2016 Annual Monitoring Report For

Crystal Pond,

Eastford & Woodstock, CT

Prepared For:

Crystal Pond Association

Prepared By:

Northeast Aquatic Research

74 Higgins Highway

Mansfield Center, CT 06250

August 8, 2017

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SYNOPSIS OF 2016 RESULTS

1. Water clarity remained excellent in 2016 with readings between 5.35 meters and 6.6 meters (17.6 to 21.7 feet) continuing trend of exceptional water clarity seen in the last few years.
2. Phosphorus was slightly above 10ppb in July for third year in row. Surface phosphorous has traditional been below 10ppb.
3. Total nitrogen was below 300ppb for the fourth year in a row. Total nitrogen in surface water has traditionally been between 300 and 500 ppb.
4. Inlet chemistry in 2016 showed streams #1 and #7 continue to have high nitrate levels, #7 also had moderate phosphorus levels.
5. Aquatic plants show the same pattern of distribution along the shorelines and in the coves, but robust pondweeds appear to be increasing in density and abundance. The state listed protected Species of Special Concern Water Marigold was present throughout most areas of 5-8 feet of water depth along the western shore where it covered the bottom as a blanket together with Robbins pondweed, another beneficial native plant. No invasive species were found in the lake specifically fanwort, despite intensive surveys seeking evidence of this noxious weed.

BACKGROUND

Crystal Pond is a 150 acre lake in the towns of Eastford, and Woodstock, CT. In July 1990, the Crystal Pond Association initiated a water quality monitoring program consisting of:

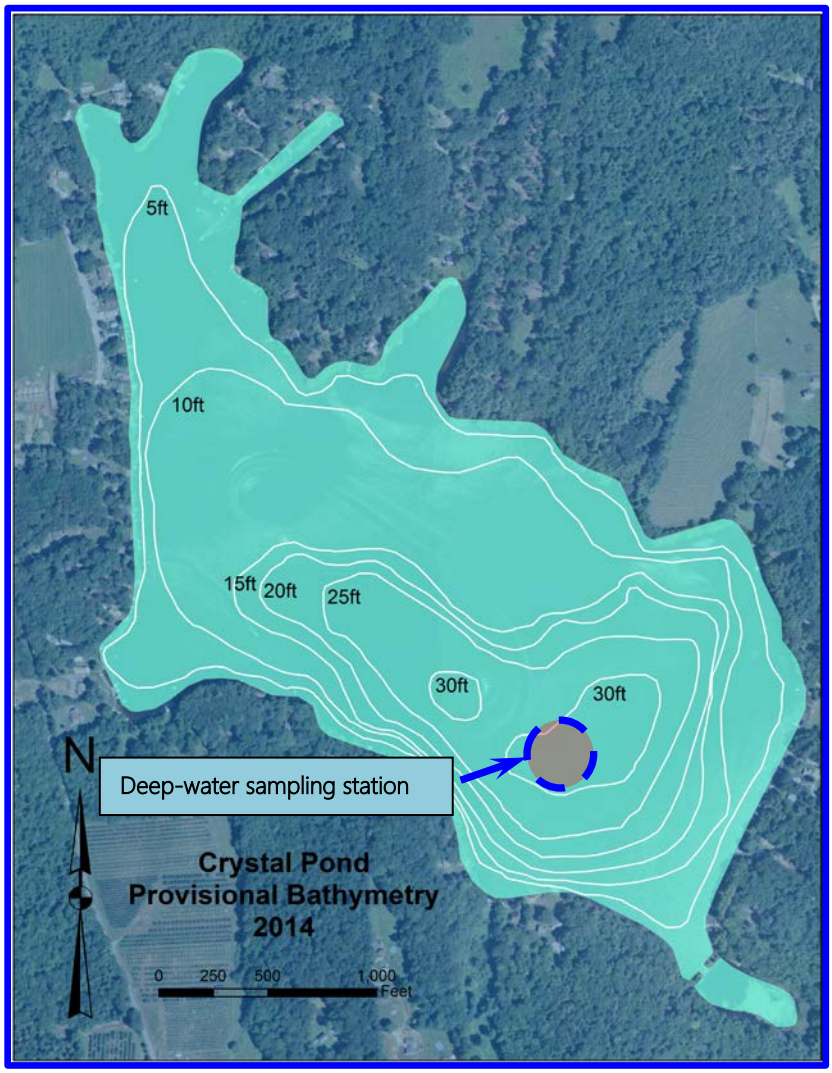
- Water clarity readings
- Measuring water temperature at 1 meter intervals
- Measuring dissolved oxygen at 1 meter intervals
- Collecting three water samples (top-middle-bottom) for analysis of nutrient levels

These tests have been conducted at the same station in the lake located over deepest water —about 32 feet, since 1992 (Figure 1).

- Northeast Aquatic Research (NEAR) took over monitoring of Crystal Pond in 2004. That year NEAR conducted end-of-July sampling and investigated aquatic plants in the coves and along northern shores.

- NEAR started surveying aquatic plants annually in 2011 and now have 6 years of surveys to compare --2011, 2012, 2013, 2014, 2015 and 2016.
- In 2012, NEAR began visiting the lake in May to collect samples of inlet waters because these small streams are dry during July and August lake visits.
- This report presents results of 26 years of consistent[1] lake water quality monitoring conducted at the same location, at the same time (end-of-July), 5 years of inlet chemistry results, and, 6 years of surveying aquatic plants.

Figure 1 – Crystal Pond water depth contours as mapped by NEAR during 2014, showing deep-water sampling station



[1] No clarity readings made in 2001 and 2003, water samples lost in 2003 and 2007

DETAILED MONITORING RESULTS

In 2016, Northeast Aquatic Research made 3 visits to Crystal Pond.

1. May 10th, to collect spring lake water quality data and investigate and collect water samples from flowing inlets.
2. August 1st, to collect the annual end-of-July water quality data.
3. September 15th, to document aquatic plants

Principal water quality trends at Crystal Lake that are addressed this report are

- Water Clarity,
- Total Phosphorus,
- Total Nitrogen,
- Anoxia (water devoid of dissolved oxygen).
- Total phosphorus from 5 inlets
- Nitrate nitrogen from 5 inlets

Crystal Pond data is assessed based on CT DEEP grouping of lakes into different categories based on the amount of total phosphorus they contain (Table 1). A trophic category is a way of categorizing the degree of plant growth that occurs in a lake, ranging from very clear water with no weeds or algae (oligotrophic), to lakes with excessive amounts of weeds and very green water (eutrophic). Plants grow in lakes due to nutrient loading from the drainage basin. The table shows lake Trophic Status, or growth categories ranked by increasing total phosphorus—first column. Targets in Green= TP <10ppb, TN <200ppb, and Secchi >6m.

