2018 Crystal Pond Monitoring Report

Prepared For:

Crystal Pond Association

Eastford & Woodstock, CT

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SYNOPSIS OF 2018 RESULTS

1. Water clarity in 2018 was again excellent, with readings ranging from 6 to 6.6 meters (19.7 to 21.7 feet). These readings are similar to the Secchi depths recorded in 2017 and better than most readings from prior years.
2. Total phosphorus concentrations averaged 11ppb, slightly higher than the upper threshold of 10ppb.
3. Phosphorus at the bottom of the lake's deep spot were low, ranging from 11ppb to 27ppb.
4. Total nitrogen concentrations in the lake were good, remaining below 300ppb for the duration of the season. Total nitrogen at the bottom of the deep spot was also low, ranging from 206ppb to 308ppb. These levels are low, although slightly higher than the concentrations recorded in 2017.
5. Inlet samples were collected in May from the five flowing inlets. Consistent with the 2017 results, total phosphorus was very low in 4 of the inlets, but Inlet #4 had elevated phosphorus (105ppb).
6. During the August 20th aquatic plant survey, 25 species were found in the lake. Three species in the lake were dominant, with frequencies above 20%: Potamogeton robbinsii (Robbin's pondweed), Potamogeton amplifolius (large-leaf pondweed), and Bidens beckii (water marigold), which is a Connecticut state listed protected Species of Special Concern. No invasive species were found in the lake in 2018.
7. A bloom of the cyanobacteria Microcystis occurred in October. Microsyctis occurred as buoyant clumps visible to the naked eye. Each clump was composed of many 1000s of cells. Clumps were distributed lake wide. Water clarity and phosphorus concentrations on October 4th were nearly identical to August and continue to indicate that Crystal Pond was Oligotrophic.
8. Freshwater Jellyfish (Craspedacusta sowerbii), were seen in the lake during October visit. For more information visit https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=1068

BACKGROUND

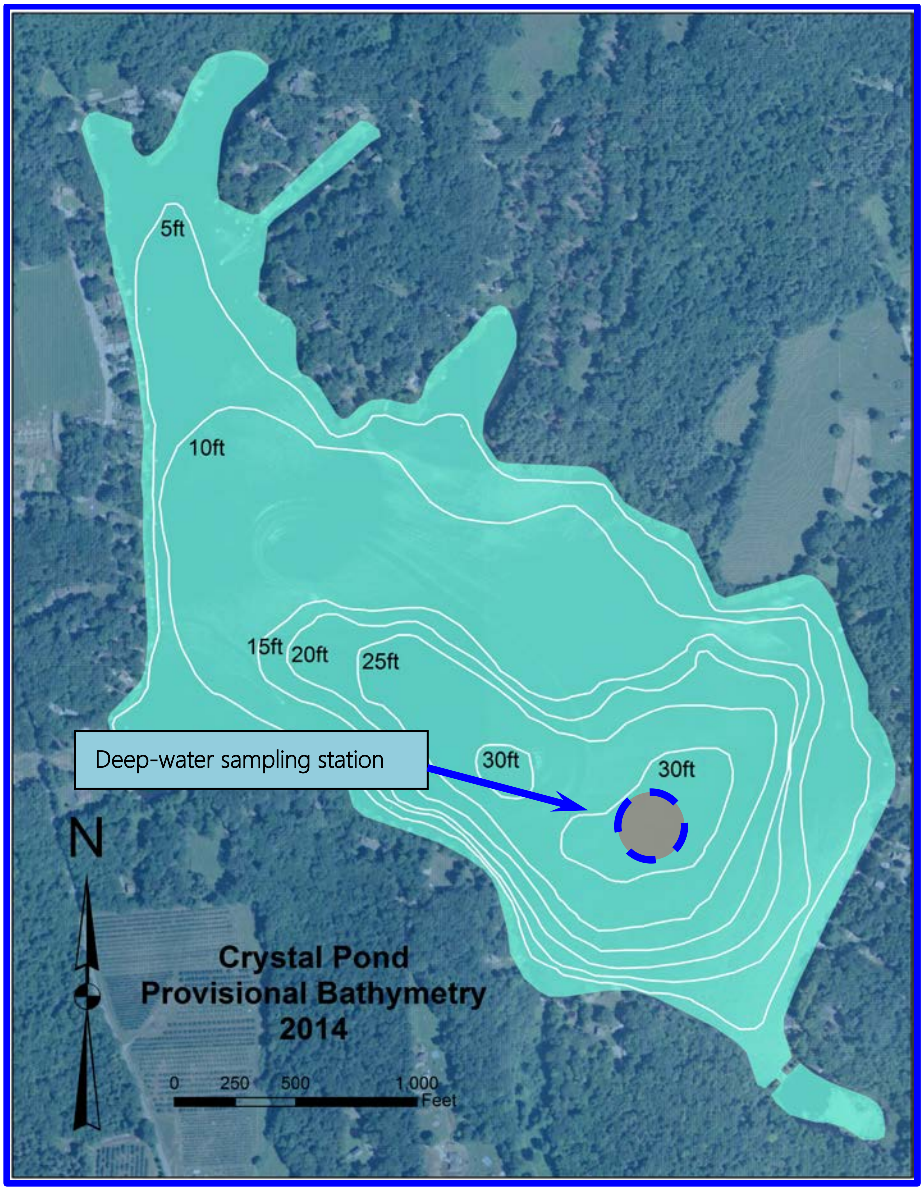
Crystal Pond is a 150-acre lake in the towns of Eastford, and Woodstock, CT. In July 1990, the Crystal Pond Association initiated a water quality monitoring program consisting of:

- 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) began monitoring water quality of Crystal Pond in 2004, which included one sampling in July, and an investigation of aquatic plants in the coves and along the northern shore.
- NEAR started surveying aquatic plants annually in 2011 and now has 8 years of surveys to compare --2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018.
- In 2012, NEAR began May inlet water sampling. May sampling is important because these small streams are dry during most of the summer.
- This report presents results of 28 years of consistent water quality monitoring conducted at the same location, at the same time (around the end-of-July), 5 years of inlet chemistry results, and 8 years of surveying aquatic plants.

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



MONITORING RESULTS

In 2018, Northeast Aquatic Research made 4 visits to Crystal Pond.

