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February 14, 2025

To: Lynn Kearcher
From: Hannah Moore and George Knoecklein
**Re: Mudge Pond 2024 Water Quality and Aquatic Plant Results**

## BACKGROUND

This report analyzes water quality and aquatic plant data collected by Northeast Aquatic Research (NEAR) in 2024 at Mudge Pond.

NEAR collected water temperature and dissolved oxygen profiles, a water clarity reading, and water samples from Station 1, the site of deepest water in the lake, once per month from April through November. Water samples were also collected from two of the lake's inlets during the April through July sampling trips. The inlets were dry at the time of the remaining monthly visits.

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

NEAR also conducted two comprehensive aquatic plant surveys, on June 7th and August 28th. Both surveys utilized meander methodology and waypoints were created throughout the littoral zone. At each waypoint, all aquatic plant species were documented, along with associated percent abundance. Special attention was given to searching for and documenting invasive species and state-listed protected species.

*Table 1. Connecticut DEEP trophic categories and ranges of indicator parameters.*

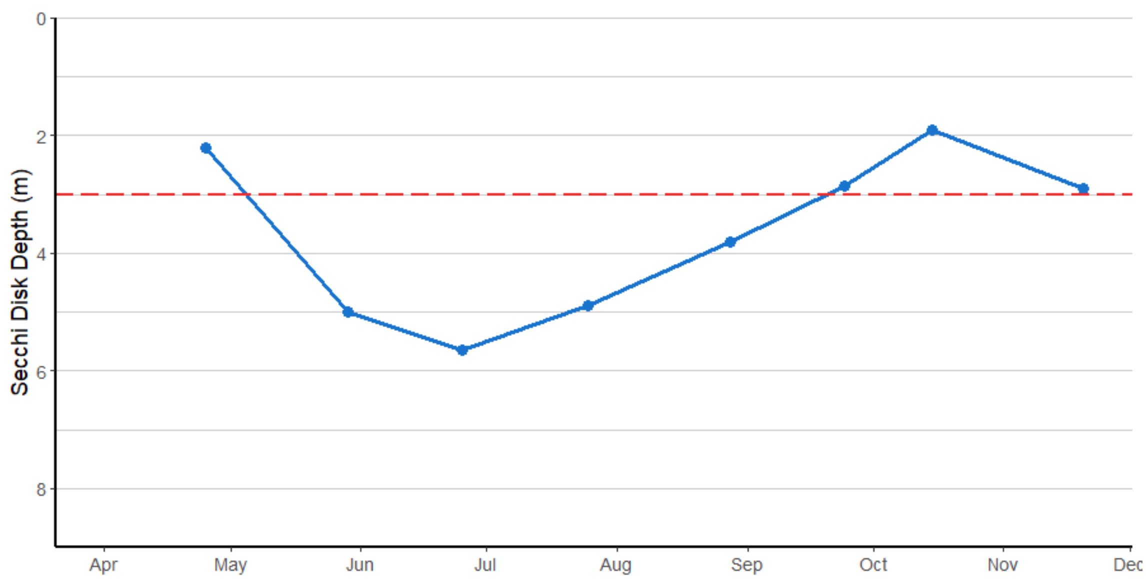
| Category | T. Phosphorus (ppb) | T. Nitrogen (ppb) | Secchi Depth (m) | Chlorophyll *a* (ppb) |
|---|---|---|---|---|
| Oligotrophic | 0 -- 10 | 2 -- 200 | 6 + | 0 -- 2 |
| Oligo-mesotrophic | 10 -- 15 | 200 -- 300 | 4 -- 6 | 2 -- 5 |
| Mesotrophic | 15 -- 25 | 300 -- 500 | 3 -- 4 | 5 -- 10 |
| Meso-eutrophic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

# 2024 Water Quality Results

## Water Clarity

Based on the trophic category parameters, the goal water clarity for Mudge Pond is greater than 3 meters. The water clarity in Mudge Pond in 2024 was poor in April but rapidly improved to 5.7 meters in June (**Figure 1**). The water clarity steadily diminished from July through October. The October 15th Secchi disk measurement of 1.9 meters was the worst reading of the season. Water clarity improved slightly in November. Typically, when water clarity declines below 2 meters, the water column is dominated by cyanobacteria.

*Figure 1. Mudge Pond Secchi disk depths, April through November, 2024.*




## Water Temperature and Dissolved Oxygen

The dissolved oxygen in a lake mostly originates from the atmosphere, diffusing into the water at the lake surface. Dissolved oxygen can also be produced by phytoplankton and aquatic plants living in the lake. The dissolved oxygen (DO) in Mudge Pond was good in upper water for most of the season (shades of blue in **Figure 2**). There was a slight decline in DO in October, when the bottom water anoxia started to be eroded away. Water below about 6 meters was severely DO-stressed for most of the season (shades of red in **Figure 2**). There was no DO in water deeper than 8 meters from the beginning of June to the end of September. The water in the bottom meter or so was not recorded with more than 50% saturation of DO (**Figure 3**). The anoxic boundary reached a maximum height of 6.4 meters as measured down from the surface (3.5m from the bottom) in late August.

