Northeast Aquatic Research

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March 2024

TO: Crystal Pond Association
ATTN: Elizabeth Murphy
Re: Crystal Pond 2023 Water Quality and Aquatic Plant Results

BACKGROUND

Crystal Pond is a 150-acre lake in the towns of Eastford and Woodstock, CT. In July 1992, the Crystal Pond Association initiated a water quality monitoring program consisting of visiting the location of deepest water (~32 feet) on or around July 31st each year (**Figure 1**).

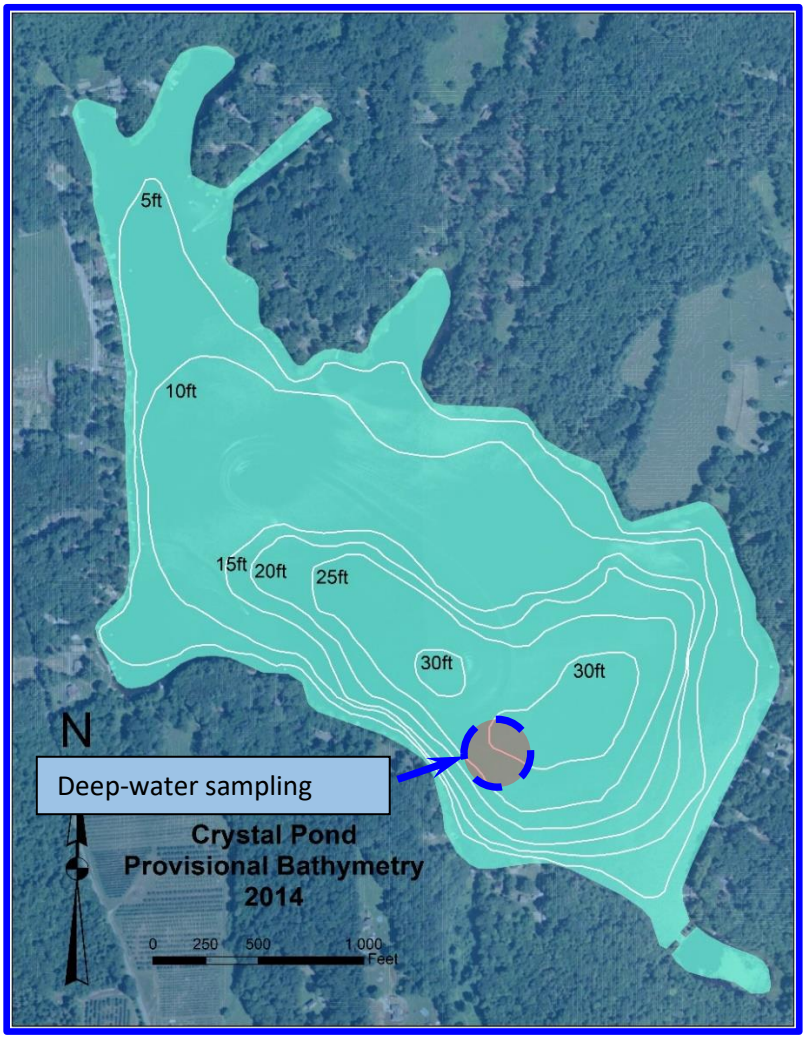
- Water quality monitoring consists of measuring the following parameters:
  - Water clarity using a Secchi disk.
  - Water temperature readings each 1-meter depth increment from top to bottom
  - Dissolved oxygen readings each 1-meter depth increment from top to bottom
  - Collection of water samples from the top, middle, and bottom of the water column for analysis of the nutrients total phosphorus, total nitrogen, and ammonia nitrogen.
- NEAR started annual surveys of aquatic plants around the whole in 2011.
- In 2012, NEAR began making two, and then three visits to the lake each year. Additional visits were made in May to collect samples of inlet waters because these small streams are dry during the July 31st visit, and in late August to conduct the annual aquatic plant survey.
- In 2021, the Crystal Pond Association started collecting the water quality data. That year, CPA volunteers measured the water clarity and water temperature/dissolved oxygen profiles 30 times between April and October. Water samples were collected 5 times.
- In 2022 and 2023, CPA volunteers visited the lake over 30 times to measure water column in-situ data as well as collect water and plankton samples.

The water quality parameters are primarily assessed using the CT DEEP's categorization of Connecticut lakes (Table 1). The goal for Crystal Pond is to remain in the oligo-mesotrophic range.

Table 1. Connecticut DEEP Trophic Categories and Ranges of Indicator Parameters.

