# MORSES POND ANNUAL REPORT: 2016

**PREPARED FOR THE TOWN OF WELLESLEY**

**BY WATER RESOURCE SERVICES, INC.**

**DECEMBER 2016**

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This report documents the implementation of the 2005 Comprehensive Morses Pond Management Plan through 2016. Program elements include: 1) phosphorus inactivation, 2) plant harvesting, 3) low impact development demonstration, 4) education, and 5) dredging.

# Phosphorus Inactivation

## Operational Background

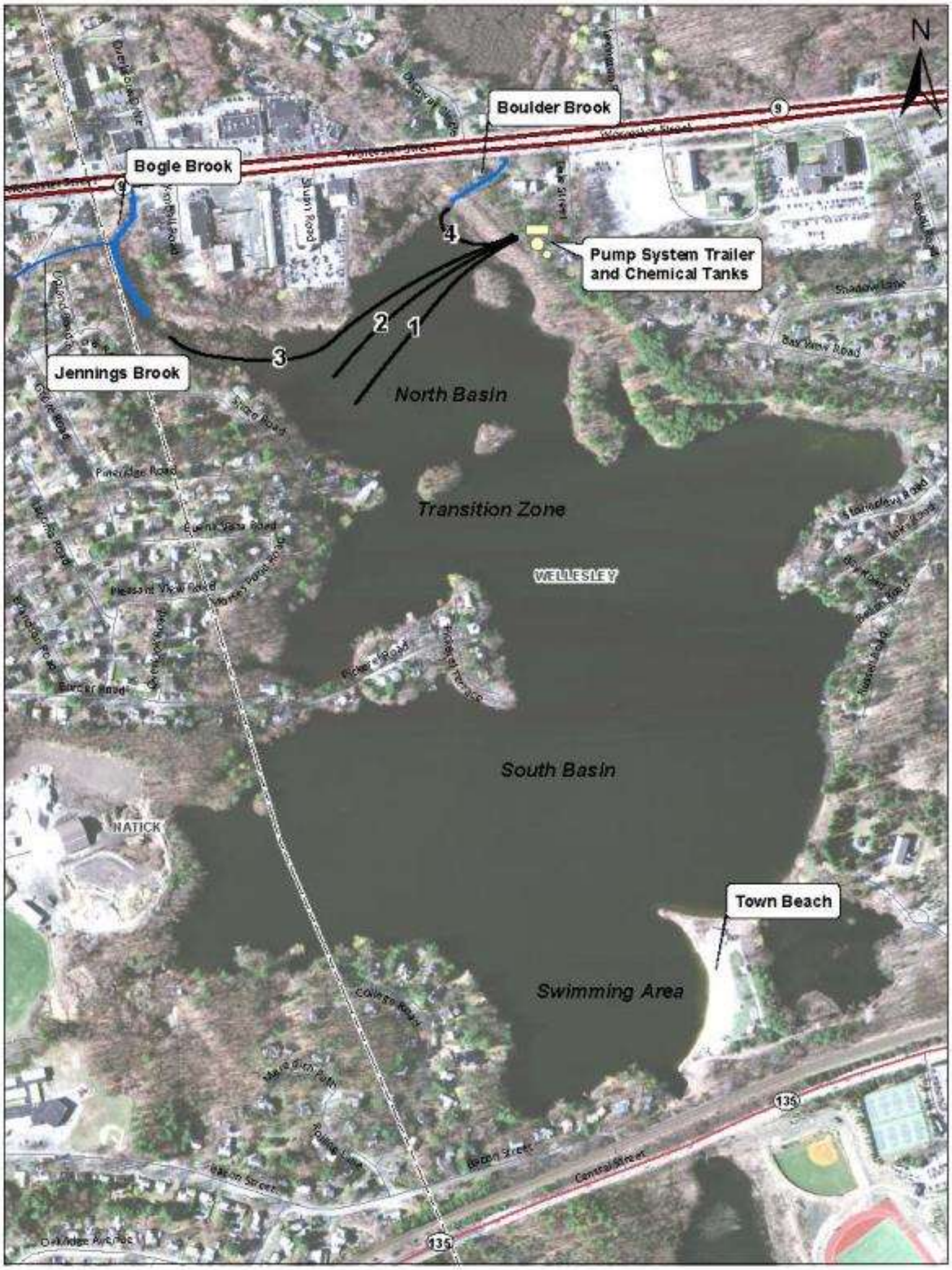
Phosphorus entering through Bogle Brook and Boulder Brook was determined to be the primary driver of algae blooms in Morses Pond. Dry spring-summer periods fostered fewer blooms than wetter seasons in an analysis of over 20 years of data. Work in the watershed to limit phosphorus inputs is a slow process and has limits related to urbanization that are very difficult to overcome. Inactivation of incoming phosphorus is possible, however, and has been used extensively and successfully in Florida to limit the impact of development on lakes there. The comprehensive plan called for a similar effort at Morses Pond.

A phosphorus inactivation system was established at Morses Pond in the spring of 2008. After testing and initial adjustment in 2008, the system has been operated in the late spring and part of summer in 2009 through 2016. The chemical pump station was initially portable, stationed for the treatment period at the Town of Wellesley Dale Street Pump Station, but in 2015 this was made a "permanent" station without the trailer. Then in 2016 the system became automated using an application for a smart phone that would allow control and monitoring of the system without people being present at the time of a wet weather event. 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 was 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 in 2014, which eliminated the need for fuel as

**Figure 1. Phosphorus Inactivation System for Morses Pond**



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. Chemical lines were extended further up Bogle Brook in 2014 and an underground electrical line was extended to the pumps in 2015.

A further development in 2014 was the switch from alum and aluminate to just one chemical, polyaluminum chloride (PAlCl). Improvement of PAlCl in recent years made it worth testing, as both alum and aluminate are more hazardous to handle and more viscous in the feed lines. PAlCl is not much more viscous that 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 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. 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.

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. 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, but pump and delivery line issues limited effectiveness.

In 2014, the change to polyaluminum chloride was made and each tank and pump combination was dedicated to a single inlet (Bogle or Boulder Brook). Initial chemical delivery (3000 gal) was at the start of June, and another delivery (just under 3000 gal) was made at the end of June, providing enough material to treat through July, although most chemical was applied prior to July 6$^{th}$. Precipitation was lower than average in June and all storms were treated. A large storm in early July was thoroughly treated. Additionally, the dredged area in the north basin increased detention time in that area. These combined factors resulted in low phosphorus in the main body (southern basin) of Morses Pond and high water clarity in summer of 2014.

In 2015 the same approach as in 2014 was applied, but 7900 gallons were applied, most of it between late May and early July. Precipitation was below average from May through August, and some portion of every storm was treated in May and June; the only significant precipitation that was not treated was a continuation of a storm at the end of May when the chemical supply was exhausted and could not be replaced immediately. As a result of this program the lowest phosphorus levels recorded for Morses Pond in over 20 years. Even with a few larger storms in July, phosphorus remained well below the 20 ug/L threshold into August, and clarity was more than acceptable throughout the summer. With two years of highly desirable operational features and in-lake results after the switch to polyaluminum chloride, the time had come to automate the system and minimize labor expense to run the system. This process was initiated in late spring and continued to the end of the year.

An automated and remote controllable system was functional going into the 2016 treatment season. The system runs on a smart phone through LoggerLink, an application produced by Campbell Scientific. It was then customized for our inactivation system by Don Cuomo of Blu-Dot Inc. The system relies on a rain gauge placed on the roof of the town pump station adjacent to the permanent inactivation station to measure precipitation, with a preselected threshold for precipitation (typically 0.1 to 0.25 inches) triggering the chemical pumps to turn on, sending PAlCl to the brooks for a predetermined length of time (typically 4 hr). Measurements are recorded by the cell application and can be observed in real time. Furthermore, settings on the application facilitate changing threshold limits for when the pumps turn on and for how long. All settings can also be overridden and turned on or off remotely as warranted.

Chemical exposure of pump parts with the diaphragm pumps lead to eventual failure of one diaphragm pump in 2015, although the remaining pump was able to handle both inlets for the remaining part of summer that year. Replacement of the aging diaphragm pumps with peristaltic pumps for 2016 reduced maintenance, limiting contact between the chemical and the actual pump system. This system puts the least amount of stress on the pump and the only replacements would be to the hose located on the outside of the pump, which is both an inexpensive and simplified fix.

A total of 5800 gallons of PAlCl were applied to Morses Pond in 2016, less than in 2015 but similar to 2014 (Table 1). Precipitation during the treatment season was the least since the inactivation process commenced, and all operations ran smoothly with only some adjustments being made to the rain gauge. Both the application and pumps functioned well and proved to be very advantageous. With 4.7 inches of rain in May-June and a total of 7.3 inches in May-August (Table 1), the system easily treated the small wet weather events on only 13 days in 2016. This enabled us to keep lake phosphorus at 0.005 mg/L with a clarity of 5.5 meters (Figure 3). The updates in the operation from 2014 to now have produced the best results of all years of application.

The record of phosphorus inactivation effort over the duration of this project is summarized in Table 1. As the chemicals used have changed, the most relevant measure of application is the pounds of aluminum applied, which has varied between 3422 (2016) to 6720 (2012) lbs per treatment season, except for the lower value for the initial testing year (2008). The amount of aluminum needed is largely a function of precipitation, particularly in May and June under the operational scenario applied.

**Table 1. Summary of Phosphorus Inactivation Effort, 2008-2016**

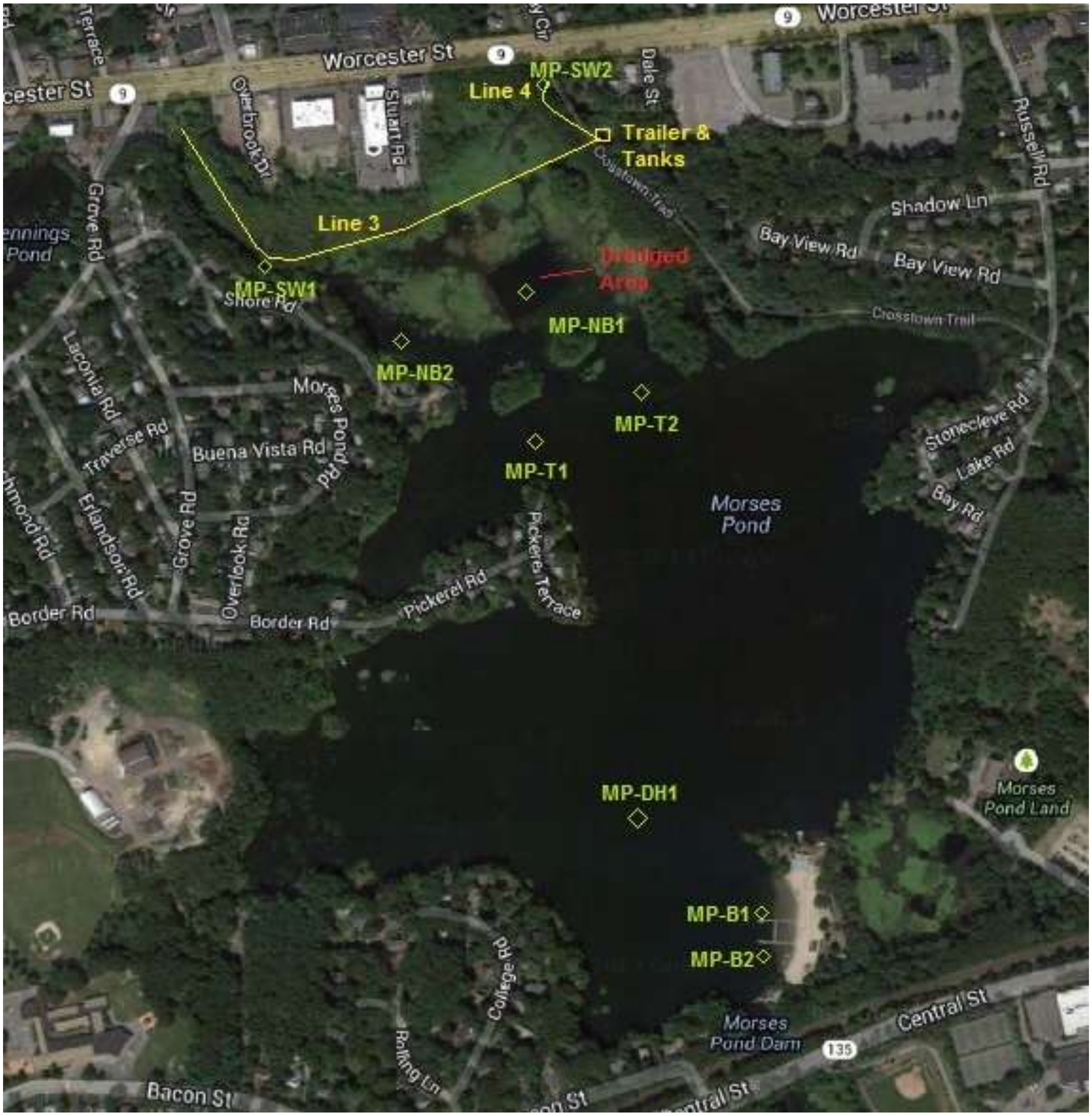
| Year | Applied Alum (gal) | Applied Aluminate (gal) | Aluminum Mass (lbs) | # of Treatment Days | May-June Precipitation (in) | May-August Precipitation (in) | Notes |
|---|---|---|---|---|---|---|---|
| 2008 | 2000 | 1000 | 2240 | 5 | 6.2 | 16.7 | Testing and adjustment phase, most treatment in July |
| 2009 | 6002 | 2900 | 6595 | 16 | 5.9 | 16.1 | Some elevated storm flow untreated |
| 2010 | 4100 | 2080 | 4630 | 13 | 6.1 | 14.5 | Additional chemical applied after early July |
| 2011 | 5000 | 2475 | 5569 | 14 | 8.0 | 17.8 | Some equipment failures. Additional chemical applied in August in response to bloom |
| 2012 | 6000 | 3000 | 6720 | 19 | 6.9 | 14.4 | Equipment problems hampered dosing during treatment |
| 2013 | 6055 | 2785 | 6476 | 20 | 13.7 | 19.1 | Very wet June (26.7 cm), unable to treat all storm flows; continued treatment through July |
| | Polyaluminum chloride | | | | | | |
| 2014 | 5985 | | 3531 | 12 | 5.5 | 11.8 | No treatment after 1st week of July, first year using polyaluminum chloride |
| 2015 | 7900 | | 4661 | 14 | 6.2 | 10.5 | Leftover chemical used in summer, but little treatment after first week of July |
| 2016 | 5800 | | 3422 | 13 | 4.7 | 7.3 | Only a little over half of the chemical was used by early July, remainder by August 15th |