The lake was just beginning to stratify at the time of our first sampling visit on April 25th. The top of the water column was warming and the water at the very bottom of the deep spot was beginning to lose dissolved oxygen (**Figure 4**). By late May, the lake was fully stratified with a thermocline at three meters (purple lines in **Figure 4**), then deepening to 6 meters for the remainder of the summer. The thermocline dissolved by the end of September, with the lake being fully mixed thermally in October.

*Figure 2. Mudge Pond 2024 dissolved oxygen isopleth.*

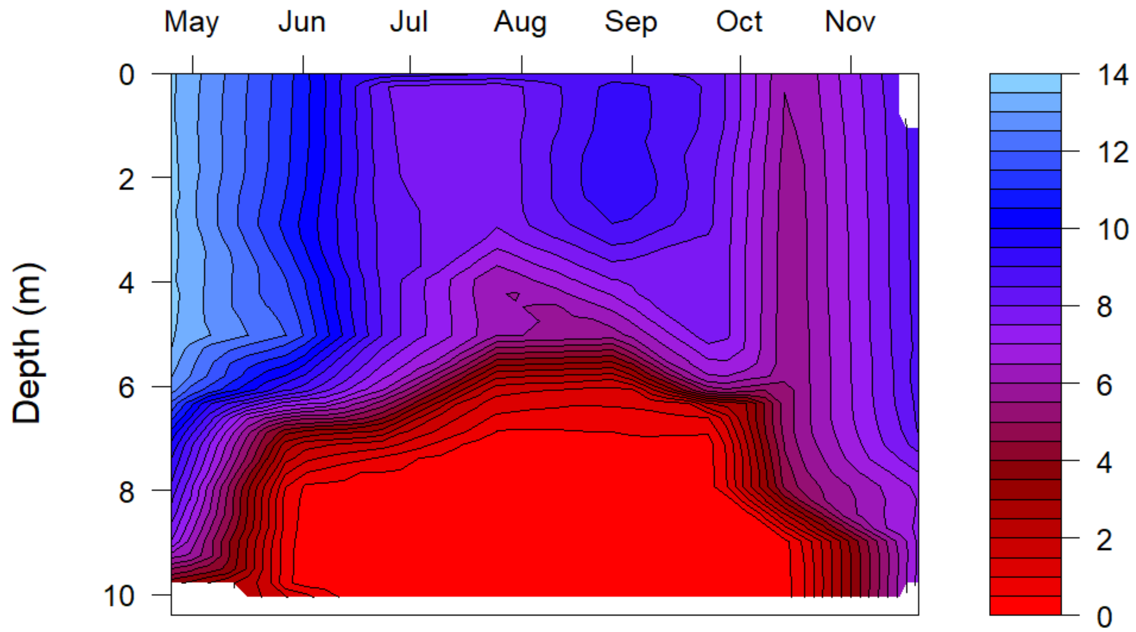



*Figure 3. Mudge Pond 2024 percent saturation of dissolved oxygen isopleth.*

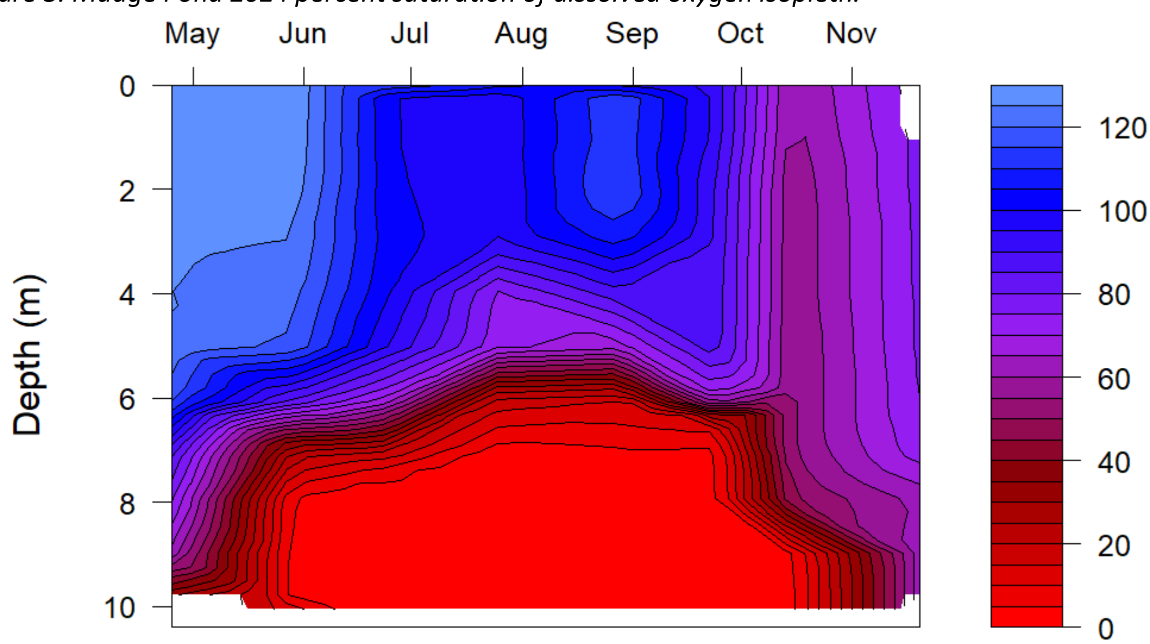
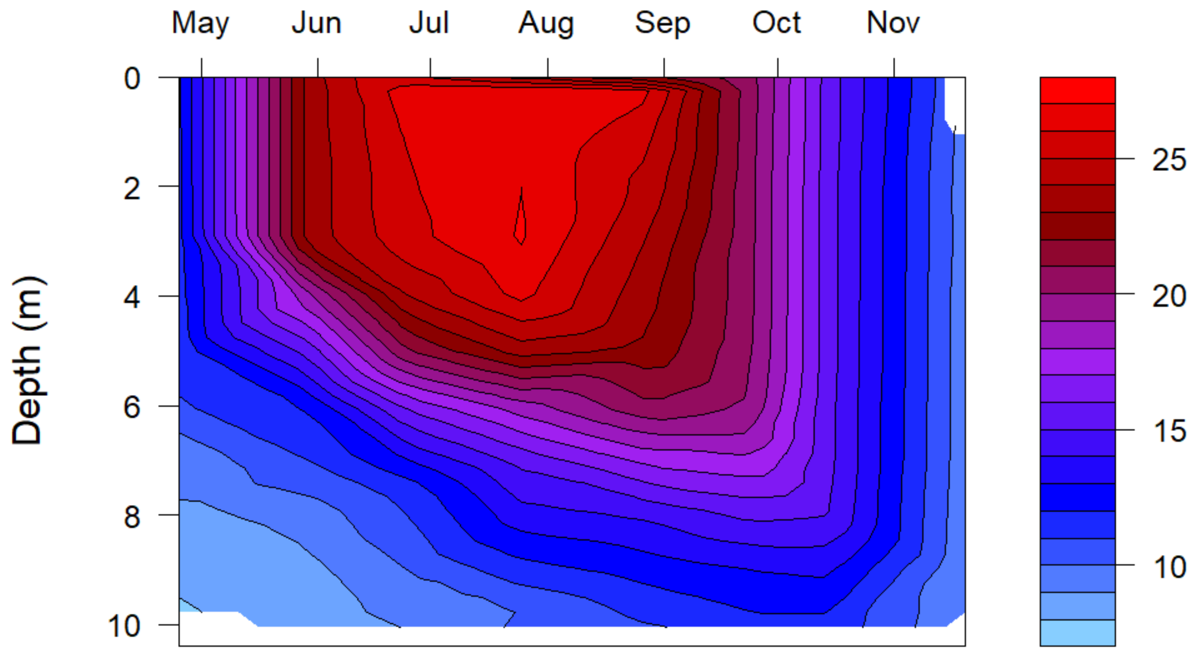


*Figure 4. Mudge Pond 2024 temperature isopleth.*