1. May 14th: collected spring lake water quality data and samples from flowing inlets
2. July 31st: collected the annual end-of-July water quality data
3. August 20th: collected water quality data and documented aquatic plants
4. October 4th: collected water quality data in response to presence of cyanobacteria in the lake

Principal water quality trends at Crystal Lake that are addressed in 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 the CT DEEP categorization of lakes that uses the amount of nutrients in surface waters during summer conditions (**Table 1**). A trophic category is a way to define the degree of plant and algae growth that occurs in a lake, which is a way to track productivity and water quality decline. Very clear water with no weeds or algae results from very low nitrogen and phosphorus and is considered oligotrophic. Lakes with excessive amounts of weeds and very green water resulting from high nutrient concentrations are eutrophic. Nutrient loading from the drainage basin leads to increased plant growth in lakes. **Table 1** shows lake Trophic Status. **Crystal Lake is considered oligotrophic (the best category). Target criteria are highlighted 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*

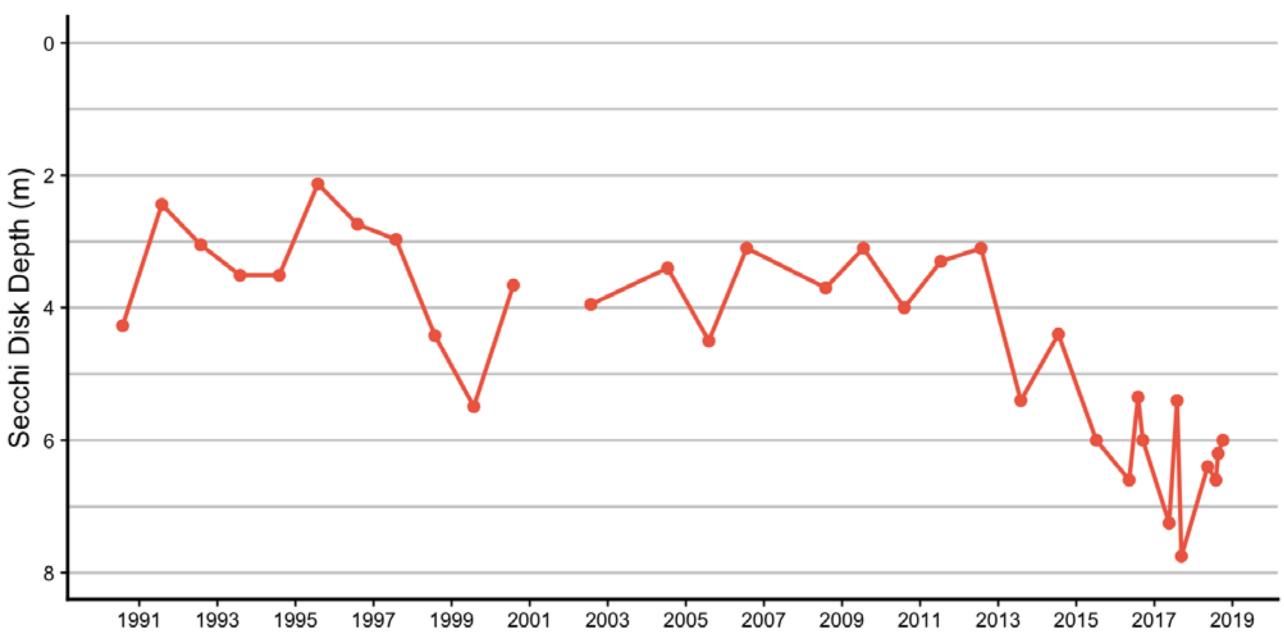
Water Clarity / Secchi Disk Depth

The summer water clarity of Crystal Pond has been consistently improving since 1990 and was excellent again in 2018, with readings between 6.0m and 6.6m. **Table 2** gives the record of Secchi disk depth readings at Crystal Pond. **Figure 2** shows trend over time of water clarity showing significant improvement beginning in 2013.

Table 2 – Secchi disk depth measurements at Crystal Pond, 1990-2018.

Date	Secchi Disk Depth	Date	Secchi Disk Depth	Date	Secchi Disk Depth
7/30/90	4.27	7/27/02	3.95	7/8/15	6.0
7/31/91	2.44	7/14/04	3.4	5/10/16	6.6
7/30/92	3.05	8/4/05	4.5	8/1/16	5.35
8/1/93	3.51	7/24/06	3.1	9/15/16	6.0
8/3/94	3.51	8/1/08	3.7	5/19/17	7.25
7/30/95	2.13	7/20/09	3.1	8/1/17	5.4
8/4/96	2.74	8/6/10	4.0	9/11/17	7.75
7/30/97	2.97	7/14/11	3.3	**5/14/18**	**6.4**
7/29/98	4.42	7/24/12	3.1	**7/31/18**	**6.6**
7/28/99	5.49	7/31/13	5.4	**8/20/18**	**6.2**
8/1/00	3.66	7/18/14	4.4	**10/4/18**	**6.0**

Figure 2 - Secchi Depths at Crystal Pond, 1990-2018.



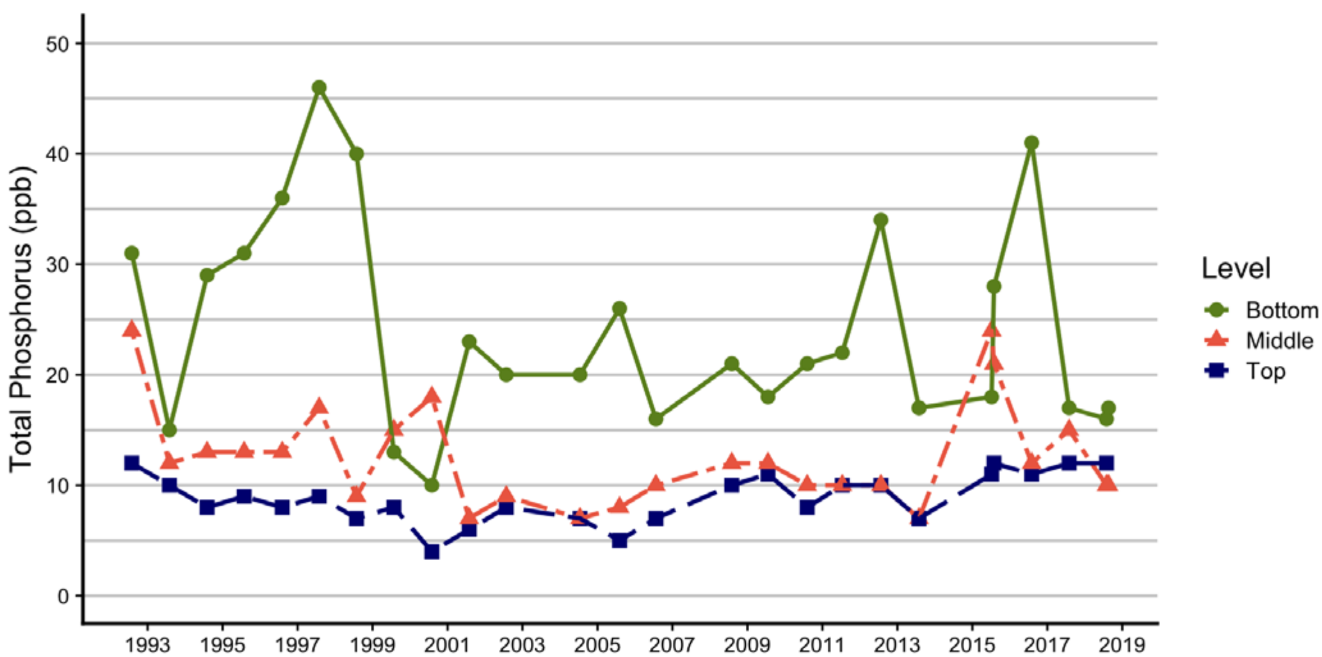
Total Phosphorus

From 1992 through 2013, total phosphorus (TP) concentrations in the surface waters of Crystal Pond remained near or below 10ppb. For the past four years however, TP has been slightly elevated, with most concentrations above 10ppb (**Figure 3**). In 2018, TP remained very consistent over the course of the season and just slightly elevated, with a concentration of 11ppb in May and 12ppb in July and October. There were only minor differences in TP between August and October, the surface concentration increased by 1ppb, not enough to account of the bloom of Microcystis. The deep water TP was lower in October--11ppb, than in August--17ppb indicating that there was no pulse of internal loading that could have triggered a bloom.

