2017 Crystal Pond Monitoring Report

Eastford & Woodstock, CT

Prepared For:

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SYNOPSIS OF 2017 RESULTS

1. Water clarity in 2017 was excellent, with readings between 5.4 meters and 7.75 meters (17.7 to 25.4 feet). These readings are better than most of the readings recorded in previous years.
2. Total phosphorus concentrations were excellent in 2017 with values between 8ppb and 19ppb. TP concentrations were excellent in May and September with top and middle depths having < 10ppb. Phosphorus on August 1 was slightly higher at those depths--12 to 15ppb.
3. Total nitrogen concentrations in the lake were very good for the duration of the season, remaining below 300ppb for the duration of the season. Total Nitrogen in the lake has been generally lower since 2011.
4. The standard five inlets to the lake were sampled in May. Total phosphorus concentrations were excellent in four of the inlets and only slightly elevated in Stream 4. Nitrate nitrogen was slightly elevated in Stream 7 but the concentrations were low in the other four inlets.
5. 30 native aquatic plant species were found in the lake during the aquatic plant survey conducted on September 11th, no invasive species were found. Five of these are considered dominants in Crystal Pond: large-leaf pondweed (*Potamogeton amplifolius*), Robbin's pondweed (*Potamogeton robbinsii*), grassy pondweed (*Potamogeton gramineus*), and water marigold *(Bidens beckii*), a state listed protected Species of Special Concern, and tape grass (*Vallisneria americana*). These species are expanding in coverage in the lake with large-leaf and grassy pondweeds becoming increasing prolific. Floating leaved species are taking over the southern lagoon.

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:

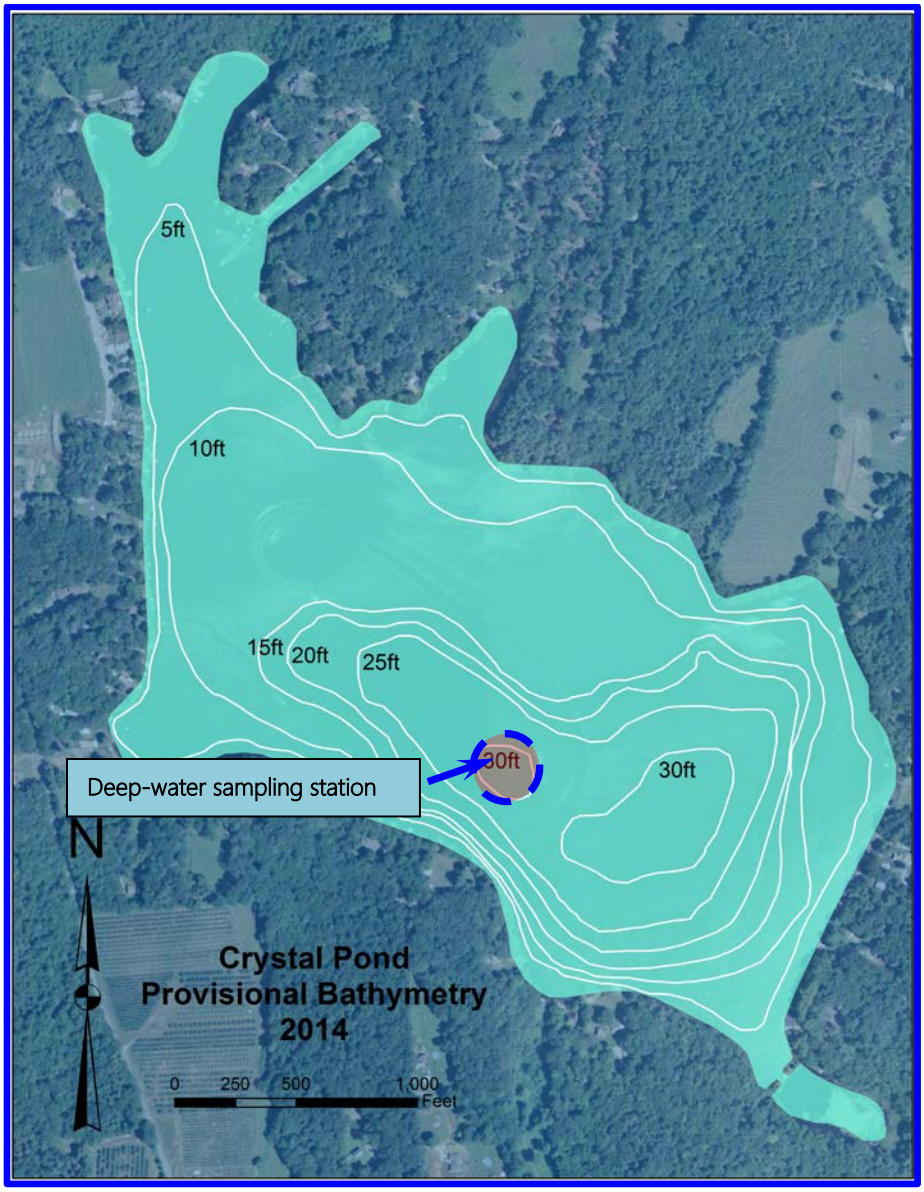
- Annually visiting lake's deep water site on or near July 31,
- Measure and record Water clarity,
- Measure water temperature at 1 meter intervals,
- Measure dissolved oxygen at 1 meter intervals,
- Collecting three water samples (top-middle-bottom) for analysis of nutrient levels

These tests have been conducted at the same station in the lake located over deepest water —about 30 feet (9.8 meters), 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 northeastern shores.

- NEAR started annually surveying aquatic plants in 2011 and now have 6 years of surveys to compare --2011, 2012, 2013, 2014, 2015, 2016 and 2017.
- 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 28 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 were made in 2001 and 2003, water samples lost in 2003 and 2007

DETAILED MONITORING RESULTS

In 2017, Northeast Aquatic Research made 3 visits to Crystal Pond.

1. May 19th: collected spring lake water quality data and investigated and collected water samples from flowing inlets.
2. August 1st: collected the annual end-of-July water quality data.
3. September 11th: collected water quality data and documented aquatic plants.

