Bare Hill Pond Watershed Management Committee
Town of Harvard
Harvard, MA 01451

August 24, 2015

Conservation Commission
Town of Harvard
Town Hall
Harvard, MA 01451

Re: 2014-15 Drawdown Report and Fall 2015 Drawdown Plans

Dear Commissioners:

On behalf of the Bare Hill Pond Watershed Management Committee, we are pleased to submit our 2015 annual report. Included with this report are our professional monitoring report from Wendy Gendron as well as observational data reported by residents and our volunteer monitoring report. We have invited Wendy Gendron, our wetlands biologist consultant to join us at the meeting on September 3, 2015.

In summary, our data indicates that we have increased phosphorous this year, in some locations and at certain times, at levels that exceed the endangerment level of 30 ug/l (0.030 mg/l) and at lower levels at other locations and at the surface areas. The higher expected levels were mostly earlier in the season, and were higher at the bottom of the Pond than in the surface areas. We have hypothesized that the higher levels could be due the significant snow fall last winter, and the significant increase of storm water runoff caused during the snowmelt. This seems supported by the decline in the over the course of the season to more acceptable phosphorous levels, but still higher than we had achieved in prior years. The higher levels at the bottom of the Pond might also be the result of an increase in anaerobic activity. Phosphorous binds to the sediment and is released into the water column by anaerobic cellular activity. A decline in oxygen levels is expected below 8-10 feet in water depth and water samples normally indicated the presence of sulfur dioxide and lower oxygen. Oxygen levels could be further lowered by increased plant biovolume being killed off in the winter triggering the use of oxygen at an increased rate, however, the plant survey shows some decline in biovolume compared to 2014 at the transects. Still, it might be caused by increase plant growth in other areas or the significant absence of sunlight due to the snow depth causing some plants to die over the winter and decomposition of the plants to deplete oxygen levels. Again these are only hypotheses and independent of the certainty of the cause, we have higher than desirable phosphorous that should be controlled and observed increases in invasive plant species in the zone above 5 feet in depth.

As background, a completely undeveloped watershed is normally 5-10 ug/l and it would be difficult to get much lower than 20 ug/l given the level of development in our watershed and the pre-existing bound phosphorous in the Pond bottom. The 1998 TDML measured the level at 44 ug/l and our target for the DEP/EPA grant was 30 ug/l.

Wendy Gendron conducted the plant survey in August so that we have current comparison data at a comparable time at the prescribed transect locations used in the prior plant surveys. The data runs back as far as 2002, and the transects were established by ENSR and used by DEP/EPA to measure our goals in the grant. As requested at the last meeting, a copy of the transect map is attached as Exhibit A. The 2015 water quality results are compared to those results to results dating from 2004, 2005, 2007, 2009, 2010, 2011, 2013, 2014 and the TDML reading from 1998. Attached as Exhibit B are results from Wendy Gendron from the Phosphorous and Secci disk readings, oxygen measurements and plant survey conducted in the Spring and Summer.

Wendy's observations at the transects indicated generally that biovolume and invasive plant species such has milfoil and fanwort have declined at the transect points from 2014-2015 due the draw down. This is good and should also help to reduce oxygen depletion this year associated with decomposition of plant matter at the end of the season when plants die, and in turn help reduce anaerobic phosphorous release from Pond sediment. She also recommends that future measurement points be added to the survey to capture areas identified by residents as sources of concern.

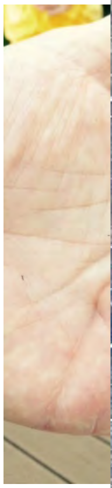
Our observations and reports of local residents using the Pond of invasive species growth is consistent with this report. Like 2014 after a year with no drawdown, we continued to see some but not prevalent milfoil and fanwort in the 0-5 foot zone. The 2014 drawdown was 5.5 feet in depth. It was a solid freeze but with the heavy snowfall the drawdown zone may not have dried and been as effective due to the extensive and long lasting snow cover. That invasive species though present in the 0-5 foot zone appeared to have been controlled. Residents routinely began reporting in July that in the 5-8 foot zone a continued increase of milfoil or fanwort (they do not often know the difference). This is the area that was beyond last year's drawdown. For this reason we are recommending an incremental increase of 6" to the 6 foot level found to be most effective prior to taking a year off in 2013. We would like to restore the level of phosphorous control and invasive species management before taking another year off.

In addition to the professional monitoring, we continue our volunteer monitoring program of frogs, fish, mussels and invertebrates, and downstream wetlands. Tom Gormley reports that the counts were similar to prior years including spring peepers, pickerel frogs, gray tree frogs and green frogs with "no signs of decreasing populations." The counts started later than normal due to the cold March and the later than previous snow melts. Tom has taken advantage of Next Door Harvard which has increased participate of volunteers and facilitated counts on a timely basis. In April there were strong choruses of peepers – to be expected – and pickerel frogs could be counted in similar numbers to prior years and a few gray tree frogs which were not always counted at this time in prior years. In later counts there were still choruses of peepers, pickerel frogs, American toads, gray tree frogs and green frogs. Bull frogs are later in the summer.

Fishing derbies reports excellent fishing and unsolicited comment on the improvement at the boat ramp. We held a mussel count at the 5 foot stage to see if they are impacted and there were many mussels as well as juveniles indicating their health. Here are a few photos taken through a thin layer of ice:

Juvenile

Adult



Here is a photo of a molted shell from a Bare Hill Pond crayfish or should I say lobster? It is the largest one I have observed in 15 years.

We continue to receiving monitoring data from the Nashua River Watershed Association which at our request has included Bowers Brook in its monitoring program. I will provide a copy of their electronic report by email because it is an interactive excel spreadsheet.

Downstream wetlands continue to appear healthy. There increasing dominance of cattails but which can now be observed in the downstream wetlands all along bowers brook to Depot Road by the Transfer Station. The draw down pumping site does not appear to be gouging or impairing plant growth as there are healthy sedges and wetland plants growing below the discharge area. We did not see any significant changes this year from last year.

I continue observed mink on our Warren Ave shoreline and beaver and otter during the fall and early spring.

Rick Dickson continues to monitor invasive water chestnut plants. Due to his success over the past several years, he did not seek volunteer help for a weed pull. The water chestnuts continue to be under control as the density of plants is low as reflected in how difficult it is to find them throughout the Pond. He asks us all to be vigilant for any remaining water chestnut plants and to pull them when we see them.

Draw Down Plan

Based on the increase in the phosphorous readings and the increased observation of invasive species, we propose to do a draw down for this Fall to restore the lower phosphorous levels and keep the invasive species from continuing to repopulate the 5-8' zone. A 6 foot draw down which is 6 inches more than 2014-2015 has shown to be sufficient in prior years and is incremental to this year. In 2012 we conducted an incrementally shallower draw down at 6 feet (compared to 6.5 feet in 2011) and had acceptable results If we are successful this year, we would hope to take a year off the in 2016 or reduce the depth of a 2016 draw down. It is important that we keep the phosphorous under control.

. Our draw down plan would be similar to last year but adjust the pumping at the end of October to achieve 6 feet before the freeze. Depth target is the maximum drawdown as of that date

Date	Depth Target (Measured from the top surface of the dam)			
	2014	2012	2015 Drawdown Depth	2015 Actual Depth**
9/24	22"	22"	22"	0"
10/1	22"	34"	22"	0"
10/15	34"	46"	36"	14"
10/24	46"	52"	48"	26"
10/28	52"	58"	56"	34"
Nov 30 or freeze*	5.5' on pipe	6' on pipe	6' on pipe	6' on pipe

*(measured on pipe marker)
**(amount of water drawn down)

Pumping would begin only when needed to maintain the rate during October but be necessary after reaching approximately 3 feet. The rate would not exceed 2 inches per day per the Order of Conditions. We think this approach will preserve Pond levels in September and October for recreational use (including the rowing season) and still achieve the beneficial draw down effects. If we are unable to achieve the 6.0 foot draw down by November 30, 2015 or a freeze occurs, we will stop and discuss it with the Commission if we have an alternative recommendation.

As in prior years, we would initiate the refill of the Pond on or before February 1, 2016 following notice to the Commission and the abutters. Because snowmelt timing is variable, it is important to timely refilling of the Pond, our experience indicates that deferring the refill beyond February 1 is unwise to ensure the habitat is restored for amphibians, fish and reptiles.

We appreciate the time the Commission has taken, and the effort made to understand, and help manage the project. We look forward to the meeting on September 3.

Sincerely,

Bruce A. Leicher
Chair, Bare Hill Pond Watershed Management Committee

Cc: Conservation Commission Members
Bare Hill Pond Watershed Management Committee Members
Board of Selectmen

Exhibit A

Figure 3-1. Bare Hill Pond macrophyte sampling transects

(From the 2002 ENSR Report to the Conservation Commission and included in the QAAP for the MA DEP/EPA Section 319 Grant)