## Nutrients

### Total Phosphorus

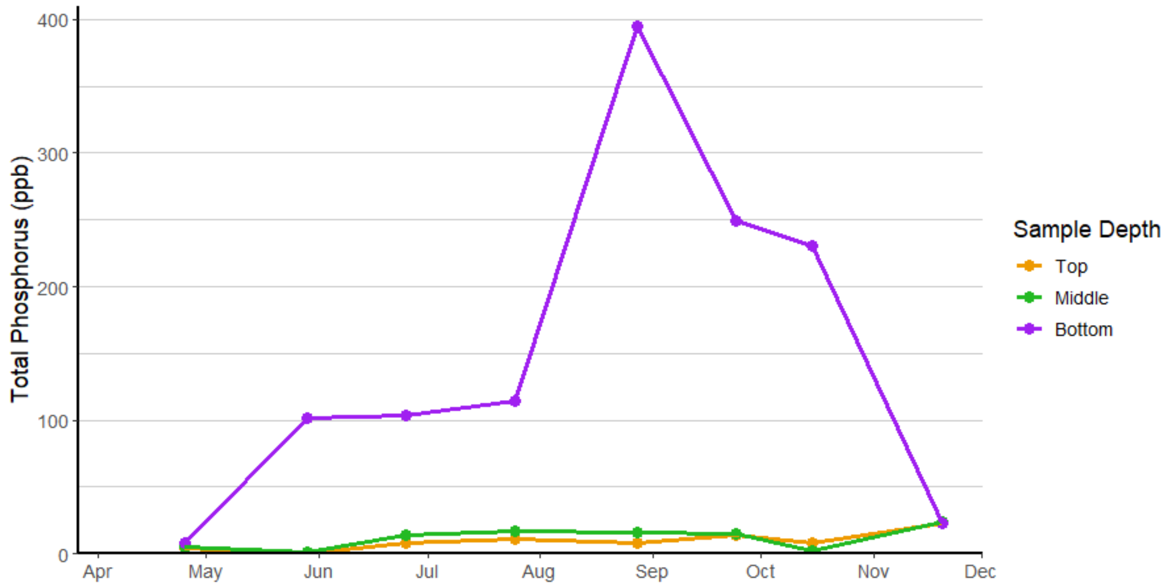
Total phosphorus (TP) concentration in the surface water ("Top" sampling depth, 1m from the surface), should consistently remain below 25ppb with a goal concentration of <15ppb. TP concentrations at the top and middle of the water column remained low, under the target concentration, during the 2024 season, with an increase in concentration in November as a result of fall overturn (**Table 2**). In the bottom water at Station 1, TP reached a high of 395ppb in August (**Table 2, Figure 5**). This was also the date of the maximum ascent depth of anoxic water. Bottom water TP remained elevated through October. Fall turnover occurred before the November sampling, so on this date the TP concentrations were consistent at all three sampling depths.