## Analysis of Program Results

Water quality is assessed prior to the start of treatment, normally in May, again in early summer, and yet again 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 (Figure 2). 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 2016 (Table 2) incorporates field and laboratory tests at multiple sites. A summary of phosphorus data for key periods since 2008 is provided (Table 3) 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 2016 were all below 20 ug/L and more often close or below 10 ug/L, indicative of less rainfall, active treatment, and effective detention in the north basin. Note that total phosphorus values in the dredged portion of the north basin (NB-1) are lower than

**Figure 2. Current system layout and water quality sampling sites in Morses Pond.**



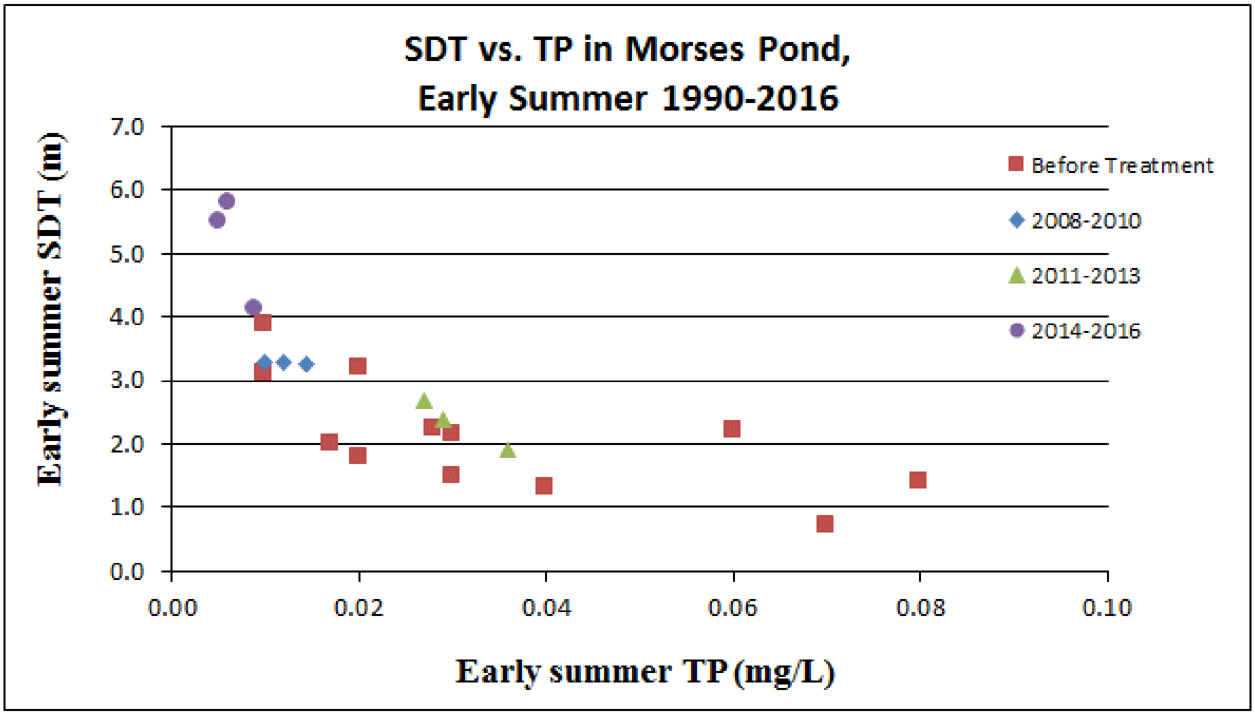
# Table 2. Water quality record for Morses Pond in 2016

| | Depth | Temp | Oxygen | Oxygen | Sp. Cond | pH | Turbidity | Alkalinity | Total P | Diss. P | TKN | NO3-N | Secchi | Chl-a |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Station** | **meters** | **°C** | **mg/l** | **% Sat** | **µS/cm** | **Units** | **NTU** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **mg/L** | **meters** | **µg/L** |
| | | | | | | | | | | | | | | |
| **Stream Inlets** | | | | | | | | | | | | | | |
| MP-SW-1 Bogle | | | | | | | | | | | | | | |
| 5/17/2016 | | | | | | | | | 0.013 | 0.005 | 0.40 | 0.66 | | |
| 6/6/2016 | | | | | | | | | 0.041 | | 0.45 | 0.60 | | |
| 6/16/2016 | | | | | | | | | 0.020 | 0.011 | 0.42 | 0.58 | | |
| 6/23/2016 | | | | | | | | | 0.024 | 0.010 | 0.38 | 0.52 | | |
| 6/29/2016 | 0.0 | 24.9 | 7.5 | 92.3 | 826 | 7.5 | 2.3 | | 0.024 | 0.012 | 0.24 | 0.55 | | 1.3 |
| MP-SW-2 Boudler | | | | | | | | | | | | | | |
| 5/17/2016 | | | | | | | | | 0.086 | 0.005 | 0.38 | 1.40 | | |
| 6/6/2016 | | | | | | | | | 0.092 | | 0.69 | 0.50 | | |
| 6/16/2016 | | | | | | | | | 0.046 | 0.005 | 0.40 | 1.30 | | |
| 6/23/2016 | | | | | | | | | 0.051 | 0.005 | 0.46 | 1.20 | | |
| 6/29/2016 | 0.0 | 28.5 | 6.1 | 80.0 | 502 | 7.3 | 0.7 | | 0.056 | 0.015 | 0.32 | 1.10 | | 5.0 |
| **5/17/2016** | | | | | | | | | | | | | | |
| **North Basin** | | | | | | | | | | | | | | |
| MP-NB-1 (dredged) | 0.3 | 16.4 | 8.9 | 92.3 | 690 | 7.0 | 2.8 | | 0.010 | 0.005 | 0.38 | 1.40 | | 2.5 |
| | 2.0 | 14.8 | 9.0 | 89.7 | 674 | 7.1 | 2.8 | | | | | | | 2.0 |
| | 3.0 | 12.6 | 8.8 | 83.6 | 1070 | 7.0 | 2.7 | | | | | | | 2.5 |
| | 3.5 | 10.5 | 7.9 | 72.2 | 2391 | 6.8 | 9.2 | | | | | | | 9.5 |
| MP-NB-2 | 0.4 | 16.8 | 9.5 | 98.9 | 710 | 7.1 | 5.4 | | 0.014 | 0.005 | 0.44 | 0.42 | | 5.1 |
| **Transition Zone** | | | | | | | | | | | | | | |
| MP-T-1 | 0.3 | 17.0 | 8.7 | 91.5 | 712 | 7.2 | 3.0 | | 0.005 | 0.005 | 0.32 | 0.38 | | 3.0 |
| MP-T-2 | 0.3 | 17.2 | 8.9 | 93.7 | 705 | 7.3 | 2.9 | | 0.005 | 0.005 | 0.34 | 0.37 | | 2.9 |
| **South Basin** | | | | | | | | | | | | | | |
| MP-B-1 | 0.2 | 16.2 | 8.6 | 88.9 | 716 | 7.3 | 3.0 | | 0.018 | 0.005 | 0.56 | 0.42 | | 2.3 |
| MP-B-2 | 0.2 | 15.9 | 8.6 | 88.2 | 716 | 7.4 | 2.7 | | 0.005 | 0.005 | 0.36 | 0.45 | | 2.2 |
| MP-1 (MP -DH1) | 0.1 | 15.8 | 8.6 | 88.0 | 715 | 7.3 | 3.0 | | 0.005 | 0.005 | 0.31 | 0.43 | 4.3 | 2.1 |
| | 1.0 | 15.8 | 8.6 | 87.5 | 715 | 7.2 | 3.0 | | | | | | | 2.7 |
| | 2.0 | 15.5 | 8.4 | 85.5 | 715 | 7.2 | 3.0 | | | | | | | 2.5 |
| | 3.1 | 15.4 | 8.3 | 83.9 | 715 | 7.2 | 3.0 | | | | | | | 2.6 |
| | 3.9 | 15.1 | 7.7 | 77.5 | 715 | 7.2 | 3.3 | | | | | | | 2.3 |
| | 5.0 | 13.9 | 6.6 | 64.5 | 714 | 7.2 | 3.7 | | | | | | | 2.1 |
| | 5.8 | 11.9 | 3.7 | 35.2 | 729 | 7.2 | 4.7 | | 0.005 | 0.005 | 0.37 | 0.41 | | 2.5 |
| **6/29/2016** | | | | | | | | | | | | | | |
| **North Basin** | | | | | | | | | | | | | | |
| MP-NB-1 (dredged) | 0.0 | 27.4 | 8.0 | 103.1 | 728 | 7.7 | 2.2 | | 0.005 | 0.005 | 0.21 | 0.03 | | 2.7 |
| | 1.0 | 24.0 | 3.1 | 37.6 | 693 | 7.4 | 1.5 | | | | | | | 3.0 |
| | 2.0 | 23.0 | 1.6 | 19.4 | 729 | 7.2 | 3.1 | | | | | | | 3.7 |
| | 3.1 | 18.5 | 5.2 | 56.9 | 2043 | 7.1 | 2.2 | | | | | | | 3.7 |
| MP-NB-2 | 0.1 | 27.9 | 8.5 | 109.7 | 743 | 7.5 | 3.4 | | 0.012 | 0.005 | 0.21 | 0.03 | | 3.9 |
| | 0.4 | 25.6 | 8.4 | 104.2 | 729 | 7.5 | 3.7 | | | | | | | 7.8 |
| **Transition Zone** | | | | | | | | | | | | | | |
| MP-T-1 | 0.0 | 27.6 | 8.3 | 106.5 | 745 | 7.6 | 5.0 | | 0.017 | 0.005 | 0.23 | 0.03 | | 5.1 |
| | 1.0 | 25.0 | 7.9 | 96.5 | 736 | 7.6 | 7.0 | | | | | | | 4.8 |
| | 1.5 | 24.6 | 7.4 | 90.7 | 741 | 7.5 | 4.7 | | | | | | | 4.7 |
| MP-T-2 | 0.0 | 27.2 | 8.1 | 103.2 | 744 | 7.8 | 5.7 | | 0.015 | 0.005 | 0.25 | 0.03 | | 5.0 |
| | 0.5 | 27.1 | 7.4 | 94.6 | 744 | 7.7 | 3.6 | | | | | | | 4.5 |
| **South Basin** | | | | | | | | | | | | | | |
| MP-B-1 | | | | | | | | | 0.005 | 0.005 | 0.25 | 0.11 | | |
| MP-B-2 | | | | | | | | | 0.005 | 0.005 | 0.15 | 0.11 | | |
| MP-1 (MP -DH1) | 0.0 | 26.1 | 8.8 | 110.6 | 754 | 8.1 | 1.9 | 36 | 0.005 | 0.005 | 0.19 | 0.11 | 5.5 | 2.5 |
| | 1.0 | 25.2 | 8.7 | 107.4 | 753 | 8.1 | 2.3 | | | | | | | 2.6 |
| | 2.0 | 25.0 | 8.7 | 107.1 | 753 | 8.1 | 2.6 | | | | | | | 2.7 |
| | 3.0 | 24.6 | 8.1 | 98.8 | 756 | 8.0 | 2.3 | | | | | | | 2.9 |
| | 4.0 | 21.4 | 7.3 | 83.7 | 729 | 7.9 | 2.8 | | | | | | | 3.0 |
| | 5.1 | 17.3 | 5.0 | 52.8 | 743 | 7.7 | 3.8 | | | | | | | 3.2 |
| | 5.5 | 15.8 | 3.6 | 36.5 | 746 | 7.3 | 3.3 | | | | | | | 4.9 |
| | 5.5 | 15.9 | 3.4 | 35.2 | 746 | 7.3 | 3.3 | | | | | | | 5.0 |
| | 5.8 | 15.2 | 2.8 | 28.4 | 750 | 7.2 | 3.1 | 40 | 0.012 | 0.005 | 0.19 | 0.06 | | 5.1 |
| **8/24/2016** | | | | | | | | | | | | | | |
| **North Basin** | | | | | | | | | | | | | | |
| MP-NB-1 (dredged) | 0.0 | 24.2 | 6.7 | 80.7 | 777 | 7.3 | 2.8 | | 0.005 | 0.005 | 0.28 | 0.06 | | 6.2 |
| | 1.0 | 23.7 | 6.1 | 72.7 | 783 | 7.2 | 2.8 | | | | | | | 2.3 |
| | 2.0 | 23.4 | 5.6 | 66.4 | 777 | 7.1 | 3.3 | | | | | | | 2.3 |
| | 3.0 | 23.1 | 5.5 | 64.8 | 1456 | 6.8 | 5.9 | | | | | | | 4.3 |
| | 3.5 | 20.8 | 4.1 | 46.9 | 1951 | 6.5 | 14.6 | | | | | | | 9.2 |
| MP-NB-2 | 0.2 | 25.5 | 9.1 | 113.4 | 761 | 7.2 | 3.0 | | 0.005 | 0.005 | 0.24 | 0.06 | | 2.2 |
| | 0.5 | 23.9 | 8.6 | 103.9 | 744 | 7.2 | 3.1 | | | | | | | 2.0 |
| **Transition Zone** | | | | | | | | | | | | | | |
| MP-T1 | 0.1 | 26.2 | 8.4 | 105.5 | 788 | 7.3 | 3.2 | | 0.005 | 0.005 | 0.26 | 0.03 | | 2.7 |
| | 1.0 | 25.0 | 8.5 | 104.4 | 775 | 7.3 | 3.2 | | | | | | | 2.9 |
| | 2.0 | 24.3 | 8.3 | 100.6 | 765 | 7.3 | 4.8 | | | | | | | 6.0 |
| MP-T2 | 0.0 | 26.1 | 9.0 | 113.0 | 796 | 7.5 | 2.5 | | 0.005 | 0.005 | 0.24 | 0.05 | | 1.1 |
| | 0.5 | 25.6 | 9.8 | 122.3 | 791 | 7.7 | 3.9 | | | | | | | 2.1 |
| **South Basin** | | | | | | | | | | | | | | |
| MP-B-1 | | | | | | | | | 0.005 | 0.005 | 0.25 | 0.03 | | |
| MP-B-2 | | | | | | | | | | | | | | |
| MP-1 (DH) | 0.0 | 26.1 | 8.5 | 106.6 | 805 | 7.7 | 2.6 | 41 | 0.005 | 0.005 | 0.23 | 0.07 | 4.5 | 1.2 |
| | 1.0 | 26.1 | 8.4 | 105.3 | 803 | 7.6 | 2.8 | | | | | | | 1.8 |
| | 2.0 | 25.9 | 8.5 | 105.7 | 803 | 7.6 | 2.9 | | | | | | | 2.8 |
| | 3.0 | 25.9 | 8.6 | 107.0 | 807 | 7.6 | 3.1 | | | | | | | 3.6 |
| | 4.0 | 25.7 | 8.0 | 99.8 | 803 | 7.6 | 3.3 | | | | | | | 2.4 |
| | 5.0 | 23.3 | 1.5 | 17.3 | 774 | 7.3 | 4.1 | | | | | | | 6.2 |
| | 6.0 | 18.4 | 0.8 | 8.7 | 808 | 6.2 | 24.0 | | 0.005 | 0.005 | 0.36 | 0.03 | | 4.9 |
| | | | | | | | | | | | | | | |

