and biomass indices were considerably higher than in past years and were in fact the highest on record since sampling began in 2002. Only in 2016 were the indices even close to this level. Most of the increased density and biomass can be attributed to two plants, both non-native invasive species: fanwort and European (spiny) naiad. Fanwort is not currently managed by this program and saw a resurgence this year likely due to poor winter drawdown conditions last winter. European naiad is a very late emerging plant and was not even observed during the June survey which was used to designate treatment areas. The graph below shows the change in the average indexes over time.



Another useful metric is the species richness index (average number of species observed at each point) and the total number of species observed. The following graph shows these metrics over time.



Both species richness and the total number of species observed increased again this year, continuing a trend since historical lows in 2017. In general, species with very low occurrence can be difficult to observe from year to year and substantially account for variability in species richness from year to year. Predominance of non-native species such as fanwort can negatively impact species diversity as well. This year's improved water clarity can help to promote the growth of native species and make them easier to observe.

The following are some general notes on this year's vegetation assemblage. Older data and summaries of historical growth can be found by referring to previous Year-End reports prepared by SOLitude and older survey data collected by Geosyntec. The complete point data table from the 2019 surveys are shown on the next page. **Figure 3 & 4** shows the late season plant density and biomass represented by color coded points.

General Notes

- Non-native milfoil species, which dominated the lake prior to management, continue to be absent.
- Curlyleaf pondweed growth, which peaked in 2016 continues to be observed in more moderate amounts on an annual basis. No curlyleaf pondweed is typically observed in the fall survey due to its growth cycle.
- Fanwort growth was heavy this year due to poor drawdown conditions last winter.
- European naiad emerges after the June survey and was particularly dense this year, although the same general pattern was observed in 2018. Since it was actively growing in June at the time of the pre-treatment survey, many area that exhibited dense growth later in the season were not treated.
- Tapegrass continue to be one of the most dominant and consistently problematic species in the lake, observed with similar occurrence to 2017, but dominant at fewer points.
- Naiad species can sometimes be difficult to distinguish depending on phenology and there could be some issues with identification during historical surveys.

The following table show a list of the consistently observed species in Lake Shirley and the % of stations present each year during the period 2016-2019

Plant Species		% stations present			
Common Name	**Scientific Name**	2019	2018	2017	2016
Fanwort	**Cabomba caroliniana**	75.76%	27.27%	10.61%	27.27%
Wild Celery	Valisneria americana	75.76%	45.45%	48.48%	78.79%
Bladderwort	Utricularia Sp.	75.76%	24.24%	33.33%	9.09%
Slender Naiad	Najas flexillis	45.45%	30.30%	60.61%	77.27%
European Naiad	**Najas minor**	90.91%	59.09%	0.00%	60.61%
Ribbon-leaf Pondweed	Potamogeton epihydrus	1.52%	3.03%	1.52%	1.52%
Clasping-leaf Pondweed	Potamogeton perfoliatus	18.18%	10.61%	4.55%	12.12%
Leafy Pondweed	Potamogeton foliosus	1.52%	0.00%	0.00%	0.00%
Coontail	Ceratophyllum demersum	7.58%	4.55%	1.52%	1.52%
Flatstem Pondweed	Potamogeton zosteriformis	3.03%	1.52%	0.00%	0.00%
Robbin's Pondweed	Potamogeton robbinsii	0.00%	1.52%	1.52%	3.03%

From the table,

- Less common native species such as ribbonleaf pondweed, clasping leaf pondweed and coontail have maintained consistent presence in the lake and in some cases have increased since 2016.
- Two new species, leafy pondweed and flatstem pondweed were observed in the last two years.

- Robbins pondweed is known to be resistant to diquat and copper products, but has fluctuated at very low levels since before 2016.
- Clasping leaf pondweed increased from 11% in 2018 to 18% in 2019.
- Despite herbicide treatments, the overall assemblage of vegetation in Lake Shirley is diverse.
- Timing of surveys and pre-approval from the Conservation Commission based on LMP criteria continues to be a challenging aspect of this program and sometimes results in areas of the lake not being treated that later exhibit problematic growth. We will continue to work with the Commission to make decisions on treatment areas based on pre-treatment survey data as well as known, historical areas of problematic growth.
- Although there have been some fluctuations in individual species, the lake has maintained and a fairly stable amount of native plant growth over the years.
- While herbicide treatments help to reduce the severity of growth, treated areas are by no means left devoid of plant growth and the presence of target species remains even following treatment.
- Fall growth this year was dominated by fanwort and European naiaid, with the higher fanwort growth likely caused by a less effective winter drawdown and growth of naiad possibly heightened by the better that average water clarity.

Table 5: Fall Aquatic Vegetation Survey Results

Date: September 19, 2019 X= Present D = Dominant

Common Name	Scientific Name	# stations present	# stations dominant	% stations present	% stations dominant
Fanwort	*Cabomba caroliniana*	50	12	76%	18%
Waterweed	*Elodea canadensis*	1	0	2%	0%
Wild Celery	*Valisneria americana*	50	16	76%	24%
Bladderwort	*Utricularia Sp.*	50	7	76%	11%
Musk Grass	*Chara sp.*	0	0	0%	0%
Stonewort	*Nitella sp.*	3	0	5%	0%
Small Pondweed	*Potamogeton pusillus*	17	1	26%	2%
Slender Naiad	*Najas flexillis*	30	0	45%	0%
European Naiad	*Najas minor*	60	25	91%	38%
Filamentous Algae	*Various*	16	2	24%	3%
Northern Naiad	*Najas gracilima*	0	0	0%	0%
Curlyleaf Pondweed	*Potamogeton crispus*	0	0	0%	0%
Ribbon-leaf Pondweed	*Potamogeton epihydrus*	1	0	2%	0%
Clasping-leaf Pondweed	*Potamogeton perfoliatus*	12	1	18%	2%
Leafy Pondweed	*Potamogeton foliosus*	1	0	2%	0%
Coontail	*Ceratophyllum demersum*	5	0	8%	0%
Flatstem Pondweed	*Potamogeton zosteriformis*	2	1	3%	2%
Yellow Waterlily	*Nuphar variegata*	6	0	9%	0%
White Waterlily	*Nymphaea odorata*	4	0	6%	0%
Water Starwort	*Callitriche sp.*	0	0	0%	0%
Quillwort	*Isoetes sp.*	1	0	2%	0%
Robbin's Pondweed	*Potamogeton robbinsii*	0	0	0%	0%