*Table 2. Total phosphorus concentrations, April to November 2024.*

| Sample Depth | 4/25 | 5/29 | 6/25 | 7/25 | 8/28 | 9/24 | 10/15 | 11/20 |
|---|---|---|---|---|---|---|---|---|
| Top | 4 | <1* | 8 | 11 | 8 | 14 | 8 | 23 |
| Middle | 5 | 1* | 14 | 17 | 16 | 15 | 2 | 24 |
| Bottom | 8 | 102 | 104 | 114 | 395 | 249 | 231 | 23 |

**We question the validity of these values and are actively working with the lab to find solutions so we can be confident in the data we receive in 2025.*

*Figure 5. Total phosphorus concentrations, April to November 2024.*



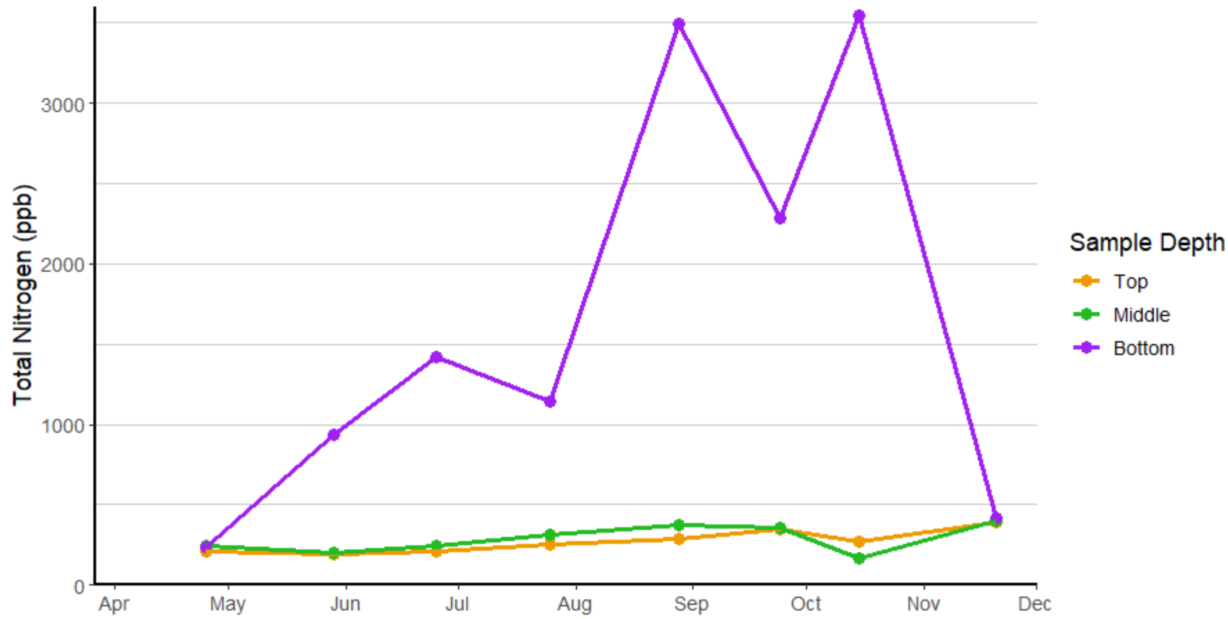

## Nitrogen

Total nitrogen concentrations in the surface water at Station 1 remained below the 300ppb oligo-mesotrophic threshold in all months except September and November (**Table 3**). TN at the middle of the water column was also generally good throughout the season. In the bottom water, however, TN reached extremely elevated concentrations from June through October, in conjunction with anoxic water causing internal loading (**Figure 6**).

*Table 3. Total nitrogen concentrations, April to November 2024.*

| Sample Depth | 4/25 | 5/29 | 6/25 | 7/25 | 8/28 | 9/24 | 10/15 | 11/20 |
|---|---|---|---|---|---|---|---|---|
| Top | 211 | 194 | 209 | 250 | 290 | 352 | 271 | 387 |
| Middle | 245 | 199 | 244 | 315 | 371 | 357 | 170 | 400 |
| Bottom | 238 | 937 | 1,419 | 1,142 | 3,495 | 2,285 | 3,545 | 414 |

*Figure 6. Total nitrogen concentrations, April to November 2024.*




## Ammonia

Ammonia at the bottom of the deep spot was low in April, but moderately elevated from May through July and extremely elevated from August through October (**Table 4**). Bottom water ammonia reached a maximum concentration of 2,941ppb in October. Ammonia at the top and middle of the water column was very low from April through September. In October and November, bottom water began to mix throughout the water column, causing ammonia concentrations at the top and middle of the water column to increase.

