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# TECHNICAL MEMORANDUM

**To:** David Morgan
Town of Arlington
730 Massachusetts Avenue
Arlington, MA 02474

**From:** Naomi Valentine, Ecological Restoration Team lead

**Date:** November 30, 2021

**Re:** **Spy Pond Management Summary Report / SWCA Job No. 68573.00**

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Dear Mr. Morgan:

***SWCA Environmental Consultants*** (SWCA) is pleased to present a summary of an assessment of Spy Pond in Arlington, Massachusetts. SWCA conducted a survey of Spy Pond on September 23, 2021. During this survey, SWCA staff collected water quality and algae samples for laboratory analysis and conducted a plant survey for submerged aquatic vegetation throughout the littoral zone of the pond. The purpose of this survey is to provide information to the Town of Arlington regarding the health of the waterbody as it pertains to recent management activities.

Other considerations and evaluations conducted with these data include potential sources of nutrient loading and the extent of aquatic plants as of the 2021 growing season. These data will be used to inform future management efforts and will be utilized as a comparison against past and future monitoring efforts. Also included in this document are recommendations for the management of invasive vegetation and algae, as well as methods to improve water quality around and within Spy Pond.

If you have any questions or comments, please do not hesitate in contacting me by phone at 413.658.2012 or by email at nvalentine@swca.com.

Sincerely,

Naomi Valentine
Ecological Restoration Team Lead

Joel Harris
Associate Project Environmental Scientist

# 1.0 OVERVIEW

Spy Pond is an approximately 103-acre kettle hole pond with a maximum depth of about 38 feet (in the north basin); however, water depths more commonly range from 6 to 19 feet.[1]. Spy Pond consists of two basins with small coves, which are separated by a substantial sill. The littoral zone within Spy Pond is approximately 40 acres and the sill that separates the basins accounts for more than half the littoral zone.

The pond is located in a densely settled area of Arlington, Massachusetts, adjacent to State Route 2. Although Spy Pond is a kettle hole pond, it receives water from Arlington Heights, Hills Pond and Menotomy Rocks Park, Route 2, and Belmont via a large storm drain in the western-most corner of Spy Pond. This storm drain drains approximately 57% of Spy Pond's watershed. The pond outlets to the southwest over a concrete outfall. This outfall leads to Little Pond in Belmont. Spy Pond was once the headwaters of the historic Great Swamp, which covered much of Cambridge Massachusetts[1], and now is a prominent feature in the 3.57-square-mile (2,282-acre) watershed that covers much of Belmont[2].

SWCA Environmental Consultants (SWCA) was tasked with assessing specific parameters within Spy Pond in 2021 to determine (1) the efficacy of these recent treatments, (2) effects of the dredging activities, and (3) to ascertain if or how management should be altered in the future. Furthermore, the assessment conducted aims to determine whether current management strategies for Spy Pond are effective in accomplishing the four pond goals detailed below. The data collected in SWCA's 2021 survey and presented in this report will act as a record of fall conditions in Spy Pond in 2021 and also as a record of post-treatment conditions.

### Spy Pond Management Goals

1. Water Quality and Control: to reduce the effects of urban runoff to control pollution, weeds, and algae, and to reduce shoreline erosion, in an ecologically sensitive manner.
2. Public Use and Access: to maintain and improve existing public access and review the possibilities for enhancing public access and recreation, while ensuring respect for private property.
3. Flora and Fauna: to promote a healthy diversity of plants and wildlife
4. Awareness: to create public awareness and focus the attention of government on the natural, economic, and cultural values of Spy Pond

## 1.1 Summary of 2021 Activities

The Town of Arlington, with assistance from the Spy Pond Committee, has performed numerous studies of Spy Pond over the years. They have also performed numerous water quality improvement and invasive vegetation management events. Treatments in 2021 included herbicide (diquat) application on May 20, 2021 and September 3, 2021. The May treatment targeted curly-leaf pondweed (*Potamogeton crispus*) with diquat (22.5 gallons) across approximately 20 acres. The September treatment targeted spiny naiad (*Najas minor*) across approximately 25 acres of the pond using 37.5 gallons of diquat. Pre-treatment surveys conducted by the Spy Pond Committee indicate that curly-leaf pondweed and spiny naiad were identified in Spy Pond during the 2021 growing season[1].

[1] Barber, Brad. September 16, 2021. *An Aquatic History of Spy Pond.* Spy Pond Committee. www.arlingtonma.gov/spypond.

[2] U.S. Geological Survey. 2016. The StreamStats program, online at http://streamstats.usgs.gov. Accessed in November 2021. Massachusetts Sustainable Yield Estimator version 2.0 (MA SYE) & Massachusetts StreamStats application.

The Massachusetts Department of Transportation also dredged the sandbar located in the western portion of the pond in 2021 (from May 24 to June 17) due to the accumulation of potentially contaminated sediment and sand and removed the stone pillars previously located near the storm drain in this area. Once the turbidity curtain in place for the dredging project was removed, local stakeholders noted the development of an algal bloom. As pollution control is one of the goals of the management program at Spy Pond, the Arlington Department of Public Works (DPW) installed a hydrodynamic separator was installed at the foot of Alfred Road, up-gradient of the input to Spy Pond[1].

SWCA conducted a survey of Spy Pond on September 23, 2021. During this survey, SWCA documented aquatic plants and collected water samples for standard water quality parameter analysis as well as algae identification and enumeration. This survey was conducted following an aquatic vegetation herbicide treatment. As the main purpose of this survey was to determine the effects of this treatment, SWCA waited the necessary 2 weeks following management before conducting our survey. Effects associated with herbicide efforts should be visible following this elapsed time. SWCA also noted the state of the bank around Spy Pond through visual observations. Bank observations and proposed improvements are included in Sections 4.0 and 5.5.2.1.1, respectively. SWCA also noted moderate (few) sightings of wading birds (great blue heron, etc.) during the September 23, 2021, and discussed the presence of Asian clams and eastern floaters (mussels) with project stakeholders during this visit. It may be possible to release mussel species (non-protected species only) into the pond to encourage native species development. However, this is not a practice that SWCA is aware of and further permitting and state program research would need to be conducted before pursuing this option.

All data collected during SWCA's survey of Spy Pond were geolocated with a submeter global positioning system (GPS) unit and have subsequently been projected onto the figure in Attachment A. This report identifies any points of concern in the water quality, algae, and aquatic plant sampling results and provides suggestions for potential pond and invasive plant management practices based on these findings.

# 2.0 PLANT COMMUNITY SURVEY

Full aquatic vegetative community surveys are commonly conducted in July and August because that is generally the time of year in which most aquatic plant species are most abundant. However, this aquatic plant survey aimed to determine the results of recent management activity; and therefore, was not scheduled until after the final treatment.

Surveys of vegetation in 2012[2] provide an overview of typical vegetation density within Spy Pond before herbicide application. Although algae concentrations were a significant problem in 2021, the density of invasive and nuisance vegetation is more frequently a concern within the waterbody. Table 1 includes a summary of vegetation density within the pond during the 2012 survey. Overall, the entire littoral zone was populated with invasive and aggressive native aquatic vegetation during the 2012 survey.

[1] Barber, Brad. September 16, 2021. *An Aquatic History of Spy Pond.* Spy Pond Committee. www.arlingtonma.gov/spypond.

[2] Aquatic Control Technology. 2012. *2012 Aquatic Management Program – Arlington, MA: Spy Pond, Arlington Mill Reservoir and Hills Pond. www.arlingtonma.gov/town-governance/boards-and-committees/envision-arlington/spy-pond-committee*

**Table 1. Spy Pond Vegetation Survey Results (June 2012)**[1]

| Vegetation | Distribution | Percent Cover | Other Notes |
|---|---|---|---|
| Eurasian milfoil, sago pondweed (less dense) | Western basin, 50% of the northwestern bank, west side of Rock Island, eastern-most cove, 50% of the southeastern littoral zone | 75% – 100% | |
| Eurasian milfoil, sago pondweed (less dense) | Eastern bank of Rock island and 50% of littoral zone in north basin, moderate pockets of the south basin | 4% – 40% | Light cover of filamentous algae |
| Sago and thin-leaf (less dense) pondweed, naiad | Central to northwestern littoral zone, pockets in southeastern-most littoral zone, and western basin/cove | 75% - 100% | |

Observations from 2021 are listed in Table 2 to better describe the usual density of vegetation before herbicide application. Submerged aquatic vegetation commonly becomes very dense by June each year and often grows up to and overtops the surface of Spy Pond.