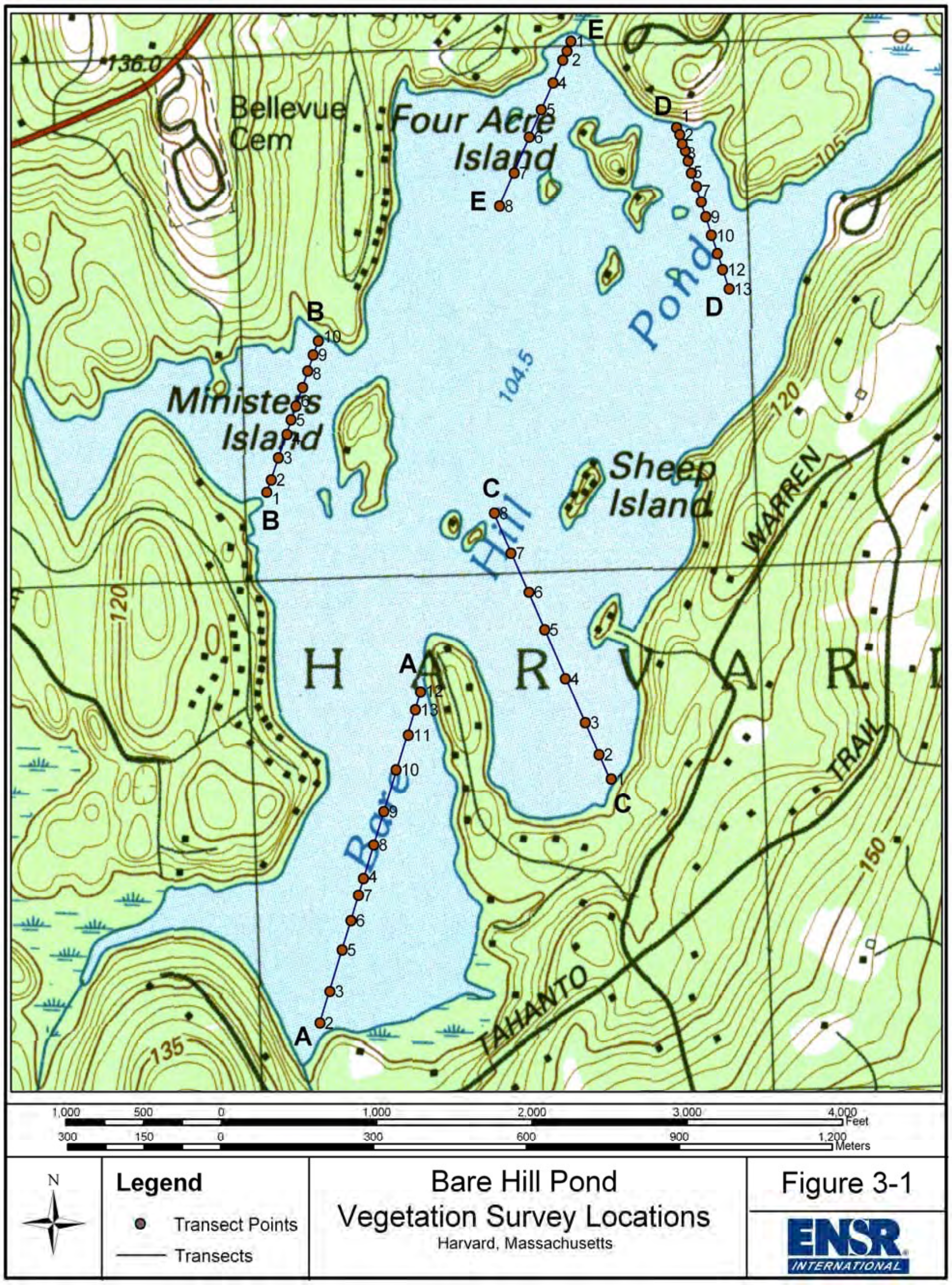


Exhibit B

Location
Ten 100' Segment Sites

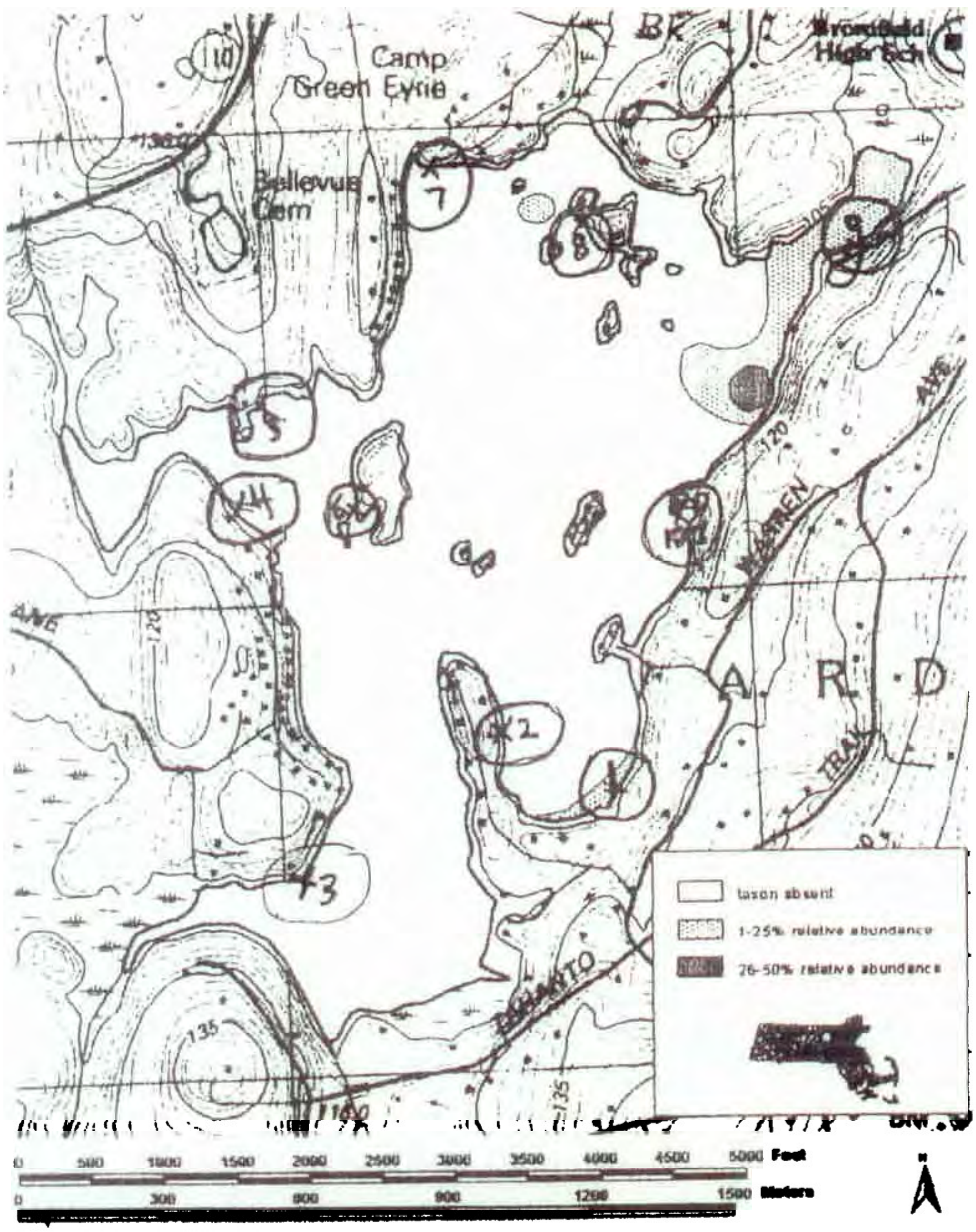


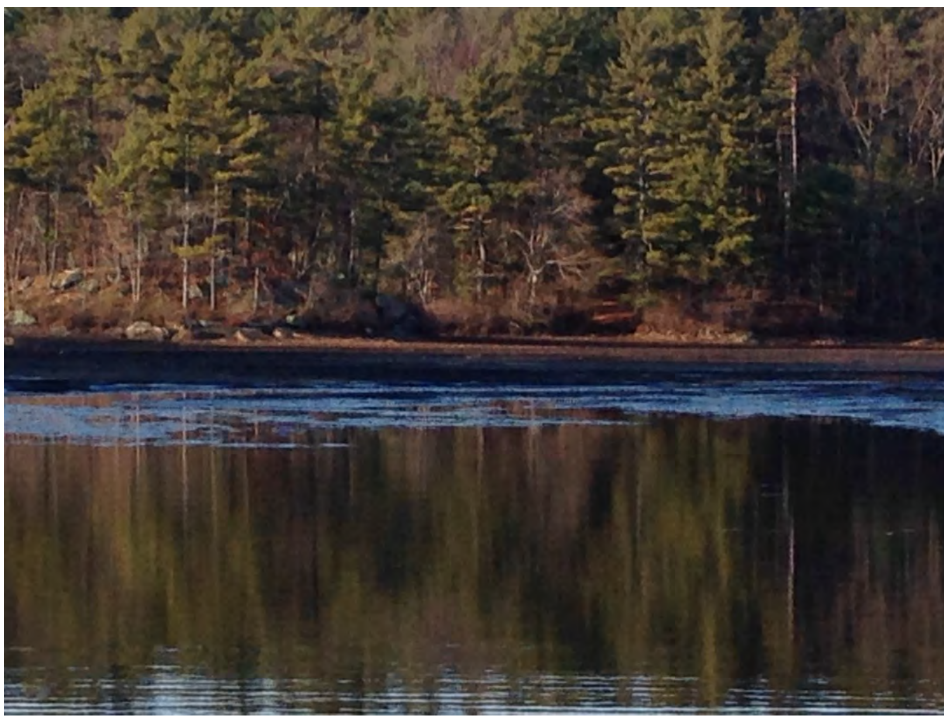
Figure 5. Distribution and relative abundance of fanwort (*Cabomba caroliniana*) in Bare Hill Pond in October 2001, from data in Appendix A.

Site 1

Site 2

Site 3

Site 4 5 and 6



Sites 4 5 6

Site 7

Site 8

Site 10

Clapp Brook Cove looking West

Aquatic Restoration Consulting, LLC

18 Sunset Drive
Ashburnham, MA 01430
Phone: 508-397-0033

August 21, 2015

Bare Hill Pond Watershed Management Committee
Bruce Leicher
Town of Harvard
99 Ann Lee Road
Harvard, MA 01451

Mr. Leicher,

Attached is a draft 2015 report for the water quality sampling and aquatic plant surveys conducted in 2015. Please let me know if you have any questions or comments regarding this report. I look forward to assisting the Committee with continuing improvements and outreach activities for Bare Hill Pond.

Sincerely,

W. Gendron

Wendy C. Gendron, CLM
Aquatic Ecologist

Repot For:

Town of Harvard
Bare Hill Pond Watershed Management Committee
Harvard Massachusetts

Bare Hill Pond In-Lake Water Quality and Plant Survey 2015

Prepared by:
Aquatic Restoration Consulting, LLC
18 Sunset Drive
Ashburnham, MA 01430

August 2015

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Figures

Introduction

Aquatic Restoration Consulting, LLC (ARC) performed in-lake water quality sampling and an aquatic plant survey of Bare Hill Pond in 2015. The intent of these surveys was to document water quality and aquatic plant presence and abundance. These data were compared to previous surveys.

The Bare Hill Pond Watershed Committee (Committee) has conducted winter water level drawdowns periodically since 2002. Early drawdown were limited to the depth of the outlet. Additional drawdown depth is achieved when water is pumped. Substantial reductions in plant cover and density were observed in association with initial extended water level drawdowns and remained consistent following subsequent drawdowns. A shift in species dominance from tall growing vegetative propagators to low growing seed producers was observed. A history of drawdown depth and summary of conditions reported by the Committee is provided in Table 1.

Table 1. History of Bare Hill Pond Winter Drawdowns.

Winter Season	Water Level Reduction and Summary of Following Growing Season Observations
2002-03	1.5 Feet
2003-04	3.5' gravity drawdown
2004-05	3.5' gravity drawdown
2005-06	3.5' gravity drawdown - these first few created evidence of efficacy in drawdown zone and no evidence of substantial issues
2006-07	5' gravity and pump drawdown - some increase in efficacy
2007-08	5' gravity and pump drawdown - good freeze and improvement
2008-09	3.5' gravity drawdown - per request to see if a year off pumping would work - limited efficacy and rebound in plants
2009-10	6' gravity and pump drawdown - planning started for beach excavation and the storm water rain gardens
2010-11	6.5' gravity and pump drawdown - continued incremental efficacy and no harm detected
2011-12	7' gravity and pump drawdown - more efficacy and depth needed for the beach excavation project
2012-13	6' gravity and pump drawdown - backed off to see if efficacy could be maintained
2013-14	No drawdown - year off to see if lower frequency worked - phosphorous stable, some re-emergence in spots
2014-15	5.5' drawdown - heavy snowfull runoff - phosphorous increase and increased observance of invasives by residents in 5-8 foot zone but overall reduction in plant volume and at transect sites

The Committee, in consultation with ARC and the Town of Harvard Conservation Commission, decided not to perform a drawdown over the winter of 2013 - 2014. The purpose of the hiatus was to determine if taking a year off would result in discernible changes to the plant community or water quality. While the 2014 survey showed no substantial evidence in the observation points to suggest a drastic increase in plant growth, fanwort (*Cabomba caroliniana*) regained dominance in a portion of the drawdown zone. Observations outside the surveyed points by ARC and lake users made note of a general increase in plant growth. Watershield (*Brasenia schreberi*) was more prevalent in many areas outside the measurement points. Measurable changes in phosphorus concentrations were not observed in 2014.

Given the observed increase in plant abundance and concerns by residents that plant density will continue to increase in absence of a drawdown, the Conservation Commission permitted a 5.5 foot winter water level drawdown in 2014 - 2015. This report summarizes data collected in 2015 and provides a comparison to data over the last five years, with emphasis on the comparison between the 2014 and 2015.

In-Lake Sampling

Dry weather in-lake sampling was conducted on May 5, June 10 and July 19, 2015. ARC used the same sampling methods as prior surveys for data collection consistency (see prior reports for methodology). In-situ water depth profile measurements of temperature, dissolved oxygen (DO), pH and specific conductivity were recorded at two locations: shallow south basin BHP-1 and the deep hole in the north basin BHP-2. These data are presented in Table 2. Figure 1 provides a graphical representation of temperature and DO data for the deep station (BHP-2).

The temperature and DO profiles suggest that the lake began to thermally stratify in May and was weakly stratified by July. Concentrations of DO in May were consistent throughout the water column until a depth of 10 feet and showed a slow decline with increased depth. DO dropped substantially after 12 feet in June and 10 feet in July. Concentrations were below the desirable level for fish [5 - 6 milligrams-per-liter (mg/L)] at and below 12 feet in July. These data are consistent over the last five years (Figure 2) but conditions are less than ideal. The lake exhibits a rapid decline in oxygen during the summer.

Depletion starts above the thermocline. Much of the cold water fish refuge is undesirable given the lack of oxygen. These data suggest that the lake has a substantial oxygen demand and is susceptible to accumulation of phosphorus in the hypolimnion from internal recycling.

The surface pH level is neutral to slightly basic at the surface and becomes more acidic with water depth. Specific conductivity is generally within a desirable range (<200 us/cm), with slightly elevated numbers in July; values above 200 us/cm can be indicative of elevated dissolved pollutants and high productivity. It is common to have increased conductivity near the water-sediment interface where suspended solids increase conductivity. Surface and mid depth values were comparable between the two stations.