*Table 4. Ammonia concentrations, April to November 2024.*

| Sample Depth | 4/25 | 5/29 | 6/25 | 7/25 | 8/28 | 9/24 | 10/15 | 11/20 |
|---|---|---|---|---|---|---|---|---|
| Top | <3 | 5 | <3 | <3 | 3 | 3 | 50 | 89 |
| Middle | <3 | 5 | 12 | <3 | 3 | 3 | 46 | 90 |
| Bottom | 6 | 525 | 634 | 481 | 2,641 | 1,725 | 2,941 | 132 |
| $NH_3$ % of total | 2.5 | 56 | 44 | 42 | 76 | 75 | 83 | 32 |
| Bottom TN | 238 | 937 | 1,419 | 1,142 | 3,495 | 2,285 | 3,545 | 414 |

## Phytoplankton

The phytoplankton are a large diverse group of microscopic mostly single celled organisms that use pigments to photosynthesize. Some phytoplankton are heterotrophic, meaning they can consume other animals. Many phytoplankton form either colonies or filaments. The most notorious group are the cyanobacteria because they can be toxic and they are mostly buoyant, meaning they can float to the surface and from scums. Diatoms tend to be plentiful only during the spring months when there is no stratification. Greens are present in late spring, generally just as the lake begins to stratify. Cyanobacteria tend to dominate once the lake is stratified. Nanoplankton are single cells that are too small to be resolved <3µm (micron) and can be either Green algae or Cyanobacteria (**Figure 7**).

The lake had only Diatoms in April at high numbers (15,000 cells/mL) and were likely responsible for the poor clarity in this month. Diatoms disappeared after the lake started to mix down in September and October. There were minor numbers of Green algae in May. Cyanobacteria occurred in very low numbers in June, but increased through July and August and into September. Cyanobacteria types during July-September were toxin producers. Raphidiopsis, very numerous in November, is not a toxin producer (**Figure 8**).

*Figure 7. Phytoplankton numbers by Group in Mudge Pond in 2024.*

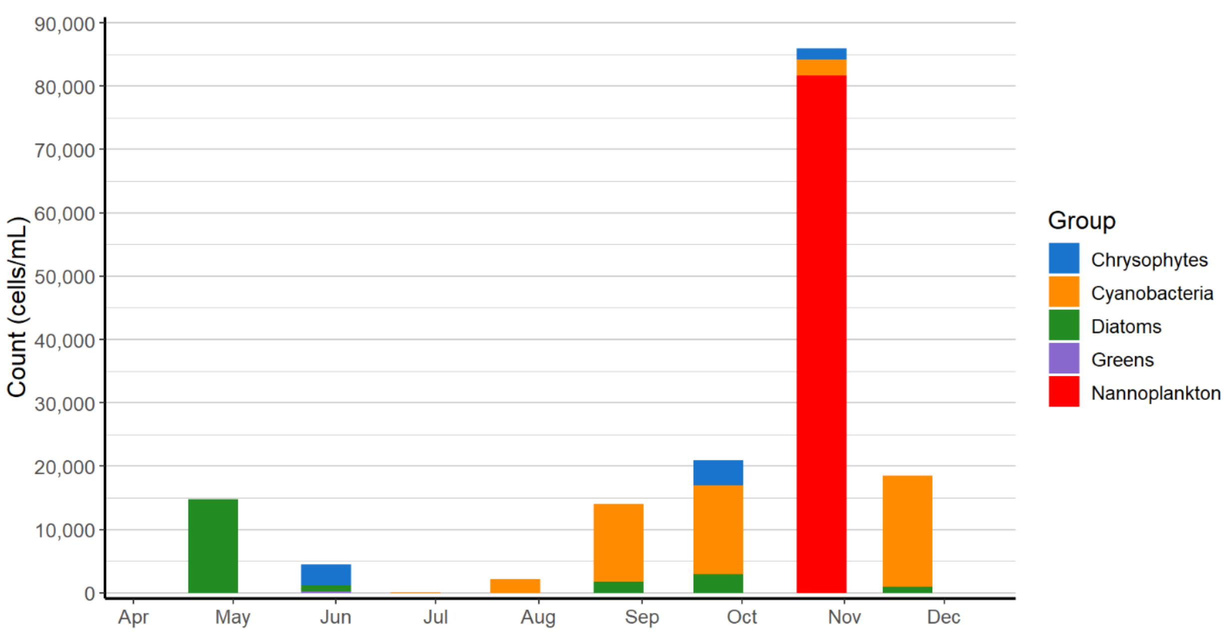
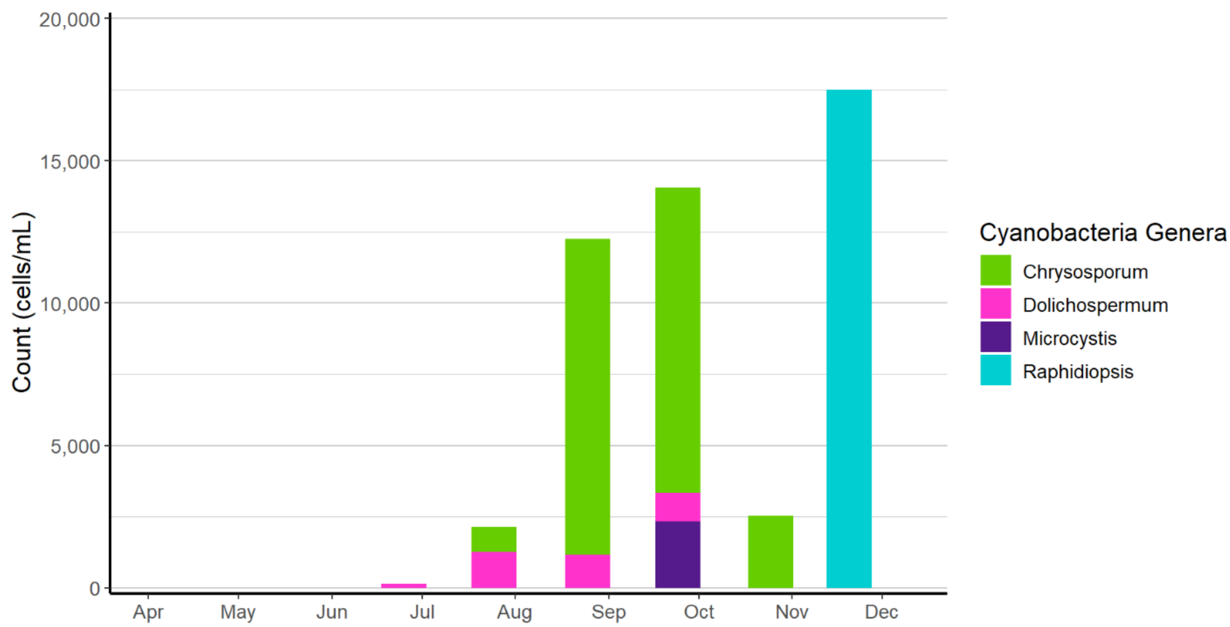