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

- Water Clarity with goal of testing results in green –see Table 1 below,
- Total Phosphorus with goal of testing results in green –see Table 1 below,
- Total Nitrogen with goal of testing results in green –see Table 1 below,
- Anoxia (water devoid of dissolved oxygen),
- Total phosphorus from 5 inlets,
- Nitrate nitrogen from 5 inlets,

Crystal Pond data is assessed based on the CT DEEP grouping of lakes into categories using 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). Nutrient loading from the drainage basin leads to increased plant growth in lakes. **Table 1** shows lake Trophic Status, or lake ageing categories ranked by increasing total phosphorus—first column--with lake management **Targets are in Green.**

TP <10ppb, TN <200ppb, Secchi disk depth >6m.

Table 1 - Lake trophic categories and ranges of indicator parameters*

Parameter = Category	T. Phosphorus (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*

< = less than

> = greater than

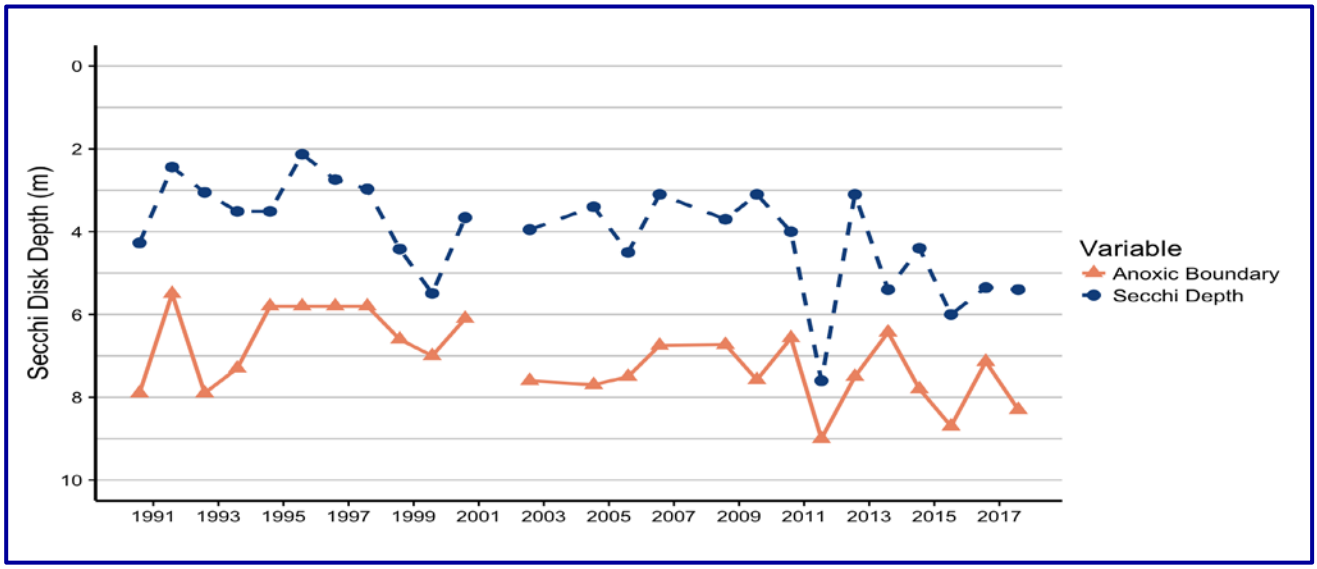
Water Clarity / Secchi Disk Depth

The water clarity in Crystal Pond was excellent in 2017, with readings between 5.4m and 7.75m. The 7.75m reading recorded in September 2017, was the best clarity reading recorded in the lake since monitoring began in 1990. Keep in mind that the lake is only 9 meters deep at its deepest. A Secchi disk reading this high in Crystal Pond is only 4 feet from the bottom. The data in **Figure 2** shows that beginning in 2011 water clarity has been considerably and consistently better than the all preceding years. When all the data is considered as shown in **Table 2**, seven readings of 6 meters or more--considered Oligotrophic in **Table 1**—have occurred since 2011--while prior to that year there were none. The best clarity prior to 2011 was 5.49 meters, an outlier among all other readings which varied between 2 and 4.5 meters more characteristic of meso-eutrophic lakes (**Table 1**). The second best clarity reading between 1990 and 2010 (4.5 meters) has been exceeded 9 times since 2011.

Table 2 – Secchi disk depth measurements at Crystal Pond, 1990-2017

Date	Secchi Disk Depth	Date	Secchi Disk Depth		Date	Secchi Disk Depth
7/30/1990	4.27	8/1/2000	3.66		7/31/2013	5.4
7/31/1991	2.44	7/27/2002	3.95		7/18/2014	4.4
7/30/1992	3.05	7/14/2004	3.4		7/8/2015	6.0
8/1/1993	3.51	8/4/2005	4.5		5/10/2016	6.6
8/3/1994	3.51	7/24/2006	3.1		8/1/2016	5.35
7/30/1995	2.13	8/1/2008	3.7		9/15/2016	6.0
8/4/1996	2.74	7/20/2009	3.1		**5/19/2017**	**7.25**
7/30/1997	2.97	8/6/2010	4.0		**8/1/2017**	**5.4**
7/29/1998	4.42	7/14/2011	7.6		**9/11/2017**	**7.75**
7/28/1999	5.49	7/24/2012	3.1			