Monitoring Locations

Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Fanwort	D	X	X	X	D	X		D	X	X	D	X	X	X	X	X	X		X	X	X	X
Waterweed																						
Wild Celery	X	X	X	D	X	X	D		X	X	X		X	X	X	D	D		X	X	X	
Bladderwort	X	X	X	X	X	X	X	X	X	D	X	D	X	X	X	X	X		X	D	X	D
Musk Grass																						
Stonewort																						
Small Pondweed			X								X		X		X						D	X
Slender Naiad	X	X									X		X		X	X					X	
European Naiad	X	D	D	X	X	D	X	X	D	X	X	X	D	D	D	X	X		D	X	X	X
Filamentous Algae					X																	
Northern Naiad																						
Curlyleaf Pondweed																						
Ribbon-leaf Pondweed																						
Clasping-leaf Pondweed			X									X	X	X	X	X	X					
Leafy Pondweed																						
Coontail		X																X				
Flatstem Pondweed																		D				
Yellow Waterlily																						
White Waterlily																		X				
Water Starwort																						
Quillwort																	X					
Robbin's Pondweed																						
Species Richness	5	6	6	4	5	4	3	3	4	4	6	4	7	5	7	6	6	3	4	4	6	4
Plant density Index	3	3	3	3	3	4	2	4	2	4	3	4	4	4	2	3	3	4	3	4	4	4
Plant biomass index	3	3	4	4	3	3	2	2	2	3	3	3	3	3	2	3	2	2	2	3	2	3

Common Name	23	24	24a	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Fanwort		X				D	X	D	X	X	X	X	X	D	D	D	X		X		
Waterweed					X																
Wild Celery		X		X		X	X	X	D	D	D	X	D	X	X	X	X	D	D	X	
Bladderwort	X	D	X	D		X	X	X	X	X	X	X	X	X	X	X	X				
Musk Grass																					
Stonewort																		X			
Small Pondweed		X	X				X		X			X	X					X			
Slender Naiad	X	X	X	X		X	X		X		X	X				X	X	X		X	
European Naiad	D	X	D	X	D	X	X	X	X		X	D		X		X	D	X	X	D	X
Filamentous Algae		X			X														X	X	D
Northern Naiad																					
Curlyleaf Pondweed																					
Ribbon-leaf Pondweed																					
Clasping-leaf Pondweed							D				X							X	X		
Leafy Pondweed																			X		
Coontail	X									X				X							
Flatstem Pondweed		X																			
Yellow Waterlily									X	X			X								
White Waterlily										X											
Water Starwort																					
Quillwort																					
Robbin's Pondweed																					
Species Richness	4	8	4	4	3	5	7	4	7	6	6	6	5	5	3	5	5	6	6	4	2
Plant density Index	4	3	3	3	1	4	3	4	4	4	4	4	4	3	3	4	3	4	4	4	4
Plant biomass index	3	2	1	2	1	2	3	2	3	3	4	3	4	3	3	4	3	4	4	2	2

Common Name	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62a	63	64
Fanwort	X	X	X	X	D	X	X		X	X	X	X	D		X			X	X	D			
Waterweed																							
Wild Celery	D	D	X	D	X	D	X		D	X	X	X			X			D				X	X
Bladderwort			X	X		X	X	X	X			D	X		X				X	X	X		X
Musk Grass																							
Stonewort	X																		X				
Small Pondweed		X								X			X		X								
Slender Naiad				X		X	X	X		X					X	X				X		X	X
European Naiad	X	X	D	X	X		D	D	X	D	D	X	X	D	D	D		X	D	X	D	X	D
Filamentous Algae		X		X				X		X	X		X							X	X	D	X
Northern Naiad																							
Curlyleaf Pondweed																							
Ribbon-leaf Pondweed												X											
Clasping-leaf Pondweed												X											
Leafy Pondweed																							
Coontail																							
Flatstem Pondweed																							
Yellow Waterlily	X		X		X																		
White Waterlily	X											X											
Water Starwort																							
Quillwort																							
Robbin's Pondweed																							
Species Richness	6	5	5	6	4	4	5	4	4	6	4	7	5	1	6	2	0	3	4	5	3	4	5
Plant density Index	4	4	4	3	4	2	3	2	3	3	4	4	4	2	4	2	0	4	3	2	3	3	3
Plant biomass index	4	3	3	2	4	2	2	1	2	2	2	4	2	3	3	1	0	2	2	1	2	1	3

***Non-native, invasive species**

Key to Density and Biomass Indices

Value	Density (% cover)	Biomass
0	Absent: 0%	No growth
1	Sparse: 1-25%	Scattered plant growth; or primarily at lake bottom
2	Moderate: 26-50%	Less abundant growth; or in less than half of water column
3	Dense: 51-75%	Substantial growth through majority of water column
4	Very Dense: 76-100%	Abundant growth throughout water column to surface

Drawdown Report

The following table presents outflow data for the 2018/2019 drawdown refill period. The lake level log for the 2018/2019 drawdown is included in the attachments.

Table 6 – Outflow Rates During Refill (2019)

Outflow Rates during refilling of Lake Shirley
at Catacunemaug Bridge

Date	Reading	Flowrates CFS
3/01/19	1.82	29.36 CFS
3/05/19	1.82	29.36 CFS
3/09/19	1.68	20.93 CFS
3/13/19	1.52	13.43 CFS
3/19/19 water flowing over spillway. lake is full.		