Category	T. Phosphorus (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)	Chlorophyll *a* (ppb)
Oligotrophic	0 -- 10	2 -- 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 +

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



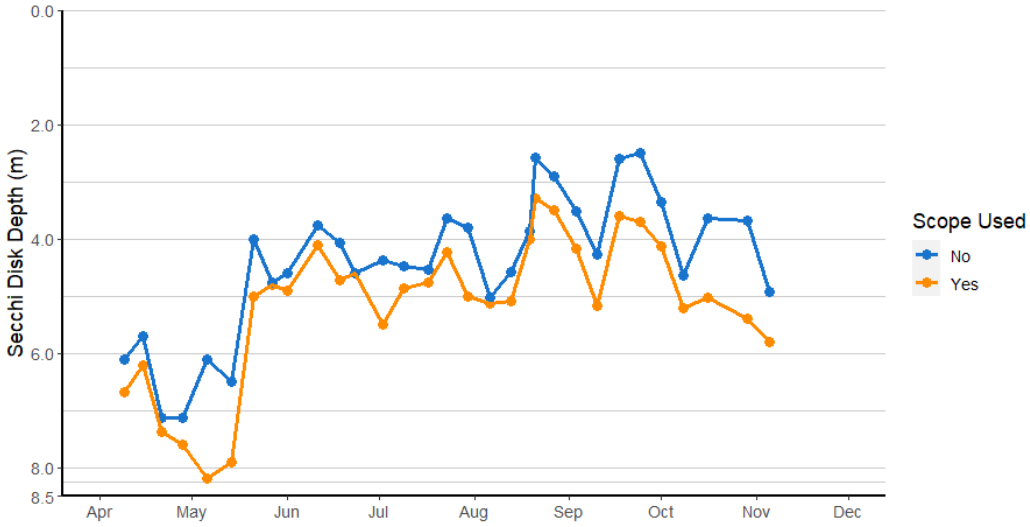
2023 Water Quality Results

Northeast Aquatic Research (NEAR) conducted one full-lake aquatic plant survey on September 6th, 2023. CPA volunteers made 31 visits to the deep-water station to measure water clarity and temperature and dissolved oxygen profiles between April and November.

Water Clarity

Water clarity was measured with and without a view scope 31 times between April 9th and November 5th (**Figure 2**). Water clarity was very good, better than 6 meters, until late May, after which clarity fluctuated between 4 and 5.5 meters. Clarity dipped below 4 meters for two brief periods, once in August and again in September. The best clarity, 8.18 meters, was recorded on May 6th. The worst clarity, 3.3 meters, was recorded on August 21st.

Figure 2. Average Secchi disk depths (m) in Crystal Pond, April to November 2023.



Temperature and Dissolved Oxygen

The water temperature was warmest in mid-July (**Figure 3**). This is earlier than the expected date of warmest lake water in our region, August 1st. The upper and middle layers of the water column remained warm through September, and even showed a second warming event in mid-September. Typically, once lakes begin cooling after August 1st, they do not gain heat again that year. After mid-September, the lake cooled quickly, becoming isothermal by October 1st.

The bottom water gradually lost dissolved oxygen (DO) beginning in early May and became fully anoxic at the bottom (red in **Figure 4**) in early June. The anoxic boundary (area between red and purple in **Figure 4**) reached a maximum ascent of approximately 6.5 meters in mid-August, although hypoxic conditions continued to about 5.5 meters. DO in the very bottom water was resistant to full oxidation until mid-October.

Figure 3. 2023 water temperature (°C)

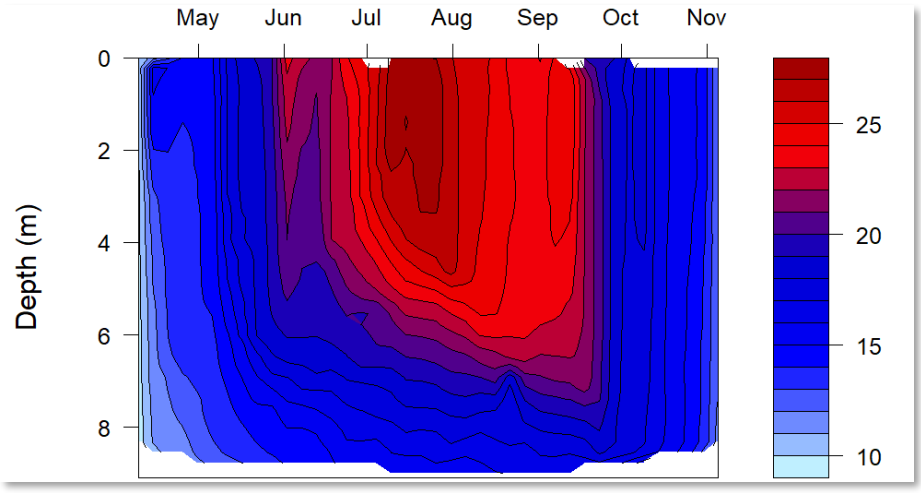
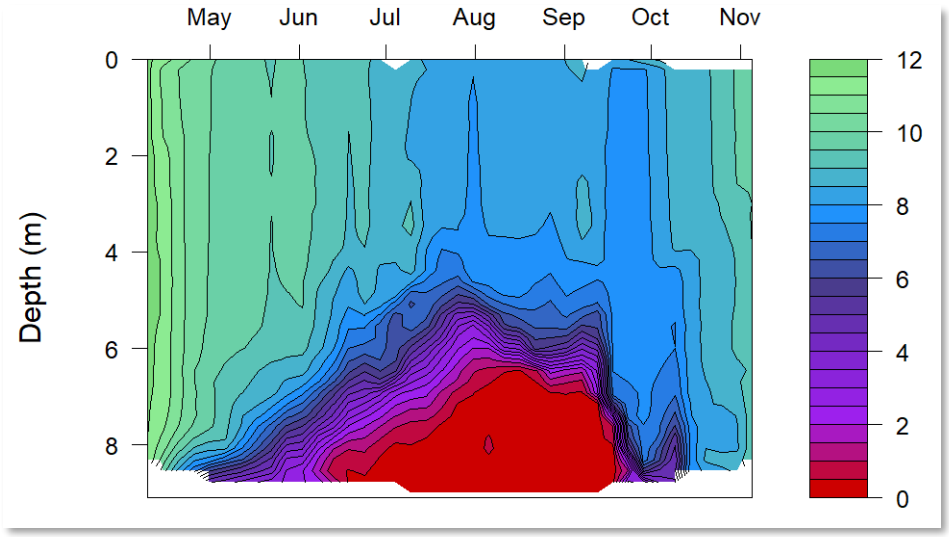


