

MORSES POND ANNUAL REPORT: 2014



PREPARED FOR THE TOWN OF WELLESLEY

BY WATER RESOURCE SERVICES, INC.

FEBRUARY 2015



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This report documents the implementation of the 2005 Comprehensive Moses Pond Management Plan through 2014. Program elements include: 1) phosphorus inactivation, 2) plant harvesting, 3) low impact development demonstration, 4) education, and 5) dredging.

Phosphorus Inactivation

Operational Background

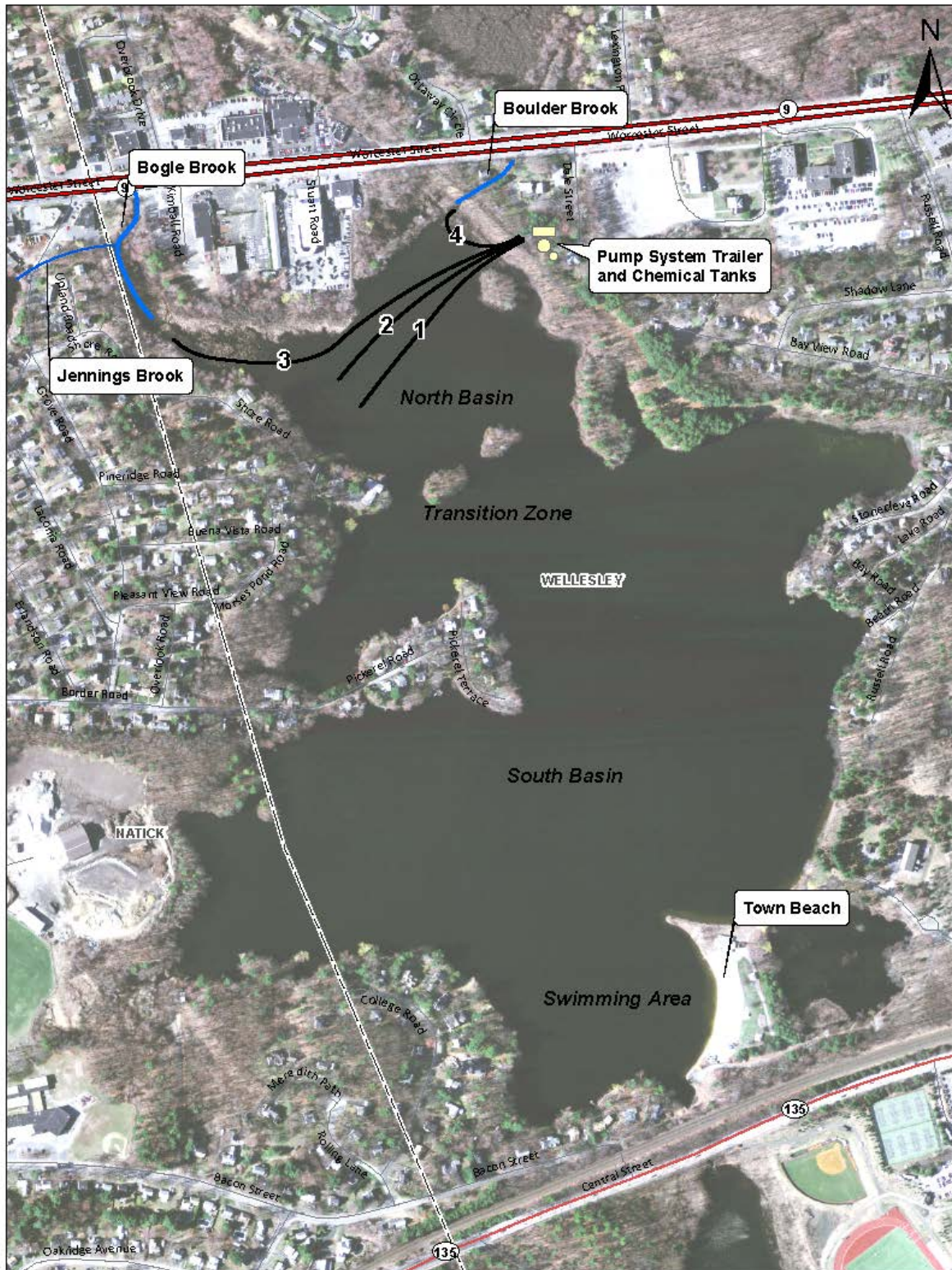
A phosphorus inactivation system was established in the spring of 2008. After testing and initial adjustment in 2008, the system has been operated in the spring and early summer of 2009 through 2014. The chemical pump station is portable, but is stationed for the treatment period at the Town of Wellesley Dale Street Pump Station. Four sets of lines initially ran from the pump station into the north basin (Figure 1), each set consisting of an air feed line and two chemical feed lines. The phosphorus inactivation chemicals used for the treatment were aluminum sulfate (alum) and sodium aluminate (aluminate). Both are flocculating agents responsible for the inactivation of phosphorus, with alum creating acidic conditions and aluminate shifting the pH to a more basic level; both were added at a roughly 2:1 ratio (alum to aluminate, by volume) to balance the pH of treatments.

Two lines with single diffusers and sets of chemical ports near the end of each line ran within the north basin to the mouths of Boulder Brook and Bogle Brook. This facilitated inlet treatment, generally considered the most effective means of inactivation, given mixing and settling as the streams proceed into the north basin. The other two lines, each with four diffusers and corresponding chemical ports, were spaced within the north basin itself to allow treatment of water in that basin. This allowed treatment if operation is not possible from the start of a storm, or if additional treatment in the basin appeared necessary. However, as spring progressed, dense vegetation within the north basin limited horizontal mixing and overall system efficiency. Additionally, once a portion of the north basin had been dredged (2012-2013), mixing that would limit particle settling became undesirable, so lines 1 and 2 that had served the north basin were removed in 2013.

The two sets of lines addressing the Bogle and Boulder Brook inlets were operated in 2013, and it was determined that the mixing function of the compressor was not needed for inlet injection to be effective. Therefore compressor use was discontinued into 2014, which eliminated the need for fuel as well; the chemical feed pumps run on electricity, potentially supplied by a generator on the trailer at first, but more conveniently provided from the Dale Street pump station by extension cord. Consequently, the system was greatly simplified in 2014 and was much quieter, with a compressor used only at the end of the season to clear the lines, no generator use, and the pumps being housed in a wooden cabinet. Lines were also extended further into Bogle Brook in 2014.

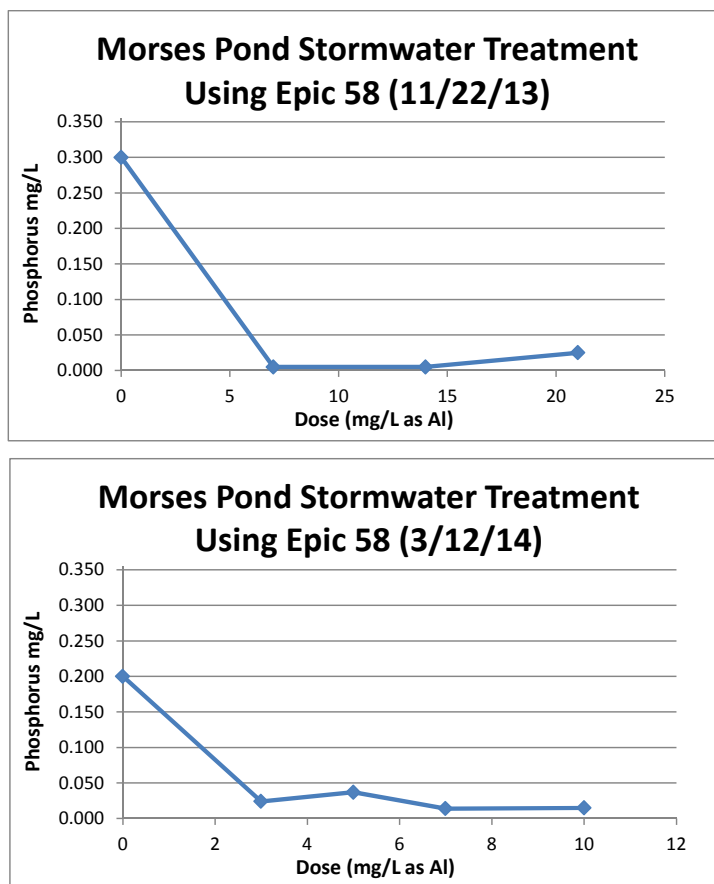
A further development in 2014 was the switch from alum and aluminate to just one chemical, polyaluminum chloride (PAICl). Improvement of PAICl in recent years made it worth testing, as both alum and aluminate are more hazardous to handle and more viscous in the feed lines. PAICl is not much more viscous than water and does not damage skin rapidly on contact. It is more pH neutral, causing no detectable fluctuation in most waters to which it is applied at typical doses. It is intermediate to alum

Figure 1. Phosphorus Inactivation System for Morses Pond



and aluminate in aluminum content (5.6%, or 0.59 lb/gal) and cost (about \$2/gal). Testing in late 2013 and early 2014 with Bogle Brook water indicated phosphorus removal rates in excess of 90% with doses between 3 and 10 mg/L as aluminum (Figure 2). Consequently, the system could be further simplified to have one chemical in each of two chemical tanks, each with a dedicated pump, and each serving one inlet stream. With flows in Bogle Brook being larger than those in Boulder Brook, the larger pump (nominal capacity of 84 gal/hr) and the larger tank (2000 gal) were assigned to Bogle Brook and the smaller pump (nominal capacity 52 gal/hr) and smaller tank (1000 gal) were assigned to Boulder Brook, although swapping of hoses from the tank to the pump or the pump to the delivery lines allows switching if necessary.

Figure 2. Phosphorus removal with polyaluminum chloride in jar tests



After a summer of initial testing (2008), alum and aluminate were added to the north basin in May through at least late June to achieve a target total phosphorus level in the south basin of <20 ppb and preferably close to 10 ppb near the 4th of July (Table 1). Traditionally, algal blooms started about that time, necessitating copper treatments to regain water clarity and keep the beach open. It was thought that additional treatment during summer might not be necessary if the starting phosphorus level was low enough. No problems were noted in 2009, but algal blooms developed in August of 2010 and 2011.

Responsive treatment helped, but was considered too late to prevent some loss of clarity. In 2010 the chemicals were available to respond to declining clarity in late July, but no action was taken. In 2011 the chemicals were not available when a response was deemed appropriate in late July, and it took two weeks to obtain the necessary chemicals. In 2012, sufficient chemical was on hand to respond to reductions in water clarity during summer, but system functionality problems limited the effectiveness of treatment. In 2013, chemicals were ordered and available from mid-July into August. In 2014, initial chemical delivery (3000 gal) was at the start of June, and another delivery (3000 gal) was made at the end of June, providing enough material to treat through July, although most chemical was applied prior to July 6th.