Table 1 - Lake trophic categories and ranges of indicator parameters

Category	T.P. (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)	Chlorophyll *a* (ppb)
Oligotrophic	0 – 10	0 – 200	6+	0 – 2
Oligo-mesotrophic	10 – 15	200- 300	4 – 6	2 – 5
Mesotrophic	15 – 25	300 - 500	3 – 4	5 – 10
Meso-eutrophic	25 – 30	500 - 600	2 – 3	10 – 15
Eutrophic	30 – 50	600 - 1000	1 – 2	15 – 30
Highly Eutrophic	50 +	1000 +	0 – 1	30 +

- *Source = CT DEP 1982*
- *Chlorophyll-a not included in testing*

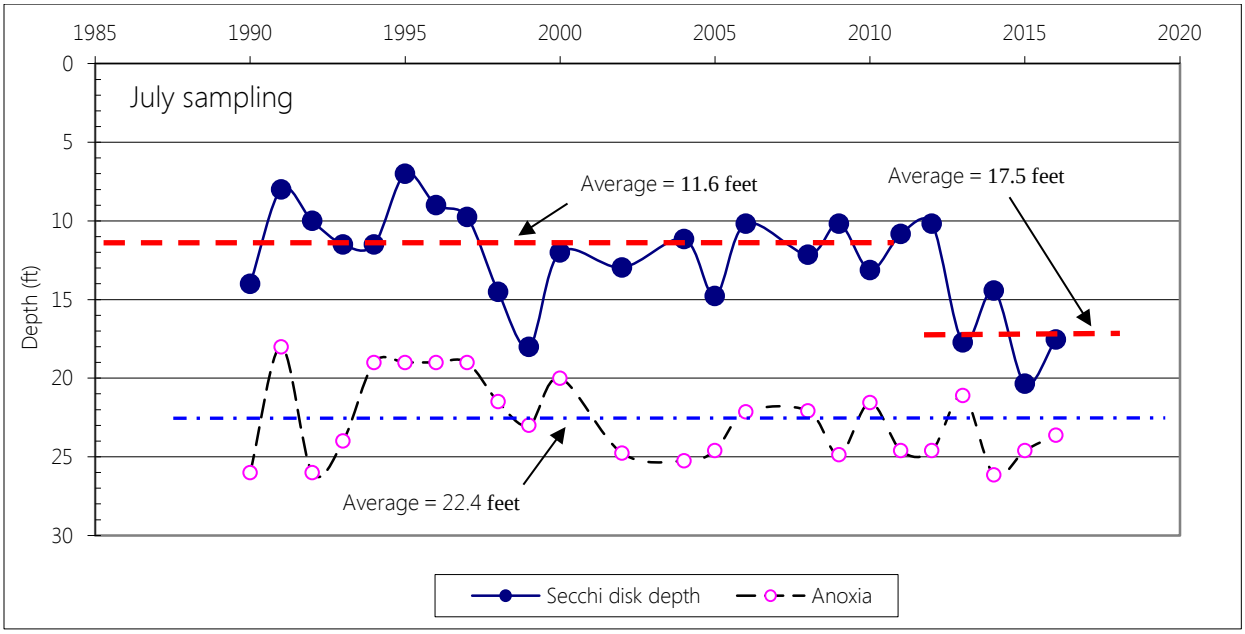
Water Clarity = Secchi Disk Depth

The Secchi disk depth was excellent in 2016, varying between 5.35 meters and 6.6 meters—17.6 and 21.7 feet (**Table 2**). Beginning in 2012, the lake has shown better readings than years prior. The best readings measured to-date occurred in late 2013 and early 2014 when clarity was 7.6 and 7.2 meters, respectively. The average of July readings between 2013 and 2016 is 17.8 feet, considerable better than 11.6 feet, the average of July readings between 1990 and 2012 (**Figure 2**).

Table 2 – Secchi disk depth measurements at Crystal Pond, 1990-2016

Date =>	5-31-16	8-1-16	9-15-16						
Depth m (ft)	6.6 (21.7)	5.35 (17.6)	6.0 19.7						
Date =>	9-1-12	5-30-13	7-31-13	9-23-13	5-19-14	7-18-14	5-8-15	7-8-15	7-31-15
Depth m (ft)	5.5 (18)	7.5 (24.6)	5.4 (17.7)	7.6 (24.9)	7.2 (23.6)	4.4 (14.4)	6.4 (21)	5.7 (18.7)	6.2 (20.3)
Date =>	8-4-05	7-24-06	8-1-08	7-20-09	8-6-10	7-14-11	6-12-12	7-24-12	
Depth m (ft)	4.5 (14.8)	3.1 (10.2)	3.7 (12.1)	3.1 (10.2)	4.0 (13.1)	3.3 (10.8)	4.4 (14.5)	3.1 (10.2)	
Date =>	8-4-94	7-30-95	8-4-96	7-30-97	7-29-98	7-28-99	8-1-00	7-27-02	7/14/04
Depth m (ft)	3.5 (11.5)	2.1 (7)	2.7 (9)	3.0 (9.75)	4.4 (14.5)	5.5 (18)	3.7 (12)	3.95 (13)	3.4 (11.2)
Date =>	7-30-90	7-31-91	7-30-92	8-1-93					
Depth m (ft)	4.3 (14)	2.4 (8)	3.0 (10)	3.5 (11.5)					