At the bottom of the deep spot, total phosphorus ranged from 11ppb to 17ppb. This is relatively consistent with the concentrations recorded in recent years.

All total phosphorus test results from 1992 – 2018 are presented in **Table 8**.

Figure 3 – Trends in July total phosphorus values from the top, middle, and bottom depths at Crystal Pond 1992-2018.

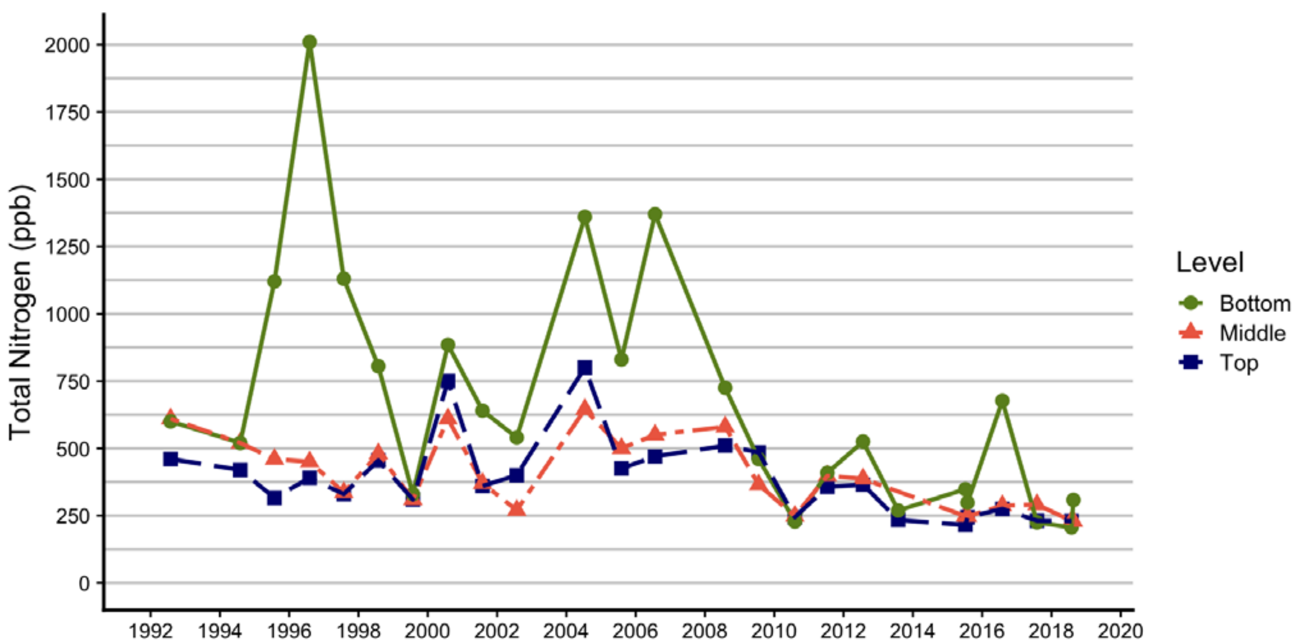


Total Nitrogen

Total nitrogen (TP) includes fractions of nitrate, ammonia, and organic components. In 2018, total nitrogen concentrations were low for the majority for the season, remaining below 300ppb. In August and October, TN in the bottom water just slightly exceeded 300ppb (**Figure 4**). Total nitrogen at the top of the water column (1 meter) remained steadily between 185ppb and 245ppb. TN in Crystal Pond seems to have come down significantly from ~500ppb to 250ppb. I'd like to see Crystal Lake TN come down to 250ppb and stay that way with no spikes.

The results for total nitrogen sampling over the last 25 years are provided in **Table 9**.

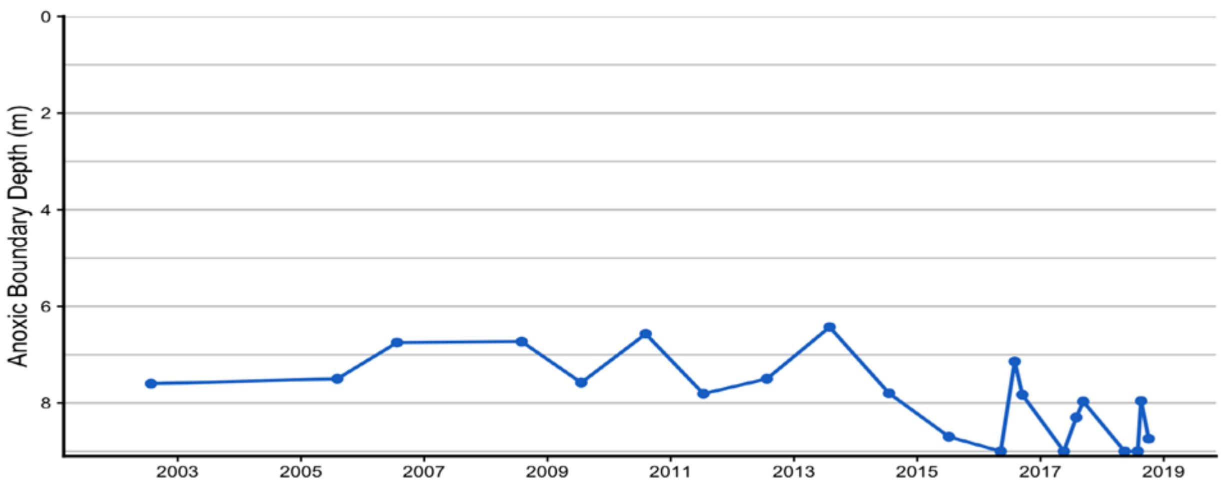
Figure 4 – Trends in July total nitrogen values from the top, middle, and bottom depths at Crystal Pond 1992-2018.