**Table 2. 2021 Aquatic Vegetation Observations**[1]

| Species Name | Observation Date | Notes |
|---|---|---|
| Curly-leaf pondweed | April 15, 2021 | Plants up to 18 inches long, densest north and northeast of Elizabeth Island; some growing in waters up to 10 feet deep |
| Curly-leaf pondweed | April 25, 2021 | Plants up to 24 inches long, densest north of Elizabeth Island and northeast of Rock Island; some growing in waters up to 17 feet deep |
| Curly-leaf pondweed | May 2, 2021 | Up to 52 inches long in southwest cove; dense near Rock Island and north and west of Elizabeth Island |
| Curly-leaf pondweed | May 13, 2021 | Clearly visible north and northeast of Rock Island and Elizabeth Island (1 and 1.5 feet below surface, respectively); additional populations in southeast and southwest coves and west of Elizabeth Island toward the Kelwyn Manor ramp |
| Curly-leaf pondweed | May 27, 2021 | No living plants observed; some dead stems noted in southeast cove (where treatment was not performed) |
| Aquatic moss | June 16, 2021 | Observed near Spring Valley Road |
| Aquatic moss | June 26, 2021 | No other aquatics located |
| Aquatic moss | July 8, 2021<br>July 23, 2021 | Trace amounts in southwest cove, north of Rock Island, north basin near Pleasant Street shore |
| Spiny naiad | July 8, 2021 | Moderate to dense 18-inch-long plants in southwest cove; 9-inch-long plants in southeast cove |
| Spiny naiad | July 23, 2021 | Moderate to full-rake plants 27 inches long in southwest cove and north basin near Pleasant Street; moderate north and northeast of Rock Island at 18-27 inches; sparse amounts of 20-inch-long plants in southeast cove |
| Nitella (stonewort) | July 23, 2021 | Observed in moderate to dense populations at multiple sites |
| Thin-leaf pondweed | July 8, 2021<br>Jul 23, 2021 | Trace amounts of plants near the Kelwyn Manor boat ramp and other locations |
| Spiny naiad | August 5, 2021 | Dense 22-inch plants in southwest cove; medium 32-33-inch plants north of Rock Island and 74 Spy Pond Pkwy dock (18 inches) |
| Spiny naiad | August 15, 2021 | Full rake of plants in southeast cove (36 inches); medium density plants near Sheraton Park shore |

[1] Barber, Brad. September 16, 2021. *An Aquatic History of Spy Pond.* Spy Pond Committee. www.arlingtonma.gov/spypond.

| Species Name | Observation Date | Notes |
|---|---|---|
| Spiny naiad | August 23, 2021 | Dense patches (36 inches) on anchor northeast of Rock Island; and same size on anchor 70 feet from Gould Road |
| Spiny naiad | August 31, 2021 | Dense population in southeast cove (38 inches to 40 inches); north and northeast of Rock Island (36 and 45 inches, respectively); and in southwest cove |
| Aquatic moss | August 31, 2021 | Much of moss northeast of Rock Island in 7 feet of water; seen north of Rock Island |
| Spiny naiad | September 2, 2021 | Sample collected – no seeds found in sample |
| Spiny naiad | September 10, 2021 | Naiad dead or dying in all locations; up to 4 feet long |

*Note: Thick double line denotes treatment event between two observation dates. Treatment events took place on May 20 and September 3, 2021.*

On the day of the survey, water clarity within Spy Pond was low. This minimized visibility for a surface visual survey of submerged aquatic vegetation. This low visibility was partially due to algae presence within Spy Pond and partially due to generally high turbidity. Due to the water quality conditions at the time of the survey, SWCA conducted rake tosses throughout the littoral zone to generate a list of submerged aquatic plant species present as well as ascertain their relative abundance.

SWCA conducted rake tosses at 28 locations around the pond. No submerged or floating aquatic plant species were observed in any of the rake toss events. Remnants of plants were observed in a few of the rake tosses but consisted of dying portions of plant material and identification was inconclusive. The locations of the rake tosses are presented in Figure 1 (Attachment A). These results, paired with the observations detailed in Table 2, indicate that while the recent diquat treatment was certainly effective in eliminating the target species, it also eliminated all other submerged aquatic vegetation throughout the pond. SWCA understands that the project stakeholders are interested in retaining a percentage of the submerged aquatic vegetation community throughout the growing season. If this herbicide application was intended to be selective to one or a few species, the management strategy should be altered for more desired results. See Section 4 for recommendations on future management options.

# 3.0 WATER QUALITY AND ALGAE ANALYSIS

SWCA collected water samples during the September 23, 2021 survey and sent them to a lab for precise analysis of water quality parameters and algae identification and enumeration. The purpose of the sampling program was to identify post-management and year-end water quality within the pond and to determine if algae populations within the pond were a concern for public health, as they had been up to the September sampling date. As described above, microscopic (as well as other alga types) were observed within Spy Pond during this survey. Based on reporting from the project stakeholders and the summary of conditions and management from the Spy Pond Committee (Barber 2021), algal blooms and chronic discoloration have been observed in Spy Pond for several years. Algae have also been managed in previous years, although no algae management was conducted in 2021. See Section 3.2 for more details on algae presence in 2021 and past years.

SWCA collected five water samples from three locations on Spy Pond. The three locations are labeled in Figure 1 (Attachment A) as "West Basin (Sample 01)”, “West Basin – West Shore (Sample 02)”, and “North Basin (Sample 03)”. Secchi disk and turbidity readings were collected at Sample locations 01 and 03 (South and North Basins, respectively). Samples points 01 Deep and 01 Shallow were collected in the vicinity of the “deep hole” in the west basin and both samples were analyzed for water quality and algae. The deep sample at sample point 01 was collected at 8.9 meters below the surface. Sample point 02

(Bloom) was collected from shallow surface waters along the west shoreline of the west basin in an area with a visible collection of algae. Sample 02 was analyzed for algae only – no water quality parameters were analyzed from this sample. Sample points 03 Deep and 03 Shallow were collected from a location in the middle of the north basin with both samples submitted for water quality analysis. The deep sample at Sample point 03 was collected at 10.6 meters below the surface. Water quality sampling locations are presented in Figure 1 (Attachment A) and results are detailed in Table 3.

## 3.1 Water Quality Analysis Results

The four water quality samples were collected in pre-cleaned laboratory containers and submitted under chain of custody to SePRO Corporation (SePRO) of Whitakers, North Carolina. The samples were analyzed for water quality parameters pH, dissolved oxygen, conductivity, alkalinity, hardness, turbidity, as well as, nutrient parameters total phosphorus, free reactive phosphorus (FRP), total Kjeldahl nitrogen (TKN), nitrate/nitrites, and total nitrogen. Laboratory analytical results are summarized in Table 3 and laboratory analytical reports are provided in Attachment B.

**Table 3. Spy Pond Water Quality Analytical Results Summary**

| Date | 2007[1] | August 2012[1] | | | | September 2021 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Location | Average | North Basin (Site 1) | | South Basin (Site 2) | | North Basin (S03) | | West Basin (S01) | |
| Parameter / Depth | | *Surface* | *10M* | *Surface* | *5M* | Surface | 10.6M | Surface | 8.9M |
| pH (SU) | 8.07 | 7.54 | 6.6 | 7.32 | 6.58 | 8 | 6.8 | 7.8 | 6.9 |
| Dissolved Oxygen (mg/L) | NA | 9.19 | 0.14* | 7.85 | 0.20** | 9.3 | 5.8 | 9.2 | 6.9 |
| Conductivity (uS/cm) | NA | NA | NA | NA | NA | 929 | 1,331 | 901 | 1,048 |
| Alkalinity (mg/L as CACO3) | 41.6 | 37 | 60 | 46 | 69 | 31.8 | 80.8 | 30.7 | 68.3 |
| Hardness (mg/L as CACO3) | NA | NA | NA | NA | NA | 51.1 | 83 | 50.6 | 55.6 |
| Turbidity (NTU) | 1.31 | 0.69 | 5.5 | 1.6 | 7.25 | 6.72 | 4.57 | 8.07 | 34.5 |
| Secchi Disk (Feet) | NA | 8.0 | NA | 6.3 | NA | 3.5 | NA | 3 | NA |
| Total Phosphorus (ug/L) | 30 | 20 | 90 | 30 | 320 | 24.9 | 1,075 | 30.5 | 455.9 |
| Free Reactive Phosphorus (ug/L) | NA | NA | NA | NA | NA | 11 | 79 | <5 | 22 |
| Total Kjeldahl Nitrogen (mg/L) | 0.81 | 0.4 | 2 | 0.7 | 3.2 | 0.9 | 6.1 | 0.9 | 4.3 |
| Nitrates & Nitrites (mg/L) | 0.63 | <0.1 | 0.124 | <0.1 | 0.106 | 0.1 | <0.02 | 0.1 | 0.1 |
| Total Nitrogen (mg/L) | 1.44 | 0.4 | 2.12 | 0.7 | 3.31 | 1 | 6.1 | 1 | 4.4 |

*Note: NA = Not Available | * = measurement taken at 9 meters depth | ** = measurement taken at 6 meters depth*

As indicated in Table 3, Secchi disk readings ranged from 3 to 3.5 feet in both the north and west basins and turbidity readings ranged from 4.57 NTUs in the surface sample from the north basin to 34.5 NTUs in the deep sample collected from the western basin. Turbidity NTUs between 10 and 50 are considered moderate, while over 50 can cause harm to aquatic life. The turbidity within Spy Pond is still below the harmful level but should be monitored moving forward to ensure it does not worsen. The turbidity readings were higher than the readings taken in 2007 and 2012. Furthermore, Secchi disk readings from 2012 were more than twice as deep as those observed during the 2021 survey. These two data points suggest that clarity in the water is worsening, or at least that water clarity in Spy Pond in 2021 was substantially worse than in 2012. Water quality parameters including pH, dissolved oxygen, conductivity, alkalinity, and hardness were found to be in the acceptable ranges for freshwater. Furthermore, pH and alkalinity readings appear to correlate with previous sampling rounds.