Table 2. Bare Hill Pond Water Depth Profiles 2015

BHP-1								
May 5, 2015			June 10, 2015			July 19, 2015		
Depth (ft)	Temp (C)	DO (mg/L)	Depth (ft)	Temp (C)	DO (mg/L)	Depth (ft)	Temp (C)	DO (mg/L)
0	18.2	8.77	0	22.15	9.07	0	26.58	7.27
1	18.23	8.71	1	22.83	9.02	1	27.04	7.40
2	18.22	8.69	2	21.50	9.38	2	26.39	7.46
3	18.21	8.75	3	20.41	9.48	3	26.15	7.51
4	18.16	8.81	4	20.3	9.46	4	26.12	7.52
5	17.58	9.48	5	20.3	9.52	4.7	26.10	7.56
BHP-2								
Depth (ft)	Temp (C)	DO (mg/L)	Depth (ft)	Temp (C)	DO (mg/L)	Depth (ft)	Temp (C)	DO (mg/L)
0	17.7	9.1	0	22.64	9.15	0	26.82	7.96
2	17.06	9.07	2	22.63	9.16	2	26.81	7.94
4	16.22	9.22	4	22.51	9.16	4	26.80	7.89
6	14.76	9.32	6	22.19	9.19	6	26.53	7.95
8	14.32	9.12	8	20.61	9.37	8	26.19	7.71
10	13.15	9.16	10	20.43	9.29	10	25.33	7.70
12	12.24	8.15	12	20.13	9.04	12	24.37	5.24
14	11.88	7.20	14	18.18	7.15	14	21.17	1.34
16	11.51	6.67	16	15.45	3.37	16	18.37	0.62
18	11.09	5.84	18	13.60	1.01	18	16.13	0.37
20	10.74	4.71	20	11.31	0.40	20	12.06	0.16
22	10.31	3.17	22	10.47	0.26	22	10.99	0.12
24	10.12	2.33	23	10.23	0.23	23	10.92	0.12

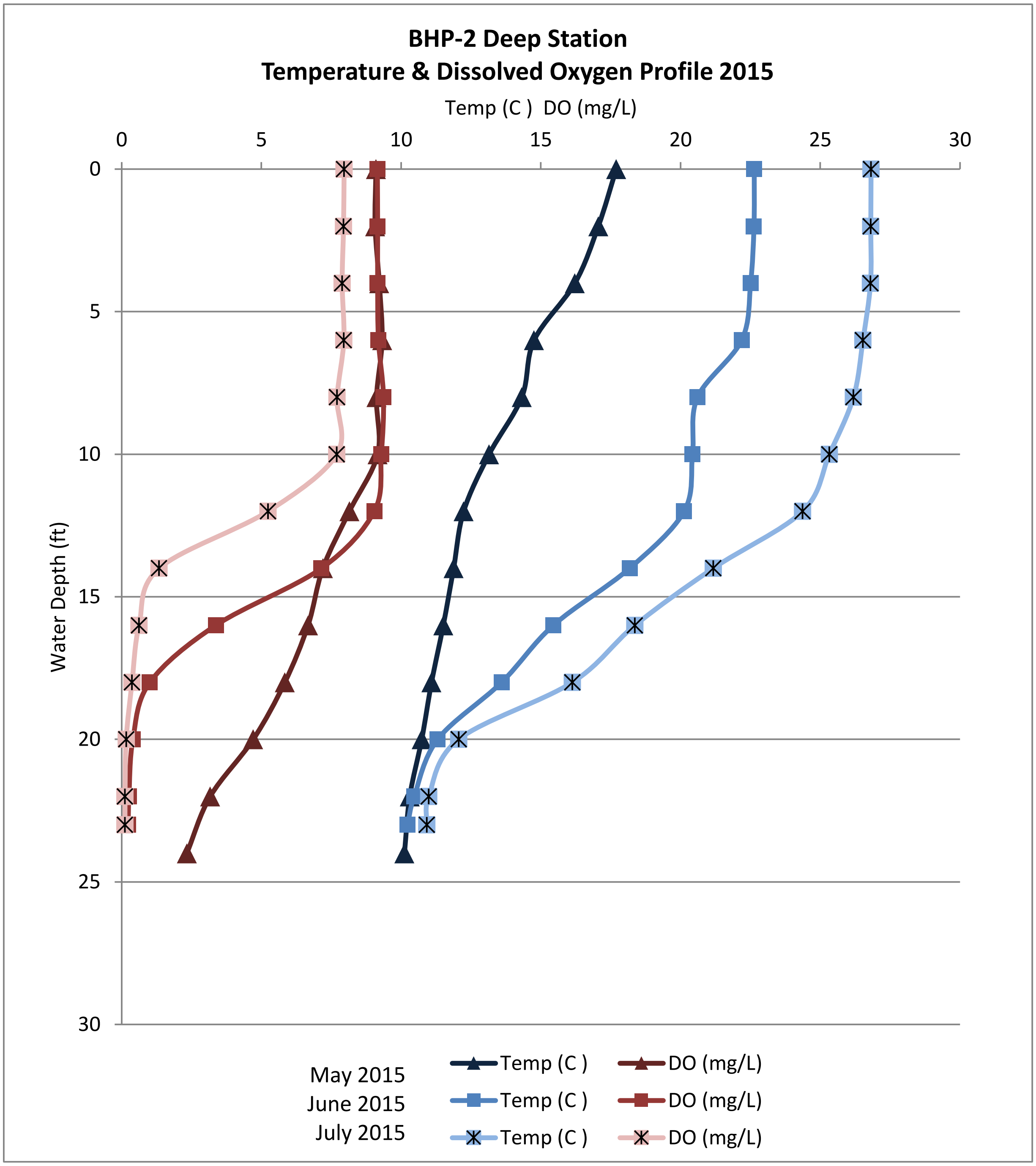
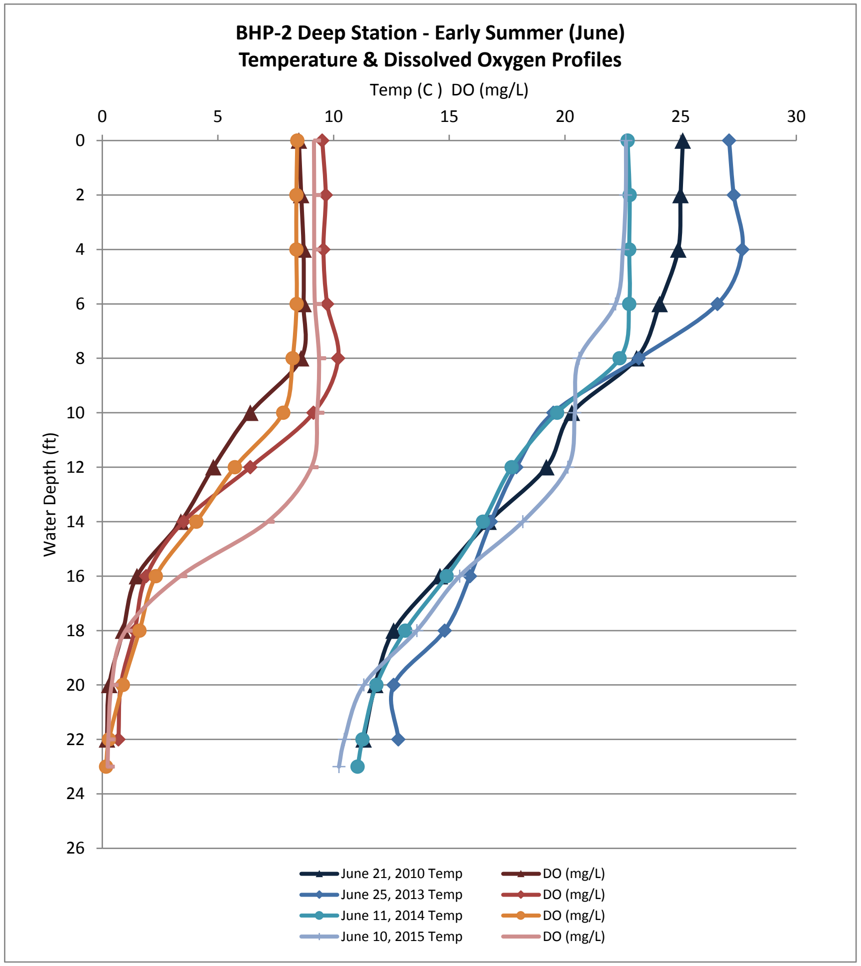


Figure 1. 2015 Temperature and Dissolved Oxygen Profiles.



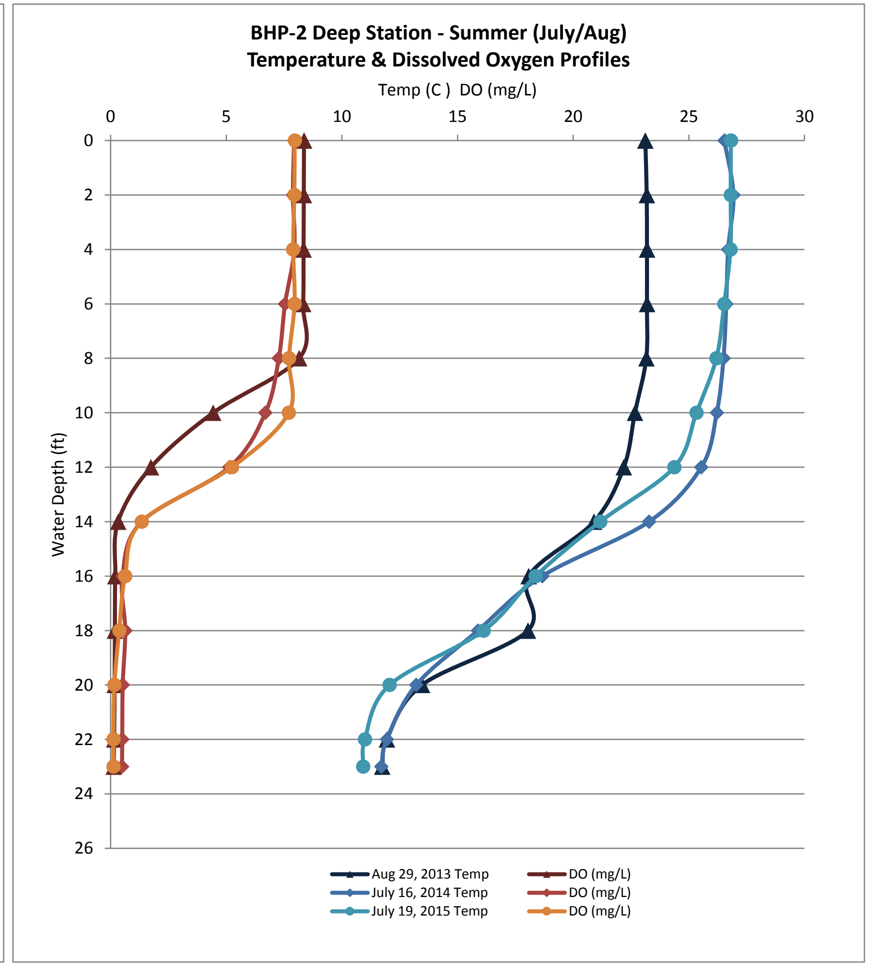


Figure 2. Temperature & Dissolved Oxygen Profiles at BHP-2 for 2010-2015

Table 3 provides phosphorus, total suspended solids and water clarity (measured by Secchi disk transparency) values during the surveys. Surface total phosphorus (TP) concentrations were variable and generally higher than the past couple years. TP ranged from 0.015 mg/L (low) to 0.216 mg/L (extreme). The extreme value occurred in June at the deep station (BHP-2). The southern cove had elevated phosphorus, but was not extreme (0.038mg/L). Even when removing the extreme value as an outlier, average surface TP in 2015 is elevated (0.033 mg/L) and is the highest surface average since 2007. Bottom TP was higher than 2014. Dissolved phosphorus, also higher in 2015, shows an interesting pattern starting in 2014. DP was less than detection in May and June of 2014 and gradually increased over time until about June 2015 when it started to decline (Figure 3). It is probable that the higher dissolved phosphorus is related to decomposition of additional plant matter observed in 2014. The observed difference could also be related to the abnormal winter of 2014 - 2015 when we experienced record setting snowfall and cold temperatures.

Secchi disk transparency in 2015 ranged from 6.3 to 9.0 feet, with increasing clarity over time. Values were comparable to 2014 (Figure 4).

Quality Control - Sample Precision and Detection of Change

Precision is the degree of similarity of two or more subsamples (replicate or duplicate samples) and is used as measure of agreement among measurements and variability. Poor precision can indicate inconsistent field techniques and/or laboratory analysis. This measurement may also include natural variability depending on how the two samples were collected, whether they are spilt samples (dividing one sample into two bottles) or replicates (collecting consecutive water samples). Precision is calculated by taking the difference between the two samples and dividing the absolute difference by the average of the two samples and multiplying by 100 to yield a percentage. The result is called the relative percent difference (RPD)

The process of sample collection and analysis can introduce variability in the sample. Although one sample is collected and split into two clean bottles for duplicates, microscopic particles in the sample may not separate evenly between the two bottles. Additionally, the process at the laboratory can introduce a small amount of phosphorus. This is even more likely when analyzing dissolved phosphorus due to the extra step of filtering.