Dissolved Oxygen

The location of the anoxic boundary in July has decreased in the last couple of years to barely reach the 8 meter depth. Between 2002 and 2014, the anoxic boundary was always over 8 meters and commonly reached 7 meters. This indicates the dissolved oxygen regime between 6 and 8 meters of water, about 15% of the lake volume has improved to now be useable by aquatic life (**Figure 5**).

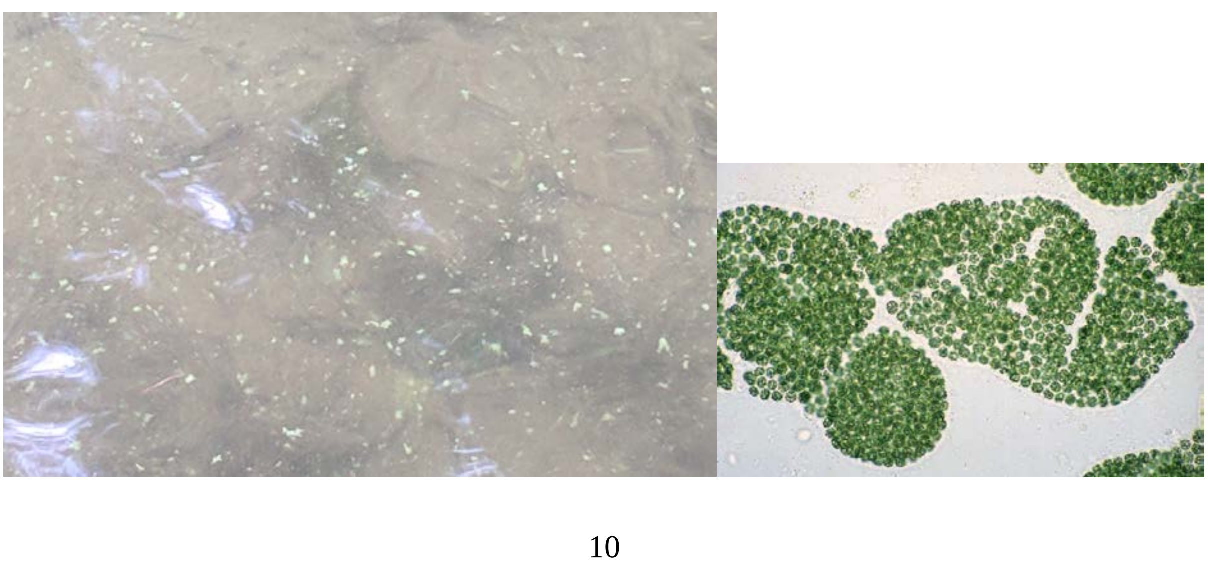
Figure 5 – Anoxic Boundary Depths at Crystal Pond, 2002-2018.



October 2018 Visit

We visited the lake in October because of possible cyanobacteria bloom, first reported in late September. The lake was found to have huge buoyant colonies of the cyanobacteria; microcystis. The colonies were spread out openly across the whole lake down to a meter or so deep (**Figure 6**). Colonies were huge clumps of many 1000s of Microcystis cells (**Figure 6-insert**). A sample of the lake water was tested for microcystin a cyanotoxin, test was negative.

Figure 6 – Photograph of Microcystis colonies in Crystal Pond October 4, 2018. Colonies, green speckles in the photo, are approximately ¼ to ½ inch in size. Insert shows Microcystis magnified ~1000x



Aquatic Plants

The aquatic plants in Crystal Pond were surveyed August 20th, 2018. No invasive aquatic plant species were found in the lake during this survey. Aquatic plant distribution and abundance were similar to 2017, with small decreases in the two robust pondweeds, grassy and large-leaf pondweed.

Five species, all of which are native, have remained dominant in the lake in all eight surveys (2004, 2011-2018). Robbins pondweed (*Potamogeton robbinsii),* water marigold (*Bidens beckii*), grassy pondweed (*Potamogeton gramineus*), and large-leaf pondweed (*Potamogeton amplifolius*) are consistently present at frequencies near or above 20%. *Vallisneria americana* (tape grass) is not as dominant as the other four species but has been increasing in abundance. Robbins pondweed and water marigold remain close to the lake bottom, rarely extending up into the water column, and tape grass becomes more of a nuisance later in the season when the flowers come to the surface. 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; but showed decreased coverage in some areas and fewer surface leaves in 2018.

Distribution maps for the 5 dominant plant species in Crystal Pond are shown below for 2017 (**Figure 7**), 2016 (**Figure 8**), 2015 (**Figure 9**), and 2014 (**Figure 10**).

Table 3 – Dominant aquatic plant species in Crystal Pond.

Scientific Name	Common Name	Percent Occurrence								
		2018	2017	2016	2015	2014	2013	2012	2011	2004
Potamogeton robbinsii	Robbins Pondweed	53	54	77	52	31	27	42	57	26
*Bidens beckii****	Water Marigold***	29	27	35	23	30	26	19	40	10
Potamogeton gramineus	Grassy Pondweed	19	31	35	15	20	21	44	23	4
Potamogeton amplifolius	Large-leaf Pondweed	34	49	33	52	43	16	19	28	24
Vallisneria americana	Tape-grass	11	11	14	10	6	5	7	6	1

*** State listed plant of special concern

Figure 7 – Aquatic Plants as mapped in Crystal Pond during 2017 approximately the same in 2018.