## Table 3. Water quality testing results to the phosphorus inactivation system

| Year | Location | Pre-Application TP (ug/L) | Early Summer TP (ug/L) | Late Summer TP (ug/L) | Algae Observations |
|---|---|---|---|---|---|
| **2008** | North Basin | 28 | 18 | 13 | Mats observed, some cloudiness |
| | Transition Zone | 31 | 22 | 14 | Some cloudiness, brownish color |
| | Swimming Area | 21 | 12 | 12 | No blooms reported, first year without copper treatment in some time |
| **2009** | North Basin | 35 | 40 | 63 | Cloudy, some green algae mats |
| | Transition Zone | 35 | 39 | 45 | Cloudy |
| | Swimming Area | 15 | 10 | 27 | Generally clear, no blooms reported |
| **2010** | North Basin | 26 | 46 | 53 | Cloudy, green algae mats evident |
| | Transition Zone | 28 | 21 | 32 | Brownish color, minimally cloudy |
| | Swimming Area | 19 | 15 | 43 | Generally clear, no blooms until late August (Dolichospermum) |
| **2011** | North Basin | 53 | 33 | 130 | Cloudy, green algae mats evident |
| | Transition Zone | 48 | 29 | 95 | Slightly brownish |
| | Swimming Area | 30 | 29 | 60 | Cyanobloom in early August (Dolichospermum), dissipated after just a few days without treatment |
| **2012** | North Basin | 32 | 24 | 48 | Very dense plant growth, associated green algae mats |
| | Transition Zone | 28 | 37 | 28 | Brownish most of summer |
| | Swimming Area | 20 | 27 | 24 | Had bloom in mid-July (Dolichospermum), treated with copper |
| **2013** | North Basin | 36 | 47 | 30 | Water brownish, but little visible algae; first year with newly dredged area within north basin |
| | Transition Zone | No Data | 78 | 32 | Generally elevated turbidity, but much of it is not living algae |
| | Swimming Area | 24 | 33 | 28 | Continued treatment kept TP down, but not to target level; June flushing minimized algae biomass |
| **2014** | North Basin | 30 | 22 | 20 | Dense plant growths outside dredged area, some green algae mats, but water fairly clear |
| | Transition Zone | 21 | 20 | 18 | Dense plant growths, some mats, water fairly clear |
| | Swimming Area | 12 | 13 | 17 | Water clear; Secchi to bottom in swimming area, no blooms reported |
| **2015** | North Basin | 12 | 17 | 23 | Dense plant growths outside dredged area, abundant green algae mats, but water fairly clear |
| | Transition Zone | 8 | 15 | 14 | Dense plant growths, but water fairly clear |
| | Swimming Area | 5 | 5 | 14 | Water clear; Secchi to bottom in swimming area, no blooms reported |
| **2016** | North Basin | 12 | 9 | 5 | A few mats but much less than in recent years |
| | Transition Zone | 19 | 16 | 5 | Dense plant growths but few mats, high water clarity |
| | Swimming Area | 14 | 5 | 5 | Water clear all summer |

**Figure 3. Relationship between water clarity and total phosphorus in Morses Pond, 1990-2016.**




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 2016.

Nitrogen values tend to be low to moderate, with total Kjeldahl nitrogen (TKN) <1 mg/L and nitrate <0.5 mg/L. Values declined over the summer. Loss of nitrate can be a concern, as low ratios of available N to available P favor cyanobacteria, but nitrate never completely disappeared and the low phosphorus levels helped with algae control overall.

There are periodic oxygen deficiencies in the deep hole area (MP-1), but not consistently. Low oxygen was observed in June and August, but oxygen was not completely depleted at the bottom on any sampling date in 2016. 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 reveal 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. The pH also tends to increase as water moves through the pond, with photosynthesis by algae and rooted plants removing carbon dioxide and raising the pH. 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 was also moderate at the deep hole location.

Water clarity was about the same in early summer in 2016 as it was in 2015, with a measurement of 5.5 m (16.4 feet) achieved in late June. The Secchi measurement was still 4.5 m (14.8 feet) in mid-August, the highest recorded measurement taken at this time in the summer. 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 2016. The dry weather, effective treatment in May-June, automated system, and improved detention through dredging in the north basin are all to be credited.

In 2016 we sampled Bogle and Boulder Brook on five different dates starting in May till the end of June. Total phosphorus ranged from 13 to 92 ug/L. Average total phosphorus concentrations over the five samplings were higher in Boulder Brook than in Bogle Brook. However, since Bogle has higher flow than Boulder the loading from Bogle was still higher. Values are below typical runoff concentrations for urban areas, and while still elevated in terms of what is desirable for Morses Pond, may reflect the reduction of phosphorus in commercial lawn fertilizers that is ongoing. Historically, inlet concentrations have averaged about 130 ug/L for both Bogle and Boulder Brooks.

The 9 year phosphorus inactivation history can be functionally divided into 3 periods: 2008-2010, 2011-2013, and 2014-2016, both in terms of system function and average summer water clarity data (Figure 4). While treatment in 2008 started late and was largely experimental, results for total phosphorus for 2008 were <20 μg/L. Similar results were achieved in 2009 and 2010; throughout these three years average summer phosphorus was 10-25 μg/L and average summer water clarity was about 3 m (10 ft). Equipment worked well and the operations team was effective in responding to storms.

Total phosphorus remained somewhat elevated in 2011-2012, with summer averages of 22-45 ug/L. 2011 and 2013 were the rainiest treatment periods on record and equipment problems became more frequent. 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 but not completed until 2013, and June of 2013 set records for precipitation and flows. Water clarity averaged slightly more than 2 m (about 7 ft), not appreciably better than pre-treatment years, although it should be kept in mind that clarity would have been lower in the pre-treatment period if not for copper treatments.

Only one algae bloom occurred during the swimming season since P inactivation commenced. The combination of treatment and detention was insufficient to prevent a cyanobacteria bloom from forming in mid-July 2012. The only copper treatment since phosphorus inactivation started 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.

Conditions in 2014-2016 were a product of dry weather, effective treatment, and improved detention in the north basin. Phosphorus was low and water clarity was the highest it has been since implementation of the comprehensive plan (and indeed going back almost 30 years). No serious problems were encountered in application, chemical costs were not elevated, and labor

**Figure 4. Average summer water clarity and total phosphorus in Morses Pond, 1994-2016.**

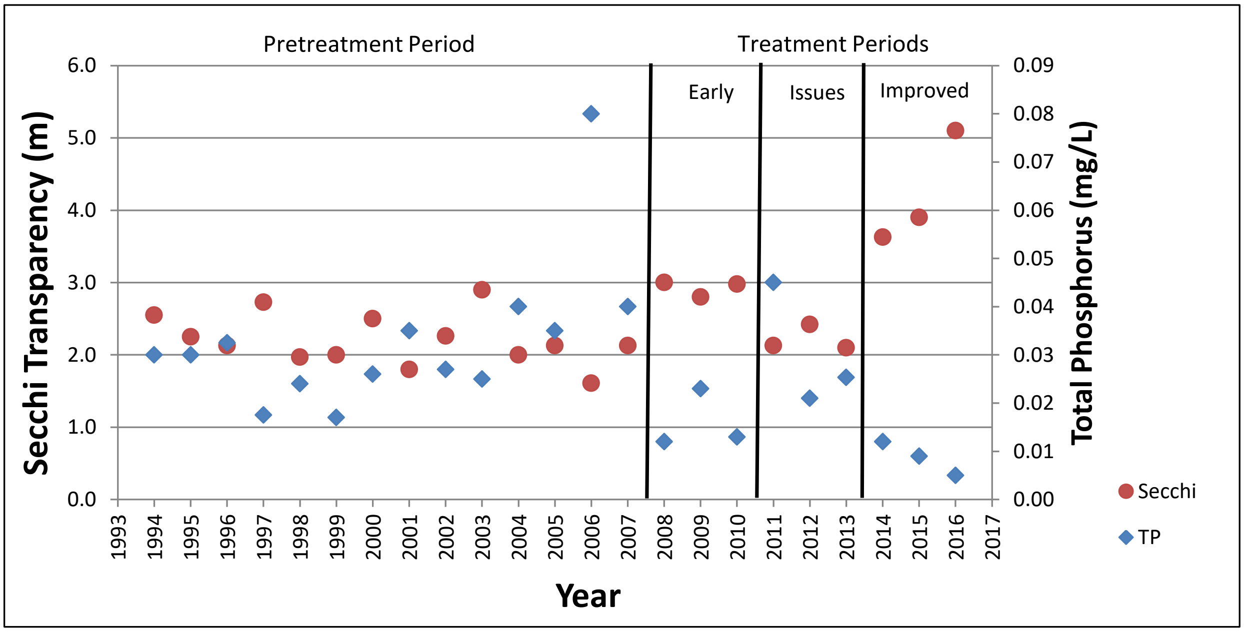
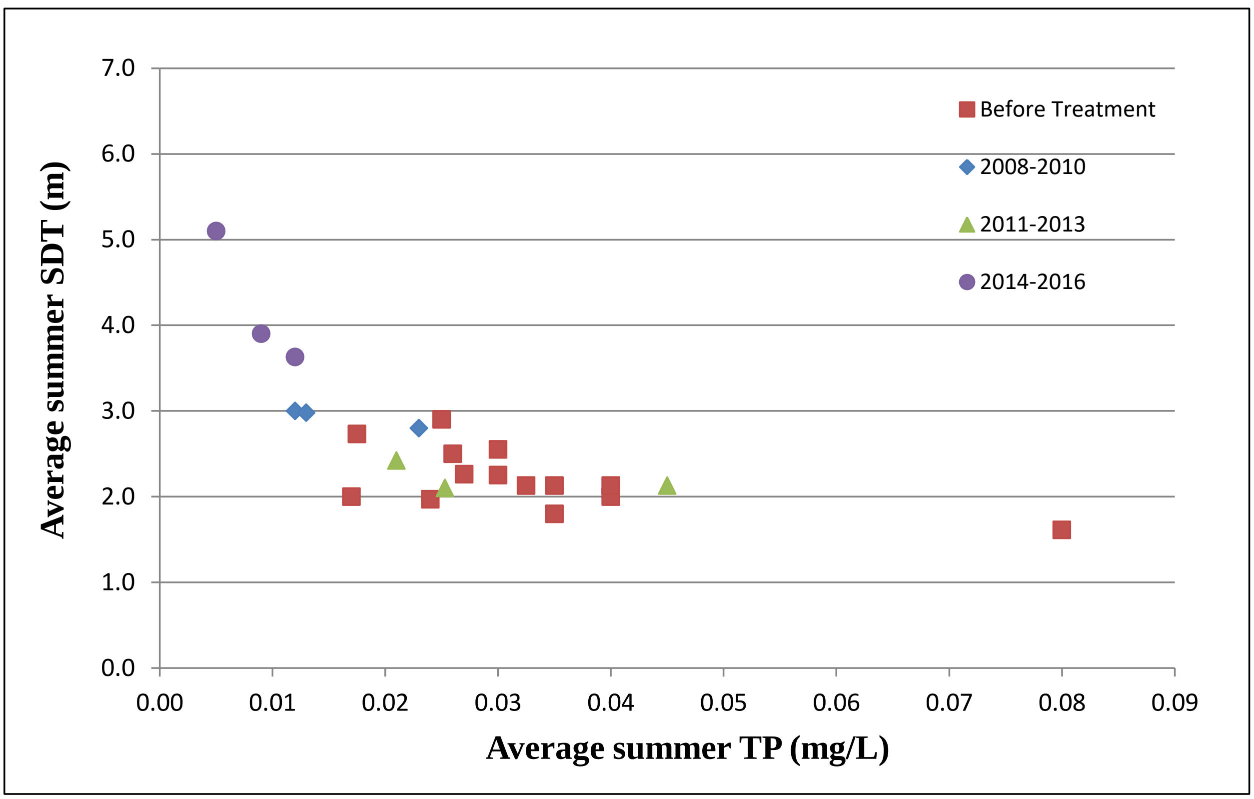



**Figure 5. Relationship between summer water clarity and total phosphorus in Morses Pond.**



costs were reduced by the automated application system in 2016. The current system is expected to run for the foreseeable future with limited adjustment or maintenance needs.