Table 1. Summary of Phosphorus Inactivation Effort, 2008-2014

Year	Applied Alum (gal)	Applied Aluminate (gal)	Period of Application	# of Treatment Days	Notes
2008	2000	1000	6/24 to 7/23	5	Testing and adjustment phase
2009	6002	2900	5/14 to 7/9	16	Very wet spring and summer
2010	4100	2080	5/11 to 7/9 + 8/24 & 8/25	13	Average spring, leftover chemical applied in late August.
2011	5000	2475	5/15 to 7/8 + 8/10 & 8/16	14	Wet spring and summer, attempted August treatments in response to bloom
2012	6000	3000	5/4 to 7/23 + 8/6 to 8/22	19	Poor system functionality hampered dosing during treatment
2013	6055	2785	4/26 to 5/24 + 5/28 to 6/27 + 7/23 to 8/2	20	Very wet June. System overwhelmed on several dates.
	Polyaluminum chloride				
2014	5985		6/2 to 7/5 + 4 dates from 7/16 to 8/2	12	Dry May and June, wet July, first year using polyaluminum chloride

2014 Phosphorus Inactivation

The record of treatment in 2014 is provided in Table 2, including the rainfall record. Storm events occurred on 35 days in May through August of 2014, down from 47 in 2013 and up from 25 in 2012. More importantly, precipitation was only 5.48 inches in May and June, 1.69 inches below the long term average; 10.5 inches of rain fell in June 2013 alone. We did not treat in May, both as a function of lower than average precipitation and time needed to modify the system for 2014; chemical delivery was also delayed for over a week. Overall, treatment occurred for 64.5 hours spread over 12 days, mostly between June 2 and July 5, 2014. This was less than the 124 hours of treatment over 20 days in 2013 and 76.5 hours over 19 days in 2012. Especially critical was coverage of the storm on July 4-5, 2014, the largest of the period and occurring at a key time for nutrient loading to Morses Pond. Treatment after July 5 was just “touch up” application in response to smaller events until the remaining chemical was used up.

Table 2. Rainfall record and related treatment actions in 2014.

	May				June				July				August			
	Precip	Treatment			Precip	Treatment			Precip	Treatment			Precip	Treatment		
Day of Month	Inches	Hours	Bogle Bk P.Al.Cl (gal)	Boulder Bk P.Al.Cl (gal)	Inches	Hours	Bogle Bk P.Al.Cl (gal)	Boulder Bk P.Al.Cl (gal)	Inches	Hours	Bogle Bk P.Al.Cl (gal)	Boulder Bk P.Al.Cl (gal)	Inches	Hours	Bogle Bk P.Al.Cl (gal)	Boulder Bk P.Al.Cl (gal)
1	0.62				0				0				0			
2	0.01				0	2.0	240	130	T				0.03	5.0	130	
3	0				0				0.28				T			
4	T				0.14	3.8	270	90	1.88				T			
5	0				0.78	7.1	810	305	0.35	20.0	980	440	0			
6	0				0				0				0.01			
7	0				0				0.08				0.01			
8	0				0				T				0			
9	T				T				0				0			
10	0.34				0.85	10.5	650	425	0				0			
11	T				T				0				0			
12	0				T				0				0			
13	0				0.54	6.5	450	135	T				1.06			
14	T				0.01				0.67				0			
15	T				0				T				T			
16	0.06				0				0.85	1.5	70		0			
17	0.65				0.02				0				T			
18	0				T				0				0			
19	0.05				0				0				0			
20	T				0				T				0			
21	0				0				0				0			
22	0.25				0				0				0.08			
23	0.02				0				0				0			
24	0.18				0	1.0	40	20	T				0			
25	0				0				0				0			
26	0.01				0.28	2.3	480	130	0				0			
27	0.48				0				0.35	2.5	80		0.02			
28	0.08				0				0.11	2.3	110		0			
29	0				0				0				0			
30	0.11				0				0				0			
31	T								0				0.54			
Sum	2.86	0.0	0	0	2.62	33.2	2940	1235	4.57	26.3	1240	440	1.75	5.0	130	0
# of Days	13		0	0	7		7	7	8		4	1	7		1	0
Long term average precip.	3.49				3.68				3.43				3.35			
Departure from normal	-0.63				-1.06				1.14				-1.60			
Greatest daily precip	0.65				0.85				1.88				1.06			

A total of 5985 gallons of PAI₂Cl₃ were applied, equating to less volume and less aluminum than any year since the testing of the system in 2008. The application rate averaged 66.8 gallons per hour for the larger pump (compared to 47 gallons of alum per hour in 2013) and 31.4 gallons per hour for the smaller pump (compared to 22 gallons of aluminate per hour in 2013), indicating better pumping rates with the less viscous PAI₂Cl₃. Pumping with the larger pump averaged 80% of capacity, while pumping with the smaller pump averaged 60% of capacity, both by intent; pumps were set to deliver a dose that equated to 3 to 5 mg/L of aluminum to each inlet.

While the weather was cooperative, the phosphorus inactivation system also worked extremely well in 2014, and this was perhaps the most successful treatment year yet. The simplified system, single and more easily managed chemical, and responsive application led to the best water quality in Morses Pond in many years. The stage is set to move toward a more automated system which would reduce labor costs.

Analysis of Program Results

Water quality is assessed prior to the start of treatment, normally in May, early summer, and later in the summer in up to three areas: the north basin, the transition zone to the south basin just south of the islands, and near the town beach at the south end of the pond. Visual and water quality checks are made on an as needed basis, as part of normal operations or in response to complaints, major storms, or town needs. The water quality record for 2014 (Table 3) incorporates field and laboratory tests at multiple sites. A summary of phosphorus data for key periods since 2008 is provided (Table 4) to put the treatments and results in perspective. It is intended that total phosphorus will decrease through the treatment, such that values in the south basin, assessed in the swimming area near the outlet of the pond, will be lower than in the north basin, with the transition zone exhibiting intermediate values. Based on data collected since the early 1980s, total phosphorus in the south basin in excess of 20 ug/L tends to lead to algal blooms, while values <20 ug/L minimize blooms and values near 10 ug/L lead to highly desirable conditions (Figure 3).

Dissolved phosphorus is a subset of total phosphorus, and tends to be near the limit of detection in many samples, as algae readily take up this available P form. The focus of management is on total phosphorus as the primary indicator of algal bloom potential. Values in 2014 were low to moderate, indicative of less rainfall, active treatment, and renewed detention in the north basin. Note that total phosphorus values in the dredged portion of the north basin (NB-1) are consistently lower than those in the undredged portion (NB-2), and that values decline from the inlets to the beach area. The combination of weather, treatment and detention provided very desirable water quality conditions in 2014.

Nitrogen values tend to be low to moderate, with total Kjeldahl nitrogen (TKN) <1 mg/L and nitrate usually <0.5 mg/L. Values declined over the summer. Loss of nitrate can be a concern, as low available N:available P ratios favor cyanobacteria, but the low phosphorus levels helped in that regard.

There are periodic oxygen deficiencies in the deep hole area (MP-1), but not consistently. Low oxygen was observed in late May, while mid-June values were slightly higher but still low at the bottom. The

storm of July 4-5 seems to have mixed the lake enough to raise deep water oxygen substantially, and oxygen had not been depleted as of Aug 20. Conductivity is high in surface waters and very high in deeper water, indicating large amounts of dissolved solids in the water, although conductivity does not tell us the nature of those solids. Salts from road management are a likely source, as are lawn fertilizers. The pH is slightly elevated near the surface and declines with depth, as decomposition adds acids at deeper locations. Turbidity is moderate in most of the water column, decreasing with distance from inlets but increasing right at the bottom in the deep hole location; accumulation of very light solids is suggested at the deep hole station, and explains most other water quality variation. Alkalinity is low to moderate at all locations assessed in 2014.

Table 3. Water quality record for Morses Pond in 2014.

Station	Depth meters	Temp °C	Oxygen mg/l	Oxygen % Sat	Sp. Cond µS/cm	pH Units	Turbidity NTU	Alkalinity mg/L	Total P mg/L	Diss. P mg/L	TKN mg/L	NO3-N mg/L	Secchi meters	Chl-a µg/L
5/20/2014														
North Basin														
MP-SW-1 Bogle	0.3	18.3	8.1	87.5	580	7.3	5.3	22	0.037	0.021	<0.50	0.40		
MP-SW-2 Boudler	0.1	15.0	9.5	95.2	397	7.1	1.1	19	0.031	0.019	<0.50	1.40		
MP-NB-1 (dredged)	0.1	17.7	7.1	75.3	537	7.0	1.3		0.024	0.017	0.54	0.36		
MP-NB-2									0.035	0.023	<0.50	0.39		
Transition Zone														
MP-T-1									0.020	0.017	<0.50	0.37		
MP-T-2									0.024	0.024	<0.50	0.36		
South Basin														
MP-B-1									0.013	<0.010	<0.50	0.42	2.9	
MP-B-2									0.012	<0.010	<0.50	0.42	3.1	
MP-1 (MP -DH1)	0.1	19.1	9.0	98.2	585	7.5	0.7	24	0.011	0.014	<0.50	0.42	3.1	1.4
	1.0	19.1	8.9	97.9	584	7.5	0.6							
	2.0	19.0	8.8	96.8	583	7.5	0.7							
	3.0	18.4	8.9	95.7	583	7.4	0.9							
	4.0	13.0	7.8	75.4	611	7.3	0.7							
	5.0	10.2	3.3	30.1	823	7.1	2.0							
	6.0	9.0	0.3	2.9	905	6.8	9.2							
	6.4	8.8	0.0	0.1	922	6.3	16.1	19	0.022	0.017	0.64	0.13		
6/17/2014														
North Basin														
MP-SW-1 Bogle	0.1	21.4	7.9	90.4	592	7.6	3.4		0.038	0.016	0.62	0.66		
MP-SW-2 Boulder	0.2	16.9	6.6	69.3	267	7.2	5.6							
MP-NB-1 (dredged)	0.3	24.6	9.7	118.5	492	7.5	4.2		0.021	0.012	<0.50	0.30		
	1.1	20.9	7.2	81.4	342	7.5	2.4							
	2.0	17.5	4.5	47.5	491	7.1	2.2							
	3.0	13.1	9.0	87.4	2476	6.8	2.3							
	3.8	11.6	4.5	42.5	2761	6.5	2.1							
MP-NB-2	0.1	24.2	9.9	120.1	462	7.6	2.3		0.034	0.014	0.53	0.26		
Transition Zone														
MP-T-1	0.3	23.3	9.0	106.6	496	7.4	6.6		0.032	0.013	0.66	0.25		
	1.2	22.1	8.1	94.6	500	7.4	15.9							
	2.0	20.4	5.7	64.4	490	7.3	4.7							
MP-T-2	0.1	24.3	9.9	119.9	496	7.6	2.8		0.020	0.012	<0.50	0.29		
	1.0	22.9	9.7	115.1	455	7.6	3.1							
South Basin														
MP-B-1									0.012	0.010	0.57	0.10	4.0	
MP-B-2								19	0.011	<0.010	<0.50	0.32	4.0	
MP-1 (MP -DH1)	0.1	23.4	8.7	103.8	504	7.6	1.6		0.012	<0.010	0.54	0.32	4.6	1.2
	1.0	22.7	8.7	101.9	503	7.5	1.5							
	2.0	22.0	8.3	96.6	502	7.5	1.7							
	3.0	21.3	7.3	84.1	501	7.5	1.7							
	4.0	15.9	6.0	61.5	527	7.4	1.9							
	5.0	11.8	2.0	19.2	681	7.3	2.3							
	6.0	10.4	1.4	12.7	732	6.9	9.5							
	6.2	10.0	0.9	8.5	754	6.8	29.4	20	0.010	0.010	<0.50	0.32		

Table 3. Water quality record for Morses Pond in 2014. Continued.