Anticipated Management in 2020

Based on the results of the 2019 management program, we anticipate seeing continued, minimal growth of watermilfoil this coming summer, however there is a likelihood that curly-leaf pondweed will be present in significant proportions early in the season as well as fanwort a short time after. Native growth, primarily tapegrass and naiad will also likely require management later in the season. We will continue to proceed and determine treatment needs based on the established criteria. While we continue to recommend planning for a two-treatment approach, herbicide applications can be combined, as has been the case in recent years, depending on observed growth and availability of funding.

The proposed plan for 2020 is as follows

Table 8 – Proposed Plan for 2020

Task	Schedule	Notes/Criteria
Early Season Survey	Mid/late April	Survey for early emerging plants, primarily curlyleaf pondweed but also milfoil. Survey will be conducted at established survey points but will not include full collection of data.
1st Treatment	Early/Mid May	Treat all areas of the lake with curlyleaf pondweed and milfoil
Mid-Season Survey	Late June/Early July	Full data point survey
2nd Treatment	Mid-Late July	Treat any additional areas of non-native growth, plus selected areas of problematic native plant growth based on density/biomass criteria.
Late Season Survey	Late September/early October	Full data point survey

Reward herbicide alone will provide good control of milfoil, curly-leaf pondweed and naiad. Tapegrass is sometimes more difficult to control and, if needed, a combination of Reward and a copper-based herbicide (Nautique) or algaecide (Captain/copper sulfate) should be used to increase effectiveness and produce more desirable results.

If desired and approved by the LSIC, areas of fanwort could be treated with the flumioxazin (ex. Clipper) herbicide. Unlike Sonar (fluridone) which has been discussed in the past, Clipper works quickly and can be used effectively to spot-treat relatively small areas of fanwort. The timing for treatment of the fanwort will most likely coincide with the 2nd treatment for later season growth. The on-going issue with the use of Clipper is that under current regulations, the same areas of the lake can only be treated once every 4 years unless it's in the immediate vicinity of a high-use area such as a beach or boat launch. While it's possible this condition may be lifted in the future, for it will be necessary to either rotate the areas treated with Clipper or treat subsections of larger areas of fanwort over the course of multiple years.

In order to use Clipper and other forms of copper besides copper sulfate, approval for use of the new products must be sought from the Shirley Conservation Commission. The Order of Conditions from the Town of Lunenburg allows the use of alternate products pending approval of annual treatment plans.

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 the algae be required in 2020, copper sulfate is again proposed for use.

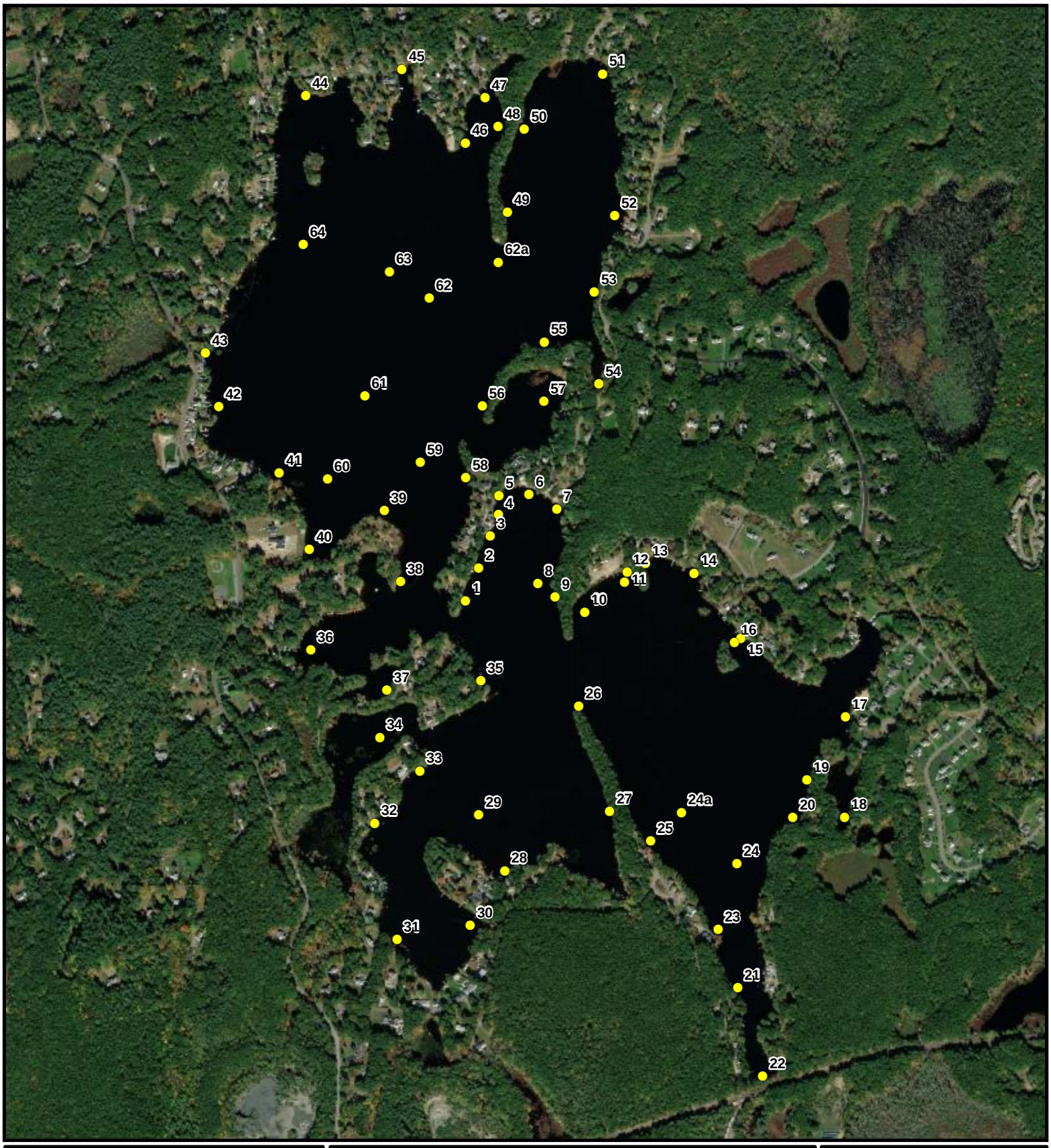
We recommend LSIC continue to pursue an integrated approach to manage nuisance plants and algae utilizing drawdown and herbicide/algaecide as required. To address overall lake management and long-term goals, the LSIC should continue the investigation and implementation of alternative in-lake methods,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

We hope this report will be of help to LSIC in planning for 2020 and beyond. If you have any questions regarding this report, please feel free to contact me. We look forward to working you again in the year ahead.