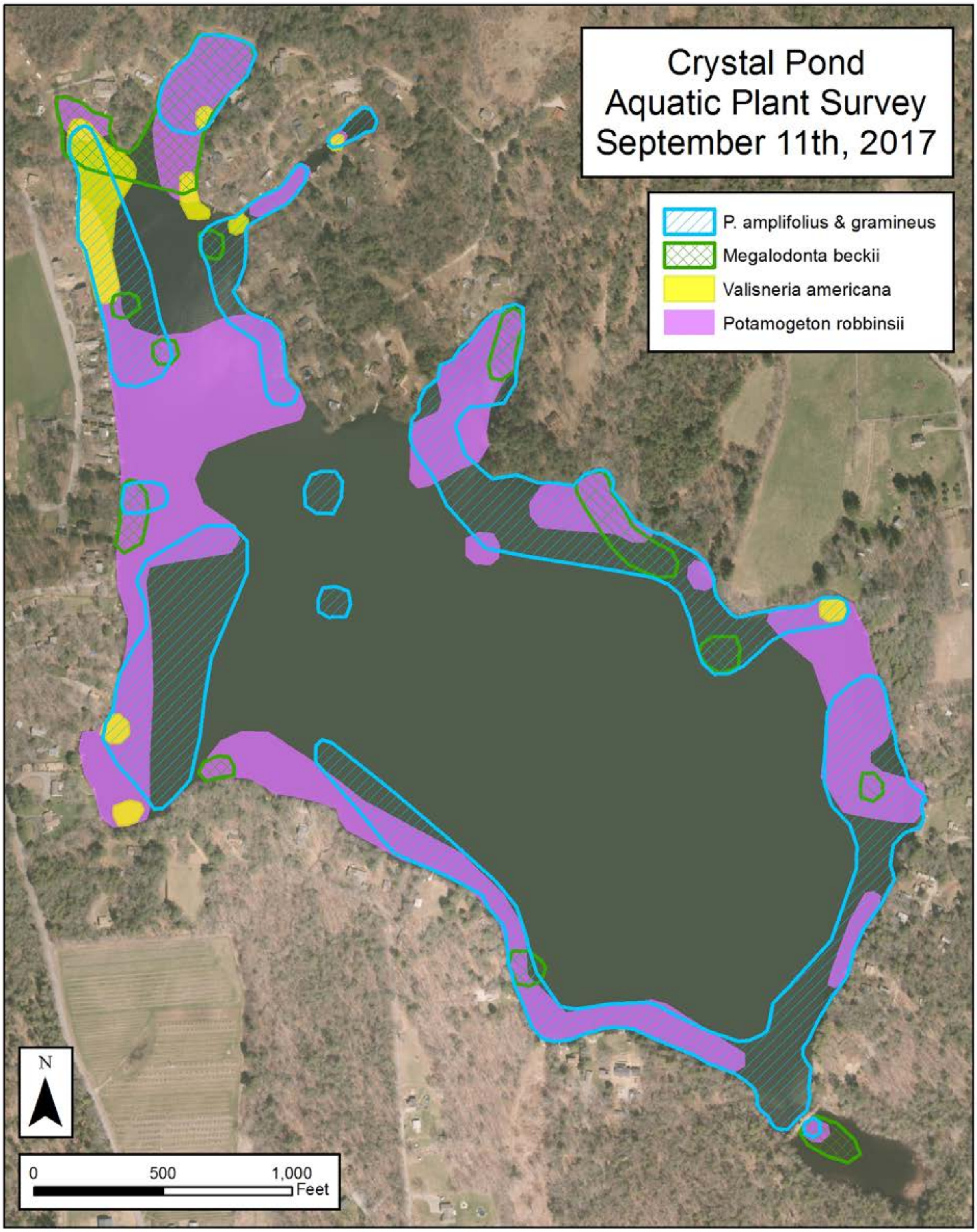


Figure 8 – Aquatic Plants in Crystal Pond, 2016.

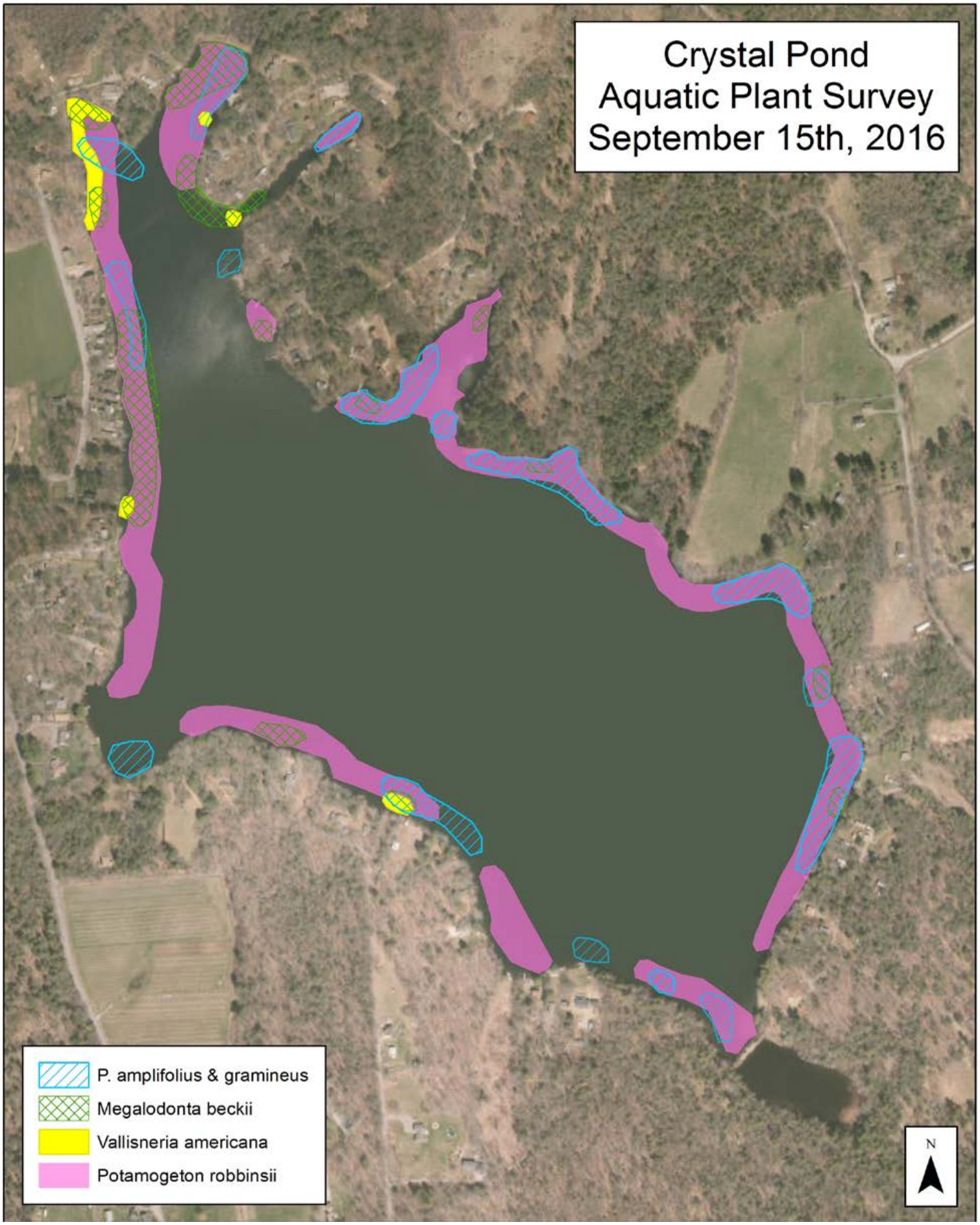


Figure 9 – Aquatic Plants in Crystal Pond, 2015.