Station	Depth meters	Temp °C	Oxygen mg/l	Oxygen % Sat	Sp. Cond µS/cm	pH Units	Turbidity NTU	Alkalinity mg/L	Total P mg/L	Diss. P mg/L	TKN mg/L	NO3-N mg/L	Secchi meters	Chl-a µg/L
7/9/2014														
North Basin														
MP-SW1 (Bogle)	0.0	25.7	7.6	95.1	671	7.6	9.1							
MP-SW2 (Boulder)	0.1	21.1	6.6	74.9	394	7.3	0.1							
MP-NB-1 (dredged)	1.0	24.9	3.0	37.3	385	6.6	0.1		0.015	0.010	<0.50	0.08		
	2.0	21.9	3.4	39.0	430	6.5	0.1							
	3.0	17.5	8.9	94.8	2492	6.6	0.1							
	3.3	15.8	8.3	85.7	2806	6.7	0.1							
MP-NB-2	0.0	27.2	8.5	108.6	454	7.7	0.1		0.028	0.018	<0.50	<0.05		
	0.5	27.2	7.3	93.0	463	6.9	0.1							
Transition Zone														
MP-T1	0.1	27.6	10.0	129.1	514	7.8	0.3		0.021	0.017	<0.50	<0.05		
	1.0	26.3	8.9	112.2	500	7.7	0.2							
	2.0	23.7	4.0	48.3	532	7.5	0.9							
MP-T2	0.0	27.4	9.6	123.5	500	7.7	0.1		0.019	0.012	<0.50	<0.05		
	1.0	26.9	9.9	125.3	512	7.8	0.1							
South Basin														
MP-B-1									0.014	0.012	<0.50	0.11	3.8	
MP-B-2									0.017	0.010	<0.50	0.12	3.8	
MP-1 (DH)	0.0	26.7	8.5	108.2	541	7.4	0.1	24					4.3	1.8
	1.0	26.7	8.5	108.0	541	7.6	0.1							
	2.0	26.5	8.5	107.3	540	7.6	0.1							
	3.0	25.5	8.5	104.7	540	7.6	0.1							
	4.0	20.6	5.2	58.3	571	7.4	1.4							
	5.0	13.6	1.8	17.9	726	7.2	0.1							
	6.0	11.6	2.5	23.6	778	7.0	12.7							
8/20/2014														
South Basin														
MP-1 (DH)	0.2	25.2	8.6	106.1	533	8.0	2.6	13	0.017	0.012	<0.50	<0.05	4.2	1.6
	1.0	24.1	8.8	105.9	531	8.0	2.7							
	2.0	23.9	8.7	105.2	530	7.9	2.6							
	3.1	23.6	8.6	102.6	529	7.9	2.5							
	4.1	23.1	7.9	93.3	532	7.8	4.2							
	5.0	19.7	5.1	57.1	656	7.7	4.6							
	6.0	13.3	1.1	10.5	831	6.8	28.7	63	0.075	<0.010	1.40	<0.05		

Water clarity was as high as we have observed in Morses Pond, with an average value in 2014 of 3.8 m (12.5 feet). Corresponding chlorophyll-a levels, indicative of algae abundance, were low. Despite the urban nature of the watershed, water quality was very desirable in most parts of the lake during the summer of 2014.

On June 5 of 2014 we sampled upstream and downstream of the treatment point on Bogle and Boulder Brooks. Access downstream is limited, and reactions occur for minutes to hours, so this is not an ideal comparison, but the immediate decline in total phosphorus was evident (Table 5). Reduction in just a short distance (50 to 200 ft) ranged from 47 to 80%. Equally important is the creation of heavier particles that will settle out more quickly, which combined with the extra detention created by dredging in the north basin, minimizes the transport of phosphorus to the south basin.

Table 4. Water Quality Testing Results Relating to the Phosphorus Inactivation System

Year	Location	Pre-Application TP (ug/L)	Early Summer TP (ug/L)	Late Summer TP (ug/L)	Algae Issues
2008	North Basin	28	18		Mats observed, some cloudiness, early summer is really July 23 at end of treatment
	Transition Zone	31	22		Some cloudiness, brownish color, early summer is really July 23 at end of treatment
	Swimming Area	21	12		Relatively clear, no blooms, early summer is really July 23 at end of treatment
2009	North Basin	35	40	63	Cloudy, some mats
	Transition Zone	35	39		Cloudy
	Swimming Area	15	10	27	Generally clear, no blooms
2010	North Basin	26	46	53	Cloudy, mats evident
	Transition Zone	28	21	32	Brownish color, minimally cloudy
	Swimming Area	19	15	43	Generally clear, no blooms until late August
2011	North Basin	53	33	130	Cloudy, mats evident
	Transition Zone	48	29	95	Slightly brownish
	Swimming Area	30	29	60	Clearest water in years in late June, but short-lived cyanobloom in early August
2012	North Basin	32	24	48	Very dense plant growth
	Transition Zone	28	37	28	Brownish most of summer
	Swimming Area	20	27	24	Had bloom in mid-July
2013	North Basin		47		Very wet June, system overwhelmed
	Transition Zone		78		
	Swimming Area	14 - 24	33	28	Continued treatment kept TP down, but not to target level
2014	North Basin	30	22		Dry May and June, wet July; dredged area trapping particulates fairly well
	Transition Zone	21	20		Dense plant growths, but water fairly clear
	Swimming Area	12	13	17	Water clear; best conditions in years

Figure 3. Relationship between water clarity and total phosphorus in Morses Pond, 1980-2013.

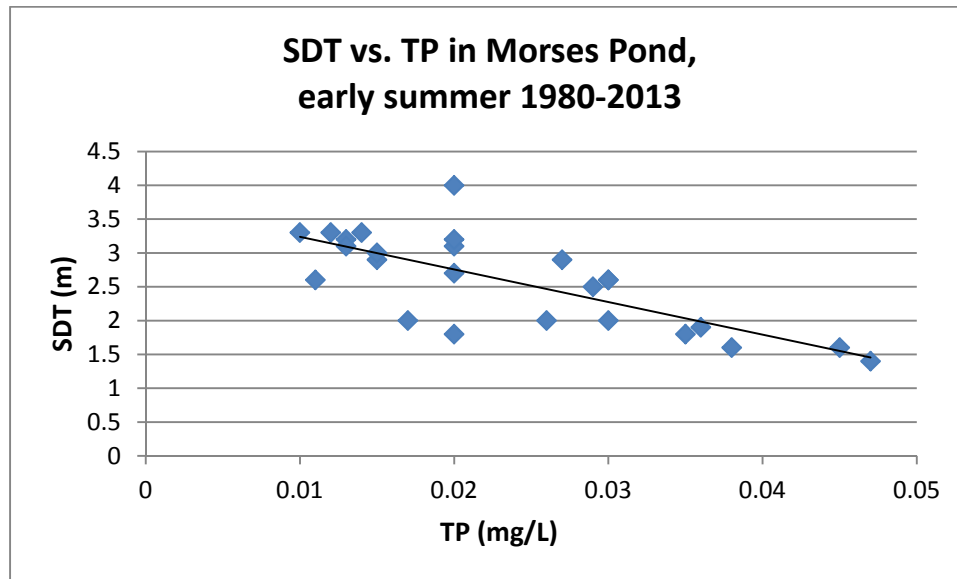


Table 5. Total phosphorus levels upstream and downstream of treatment on one 2014 date.

6/5/2014	mg/L	mg/L
North Basin		
MP-SW-1 untreated Bogle	0.073	0.015
MP-SW-1 treated Bogle	0.051	0.027
MP-SW-2 untreated Boulder	0.100	0.026
MP-SW-2 treated Boulder	0.059	0.024

From a longer term perspective (Table 4), while treatment in 2008 started late and was largely experimental, results for total phosphorus at the end of the initial treatment period for 2008 were <20 µg/L. Similar results were achieved in 2009 and 2010; throughout these three years values approached the ideal 10 µg/L level in early summer. Total phosphorus remained somewhat elevated in early summer of 2011; we do not know if there was some lab error associated with the 2011 early summer values, but the water was fairly clear at that time, so available phosphorus had to be very low, even if the total phosphorus was somewhat elevated.

Treatment problems were encountered on most treatment days in 2012, and total phosphorus increased in early summer of 2012. Frequent and timely repairs kept the treatments going, but they were not as efficient and apparently not as effective as in the previous three years. Detention capacity of the north basin was limited by shallow depth resulting from years of sediment deposition; dredging was planned for fall 2012. Consequently, the combination of treatment and detention was insufficient to prevent a bloom from forming in mid-July, and the phosphorus level in the south basin was >20 ug/L. A copper treatment was conducted in the swimming area to reduce algae and increase clarity in mid-July, but

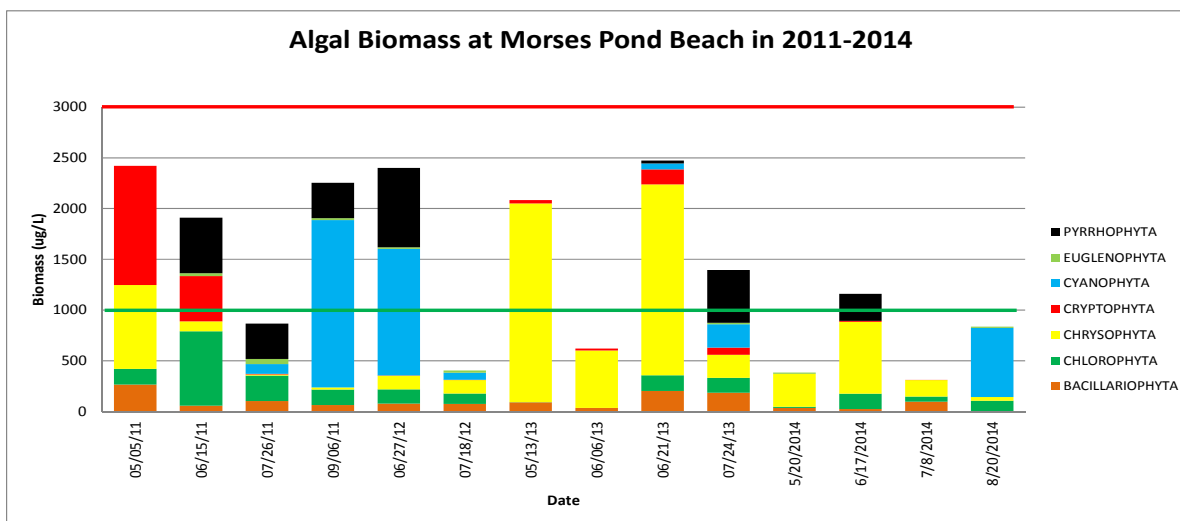
a major storm within a few days resulted in a major flushing of the lake. The storm inputs were treated with aluminum, and no further algal blooms occurred in the summer of 2012.

System repairs by the Wellesley DPW and WRS Inc. made more effective treatment possible in 2013, but rain in June was about 2.5 times the long-term average, and not all incoming runoff could be treated. Phosphorus levels never reached the early summer target, although continued treatment kept values lower than they would have been through early August, when treatment was ceased. Fortunately, high runoff leads to a higher flushing rate, and no algal blooms occurred in 2013.