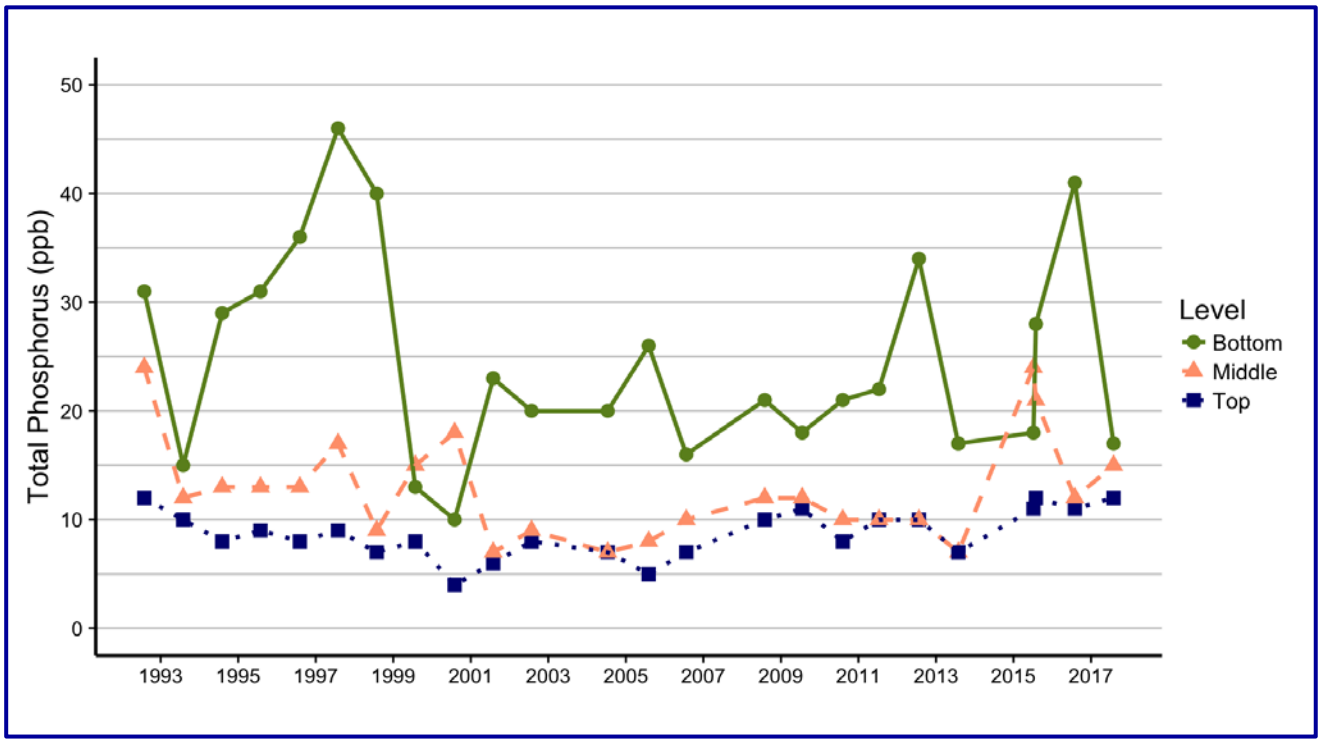
Figure 2 - Secchi depths and anoxic boundaries at Crystal Pond in July 1990-2017



Total Phosphorus

Total phosphorus concentrations in the surface waters of Crystal Pond have consistently remained near or below 10ppb although the last three years has seen TP at 1m at slightly higher than 10ppb (**Figure 3**). Total phosphorus at the bottom of the deep spot in 2017 was lower than the previous two years, with concentrations between 10ppb and 20ppb suggesting that internal loading doesn't occur to any great degree. All total phosphorus test results from 1992 – 2017 are presented in **Table 6** in the appendix.

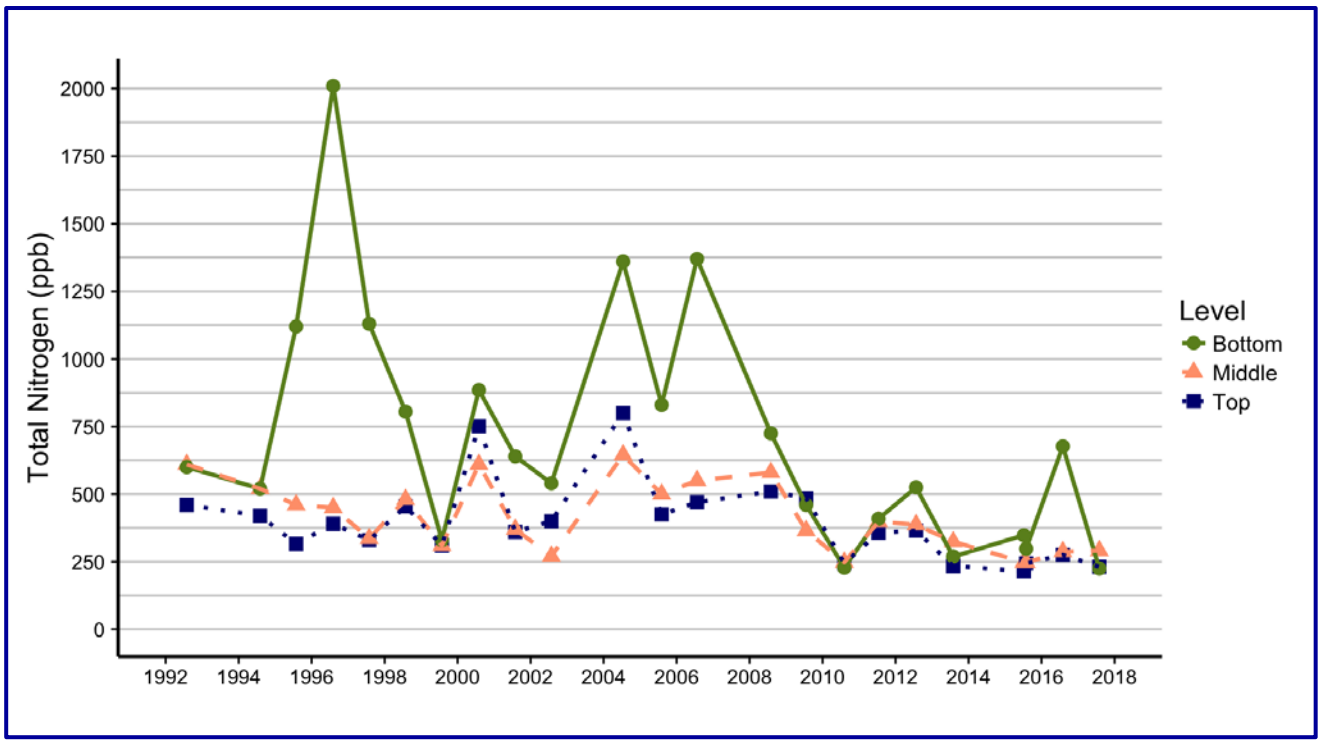
Figure 3 – Trends in July total phosphorus values from the top, middle, and bottom depths at Crystal Pond 1992-2017



Total Nitrogen

Total nitrogen (TP) includes fractions of nitrate, ammonia, and organic components. The goal for total nitrogen in lake water is 200ppb. Crystal Pond has had high, to very high, total nitrogen values over the years with surface concentrations as high as 750 ppb and bottom values as high as 2,000ppb **(Figure 4)**. The long term trends show that beginning in 2010, total nitrogen in the lake has declined at all sampling depths. In 2017, Aug 1st total nitrogen concentrations were all below 300ppb. The decline in nitrogen in the lake may have a large part to play in the improvement of water clarity. The results for total nitrogen sampling over the last 25 years are presented in **Table 7** in the appendix.