Phosphorus values measured at Bare Hill Pond are generally very low and are close to the method detection limit (MDL), which is typically 0.01 mg/L. Precision decreases rapidly the closer the measurement is to the MDL. Ideally samples should be five times the value of the MDL in order to calculate an accurate RPD. Bare Hill Pond samples are much lower than five times this value therefore the RPD could be unnecessarily inflated. Samples with RPD values above 25% should be viewed with caution.

Over the years, scientist have collected three in-lake duplicate samples since 2004 (additional watershed duplicates were evaluated but not discussed here). The absolute difference between these paired samples ranged from 0.002 and 0.007 mg/L, with RPD ranging from 19 to 25%. Any given sample should be viewed as if the actual value could be 25% higher or lower than its reported value. Figure 5 presents BHP-2 surface total phosphorus samples with 25% of the reported value represented as a bar around the sample. Samples where the bar does not overlap others are likely a true difference. Other differences could be explained by sampling and laboratory variability.

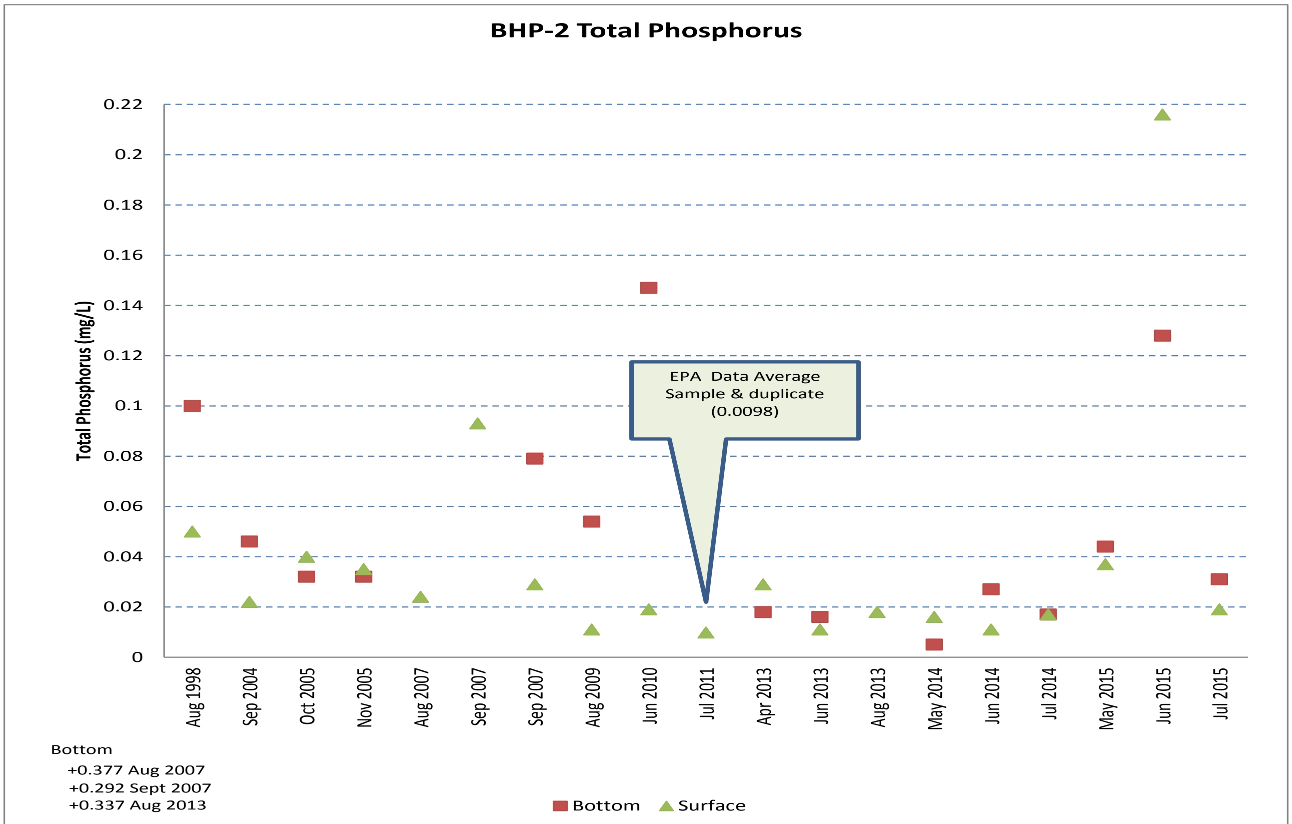
Table 3. Bare Hill Pond In-lake Water Quality Data.

Station	Date	Time	TP (mg/L)	DP (mg/L)	TSS (mg/L)	Secchi (ft)
2S	9/16/2004	11:01	0.022	0.016		12
2B	9/16/2004	11:04	0.046	0.014		
1S	9/16/2004	8:59	0.022	0.022		
1B	9/16/2004	9:01	0.022	0.022		
2S	10/4/2005	12:50	0.040	0.019		10.8
2B	10/4/2005	13:11	0.032	0.022		
1S	10/4/2005	12:25	0.027	0.019		8.7 (bottom)
1B	10/4/2005	12:29	0.032	0.022		
2S	11/3/2005	12:50	0.035	0.029		11
2B	11/3/2005	13:06	0.032	0.024		
1S - Duplicate	11/3/2005	11:25	0.024	0.024		
1S	11/3/2005	11:25	0.029	0.024		
1B	11/3/2005	11:29	0.051	0.024		
BHP-BK	8/28/2007	9:30	<0.010	<0.010		
BHP-2S	8/28/2007	13:14	0.024	0.015		6.5
BHP-2B	8/28/2007	13:15	0.377	0.259		
BHP-1S-DUP	8/28/2007	12:11	0.024	<0.010		
BHP-1S	8/28/2007	12:10	0.031	0.01		4.5 (bottom)
BHP-1B	8/28/2007	12:12	0.039	0.016		
BHP-2S	9/7/2007	14:01	0.093	0.074		5.8
BHP-2B	9/7/2007	14:02	0.292	0.197		
BHP-1S	9/7/2007	13:10	0.091	0.086		4.5 (bottom)
BHP-1B	9/7/2007	13:11	0.092	0.069		
BHP-2S	9/20/2007	9:30	0.029	<0.010		6.5
BHP-2B	9/20/2007	9:32	0.079	0.037		
BHP-1S	9/20/2007	9:10	0.037	0.018		4.8 (bottom)
BHP-1B	9/20/2007	9:11	0.037	<0.010		
2S	8/30/2009	15:15	0.011	NA	<5	
2B	8/30/2009	15:00	0.054	NA	51	
2S	6/21/2010	19:15	0.019	0.015	1	11.8
2B	6/21/2010	19:15	0.147	0.047	14	
1S	6/21/2010	18:48	0.022	0.015	0.5	11.5
BH01 (EPA; close to BHP-1S)	7/19/2011	14:29	0.007			
BHP02 (EPA)	7/19/2011	14:48	0.0056			
BHP03 (EPA; close to BHP-2S)	7/19/2011	15:06	0.0086			
BHP030 (EPA; Dup of BHP03)	7/19/2011	15:06	0.011			
BHP04 (EPA)	7/19/2011	15:15	0.012			

Table 3. Bare Hill Pond In-lake Water Quality Data (continued).

Station	Date	Time	TP (mg/L)	DP (mg/L)	TSS (mg/L)	Secchi (ft)
BHP-2S	4/17/2013	17:30	0.029	<0.01	<5	7
BHP-2B	4/17/2013	17:20	0.018	<0.02	<5	
BHP-1S	4/27/2013	17:55	0.020	<0.02	<5	4.5 (bottom)
BHP-2S	6/25/2013	18:15	0.011	0.013	<5	7
BHP-2B	6/25/2013	18:20	0.016	0.02	<5	
BHP-1S	6/25/2013	18:45	0.013	0.014	<5	4.5 (bottom)
BHP-2S	8/29/2013	17:50	0.018	0.021	<5	6.5
BHP-2B	8/29/2013	18:10	0.337	0.225	21	
BHP-1S	8/29/2013	18:25	0.012	0.016	<5	4.5 (bottom)
BHP-2S	5/21/2014	18:55	0.016	0.005	<5	6
BHP-2B	5/21/2014	19:00	0.005	0.005	<5	
BHP-1S	5/21/2014	19:05	0.012	0.005	<5	5.5
BHP-2S	6/11/2014	18:00	0.011	<0.010	<5	9.5
BHP-2B	6/11/2014	18:05	0.027	<0.010	10	
BHP-1S	6/11/2014	17:40	0.031	<0.010	<5	4.5 (bottom)
BHP-2S	7/16/2014	17:40	0.017	0.015	<5	6.5
BHP-2B	7/16/2014	18:13	0.017	0.017	18	
BHP-1S	7/16/2014	18:30	<0.010	<0.010	<5	5 (bottom)
BHP-2S	5/5/2015	18:05	0.037	0.034	<5	6.3
BHP-2B	5/5/2015	18:10	0.044	0.027	<5	
BHP-1S	5/5/2015	18:25	0.056	0.026	<5	5.5 (bottom)
BHP-2S	6/10/2015	18:40	0.216	0.028	<5	8.5
BHP-2B	6/10/2015	18:42	0.128	0.038	10	
BHP-1S	6/10/2015	19:00	0.038	0.036	<5	5.5 (bottom)
BHP-2S	7/19/2015	19:08	0.019	0.016	<5	9
BHP-2B	7/19/2015	19:10	0.031	0.031	<5	
BHP-1S	7/19/2015	19:15	0.015	0.014	6	4.5 (bottom)

TSS = Total Suspended Solids
NA = not available, problem with laboratory analysis
"Bottom" indicates the Secchi disk reached the pond bottom



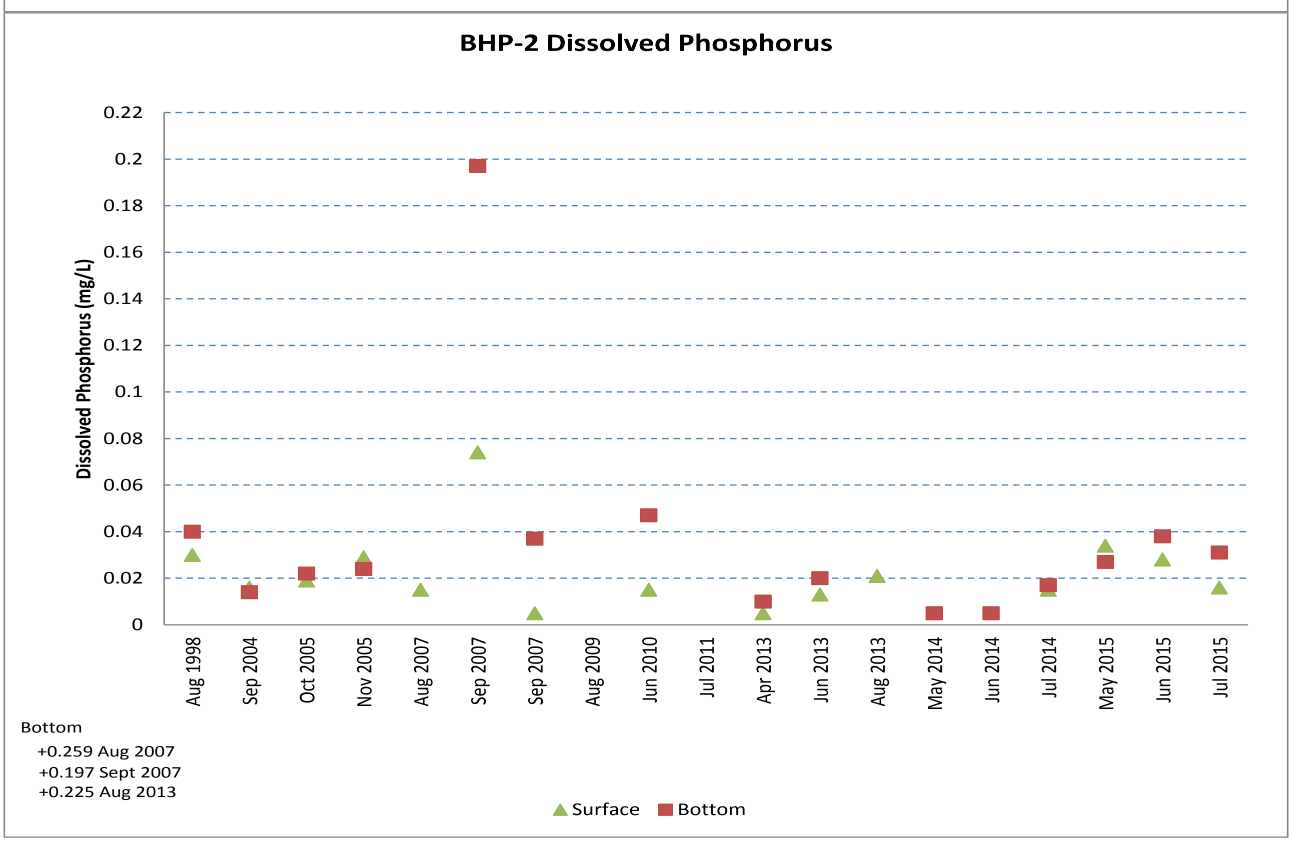


Figure 3. BHP-2 Total and Dissolved Phosphorus Concentrations.