Conditions in 2014 are a product of weather, effective treatment, and improved detention in the north basin. Water clarity was the highest it has been since implementation of the comprehensive plan, no serious problems were encountered in application, and less was spent on chemicals than in the previous 5 years. The relationship depicted in Figure 3 has been upheld; maintenance of total phosphorus <20 ug/L minimizes bloom potential. It is possible to have higher phosphorus and no blooms if flushing is consistently high through the summer, but there is usually a dry period during which blooms use nutrients input in prior months unless treatment has occurred.

Algal data for 2011-2014 illustrate processes in Morses Pond over the summer (Figure 4). Algae biomass and composition can be very variable, depending on combinations of nutrient levels, light, temperature and flushing. The record for Morses Pond phytoplankton over the last 4 years is varied, but since spring phosphorus inactivation began, biomass values have not exceeded the general threshold of 3000 ug/L that signals low clarity (note that there is no official threshold for algae, but the red line in Figure 3 is a useful limit). Phytoplankton biomass has often been below the 1000 ug/L threshold indicative of low biomass, including 3 of 4 values for 2014. Cyanobacteria were moderately abundant in late summer 2011 and late spring 2012, but have not been common since then. The few cyanobacteria that were detected in August of 2015 were bloom forming species, but did not reach bloom proportions in 2015.

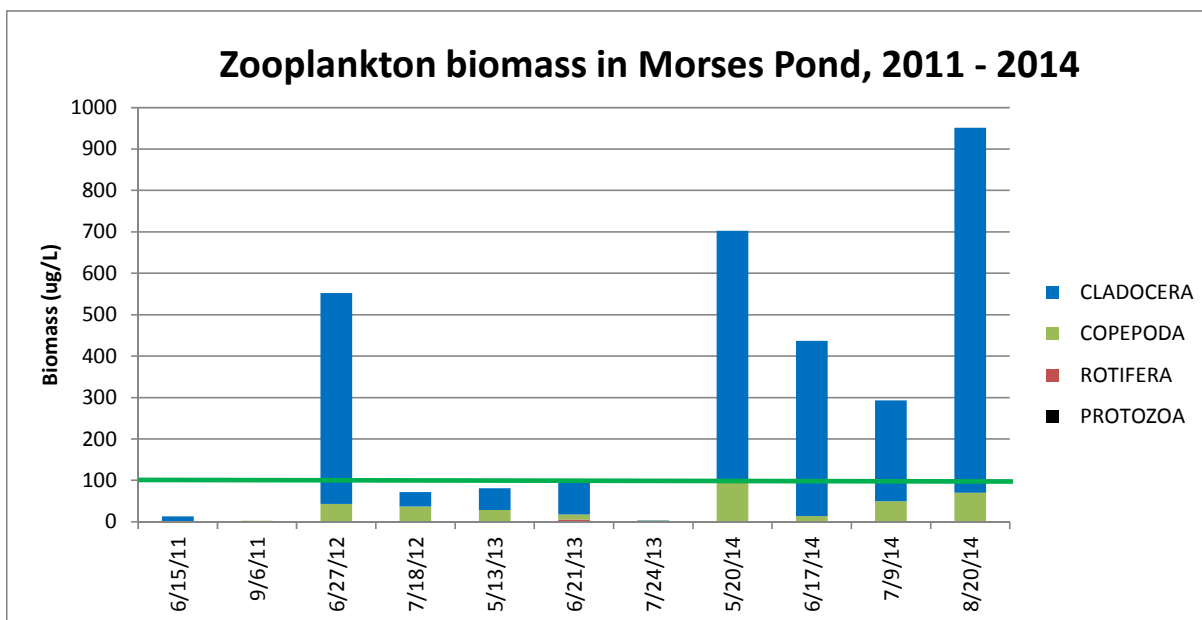
Figure 4. Algal Data for 2011-2014



Zooplankton have also been sampled, and while not as tightly linked to nutrients, provide important information on the link between algae and fish (Figures 5 and 6). Zooplankton biomass varies strongly between and within years. Values <25 ug/L are low and values higher than 100 ug/L are high; Morses Pond values span that range and more. Values in later summer are expected to be lower than in late spring or early summer, as fish predation by young-of-the-year fish (those hatching that year) reduces populations of zooplankters. Spring levels will depend on water quality, predation by adult fish, and available algae, which are food for zooplankton. The dominant zooplankton tend to be cladocerans and copepods, both groups of micro-crustaceans. *Daphnia*, among the larger cladocerans, filters the water to accumulate algae as food, and can increase water clarity markedly.

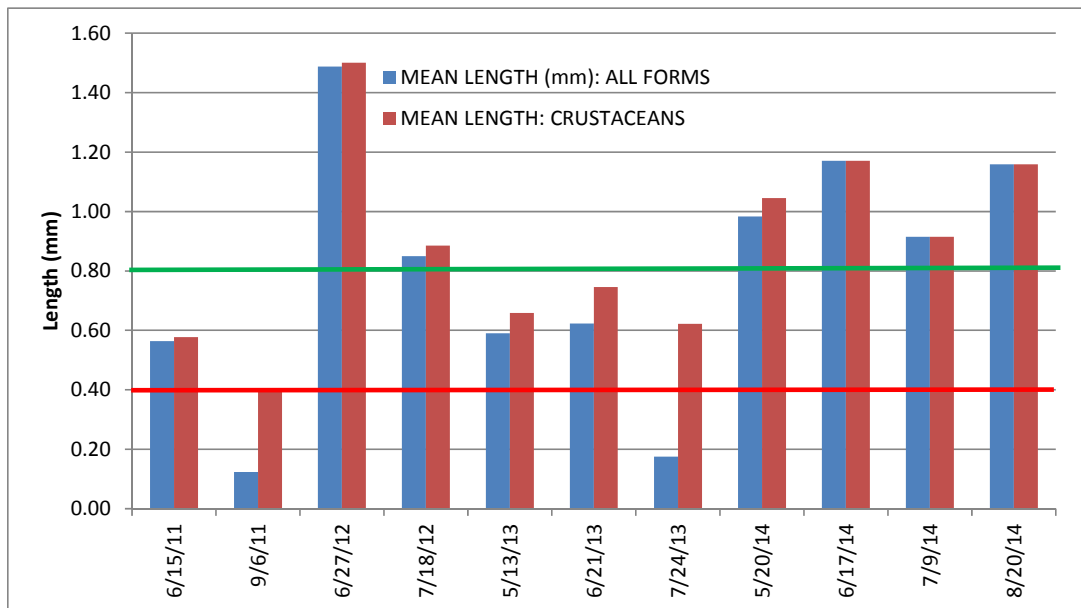
Daphnia were present in Morses Pond in all years, a good sign, and abundance was elevated in late spring of 2012, 2013 and 2014. The late summer zooplankton population was very low in 2011 and 2013, but was substantial in 2012 and hit an all-time record (for any lake on which we have worked) in 2014. Variation does not appear to relate to aluminum treatments, which could be toxic at high concentration and high or low pH; the treatment protocols minimize this probability. Variation in fish reproduction and predation and flushing rate may have considerable influence, but maintaining a desirable algae community is also important. Algae productivity may still be high in Morses Pond, but as long as the algae are edible and there are plenty of large grazing zooplankton, the standing crop of algae will be low.

Figure 5. Zooplankton abundance for 2011-2014.



The size distribution of zooplankton is important, as larger individuals are more effective grazers and represent better food for small fish. Mean lengths for at least crustacean zooplankton usually exceed the minimum desirable threshold, and are often higher than the highly desirable threshold, including for all samples from 2014. The grazing capacity in 2014 was very high, and undoubtedly contributed to low algae abundance and high clarity.

Figure 6. Zooplankton mean length, 2011-2014.



Plant Harvesting

Harvesting Strategy

The Town of Wellesley initiated the enhanced Morses Pond vegetation harvesting program in 2007. The zoned vegetation harvesting strategy originates from the 2005 pilot program and comprehensive management plan written that year. For the pilot program, Morses Pond was divided into seven zones in order to better track the harvesting process. Figure 7 shows these zones and Morses Pond bathymetry. Harvesting protocols have been adjusted through experience to maximize effectiveness and minimize undesirable impacts, such as free fragments that accumulate along shore. The refinement process was detailed in the 2010 annual report. The current approach is to harvest all areas by the end of June, sometimes using both harvesters, with a cutting order and pattern that limits fragment accumulation, especially at the town swimming beach. This usually involved cutting in area 6 first, with any work around the edge of area 7 second, followed by work in areas 2, 3 and 4 in whatever order appears warranted by conditions. Area 5 is in Natick and is usually not cut, and area 1 is the north basin and is also not cut, except when the dredging was planned and clogging of the pipeline was desired. A second cutting occurs from August into September.

The keys to successful harvesting include:

- Initiating harvesting by the Memorial Day weekend.
- Cutting with or against the wind, but not perpendicular to the wind, to aid fragment collection.
- Limiting harvesting on very windy days (a safety concern as well as fragment control measure).
- Using the second, smaller harvester to pick up fragments if many are generated.

- Cutting far enough below the surface to prevent rapid regrowth to the surface, but not so far as to cut desirable low growing species such as Robbins' pondweed.
- Minimizing travel time on the water with a cutting pattern that does not end a run any farther from the offloading point near the outlet than necessary.
- Preventive maintenance in the off season to minimize down time during the harvest season.
- Using trained personnel who know what to cut, where to cut, and how to avoid damage that would necessitate maintenance of the harvester.

The second, older harvester has been used mainly to collect fragments released by the larger, newer harvester, or to accelerate harvesting at key times and in key places, and this approach has worked well.

Harvesting Record

Records provided by the Town of Wellesley indicate the harvesting effort expended on Morses Pond (Table 6). Although the record is not always complete, records have been kept since 2007. Between late May and early September, from 2007 through 2014, harvesting was conducted on a range of 43 to 76 days. This represents a range of 303 to 520 total hours devoted to some aspect of the harvesting program, and 223 to 335 hours of actual harvesting time. Total loads of aquatic plants harvested have ranged from 78 to 125 per harvesting season. Total weight of plants harvested, as measured upon entry to the composting facility (so some draining of water, but not a dry weight) has ranged from 224,000 to 808,000 lbs, with larger weights in more recent years. There is speculation that this is a function of record keeping and not an actual increase in harvest weight, but we cannot be sure.

Between 6.4 and 7.7 hours are spent on a day when harvesting occurs, including transport to and from the pond, actual cutting, transport on the water, loading and unloading, and harvester maintenance. 2014 provided the second highest number of days when harvesting occurred, but the lowest average hours per day in the record. A range of 3.5 to 5.4 hours per day are spent on actual cutting, with a decline since 2009, and 2014 yielding the lowest cutting hours per day. Data for 2012 may be different from those of other years, at least partly due to cutting in area 1 in preparation for dredging; plant density is very high in this section of the pond, which is not normally harvested, and resulted in faster load generation but more travel time, reducing hours spent actually cutting each day but raising the biomass removed. Yet the declining pattern is observed in all years since 2009 (Figure 8), and the reason for continued decline in cutting hours per day is not known. Decreased productivity could be related to increased maintenance needs, but 2014 is the first year in which records for non-cutting hours have been broken into categories including transport time on the water, transport time on land, and maintenance. The 2014 record indicates a fairly even split of the 211 non-cutting hours among those categories. This is a concern in terms of program efficiency and effectiveness, and should be investigated further prior to the 2015 harvesting program initiation.