Figure 4. Distribution of dissolved oxygen (mg/L) in Crystal Pond during 2023.



Nutrients

Total phosphorus (TP) concentrations at the top and middle of the water column were generally similar in value, ranging from a low of 7ppb to a high of 17pppb (**Table 2**). The highest concentrations occurred in early May. TP in the surface water decreased during the summer, with lowest concentrations in August. Bottom water TP reached a maximum concentration of 31ppb on August 21st, decreasing slightly to 23ppb in late September.

Table 2. Total phosphorus concentrations (ppb) in Crystal Pond in 2023.

Water Depth	6-May	2-Jul	21-Aug	24-Sep
Top	14	12	7	10
Middle	17	12	10	13
Bottom	9	19	31	23

Total nitrogen (TN) at the top and middle of the water column ranged from 249ppb to 322pbb (**Table 3**). The lowest values occurred in May, while highest values were recorded in August, in contrast to TP. TN in the bottom water reached a maximum concentration of 584ppb in August, consistent with elevated bottom water TP on the same date.

Table 3. Total nitrogen concentrations (ppb) in Crystal Pond in 2023.

Water Depth	6-May	2-Jul	21-Aug	24-Sep
Top	249	251	322	266
Middle	259	264	317	268
Bottom	218	266	584	561

Ammonia-nitrogen is the reduced form of nitrogen that exists mainly in anoxic water. Ammonia was detected at low to very low levels in the top and middle water depths between May and August (**Table 4**). Ammonia in the bottom water reached a maximum concentration of 239ppb in September, offset from the maximum concentration of TN. Elevated ammonia at the top and middle of the water column in September was caused by the mixing depth descending into the anoxic boundary.

Table 4. Ammonia-nitrogen concentration (ppb) in Crystal Pond in 2023

Water Depth	6-May	2-Jul	21-Aug	24-Sep
Top	7	4	<3	22
Middle	7	4	10	22
Bottom	9	5	98	239

Plankton

The plankton community of freshwater lakes is composed of microscopic animals and a large group of non-animals, or phytoplankton, many of which are single-celled photosynthetic "plants". Some are also heterotrophic, meaning they are freely floating in the water column.

Zooplankton

The zooplankton community in lakes consists primarily of Rotifers and the Crustaceans: Cladocera, Copepods, and Calanoids. All are predators, the latter two on other animals. Cladoceran (Daphnia) predominantly feed on phytoplankton. The zooplankton population in Crystal Pond in 2023 was excellent. Calanoids were large and present at high numbers for most of the season (**Figure 5**, **Figure 6**). Large Daphnia were present in good numbers from July onward.