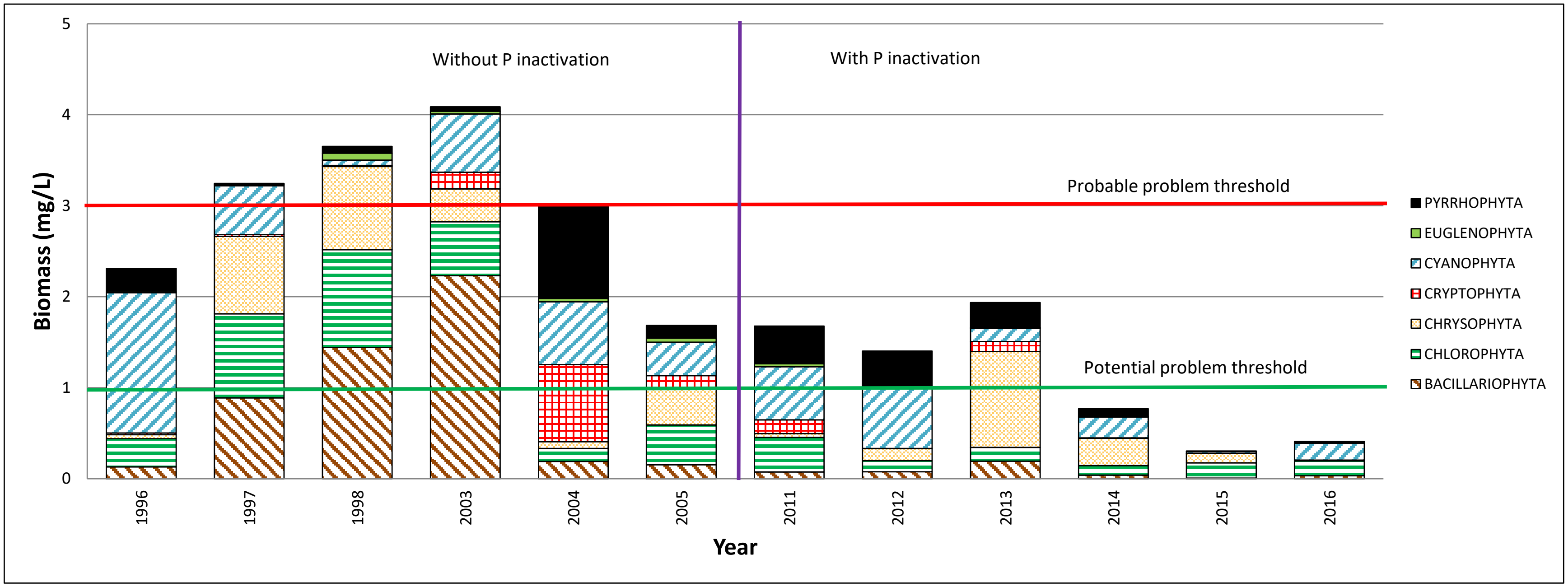
The higher clarity is related to lower algae abundance, which is in turn related to lower phosphorus levels. The relationship between clarity as Secchi transparency and total phosphorus (Figure 5) is fairly tight for Morses Pond. The early program (2008-2010) results were among the best observed to that time, while the middle program (2011-2013) results were not obviously better than the pre-treatment record. The last three years (2014-2016) have been the best on record.

Algal data for 2011-2016 illustrate processes in Morses Pond over the summer (Figure 6). 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 6 years is varied, but since spring phosphorus inactivation began, biomass values have not exceeded the general threshold of 3 mg/L that signals low clarity (note that there is no official threshold for algae, but the red line in Figure 6 is a useful limit). Phytoplankton biomass has often been below the 1 mg/L threshold indicative of low biomass, including 3 of 4 values for 2014 and all values for 2015 and 2016.

Cyanobacteria were moderately abundant in late summer 2011 and at times in 2012, but have not been common since then. The few cyanobacteria that were detected since 2012 did not reach bloom proportions. Cyanobacteria were the most abundant algae in August 2014, but overall biomass was low. Bloom forming cyanobacteria were observed in small clumps along the shoreline in late September of 2015, but were absent from plankton samples. In 2016 cyanobacteria were present in the August sample, but were not measured in bloom amounts and all phytoplankton for both samples were still well under the potential problem threshold.

Morses Pond has been plagued by a variety of algae blooms in summer over the years of monitoring (Figure 6), but biomass has been lower since phosphorus inactivation commenced and resulting water clarity has been higher (Figures 4 and 5). This program has been very successful and is reflected in beach and lake use.

**Figure 6.  Summer average algae biomass divided into major algae groups for 1996-2016**



Zooplankton have also been sampled, and while not as tightly linked to nutrients, provide important information on the link between algae and fish (Figures 7 and 8). Zooplankton biomass varies strongly between and within years. Values <25 ug/L are low and values higher than 100 ug/L are high as rough thresholds; 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 tends 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 monitored years, a good sign, and abundance was elevated in most of spring and summer of 2014 and 2015. The late summer zooplankton population was very low in 2011 and 2013, but was substantial in 2012 and hit an all-time record in 2014. Late summer biomass was also high in 2015, although much lower than in 2014. 2016 June samples exhibited biomass above the desirable 100 ug/L threshold, but declined markedly in August. A pattern of reduced zooplankton by late summer is expected with less available algae for food under low phosphorus levels and greater predation by small fish, many of which hatch from eggs in June. The harvesting program tends to reduce refuges for small fish, allowing more predation by larger fish and potentially allowing large and more zooplankton to survive into late summer. Weedier conditions in some years protect small fish from their predators and lead to greater predation on zooplankton, so variation is explainable but not very predictable. There is no indication of any aluminum toxicity to zooplankton; the treatment protocols minimize this probability.

The size distribution of zooplankton (Figure 7) is important, as larger individuals are more effective grazers and represent better food for small fish. Mean lengths for at least crustacean zooplankton exceed the minimum desirable threshold (0.4 mm) in all samples, and exceed the preferred threshold (0.6 mm) in all but a few samples. Yet average length tends to be higher and more desirable in samples since phosphorus inactivation commenced when compared to the limited pre-treatment data base. Grazing capacity in 2014 through 2016 was very high, and undoubtedly contributed to low algae abundance and high clarity. August 2016 biomass and mean length declined substantially, probably a consequence of very low algae levels and weedier conditions than usual that protected small fish (see the harvesting review below for more explanation). The mean length data are indicative of game fish abundance and suggest good fishing. This is consistent with angler observations. Although too many gamefish for too many years can cause fishery problems, this tends to be a naturally mitigated situation; if food resources are inadequate, the feeders will decline and the food populations will increase. As it is now, the biological structure of Morses Pond is almost ideal from a human use perspective, featuring lots of game fish for anglers and relatively clear water for swimmers.

**Figure 7. Zooplankton abundance for 1996-2016.**

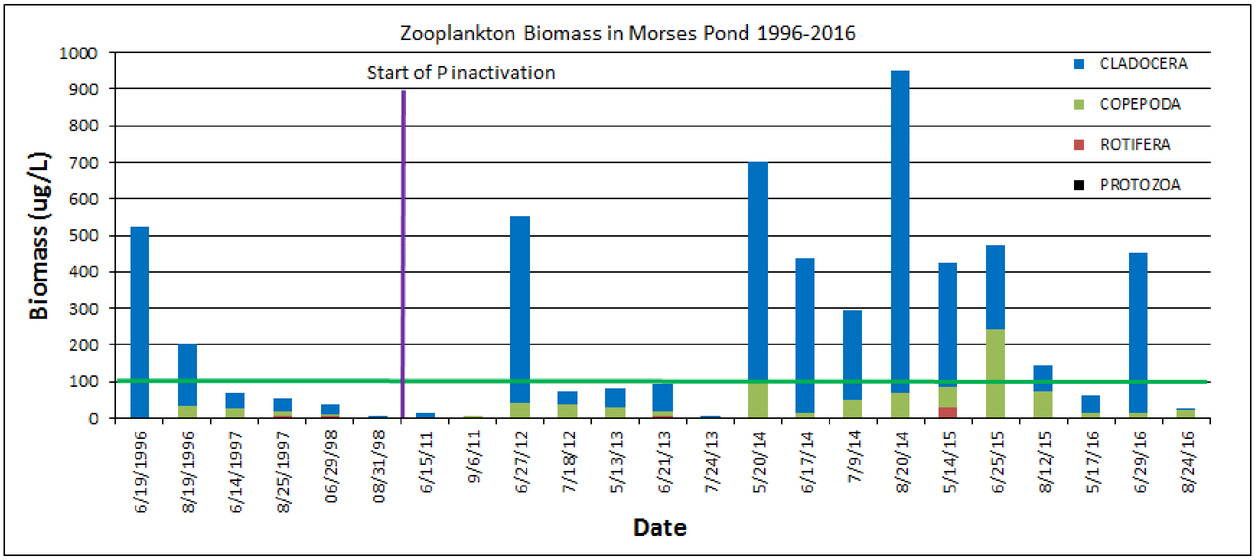
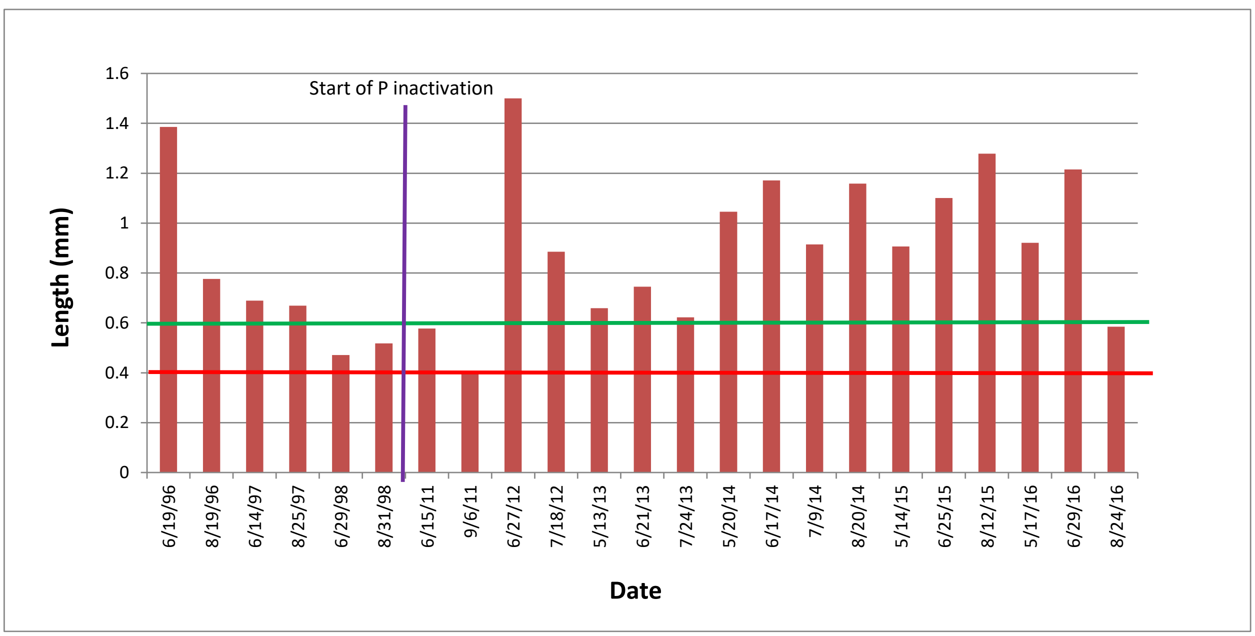



**Figure 8. Crustacean zooplankton mean length, 1996-2016.**



# 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 9 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 goal is to complete one harvest all targeted 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 avoidance pipeline clogging was desired. A second cutting occurred from August into October until 2015, when the second cutting was initiated in July and completed by early September. The intent for 2016 was to repeat the 2015 pattern, although equipment issues limited activity.