Weight per day, per load, per total hour and per cutting hour vary considerably among years, and will vary substantially among days within years. Some periods are more productive than others, owing to areas of variable plant density and distance to the offloading area between the beach and outlet. Weight per cutting hour is viewed as highly relevant, and excluding early "training" years and 2012, ranges from 1000 to 1800 lbs/cutting hour. With a weight per load that is typically between 3000 and 5000 lbs, the operator is ideally cutting for between 2 and 3 hours, coming in to unload and get a break,

Figure 7. Plant Management Zones for Morses Pond.

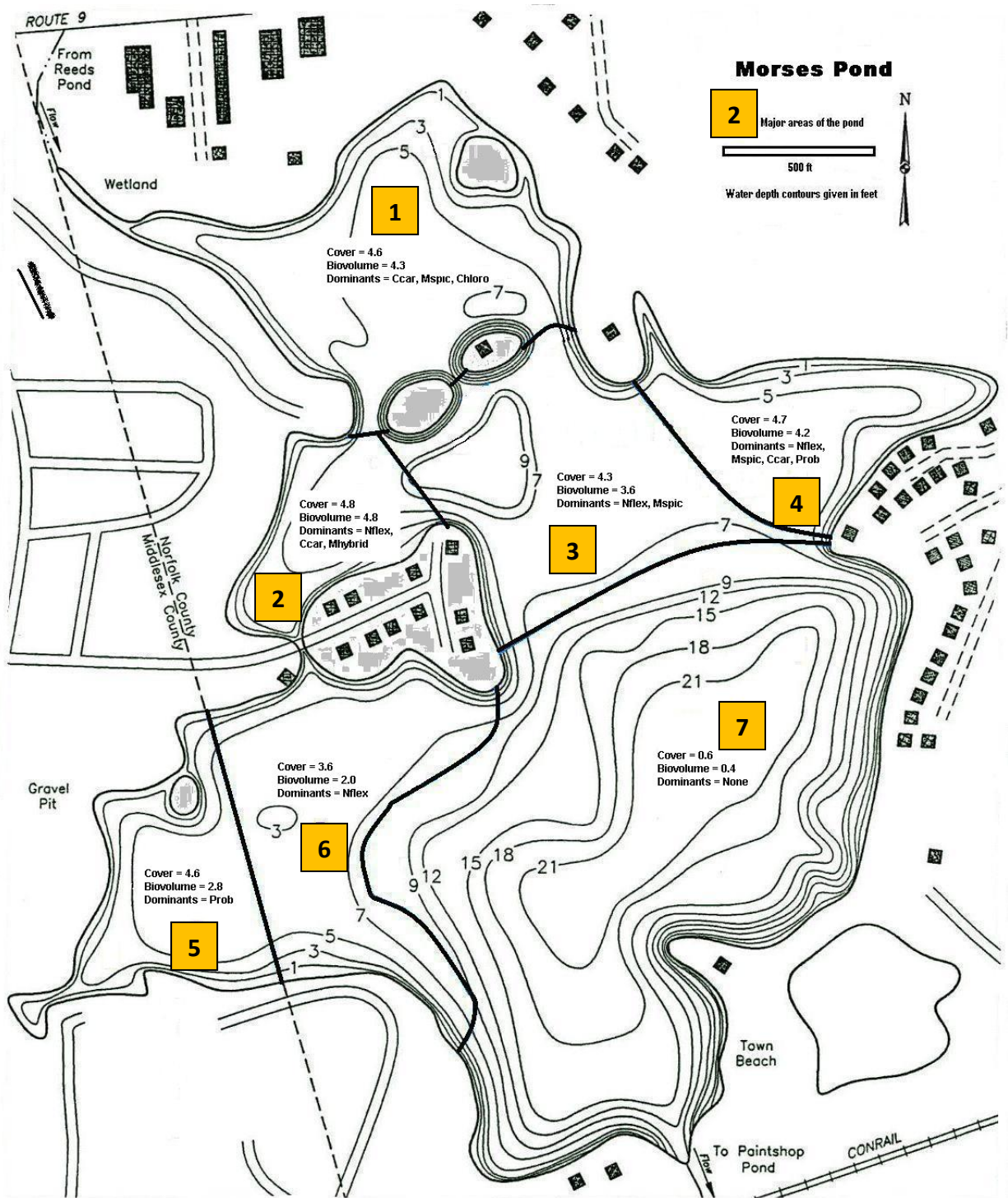


Table 6. Harvesting Record for Morses Pond.

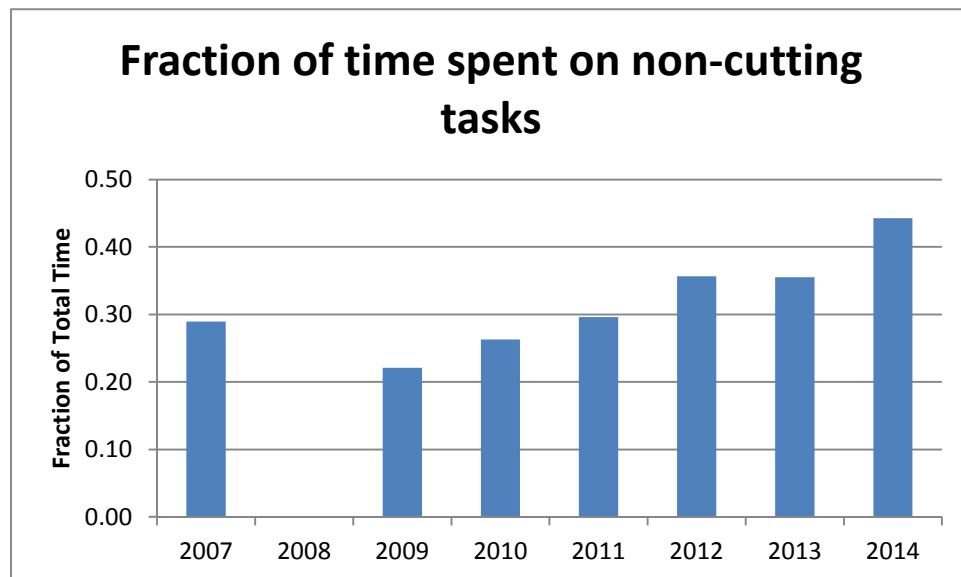
Year	Days of Harvesting per Year	Total Hours per Year	Cutting Hours per Year	Total Hr/Day	Cutting Hr/Day	Total Loads	Total Weight	Weight/ Day	Weight/ Load	Weight/ Total Hr	Weight/ Cutting Hr
	(Days)	(Hr)	(Hr)	(Hr)	(Hr)	(Load)	(Pounds)	(Pounds)	(Pounds)	(Pounds)	(Pounds)
2007	49	359	255	7.3	5.2	109	NA	NA	NA	NA	NA
2008	43	NA	NA	NA	NA	NA	270320	6287	NA	NA	NA
2009	57	390	304	6.8	5.3	78	224060	3931	2891	575	738
2010	44	303	223	6.9	5.1	78	226960	5278	2900	749	1017
2011	54	414	291	7.7	5.4	102	292000	5407	2863	706	1003
2012	70	460	296	6.6	4.2	124.5	807760	11539	6488	1756	2729
2013	76	519.5	335	6.8	4.4	119.5	595277	7833	4981	1146	1777
2014	75	476.5	265.5	6.4	3.5	110	455220	6070	4138	955	1715

For 2009 total hours, assumes 1.5 hr/harvesting day of non-cutting time, based on values for those days with total and cutting hours.

For 2010 total weight, assumes 202,000 pounds resulting from hydroraking, based on values for days when hydroraking occurred.

For 2012, harvesting includes Area 1, which had very dense plant growths and may account for additional weight removed.

Figure 8. Non-cutting hours associate with the harvesting program.



and getting a second cutting session in the same day. This should result in at least 5 hr of cutting per day; this target was met in the first 4 years with records but has not been met in the last 3 years. Yet the harvester has met its goal of at least one complete cut of the roughly 45 acres of dense vegetation outside area 1 before the 4th of July weekend in each year. Harvesting in August and September has also occurred as planned. The equipment appears to have been the correct choice for the Morses Pond program. Current issues relate mainly to efficiency and presumably cost control.

We are missing plant weight data from 2007 and hourly activity data from 2008, and the identification of plants being targeted by harvesting is not always consistent with what has been observed by staff in the field. Robbins' pondweed, a desirable species, was the dominant plant harvested on 3 days early in the 2014 program. There have been problems with plant fragment creation and accumulation along shorelines in some years. Some fragment release is unavoidable, but adjustments were made that greatly improved performance in subsequent years. There have been changes in personnel and procedures, so continued training should be emphasized. Overall, the plant harvesting program has been proceeding well, achieving desirable results, and being adjusted to enhance performance as warranted. Improved efficiency is the primary goal moving forward.

There have been some plant controls additional to mechanical harvesting with "standard" weed cutters. A benthic barrier was installed at the swimming beach in 2008 as a pilot study, but no further application occurred. The original benthic barrier is still in place, but is buried under sand. Hand harvesting of water chestnut is practiced each spring by a group of volunteers supported by the town. This effort has kept water chestnut in check, with only scattered plants found and removed each year.

Hydroraking occurs annually if needed in the beach area, prior to setting up the ropes and docks. In 2013 there was no hydroraking, but dredging of sand deposits to deepen the north basin facilitated beach nourishment in the swimming area, and any plants in that area were buried by sand transported in the dredging pipeline. Hydroraking of the swimming area was conducted in 2014, with 6700 lbs of plants removed. Hydroraking of shallow areas was desired by many shoreline residents, and was planned for 2009. However, equipment problems precluded execution of hydroraking beyond the beach area that year. Hydroraking of peripheral areas was conducted in 2010, with residents paying for those services off their shoreline parcels.

Plant Surveys

Plant surveys were conducted in early to mid-May of 2008, 2009, and 2010 prior to plant harvesting to determine the assemblage features and facilitate recommendation of any program adjustments. These surveys have helped to identify areas supporting very dense aquatic plant growths and helps set priorities for harvesting. Shoreline surveys were also performed to guide localized plant control by shoreline residents, including proposed hydroraking. In 2011, with the harvesting program protocols generally well known to the DPW staff involved in the project, we opted to survey the plants at selected stations during the harvesting, allowing some comparison among harvested areas as a consequence of harvesting. This process was repeated in 2012 and 2013 for continued comparison of harvested vs unharvested areas. In 2014 we returned to a pre-harvesting survey to determine if there had been any cumulative impact of harvesting, as it is possible that repeated harvesting could shift the plant community to lower growing, more desirable forms.

Methods

Surveys applied the point-intercept method, resulting in 306 survey points on Morses Pond the same as utilized during the 2005 vegetation survey that set the stage for the comprehensive plan as relates to plant control in Morses Pond. The point-intercept methodology is intended to document the spatial

distribution and percent cover and biovolume of aquatic plants at specific re-locatable sites. At each point the following information is recorded:

- The GPS waypoint.
- Water depth using a metal graduated rod or a mechanical depth finder.
- Plant cover and biovolume ratings using a standardized system.
- Relative abundance of plant species.