Figure 5. Zooplankton numbers in Crystal Pond in 2023

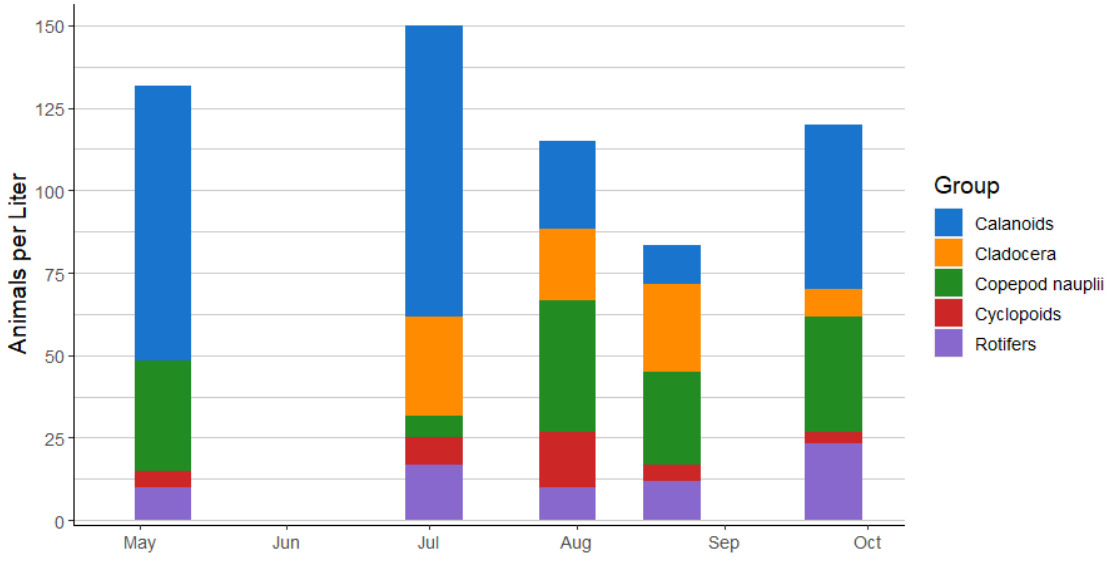
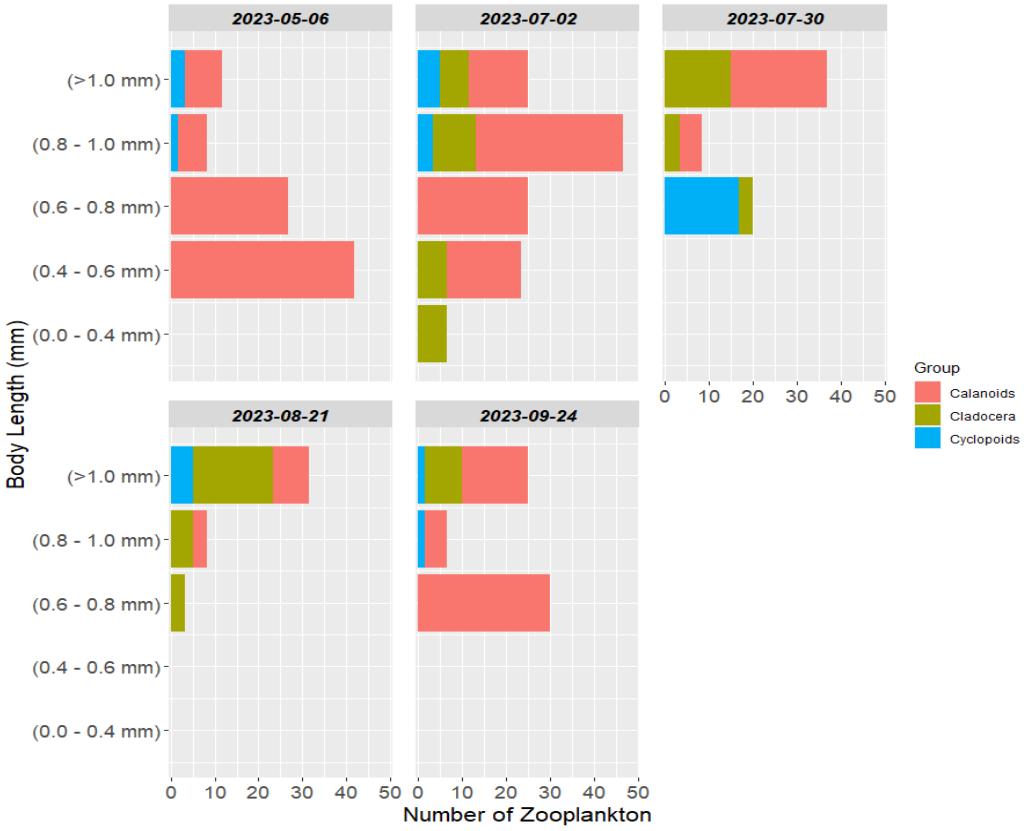


Figure 6. Zooplankton numbers by size classes in Crystal Pond in 2023



Phytoplankton

Phytoplankton are grouped into several large taxonomic units in which genera behave in similar ways. The groups represented in Crystal Pond in 2023 were Greens, Diatoms, Dinoflagellates, and Cyanobacteria (**Figure 7**). Greens are single-celled, tiny, and represent the major food source for Daphnia zooplankton. Dinoflagellates are single-celled but are capable of some mobility. Diatoms are mostly single-celled but use silica in the water to make glass cell walls. Cyanobacteria are a group of phytoplankton that can regulate cell buoyancy and produce toxins.

Greens and Diatoms dominated the plankton community in May and July, but Cyanobacteria dominated in August, September, and October (**Figure 8**). Cyanobacteria reached highest cell counts in October at nearly 20,000 cells/mL. World Health Organization (WHO) guidance states that cyanobacteria density of between 20,000 and 100,000 cells/mL has a moderate probably of acute health effects from exposure (**Table 5**).