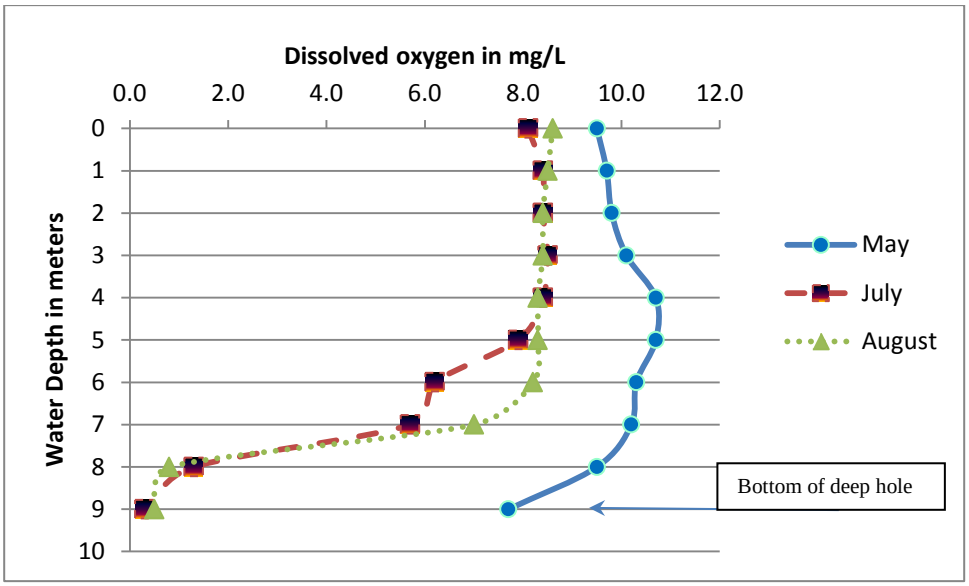
Figure 4 – Trends in July total nitrogen values from the top, middle, and bottom depths at Crystal Pond 1992-2017



Dissolved Oxygen

The location of the anoxic (anoxia is where the dissolved oxygen has declined to less than 1 mg/L) boundary at the time of the late July sampling has fluctuated between 5.5 and 7.9 meters between 1990 and 2011 **(Figure 2)**. Beginning in 2012 the anoxic boundary has been erratic but has been generally better—that is deeper in the lake; with three readings showing the anoxic boundary deeper than 8 meters, and only minor anoxic development at the very bottom in 2012 see **Figure 5**.

Figure 5 – Detailed oxygen values at each meter depth in Crystal Pond from measurements made in 2017



Aquatic Plants

The aquatic plants in Crystal Pond were surveyed on September 11th, 2017 (see **Figure 6** for distribution map of dominant plants found during the survey). No invasive species were found in the lake during this survey.

Five species, all of which are native, have remained dominant in the lake in all eight surveys (2004, 2011-2017). *Potamogeton robbinsii* (Robbins pondweed), *Bidens beckii* (water marigold), *Potamogeton gramineus* (grassy pondweed), and *Potamogeton amplifolius* (large-leaf pondweed) are consistently present at frequencies over 20%. *Vallisneria americana* (tape grass) is not as abundant as the other four species and has for years been mostly limited to beds in the northern shallow cove. However, the plant has been increasing in abundance over the last several years. Robbins pondweed and water marigold remain close to the lake bottom, never extending up far into the water column. Conversely, large-leaf pondweed and grassy pondweed form dense beds and grow to the water's surface where they develop floating leaves. These two species have been expanding in the lake over the past several years; now present along nearly the entire lake perimeter and in somewhat shallower water in the center of the lake (**Table 3**). These two species have the potential to become a nuisance in the lake by deterring boat access. The increased plant growth and distribution is likely due to increased light penetration due to much better water clarity.

Not shown in **Figure 6** are floating leaved plants that have spread in the southern lagoon. Our survey in 2017 found all areas not occupied by the pondweeds to have dense floating leaved cover or about 2/3rds of the area.

Distribution maps for the 5 dominant plant species in Crystal Pond are shown below for 2017 (**Figure 6**), 2016 (**Figure 7**), 2015 (**Figure 8**), and 2014 (**Figure 9**).

Table 3 – Dominant aquatic plant species list for Crystal Pond.

Scientific Name	Common Name	Acres of coverage			
		2017	2016	2015	2014
Potamogeton robbinsii	Robbins Pondweed	38.6	26.5	7.2	8.9
*Bidens beckii****	Water Marigold***	4.6	6.3	3.5	3.6
Potamogeton gramineus	Grassy Pondweed	44	6.5	8	1.5
Potamogeton amplifolius	Large-leaf Pondweed				
Vallisneria americana	Tape-grass	3.5	1.2	1.8	.2