[1] Aquatic Control Technology. 2012. *2012 Aquatic Management Program – Arlington, MA: Spy Pond, Arlington Mill Reservoir and Hills Pond. www.arlingtonma.gov/town-governance/boards-and-committees/envision-arlington/spy-pond-committee*

The SePRO analysis data indicate that concentrations of total nitrogen have increased over previous sampling rounds, especially in the deeper samples collected from the north and west basins. Nitrogen should typically remain below a concentration of 1 mg/L in freshwaters. While all readings for nitrites and nitrates for Spy Pond are well under 1 mg/L and some were below the recording level of 0.02 mg/L, total nitrogen and total Kjeldahl nitrogen (TKN) concentrations are all around 1 or greater than 1 mg/L, at potentially harmful levels. TKN essentially acts as a measure of total nitrogen (organic nitrogen, nitrate, and nitrate, as well as ammonia) within the waterbody. Since each component of TKN can have negative effects within the waterbody when elevated, this is the value of focus in this assessment. Increases in nitrogen can come from multiple sources, but one of the largest in Spy Pond is likely the death of vegetation following the diquat (herbicide) application two weeks before the 2021 sampling event. Plant decomposition results in a number of water chemistry changes: increased nitrogen and phosphorus, and decreased dissolved oxygen, among others.

In addition, total phosphorus, and free reactive phosphorus (FRP) concentrations in the deeper samples were found to be much higher than previous sampling events, at eutrophic to hypereutrophic levels. FRP includes the forms of phosphorus compounds that are readily available for uptake by plants and algae. In general, phosphorus levels during the September 2021 survey were found to be higher in the deep samples than in the surface samples. August 2012 data from Aquatic Control Technologies show a similar trend, with 20 to 30 ug/l of total phosphorus at the surface sample and significantly higher concentrations in deeper water samples. The north basin has a particularly high (hypereutrophic) concentration of phosphorus, which is far higher than previous readings. The deepwater samples in 2021 contained ten times the concentrations of phosphorus compared to those in 2012. Since most water contributions to this section of the pond are from over-ground flow and various stormwater basins, these data suggest that the increased rainfall and intensity of storm events in 2021 may have negatively affected the water quality of Spy Pond in the north basin.

Dredging activities and dewatering of dredged material in the west basin also could have been a contribution of phosphorus to that section of the pond, since the water that drained from the dewatering areas for that project were likely very high in nutrients. These nutrients would have been stored in the pond regardless; however, this process would have released any nutrients stored in the dredged material and resulted in a short spike in nutrients in the surface layer of the pond. The concern with this is that harmful algal blooms (HAB) could develop early and often each year in this region and spread to the rest of the pond. Furthermore, these nutrient-laden sediments could redistribute through other portions of the pond and may not necessarily stay in the west basin.

The high concentrations of total phosphorus/FRP levels, increased total nitrogen levels and high turbidity readings recorded in the deeper water column of the west basin are likely attributable to the stormwater runoff and the deposition of mineral and nutrient-rich sediment into Spy Pond. Stormwater events also can increase mixing in water bodies, which could result in more FRP readily available for algae uptake. Algal blooms from August 21 – August 31, 2021 were preceded by 3 inches of rain on August 19, 2021. The spike in nutrient levels and subsequent algal growth in 2021 could also be partially due to the rapid degradation of plant material following the September 2021 vegetation management event. The deeper water column of the north basin is also likely impacted by urban stormwater runoff from drainage culverts on the northern and eastern perimeter.

Based on the water quality testing described above, Spy Pond is a highly productive waterbody in a eutrophic to hypereutrophic state. Spy Pond has been eutrophic since the 1950s[1]. The increased nutrient levels and higher turbidity also correlate with the dense algal growth that was identified in the samples collected in the north and west basins, especially at depth, as described in Section 3.2.

[1] Cortell, J. 1973. Conditions in Spy Pond, Arlington, Massachusetts; a historical synopsis. Jason M. Cortell & Associates.

## 3.2 Algae Sampling Results

Algae concentration within Spy Pond was particularly high during the 2021 growing season. While algae have been observed in previous years, they have dissipated quickly in the past and/or limited themselves to the coves. Most algal blooms were noted following aquatic vegetation management, due to the decomposition of that plant material and the resulting nutrient spikes. SWCA was tasked with sampling algae within the pond to document the late-season concentration of the various algae species.

SWCA collected three water samples for algae identification and enumeration. These three algae samples were collected in pre-cleaned laboratory containers and submitted under chain of custody to SePRO. The samples were submitted for algae identification and calculation of density/biomass. Laboratory analytical results are summarized in Table 3 and laboratory analytical reports are provided in Attachment B.

**Table 3. Dominant Phytoplankton Genera**

| Sample Location | Depth (Meters) | *Genus (species when known) (Major Group)* | Density/Biomass (cells/mL) |
|---|---|---|---|
| West basin (01) | Surface | Microcystis (Cyanophyte) | **38,800** |
| | | Dilochospermum (Cyanoophyte) | **1,200** |
| | | Coelastrum (Chlorophyte) | <100 |
| | | Scenedesmus (Chlorophyte) | <100 |
| | | Pseudanabaena (Cyanophyte) | <100 |
| | | Trachelomonas (Euglenophyte) | <100 |
| West basin (01) | 8.9 | Microcystis (Cyanophyte) | **77,000** |
| | | Fragilaria (Bacillariophyte) | <100 |
| | | Micractinium (Chlorophyte) | <100 |
| | | Scenedesmus (Chlorophyte) | <100 |
| | | Dolichospermum (Cyanophyte) | <100 |
| | | Phormidium (Cyanophyte) | <100 |
| | | Planktolyngbya (Cyanophyte) | <100 |
| | | Pseudanabaena (Cyanophyte) | <100 |
| West Basin – W. Shore (02) | Surface | Microsystis (Cyanophyte) | **34,400** |
| | | Dolichospermum (Cyanophyte) | **3,800** |
| | | Fragilaria (Bacillariophyte) | <100 |
| | | Staurastrum (Charophyte) | <100 |
| | | Crucigenia (Chlorophyte) | <100 |
| | | Pseudanabaena (Cyaonophyte) | <100 |
| | | Trachelomonas (Euglenophyte) | <100 |
| North Basin (03) | Surface | Microcystis (Cyanophyte) | **9,900** |
| | | Dolichospermum (Cyanophyte) | **1,900** |
| | | Fragilaria (Bacillariophyte) | <100 |
| | | Closterium (Charophyta) | <100 |
| | | Aphanizomenon (Cyanophyte) | <100 |
| | | Pseudanabaena (Cyanophyte) | <100 |

| Sample Location | Depth (Meters) | *Genus (species when known) (Major Group)* | Density/Biomass (cells/mL) |
|---|---|---|---|
| | | Trachelomonas (Euglenophyta) | <100 |

As indicated in Table 3, analysis by biomass shows that Cyanophytes dominated the community biomass during the September 23, 2021 samples. Microcystis was identified at the highest density in this group, followed by Dolichospermum. Cyanobacteria, also known as blue-green algae, are capable of producing toxins that can pose significant risks to humans and wildlife, as well as producing taste and odor issues within the waterbody. The highest density of Microcystis identified out of the three samples was enumerated at 77,000 cells/mL. This sample was collected 8.9 feet from the surface in the deep portion of the west basin, which is considered a moderate exposure risk and above the 70,000 cell/mL limit set by the board of health. Moderate risk densities (20,000 to 100,000 mg/L) were also detected in the surface samples collected from the west basin and deeper samples from the north basin, although below the level set by the Board of Health.

Overall, the density of the HAB identified is a concern to human and wildlife health, particularly since these concentrations were recorded late in the growing season. The Board of Health issued a HAB advisory on August 27, 2021, due to conditions by the Route 2 storm drain (the southwestern portion of the pond), which is where algae blooms were the worst. However, a district green scum (likely cyanophyte algae based on the description) was noted as early as July 29, 2021 and a similar discoloration was noted in the west basin by August 14, 2021. By August 31, 2021, an extensive patch of HAB was noted in the north basin (in front of the Spy Pond Condominiums). Water clarity remained low and murky through October 2021. Algae samples were collected on October 4 and 11, 2021, and the HAB advisory was lifted on October 12, 2021. Previous Board of Health advisories were issued in 2007, 2008, and 2011.