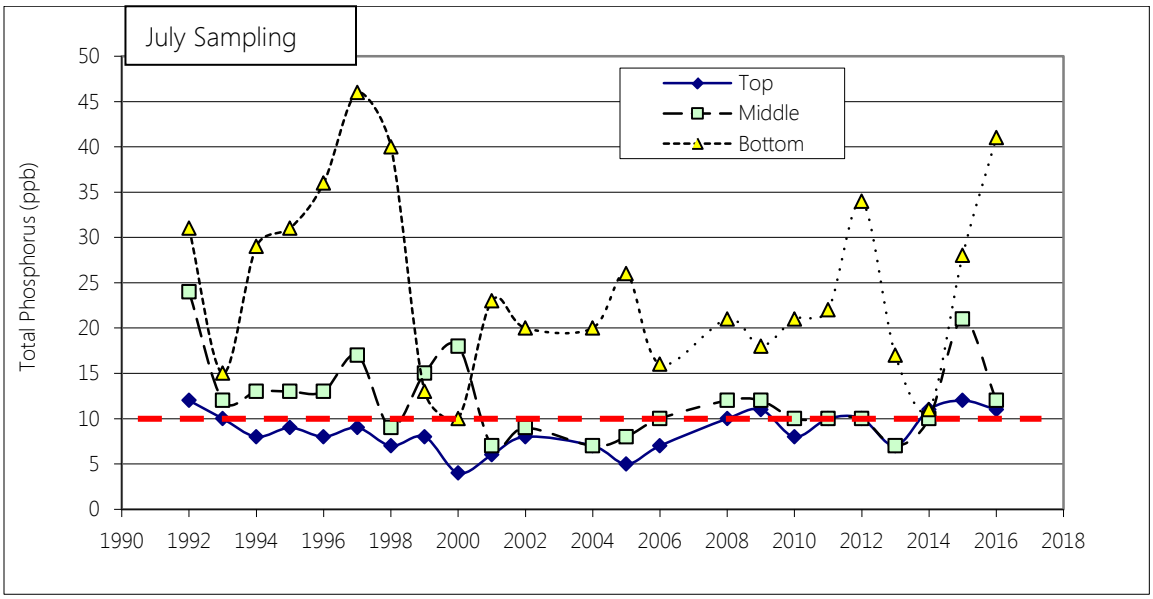
Figure 2 - Secchi Depths and Anoxic Boundaries at Crystal Pond, 1990-2016



Total Phosphorus

Water sampling at Crystal Pond is done specifically to track the phosphorus concentration in the lake over time. Crystal Pond has traditionally had surface samples <10ppb. In 2016, no values less than 10ppb were collected. The long-term trend in total phosphorus—1992 to 2016—at all three depths of measurement are shown in **Figure 3**. The red dashed line in **Figure 3** signifies the upper limit for High Quality (Oligotrophic on **Table 1**) lakes illustrating that values from 2014, 2015 and 2016 show end-of-July surface phosphorus >10ppb. All phosphorus test results are presented in the appendix.

Figure 3 – Trends in July phosphorus values from the top, middle, and bottom, depths at Crystal Pond 1992-2016



Total Nitrogen

The results for total nitrogen sampling over the last eleven years are given in **Table 3**. Total nitrogen includes fractions of nitrate, ammonia, and organic components. In 2016, total nitrogen at the 1 meter depth varied between 189 ppb and 291 ppb; lower than most results from the past several years.

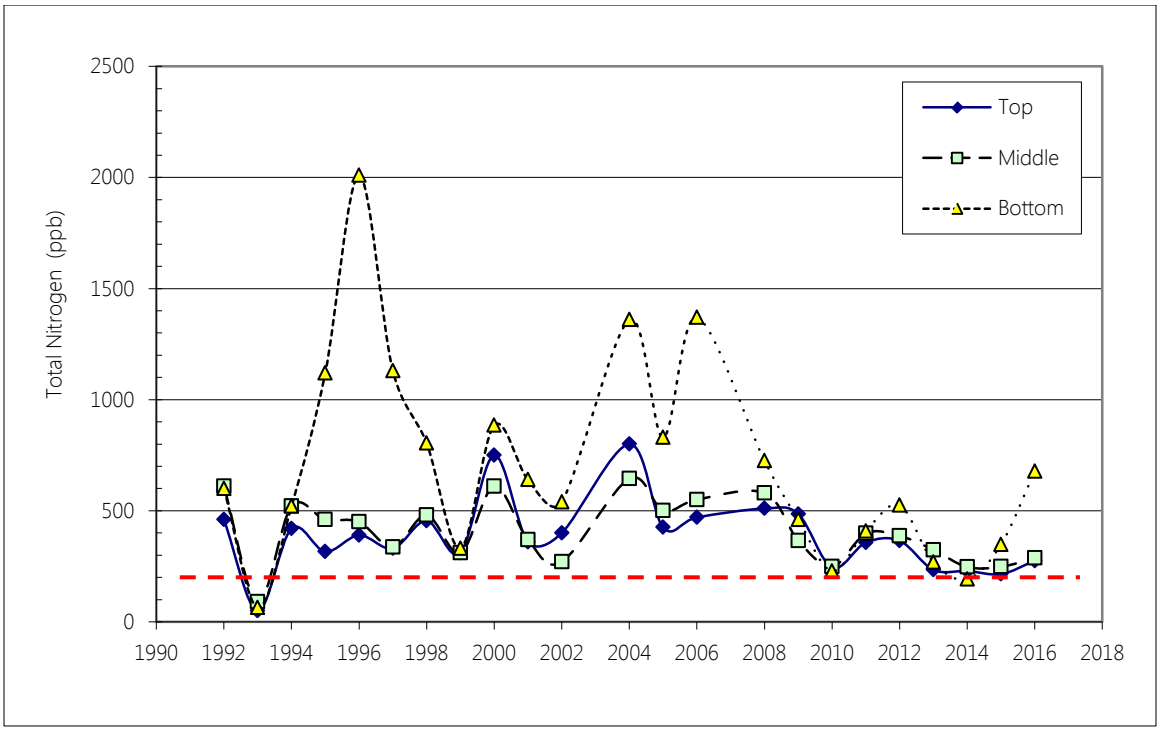
Table 3 – Twelve years of total nitrogen (ppb) results for Crystal Pond

Depth (m) (ppb)	5/10/16	8/1/16	9/15/16	2016 average				
1	189	275	291	252				
5	205	287	310	267				
9	193	677	641	504				
Average								
Depth (m) (ppb)	9/13/12	5/30/13	7/31/13	9/23/13	5/19/14	7/18/14	5/18/15	7/8/15 7/31/15

1	310	401	234	233	174	261	245	215/244
5	420	256	324	311	176	229	207	248/247
9	550	276	269	234	186	247	307	348/298
Average	*427*	*311*	*275*	*259*	*179*	*246*	*253*	*270/263*
Depth (m) (ppb)	8/4/05	7/24/06	8/1/08	7/20/09	8/6/10	7/14/11	6/11/12	7/24/12
1	425	470	510	485	244	357	420	Samples
5	500	550	580	365	248	398	355	lost
9	830	1,370	725	460	228	409	500	
Average	*585*	*797*	*605*	*437*	*240*	*388*	*425*	

The total nitrogen in the lake has been decreasing over the past 7 years (see **Figure 4**). Average TN for 2005-2008 was around 600ppb, the 2009-2012 average is around 400ppb. Beginning in 2013 the average has been <300ppb. This is a good sign for lake condition and could indicate the alleviation of watershed nitrogen loading. The deep-water samples show a large range over the years with highest values near 2,000ppb. Recently, bottom water concentrations have been low, close to or less than upper water values, indicating that total nitrogen was overall lower in the whole water column.