*** State listed plant of special concern

Figure 6 – Dominant aquatic plants in Crystal Pond, 2017

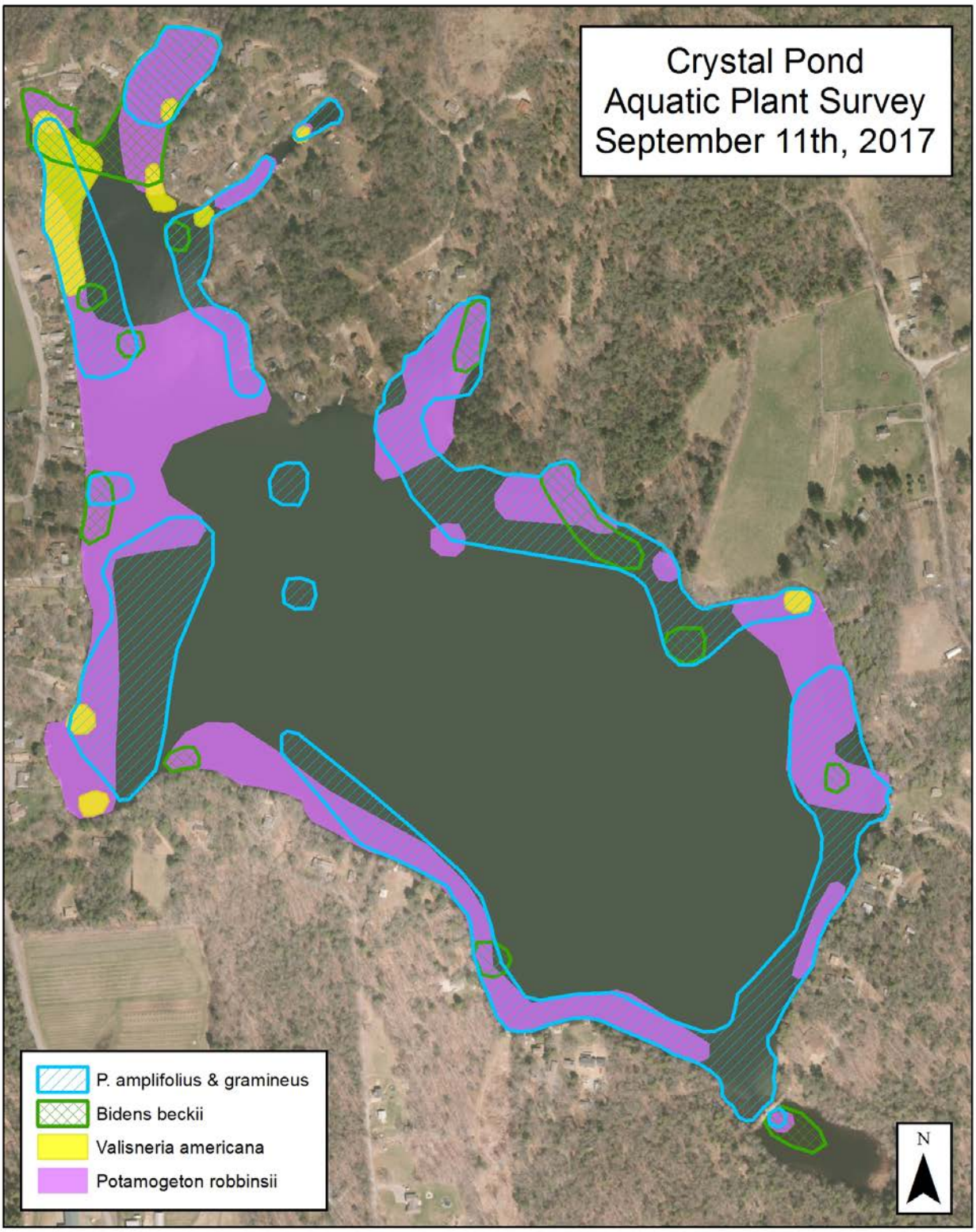


Figure 7 – Dominant aquatic plants in Crystal Pond, 2016