*Figure 8. Cyanobacteria numbers by Genera in Mudge Pond in 2024.*




## Inlet Nutrients

Water samples were collected from two inlets in 2024: East Brook (Inlet 1) and Indian Mountain Brook (Inlet 2) (**Map 1**). Samples were collected from Inlet 1 monthly from April through July. Samples were collected from Inlet 2 in April and May. Inlet 2 was dry in subsequent months, so water samples could not be collected.

Total phosphorus concentrations were low to moderate in the inlets (**Table 5**). Total nitrogen was extremely elevated at Inlet 1, particularly in April and May. Total nitrogen in Inlet 2 was very low. Ammonia nitrogen, which is a component of total nitrogen, was relatively low in both inlets. This suggests that the nitrogen source is primarily nitrate or organic nitrogen. Inlet 1 flows through a wetland before entering Mudge Pond. It is concerning that the nitrogen concentration is so high even after moving through the wetland because wetlands act as biofilters, removing nutrients from the water. We need to further investigate the source of the elevated nitrogen in this inlet.

*Map 1. Locations of Mudge Pond sampling stations.*


*Table 5. Mudge Pond Inlet 1 and Inlet 2 nutrient concentrations – total phosphorus, total nitrogen, and ammonia.*

| Total Phosphorus (ppb) | | | | |
|---|---|---|---|---|
| Station | 4/25/2024 | 5/29/2024 | 6/25/2024 | 7/25/2024 |
| Inlet 1 | 9 | 25 | 25 | 29 |
| Inlet 2 | 0.5 | 1 | dry | dry |

| Total Nitrogen (ppb) | | | | |
|---|---|---|---|---|
| Station | 4/25/2024 | 5/29/2024 | 6/25/2024 | 7/25/2024 |
| Inlet 1 | 1,315 | 1,085 | 776 | 661 |
| Inlet 2 | 48 | 90 | dry | dry |

| Ammonia Nitrogen (ppb) | | | | |
|---|---|---|---|---|
| Station | 4/25/2024 | 5/29/2024 | 6/25/2024 | 7/25/2024 |
| Inlet 1 | 4 | 15 | 5 | 4 |
| Inlet 2 | 3 | 8 | dry | dry |

## Aquatic Plants

A total of 32 aquatic plant species were documented in Mudge Pond in 2024 (**Table 6**). Filamentous algae was also documented, though it is not a plant. 27 species were documented on June 7th. 25 species were documented on August 28th. Five invasive species were observed in 2024: Fanwort (*Cabomba caroliniana*), Eurasian Milfoil (Myriophyllum spicatum), Brittle Naiad (*Najas minor*), Curly-leaf Pondweed (*Potamogeton crispus*), and Water Chestnut (*Trapa natans*). Two species are protected by the State of CT - *Potamogeton friesii* and *Schoenoplectus acutus*.