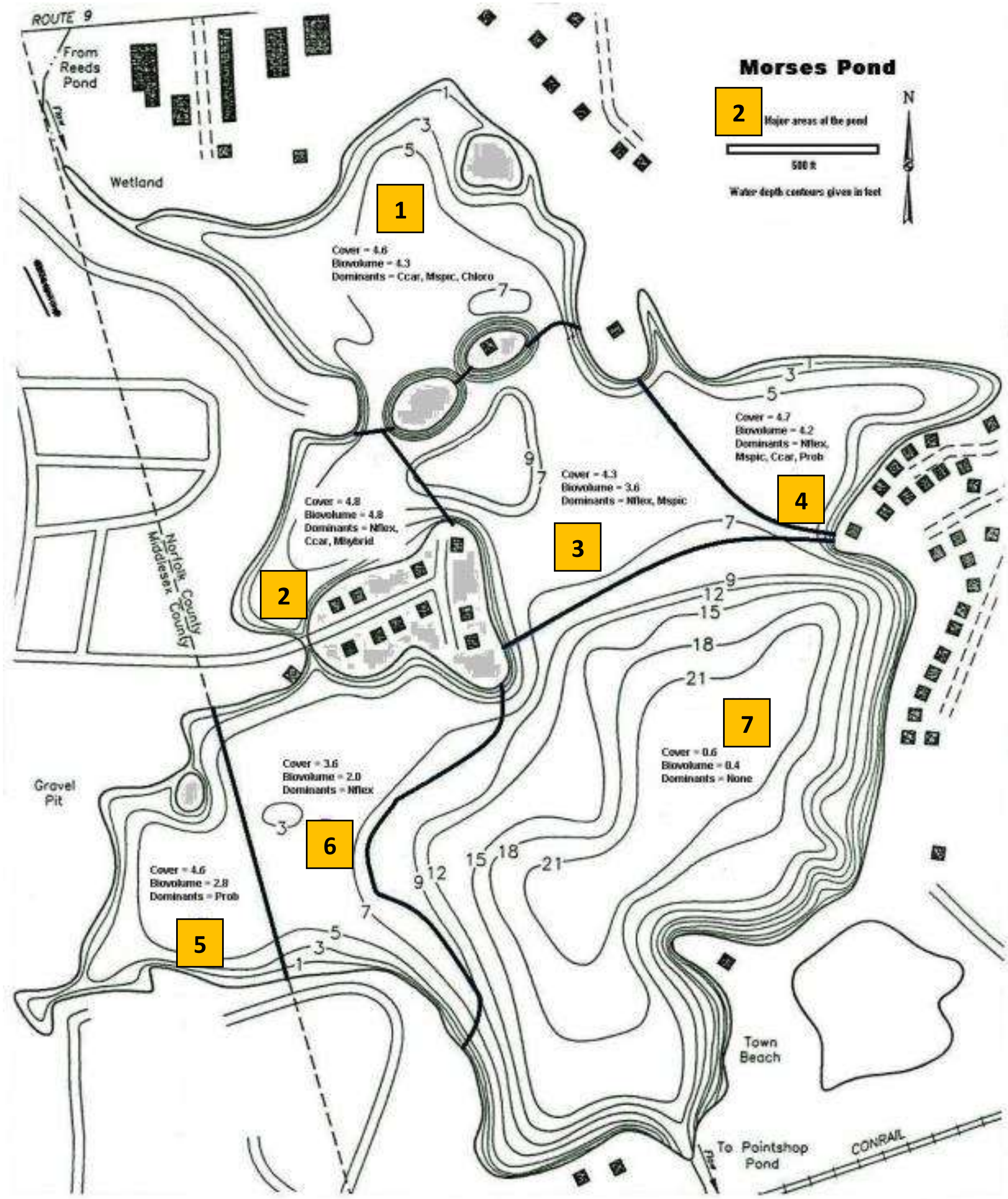
The keys to successful harvesting include:

- Initiating harvesting by the Memorial Day weekend, sooner if plant growths start early in any year.
- 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.

A change was made in 2015, when a seasonal employee was hired and dedicated to the harvesting project. Concern over declining cutting hours per day and competing commitments for staff who normally provide harvesting effort prompted this shift in staffing. Cutting began in late May as usual, but continued through the summer until the seasonal employee returned to college in late August. Cutting by permanent staff was deferred until October. There was a two-week period in mid- to late June when the large harvester was inoperative until parts were obtained for repairs, but overall harvesting results were very similar to past years. In 2016 we followed the same approach of having the same seasonal

**Figure 9. Plant Management Zones for Morses Pond.**



harvester employee, but there were problems with the larger harvester from the start and it was not operational until the second week of June. The smaller harvester was used in areas 6 and 7 to achieve target conditions for the beach area, but much of the rest of the pond was not harvested until later in June. Additional mechanical issues with both harvesters and staffing issues limited cutting time after Labor Day in 2016. Changes in equipment and maintenance approach, and possibly addition of some contract harvesting, are being considered for 2017 and are discussed later in this report.

## Harvesting Record

Records provided by the Town of Wellesley document the harvesting effort expended on Morses Pond (Table 4). Although the record is not always complete, records have been kept since 2007. Between late May and late October, from 2007 through 2016, 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 between 2009 and 2014. 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.

An increasing number of non-cutting hours was observed from 2009 until 2015 (Figure 10), and appears related to increases in time for maintenance and travel. Beginning in 2014, records were kept for non-cutting hours in categories including transport time on the water, transport time on land, and maintenance (Figure 11). The 2015 record indicates that non-cutting time was roughly cut in half. Non-cutting time increased very slightly in 2016 and was still less than in 2014. Better and more detailed record keeping may be a contributing factor, as well as having a seasonal staff person dedicated to the harvesting program. However, delays in parts acquisition increased downtime in 2016, time not accounted for as a category in this analysis.

Considering total time spent and dividing that total into cutting and non-cutting hours (Figure 12), it is apparent that actual hours of time spent cutting plants has declined since 2013, even with a decrease in non-cutting hours since 2014 and dedication of a staff member to the harvesting program. Time spent waiting for parts to repair harvesters is not represented in Figure 12, and cost the program several weeks in each of 2014 and 2015, enough to make up the difference from previous years when more time was spent cutting.

**Table 4. Harvesting record summary 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 |
| 2015 | 57 | 363 | 268 | 6.4 | 4.7 | 90 | 607710 | 10662 | 6752 | 1674 | 2268 |
| 2016 | 48 | 350 | 252 | 7.3 | 5.3 | 85 | 521000 | 10854 | 6129 | 1489 | 2067 |
| 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 10. Non-cutting hours associate with the harvesting program.**

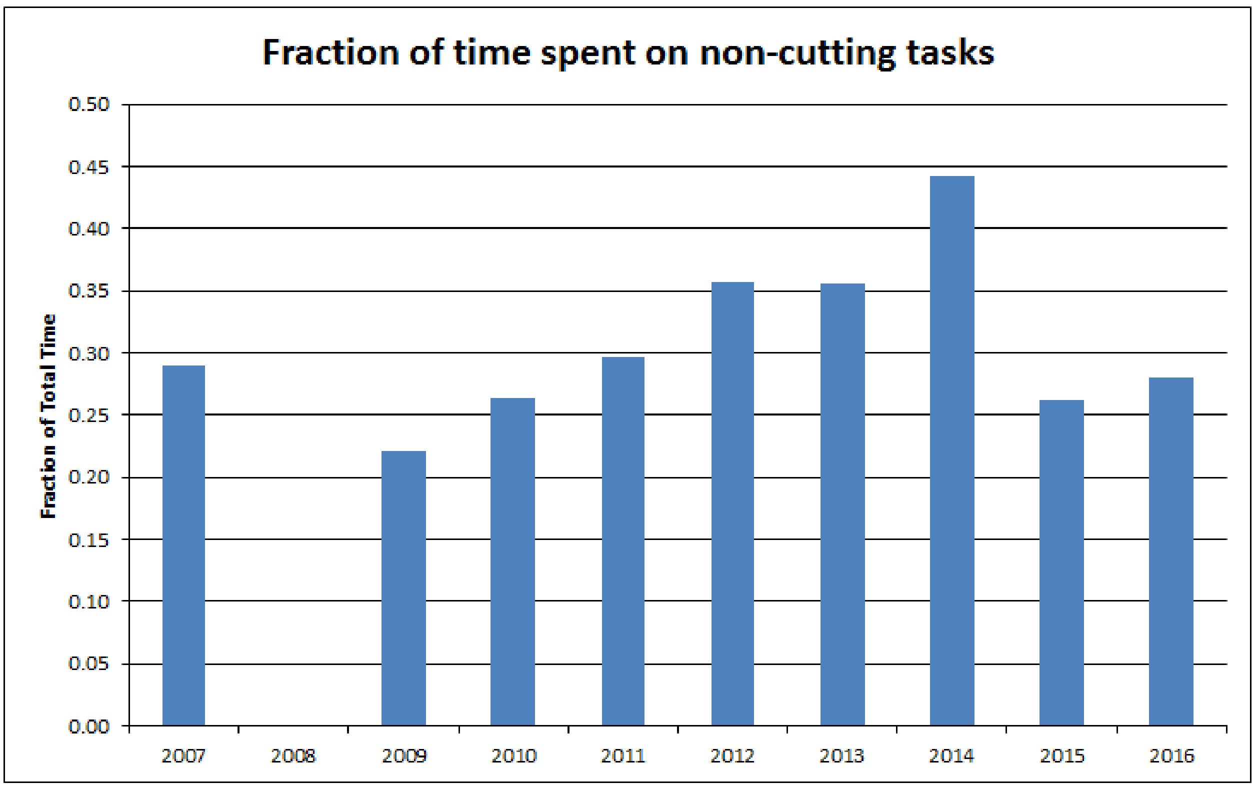


Figure 11. Fraction of logged hours spent on all tasks for harvesting program

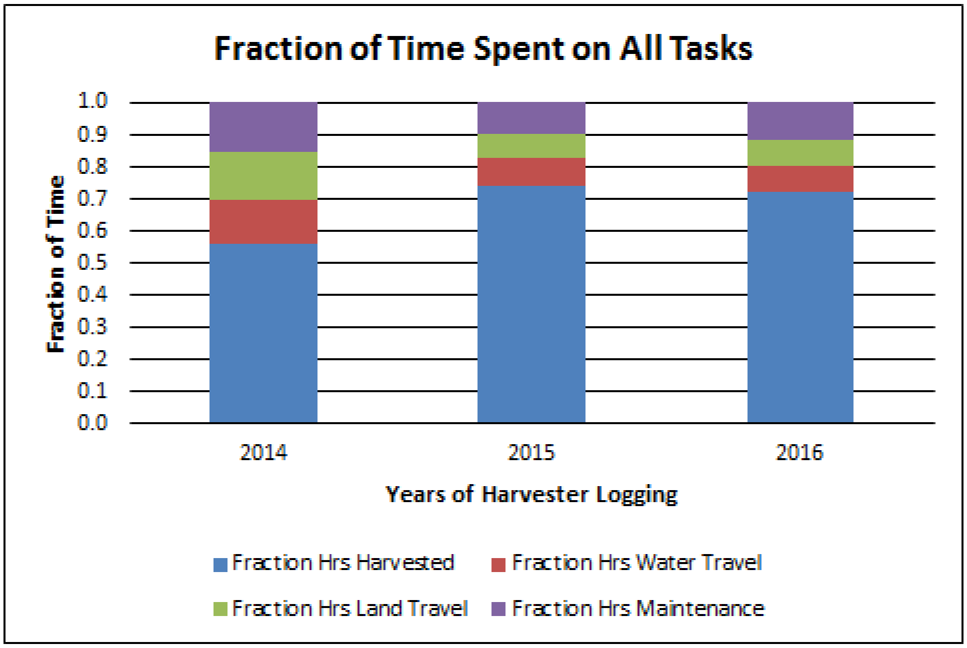
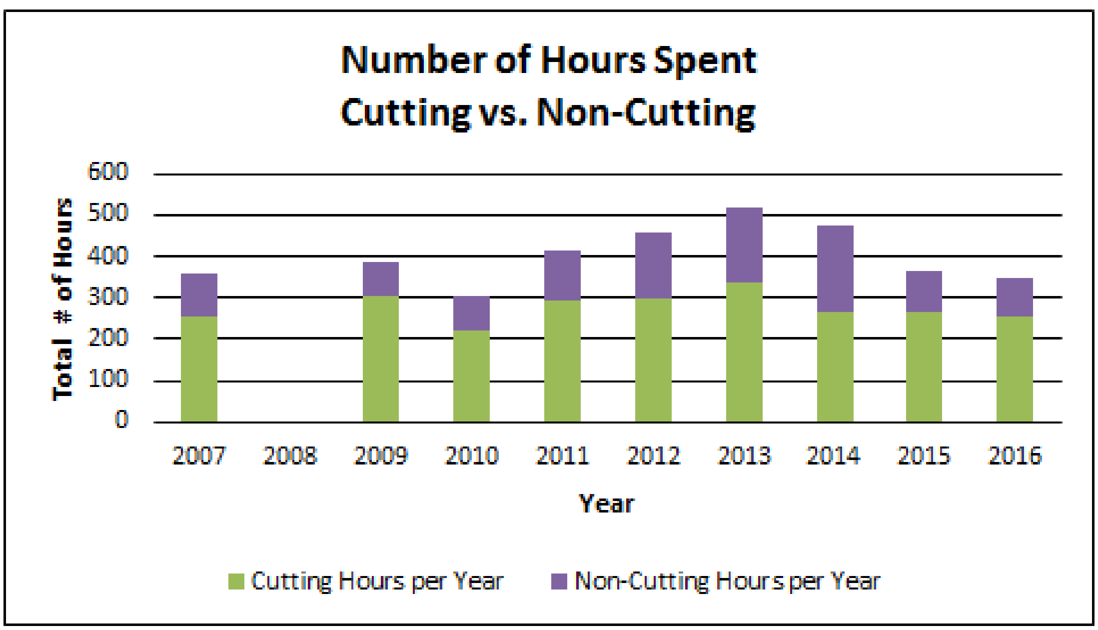



Figure 12. Number of hours spent on cutting and non-cutting tasks for harvesting program



Total weight of plants harvested increased dramatically in 2012 from previous years (Figure 13), presumably as a result of harvesting area 1 where plants grow dense and harvesting rarely occurs. This was done in preparation for dredging in that area. Yet total weight remained higher in 2013-2016 than in years before 2012, suggesting more hours spent harvesting (true of 2013 and 2014) or improved harvesting efficiency (true of 2015 and 2016). The key is combine both in the future, which is largely a function of harvester condition, and both harvesters now have age-related issues.