While toxins were not directly tested, it is best to assume that these toxin-producers are actively producing toxins at any point in the year. Any amount of toxin is concerning and attempts to reduce the overall concentrations and biomass of HAB should continue to be a focus in future growing seasons.

It is possible that the death of vegetation following management activities in early September cause a spike in nutrient levels (phosphorus and nitrogen) and resulted in subsequent increases in the concentration of algae. However, without water quality readings from immediately before management, it is impossible to know with any certainty.

# 4.0 BANK STABILIZATION OBSERVATIONS

SWCA also made notes of bank stabilization around Spy Pond during the September 23, 2021 survey. These observations were conducted via visual survey only and did not include a detailed assessment of the bank, vegetation within bank and buffer, nor a detailed account of previous restoration success. SWCA also photo-documented much of the bank during the survey. Examples of different bank conditions around Spy Pond can be viewed in the attached photo pages (Attachment D).

Property owners around the pond have installed bank stabilization measures (stone armoring and coir log installation) in past years. These measures were observed in various states of stability and effectiveness during SWCA's survey. Many areas where stone have been installed are in good shape; however, there are large stretches of mown lawn that extend up to the top of the stone. This means that any nutrients or contaminants within or applied to the top of the lawn surface run directly into Spy Pond during storm events. The primary issue with highly manicured lawns up against pond banks is that there is almost no above-ground vegetation to slow the velocity of water, fines, and any particulates held within either before they enter the water. Furthermore, there is little chance that particulates and soil to settle in the buffer zone in a lawn setting. It is much more likely that they will flow directly into the water. Cutting grass at a taller height and installing hardier vegetation and shrubs at the top of the bank are small measures that can improve the quality of water entering the pond via overground/sheet flow.

The sections of coir logs that have been installed appear to be stable in all locations noted during SWCA's survey. However, most coir logs do not appear to be vegetated. This is fairly common because coir logs are very densely packed with coconut fiber. Some practitioners will attempt to aid the process of vegetation by punching holes in the coir logs and installing small, quick-growing shrubs (willows, dogwoods, etc.). Even this is not always extremely effective though, due to the density of the log surrounding each hole. The setting in which coir logs are most effective is when they are periodically inundated with water and/or washed over by nutrient-rich sediments. This allows sediment to fill in the coir logs as the coconut fiber compresses and/or decays. Vegetation can then more easily establish on the surface. The hope is that the roots of early established vegetation within or nearby the coir logs will fill in the space in which the coir log was originally installed. If vegetation does not establish, the section of the bank in which the coir log was installed will be left with an unvegetated and vulnerable hole once it fully decays or is dislodged. Therefore, regular maintenance of coir logs is very important to the long-term efficacy of this type of bank restoration. Additional soil and seed or containerized plant material can be added to help the natural process of revegetation in areas where coir logs have been installed.

There are also sections of the bank around the pond that are showing signs of erosion. Photo D-6 (Attachment D) is an example of the most common type of bank erosion noted during the September 2021 survey. The bank is more or less unvegetated aside from lawn and trimmed herbaceous material. There is a large tree growing right on the bank, the roots of which extend laterally along the bank for stability. However, it appears that the flow of water against the short (but abruptly steep) bank has begun to undercut the roots. The roots are now exposed and there is a section of the mid to lower bank that is unstable and will continue to erode if no action is taken. The sediments from the bank will continue to settle into the pond and increase the build-up of sediments (potentially nutrient-laden) within the pond.

There are sections of the bank around Spy Pond that are very well vegetated and stable. These sections are areas in which there is a stable emergent shelf, with herbaceous and woody hydrophytic vegetation behind (on the landward side) it, and larger shrubs and small trees in the layer behind that. Photo D-7 (Attachment D) shows a very good example of one such area in front of a home, although ideally the home would be set back further from the bank of the pond. These sections of high-performing vegetated and stable banks should be modeled in future bank stabilization efforts. See Section 5.2.1.1 for suggestions on bank restoration and examples of where they may be most useful.

# 5.0 SUMMARY AND RECOMMENDATIONS

SWCA's survey of Spy Pond, while limited in scope and tangible vegetation results, presents data on recent management activities and the current state of the pond that could inform future management activities. The issues most important to the project stakeholders can be broken into two categories: (1) Aquatic invasive plant management, and (2) phosphorus loading and HAB.

A robust population of submerged aquatic vegetation (while mostly invasive) has been well documented in 2021 as well as in previous years. Aside from occupying suitable native vegetation habitat, the largest issue with submerged invasive plant material in terms of water quality is that it can create a very dense monoculture of robust plant material. These plants can often flourish in areas that our native vegetation cannot and can sometimes persist in deeper waters – occupying more of the pond's bottom. The natural cycle of growth and decay can cause significant reductions in dissolved oxygen, and perpetuation high concentrations of nutrients within the waterbody. However, the current management protocol is doing more than simply eliminating target plants, it is eliminating all vegetation by the end of the growing season.

Nutrients within the pond are high, which has been well documented for approximately 70 years. The HABs in 2021 were long-lasting, dense, and problematic. The data seem to indicate that the dredging and stormwater contributions around the pond and infrastructure improvements at the Route 2 inlet may have introduced more phosphorus-laden sediment into the pond. The long-term effects of these inputs are not yet known. However, it does seem apparent that conditions in 2021 have resulted in more aggressive HAB in larger sections of the pond. Increasing rainfall seems to be bringing more phosphorus through overground flow into the pond, which will need to be addressed at a community level (fertilizers on lawns, etc.). There is not enough data on fertilizing practices, although SWCA did note that the Town has updated its pamphlet of information on lawn fertilizing practices to educate the public. This is likely the best solution to overground flow contributions in place of a (potentially difficult to pass) bylaw for lawncare practices.

While it is certainly clear that aquatic invasive plant management and nutrient inactivation/management is necessary within Spy Pond, SWCA suggests the following alterations to the existing management plan as well as alternative options for waterbody management.

## 5.1 Invasive Aquatic Vegetation Management

There are a variety of aquatic vegetation management strategies. These can be mechanical/manual, biological, or chemical. Due to the size of Spy Pond, SWCA does still think a chemical management option would be the most cost-effective means of invasive aquatic vegetation management. However, SWCA proposes working closely with herbicide manufacturers (such as SePRO, who commonly consults on herbicide application strategies) to minimize herbicide applications to the extent possible. This will allow for a more targeting approach to invasive plant management, as the invasive plants are the densest and tallest plants present within Spy Pond. A lower dose of herbicide would increase the chance that the herbicide will be completely taken up by target vegetation, leaving other plant species to remain in their place. Lower concentrations will also increase the likelihood that the chemicals will degrade quickly enough to lower the impact on new vegetation growth within the pond. While SWCA does not suggest the use of other herbicides other than diquat, Attachment E includes a matrix comparing diquat and other approved herbicides as well as non-chemical options (both described in this report and some that have not been suggested). Note that the prices included in this matrix may be out of date and would require specific quotes from qualified professionals.

However, the herbicides used in 2021 (diquat) are not systemic, therefore they will need to be utilized each year; similar to mowing a lawn. The hope and desired outcome is always that the invasive vegetation is weakened each year, allowing native vegetation time to fill in around the invasive plants. However, this can require many repetitive treatments and is not always possible. SWCA does still suggest that more targeted herbicide applications at lower concentrations of herbicides be attempted in the 2022 growing season. Furthermore, herbicide applications should be conducted before aquatic vegetation reaches the surface. Planning herbicide application to occur when target vegetation is 1.5 feet or taller (but before topping out over the water’s surface) will allow for successful treatment at lower herbicide concentrations. Diquat is most effective on rapidly growing vegetation and treatment of younger vegetation simply requires less herbicide due to the smaller biomass of plant material.

The use of a more selective herbicide is not possible for the Potamogeton or Naiad species. Therefore, the project stakeholders may wish to attempt a mechanical approach to management. Mechanical options include diver-assisted suction harvesting (DASH), eco-harvesting, and hydroraking. DASH can be very costly, due to the need for a certified SCUBA diver, but allows for the most selective manual/mechanical management, as the diver manually hand-pulls the target vegetation and feeds the vegetation into a suction tube for collection on the device.

Hydroraking may be a good option for vegetation management within Spy Pond, but would only be selective by the areas chosen to rake or not. There would be no selectivity in areas that are hydroraked. The benefit to hydroraking is that the root system as well as the sediments attached to plant roots can be removed from the waterbody during the hydroraking process. This could offer more long-term management effects if the plant material is robust enough to remove the majority of a population by the root.