Fanwort was abundant in both June and August, though it increased in both frequency and density between the two surveys (**Map 2**). Particularly dense growth was documented at the northern end of the lake.

Eurasian Milfoil was one of the most dominant species in the lake in 2024. It was present at 30% of the survey waypoints in June and 40% of the survey waypoints in August (**Map 3**). The beds of Milfoil increased in density over the season. By August, most of the Milfoil beds were extremely dense.

Curly-leaf Pondweed was the most abundant species in the lake in June, present at 41% of survey waypoints throughout the littoral zone (**Map 4**). This species begins growing early in the season and starts to die off by mid-summer. By the time of the late August survey, the species was found at just 13% of the survey waypoints and the patches were sparse.

Five patches of Water Chestnut were present in June (**Map 5**). In August, only one patch of Water Chestnut was present, by the State of CT boat launch. The White Waterlily growth in August made it very difficult to access the shallow areas where the Water Chestnut was observed in June.

Brittle Naiad was not found in the lake in June but was present at four waypoints in August (**Map 6**).

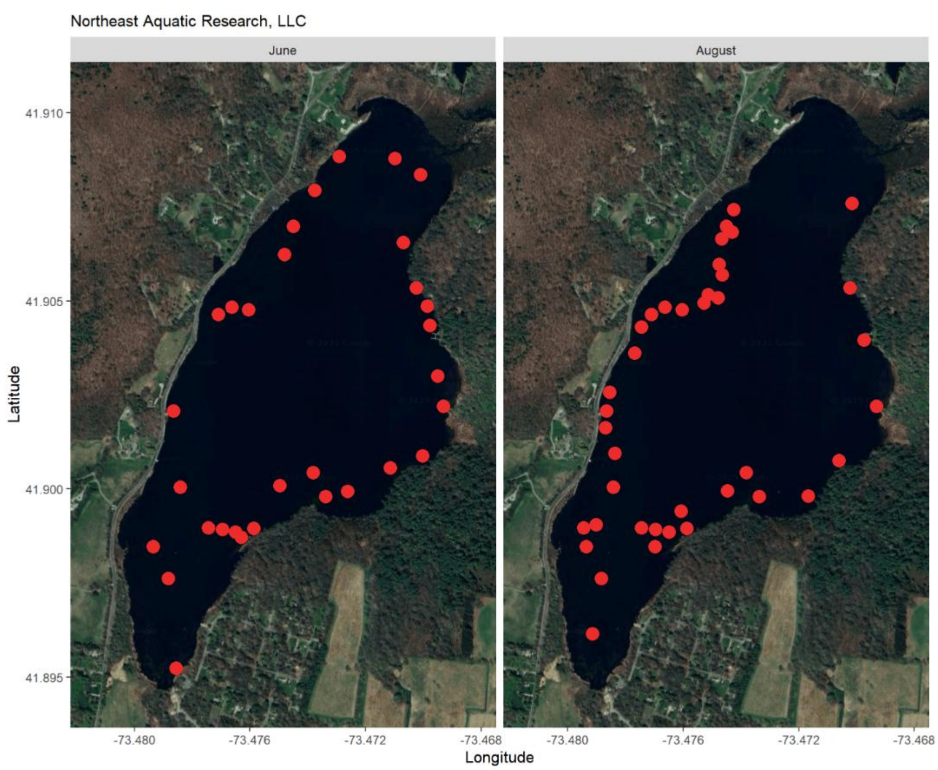
Floating-leaf plants (Water Lilies and Watershield) were abundant throughout the littoral zone during both surveys (Map **7**). While these plants are native, they can be a nuisance because they impede boating and other recreational activities. These plants were particularly dense at the southern end of the lake. A narrow channel through the floating-leaf plants allows access from the town boat launch to the open water.

*Table 6. Aquatic plant species observed in Mudge Pond during the June 7th and August 28th, 2024 aquatic plant surveys, with associated frequency of occurrence and average density. Red lettering indicates invasive species. Blue highlight indicates protected species.*