For each plant species, staff recorded whether the species was present at trace (one or two sprigs), sparse (a handful of the plant), moderate (a few handfuls of the plant), or dense (many handfuls of the plant) levels at each site. Plant cover represents the total surface area covered in plants (2 dimensions). For cover, areas with no plants were assigned a “0,” areas with approximately 1-25% cover were assigned a “1,” a “2” for 26-50%, a “3” for 51-75%, a “4” for 76-99%, and a “5” for 100% cover. Like plant cover, a quartile scale was used to express plant biovolume, defined as the estimated volume of living plant material filling the water column (3 dimensions). For biovolume, 0= no plants, 1= 1-25%, 2=26-50%, 3=51-75%, 4=76-100%, and 5= 100% of plants filling the water column.

Shoreline surveys to support hydroraking were described in the 2010 annual report. No such surveys were conducted after 2010. The number of points surveyed has been reduced since 2011, based on statistical analysis of how many points are necessary to get an accurate appraisal of plant conditions, but the choice of points is randomized within each established zone each year, so the 306 point configuration remains valid and useful.

2014 Results

For the point-intercept surveys, 37 species are known from Morses Pond, with 23 plant species detected in 2005, 20 plant species encountered in the 2008 and 2009 surveys, 24 in 2010 and 2011, 25 species in 2012, 20 species in 2013, and now 18 species in 2014 (Table 7). Oscillations in species richness are largely a function of a few rare species being found or not found in any given year; the dominant suite of species remains the same. The four invasive submerged aquatic plant species encountered include:

- *Cabomba caroliniana* (Fanwort)
- *Myriophyllum spicatum* (Eurasian watermilfoil)
- *Myriophyllum heterophyllum* (Variable watermilfoil)
- *Potamogeton crispus* (Curlyleaf pondweed)

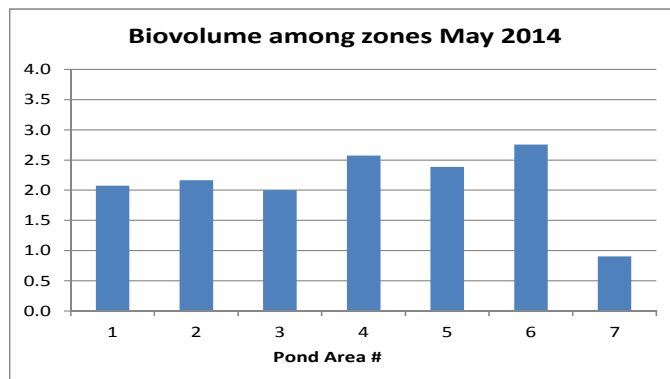
Note that *Trapa natans*, water chestnut, is also known from Morses Pond, but owing to the efforts of volunteer water chestnut pullers, it has never been found in the standard survey. Also note that *Lythrum salicaria* (Purple loosestrife) is a peripheral species that is abundant but not always picked up by our aquatic surveys.

Overall, Morses Pond exhibits moderate to dense vegetation cover and biovolume prior to harvesting (Figure 9). This is not appreciably different than other years. Dominant species include fanwort (*Cabomba caroliniana*), variable watermilfoil (*Myriophyllum heterophyllum*) and Eurasian watermilfoil (*M. spicatum*), all invasive species. Other species are locally abundant, but these three invasive species represent most of the submergent plant biomass and are the targets of harvesting. The primary goal of harvesting is to keep these species at low enough biovolume (portion of the water column filled) to

Table 7. Aquatic Plants in Morses Pond.

Scientific Name	Common Name	Plant Rating for Year							
		2005	2008	2009	2010	2011	2012	2013	2014
<i>Brasenia schreberi</i>	Watershield							P	P
<i>Callitriche</i> sp.	Water starwort	P		P					
<i>Cabomba caroliniana</i>	Fanwort	A	A	A	A	A	A	A	A
<i>Ceratophyllum demersum</i>	Coontail	C	C	C	A	C	C	C	C
<i>Chlorophyta</i>	Green algae	C	C	C	A		P	C	P
<i>Cyanobacteria</i>	Blue green algae		P		C	P	P		P
<i>Decodon verticillatus</i>	Swamp loosestrife	C	P		P	P			
<i>Elodea canadensis</i>	Waterweed	C	C	C	C	C	C	C	C
<i>Lemna Minor</i>	Duckweed	P	P	P	P	P	P	P	
<i>Lythrum salicaria</i>	Purple loosestrife	P	P	P	P	P	P		
<i>Myriophyllum heterophyllum</i>	Variable watermilfoil	P	C	C	A	A	A	C	C
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	A	A	A	A	C	C	A	A
<i>Najas flexilis</i>	Common naiad	C	C	C	C	P	P	P	P
<i>Nymphaea odorata</i>	White water lily	C	C	C	C	C	C	C	P
<i>Nuphar variegatum</i>	Yellow water lily	C	P	P	P	P	P	P	P
<i>Polygonum amphibium</i>	Smartweed	P	P	P	P	P	P	P	P
<i>Pontederia cordata</i>	Pickrelweed	P		P	P			P	
<i>Potamogeton amplifolius</i>	Broadleaf pondweed	C	C	C	C	C	C		C
<i>Potamogeton crispus</i>	Crispy pondweed		C	C	C	P	P	P	C
<i>Potamogeton epihydrus</i>	Ribbonleaf pondweed		P	P	P	P	P	P	C
<i>Potamogeton perfoliatus</i>	Claspingleaf pondweed					P	P		P
<i>Potamogeton pulcher</i>	Spotted pondweed	P			P	P	P	P	P
<i>Potamogeton robbinsii</i>	Fern-leaf pondweed	C	C	C	C	P	P	P	C
<i>Potamogeton spirillus</i>	Spiral seed pondweed					P	P	P	P
<i>Potamogeton zosteriformis</i>	Flatstem pondweed						P	P	
<i>Ranunculus</i> sp.	Water crowfoot								
<i>Salix</i> sp.	Willow				P				
<i>Sagittaria gramineus</i>	Submerged arrowhead	P	P	P		P	P		
<i>Sparganium</i> sp.	Burreed								
<i>Spirodela polyrhiza</i>	Big duckweed	P				P		P	
<i>Typha latifolia</i>	Cattail			P					
<i>Trapa natans</i>	Water chestnut								
<i>Utricularia geminiscapa</i>	Bladderwort	P	P		P		P	P	
<i>Utricularia gibba</i>	Bladderwort	C				P			
<i>Valisneria americana</i>	Water celery				P	P	P		
<i>Wolffia columbiana</i>	Watermeal	P			P		P		
	# of Species	23	20	20	24	24	25	20	18
	P=Present, C=Common, A=Abundant								

Figure 9. Biovolume of Plants in Areas of Morses Pond in 2014.



minimize interference with recreation and to maximize habitat for the range of aquatic species and water dependent wildlife using the pond. The harvesting operation accomplishes that goal in target areas most of the time, but growth prior to harvesting in the spring can be substantial, and getting to all areas requires effort through June.

Multi-Year Results

One central question is whether or not the harvesting is making any longer term difference. It is possible that the twice per year cutting will favor low growing species over the invasive species that fill the water column over time, but no evidence has been obvious since the new harvesting program began in 2007. With start up and training, it was not until about 2011 that the program was running at full capacity; the 2010 plant survey occurred prior to harvesting and makes a good point of comparison for 2014 data, also collected prior to harvesting that year. Comparing 2014 data prior to any harvesting with data from 2010 prior to any harvesting, we do not see a decrease in the biovolume of plants coming into the harvesting season (Figure 10). In essence, the plant community grows back to its original biovolume status each year, despite harvesting in many (but not all) areas. Note that Area 5 is not harvested, Area 7 is minimally harvested, and Area 1 was only harvested twice, but part of it was dredged. Yet areas 2, 3, 4 and 6, which are harvested twice per year, show no indication of decreased biovolume the following spring.

However, the frequency of the main invasive species, fanwort and two milfoil species, does show a decrease between 2010 and 2014 (Figures 11-13) for nearly all harvested areas. There are decreases in Area 1 that are most likely related to dredging, and smaller changes in Areas 5 and 7 that are probably not significant. Area 6 showed a decrease for fanwort but not for milfoil species. However, two of the more desirable species, common naiad (Figure 14) and Robbins' pondweed (Figure 15), show even more pronounced decreases, even in unharvested areas. The overall plant community is not especially stable, but there is not strong indication of a decrease in nuisance species and no indication at all of an increase in desirable species as of 2014.

The decline in the frequency of invasive species in harvested areas may be a consequence of reduced species richness. There is a decline in the number of species found at each survey station (Figure 16) for all pond areas, although the decline is smaller for Areas 5 and 7, with no and less harvesting, respectively. The decline in Area 1 is most striking, and probably relates to dredging. The decreases in Areas 2, 3, 4 and 6 are not outside the range of natural variability, but it cannot be claimed that harvesting is increasing species richness.

Figure 10. Biovolume Comparison, 2010 vs. 2014.

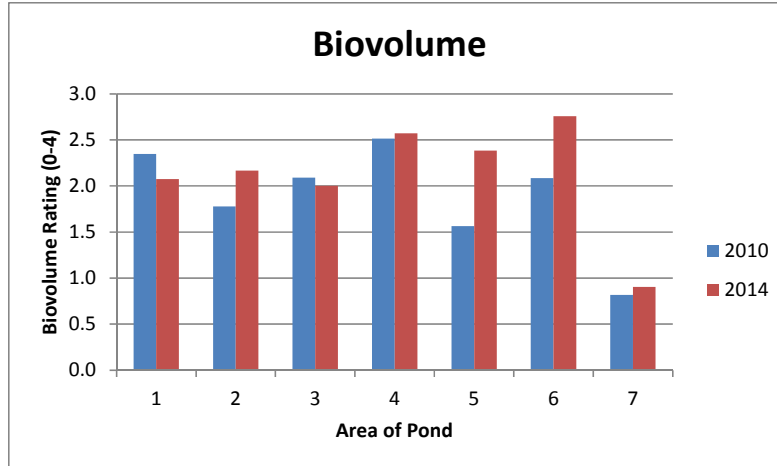


Figure 11. Fanwort Frequency Comparison, 2010 vs. 2014.

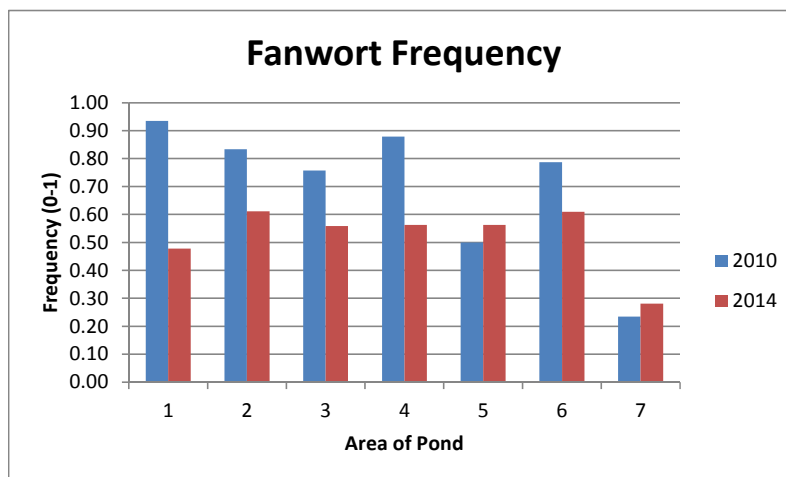


Figure 12. Variable Milfoil Frequency Comparison, 2010 vs. 2014.