Eco-harvesting could have similar selectivity issues as hydroraking but is less invasive to the substrate than hydroraking. Eco-harvesting can remove the roots of a plant in the best conditions but could also lead to fragmentation. Some aquatic plant species, such as naiad and curly-leaf pondweed, can spread through fragmentation and seed production. While methods that reduce fragmentation are the best option for the management of these types of aquatic plants, when the plants are already widespread, more aggressive mechanical methods are sometimes preferred to reset conditions within the pond and reduce the need for continued herbicide application. In general, it is best to avoid fragmentation of plants that can spread in this manner, but depending on preferences in herbicide use, hydroraking and harvesting are still good tools to consider in an integrated management program. In the best conditions, harvesting can offer prolonged relief from overpopulation of target invasive plants and at worst would act similarly to herbicide application, as a "mowing the lawn" approach to annual management.

# 5.2 Waterbody Management

The problem of highest concern within Spy Pond itself is the presence of HAB within the waterbody. Algae management can more or less be broken down into two general methods: (1) nutrient management to reduce the “food source” of algae, and (2) direct management of algae itself.

## 5.2.1 Nutrient Management

Nutrient management should ideally be performed on a watershed scale. It is important to understand the source of nutrients and minimize their continued contribution to the waterbody as well as to quantify and potentially manage the existing nutrient load that is “locked” in the system. One way in which this can be done on a watershed scale is to reduce the continued contribution of nutrients via lawn and landscaping fertilization throughout the watershed. Another more localized approach is to increase the stability of banks and the buffer zone to banks around the pond. This will reduce the amount of soil deposition during storm events.

The project stakeholders have conducted surveys of storm drains, but those assessments are approximately 40 years old and may need to be updated. Minimizing the contaminants and nutrients entering the pond through these storm drains could be an effective way to slow the process of eutrophication within Spy Pond. Spy Pond has been eutrophic for many years. However, algae densities in 2021 were much worse than in the past, and finding ways to mitigate continuous nutrient-loading will be important to the health of Spy Pond.

There are a few different means of managing nutrients within the waterbody itself. SWCA suggests the following approaches to nutrient management, which are not mutually exclusive and work better when conducted in concert with each other in an integrated management plan: (1) Consideration of ecological restoration and stabilization projects in and around the pond, (2) aeration, (3) dredging, (4) phosphorus inactivation, and (5) application of biological and/or enzyme products.

#### 5.2.1.1 RESTORATION CONSIDERATIONS

One traditional approach to water quality improvement through ecological restoration is bank restoration. As banks degrade, they deposit sediment and vegetation into the pond, furthering nutrient loading, sediment accretion, and eutrophication. Furthermore, a degraded bank will not function to buffer the pond from contaminant and nutrient additions during large storm events. As described in Section 4 of this report, there have been several bank restoration projects around Spy Pond. Maintenance and regular inspections of these areas should continue to ensure their stability and efficacy. There are also sections of the bank around the pond that are well stabilized and should be considered suitable reference areas for future bank restoration and improvement projects. These areas include stable in-water and emergent vegetation (wetland plants that can withstand both prolonged inundation and periodic dry conditions), as well as layers of herbaceous and woody wetland vegetation up-gradient from the emergent shelf. Restored banks should be fully vegetated and consist of a gradual incline to upland elevation. New bank restoration projects should be focused on areas of degraded or undercut bank faces and stormwater input areas (catch basin outflows, culverts, sections of channelized flow) should be prioritized for restoration. Installing an emergent shelf and wetland vegetation that has a high propensity for nutrient uptake will help reduce the continued input of nutrients in these stormwater inlet areas.

There are sections of cattail (*Typha* spp.) and phragmites (*Phragmites australis*) along some of the bank and emergent zones around Spy Pond. Although phragmites is a non-native invasive plant and cattail is considered invasive by some, these plants are very effective at sequestering nutrients. Therefore, they can be used as a source of small-scale phytoremediation along the banks that they exist. If the project stakeholders are interested in harvesting and disposing of the above-ground cattail and phragmites vegetation each year. It is possible to slowly remove existing pollutants from the sediment in the areas that these plants exist. Other native species are proficient in the processing and storage of nutrients as well, including the stonewort (Nitella, a structural alga), which has been observed in Spy Pond. The project stakeholders could work with local Universities and other research-based groups in developing a seed mix with various species that will perform highly in nutrient processing and capture. In addition, it may be possible to test the soil at this site for arbuscular mycorrhizal (AM) fungi and inoculate the soil with AM during seeding activities if quantities are low. AM is known to greatly increase nutrient uptake in host plants and inoculation of soil with local sources of AM could increase the efficacy of nutrient uptake in the surrounding established shrub layer as well as the established restoration vegetation (germinated through seeding activities).

Another restoration consideration for nutrient reduction within Spy Pond is the installation of a floating island (sometimes referred to as floating wetlands or floating treatment wetlands). These can be constructed out of natural or synthetic bases (synthetic last longer and require less maintenance) and involve the creation of a small floating bog of sorts. Vegetation installed within floating islands includes those that are most effective at nutrient uptake and thrive in high-nutrient systems. See Attachment C for recent articles on the successes and failures of floating islands.

Floating islands can help increase dissolved oxygen, reduction of phosphorus and nitrogen, and help balance a healthy food web within a waterbody. Some of the challenges with floating island installation include properly securing the islands to withstand high wind events and problems with plant development. High wind speeds could be a concern within Spy Pond due to its large size, but many different anchoring methods have been developed that could overcome this obstacle. Plant development can be stunted or halted on installed floating islands if there are not sufficient levels of dissolved nutrients (required for optimal hydroponic growth in the first year). Even waterbodies that are eutrophic with problematic algal growth, such as Spy Pond, could lack sufficient dissolved nutrients. Material may need to be added on top of an installed floating island if this is a concern.

#### 5.2.1.2 AERATION

The first proposed in-water approach to nutrient management is the installation of aerators throughout the pond. Spy Pond contains very deep pool sections as well as shallower water depths. Proper aeration could improve the natural processing of nutrients within the waterbody. A more complete study of certain hydrologic factors would need to be studied before determining if this would be a viable option to improve water quality within Spy Pond. Factors that may contribute to a comprehensive and effective aeration plan include prevailing water flow and natural circulation throughout the pond, quantity, and location of available power sources, current mixing within the pond, and depth and placement of the deepest unit. Aeration is often an important first step to nutrient processing and should be considered as an integrated part of all other options for nutrient management.

#### 5.2.1.3 DREDGING

Due to the size of Spy Pond, dredging may not be the most feasible option. However, targeted dredging areas; where the accumulation of phosphorus is known, can be an effective method to remove FRP in a waterbody. Traditional excavation dredging may or may not be feasible depending on where the chosen dredging areas are located. Another option is hydraulic (suction) dredge, which must occur when the pond has water in it and does not require large-scale pond dewatering to expose sediments. This type of dredging should focus on the deepest areas of accumulated sediment and the areas with the highest concentrations of phosphorus. Another benefit to hydraulic dredging is that the contents removed are collected in a contained sediment sack, which allows for easier clean-up and less disturbance than a traditional dewatering area. However, these sediment sacks are relatively small and large-scale dredging projects can take a very long time if it is the only method of sediment collection.

The primary drawback to hydraulic dredging is that it can be much more expensive than a traditional dredge; a pond of this size would require many days of dredging to reduce a significant quantity of accumulated sediment.

#### 5.2.1.4 PHOSPHORUS INACTIVATION

Phosphorus inactivation is a popular means of indirect algae management. There are two major products used to achieve phosphorus inactivation. One is the application of alum and the other is the use of lanthanum-based products (such as PhosClear). The benefit of using alum is that it will precipitate all forms of phosphorus in the water column, whereas lanthanum products only bind to FRP.

An alum application in Spy Pond would consist of a water column treatment of alum in late spring to early summer when algae concentrations are low, and less phosphorus has become available for uptake. One-half of the waterbody would be treated at once, with each partial application separated by at least 1 day. The final dose calculation for each alum application involves determining the correct amount of aluminum needed to inactivate available phosphorus as well as including the appropriate mix of aluminum salts to keep an acceptable pH level. This would need to be determined a few days before the application date by using a "Jar Test" of the pond water. Phosphorus would be estimated as grams per square meter based on this test and the aluminum dose will be set to a minimum of 10 times the iron-bound phosphorus concentration. The default ratio for alum dosing will include two parts aluminum sulfate to one part sodium aluminate by volume but will be adjusted to achieve pH from 6.0 to 8.0.

Phoslock applications would occur during the same timeframe (spring/early summer) before most algae species are active and would be applied as an aqueous slurry, per label recommendations. Rates will be determined in the same or similar manner as detailed above and include the up-to-date water quality data.

#### 5.2.1.5 BIOLOGICAL/ENZYME ADDITIVES

While not necessarily an immediate solution, the addition of biological, enzyme, and/or mineral-based products could help improve the long-term processing and cycling of nutrients throughout Spy Pond and significantly reduce the organic material buildup within the water body over time, assuming the substrate has a high organic content. These types of natural additives have been shown to significantly improve water quality over time and dramatically reduce or eliminate the need for continued algae management. SWCA consulted an industry expert in these types of natural additives (EcoTerra Design & Consulting, LLC) to determine the efficacy of this management approach.