2019 Year-End Report

ATTACHMENTS

- Figures
  - Figure 1 – Survey Points
  - Figure 2 – Herbicide Treatment Map with Tracks
  - Figure 3 – Late Season Survey Plant Density Map
  - Figure 4 – Late Season Survey Plant Biomass Map
- 2019 Pre-Treatment Report
- Lake Level Log



Lake Shirley

Lunenburg/Shirley, MA

Survey Points

FIGURE:	SURVEY DATE:	MAP DATE:
1		11/27/17

N

Survey points

0 250 500 1,000 1,500 2,000 Feet

SOLITUDE LAKE MANAGEMENT

11 JOHN ROAD
SUTTON, MASSACHUSETTS 01590
PHONE: (508) 865-1000
FAX: (508) 865-1220
WEB: WWW.AQUATICCONTROLTECH.COM

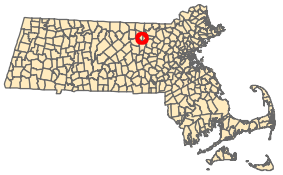


Figure 2 - Recorded GPS Treatment Tracks

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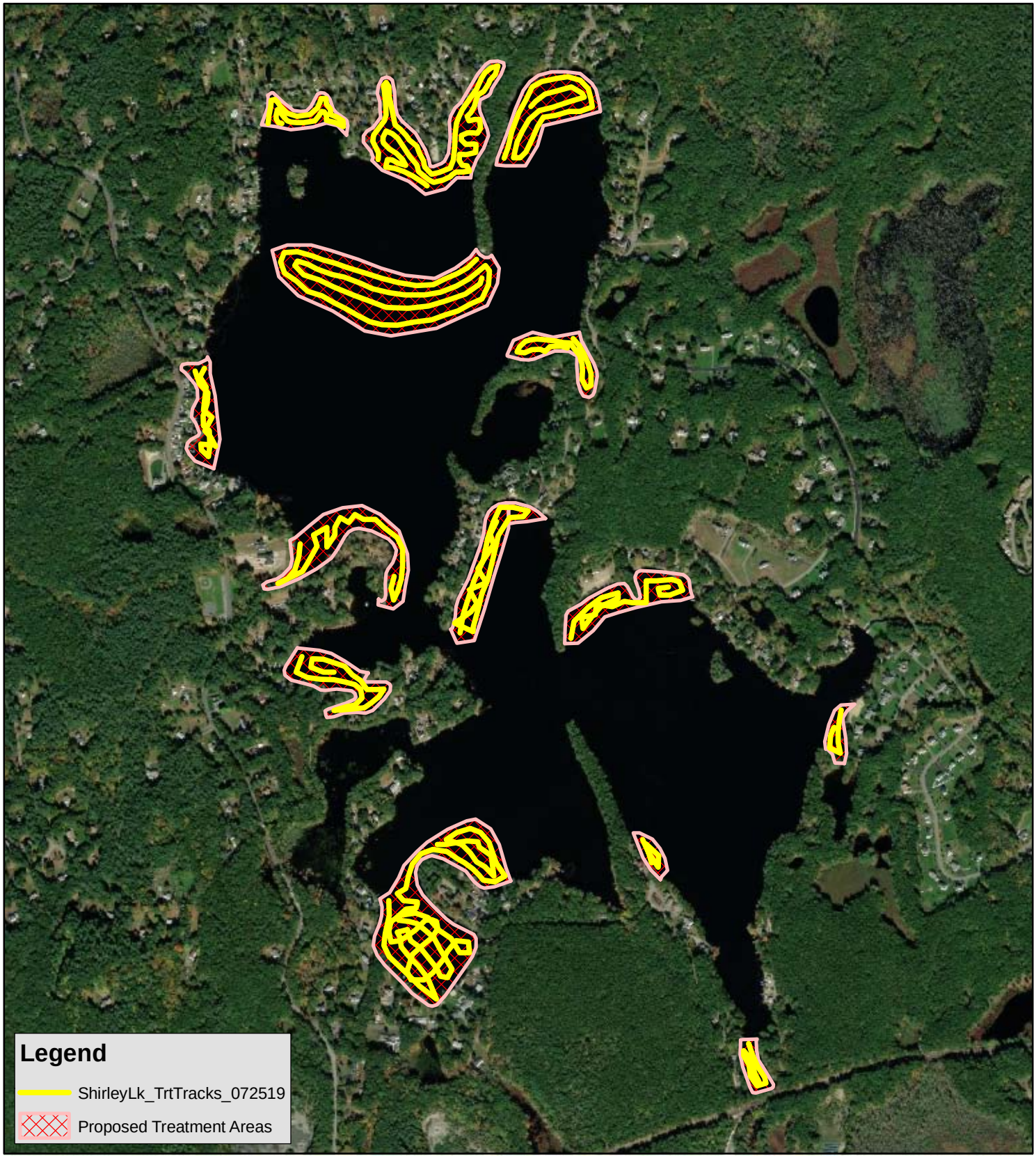
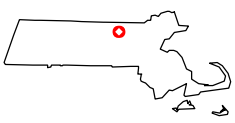
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Lake Shirley
Lunenburg, MA