Weight per day, per load, per total hour and per cutting hour (Figure 14) 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. 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, then getting a second cutting session in the same day. This should result in slightly more than 5 hr of cutting per day; this target was met in the first 4 years with records but not been met in the next 4 years. The staffing adjustment of 2015 improved this metric, with 4.7 hours of cutting time achieved per day, and the 5 cutting hr/day threshold was achieved in 2016.

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 until 2015, when necessary repairs and a delay in parts acquisition limited harvesting in the last half of June. Harvesting in 2015 continued through July, however, making it a more continuous process. Maintenance needs and parts delivery delays again caused problems in 2016, and with the mild winter many lakes and ponds like Morses experienced early invasive species nuisances as these plants were able to grow through winter under favorable conditions. Conditions suitable for harvesting were encountered by late April, yet the operator was not available until mid-May and the large harvester was not operational until the second week of June. The smaller harvester cannot accomplish what the larger one can, so plant growths were very dense by the time the harvesting program was running as planned with two harvesters available. Despite putting in extra hours that brought the hourly cutting total and the weight of plants removed near the range for recent years, the program never caught up and plant growths in areas 2-4 were excessive for much of the summer.

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, but is generally avoided. Two species of milfoil and fanwort are the primary targets of harvesting, amounting to more than ¾ of all biomass harvested based on 2014 through 2016 records. Some water lilies are also targeted to maintain thin patches of this native plant that can still cause nuisance conditions. 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 recent years. There have been changes in personnel and procedures, so continued training should be emphasized. Overall, however, the plant harvesting program achieved desirable results and was properly adjusted to enhance performance as warranted through 2015.

**Figure 13. Total weight of harvest material per year for harvesting program**

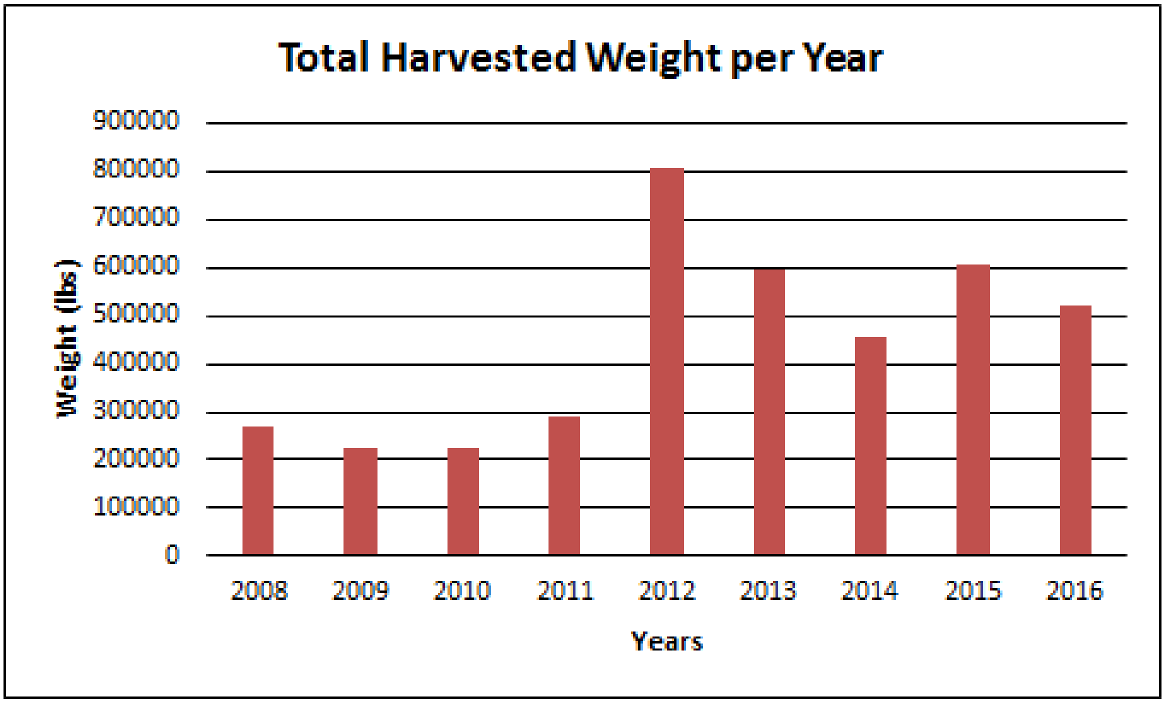
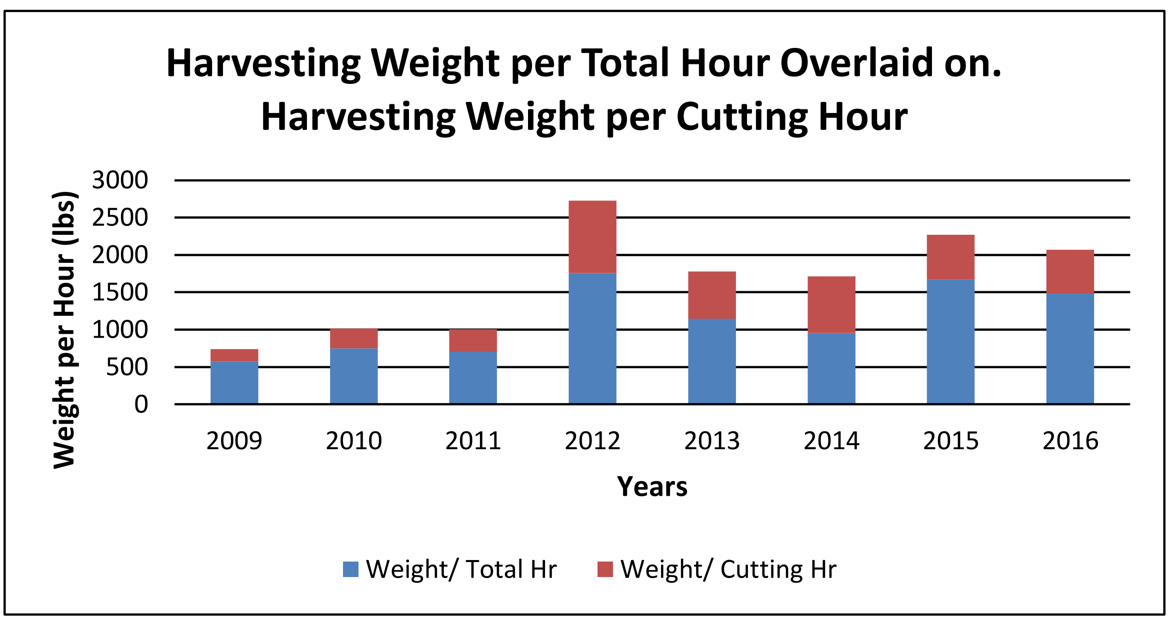



**Figure 14. Harvested weight per total and cutting hours for harvesting program**



The combination of early onset of the growing season and a late start to the full harvesting program in 2016 resulted in failure to completely achieve rooted plant management goals in Morses Pond. The town beach complex was managed successfully, as this area is near the offloading location and the small harvester was sufficient to maintain areas 6 and 7. But without the large harvester for several weeks it was not possible to keep areas 2-4 in the desired condition. Improved efficiency is the primary goal for moving forward and the key step is to limit the amount of harvester downtime during the harvesting season. Better maintenance and rehabilitation in the off season is a key component of this strategy, facilitated by a detailed assessment of needs at the end of the harvesting season, conducting mechanical maintenance in the fall rather than spring, and having parts that are likely to be needed on hand going into the harvesting season.

The larger harvester will be 10 years old when it operates in 2017, and maintenance needs for harvesters in their second decade increase substantially. The downtime in 2015 and 2016 are indications of what is to come if off season storage and maintenance are not improved. A more detailed memo about conditions and options has been prepared, but the short summary is as follows:

1. Routine maintenance needs are known and can be conducted in early spring without causing operational delays, as long as staff time is allocated and any needed parts are in stock.
2. Specific but less predictable maintenance needs are sometimes known when the harvesters come off the water at the end of the cutting season, but are rarely acted upon until spring when the risk of operational delays increases.
3. Careful inspection at the end of the season may reveal more maintenance issues and allow pro-active management that will both extend harvester life and avoid spring delays to cutting.
4. Uncovered outdoor storage is resulting in increased rust and potential metal failure. If storage in a building is not possible, use of a tarp over a frame or even just draped over the harvesting equipment (harvesters and shore conveyors) would at least limit winter weather impacts.
5. Another 10 years of reliable service are possible for the larger harvester if the above steps are taken. If not, we can expect increasing downtime each harvesting season and increased risk of not achieving plant management goals.
6. The smaller harvester, now 33 years old, has probably reached the end of its reliable lifespan. Rehabilitation is possible, but some design features of this older harvester make acquisition of a replacement preferable.
7. The cost of replacement is expected to be $50,000 at a minimum for a reconditioned harvester about 20 years in age to $150,000 for a new harvester meeting ideal specifications for its intended work.
8. The only viable alternative to maintenance and/or purchase is contract harvesting. It will be difficult to get an arrangement whereby a contractor responds to an intermittent need when one of the Wellesley harvesters breaks down, but early season support is possible with winter contracting if there is an expectation of a delayed start due to needed harvester maintenance. The cost for about 20 days of effort is expected to be about $30,000. If we contracted for the normal full season of harvesting, it would cost about $125,000.

There have been some plant controls additional to mechanical harvesting. Hydroraking has occurred 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 most 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. Hydroraking of the beach area and several peripheral areas subsidized by private citizens occurred in 2015 and 2016 as well.

A benthic barrier was installed at the swimming beach in 2008 as a pilot study, but no further application or maintenance occurred. The original benthic barrier is still in place, but is buried under sand. The Recreation Department has expressed renewed interest in using benthic barriers to control plants in deeper portions of the swim area, and WRS will work with the Recreation Department in 2017 to develop an effective program. Done properly, this would replace the need to hydrorake the swimming area prior to dock and rope deployment each spring and allow greater flexibility of management within the swimming area during the swimming season. Benthic barriers may be an attractive option for shoreline property owners as well.

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. Preventing this invasive species from getting established in Morses Pond is an important function that a group within the Friends of Morses Pond has fulfilled well.

## 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 and 2015 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. In 2016 we expected to survey when harvesting was well underway, but with harvester downtime, only areas 6 and 7 had been partially harvested when we performed the survey.

### *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.

### *2016 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, 18 species in 2014, 25 species in 2015, and 22 species in 2016 (Table 5). 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 rarely picked up by our aquatic surveys.