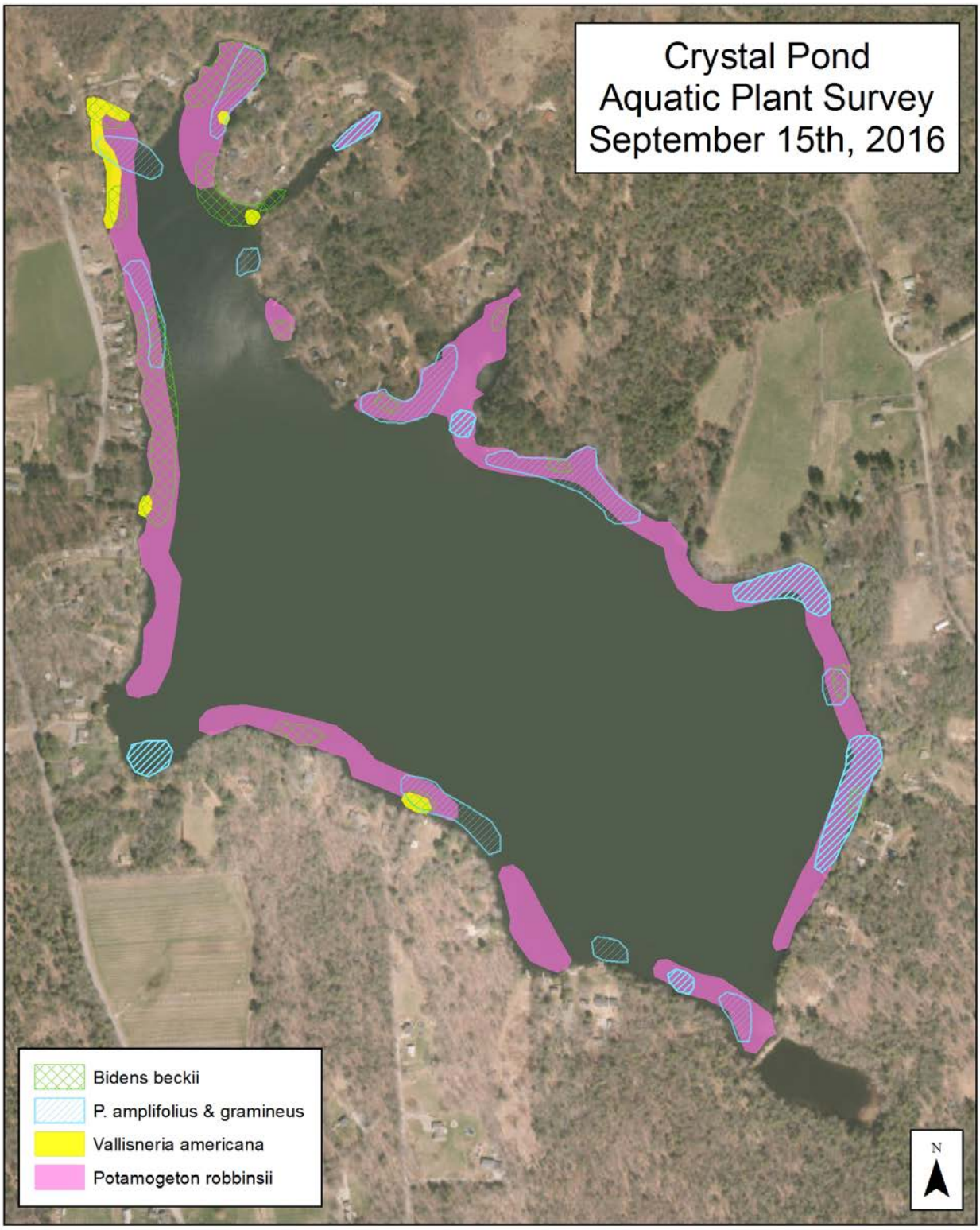


Figure 8 – Dominant aquatic plants in Crystal Pond, 2015

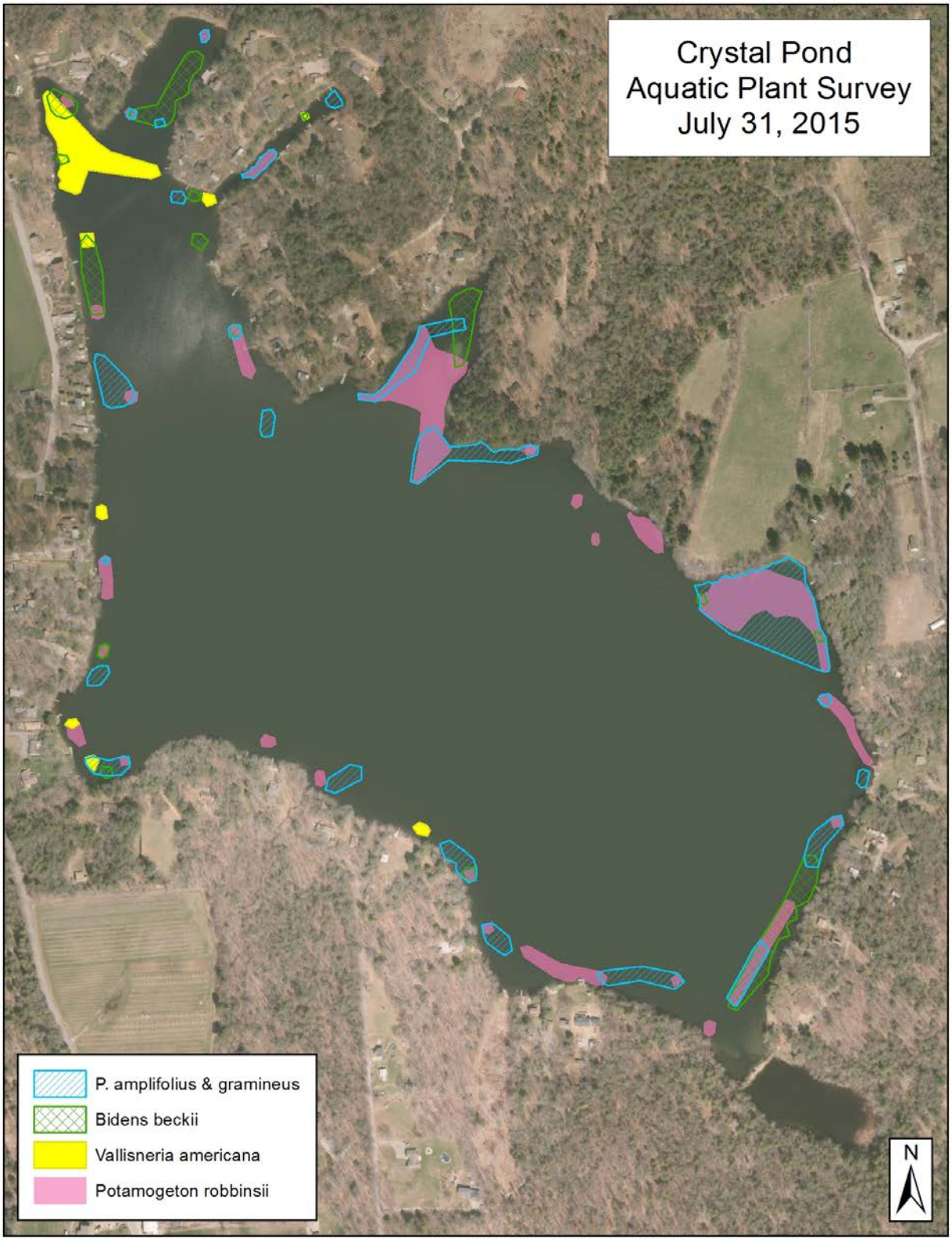
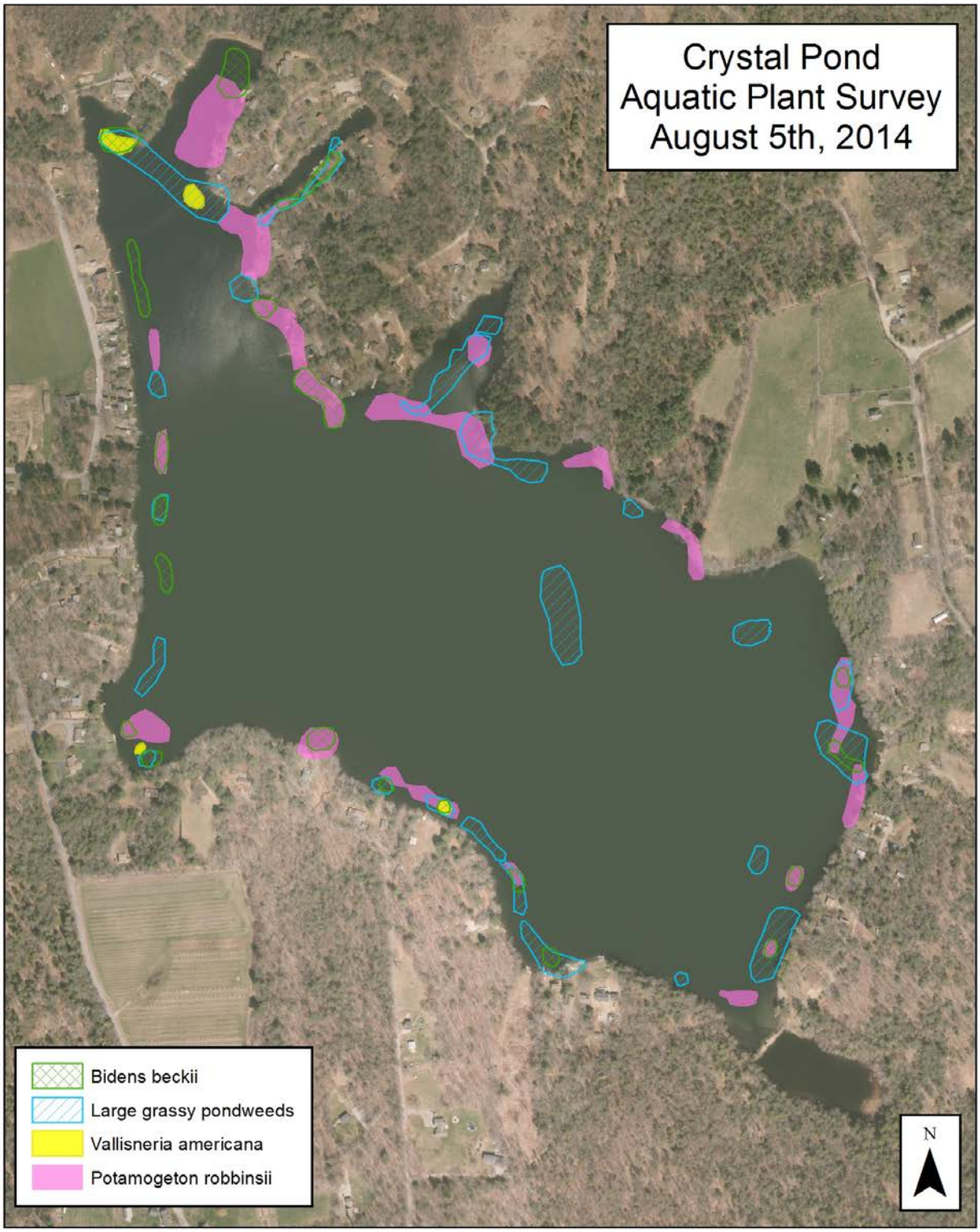