Lake Shirley

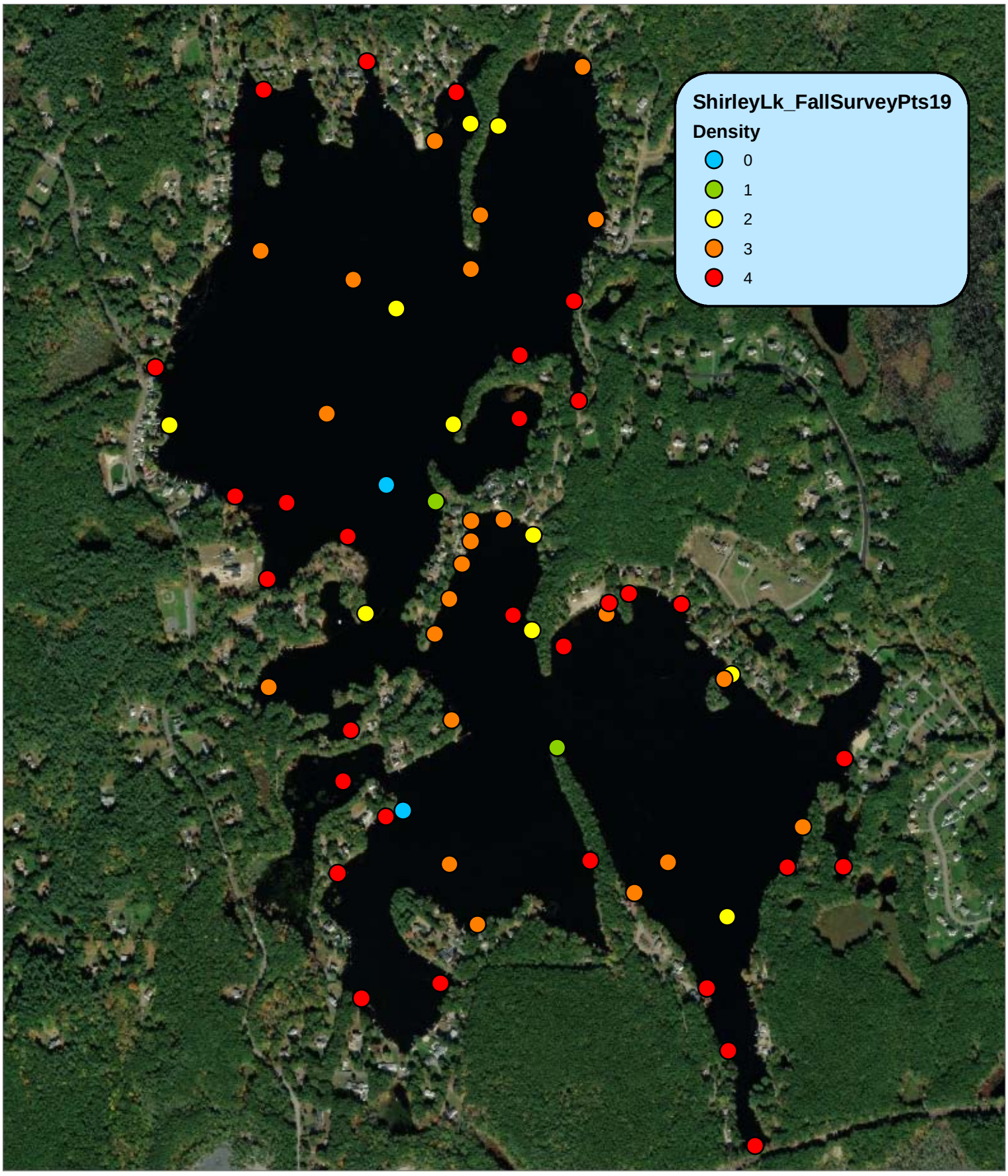
0 910 1,820 Feet

1:11,868

N

Map Date: 11/27/19
Prepared by: DMM
Office: SHREWSBURY, MA

Figure 3: Late Season Plant Density



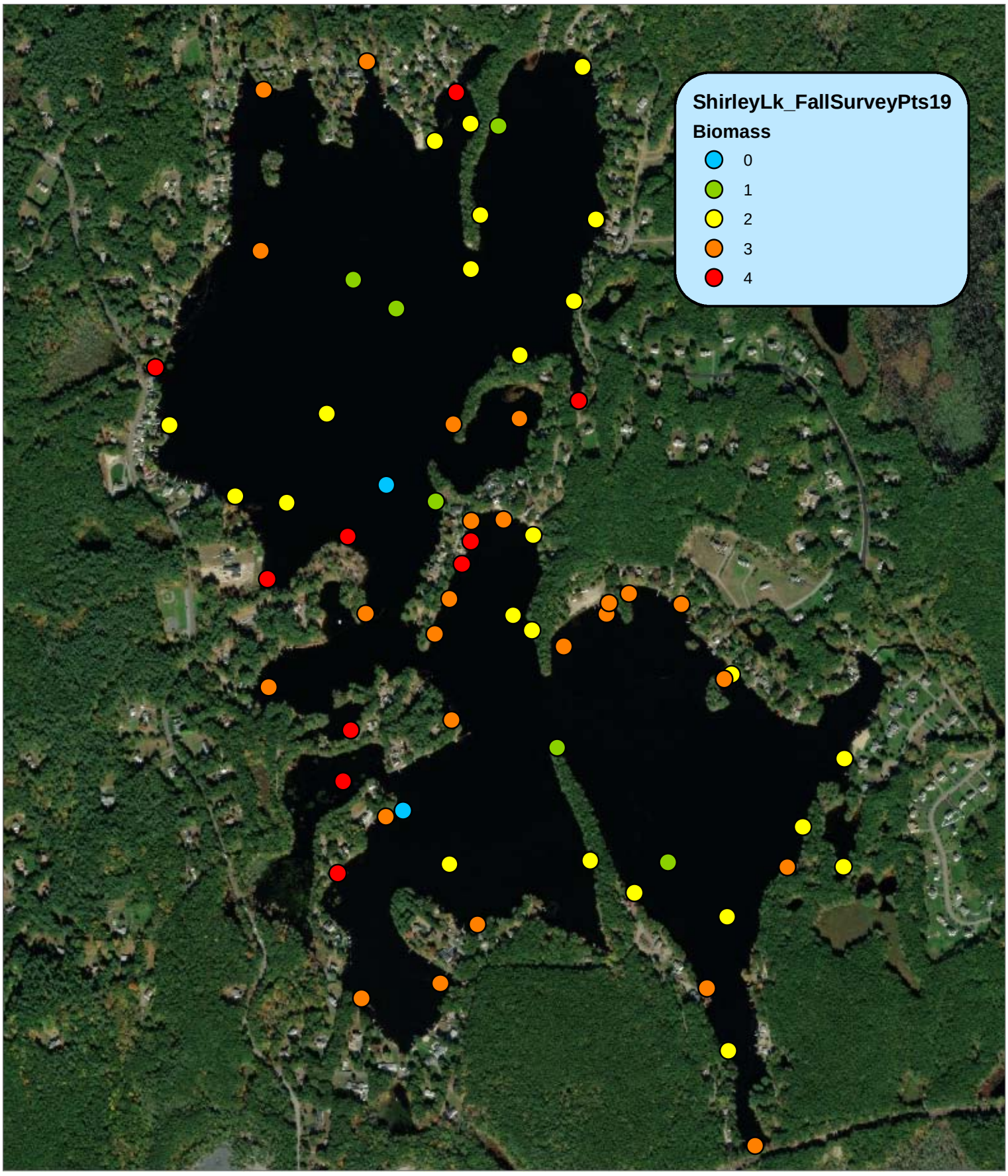
Shirley, Lake
Lunenburg/Shirley, MA

0 305 610 1,220
1:10,560 Feet

N

SOLITUDE LAKE MANAGEMENT

Figure 4: Late Season Plant Biomass



Shirley, Lake
Lunenburg/Shirley, MA

0 305 610 1,220
1:10,560 Feet

N

SOLITUDE LAKE MANAGEMENT

590 Lake Street
Shrewsbury, MA 010545

Phone: (508) 865-1000
FAX: (508) 865-1220
e-mail: info@solitudelake.com
Internet: www.solitudelakemanagement.com

Date: July 16, 2019

To: Lunenburg Conservation Commission

From: Dominic Meringolo, Senior Environmental Engineer/Regional Leader

Re: Lake Shirley – Survey and Treatment Plan for Mid-Season Weed Treatment

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Dear Commissioners,

Based on a survey conducted by our Biologists on June 17th, we are recommending treatment to approximately 77-acres of Lake Shirley to manage nuisance weed growth, primarily naiad (*Najas sp*.) and tapegrass (*Vallisneria Americana*). Per the Lake Management Plan, areas of the lake that exhibit either density or biomass factors of 3 or greater (>50%) are candidates for management. Additionally, any growth of non-native species, in this case curlyleaf pondweed (*Potamogeton crispus*) can also be treated. Some