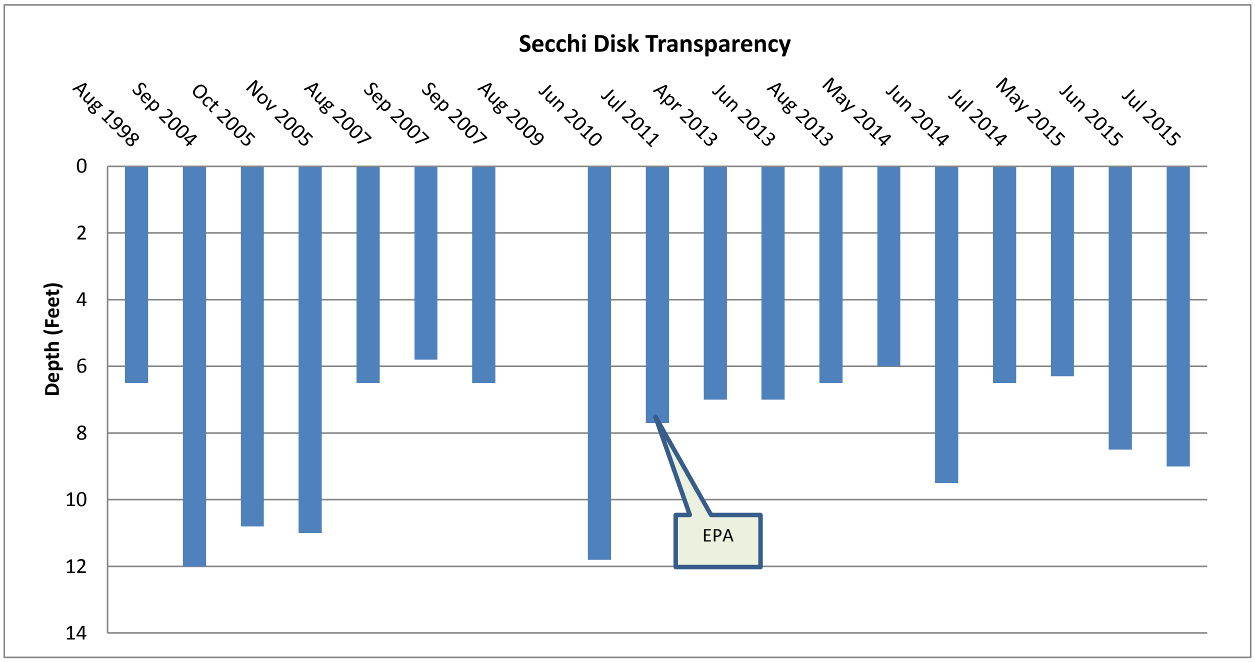


Figure 4. Bare Hill Pond (BHP-2) Secchi Disk Transparency.

Several dissolved phosphorus results were reported by the laboratory higher than total phosphorus. Theoretically this cannot occur, as dissolved phosphorus is a portion of the total phosphorus in the sample. However as discussed above, the variability between samples could account for this reporting difference. The absolute difference between the total and dissolved phosphorus in samples when DP is greater than TP ranged from 1 to 4 ppb (0.001 to 0.004 mg/L). Variability is expected to be higher within the DP samples given that concentrations are even lower, and closer to the MDL and the extra step during analysis. The laboratory reported an analytical RPD for DP of 22% for the August 2013 sampling, which had the largest difference between total and dissolved values.

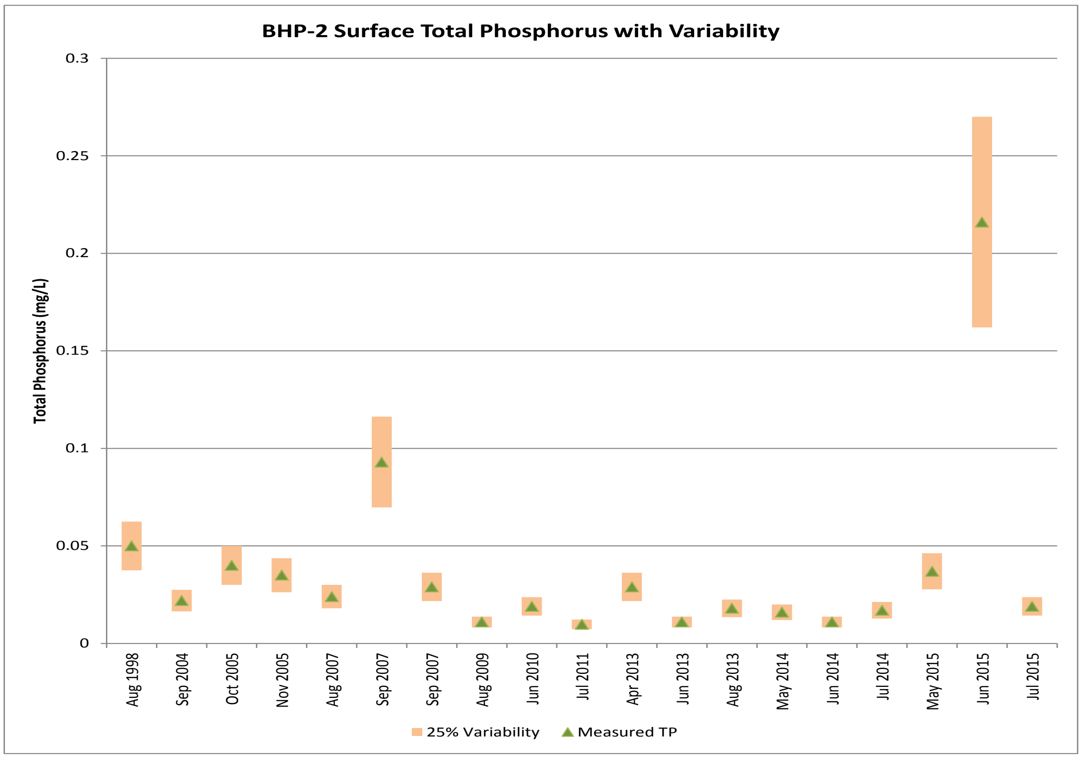


Figure 5. Bare Hill Pond (BHP-2) Surface Total Phosphorus and Variability.

In-lake Plant Survey

ARC conducted a plant survey on August 16, 2015. We used the same methods employed during the previous surveys conducted in 1998, 2001, 2004, 2007, 2010, 2013 and 2014. ARC mapped pond aquatic vegetation along the five transects (A through E) established in 1998. Each transect was divided into a series of observation points and were located using Global Positioning System (GPS). A total of 52 points were assessed during the survey.

The plant survey focused on macroscopic fully submerged (e.g., milfoil), floating-leaved (e.g., pond lily), and/or free floating plants (e.g., duckweed). At each transect point, we recorded the percent cover of all plants, the percent biovolume (as measured by the amount of the water column filled with plants) using a semi-quantitative (0-5) ranking system. A rank of 0 represented 0% cover/biovolume. A rank of 1 corresponded to 1 - 25% cover/biovolume; 2 = 26 - 50%; 3 =

51 - 75%; 4 = 76 - 99; and 5 = 100%. Species observed in each transect were identified and assigned a percent of composition of all species present. Water depth was also recorded at each transect point. These data are presented in Table 4.

Just over half the observed points remained unchanged in terms of cover (52%) and biovolume (54%) in 2015 from 2014. Of the points that changed, increased cover was observed at 35% of the sample locations and 29% of the locations had increased biovolume (Table 5). Only 13% and 17% of cover and biovolume points decreased in 2015. However, using only data with five feet or less in water depth (drawdown effective zone), cover decreased at 28% of the observation locations (increased at 16% and stayed the same at 56%) and biovolume decreased at 36% of the locations (increased at 16% and stayed the same at 48%). Most changes in biovolume were one rank (except one location that decreased by 2 ranks) and may not represent a statistically significant change. Generally a shift by two or more ranks (e.g. change from rank 1 to 3) is required before statistical significance is reportable.

The general appearance of the pond showed substantially less growth than in 2014. This observation is supported by the frequency data and general observations outside the survey points. Watershield and fanwort were encountered less frequently at the sampling locations in 2015. Observation outside the sample locations also suggest that watershield was less abundant overall and that fanwort and variable milfoil (*Myriophyllum heterophyllum*) topping out at the surface was less apparent. There was a shift in species dominance from 2014 to 2015, similar to the first few years of the extended drawdown. Macro algae was more abundant in 2015. This non-vascular plant is low growing and forms a carpet on the bottom. While this shift may not result in a decrease in plant cover, it will reduce plant biovolume if widespread. This is the same pattern that was observed in the prior drawdown years where low growing species, such as macro algae and naiads (*Najas spp.*), replaced fanwort and milfoil in the drawdown zone.

Figures 6 and 7 provide a transect point summary for plant cover and biovolume for the 2015 data. Figures 8 through 10 provide a graphical representation of survey water depth, plant cover and biovolume for survey years since 2010. Figure 11 illustrates the most frequently encountered species data since 2010.

Conclusion

While 2014 point data was not deterministic, 2015 data showed a difference from 2014 in the drawdown zone. There was a reduction in watershield and fanwort in 2015, two species of common complaint for recreation. There was an increase in low growing species which is consistent with other years following drawdown. The increase in phosphorus concentrations is concerning. However, sampling results in July 2015 and general trend this year seemed to indicate that concentrations were declining. This could be the result of the abnormal weather or decomposition of plant biomass from the 2014 growing season, when there was a perceived increase in plant density due to a lack of winter drawdown in 2013 - 2014. Continuing the in-lake water quality sampling program is recommended. I also recommend adding points in the vicinity of transect A, B and D, where we have documented the greatest change associated with the drawdown. Additional sampling locations will increase the likelihood of detecting change at observation points. It is likely that we would have detected the increase in biovolume in 2014 if additional points were sampled and would have corroborated the general observations made during the survey and those by residents.

Table 4. Bare Hill Pond Macrophyte Survey Data 2015.

Point	Water Depth (ft)	Cover	Bio -vol	Bs	Cc	Cd	Ec	FG	Iso	Mh	Macro	Nf	Nm	No	Nv	Pa	Pc	P rob	P spir	Spa	Usp	Va
A-1	3	1	1											100								
A-2	3	2	1	90																	10	
A-3	4	3	2	30						10					60							
A-4	3.7	2	1	90																	10	
A-5	4	2	1	80										10							10	
A-6	4.3	1	1							10	5			85								
A-7	5.2	4	1								60										40	
A-8	6	1	1			100																
A-9	8.3	2	1			50		50														
A-10	9.6	2	1					100														
A-11	11.4	1	1					90										10				
A-12	13.1	0	0																			
A-13	6.1	1	1						100													
B-1	4.5	5	2	10							50		30									10
B-2	4.5	5	1								30			40								30
B-3	4.5	5	1								90			10								
B-4	4.8	5	1								90				5							5
B-5	4.5	5	1								70			20								10
B-6	4.5	5	1								80				5							15
B-7	4	5	2								80			10								10
B-8	3	3	1								45			15	5							35
B-9	4.5	5	1	20							40										20	20
B-10	2.9	5	2								60											40

Table 4. Bare Hill Pond Macrophyte Survey Data 2015 (continued).

Point	Water Depth (ft)	Cover	Bio -vol	Bs	Cc	Cd	Ec	FG	Iso	Mh	Macro	Nf	Nm	No	Nv	Pa	Pc	P rob	P spir	Spa	Usp	Va
C-1	5.8	5	2		40	1				30								27	1		1	
C-2	8	5	2		70					20								10				
C-3	9	5	3		20					70								10				
C-4	10.5	4	2		60					40												
C-5	12	1	1		100																	
C-6	12.5	3	2		100																	
C-7	12.5	1	1		100																	
C-8	6.3	4	1		10					20								10				60
D-1	4	5	2		20				5		40		5	30								
D-2	4.5	5	2								60			40								
D-3	4.5	5	1								100											
D-4	4.3	5	1	20							80											
D-5	4.3	5	1	20					10		70											
D-6	4.3	5	1	10							90											
D-7	4.5	5	1						20		60			10								10
D-8	4.4	5	1								100											
D-9	5.5	5	1								100											
D-10	5.5	5	1								100											
D-11	5.5	5	1		20						80											
D-12	7	5	2		15					20						5		60				
D-13	9	4	2		70					20								10				

Table 4. Bare Hill Pond Macrophyte Survey Data 2015 (continued).