Figure 4 – Trends in July total nitrogen values from top, middle, and bottom depths in Crystal Pond 1992-2016



Dissolved Oxygen

The location of the anoxic boundary during the month of July has fluctuated between 19 and 27 feet with an average of 22.8 over the period on record (see Figure 2 for the trend in anoxic boundary). In 2016, the anoxic boundary was located at 23.4 feet in July and 25.7 feet in September. The deeper the anoxic boundary, the smaller the area of lake bottom exposed to anoxic conditions.

Aquatic Plants

The aquatic plants in Crystal Pond were surveyed on September 15, 2016 (see Figure 5 for distribution map of dominant plants found during that survey) – no invasive species were found (specifically fanwort). Generally plant beds were similar to those mapped in 2014 (Figure 6). Dominant plants noted in Table 5 appear to be increasing in distribution and abundance, although we have also noted some shifting of bed location.

All seven surveys (2004, 2011 – 2016) show the same 5 species to be dominant in the lake Table 4 (Robbins pondweed, large-leaf pondweed, water marigold, large-leaf and grassy pondweeds, and recently--tape-grass). Although the percent occurrence numbers vary year-to-year for each of these five species, values appear to be going up. Robbins pondweed and water marigold are low-growing plants that remain close to the bottom. Large-leaf and grassy pondweeds form beds of tall plants that reach the water surface in 4-8 feet of water depth and develop floating leaves.

Table 4 - Aquatic plant species list for Crystal Pond

Scientific Name	Common Name	Percent Occurrence						
		2016	2015	2014	2013	2012	2011	2004
Potamogeton robbinsii	Robbins Pondweed	77	52	31	27	42	57	26
*Bidens beckii****	Water Marigold***	35	23	30	26	19	40	10
Potamogeton gramineus	Grassy Pondweed	35	15	20	21	44	23	4
Potamogeton amplifolius	Lg-leaved Pondweed	33	52	43	16	19	28	24
Valisneria americana	Tape-grass	14	10	6	5	7	6	1

*** State listed plant of special concern

Distribution maps for the 5 dominant plant species in Crystal Pond are shown below for 2016 (Figure 5), 2015 (Figure 6), and 2014 (Figure 7). The three pondweeds show gradual increase in coverage

around the lake. Robbins Pondweed doesn't present a threat to impairment due to its habit of remaining close to the bottom, however, both grassy and large-leaf pondweeds will develop dense stands of coverage at the surface that can interfere with use.