Figure 7. Phytoplankton numbers by Group in Crystal Pond in 2023

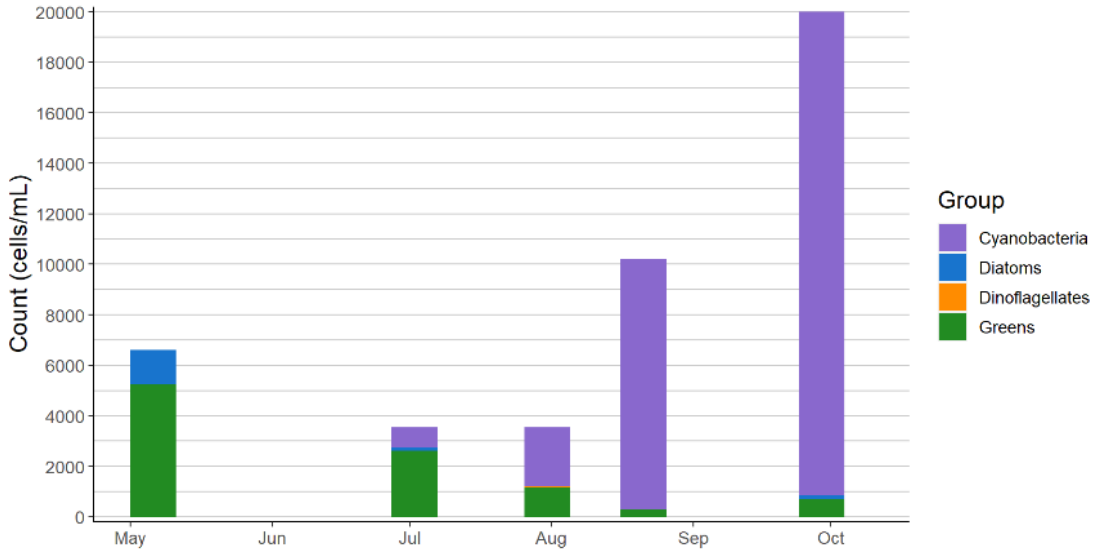


Figure 8. Cyanobacteria numbers by Group in Crystal Pond in 2023

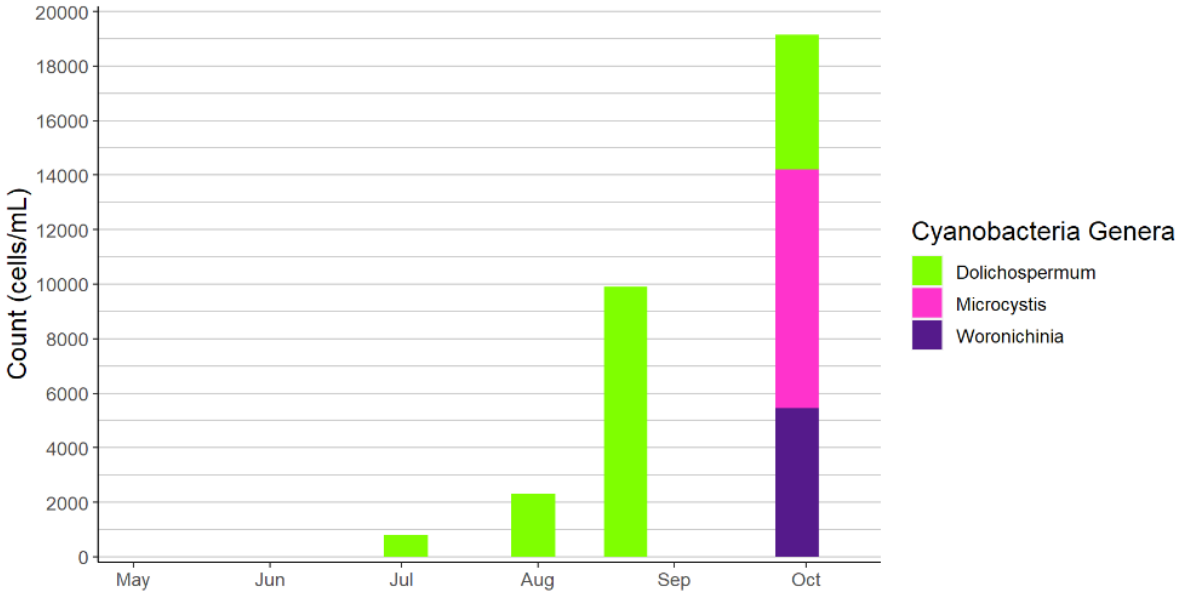


Table 5. WHO guidance values for the relative probability of health effects resulting from exposure to cyanobacteria.

Relative Probability of Acute Health Effects	Cyanobacteria Density (Cells/mL)
Low	< 20,000
Moderate	20,000-100,000
High	100,000-10,000,000
Very High	> 10,000,000

Inlet Nutrients

Stormwater inlet sampling occurred on July 4th at inlets 4, 7, 8, and 9 (**Table 6**). Additional samples were collected at Lake Drive drain, surface grab road runoff, Eastford Road, and the road south of Lychfield. Total phosphorus concentrations ranged from 25ppb to 406ppb at these sites. Total nitrogen concentrations ranged from 446ppb to 1,432ppb.

Inlets 4, 7, 8 and 9 were sampled on October 1st (**Table 7**). Total phosphorus concentrations ranged from 18ppb to 34ppb, and total nitrogen concentrations ranged from 258ppb to 488ppb. Inlet 5 and the outlet were sampled on November 26th.

Nutrient concentrations in 2023 were generally elevated. The surface grab collected from road runoff on July 4th contained the highest concentrations of both total phosphorus and total nitrogen.

Table 6. July 4th, 2023 stormwater inlet sampling results.

Inlet	Total Phosphorus (ppb)	Total Nitrogen (ppb)
Inlet 4	44	469
Inlet 4 (D)	40	446
Inlet 7	33	589
Inlet 8	25	451
Inlet 9	31	619
Lake Drive Drain	75	578
Surface Grab Road Runoff	406	1,432
Eastford Rd Surface Grab	60	726
Road S of Lychfield	150	603

Table 7. October 1st and November 26th, 2023 inlet sampling nutrient results.