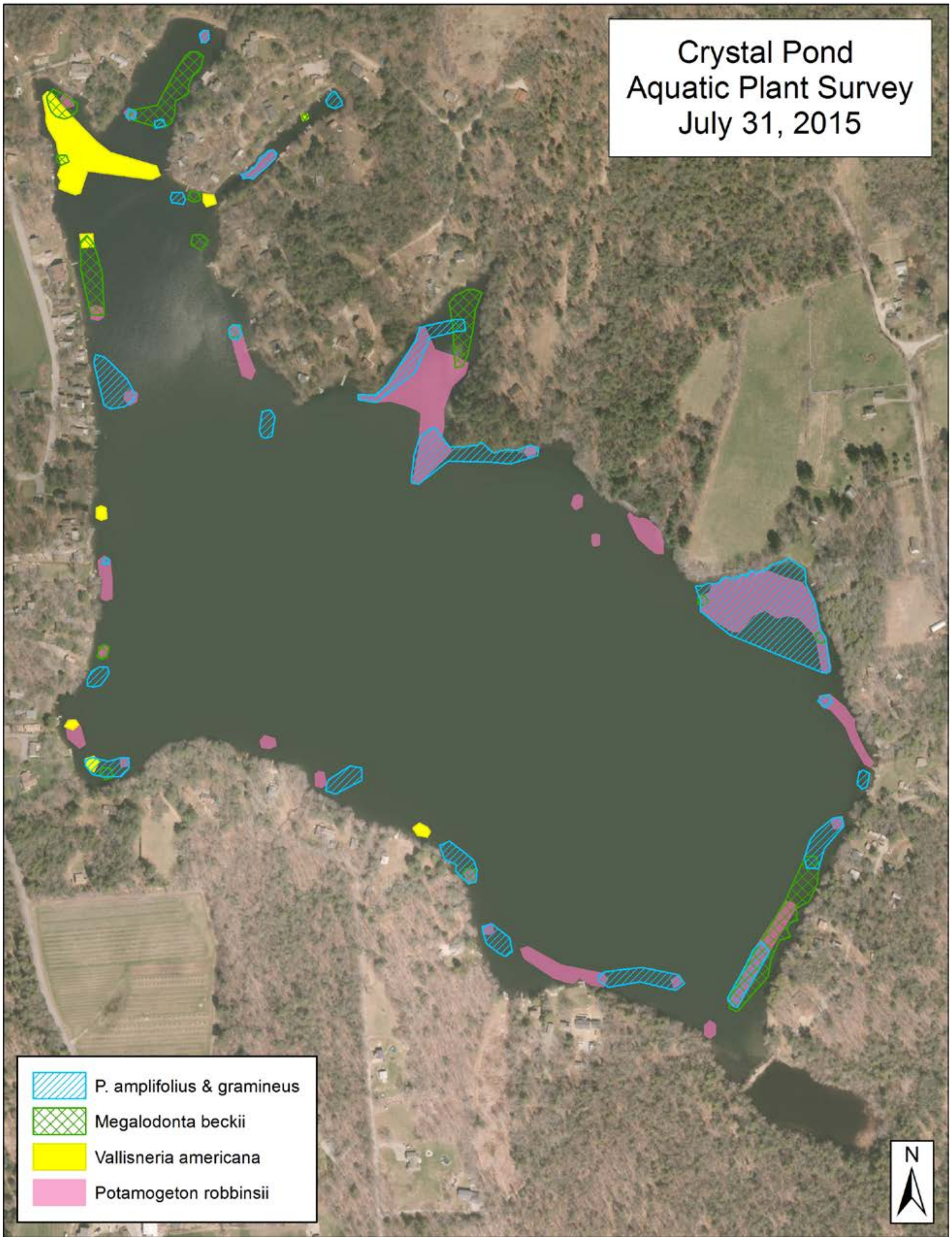
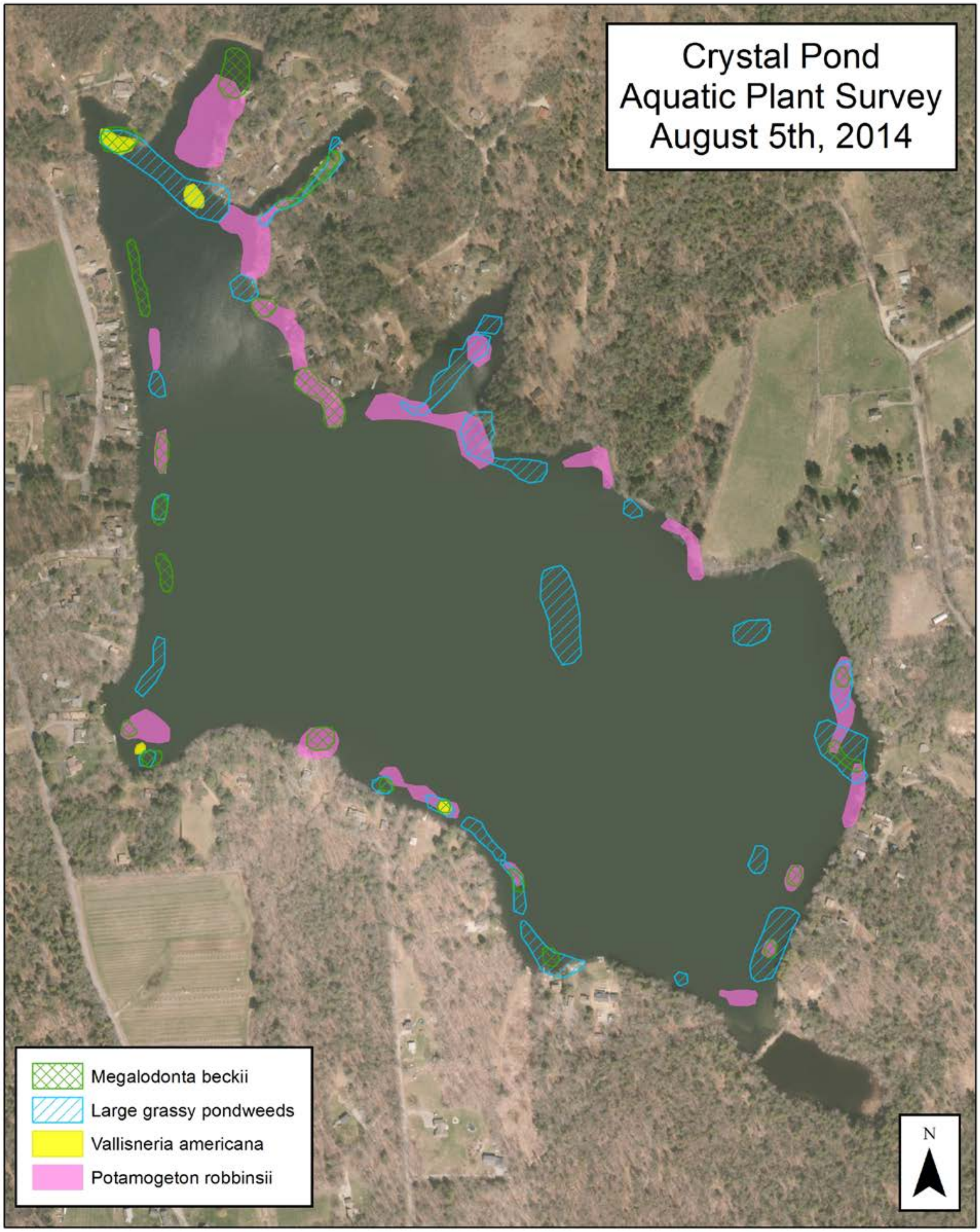


Figure 10 – Aquatic Plants in Crystal Pond, 2014.