Figure 5 – Aquatic Plants in Crystal Pond 2016

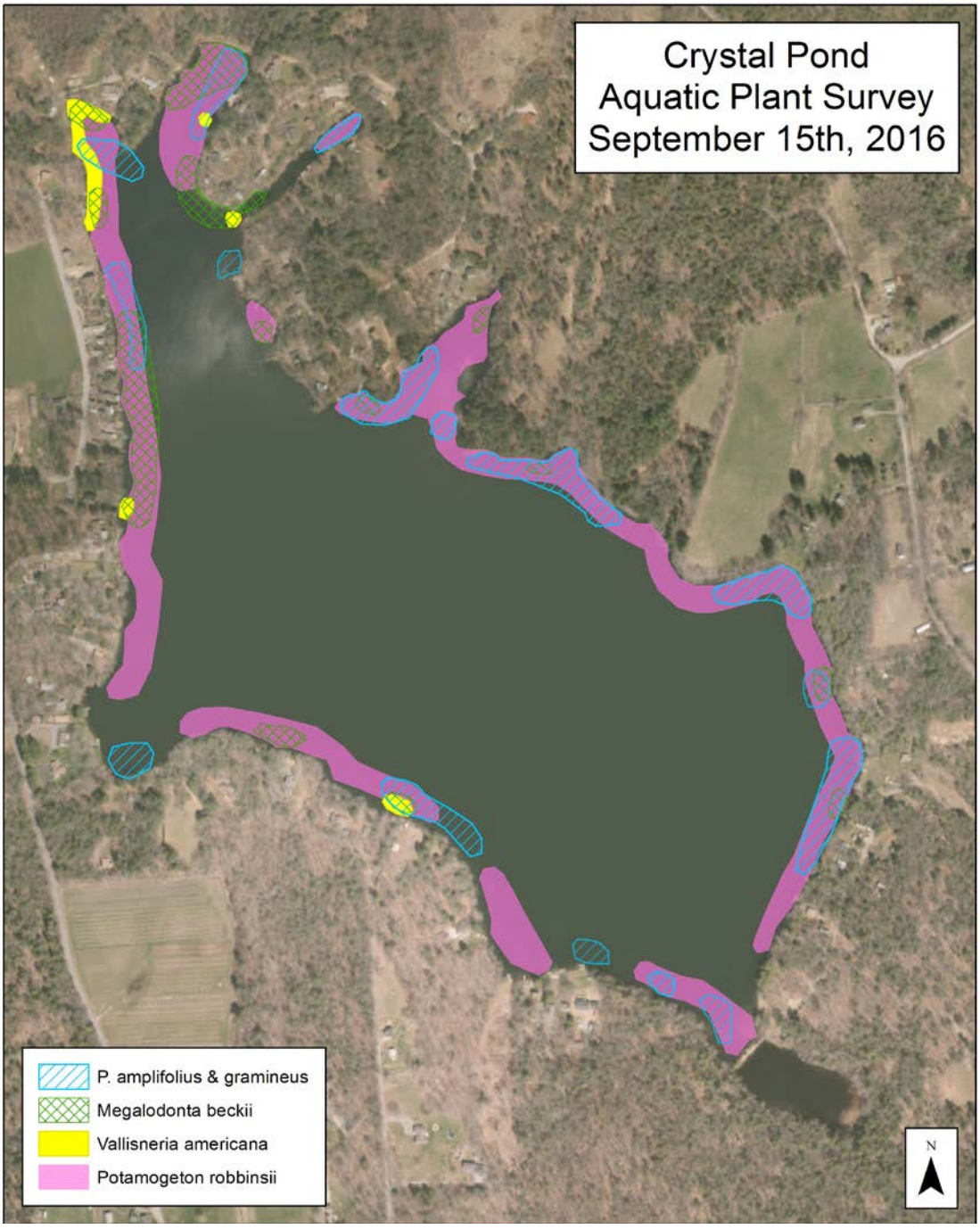


Figure 6 – Aquatic