candidate areas were not designated for treatment due to their proximity to undeveloped shorelines and/or the presence of non-nuisance species (ex. Stonewort/Chara) or unmanaged species such as fanwort (*Cabomba caroliniana*).

The entirety of the Southwest cove of the middle basin (bordered by Round Road, Parmenter Street and Johnson Street) has been designated for treatment based on observations of tapegrass growth not captured by data points. This shallow cove has historically been one the most heavily grown in areas of the lake with tapegrass.

Treatment is tentatively scheduled for July 25th. The Reward (diquat) herbicide will be used for this treatment at a rate of 1.0-1.5 gallons per acre and a copper-based product, either Nautique or copper sulfate will also be applied in areas dominated by tapegrass.

A map of the recommended treatment areas is attached as well as the June survey data table. The LSIC will be attending the July 17th meeting of the Conservation Commission to discuss this plan and answer any questions.

Regards,
SOLitude Lake Management

Dominic Meringolo

Dominic Meringolo
Senior Environmental Engineer/Regional Leader

Proposed Treatment Areas (July 2019)

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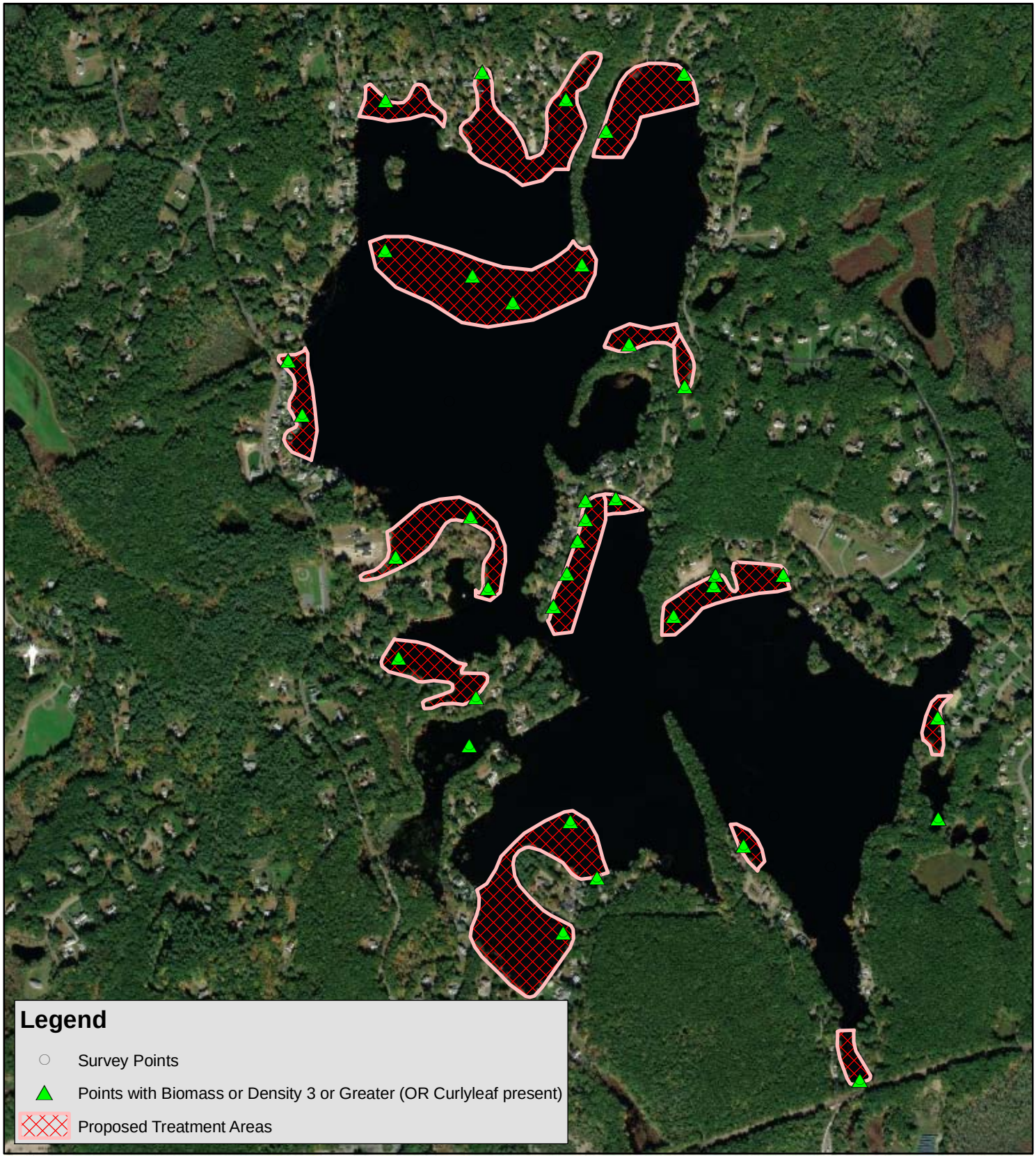
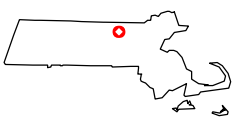
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Lake Shirley
Lunenburg, MA