The use of natural biological, enzyme and mineral-based products can be very effective in nutrient management. However, if not paired with sufficient aeration, can result in little to no notable results (particularly in the short-term). Therefore, aeration is an integral portion of this management approach, and a full aeration system should be installed before application. This management approach is also contingent on regular monitoring of water quality parameters within the pond.

EcoTerra Design & Consulting, LLC would need to conduct a pre-management survey to determine the precise type and mode of natural product application. Factors that would influence the management approach would be percent organics in the sediment, existing mixing within the water column, level of aeration possible, and understanding of influence from surrounding septic systems.

### 5.2.2 Direct Algae Management

SWCA understands that while algaecide applications have been conducted within Spy Pond in the past, recent recommendations have steered the project stakeholders away from this management method. SWCA agrees that algaecide application alone can act as a band-aid approach only or even at times perpetuation nutrient cycling issues with a waterbody. However, water bodies across the commonwealth are experiencing warmer waters, more severe storm events (increased mixing), and an overall higher frequency of algal blooms. Spy Pond experienced persistent HAB throughout 2021 and although there may not have been a consistent trend of HAB in past years, they may become more persistent and could worsen in our changing climate. Furthermore, while toxins were not directly tested, it is best to assume toxin-producing algae are actively producing toxins any time they are identified. As-needed spot treatment of algae should be considered along with other nutrient management approaches to ensure the safety of humans and wildlife around the pond.

SWCA proposes an application of a copper-based algaecide following phosphorus inactivation to manage the harmful algal blooms within Spy Pond. These applications would serve as a means to reduce the risk of toxin production while the background causes of algal blooms within Spy Pond are being addressed (aka nutrient management, as detailed in the management options above). Algaecide application should occur as soon as algae are detected. This will allow for lower application concentrations and also increase the efficacy of the treatment. It can be difficult to manage algae with algaecides if waiting to apply until a significant bloom has formed. This management approach would require regular testing or at least testing when water clarity appears to decline. SWCA suggests the use of either CaptainXTR or SeClear. Captain XTR is a standard copper-based algaecide that is effective on the genera of algae of concern within Spy Pond. This would be applied as two half treatments and at least two weeks would need to lapse between each partial treatment event. This series of partial treatments are performed to reduce the risk of dissolved oxygen dropping below habitable levels.

The active ingredient in SeClear is also copper (copper sulfate pentahydrate), but it also includes water clarity enhancement ingredients that reduce the amount of available phosphorous as well as suspended solids. The application of this product often results in longer intervals between applications, due to this duel-acting formulation. If phosphorus levels begin to rise following phosphorus inactivation treatments, and HABs require management, SWCA suggests the use of SeClear to eliminate the algae present and reduce the potential for quickly reappearing blooms.

Both of these copper-based algaecides have been permitted for use in the region and are widely used across the Commonwealth.

# ATTACHMENT A

## Figure 1


SPY POND ASSESSMENT

**Figure 1. Sampling**

- North Basin (Sample 03)
- West Basin (Sample 01)
- West Basin - West Shore (Sample 02)
- Plant Survey Rake Toss Location

Arlington, MA
71.1552°W 42.4069°N

N
1:6,250

0 200 400 Feet
0 50 100 Meters

*Updated: 10/26/2021*
*Project No. 68573*

SWCA® ENVIRONMENTAL CONSULTANTS

# ATTACHMENT B

## Water Sample Analysis Results

SePRO Research & Technology Campus

SWCA ENVIRONMENTAL CONSULTANTS

# SeSCRIPT Analysis Report: *Spy Pond*

**Company:** SWCA

**Address:** 15 Research Dr, Amherst, MA 01002

**Contact Person:** Naomi Valentine

**Phone:** (413) 256-0202

**Email:** nvalentine@SWCA.com

**Project Name:** Spy Pond

**Surface Area:** NA

**Average depth:** NA

**Date Sample Received:** 09/30/2021

**SeSCRIPT Analysis Performed:** Algae and Water Quality Baseline Plus Bundle

## *Algae ID Results*

## Spy Pond

| Identification | Classification | Description | Density/Biomass (cells/mL) |
|---|---|---|---|
| **01 Deep** | | | ★★ |
| ***Microcystis* sp.** | Cyanophyta- Blue-green algae | Colonial, scum-former, planktonic, potential toxin and taste/odor producer | 77,000 |

Other algae in the sample at densities lower than 100 cells/mL include: *Fragilaria* (Bacillariophyta); *Micractinium, Scenedesmus* (Chlorophyta); *Dolichospermum, Phormidium, Planktolyngbya, Pseudanabaena* (Cyanophyta)
Much particulate organic matter observed

| Identification | Classification | Description | Density/Biomass (cells/mL) |
|---|---|---|---|
| **01 Shallow** | | | ★★ |
| ***Microcystis* sp.** | Cyanophyta- Blue-green algae | Colonial, scum-former, planktonic, potential toxin and taste/odor producer | 38,800 |
| ***Dolichospermum* sp.** | Cyanophyta- Blue-green algae | Filamentous, scum-former, planktonic, potential toxin and taste/odor producer | 1,200 |

Other algae in the sample at densities lower than 100 cells/mL include: *Coelastrum, Scenedesmus* (Chlorophyta); *Pseudanabaena* (Cyanophyta); *Trachelomonas* (Euglenophyta)

## *Algae ID Results (cont.)*

### Spy Pond

| Identification | Classification | Description | Density/Biomass (cells/mL) |
|---|---|---|---|
| **02 Bloom** | | | ★★ |
| ***Microcystis* sp.** | Cyanophyta-Blue-green algae | Colonial, scum-former, planktonic, potential toxin and taste/odor producer | 34,000 |
| ***Dolichospermum* sp.** | Cyanophyta-Blue-green algae | Filamentous, scum-former, planktonic, potential toxin and taste/odor producer | 3,800 |

Other algae in the sample at densities lower than 100 cells/mL include: *Fragilaria* (Bacillariophyta); *Staurastrum* (Charophyta); *Crucigenia* (Chlorophyta); *Pseudanabaena* (Cyanophyta); *Trachelomonas* (Euglenophyta)

| Identification | Classification | Description | Density/Biomass (cells/mL) |
|---|---|---|---|
| **03 Shallow** | | | |
| ***Microcystis* sp.** | Cyanophyta-Blue-green algae | Colonial, scum-former, planktonic, potential toxin and taste/odor producer | 9,900 |
| ***Dolichospermum* sp.** | Cyanophyta-Blue-green algae | Filamentous, scum-former, planktonic, potential toxin and taste/odor producer | 1,900 |

Other algae in the sample at densities lower than 100 cells/mL include: *Fragilaria* (Bacillariophyta); *Closterium* (Charophyta); *Aphanizomenon*, *Pseudanabaena* (Cyanophyta); *Trachelomonas* (Euglenophyta)

| SeSCRIPT* ALERT INDEX | EXPOSURE RISK | CYANOBACTERIA LEVELS (cells/mL) |
|---|---|---|
| ★ | Low | <20,000 |
| ★★ | Moderate | 20,000 to 100,000 |
| ★★★ | High | >100,000 |
| ★★★★ | Extreme | >100,000 with scums/mats |

*See the following Cyanobacteria Alert Guide for additional information*

## *Water Quality Results*
### Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **01 Deep** | | |
| pH (SU) | 6.9 | Near neutral |
| Dissolved Oxygen (mg/L) | 6.9 | Acceptable for freshwater |
| Conductivity (µS/cm) | 1048.0 | Acceptable for freshwater |
| Alkalinity (mg/L as $CaCO_3$) | 68.3 | Moderately buffered |
| Hardness (mg/L as $CaCO_3$) | 55.6 | Soft |
| Turbidity (NTU) | 11.5 | Moderate |

## *Nutrient Results*
### Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **01 Deep** | | |
| Total Phosphorus (µg/L) | 455.9 | Very high amount: Hypereutrophic |
| Free Reactive Phosphorus (µg/L) | 22 | High |
| Total Kjeldahl Nitrogen (mg/L) | 4.3 | High |
| Nitrates & Nitrites (mg/L) | 0.1 | Moderate |
| Total Nitrogen (mg/L) | 4.4 | Moderate |
| Chlorophyll *a* (µg/L) | NA | NA |

## *Water Quality Results*

### Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **01 Shallow** | | |
| pH (SU) | 7.8 | Near neutral |
| Dissolved Oxygen (mg/L) | 9.2 | Acceptable for freshwater |
| Conductivity (µS/cm) | 901.0 | Acceptable for freshwater |
| Alkalinity (mg/L as $CaCO_3$) | 30.7 | Low buffered |
| Hardness (mg/L as $CaCO_3$) | 50.6 | Soft |
| Turbidity (NTU) | 5.2 | Low |