Figure 9 – Dominant aquatic plants in Crystal Pond, 2014



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 overland flows or is infiltrated into soils and flows into the lake as ground water. Site 10 has subsequently been identified as a culvert that enters the lake subsurface so cannot be sampled. **Table 5,** lists the approximate drainage area of each basin.

Figure 10 - Drainage basin of Crystal Pond-Red and principal sub-basins-Black

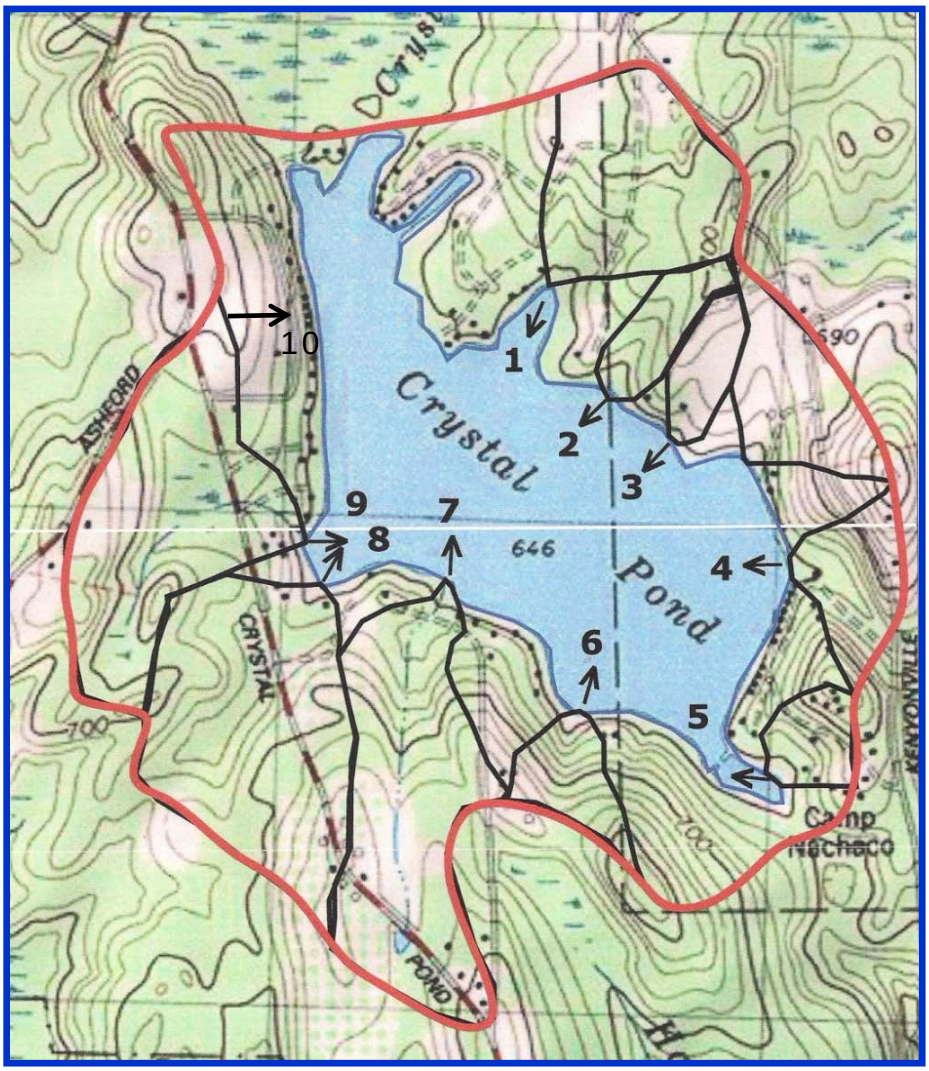


Figure 11 - Drainage basin of Crystal Pond showing inlets and sub-basin areas

The locations of flowing streams 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 4 – Drainage basins of Crystal Pond

Sub-basin Number Referenced on Figure 10	Acres	Notes
1	**34**	**Flowing inlet= samples collected**
2	9	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 5** below. A cell with no value indicates no sample was collected at that site because stream was dry.

Table 5 – Testing results from water entering Crystal Pond.

Stream number	Total Phosphorus (ppb) >10 bold						Nitrate Nitrogen (ppb) >200 bold					
	6/11/12	5/30/13	5/19/14	5/18/15	**5/10/16**	**5/19/17**	6/11/12	5/30/13	5/19/14	5/18/15	**5/10/16**	**5/19/17**
1		2	7	8	8	2		182	**514**	178	**271**	94
4		6	**14**		**18**	**23**		0	0		12	12
7	**39**	**16**	**23**		10	9	**330**	174	**370**		**358**	**391**
8	**11**	5	9	**16**	**11**	**8**	57	42	92	105	68	42
9		8	**16**	**26**	**13**	**11**		0	14	19	12	4

Stream 1 – Total phosphorus values from 2012-2017 have been very low, never exceeding 8ppb. TP in 2017 was exceptionally low in 2017, with just 2ppb of TP. Nitrate nitrogen was elevated in 2014 and 2016. However, 2017 showed decreased TN concentrations, lower than any concentrations recorded in previous years.