## Table 5. Aquatic plants in Morses Pond

| | | Plant Rating for Year | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **2005** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** |
| *Brasenia schreberi* | Watershield | | | | | | | P | P | | P |
| *Callitriche sp.* | Water starwort | P | | P | | | | | | | |
| *Cabomba caroliniana* | Fanwort | A | A | A | A | A | A | A | A | A | A |
| *Ceratophyllum demersum* | Coontail | C | C | C | A | C | C | C | C | C | A |
| *Chlorophyta* | Green algae | C | C | C | A | | P | C | P | P | A |
| *Cyanobacteria* | Blue green algae | | P | | C | P | P | | P | P | P |
| *Decodon verticillatus* | Swamp loosestrife | C | P | | P | P | | | | | |
| *Elodea canadensis* | Waterweed | C | C | C | C | C | C | C | C | A | A |
| *Lemna Minor* | Duckweed | P | P | P | P | P | P | P | | P | |
| *Lythrum salicaria* | Purple loosestrife | P | P | P | P | P | P | | | P | |
| *Myriophyllum heterophyllum* | Variable watermilfoil | P | C | C | A | A | A | C | C | C | A |
| *Myriophyllum spicatum* | Eurasian watermilfoil | A | A | A | A | C | C | A | A | C | A |
| *Najas flexilis* | Common naiad | C | C | C | C | P | P | P | P | P | A |
| *Nymphaea odorata* | White water lily | C | C | C | C | C | C | C | P | P | A |
| *Nuphar variegatum* | Yellow water lily | C | P | P | P | P | P | P | P | P | P |
| *Polygonum amphibium* | Smartweed | P | P | P | P | P | P | P | P | P | P |
| *Pontederia cordata* | Pickerelweed | P | | P | P | | | P | | P | |
| *Potamogeton amplifolius* | Broadleaf pondweed | C | C | C | C | C | C | | C | C | A |
| *Potamogeton crispus* | Crispy pondweed | | C | C | C | P | P | P | C | C | A |
| *Potamogeton epihydrus* | Ribbonleaf pondweed | | P | P | P | P | P | P | C | P | |
| *Potamogeton perfoliatus* | Claspingleaf pondweed | | | | | P | P | | P | P | A |
| *Potamogeton pulcher* | Spotted pondweed | P | | | P | P | P | P | P | P | P |
| *Potamogeton robbinsii* | Fern-leaf pondweed | C | C | C | C | P | P | P | C | A | P |
| *Potamogeton spirillus* | Spiral seed pondweed | | | | | P | P | P | P | P | P |
| *Potamogeton zosteriformis* | Flatstem pondweed | | | | | | P | P | | | |
| *Ranunculus sp.* | Water crowfoot | | | | | | | | | | A |
| *Salix sp.* | Willow | | | | P | | | | | | C |
| *Sagittaria gramineus* | Submerged arrowhead | P | P | P | | P | P | | | P | |
| *Sparganium sp.* | Burreed | | | | | | | | | | P |
| *Spirodela polyrhiza* | Big duckweed | P | | | | P | | P | | | |
| *Typha latifolia* | Cattail | | | P | | | | | | | |
| *Trapa natans* | Water chestnut | | | | | | | | | | P |
| *Utricularia geminiscapa* | Bladderwort | P | P | | P | | P | P | | P | |
| *Utricularia gibba* | Bladderwort | C | | | | P | | | | P | C |
| *Valisneria americana* | Water celery | | | | P | P | P | | | P | |
| *Wolffia columbiana* | Watermeal | P | | | P | | P | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | # of Species | 23 | 20 | 20 | 24 | 24 | 25 | 20 | 18 | 25 | 22 |
| | **P=Present, C=Common, A=Abundant** | | | | | | | | | | |

Overall, Morses Pond exhibited moderate to extensive vegetation biovolume in the spring 2016 survey (Figure 15). This is more vegetation than we usually observe in spring surveys, a function of rapid plant growth after a mild winter and early ice out. Note that areas 6 and 7 were in the process of being harvested during the plant survey, accounting for lower biovolume than in the other zones. Except where harvesting occurred in 2016, biovolume values were substantially higher in comparison to 2015 prior to any harvesting (Figure 16). Even where harvesting was in progress in 2016, biovolume was not lower than in those areas in 2015 prior to harvesting. This is attributed to the mild winter, allowing more survival and starting the growing season earlier, especially for the invasive species. Cover and biovolume have not reached maximum levels in May surveys, but in 2016 biovolume was already excessive.

**Figure 15. Biovolume of plants in areas of Morses pond in 2016**

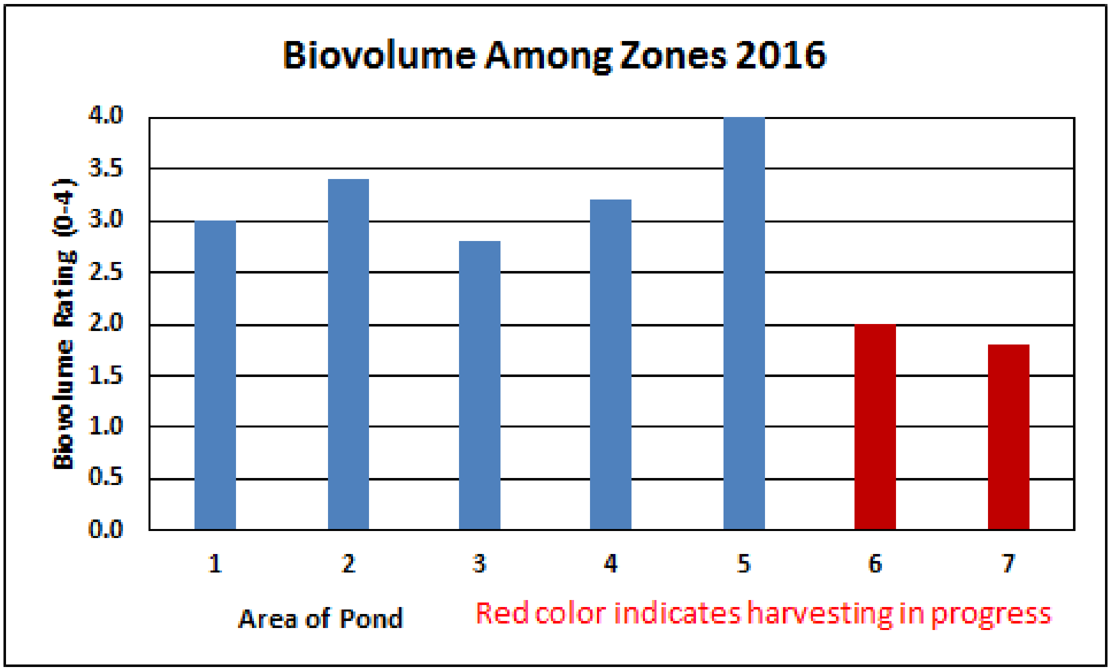
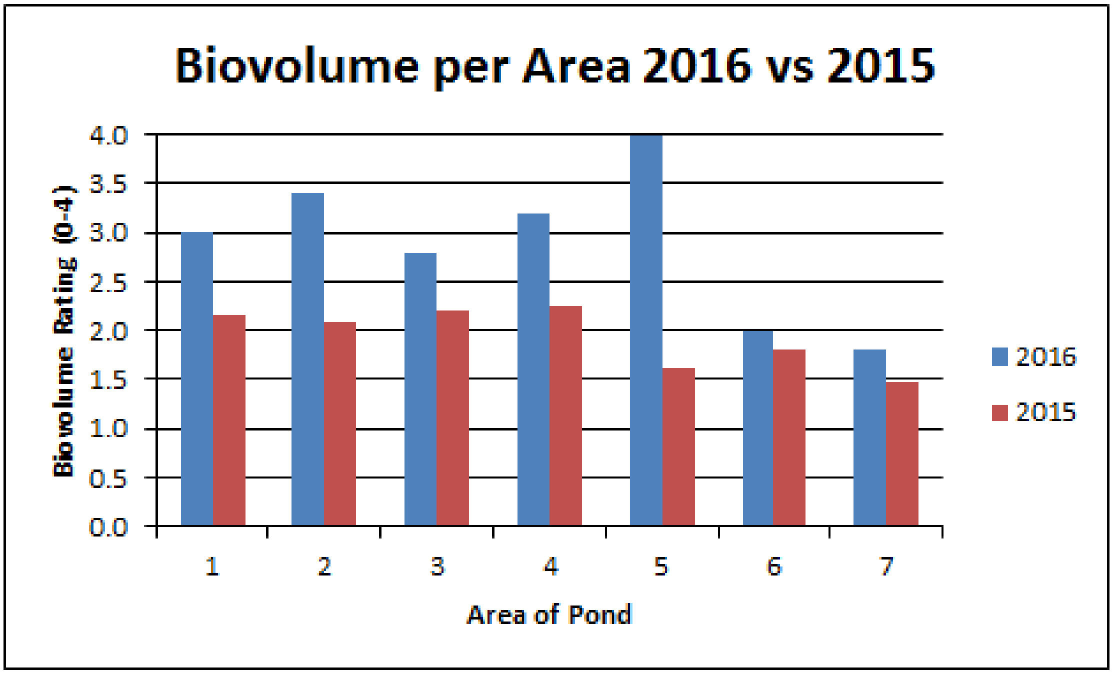



**Figure 16. Biovolume comparison, 2016 vs. 2015**



Dominant plants 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 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 the 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.

One ecological limitation on the harvesting approach is that fanwort tends to initiate growth later than the milfoil species, such that spring harvesting does not greatly retard its growth. Spring cutting largely misses low growing fanwort, and that was the case even in 2016 with the early start to the growing season. The two milfoil species were dominant in most areas, having topped out already in many locations before harvesting had commenced. Fanwort then grows to the surface in July or early August, when harvesting has been suspended in many past years. The move to a second cut shortly after the completion of the first cut in 2015 was intended to counter that ecological issue, but harvester downtime during the first cut in both 2015 and 2016 delayed the start of the second cut, so this approach has not yet been fully tested as a means to limit fanwort.

### *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 startup 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 later data that are also collected prior to harvesting. No decreasing trend in the biovolume of invasive species has been observed, although favorable shifts in the abundance of some more desirable plants (e.g., Robbins' pondweed) have been documented. In 2016 we compared biovolume data to 2015 biovolume data (Figure 16). Even with zones 6 and 7 being harvested during the 2016 survey, the biovolume is more than in 2015 and is dominated by invasive species. In essence, the plant community grows back to its original biovolume status each year, despite harvesting in many (but not all) areas. Areas 2, 3, 4 and 6, which are harvested twice per year, show no indication of decreased biovolume or fewer invasive plants the following spring after repeated years of harvest.

The frequency of the main invasive species, fanwort and two milfoil species, showed an encouraging albeit slight decrease between 2010 and 2014, but only Eurasian watermifoil exhibited such a decrease in 2015. Fanwort frequency of occurrence declined slightly in 2016 vs. 2015, but variable and Eurasian watermilfoil increased (Figures 17-19). Native species also exhibited fluctuations that do not appear clearly related to harvesting. The plant community is not especially stable, but there is no strong indication of a decrease in nuisance species or a steady increase in desirable species as a result of harvesting.