## *Nutrient Results*

### Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **01 Shallow** | | |
| Total Phosphorus (µg/L) | 30.5 | High amount: Eutrophic |
| Free Reactive Phosphorus (µg/L) | < 5 | Low |
| Total Kjeldahl Nitrogen (mg/L) | 0.9 | Low |
| Nitrates & Nitrites (mg/L) | 0.1 | Moderate |
| Total Nitrogen (mg/L) | 1.0 | Moderate |
| Chlorophyll *a* (µg/L) | NA | NA |

## *Water Quality Results*
## Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **03 Deep** | | |
| pH (SU) | 6.8 | Near neutral |
| Dissolved Oxygen (mg/L) | 5.8 | Acceptable for freshwater |
| Conductivity (µS/cm) | 1331.0 | Acceptable for freshwater |
| Alkalinity (mg/L as $CaCO_3$) | 80.8 | Moderately buffered |
| Hardness (mg/L as $CaCO_3$) | 83.0 | Moderately hard |
| Turbidity (NTU) | 7.2 | Low |

## *Nutrient Results*
## Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **03 Deep** | | |
| Total Phosphorus (µg/L) | 1075 | Very high amount: Hypereutrophic |
| Free Reactive Phosphorus (µg/L) | 79 | Very high |
| Total Kjeldahl Nitrogen (mg/L) | 6.1 | Very high |
| Nitrates & Nitrites (mg/L) | < 0.02 | Low |
| Total Nitrogen (mg/L) | 6.1 | High |
| Chlorophyll *a* (µg/L) | NA | NA |

## *Water Quality Results*
### Spy Pond

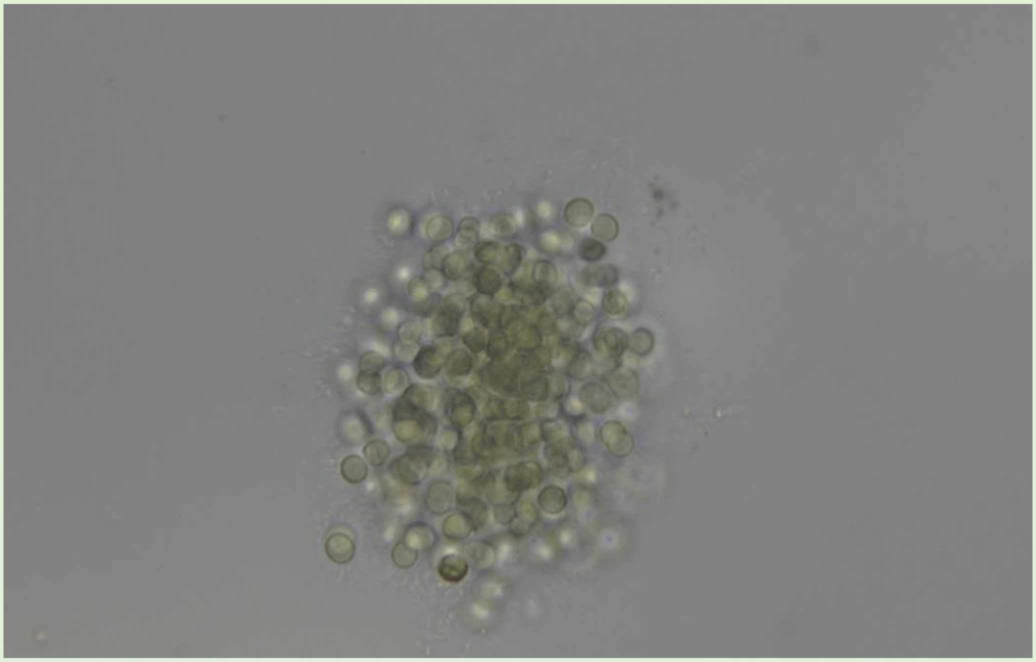
| Analysis | Measurements | Description |
|---|---|---|
| **03 Shallow** | | |
| pH (SU) | 8 | Near neutral |
| Dissolved Oxygen (mg/L) | 9.3 | Acceptable for freshwater |
| Conductivity (µS/cm) | 929.0 | Acceptable for freshwater |
| Alkalinity (mg/L as $CaCO_3$) | 31.8 | Low buffered |
| Hardness (mg/L as $CaCO_3$) | 51.1 | Soft |
| Turbidity (NTU) | 5 | Low |

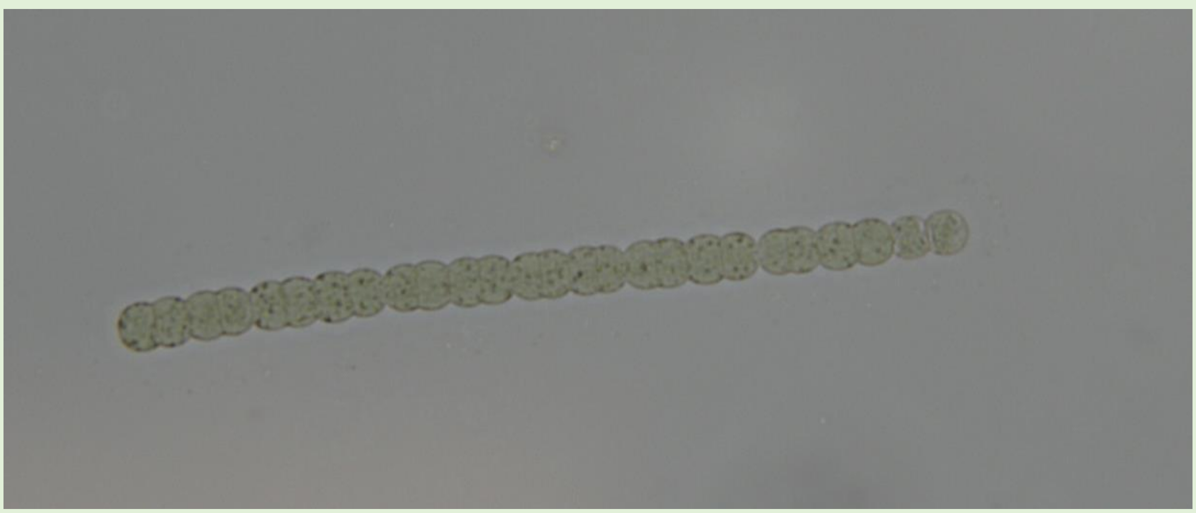
## *Nutrient Results*
### Spy Pond

| Analysis | Measurements | Description |
|---|---|---|
| **03 Shallow** | | |
| Total Phosphorus (µg/L) | 24.9 | High amount: Eutrophic |
| Free Reactive Phosphorus (µg/L) | 11 | Low |
| Total Kjeldahl Nitrogen (mg/L) | 0.9 | Low |
| Nitrates & Nitrites (mg/L) | 0.1 | Moderate |
| Total Nitrogen (mg/L) | 1.0 | Moderate |
| Chlorophyll *a* (µg/L) | NA | NA |

***Algae Pictures***

Spy Pond





# Water Quality Analysis Explanation

These water quality parameters are essential to document the condition of a water body and design custom treatment prescriptions to achieve desired management objectives.

**pH:** Measure of how acidic or basic the water is (pH 7 is considered neutral).

*<6 notably acidic* | *6 - 9 standard for typical freshwaters* | *>9 notably basic*

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

**Hardness:** Measure of the concentration of divalent cations, primarily consisting of calcium and magnesium in typical freshwaters. *0-60 mg/L as $CaCO_3$ soft; 61-120 moderately hard; 121-180 hard; > 181 very hard*

**Alkalinity-** Measure of the buffering capacity of water, primarily consisting of carbonate, bicarbonate and hydroxide in typical freshwaters. Waters with lower levels are more susceptible to pH shifts.
*≤ 50 mg/L as $CaCO_3$ low buffered; 51-100 moderately buffered; 101-200 buffered; > 200 high buffered*

**Conductivity-** Measure of the waters ability to transfer an electrical current, increases with more dissolved ions.
*< 50 uS/cm relatively low concentration may not provide sufficient dissolved ions for ecosystem health; 50-1500 typical freshwaters; > 1500 may be stressful to some freshwater organisms, though not uncommon in many areas*

**Dissolved Oxygen-** amount of diatomic oxygen dissolved in the water.
*< 2 mg/L likely toxicity with sufficient exposure duration; < 5 stressful to many aquatic organisms; ≥ 5 able to support most fish and invertebrates*

**Phosphorus:** Essential nutrient often correlating to growth of algae in freshwaters.

**Total Phosphorus (TP)** is the measure of all phosphorus in a sample as measured by persulfate strong digestion and includes: inorganic, oxidizable organic and polyphosphates. This includes what is readily available, potential to become available and stable forms.
*<12 µg/L oligotrophic; 12-24 µg/L mesotrophic; 25-96 µg/L eutrophic; > 96 µg/L hypereutrophic*

**Free Reactive Phosphorus (FRP)** is the measure of inorganic dissolved reactive phosphorus ($PO_4^{-3}$, $HPO_4^{-2}$, etc.). This form is readily available in the water column for algae growth.