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 11),** 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**,** draining 206.7 acres or roughly half the total watershed area (**Figure 12**). The remaining 193 acres 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, **Table 5** lists the testing results.

Figure 11 - Drainage basin of Crystal Pond showing principal sub-basins.

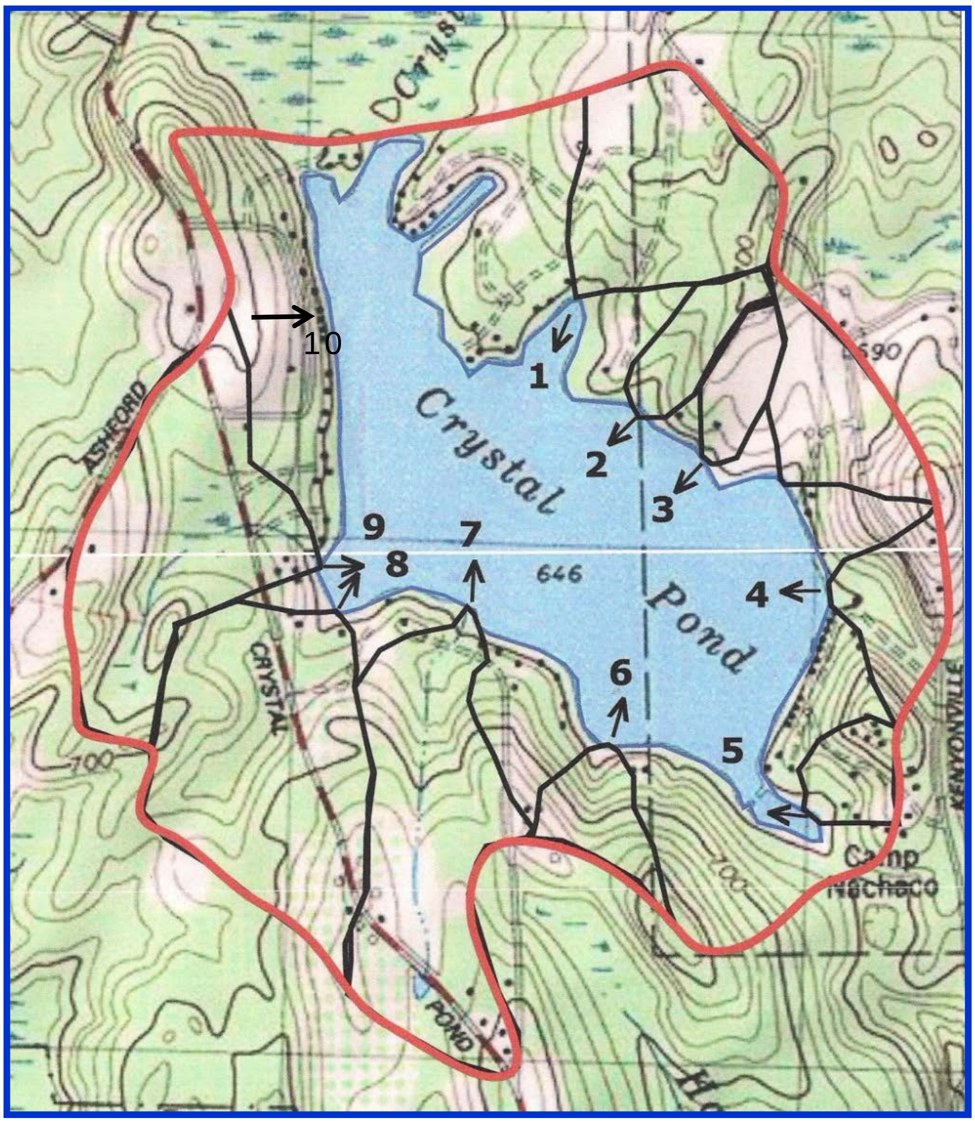
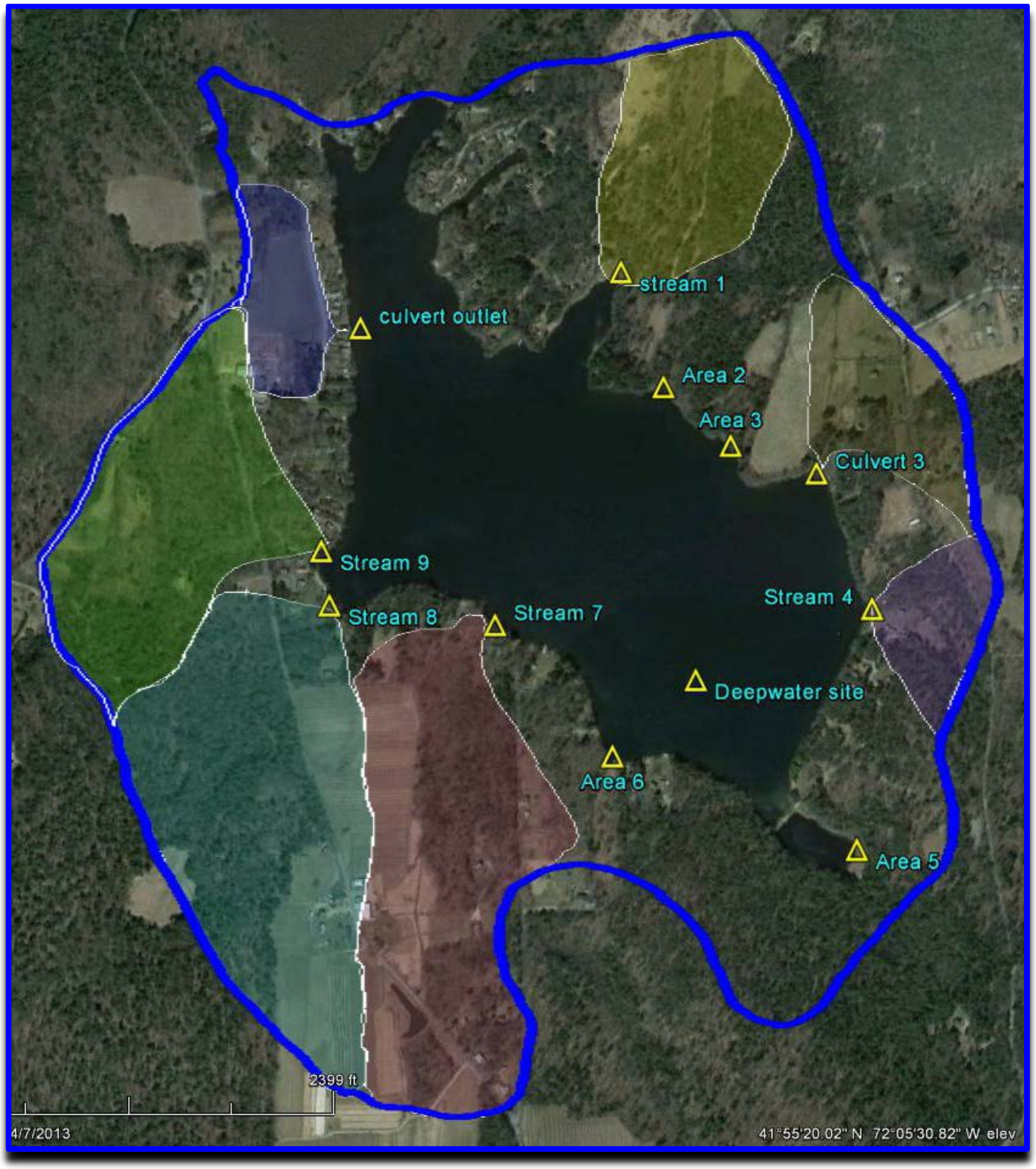