Point	Water Depth (ft)	Cover	Bio -vol	Bs	Cc	Cd	Ec	FG	Iso	Mh	Macro	Nf	Nm	No	Nv	Pa	Pc	P rob	P spir	Spa	Usp	Va
E-1	4.3	5	1								70							5				25
E-2	5.1	5	1								90											10
E-3	6	5	2		25		1		5	10	50							10				
E-4	6.5	5	2		40		1			10	30		5			5		10				
E-5	7.5	5	3				1			40	30					25		5				
E-6	8.3	5	3							80						20						
E-7	9	4	2		40					60												
E-8	10	4	2		30					70												
Frequency of Occurrence				9	16	3	3	3	5	15	28	0	3	11	4	4	0	11	1	0	6	13

Legend:

FG – filamentous algae

Bs – *Brasenia schreberi* (watershield)

Cc – *Cabomba caroliniana* (fanwort)

Cd - *Ceratophyllum demersum* (coontail)

Ec – Elodea canadensis (waterweed)

Iso – *Isoetes* (quillwort)

Mh – *Myriophyllum heterophyllum* (variable-leaf milfoil)

Macro – Chara (macro algae)

Nf – *Najas flexilis* (slender naiad)

Nm - *Najas minor* (waternymph)

No – *Nymphaea odorata* (white-flower waterlily)

Nv – *Nuphar variegata* (yellow-flower waterlily)

Pc - *Potamogeton crispus* (curly-leaf pondweed)

Pspir - *Potamogeton spirillus* (spiral pondweed)

Psp – *Potamogeton* spp. (pondweeds)

Prob – *Potamogeton robbinsii* (Robbins pondweed)

Spa – Sparganium sp. *(bur-reed)*

Usp – *Utricularia* spp. (bladderwort)

Va - *Vallisneria americana* (tapegrass)

Table 5. Bare Hill Pond Macrophyte Cover, Biovolume Change in the Drawdown Zone (<5;).

		Cover					Biomass				
	Water Depth	2015	2014	2013	14 vs 13	15 vs 14	2015	2014	2013	14 vs 13	15 vs 14
A - 1	3	1	5	5	0	(4)	1	2	2	0	(1)
A - 2	3	2	5	5	0	(3)	1	2	2	0	(1)
A - 3	4	3	5	5	0	(2)	2	1	2	(1)	1
A - 4	3.7	2	5	5	0	(3)	1	3	2	1	(2)
A - 5	4	2	5	3	2	(3)	1	1	1	0	0
A - 6	4.3	1	5	3	2	(4)	1	1	1	0	0
B - 1	4.5	5	3	2	1	2	2	1	1	0	1
B - 2	4.5	5	5	5	0	0	1	2	1	1	(1)
B - 3	4.5	5	5	5	0	0	1	2	1	1	(1)
B - 4	4.8	5	5	5	0	0	1	1	1	0	0
B - 5	4.5	5	5	5	0	0	1	2	2	0	(1)
B - 6	4.5	5	5	5	0	0	1	1	1	0	0
B - 7	4	5	5	5	0	0	2	1	1	0	1
B - 8	3	3	5	5	0	(2)	1	1	1	0	0
B - 9	4.5	5	4	5	(1)	1	1	1	2	(1)	0
B - 10	2.9	5	5	5	0	0	2	1	2	(1)	1
D - 1	4	5	5	4	1	0	2	2	1	1	0
D - 2	4.5	5	5	5	0	0	2	2	1	1	0
D - 3	4.5	5	5	5	0	0	1	2	1	1	(1)
D - 4	4.3	5	5	5	0	0	1	2	1	1	(1)
D - 5	4.3	5	5	5	0	0	1	1	1	0	0
D - 6	4.3	5	5	5	0	0	1	1	1	0	0
D - 7	4.5	5	5	4	1	0	1	1	1	0	0
D - 8	4.4	5	3	5	(2)	2	1	1	1	0	0
E - 1	4.3	5	3	5	(2)	2	1	2	1	1	(1)
					14 vs 13	15 vs 14				14 vs 13	15 vs 14
	Number of Sample Locations Higher				5	4				8	4
	Percent Locations Higher				20%	16%				32%	16%
	Number of Sample Locations Lower				3	7				3	9
	Percent Locations Lower				12%	28%				12%	36%
	Unchanged					56%					48%
	Total Locations <5' Water Depth				25						

(#) Green numbers with parentheses and shading indicate a decrease in rank

\# Red numbers with shading indicate an increase in rank

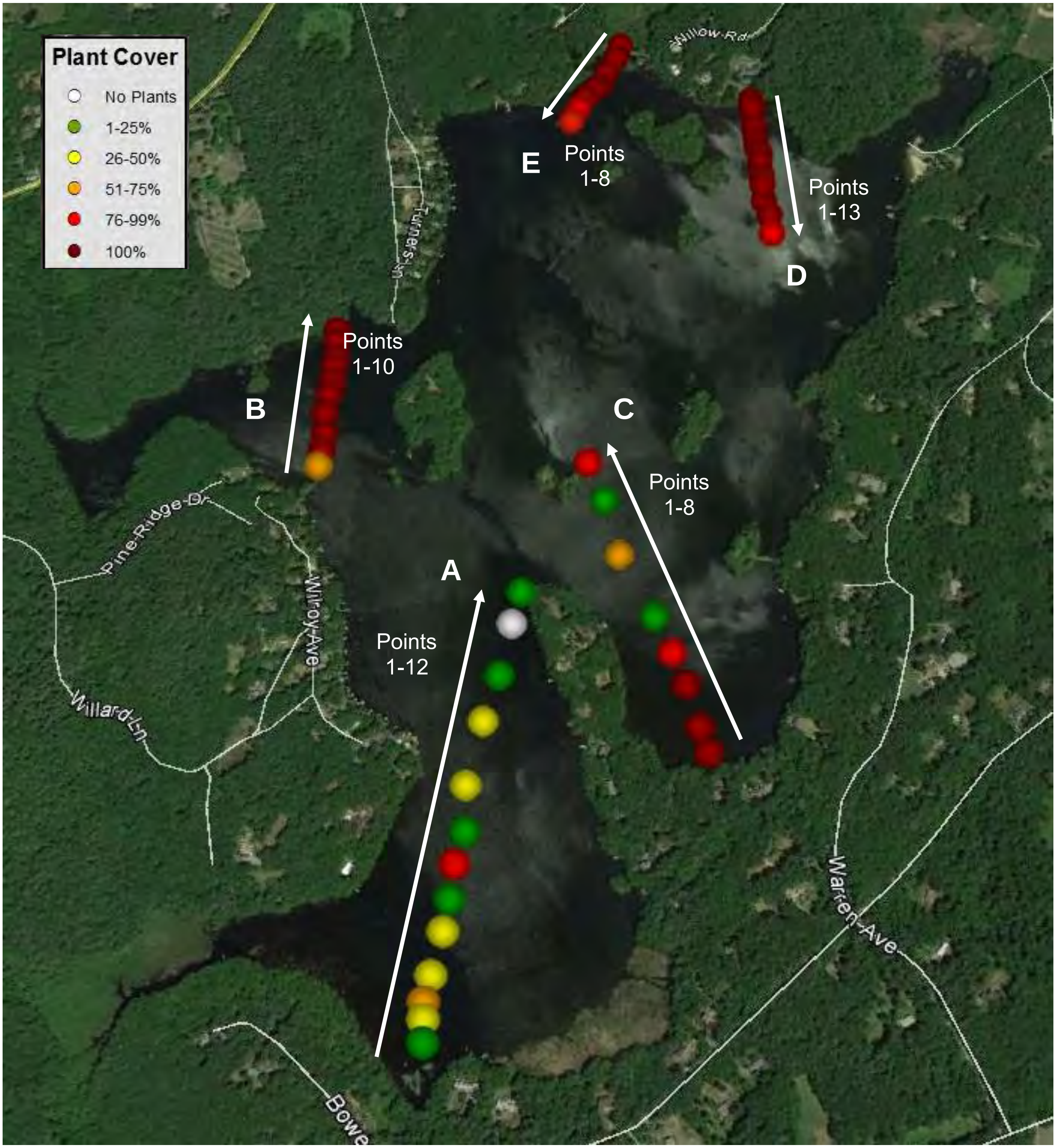


Figure 6. Bare Hill Pond 2015 Macrophyte Cover.

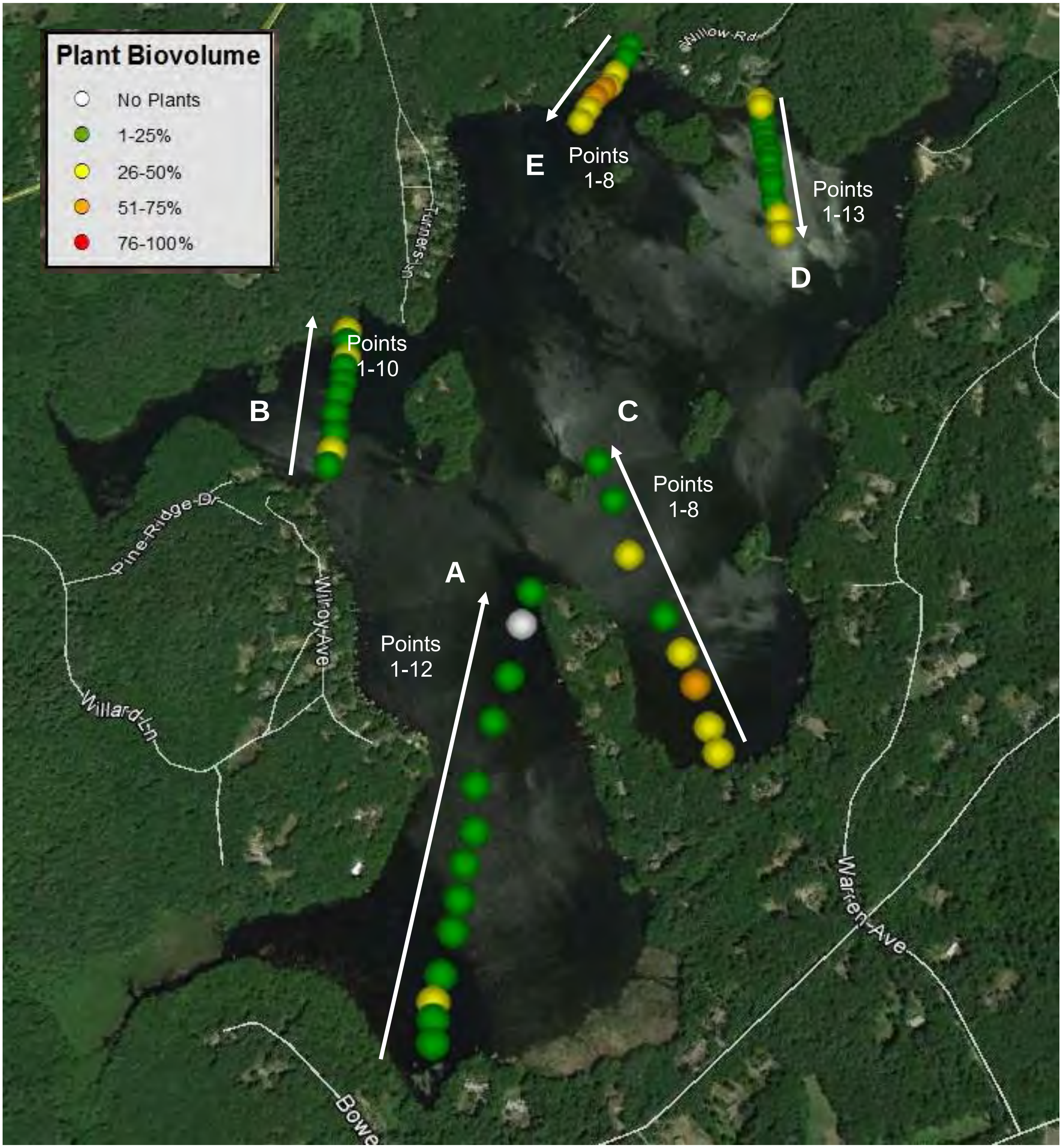


Figure 7. Bare Hill Pond 2015 Macrophyte Biovolume.