Date	Inlet	Total Phosphorus (ppb)	Total Nitrogen (ppb)
10/1/23	Inlet 4	32	258
11/26/23	Inlet 5	15	121
10/1/23	Inlet 7	18	383
10/1/23	Inlet 8	23	299
10/1/23	Inlet 9	34	488
11/26/23	Outlet from CPP Pond/Inlet	9	257

Aquatic Plants

NEAR conducted an aquatic plant survey of Crystal Pond on September 6th. During this survey, a total of 19 aquatic plant species were identified, along with Filamentous Algae and Cyanobacteria Mat (*Lyngbya sp.*) (**Table 8**). Four species, *Potamogeton robbinsii*, *Potamogeton amplifolius*, *Potamogeton gramineus* and *Bidens beckii* were dominant, meaning they were present at greater than 20% of the survey waypoints. The Connecticut State-listed species *Bidens beckii* was present at 25% of survey waypoints,

mainly at the northern end of the pond and in the coves. One invasive species, Mudmat (*Glossostigma sp.*) was found at two locations along the eastern shoreline. Mudmat is a low-growing plant often found in waters shallower than 2 feet.

Aquatic plant maps are included in an appendix at the end of this report.

Table 8. Aquatic plant species observed in Crystal Pond during Sept. 6th, 2023 aquatic plant survey, with associated perfect frequency and average density. CT state-listed species is highlighted in blue. Invasive species is highlighted in red.

Common Name	Scientific Name	% Frequency	Avg. Density
Robbins Pondweed	*Potamogeton robbinsii*	79	61
Large-Leaf Pondweed	*Potamogeton amplifolius*	57	49
Grassy Pondweed	*Potamogeton gramineus*	37	32
Water Marigold	*Bidens beckii*	25	39
Tapegrass	*Vallisneria americana*	16	52
Cyanobacteria mat	*Lyngbya sp.*	9	14
Small Pondweed	*Potamogeton pusillus*	7	21
Common Bladderwort	*Utricularia macrorhiza*	7	28
Little Floating Bladderwort	*Utricularia radiata*	6	9
Muskgrass sp.	*Chara sp.*	5	50
Filamentous Algae	*NA*	5	18
Grassy Arrowhead	*Sagittaria graminea*	4	24
Eastern Purple Bladderwort	*Utricularia purpurea*	3	15
Watershield	*Brasenia schreberi*	2	20
Mudmat	*Glossostigma sp.*	2	15
Yellow Water Lily	*Nuphar variegata*	2	80
White Water Lily	*Nymphaea odorata*	2	60
Nuttall's Waterweed	*Elodea nuttallii*	<1	5
Stonewort sp.	*Nitella sp.*	<1	NA
Snail-Seed Pondweed	*Potamogeton bicupulatus*	<1	5
Ribbon-Leaf Pondweed	*Potamogeton epihydrus*	<1	5

Recommendations for 2024

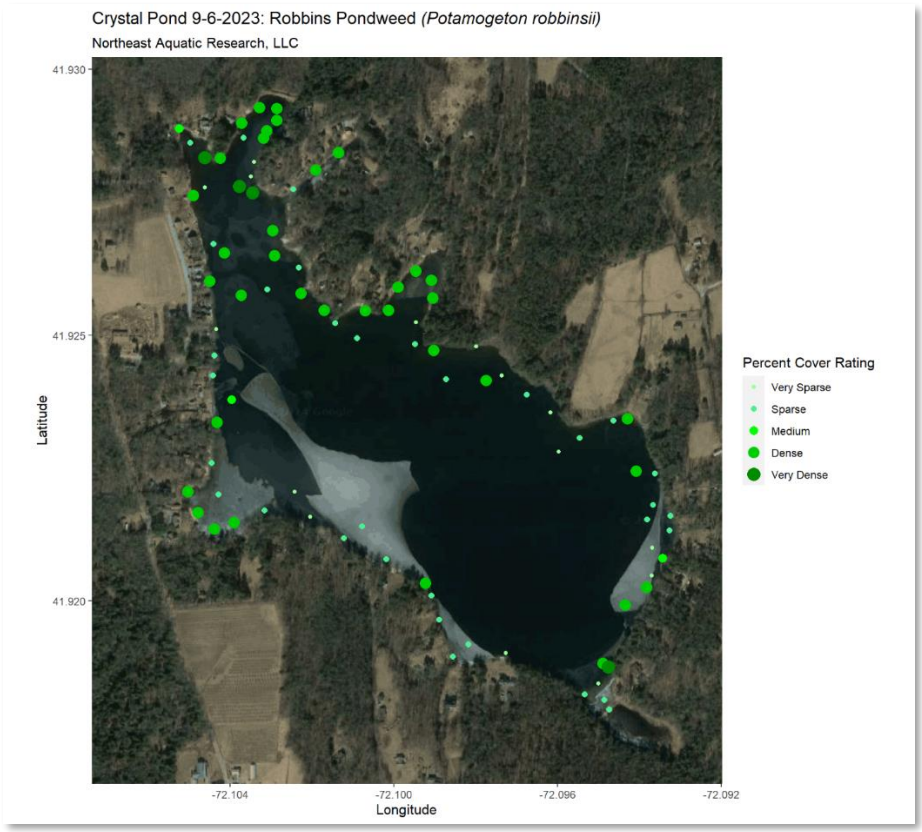
The CPA lake monitoring program has been hugely successful, with water clarity and profile data collected frequently and regularly between April and November. Water quality samples are currently collected 5 times a year. We recommend expanding water sample collection, including plankton, to monthly from April through November.