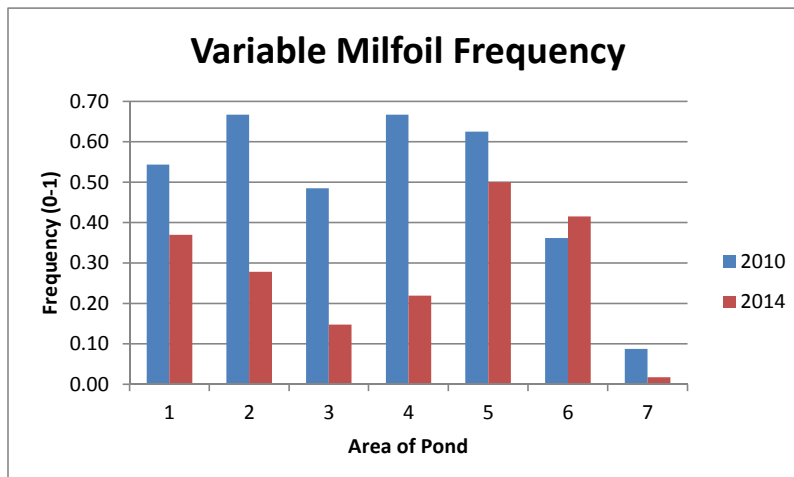


Figure 13. Eurasian Milfoil Frequency Comparison, 2010 vs. 2014.

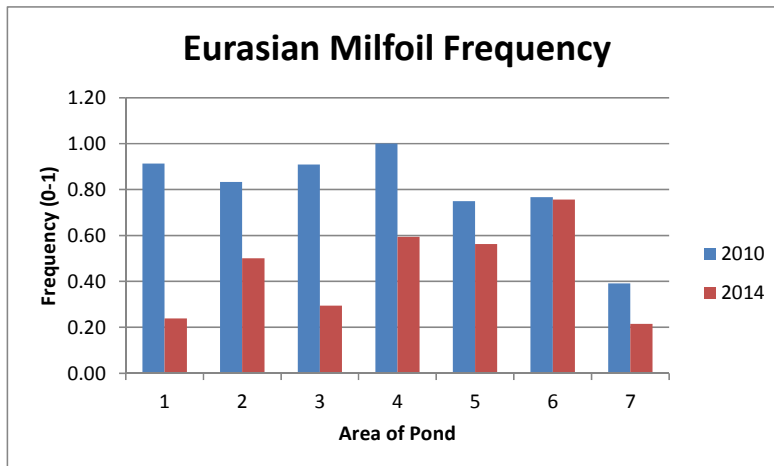


Figure 14. Common Naiad Frequency Comparison, 2010 vs. 2014.

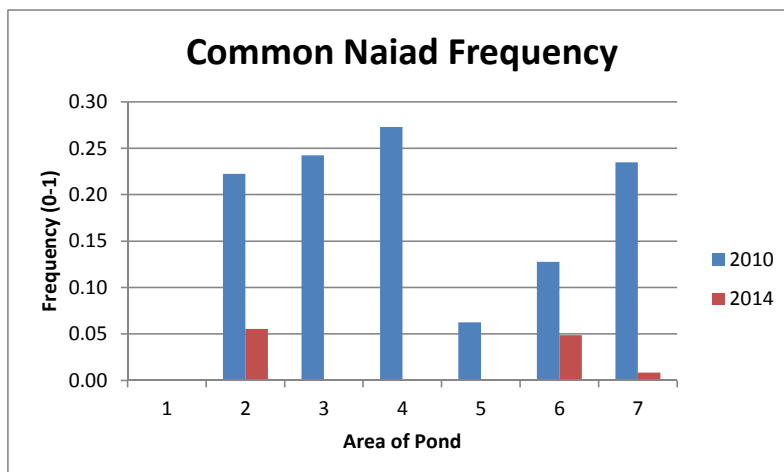


Figure 15. Robbins' Pondweed Frequency Comparison, 2010 vs. 2014.

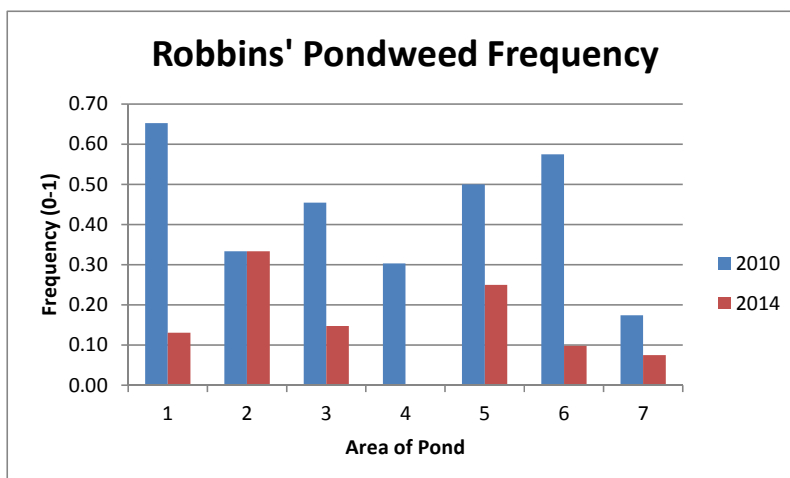
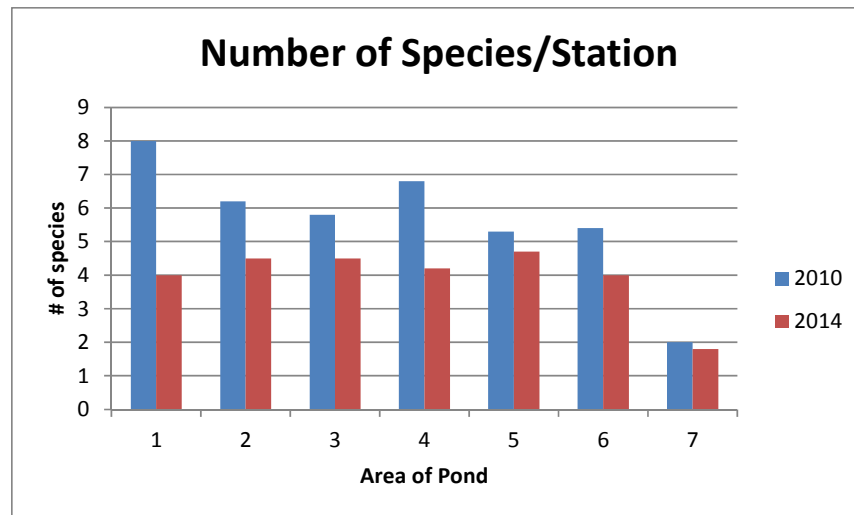


Figure 16. Comparison of Number of Species per Survey Station, 2010 vs. 2014.



Conclusions Relating to Plants and Mechanical Harvesting

The plant community of Morses Pond would still be too dense in most areas without harvesting and is dominated by invasive species. Harvesting with the new harvester and an adjusted approach appears to be controlling biomass and the portion of the water column filled, but shifts in species dominance are not extreme; invasive species have been reduced in frequency of occurrence, but so have other species. Harvesting keeps areas open for habitat and recreational use, but must occur each year to maintain those gains. Harvesting is a reliable maintenance technique, but has not yet been demonstrated as a strong force in shaping the longer term plant community in Morses Pond.

Hand Harvesting

A group of volunteers within the Friends of Morses Pond has accepted responsibility for finding and pulling out water chestnut (*Trapa natans*) plants in Morses Pond each spring and summer. This group uses kayaks and manual removal to eradicate pioneer infestations before seeds can be formed and deposited. This effort continues to be very successful; no water chestnut has been recorded in any lakewide plant survey to date. Plants are typically encountered in peripheral areas with considerable emergent or surface vegetation and are attributed to seeds being transported to Morses Pond by waterfowl, a common dispersal method for this invasive species.

As a seed producing annual species, water chestnut is best controlled by plant removal prior to seed production. Once seeds have been produced and dropped by the plant, removal will not prevent recurrence the following year. Consequently, it is important to locate each new plant and pull it prior to seed release, usually by the end of July. The Morses Pond program concentrates on early detection and removal, and has been supported by the town through the provision of kayaks, but is otherwise a completely volunteer effort that has proven very effective.

Low Impact Development Demonstration

In the spring of 2008, AECOM evaluated public sites within the Morses Pond watershed for future application of Low Impact Development (LID) techniques. A desktop analysis was conducted on the approximately 60 parcels identified. Out of the 60 parcels, 13 locations were identified for further field investigation. Based on the field investigation, the Upham Elementary School and Bates Elementary School were chosen as the best properties for a LID demonstration.

The Upham Elementary School was selected for further design, and in 2009 preliminary design plans and specifications were prepared. The design included conversion of grassed islands and a portion of the paved play yard in front of the school to a series of water quality swales with added bioretention filtration of stormwater. The design also included a larger bioretention area behind the school by the ball field parking. AECOM worked with Wellesley DPW and the Natural Resource Commission (NRC) on fine tuning the design to provide a demonstration project that would provide water quality treatment with minimal maintenance requirements. In early 2011 the plans were rejected by the school board due to impacts to trees in the area. This was a surprising turn of events, and the NRC developed an alternative plan a LID demonstration project.

As an alternative, a demonstration project was completed in the Morses Pond beach complex area. This was viewed as a high visibility site during the beach season, and could be used to educate residents about the need for and potential of simple landscaping techniques in managing urban water quality. Two rain gardens were established and a roof drip line erosion control system was installed. This was meant as both a functioning system for the beach complex and as an educational tool. There has not been any follow up activity, however, and this sort of effort needs to be expanded within Wellesley.

Education

The Town of Wellesley produced an informative brochure on the importance of phosphorus control many years ago, and has expanded on this approach to resident education since then. Everyone interacting with the Natural Resources Commission is provided an educational packet which contains brochures and other materials under the theme of the Green Wellesley Campaign. The packet focuses on protecting the environment and living a more sustainable lifestyle as a resident of Wellesley, although the contents are applicable to almost any town in the area. Included is information on:

- Understanding storm water and its impact on our streams and ponds.
- The impact of phosphorus on ponds.
- The importance of buffer strips and how to establish and maintain them.
- Managing residential storm water through rain gardens, infiltration trenches, rain barrels and other Low Impact Development (LID) techniques.
- Organic lawn and landscape management.
- Tree maintenance and related town bylaws.
- Recycling needs and options.
- Energy efficiency in the home.

The NRC has assembled an excellent suite of educational materials, and while it may take years to affect the cultural shift in our thinking and habits that protects and improves our environment, this is an important step in the right direction.

The Town also has bylaws relating to lawn watering and other residential activities that affect water quality in streams and lakes, including Morses Pond. The extent to which residents understand these regulations is uncertain, but the educational packet helps in this regard. The right messages are being sent, but reception and reaction have not been gauged recently.

In 2006 a survey was conducted by AECOM on behalf of the Town to assess resident awareness and practices. It appeared that more people handled their own lawn care than expected, and that most were anxious to learn about approaches that might have less impact on water quality. Most homeowners had little background knowledge of issues relating to fertilizer use and other residential management practices.