Stream 4 – Total phosphorus was slightly elevated in 2017, with the highest recorded concentration of all the streams. Conversely, nitrate nitrogen was very low in Stream 4.

Stream 7 – This stream has exhibited the highest TP concentrations in previous years. However, 2017 had a lower concentration of TP. Nitrate nitrogen has consistently been elevated in Stream 7 and 2017 had concentrations higher than any of the previous years.

Stream 8 – Both total phosphorus and nitrate nitrogen were low in Stream 8 and were lower than the previous three years.

Stream 9 – Total phosphorus was just barely higher than 10ppb and was lower in 2017 than in the previous three years. Nitrate nitrogen has consistently been low in this stream but in 2017 Nitrate nitrogen was lower than the concentrations recorded in the previous three years.

SUMMARY and RECOMMENDATIONS

Monitoring of water quality and aquatic plants in 2017 showed:

1. Excellent water clarity
2. Total phosphorus in the lake was above 10ppb in July, for the fourth year in a row
3. Total nitrogen in the lake was less than 300ppb for the fourth year in a row.
4. Total phosphorus was elevated in Stream 4 but was low in the four other inlets that were sampled.
5. Nitrate nitrogen was elevated in Stream 7 but was low in the four other inlets that were sampled.
6. Aquatic plants remained consistent with prior year's surveys with respect to dominant plant species.
7. No invasive species were found in the lake
8. *Potamogeton amplifolius* (large-leaf pondweed) and *Potamogeton gramineus* (grassy pondweed) are native species that are abundant in the lake and grow to the water's surface in dense patches. These plants do not appear to be an issue at this time but if they continue to expand and deter boat access, management measures may need to be considered.
9. *Floating leaved plants have spread to cover over 50% of the southern lagoon.*

Suggested 2018 Actions

1. Continue the in-lake water quality monitoring, gathering data in May, July and September.
2. Collect inlet samples from all flowing inlets in May and test the samples for total phosphorus and nitrate nitrogen.
3. Conduct a late-season full-lake aquatic plant survey to document the presence and abundance of aquatic plant species in the lake.
4. Develop and homeowners planning handout giving practical advice and listing simple things to do around the yard that make a big difference to the health of the lake.
5. **MAINTAIN EXTREME VIGILANCE FOR:**

   HYDRILLA – NOW PRESENT IN COVENTRY LAKE, COVENTRY, CT

   FANWORT – 2016/2017 INFESTATION OF MIDDLE BOLTON LAKE, VERNON, CT

Appendix

Table 6 – Total phosphorus (TP) testing results from top, middle, and bottom depths in Crystal Pond 1992-2017

Depth (m)	5/19/17	8/1/17	9/11/17	**2017 Average**
1	**8**	**12**	**9**	**6**
5	**8**	**15**	**8**	**10**
9	**12**	**17**	**19**	**16**
Average	***9***	***15***	***12***	***12***

Depth (m)	5/19/14	7/18/14	5/18/15	7/8/15	7/31/15	5/10/16	8/1/16	9/15/16
1	23	11	17	11	12	17	11	15
5	13	10	12	24	21	13	12	12
8	13	11	21	18	28	13	41	42
Average	***16.3***	***11***	***16.7***	***17.7***	***20.3***	***14.3***	***21.3***	***23***

Depth (m)	8/6/10	7/14/11	6/16/12	7/24/12	9/13/12	5/20/13	7/31/13	9/23/13
1	8	10	11	10	9	12	7	11
5	10	10	19	10	9	13	7	11
9	21	22	13	34	32	10	17	12
Average	***13***	***14***	***14***	***18***	***17***	***10.7***	***10***	***11.3***

Depth (m)	8/1/00	7/31/01	7/27/02	7/14/04	8/4/05	7/24/06	8/1/08	7/30/09
1	4	6	8	7	5	7	10	11
5	18	7	9	7	8	10	12	12
9	10	23	20	20	26	16	21	18
Average	***11***	***12***	***12***	***11***	***13***	***11***	**14**	***14***

Depth (m)	7/30/92	8/1/93	8/3/94	7/30/95	8/4/96	7/30/97	7/28/98	7/28/99
1	12	10	8	9	8	9	7	8
5	24	12	13	17	13	17	9	15
9	31	15	29	46	36	46	40	13
Average	***22***	***12***	***17***	***18***	***19***	***24***	***19***	***12***

Table 7 – Total nitrogen (TN) testing results from top, middle, and bottom depths in Crystal Pond 1992-2017

Depth (m)	5/19/17	8/1/17	9/11/17	2017 Average
1	**231**	**231**	**233**	232
5	**248**	**291**	**263**	267
9	**295**	**225**	**271**	264
Average	***258***	***249***	***256***	***254***

Depth (m)	5/19/14	7/18/14	5/18/15	7/8/15	7/31/15	5/10/16	8/1/16	9/15/16
1	174	261	245	215	244	189	275	291
5	176	229	207	248	247	205	287	310
9	186	247	307	348	298	193	677	641
Average	***179***	***246***	***253***	***270***	***263***	***196***	***413***	***414***

Depth (m)	8/6/10	7/14/11	6/11/12	7/24/12	9/13/12	5/30/13	7/31/13	9/23/13
1	244	357	420	Samples	310	401	234	233
5	248	398	355	lost	420	256	324	311
9	228	409	500		550	276	269	234
Average	***240***	***388***	***425***		***427***	***311***	***275***	***259***

Depth (m)	8/1/00	7/31/01	7/27/02	7/14/04	8/4/05	7/24/06	8/1/08	7/30/09
1	750	360	400	800	425	470	510	485
5	610	370	270	645	500	550	580	365
9	885	640	540	1,360	830	1,370	725	460
Average	***580***	***457***	***403***	***935***	***585***	***797***	***605***	***437***

Depth (m)	7/30/92	8/1/93*	8/3/94	7/30/95	8/4/96	7/30/97	7/28/98	7/28/99
1	460	50	420	316	390	330	455	310
5	610	90	520	460	450	336	480	310
9	600	64	520	1120	2010	1130	805	330
Average	***557***	***68***	***487***	***632***	***950***	***599***	***580***	***371***

* These values are unusually low and considered aberrant