Lake Shirley

0 820 1,640 Feet

1:11,848

N

Map Date: 07/15/19
Prepared by: DMM
Office: SHREWSBURY, MA

Table 1: Aquatic Vegetation Survey Results

Date: June 17, 2019 X= Present D = Dominant

Plant Species: Common Name	Scientific Name	# stations present	# stations dominant	% stations present	% stations dominant
Fanwort	*Cabomba caroliniana*	27	15	41%	23%
Waterweed	*Elodea canadensis*	1	0	2%	0%
Wild Celery	*Valisneria americana*	30	5	45%	8%
Bladderwort	*Utricularia Sp.*	34	10	52%	15%
Musk Grass	*Chara sp.*	2	1	3%	2%
Stonewort	*Nitella sp.*	4	4	6%	6%
Thin-leaf Pondweed	*Potamogeton sp.*	0	0	0%	0%
Slender Naiad	*Najas flexillis*	12	0	18%	0%
European Naiad	*Najas minor*	0	0	0%	0%
Filamentous Algae	*Various*	7	4	11%	6%
Northern Naiad	*Najas gracilima*	10	2	15%	3%
Curlyleaf Pondweed	*Potamogeton crispus*	7	0	11%	0%
Ribbon-leaf Pondweed	*Potamogeton epihydrus*	2	1	3%	2%
Clasping-leaf Pondweed	*Potamogeton perfoliatus*	8	2	12%	3%
Leafy Pondweed	*Potamogeton foliosus*	26	11	39%	17%
Coontail	*Ceratophyllum demersum*	4	0	6%	0%
Flatstem Pondweed	*Potamogeton zosteriformis*	0	0	0%	0%
Yellow Waterlily	*Nuphar variagata*	6	0	9%	0%
White Waterlily	*Nymphaea odorata*	2	0	3%	0%
Water Starwort	*Callitriche sp.*	0	0	0%	0%
Robbin's Pondweed	*Potamogeton robbinsii*	1	0	2%	0%

Monitoring Locations

Common Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Fanwort	D	X	D	D	D	D			D		D	X		X			X	X				X
Waterweed	X																					
Wild Celery			X			X	X							X	D	X	X				X	X
Bladderwort	X	D	X	X		X	X				X	D				D		X				X
Musk Grass																						
Stonewort							D							D			D					
Thin-leaf Pondweed																						
Slender Naiad				X												X		X			X	
European Naiad																						
Filamentous Algae																						
Northern Naiad														X			X	X			D	X
Curlyleaf Pondweed						X											X					
Ribbon-leaf Pondweed																						
Clasping-leaf Pondweed								X			X	X	D									
Leafy Pondweed	X					X		D		D	X											D
Coontail																						
Flatstem Pondweed																						
Yellow Waterlily										X												
White Waterlily																						
Water Starwort																						
Robbin's Pondweed																		X				
Species Richness	4	2	3	3	1	5	3	2	1	2	4	3	1	4	1	3	5	5	0	0	3	5
Plant density Index	3	3	4	4	4	4	2	2	1	1	3	3	1	3	1	2	3	4	0	0	2	4
Plant biomass index	2	2	2	2	3	2	1	2	1	4	2	2	1	1	1	1	2	4	0	0	1	3

Common Name	23	24	24a	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
Fanwort						D	X	X					X	D	D	D	X					X	X
Waterweed																							
Wild Celery							X	X	X		D	X				X	X			X	X	X	
Bladderwort		D	X	D			D	X	X	D		X	X		X	X	D			X			X
Musk Grass									X														
Stonewort																							
Thin-leaf Pondweed																							
Slender Naiad									X								X	X					X
European Naiad																							
Filamentous Algae			X																X		D		
Northern Naiad									X								X			X			
Curlyleaf Pondweed															X		X						X
Ribbon-leaf Pondweed																							D
Clasping-leaf Pondweed																X		D	X				X
Leafy Pondweed							X	D		X		X	D		X	X		X	D	D		D	
Coontail															X								
Flatstem Pondweed																							
Yellow Waterlily									X		X											X	
White Waterlily										X												X	
Water Starwort																							
Robbin's Pondweed																							
Species Richness	0	1	2	1	0	1	4	4	6	3	2	3	3	1	5	5	6	3	3	4	2	5	6
Plant density Index	0	2	2	3	0	1	3	4	3	2	2	2	4	1	4	4	3	4	4	2	3	4	3
Plant biomass index	0	1	1	1	0	1	2	3	2	1	2	2	4	1	2	3	3	4	3	1	2	3	2