Plants in Crystal Pond 2015

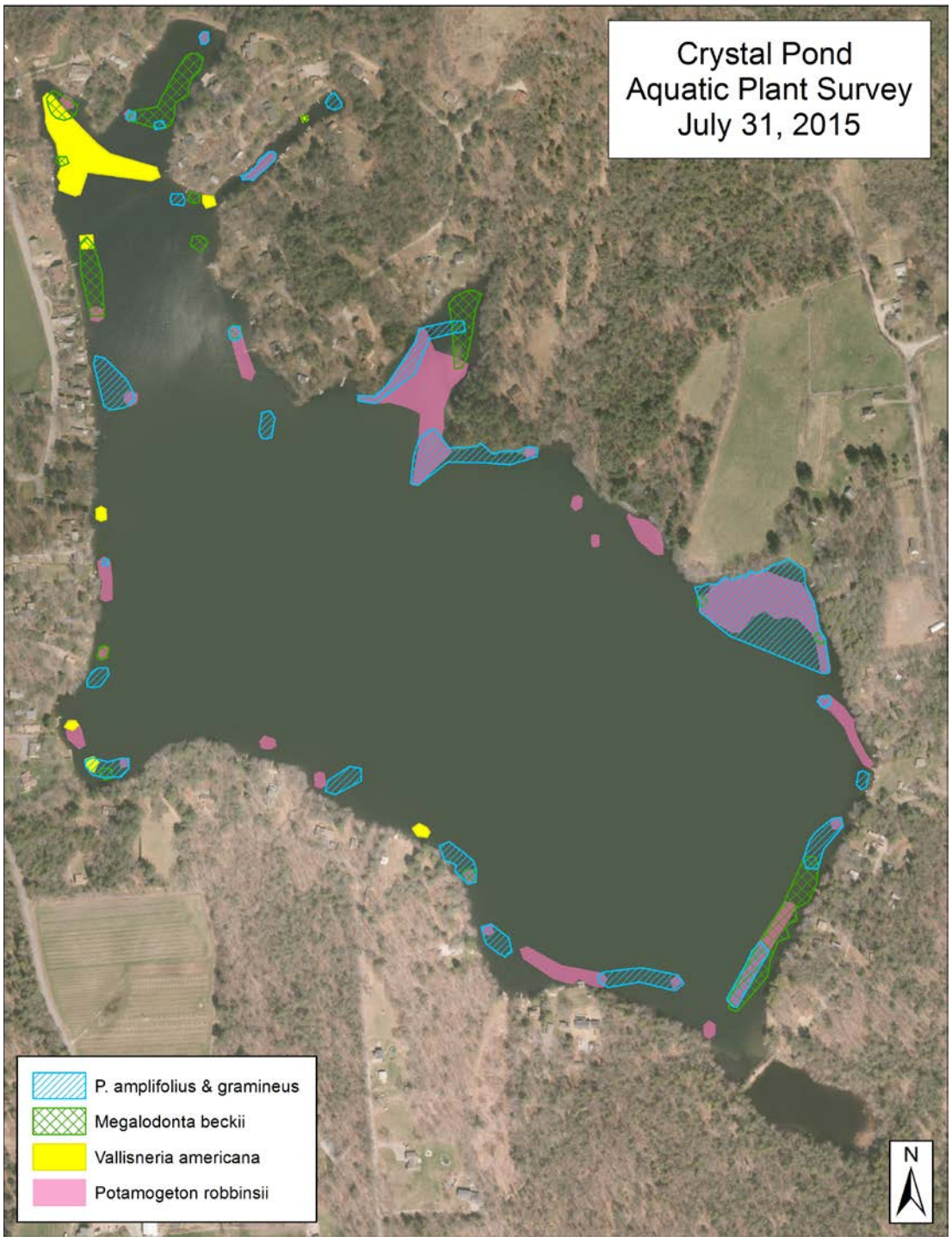
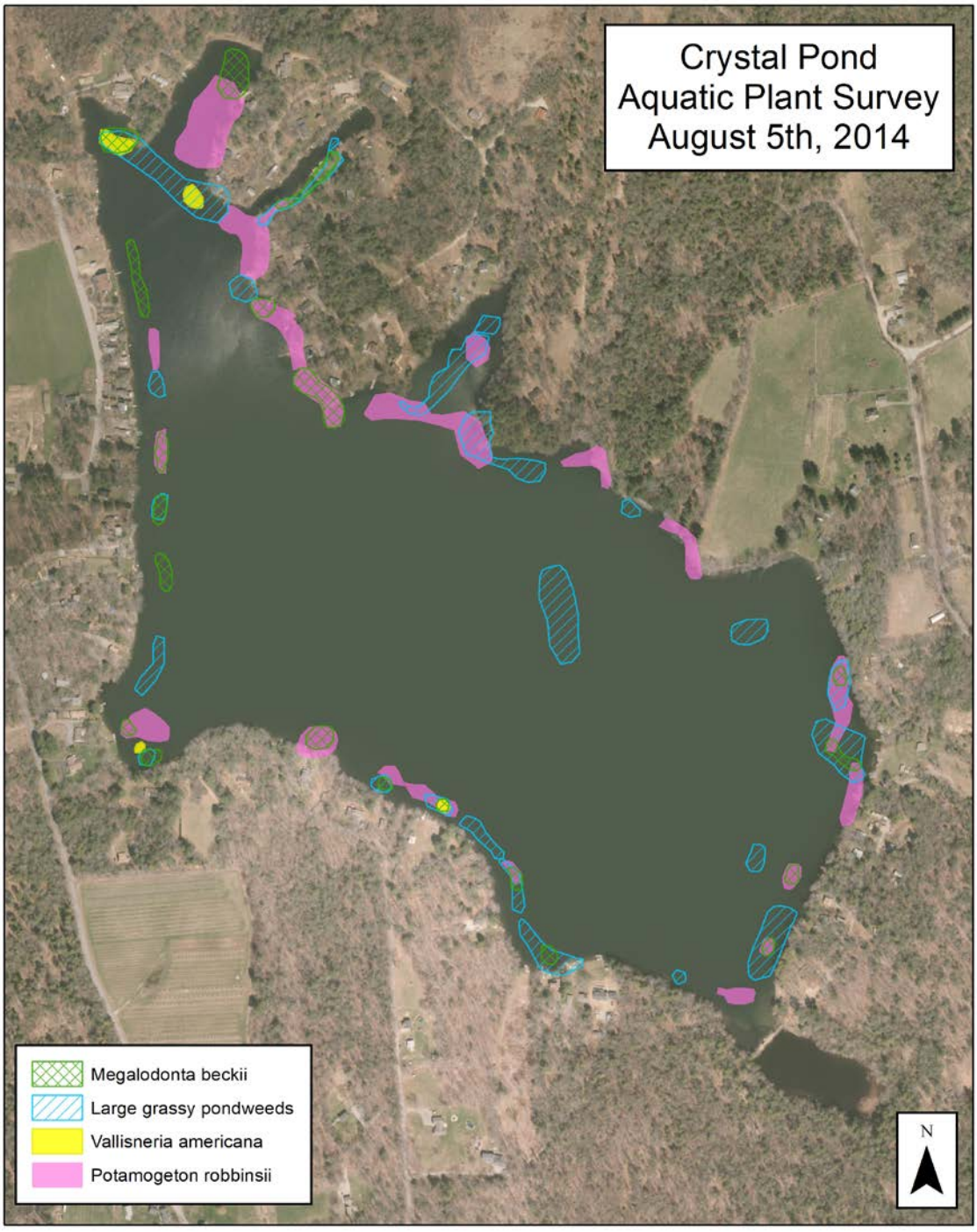