It was determined that a website would be a desirable additional means of communicating with residents on their role in protecting water quality through desirable residential practices. Morses Pond pages were constructed to be incorporated into the Town's website. Layout and content were adapted from existing materials and subject to review. Revision has been underway since summer of 2011, but town staff time for review and direction has been very limited. Expenditure of time and funds on the phosphorus inactivation system in 2012 and 2013 limited resources by the Pond Manager to devote to this effort as well. We need to revisit this resource, update and improve it, and perhaps resurvey the town population for environmental awareness and actions in 2015.

Dredging

The Town of Wellesley arranged for the North Basin to be dredged in the late 1970s; no dredging had been conducted since 1979, and both natural and anthropogenic sources of sediment have caused considerable infilling of the North Basin since that time. Dense growths of submergent and emergent vegetation limit recreational utility and habitat value in the North Basin, although some forms of water-dependent wildlife benefit from these conditions. While dense vegetation does provide some filtering capacity, the overall loss of depth limits detention time and facilitates resuspension during storms, threatening water quality in the main body of the pond. It was determined as part of the comprehensive planning process that the North Basin should be dredged again to restore detention capacity.

In 2009 the Town hired Apex Inc. to develop dredging plans and shepherd them through the dredging process. Sediment quantity and quality were assessed, plans were developed, and permits were secured. A number of complications arose, including the need to document yet again that Morses Pond was not a Great Pond under the laws of the Commonwealth and therefore not subject to Chapter 91, an additional regulatory process. That effort was ultimately successful.

More troublesome was the detection of metals and hydrocarbon contamination in the north basin, something not observed previously. However, dredging regulations and related contamination thresholds had changed since the previous sediment assessment in 2004, and not all the same tests were run in earlier sampling. The result was that the permitting process took longer than hoped and the cost to dispose of the sediment was considerably higher than initially expected. The targeted area was reduced to about two acres to both avoid areas of greater contamination and to attempt to keep the cost within the allocated amount.

An agreement was secured from the Catholic Diocese of Massachusetts to utilize the parking lot of the “closed” Catholic Church on Rt 9 as a dredged material processing area. However, material had to be removed by March of 2011, and delays in the permitting process caused bids to be secured for the work in September, with an anticipated starting date of early November 2010. Contractors were clearly uncertain about dredging in late autumn and achieving adequate dewatering over the winter to clear the parking area by spring. As a result, fewer contractors submitted bids, and the lowest bid was approximately twice the amount allocated for the dredging.

It was decided that no bid would be accepted and that the dredging project would be revisited in a year or two, when additional funds could be secured and when the timing of the project could be potentially made more advantageous. No further action occurred in 2011, but additional funds to pursue dredging were allocated in 2012 and the project was put out to bid successfully. Cashman Construction was the successful bidder, and Apex has acted as the Town’s agent in the process. The Pond Manager had minimal involvement with the dredging project, but dredging has now been completed and summary information is available.

Soft sediment was dredged in the fall of 2012. Soft sediment was dried in geotubes on the adjacent property (former St. James parish, eventually to be a town facility) until spring 2013, when it was hauled away and the parking area was restored to its former condition. Additional dredging of coarser sediment (mostly sand) exposed by soft sediment removal was conducted in the spring of 2013 and used for beach nourishment in the town swimming area. Visual inspection of the swimming area during summer 2013 indicated that the added sand buried most plants and created a more favorable substrate for human uses. However, by mid-summer there were some milfoil and fanwort plants colonizing the deposition area. No nuisance conditions were observed, but the substrate appears hospitable for at least some plant growth. The swimming area was hydroraked in 2014 prior to opening for the season, with 6700 lbs of mostly invasive plants removed.

The reported sediment removal tally was 12,104 cubic yards (cy), with 6,383 cy of mainly muck sediments that was dried at the St. James site and disposed of in an approved landfill, and 5,721 cy of sandy material that was pumped to the beach area. The contract value was just under \$820,000.

The dredging of the north basin was an expensive project and only a few acres of area have actually been dredged. Any sediment removal increases detention capacity of the north basin, however, an important settling and pollutant processing area within the pond, and is highly desirable. A smaller area was dredged to a deeper depth, expecting that other material will slough into the depression and result

in a less topographically severe slope over time, but still providing increased detention time (about 20% more). It may be desirable to hydrolake a channel through the dense growths to direct inflow from Bogle Brook to the newly deepened area, but this may not be necessary. Evaluation of flow path in 2013 and 2014 indicated that most flow did move through the newly dredged area, maximizing detention.

The plant survey included some points in the dredging area, allowing comparison with non-dredged, unharvested areas. Cover and biovolume were both substantially reduced. However, invasive submergent species were the most common plants found in the dredged areas, albeit at low densities. Visual assessment indicated some accumulation of fine silt after only a month since dredging ended, but this sloughing of nearby organic matter into the new “hole” was expected. The substrate is mostly sandy, but plant growth can be expected in water <8 ft deep. A substantial portion of this area is deeper than 8 ft, however, so regrowth may be low as a function of light limitation.

Financial Summary

The entire allocation for FY14 was expended as of the end of June 2014, including \$51,020 under the Pond Manager account and \$7,140 under the monitoring account. Sometimes funds from the phosphorus inactivation account are allocated to WRS for additional labor as needed, but no funds were used by WRS in FY14. Rather, funds were used for chemical supplies and system repairs by the DPW.

As of the last invoice in late August of 2014, 13.5% of the FY15 allocation for the Pond Manager was expended, while 22.3% of the FY15 allocation for monitoring was expended. No further invoices have been submitted, but work through the production of this annual report will consume \$4643.50 of the Pond Manager budget, raising the expended total to 22.6% of the FY15 budget. This is normal for this point in the fiscal year. A total of \$39,480 remains to be expended from the Pond Manager account and \$5550 from the monitoring account between now and June 30th of 2015. Most funds are expended between March and the end of June in this project.

It is our impression that additional funds are available for the automation of the phosphorus inactivation system, which could cost up to \$75,000. We can proceed with that enhancement when availability of those funds is confirmed.

2015 Work Plan

The phosphorus inactivation and harvesting programs should proceed as in recent years, with improvements as warranted and supported by past experience and current budget. The education and LID programs should be dovetailed and advanced via the town website and follow up public actions. Such actions would appropriately focus on LID techniques (e.g., rain barrels and rain gardens) to minimize runoff, and minimization of pesticide and fertilizer use. Fortunately, phosphate lawn fertilizers are expected to be phased out over the next few years, but it may take another decade before the residual quantities in the watershed are exhausted. The dredging is now complete, and only monitoring is needed on an ongoing basis. The 2015 work plan is therefore structured to pursue the above goals, all part of the original comprehensive plan.

The following actions are suggested:

Phosphorus Inactivation

March – Apply for permits necessary for 2015 application of aluminum to Morses Pond; this includes a renewed Order of Conditions from the Wellesley Conservation Commission for 2015 and the License to Apply Chemicals from the DEP.

April – Assuming funds are available, initiate consultation and equipment purchases to allow the system to turn on automatically in response to significant rainfall and/or increased flows in Bogle or Boulder Brooks at Morses Pond. The intention would be to have the system operational for the 2015 treatment season, and to observe it and fine tune it over that period.

May – Check and repair in-lake components of the system (chemical feed lines) as needed, install pump cabinet adjacent to the chemical tanks and run electricity from the Dale Street Pump station or nearest power pole to the pump cabinet. Test pumps and overall system function. Order appropriate chemicals and receive by mid-May if possible, to facilitate any further testing and system readiness by late May.

Late May – Initiate treatment at inlets in response to storm events. Continue into summer as needed. Track weather and focus on June as key treatment time. Sample pond water prior to start of treatment and again in mid- to late June and again in July and August. Assess both inactivation success and impact of increased detention in the north basin as a result of dredging. Monitor automated system if installed as such.

Harvesting

March – Meet with staff to discuss increase in non-cutting time in harvesting program. Set a goal for cutting and non-cutting time categories based on realistic expectations. If maintenance is consuming a disproportionate amount of time, contact the harvester manufacturer (Aquarius Systems) for advice. If other factors are involved, consider ways to minimize time spent on non-cutting tasks.

May – Get harvesters on the lake prior to Memorial Day. Hold harvesting staff field meeting, if needed, to discuss the approach and ensure that common species can be identified. 2014 staff has been trained, but a refresher may be in order. Check swimming area for signs of plant colonization early in May.

May-June – Conduct spring harvesting program. Emphasize fragment minimization and maximum removal of invasive species, as well as maximizing cutting time.

June – Conduct plant survey, compare harvested and unharvested areas. Assess conditions going into the summer and adjust any priorities for the August-September harvesting effort. As part of this survey effort, since we will be covering most of the lake area anyway, evaluate shoreline plant conditions and any areas of shoreline erosion that might require attention. There may not be any hydroraking beyond the beach area in 2015, but assessment should be conducted to support any needs in 2015.

August-September – Conduct summer harvesting program.

Education

March – Convene a group to go over the web pages and request any final format adjustments.

April-May – Finalize content and publicize. Maximize linkage of Morses Pond pages with other town pages and the Friends of Morses Pond website to maximize impact.

Summer – Consider re-survey of residents regarding awareness of water and land management issues, actual landscape management practices, and impact of ongoing education campaigns.

Stormwater Control/LID Program

We can support town effort as desired and requested. We need to discuss how best to promote LID techniques beyond the educational packet and website, and what the Pond Manager can do to help.

Dredging

Actual dredging is complete. Track conditions in dredged area as part of water and plant monitoring program.

Financial Projections

Note that this work plan covers calendar year 2015, which spans FY14 and FY15. There remains \$45,030 as of about March 1 to be spent in FY15. The budget for FY16 is assumed to be \$58,160, only a relatively small portion of which would be expended in 2015, but confirmation of the total would be appreciated. No allocation from the phosphorus inactivation account to pond manager activities is requested for FY15 or FY16, but any funds left in the phosphorus inactivation account could be used toward possible system modifications (permanent dosing site off the trailer, automation). Up to \$75,000 would be needed to automate the phosphorus inactivation system, which we understand may be available from capital account holdovers within NRC.

The financial outlook for calendar year 2015 is summarized in Table 8, but is subject to change with NRC and DPW input.

Renewed Contract

It may be time for the Pond Manager contract to be renewed; the contract does not correspond to the fiscal year and may need to be put out for bid in 2015. The NRC should confirm this need and act accordingly.

Table 8. Financial Projections for 2015.

	Period	Jan-Jun	Jul-Dec
	Fiscal Year	FY15	FY16
Task	Account		
P Inactivation			
P inactivation system repairs	(DPW work, no allocation to WRS)	\$0.00	\$0.00
P inactivation system operation	Pond Manager	\$27,479.50	\$5,000.00
P inactivation system monitoring	Monitoring	\$5,550.50	\$2,000.00
Harvesting			
Plant survey/harvesting support	Pond Manager	\$6,000.00	\$1,500.00
Education			
Web site upgrade/Ed. efforts	Pond Manager	\$5,000.00	\$5,000.00
Administrative			
Meetings	Pond Manager	\$1,000.00	\$2,000.00
Annual report	Pond Manager	\$0.00	\$3,000.00
Total from normal accounts		\$45,030.00	\$18,500.00
Optional P inactivation automation	P Inactivation/capital holdover	75,000?	\$0.00