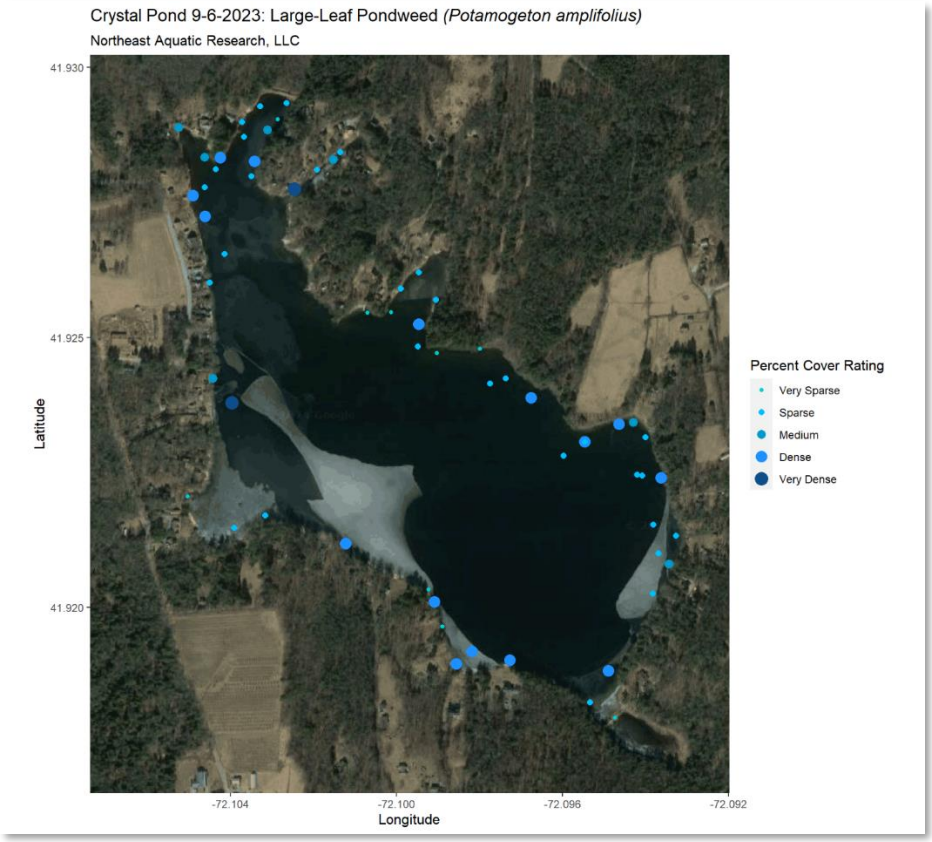
A great deal of data has been collected by CPA since increasing the frequency of data collection in 2021. In addition, the lake has a water quality data set that spans 30 years. We recommend some increased level of effort be given to assessing this long-term data set as part of the 2024 monitoring report.

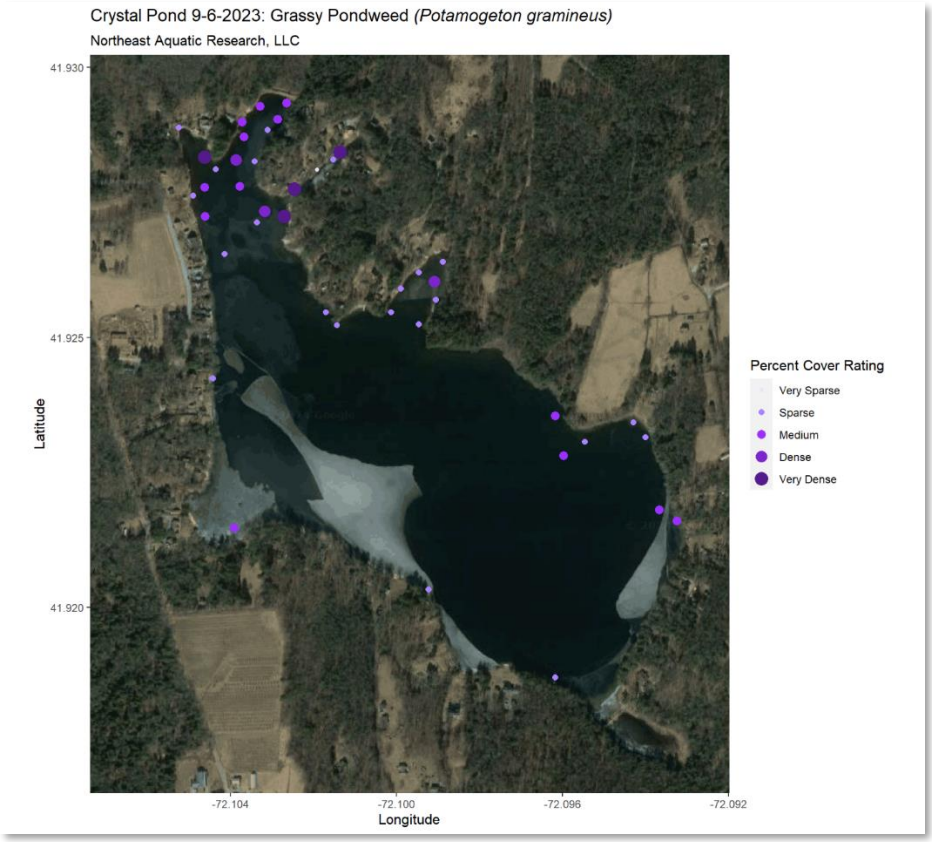
Focus efforts on tracking down the source(s) of elevated nutrients in the tributary waters. NEAR can help facilitate this.