Figure 17. Fanwort frequency comparison, 2016 vs. 2015

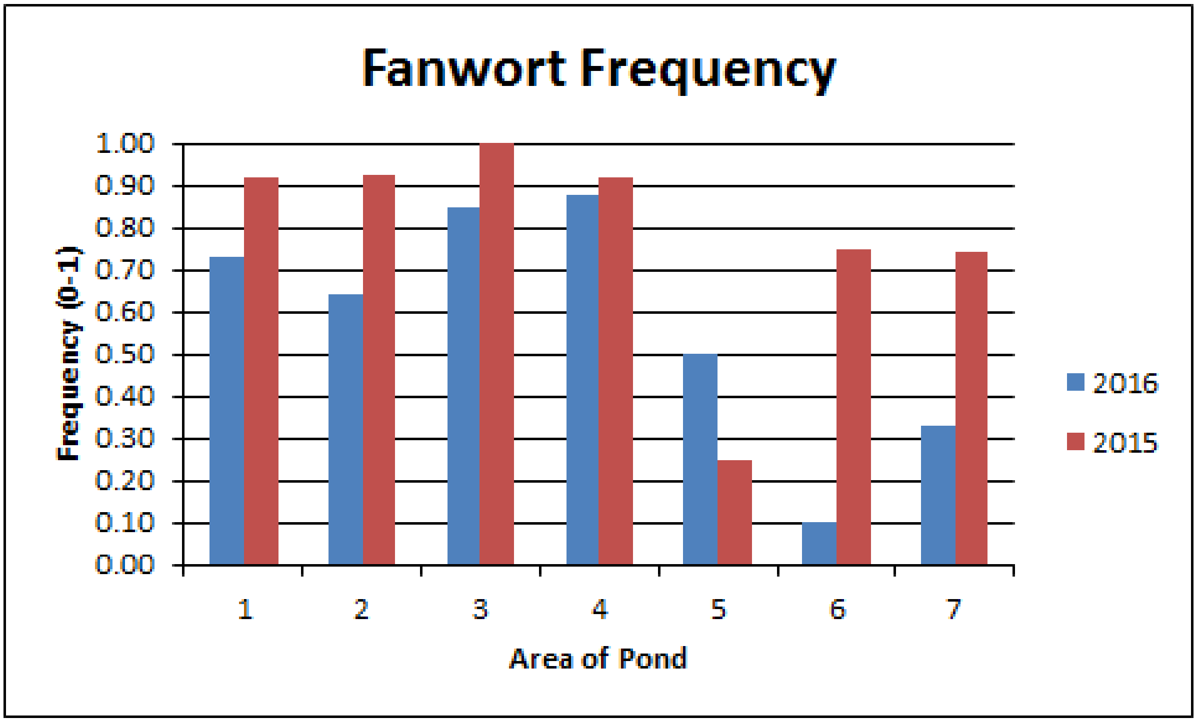



Figure 18. Variable milfoil frequency comparison, 2016 vs. 2015

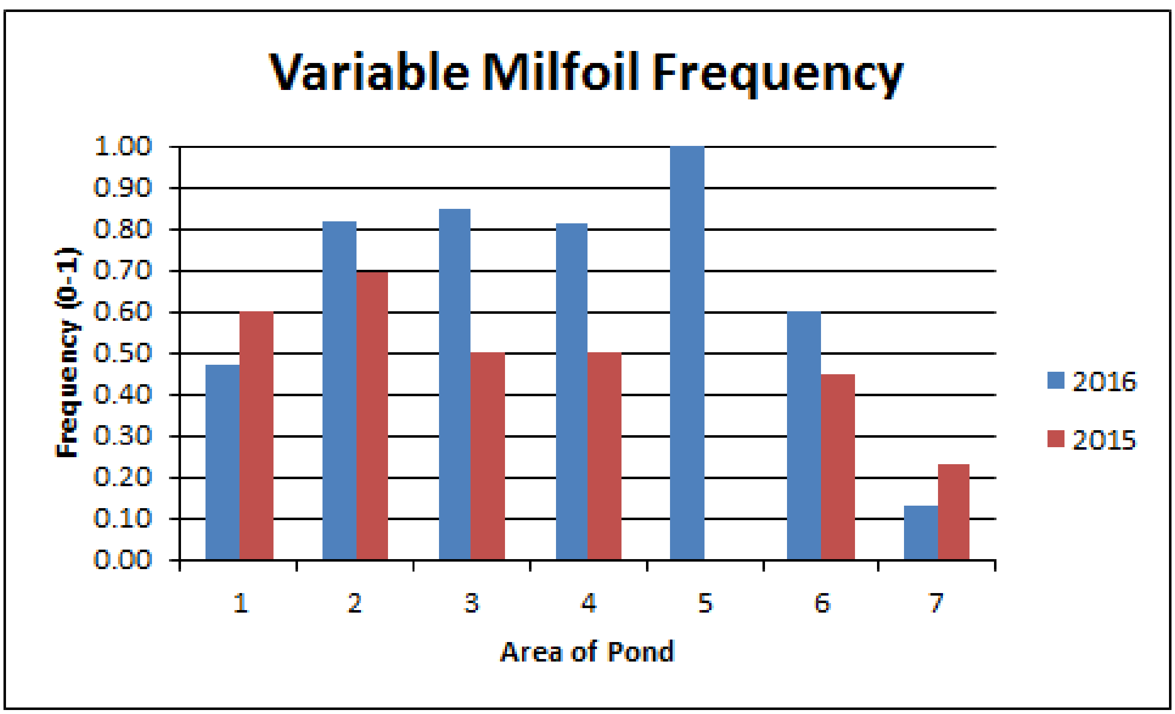


**Figure 19. Eurasian milfoil frequency comparison, 2016 vs. 2015**

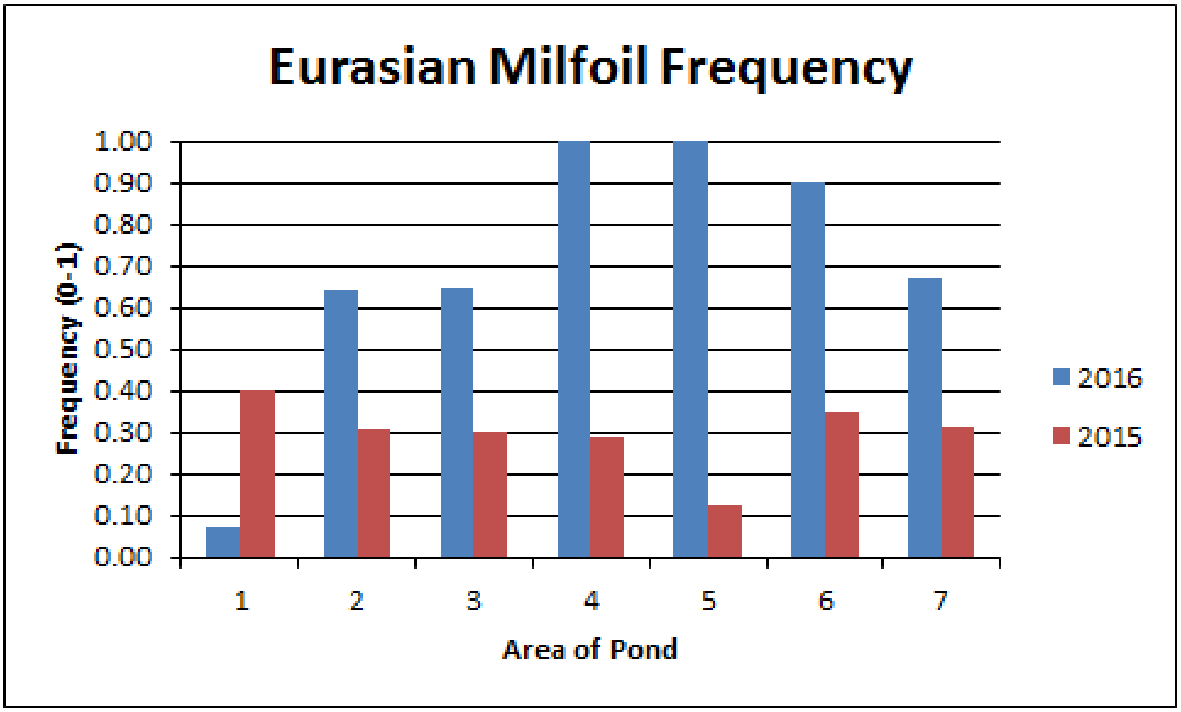
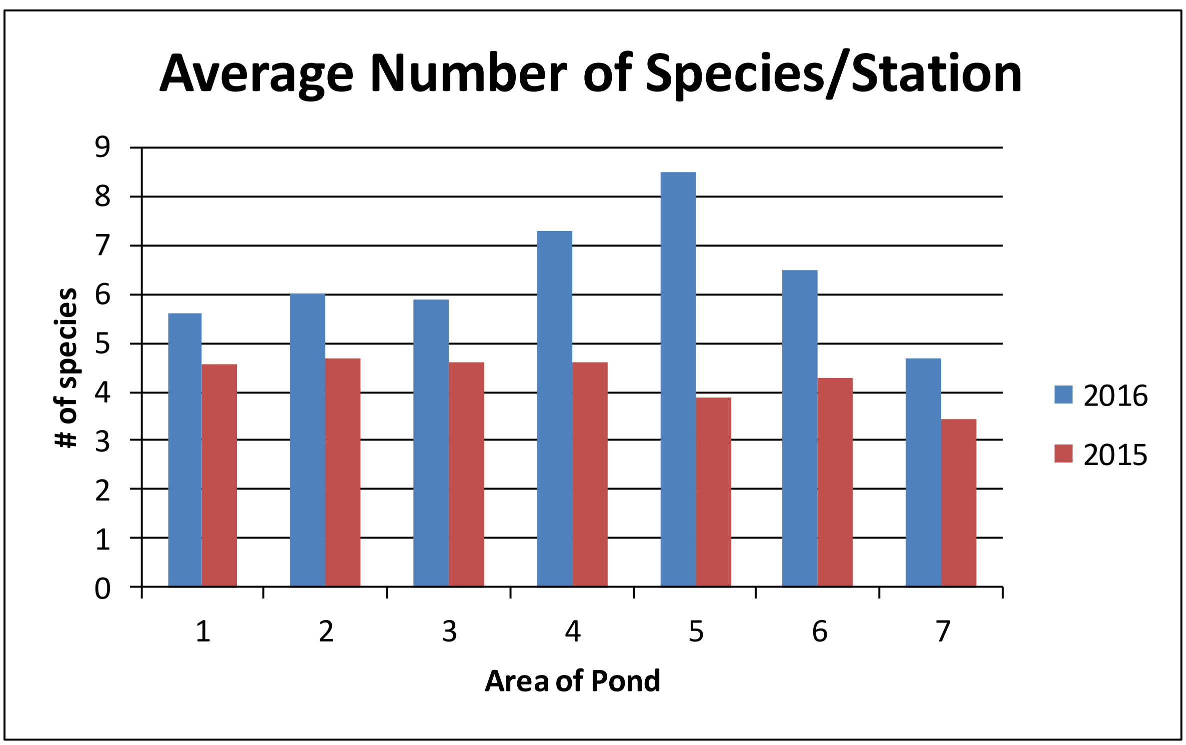



**Figure 20. Comparison of number of species per survey station, 2016 vs. 2015**



Depression of invasive species biomass by harvesting may at least facilitate more native species being present. The average number of species found at each survey station (Figure 20) for all pond areas increased somewhat in 2016 over 2015 values. Bear in mind that assessment based on frequency of occurrence does not necessarily reflect biomass, so even though the two milfoil species were found at more sites in 2016 than 2015, so were many native species. The early ice out and start of the growing season appears to have benefitted all plants, not just invasive species.

### *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 newer, larger harvester and an adjusted approach appears to be controlling biomass and the portion of the water column filled when the harvester is operational, but shifts in species dominance are not extreme; invasive species have been reduced in frequency of occurrence in some years, but so have other species, and changes are not lasting or unidirectional. Harvesting keeps areas open for habitat and recreational use, but apparently 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. The Friends of Morses Pond are to be congratulated for their successful effort.

## 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 biorentention 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. Expenditure of time and funds on the phosphorus inactivation system in 2012 - 2015 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 2017.

With the automation of the phosphorus inactivation system, labor hours were freed up that could be devoted to other pursuits, and education was perceived as a primary need. WRS conducted multiple programs during summer of 2016, including two invasive species poster development sessions for youth in connection with the summer concert series, a summer school program about aquatic invertebrates and ecological health of streams, and a painting session with a lake landscape theme with discussion of watershed influence for adults. All were well received and plans have been made to work through the Recreation Department in 2017 to advance similar educational efforts.

## 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 had 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, the agreement with the Catholic Diocese was extended, and the project was put out to bid successfully. Cashman Construction was the successful bidder, and Apex 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 for proper disposal 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. 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.

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 through 2016 prior to opening for the season. Since sand deposition in 2013, human activity in the central part of the swimming area has spread the deposited sand to a reasonable degree and created a gradual slope. However, the northern and southern ends of the swimming area have steep drop offs where sand has not moved much since deposition.

There was a drowning in 2013 at the northern end of the swimming area, and the steep drop off has been implicated as a possible factor. The Recreation Department is moving to rectify this situation, developing a plan to regrade the north and south ends of the swimming area and reconfigure the dock for maximum safety. Permits are expected in 2017 and it is intended that the work be done by the start of the 2017 swimming season. Another drowning occurred in 2016, away from the swimming area off private property. While this incident was not linked to the town beach complex, the person drowned only 50 ft from shore in an area with a steeper drop off and dense rooted plants. The need to manage the swim area for a safe slope and limited rooted plants was underscored.

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). Evaluation of flow paths in 2013 - 2016 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 since dredging, but sloughing of nearby organic matter into the new "hole" was expected and the substrate is still mostly sandy. Plant growth can be expected in water <8 ft deep, but the dredged area remains deep (13 ft) and relatively plant free.

## Financial Summary

At the end of the FY2016 fiscal year on June 30, 2016, a total of $58,204.69 had been expended by WRS for the management of Morses Pond in FY2016. There were a few accounting issues that resulted in some subaccounts being exceeded and others not being used up, but ultimately $3795.31 of a total $62,000 budget was unexpended (6.1%). This budget encompassed funds in the Pond Manager, Other Professional Services, and Monitoring accounts. No funds from the Phosphorus Inactivation account were used by WRS for additional labor for spring treatment of incoming storm water. Rather, funds from that account were used for chemical supplies and system repairs by the DPW.

It is our understanding that the allocations for FY17 are $45,000 for the Pond Manager account and $7000 for the Monitoring account, a total of $52,000. Based on the automation of the P inactivation system, the reduction is manageable. We anticipate less labor going toward P inactivation in spring of 2017, and will be applying more time to environmental education, a longstanding need.

Only one invoice has been submitted so far in FY17, that for $17,657.70 at the start of September, covering some P inactivation support over the summer, water quality and biological monitoring, and summer educational programs. With work done since September in relation to analysis of the phosphorus inactivation system and harvesting program under the implementation of the comprehensive plan and preparation of this annual report, we expect to submit another invoice for about $15,000 by the end of the calendar year. This will bring the total FY17 expense to slightly less than $33,000 and leave about $19,000 for the remainder of FY17. This is expected to cover winter and spring education program support through the Recreation Department, spring vegetation and water quality monitoring, and phosphorus inactivation operational support through June 2017. WRS is also attempting to support the Recreation Department's efforts to regrade the swimming area and control rooted plants in that area for safety of users.

## Important Steps for the Remainder of FY2017

Based on the above information and analysis, the following key steps are outlined for the remaining 6 months of FY2017:

1. Secure funds for a new, smaller harvester for use on Morses Pond and other Wellesley ponds. Aside from taking no action and risking being unable to conduct the harvesting program as planned, the one viable alternative is to contract with a vendor to provide harvesting services, either for the early season period (usually May) or the entire season. It is unlikely that any vendor will contract to provide on-call services in the event of a harvester breakdown, as they tend to commit their machines to full time work after late May.
2. Maintain the larger harvester as far in advance of the harvesting season as possible. A list of needs has been generated and is under review by involved parties. Once finalized staff time and parts will be needed to get this harvester in best working condition. An additional list of parts likely to be needed in the near future is also under review, and as many of those parts as possible should be ordered and kept ready to minimize downtime during the harvesting season.
3. Secure permits and contract a vendor to regrade the swimming area to avoid steep drop offs that constitute a severe safety hazard. The Conservation Commission can declare this to be a health and safety emergency, negating the need for a Section 401 Water Quality Certificate and review under the Massachusetts Environmental Policy Act. An Order of Conditions will be needed under the Wetlands Protection Act. A Section 404 Permit will be needed from the US Army Corps of Engineers, but a general permit is available to cover this activity and should be relatively easy to procure. So the key step is discussing this situation with the Conservation Commission. SOLitude, under contract to the Recreation Department in recent years, is capable of conducting the regrading if so desired.
4. File with the Conservation for a Determination of Applicability for deployment of benthic barriers in deeper portions of the swimming area subject to dense plant growth. The use of benthic barriers is eligible for a Negative Determination, allowing deployment without further permitting. Two types of barrier are available and some prep work will be necessary to create panels that can be easily handled and placed, but this is a relatively straightforward approach to minimizing plant nuisances that constitute a safety risk in the swimming area.
5. Schedule educational activities through the school system and Recreation Department. A set of 4-6 after school programs are envisioned and a repeat of some of the summer programs from 2016 seems desirable.
6. Prepare the phosphorus inactivation system for use in 2017. Order polyaluminum chloride and have it delivered by mid-May. Run compressed air through the lines to ensure no blockages. Check the rain gauge for blockages and functionality after winter. Test the automated system to be sure it will come on as needed and fill the lines with chemical to be ready for treatment prior to Memorial Day.