Figure 7 – Aquatic Plants in Crystal Pond 2014



Watershed Characteristics

Crystal Pond has a watershed area of 545 acres and a drainage area of only 400 acres (watershed minus the lake area). The lake has no large inlets; instead, water flows into the lake via several small creeks and drains. The map below (**Figure 8),** showing the drainage basin of Crystal Pond, identifies nine natural sites where surface water could flow into Crystal Pond based on topography. The map doesn't show possible drainage conveyance in the northwestern shoreline area. Investigation of each verified that only sites 1, 4, 7, 8, and 9 were actual tributary locations **Figure 9,** draining 206.7 acres or roughly half the total watershed area. The remaining 193 acres presumably drains to the lake via ground water. Site 10 has subsequently been identified as a culvert that enters the lake subsurface so cannot be sampled. **Table 5,** lists approximate drainage area of each basin.

Figure 8 - Drainage basin of Crystal Pond showing principal sub-basins

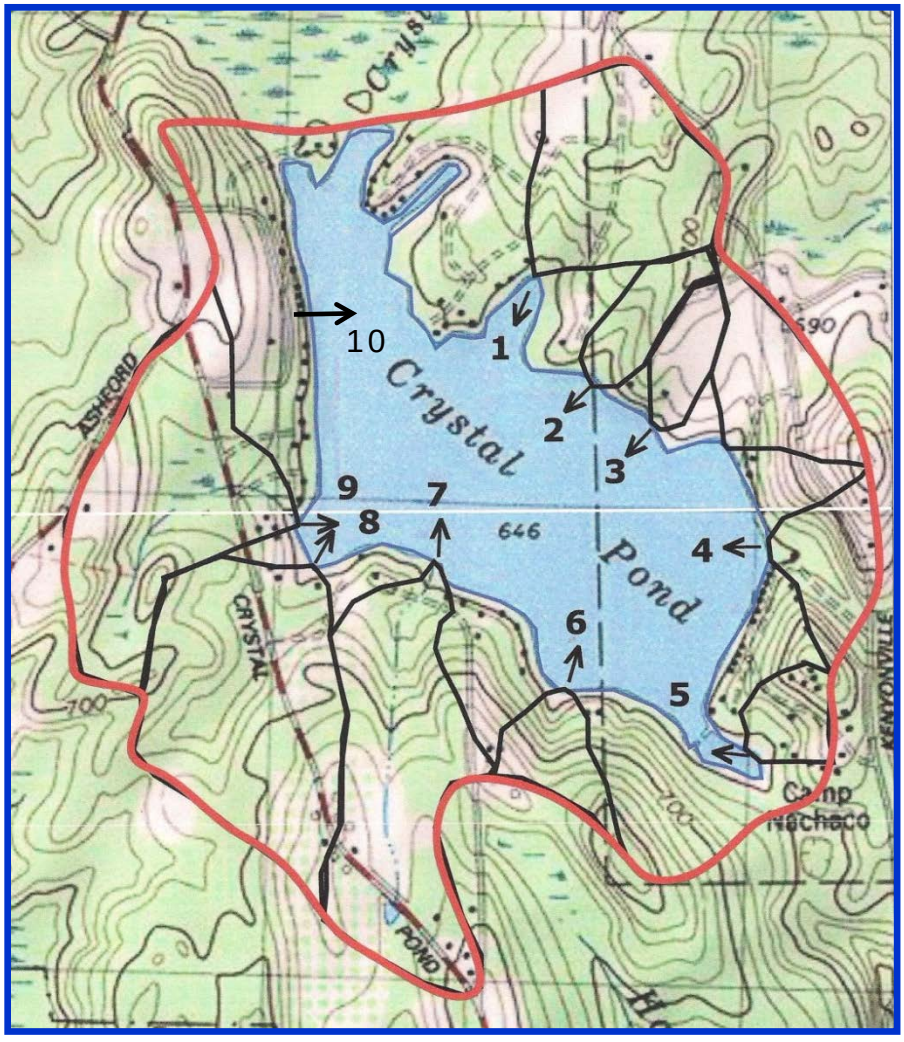
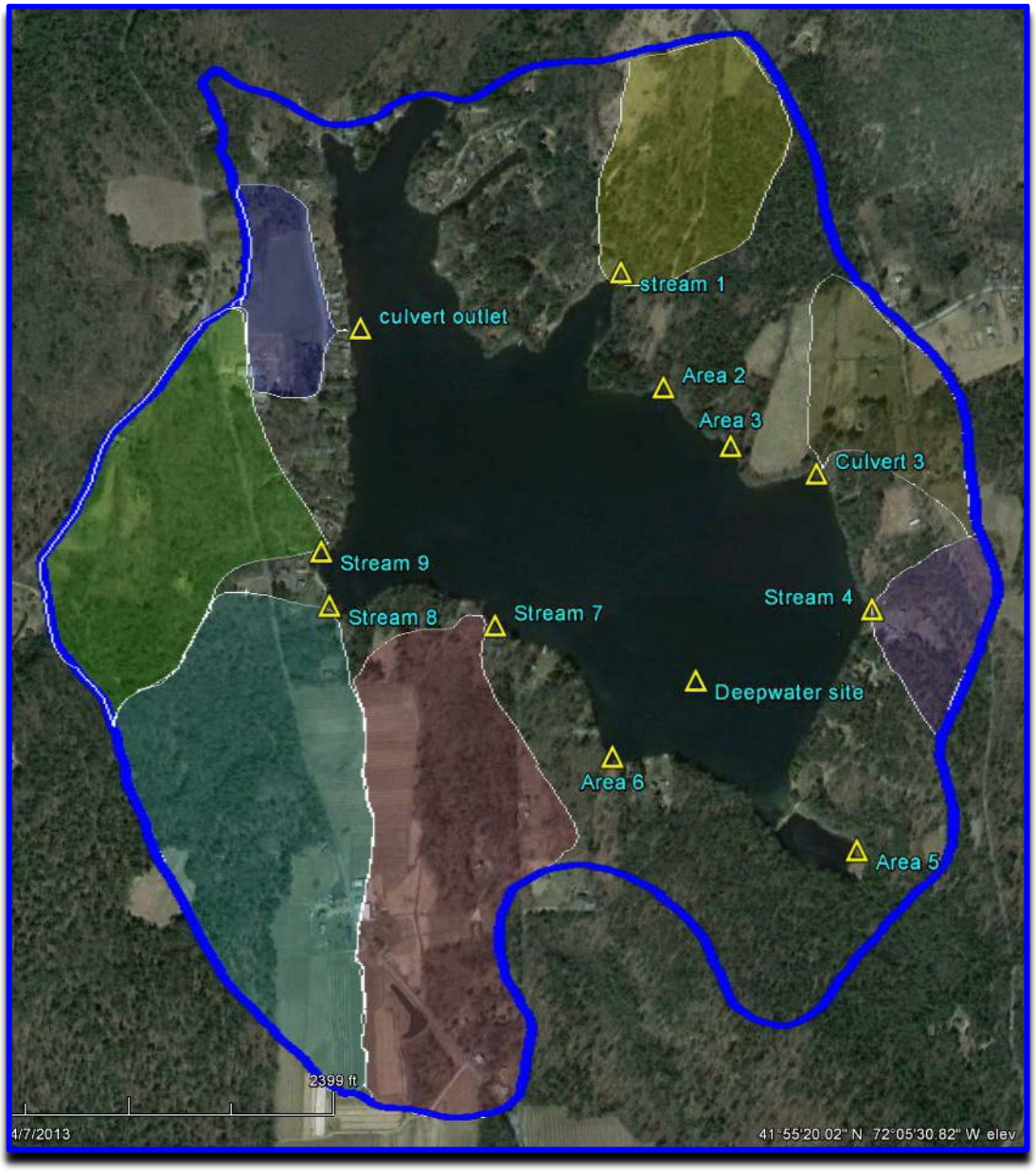


Figure 9 - Drainage basin of Crystal Pond showing inlets and sub-basins



The locations where water was found be flowing into the lake are labeled as Streams 1, 4, 7, 8 and 9 in Figures 8 & 9. Other sites, Culvert 3, and Areas 2, 3, 5, and 6, have not had flowing water on any of our sampling visits. At the location marked as 'Culvert Outlet', the end of a culvert was found in approximately 5 feet of water. The culvert pipe was buried with only the top 5-6 inches visible. It appeared to be the outlet pipe for runoff from a field and roads on the adjacent western shore of the lake.

Table 5 – Drainage basins of Crystal Pond

Sub-basin Number Referenced on Fig 10	Acres	Notes
1	**34.0**	**Flowing inlet= samples collected**
2	9.0	No inlet to the lake found in this area
3	7.7	Culvert in wall with no flow
4	**18.8**	**Flowing inlet= samples collected**
5	7.8	Possible inlet into contiguous swamp at southern end of cove but couldn't be accessed
6	9.7	No inlet to the lake found in this area
7	**49.6**	**Flowing inlet= samples collected**
8	**54.8**	**Flowing inlet= samples collected**
9	**49.5**	**Flowing inlet= samples collected**
Culvert outlet	12.1	Culvert discharges at lake bottom in 5 feet of water

Water sampling results for phosphorus and nitrate tests are shown in **Table 6** below. A cell with no value indicates no sample was collected at that site on that date because no water was found to be flowing into the lake.

Table 6 – Testing results from water entering Crystal Pond

Stream number	Total Phosphorus (ppb) >10 bold					Nitrate Nitrogen (ppb) >200 bold				
	6/11/2012	5/30/2013	5/19/2014	5/18/2015	**5/10/2016**	6/11/2012	5/30/2013	5/19/2014	5/18/2015	**5/10/2016**
1		2	7	8	8		182	**514**	178	**271**
4		6	**14**		**18**		0	0		12
7	**39**	**16**	**23**		10	**330**	174	**370**		**358**
8	**11**	5	9	**16**	**11**	57	42	92	105	68
9		8	**16**	**26**	**13**		0	14	19	12

Streams results discussion:

1 Phosphorus has been consistently low, no concern at this time. Nitrate has been high with some very high values, all over 100ppb and one over 500ppb. Continued high values should be taken seriously with some preliminary investigation of the drainage basin.

4 Phosphorus has varied between a low value 6 ppb and some slightly elevated values (10-20ppb). At this time phosphorus values in this stream are under watch. Nitrate has been low to non-detectable so not a concern at this time.