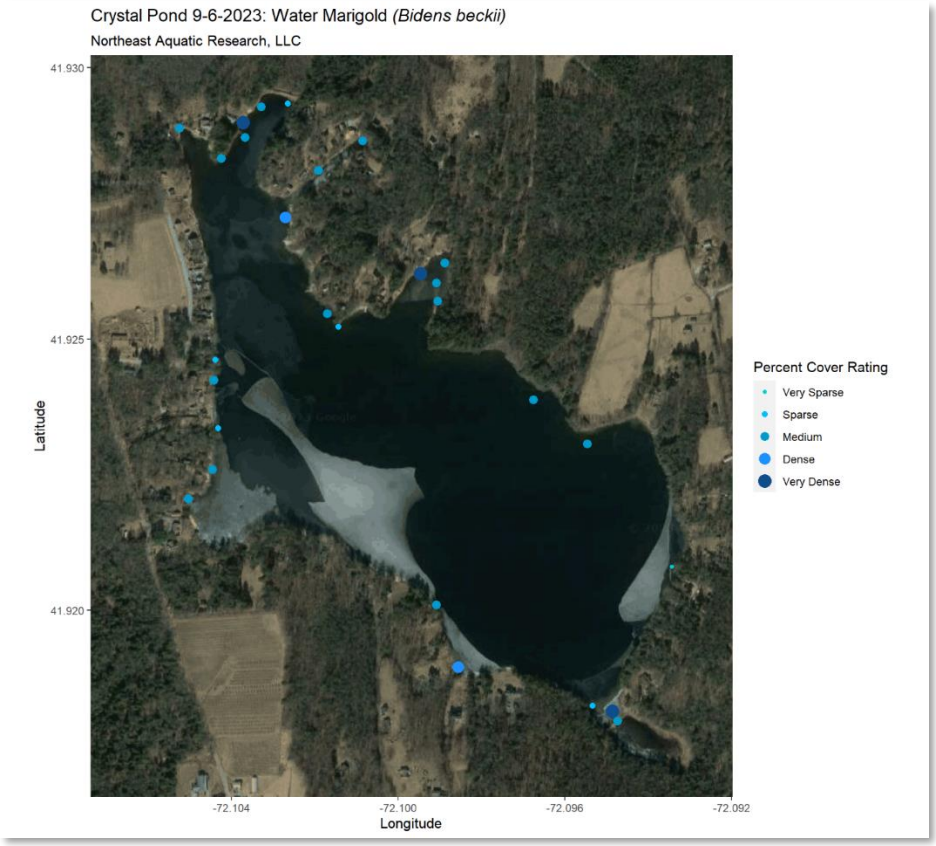
Conduct a full-lake aquatic plant survey in late summer 2024 to assess the plant community and search for invasive species.

Appendix – 9/6/2023 Aquatic Plant Survey Maps




Crystal Pond 9-6-2023: Large-Leaf Pondweed (Potamogeton amplifolius)
Northeast Aquatic Research, LLC
41.930
41.925
41.920
Latitude
-72.104
-72.100
-72.096
-72.092
Longitude
Percent Cover Rating
Very Sparse
Sparse
Medium
Dense
Very Dense


Crystal Pond 9-6-2023: Grassy Pondweed (Potamogeton gramineus)
Northeast Aquatic Research, LLC
41.930
41.925
41.920
Latitude
-72.104
-72.100
-72.096
-72.092
Longitude
Percent Cover Rating
Very Sparse
Sparse
Medium
Dense
Very Dense


Crystal Pond 9-6-2023: Water Marigold (Bidens beckii)
Northeast Aquatic Research, LLC
41.930
41.925
41.920
Latitude
-72.104
-72.100
-72.096
-72.092
Longitude
Percent Cover Rating
Very Sparse
Sparse
Medium
Dense
Very Dense


Crystal Pond 9-6-2023: Invasive Mudmat (Glossostigma sp.)
Northeast Aquatic Research, LLC
41.930
41.925
41.920
Latitude
-72.104
-72.100
-72.096
-72.092
Longitude
Percent Cover Rating
Sparse
Medium