Figure 12 - Drainage basin of Crystal Pond showing inlets and sub-basins.



The locations where water was found to be flowing into the lake are labeled as Streams 1, 4, 7, 8 and 9 in **Figures 10 & 11**. 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

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**	**5/14/18**	6/11/12	5/30/13	5/19/14	5/18/15	**5/10/16**	**5/19/17**	**5/14/18**
1		2	7	8	8	2	7		182	**514**	178	**271**	94	149
4		6	**14**		**18**	**23**	**105**		0	0		12	12	32
7	**39**	**16**	**23**		10	9	**15**	**330**	174	**370**		**358**	**391**	**566**
8	**11**	5	9	**16**	**11**	**8**	**15**	57	42	92	105	68	42	130
9		8	**16**	**26**	**13**	**11**	**17**		0	14	19	12	4	23

Streams Results Discussion

Water sampling results for phosphorus and nitrate tests are shown in **Table 5** above. 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.

Stream 1 – Total phosphorus values from 2012-2018 have remained very low, never exceeding 8ppb.

2017 showed significantly decreased NOX and while it rose again in 2018, it remained lower than levels recorded from 2013 through 2016.

Stream 4 – Total phosphorus was elevated at Stream 4 in 2018, with the highest TP concentration recorded at any of the streams since inlet sampling began in 2012. It is very possible that this high concentration was caused by sediment in the sample, which would mean this sample should be omitted.

While TP was elevated, nitrate nitrogen remained low, at just 32ppb.

Stream 7 – In this stream, total phosphorus was slightly elevated at 15ppb. This is higher than the concentrations seen in the previous 2 years, but lower than the concentrations recorded in 2012 – 2014.

Consistent with results from previous years, nitrate nitrogen was very elevated in 2018. NOX has been increasing over the past three years. 2017 had concentrations higher than any previous year, and the concentration in 2018 was even higher than that. The elevated nitrate nitrogen in this stream could be explained by a wetland or a large number of houses in the area.

Stream 8 – Total phosphorus in Stream 8 has historically remained low, but was slightly elevated in 2018, at 15ppb. It would be beneficial to test Stream 8 for orthophosphate in 2019, to determine whether this is the cause of the elevated TP concentrations. This is the second highest concentration recorded over the last 7 years, just 1ppb lower than the 2015 level. Nitrate nitrogen remained within the acceptable limit this year, but was still higher than any concentration recorded at this stream in prior years.

Stream 9 – Total phosphorus was elevated at 17ppb, which is the second highest concentration recorded at this inlet. Nitrate nitrogen has consistently been low in this stream and remained low in 2018.

SUMMARY and RECOMMENDATIONS

Monitoring of water quality and aquatic plants in 2018 showed:

1. Excellent water clarity
2. Total phosphorus in the lake was above 10ppb in July, for the fifth year in a row
3. Total nitrogen in the lake remained below 300ppb in May and July, but rose to slightly above 300ppb in the bottom waters in August and October, likely due to the internal anoxic release of ammonia in the bottom water.
4. Total phosphorus was very elevated in Stream 4 and slightly elevated in Streams 7, 8 and 9. TP remained low in Stream 1.
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 aquatic plant 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 they may soon become problematic in some areas as they grow more densely and reach the surface. If this becomes the case, management measures may need to be considered.

<u>Suggested 2019 Actions</u>

1. Continue the in-lake water quality monitoring. It would be beneficial to gather lake data once per month from May through October to track the full extent of seasonal fluctuations, including peak extent of anoxic water, best and worst seasonal clarity, and peak nutrient concentrations. The Microcystis likely came from resting spores on the bottom sediments with growth triggered by some set of conditions that were just right. More frequent testing in the summer and late fall would help understand how and why the bloom occurred.
2. Collect inlet samples from all flowing inlets in May and test the samples for total phosphorus and nitrate nitrogen. Inlet #4 had high phosphorus this May and inlet #7 had high nitrate. Some investigation in the watershed should be conducted to note anything obviously different.
3. Conduct a late-season full-lake aquatic plant survey to document the presence and abundance of aquatic plant species in the lake.

4. **MAINTAIN EXTREME VIGILANCE FOR:**

   HYDRILLA – NOW PRESENT IN COVENTRY LAKE, COVENTRY, CT

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

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 6** 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 7**. Record of nitrogen testing at Crystal Pond is given in **Table 8**

Table 6 - 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 7 – Total phosphorus (TP) testing results from top, middle, and bottom depths in Crystal Pond, 1992-2018.

Depth (m)	5/14/18	7/31/18	8/20/18	10/4/18	**2018 Averages**
1	11	12	10	12	**11**
5	12	10	11	6	**10**
9	12	16	17	11	**14**
Average	*12*	*13*	*14*	*10*	**12**

Depth (m)	5/19/17	8/1/17	9/11/17	**2017 Averages**
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)	7/30/95	8/4/96	7/30/97	7/28/98	7/28/99	7/30/92	8/1/93	8/3/94
1	9	8	9	7	8	12	10	8
5	17	13	17	9	15	24	12	13
9	46	36	46	40	13	31	15	29
Average	*18*	*19*	*24*	*19*	*12*	*22*	*12*	*17*

Table 8 – Total nitrogen (TN) testing results from top, middle, and bottom depths in Crystal Pond, 1992-2018.

Depth (m)	5/14/18	7/31/18	8/20/18	10/4/18	**2018 Averages**
1	185	230	229	245	222
5	202	230	269	251	228
9	226	206	308	306	262
Average	***204***	***222***	***269***	***267***	***237***

Depth (m)	**5/10/16**	**8/1/16**	**9/15/16**	**5/19/17**	**8/1/17**	**9/11/17**	**2017 Averages**
1	189	275	291	231	231	233	232
5	205	287	310	248	291	263	267
9	193	677	641	295	225	271	358
Average	***196***	***413***	***414***	***258***	***249***	***256***	***286***

Depth (m)	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)	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***	