7 Phosphorus has been slightly (10-20ppb) to moderately (>20ppb) elevated with a maximum value of 39ppb reported in 2012. Nitrate has generally been very high, all values over 100ppb, and three values over 300ppb. Continued high values should be taken seriously with some preliminary investigation of the drainage basin.

8 Phosphorus has varied between low (<10ppb) to slightly (10-20 ppb) elevated values. Nitrate has been continuously detected but values have been mostly <100ppb. Nutrient levels in this stream are under watch.

9 Phosphorus has varied between low and moderately elevated values. Should more moderately elevated values be detected further investigation will be warranted. Nitrate has been low to non-detectable so is not a concern at this time.

SUMMARY and RECOMMENDATIONS

Water quality monitoring conducted in 2016 showed:

1. Water clarity was excellent,
2. Total phosphorus was above 10ppb in July, for the third year in a row,
3. Total nitrogen was less than 300ppb for the fourth year in a row,
4. Aquatic plants remained consistent with prior year's surveys with respect to dominant plant species.
5. NO NON-NATIVE SPECIES HAVE BEEN FOUND IN THE LAKE,
6. Robust pondweeds, Large-leaf pondweed and Grassy pondweed appear to have expanded coverage around the lake. These two plants grow to the lake surface and develop floating leaves, tend to occur in dense clumps and can break or fragment into floating stems that can raft together. Robbins pondweed and water marigold also show expanded coverage but these plants are bottom hugging species that very rarely reach the water surface so typically go unnoticed,.

Suggested 2017 Actions

7. Collect up-to-date plant coverage data from the Eastern Lagoon. The last record of NEAR conducting weed survey work in the lagoon was 5-20-2013. Google imagery below **Figure 9** shows large expansion of the floating leaved plants; red area is floating-leaved plant coverage on October 2016 and gold area is coverage on July 2005. The change in coverage shown below is from 17,478 ft^2 in 2005, to 91,145 ft^2 in 2016, an increase of 73,667 ft^2. or 1.7 acres over 11 years.

8. Collect detailed distribution data for the two robust pondweeds, Large-leaf and Grassy pondweed, including the center of the lake where pondweeds were reported in 2014. Retrieve sufficient data to make comparisons with prior mapping and estimate current coverage and density.
9. Develop a homeowners planning handout giving practical advice and listing simple things to do around the yard that make a big difference.
10. Maintain lake monitoring at 2016 level, three visits; end-of-July sampling, spring investigation of the inlets and fall aquatic plant survey.

MAINTAIN EXTREME VIGILANCE FOR:

HYDRILLA – NOW KNOWN IN COVENTRY LAKE COVENTRY, CT

FANWORT – 2016 INFESTATION OF MIDDLE BOLTON LAKE VERNON, CT

Figure 10 – Google Image of Floating leaved plant coverage in Lagoon of Eastern end of Crystal Pond

Appendix

General Water Quality and Lake Trophic State Concept

Total phosphorus is usually the nutrient limiting growth of phytoplankton in freshwater such that growth of microscopic algae is related to the quantity of phosphorus available in the water; excess phosphorus is the primary cause of nuisance algae blooms in lakes. In this way water clarity of lake water is based on the amount of total phosphorus available for microscopic algae growth. Higher amounts of phosphorus correlate with higher growth rates of these microscopic algae leading to reduced water clarity.

The values arranged in **Table 7** show how increasing phosphorus, TP second column, causes Secchi disk fourth column to decrease quickly with only small increases in phosphorus. Target levels are lowest phosphorus and lowest nitrogen possible. Record of phosphorus testing at Crystal Pond is given in **Table 8**.

Table 7 - Lake trophic categories and ranges of indicator parameters

Category	T.P. (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)	Chlorophyll *a* (ppb)
Oligotrophic	0 – 10	0 – 200	6+	0 – 2
Oligo-mesotrophic	10 – 15	200- 300	4 – 6	2 – 5
Mesotrophic	15 – 25	300 - 500	3 – 4	5 – 10
Meso-eutrophic	25 – 30	500 - 600	2 – 3	10 – 15
Eutrophic	30 – 50	600 - 1000	1 – 2	15 – 30
Highly Eutrophic	50 +	1000 +	0 – 1	30 +

- *Source = CT DEP 1982*
- *Chlorophyll-a not included in testing*

Table 8 - Total phosphorus [TP] testing results for Crystal Pond

Depth (m) (ppb)	5/10/16	8/1/16	9/15/16	2016 average
1	17	11	15	14
5	13	12	12	12
9	13	41	42	32
Average	*14.3*	*21.3*	*23*	***19.3***

Depth (m) (ppb)	5/18/15	7/8/15	7/31/15	2015 average
1	17	11	12	13
5	12	24	21	19
9	21	18	28	22
Average	*16.7*	*17.7*	*20.3*	***18.0***

Depth (m) (ppb)	5-19-14	7-18-14	2014 average
1	23	11	17
5	13	10	12
8	13	11	12
Average	*16.3*	*11*	***13.7***

Depth (m) (ppb)	5-20-13	7-31-13	9-23-13	2013 average
1	12	7	11	10
5	13	7	11	10
9	10	17	12	13
Average	*10.7*	*10*	*11.3*	***11***

Depth (m) (ppb)	6/16/12	7/24/12	9/13/12	2012 average
1	11	10	9	10
5	19	10	9	13
9	13	34	32	26
Average	*14*	*18*	*17*	***16.3***

Depth (m) (ppb)	7-14-11	8-6-10	7-30-09	8-1-08	7-24-06
1	10	8	11	10	7
5	10	10	12	12	10
9	22	21	18	21	16
Average	*14*	*13*	*14*	14	*11*

Depth (m) (ppb)	8-4-05	7-14-04	7-27-02	7-31-01	8-1-00
1	5	7	8	6	4
5	8	7	9	7	18
9	26	20	20	23	10
Average	*13*	*11*	*12*	*12*	*11*

Depth (m) (ppb)	7-28-99	7-28-98	7-30-97	8-4-96	7-30-95
1	8	7	9	8	9
5	15	9	17	13	17
9	13	40	46	36	46
Average	*12*	*19*	*24*	*19*	*18*

Depth (m) (ppb)	8-3-94	8-1-93	7-30-92
1	8	10	12
5	13	12	24
9	29	15	31
Average	*17*	*12*	*22*