**Nitrogen:** Essential nutrient that can enhance growth of algae.

**Total N** is all nitrogen in the sample (organic $N^+$ and Ammonia) determined by the sum of the measurements for Total Kjeldahl Nitrogen (TKN) and ionic forms.

**Nitrites and Nitrates** are the sum of total oxidized nitrogen, often readily free for algae uptake.
*< 1 mg/L typical freshwater; 1-10 potentially harmful; >10 possible toxicity, above many regulated guidelines*

**Chlorophyll *a*:** primary light-harvesting pigment found in algae and a measure of the algal productivity and water quality in a system.
*0-2.6µg/L oligotrophic; 2.7-20 µg/L mesotrophic; 21-56 µg/L eutrophic; > 56 µg/L hypereutrophic*

**Turbidity-** Measurement of water clarity. Suspended particulates (algae, clay, silt, dead organic matter) are the common constituents impacting turbidity.
*< 10 NTU drinking water standards and typical trout waters; 10-50 NTU moderate; > 50 NTU potential impact to aquatic life.*

# ATTACHMENT C

## Floating Island Articles

# wetland science & practice

published by the Society of Wetland Scientists

Vol. 36, No. 2 April 2019

Seclection of Articles

## FROM THE EDITOR'S DESK

**Greetings! Spring is in the air here in New England as it is sunny and in the 50s today.** Snow is gone from the valley here, yet higher elevations still have patches of snow and ice-covered ponds. The sugar houses are busy making maple syrup, but still haven't heard any wood frogs or spring peepers. I spent a few weeks in Florida this winter that included visiting several national, state, and county parks. Since I took hundreds of photos, I decided to post a number of them in *Notes from the Field*. I encourage others to submit photos for future issues.

Ralph Tiner
WSP Editor

This issue is largely devoted to articles about constructed floating islands. While attending our Denver conference, I sat in a couple of presentations on this topic and thought it would be of interest to a wider audience so I contacted Mason Bowles, workshop coordinator about getting presenters to write articles for *Wetland Science & Practice*. They responded positively and you'll find all except one published in this issue. The final article is on natural floating islands and we'll publish that in the October issue. Along with these articles, you'll find one by Max Finlayson and others on our Denver Declaration about wetland management and restoration and a student grant research report by Elizabeth Perera and Kathy Young on the hydrology of some Icelandic wetlands. You'll also see Rick Smardon's book review of *Eden Again: Hope in the Marshes of Iraq* by Suzanne Alwash, many wetland wildlife images in *Notes from the Field* and Doug Wilcox's cartoon (*From the Bog*). Thanks again to all contributors.

On the news front, in February the Society and others requested that the US EPA and Corps of Engineers extend the comment period for the review of the proposed definition of "waters of the United States." The agencies have rejected these requests, so comments are due by April 15.

Meanwhile, we'll keep doing our best to maintain and restore wetlands around the globe and to educate the public on wetlands, their functions, values, and threats. Happy Swamping. ■

**Note to Readers:** All State-of-the-Science reports are peer reviewed, with anonymity to reviewers.

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**COVER PHOTO:**

Limpkin at Rock Springs Run, Orange County, Florida, USA
(Ralph Tiner photo)

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# ATTACHMENT D

## Photo Pages

# ATTACHMENT E

## Aquatic Vegetation Management Matrix

| Plant Management Strategy | Type | Efficacy of Control | Cost** | Timing | Notes |
|---|---|---|---|---|---|
| DASH (Diver-Assisted Suction Harvesting) | Mechanical | High | $15,000/acre | Growing Season | • Diver can very selectively choose which plants to manage<br>• Fairly expensive due to equipment needs and diver hours<br>• Low to no impact on non-target species |
| Hand Pulling | Mechanical | Mid to High | $12,000/acre | Growing Season | • High efficacy but not efficient<br>• Chance that vegetation would not be completely removed due to fragmentation<br>• Fairly expensive if contracted – could be completed through volunteer effort<br>○ Volunteers would need to be trained in either SCUBA or snorkel to hand-pull<br>• Low to no impact on non-target species |
| Harvester | Mechanical | Mid to High | $1,000 - $3,000/acre | Growing Season | • Likely effective, but no data found on low watermilfoil<br>• Fairly inexpensive if a local contractor can be located<br>• Could include impact to non-target species |
| Hydroraking | Mechanical | Mid to High | $10,000 - $12,000/acre | Growing Season | • Fairly high efficacy for removal of vegetation<br>• Milfoil species may be difficult to collect due to low vegetation height<br>• Fairly expensive mechanical management option<br>• Could include impact to non-target species |
| Benthic Barrier/Shading | Mechanical | Low | $24,000 - $54,000/acre | Growing Season | • Low efficacy for target species<br>• Not appropriate for large-scale management efforts<br>• Fairly effective when used as part of an integrated management strategy on smaller populations<br>• Could include impact to non-target species |
| Dredging | Mechanical | High | $55,000 - $80,000/acre | Autumn or During Low Water | • High efficacy when performed properly, but would disturb substrate where dredged<br>• Extremely expensive and requires additional permitting<br>• Would remove all vegetation in dredged areas |
| Grass Carp | Biological | Fair | $50-$300/acre | Stock in Late Winter or Early Spring | • May reasonably decrease milfoil species (if needed)<br>• May negatively affect native vegetation<br>• Possibly spread fish disease amongst native fish<br>• Additional permitting required<br>• May negatively affect water quality |
| Milfoil Weevil | Biological | Unknown/Poor | $6,000-$200,000/year | Growing Season | • Unpredictable diet – possibility of decreasing native vegetation<br>• Poor efficacy on all target species<br>• Low efficacy in large lakes, but may have higher efficacy in Crystal Lake (unproven)<br>• Can be expensive depending on how many restocking events<br>• Requires multiple levels of permitting |
| ProcellaCOR | Chemical | Good | $700 -$800/acre | Early June and Mid-July | • Half-Life: 1-2 days<br>• Systemic treatment allows for full plant management (through roots)<br>• Rapid weed uptake<br>• Very low environmental and human impact<br>• Low impact on non-target organisms (birds, fish, plants)<br>• Low use rates<br>• Selective to watermilfoil and limited other plant species |

**All included costs are intended for comparison purposes only. These relative costs do not include mobilization and would need to be verified by a qualified vendor.

| Plant Management Strategy | Type | Efficacy of Control | Cost** | Timing | Notes |
|---|---|---|---|---|---|
| 2-4D | Chemical | Good | $300-$800/acre | Early June | • Half-Life: 13-40 days<br>• Multiple treatments needed<br>• Negative human health effects possible |
| Carfentrazone | Chemical | Good | $690/acre | Spring/Early Summer | • Half-Life: 3-9 days<br>• Meets regulation-required distance from reservoir<br>• In least/second least EPA toxicity category<br>  ○ Concentrations below EPA's level of concern - at application rate<br>• Not well documented/tested |
| Diquat | Chemical | Good | $320/acre | Growing Season | • Half-Life: 12-48 hours in the environment (non-lab setting)<br>• Immediately binds to organic matter<br>  ○ Not biologically available in water very long<br>• Non-toxic to aquatic organisms<br>• Acutely toxic when in contact with skin (applicator risk)<br>• pH restrictions<br>• Not effective in dense or turbid water environments – because of high sorption rates |
| Endothall | Chemical | Poor | $400-$700/acre | Spring/Early Summer | • Half-Life: 5-10 days<br>  ○ Disappears from soil in 7-21 days<br>• Liquid formulations are toxic to fish and aquatic invertebrates/wildlife<br>• Decrease in dissolved oxygen (toxic to fish)<br>• Not permitted for use in public water supply watershed<br>• Not particularly effective on any of target vegetation |
| Fluridone | Chemical | Good | $500-$1,000/acre | Spring/Early Summer | • Half-Life: 4-97 days<br>• High efficacy on milfoil species<br>• Requires 3-5 applications in one season<br>• Low toxicity to humans and fish<br>• Low risk of oxygen depletion (relatively)<br>• Allowed with permitted constrictions near public water wells |
| Flumioxazin | Chemical | Good | $910-$1,500/acre | Growing Season | • Half-Life: 1-5 days<br>• High efficacy for target species<br>• Slightly to moderately toxic to fish (dissolved oxygen concern)<br>• Moderately to highly toxic to aquatic invertebrates<br>• Highly regulated for human health safety<br>• No signs of human toxicity under regulated parameters |
| Triclopyr | Chemical | Poor | $500/acre | Spring/Early Summer | • Half-Life: 1-10 days<br>• Poor efficacy on target vegetation<br>• Not selective<br>• No groundwater contamination<br>• Threat of oxygen depletion |

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