Common Name	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	62a	63	64
Fanwort	D		D							D			D								
Waterweed																					
Wild Celery	X	X	X		D	X	X	X	X	X				D		D					
Bladderwort		X			X	D	X	X		X	X			X					D		
Musk Grass				D																	
Stonewort															D						
Thin-leaf Pondweed																					
Slender Naiad	X					X													X		X
European Naiad																					
Filamentous Algae		D																D	X	D	
Northern Naiad								D										X			
Curlyleaf Pondweed	X		X																		
Ribbon-leaf Pondweed										X											
Clasping-leaf Pondweed																					
Leafy Pondweed			X			X	X	X			D	D	X						X		D
Coontail									X	X											X
Flatstem Pondweed																					
Yellow Waterlily										X						X					
White Waterlily																					
Water Starwort																					
Robbin's Pondweed																					
Species Richness	4	3	4	1	2	4	3	4	2	6	2	1	2	2	1	2	0	2	4	1	3
Plant density Index	4	2	4	2	2	3	4	2	1	4	4	1	1	1	1	1	0	3	3	3	3
Plant biomass index	3	1	2	1	2	2	2	2	1	3	2	1	1	1	1	2	0	1	1	1	2

*Non-native, invasive species

Key to Density and Biomass Indices		
Value	Density (% cover)	Biomass
0	Absent: 0%	No growth
1	Sparse: 1-25%	Scattered plant growth; or primarily at lake bottom
2	Moderate: 26-50%	Less abundant growth; or in less than half of water column
3	Dense: 51-75%	Substantial growth through majority of water column
4	Very Dense: 76-100%	Abundant growth throughout water column to surface

Drawdown 2018 Lake Shirley Dam

Date	Time	Mid Valve	Low Valve	Levels
12/6/2018	11:05	Open	Open	+
12/7/2018	10:05	"	"	+
12/8/2018	9:30	"	"	+
12/11/2018	9:15	"	"	0
12/12/2018	10:00	"	"	
12/13/2018	10:00	"	"	-2
12/14/2018		"	"	-4
12/15/2018	9:05	"	"	-6
12/16/2018	9:15	"	"	-8
12/18/2018	9:00	"	"	-8
12/20/2018	5:30	"	"	-10
12/22/2018	10:15	"	"	-8
12/23/2018	4:30	"	"	-6
12/24/2018	9:00	"	"	-6
12/27/2018	8:30	"	"	-8
12/28/2018	9:00	"	"	-9
12/31/2018	8:30	"	"	-10
1/3/2019	9:00	"	"	-10
1/5/2019	9:00	"	"	-11
1/7/2019	9:00	"	"	-13
1/9/2019	1:30	Closed	"	-15
1/11/2019	9:30	"	"	-15
1/13/2019	9:30	"	Closed 100	-17
1/17/2019	9:30	"	Closed 225	
1/23/2019	12:00	Open	Open	

1/24/2019		"	"	
2/3/2019	9:30	Closed	"	-15
2/6/2019	8:30	"	"	-15
2/8/2019	9:00	"	"	-12
2/12/2019	9:30	"	"	-11
2/16/2019	9:00	"	"	-12
2/20/2019	9:30	"	Open	-13
2/25/2019	10:00	"	"	-13
3/1/2019	12:30	"	"	-14
3/5/2019	1:00	"	Closed 150	-16
3/9/2019	9:00	"	Closed 210	-15
3/13/2019	10:30	"	Closed 225	-15
3/16/2019	10:00	"	"	-11
3/19/2019	8:30	"	"	
3/20/2019	9:00	"	Open	+2
3/24/2019	9:30	"	"	+3
3/26/2019	12:30	"	Closed	+2
3/30/2019	9:00	"	"	+5
4/3/2019	9:00	"	"	+6
4/7/2019	10:00	"	"	+5
4/11/2019	9:00	"	"	+6
4/15/2019	11:00	"	"	+8
4/19/2019	9:00	"	"	+5
4/24/2019	9:10	Open	"	+6
4/28/2019	10:10	"	"	+7
5/1/9/19	4:00	"	"	+5
5/6/2019	8:30	"	"	+5

5/8/2019	8:30	Closed	"	+4
5/11/2019	1:30	"	"	+6
5/13/2019	9:30	"	"	+5
5/17/2019	10:00	"	"	+5
5/22/2019	9:40	"	"	+5
5/28/2019	9:00	"	"	+4
6/6/2019	9:15	"	"	+5
6/12/2019	1:00	"	"	+4
6/18/2019	9:15	"	"	+4
6/25/2019	3:00	"	"	+5
7/2/2019		"	"	+4
7/9/2019	10:30	"	"	+5
7/17/2019	10:00	"	"	+5
7/23/2019	0:00	"	"	+4
7/30/2019	9:00	"	"	+4
8/7/2019		"	"	+3
8/14/2019	3:00	"	"	+3
8/20/2019	1:15	"	"	+2
8/28/2019	10:00	"	"	0
9/4/2019	10:30	"	"	+1
9/18/2019	2:00	"	"	0
9/25/2019	9:00	"	"	-1
9/2/2019	9:00	"	"	-1
10/9/2019	4:30	"	"	1
10/16/2019	9:15	"	"	0
10/17/2019		"	"	+4
10/18/2019		"	"	+5

10/19/2019	11:00	"	Open 150	+6
10/20/2019	2:00	"	"	+4
10/21/2019	9:00	"	"	+2
10/23/2019	9:20	"	"	-1
10/26/2019	9:00	"	"	+2
10/29/2019	9:00	"	"	+4
11/1/2019	2:00	"	"	+5
11/11/2019	0:00	"	"	+3
11/13/2019	9:10	"	"	+3
11/20/2019	8:45	"	"	+3
11/24/2019	3:30	Open 150	"	+6
11/26/2019	7:45	Open	Open	+2
11/27/2019	9:00	"	"	-1
11/29/2019		"	"	-4
11/30/2019		"	"	-7