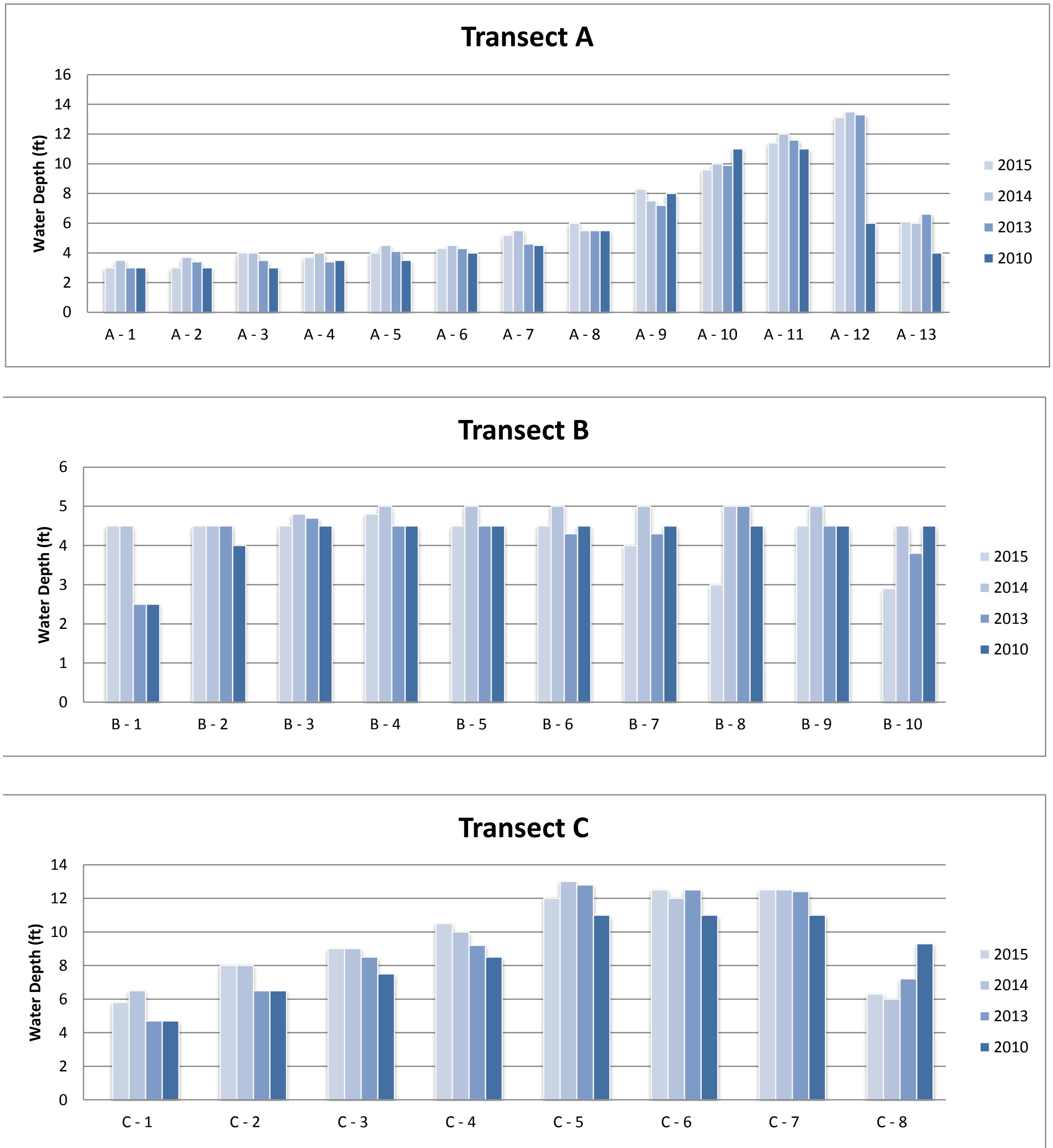
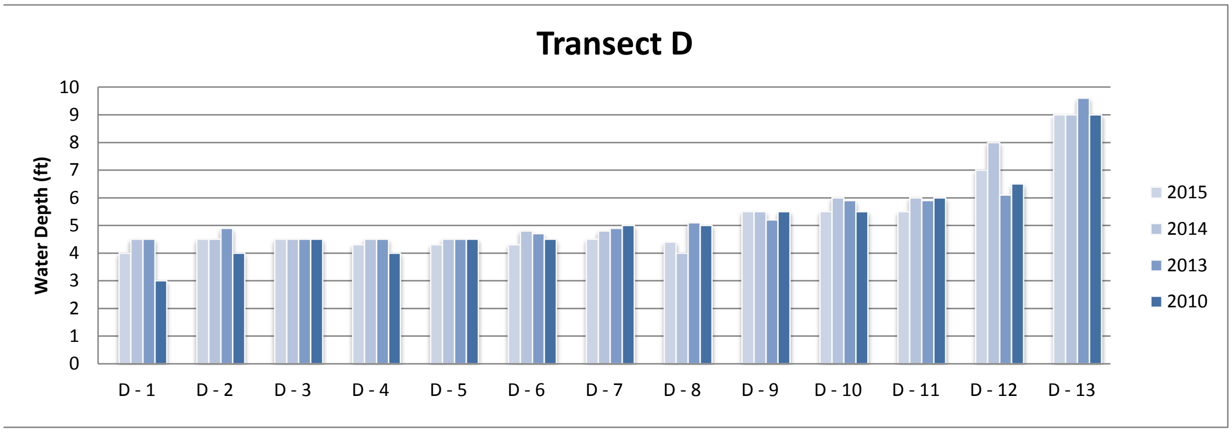


Figure 8. Bare Hill Pond Water Depth.



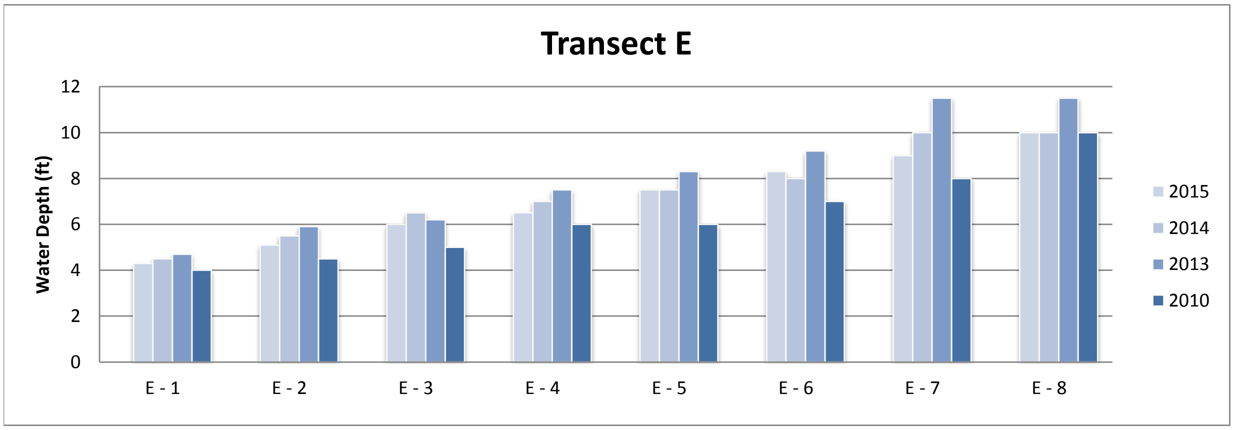


Figure 8. Bare Hill Pond Water Depth (continued)

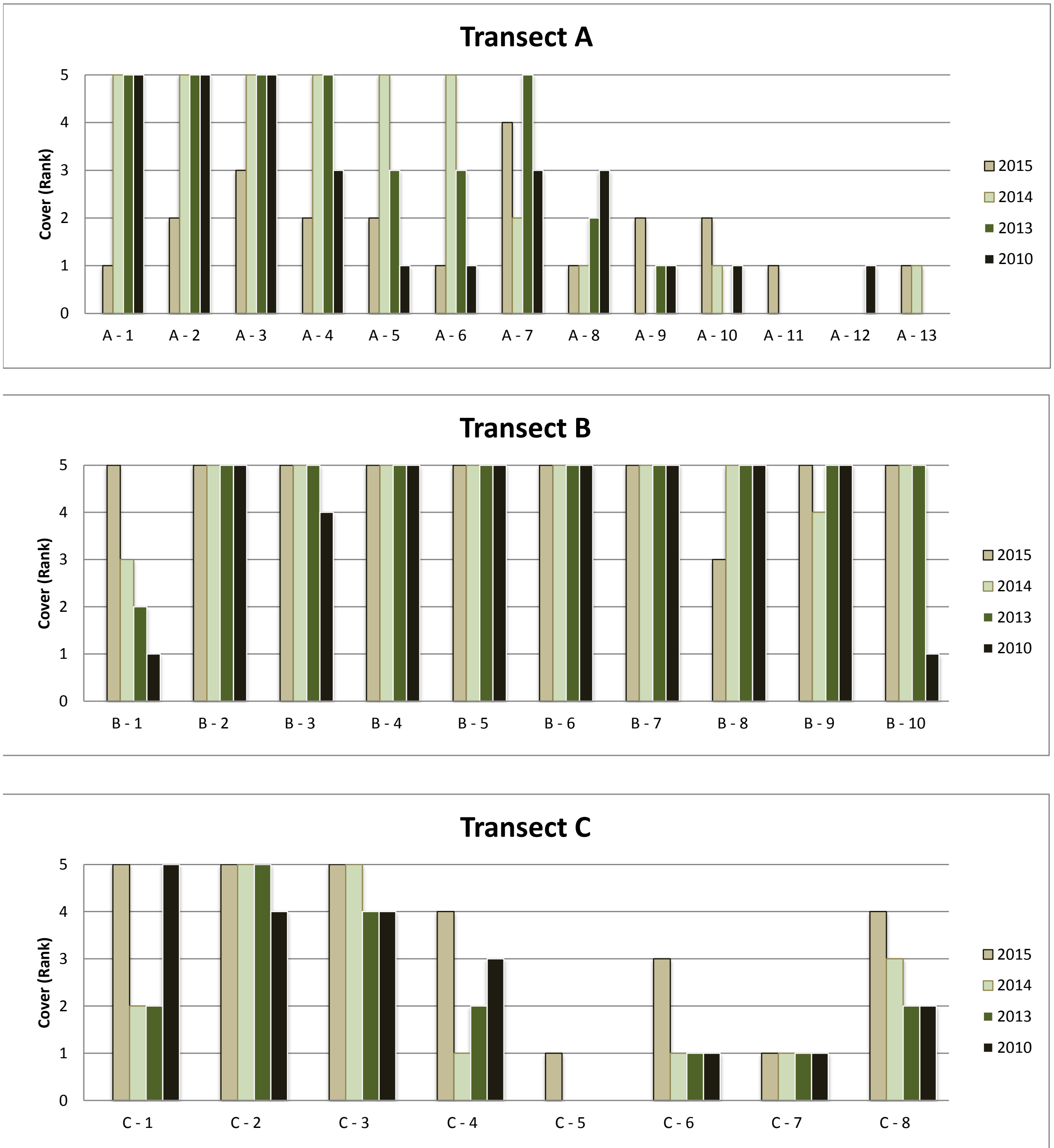
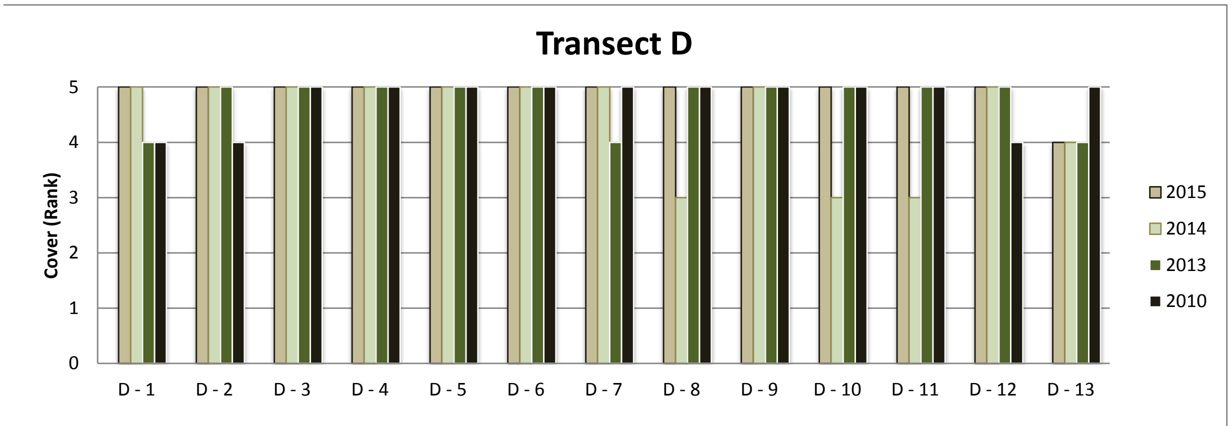


Figure 9. Bare Hill Pond Macrophyte Cover.



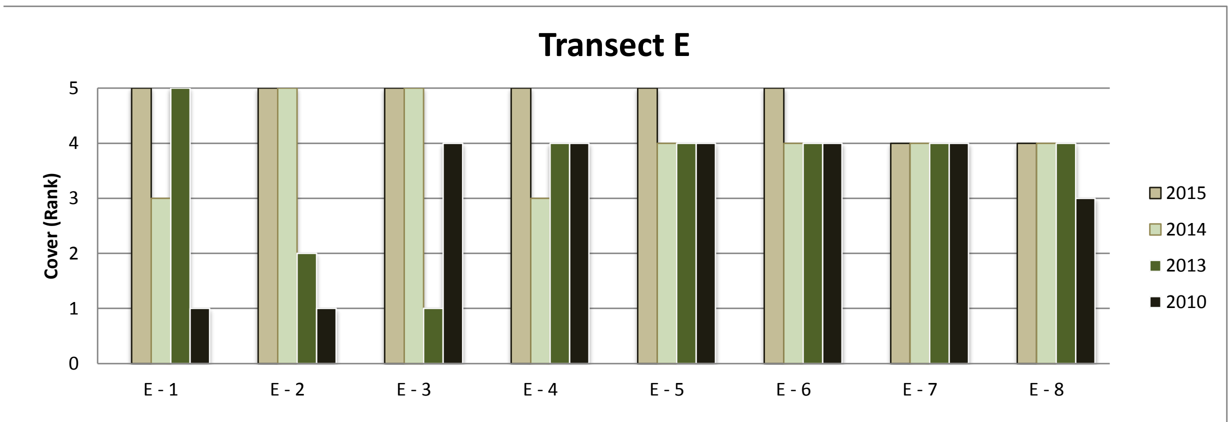


Figure 9. Bare Hill Pond Macrophyte Cover (continued).

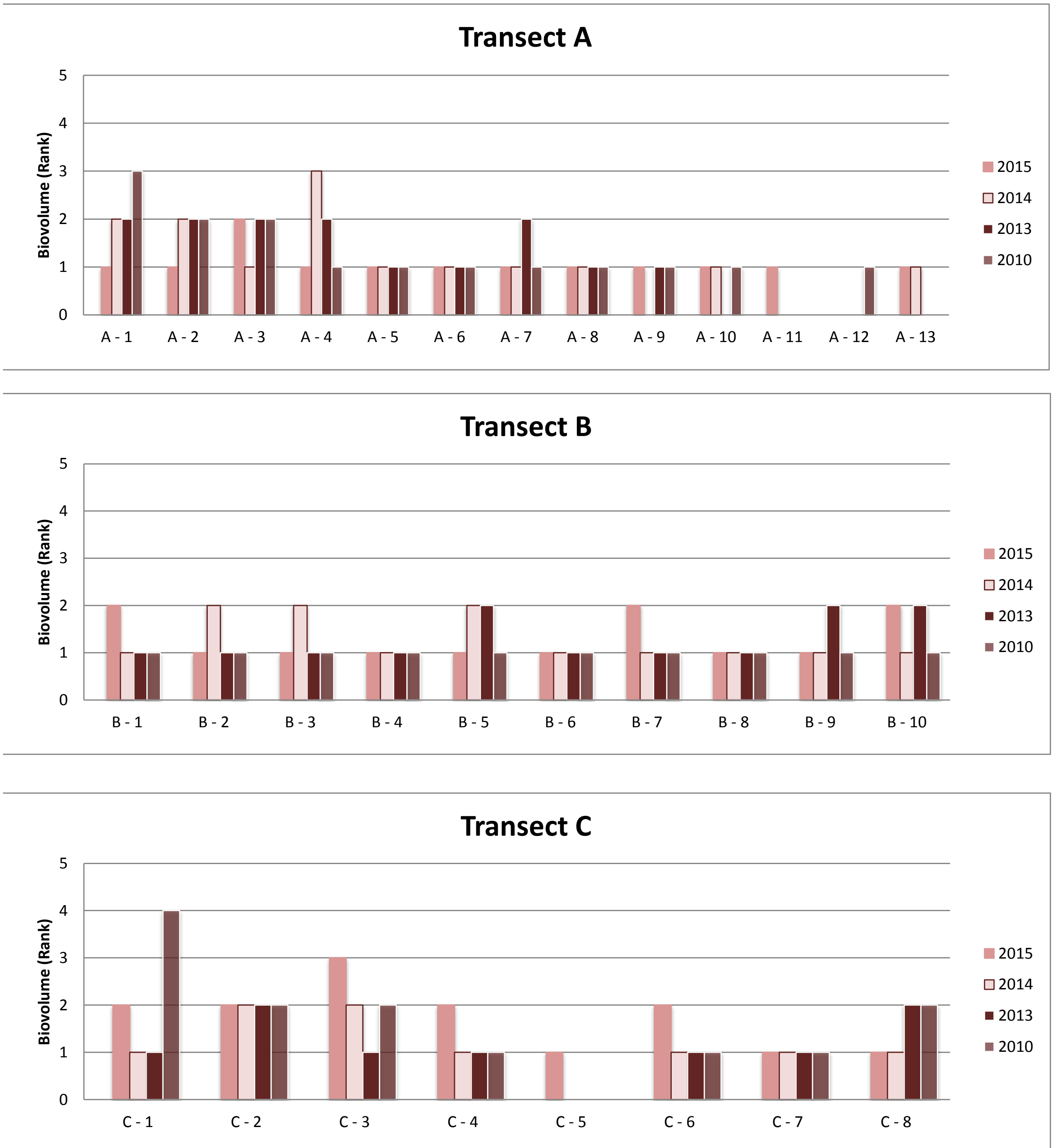
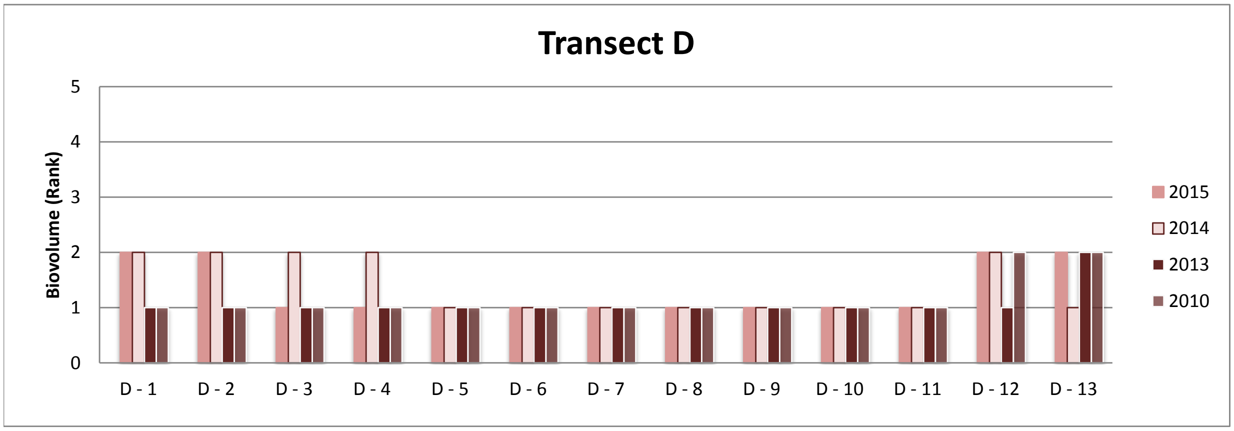


Figure 10. Bare Hill Pond Macrophyte Biovolume.



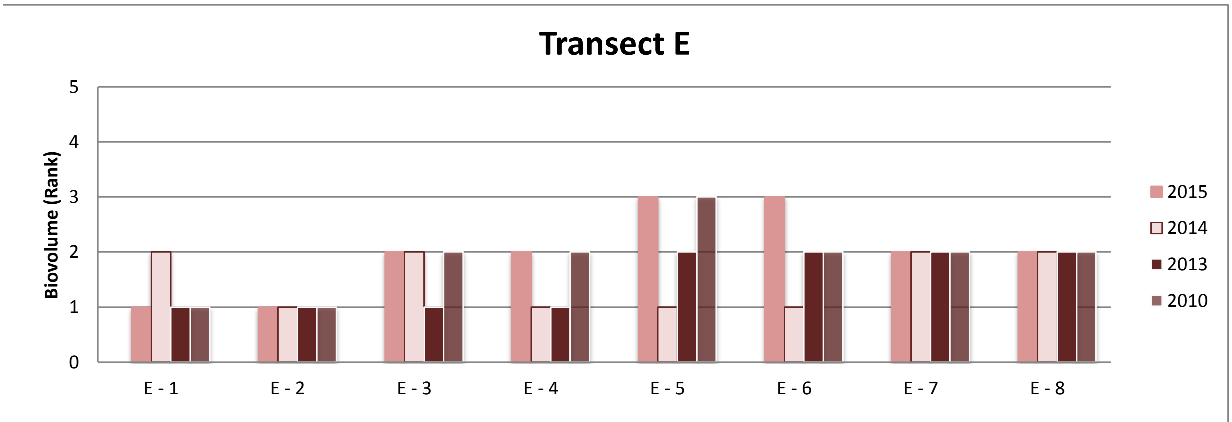
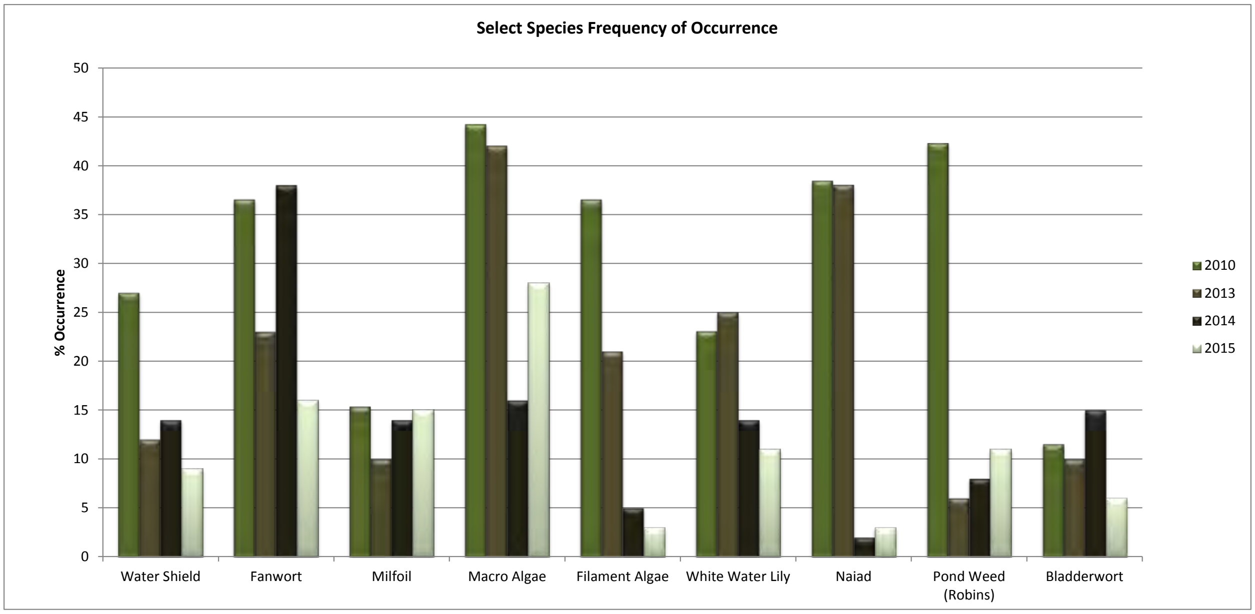


Figure 10 (continued). Bare Hill Pond Macrophyte Biovolume



Legend:
Water Shield – *Brasenia schreberi*
Fanwort – *Cabomba caroliniana*
Milfoil – *Myriophyllum heterophyllum* (variable-leaf milfoil)
Macro Algae – *Chara*
Filamentous Algae
White Water Lily - *Nymphaea odorata*
Naiad – *Najas sp*
Robins Pondweed – *Potamogeton robbinsii* (
Bladderwort – *Utricularia* spp.

Figure 11. Select Plant Species Frequency of Occurrence.