| Scientific Name | Common Name | 6/7/2024 | | 8/28/2024 | |
|---|---|---|---|---|---|
| | | % Frequency | Avg. Density | % Frequency | Avg. Density |
| *Brasenia schreberi* | Watershield | 6 | 21 | 5 | 50 |
| *Cabomba caroliniana* | Fanwort | 19 | 48 | 26 | 81 |
| *Ceratophyllum demersum* | Coontail | 29 | 13 | 14 | 10 |
| *Chara sp* | Muskgrass | 3 | 37 | 4 | 40 |
| *Elodea canadensis* | Canadian Waterweed | 18 | 19 | 2 | -- |
| *Elodea nuttallii* | Nuttall's Waterweed | 0 | -- | 8 | 12 |
| *Filamentous algae* | Filamentous Algae | 5 | 12 | 0 | -- |
| *Myriophyllum spicatum* | Eurasian Milfoil | 30 | 29 | 40 | 82 |
| *Najas flexilis* | Nodding Waternymph | 0 | -- | 1 | 5 |
| *Najas minor* | Brittle Naiad | 0 | -- | 4 | -- |
| *Nitella sp.* | Stonewort | 0 | -- | 1 | 1 |
| *Nuphar variegata* | Yellow Waterlily | 32 | 37 | 39 | 28 |
| *Nymphaea odorata* | White Waterlily | 18 | 31 | 35 | 51 |
| *Polygonum amphibium* | Smartweed | 0 | -- | 4 | -- |
| *Pontederia cordata* | Pickerelweed | 3 | 13 | 4 | -- |
| *Potamogeton amplifolius* | Large-leaf Pondweed | 25 | 32 | 23 | 62 |
| *Potamogeton crispus* | Curly-leaf Pondweed | 41 | 20 | 13 | 8 |
| *Potamogeton foliosus* | Leafy Pondweed | 1 | 5 | 0 | -- |
| *Potamogeton friesii* | Flat-stalked Pondweed | 1 | 10 | 0 | -- |
| *Potamogeton illinoensis* | Illinois' Pondweed | 1 | 15 | 0 | -- |
| *Potamogeton natans* | Floating Pondweed | 2 | 13 | 0 | -- |
| *Potamogeton perfoliatus* | Clasping-leaf Pondweed | 2 | 15 | 4 | 23 |
| *Potamogeton praelongus* | White-stem Pondweed | 13 | 11 | 29 | 40 |
| *Potamogeton strictifolius* | Straight-leaf Pondweed | 2 | 15 | 0 | -- |
| *Potamogeton zosteriformis* | Flat-stem Pondweed | 20 | 21 | 6 | 39 |
| *Ranunculus sp* | Water Buttercup | 17 | 34 | 1 | 5 |
| *Schoenoplectus acutus* | Hardstem Bulrush | 2 | 80 | 2 | 80 |
| *Spirodela polyrhiza* | Great Duckweed | 1 | 15 | 0 | -- |
| *Stuckenia pectinata* | Sago Pondwed | 6 | 18 | 3 | 30 |
| *Trapa natans* | Water Chestnut | 5 | 18 | 1 | -- |
| *Utricularia geminiscapa* | Hidden-fruit Bladderwort | 5 | 14 | 0 | -- |
| *Utricularia macrorhiza* | Common Bladderwort | 0 | -- | 4 | 15 |
| *Vallisneria americana* | Tape Grass | 13 | 33 | 45 | 56 |

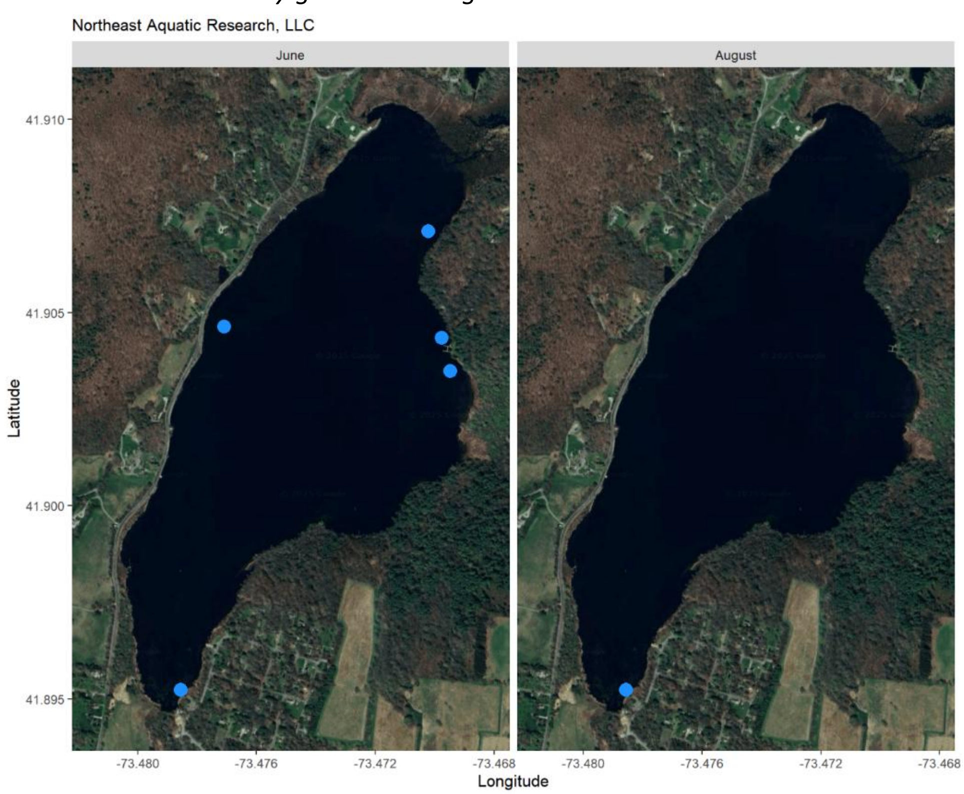
*Map 2. Locations of Fanwort in June and August 2024.*


*Map 3. Locations of Eurasian Milfoil in June and August 2024.*



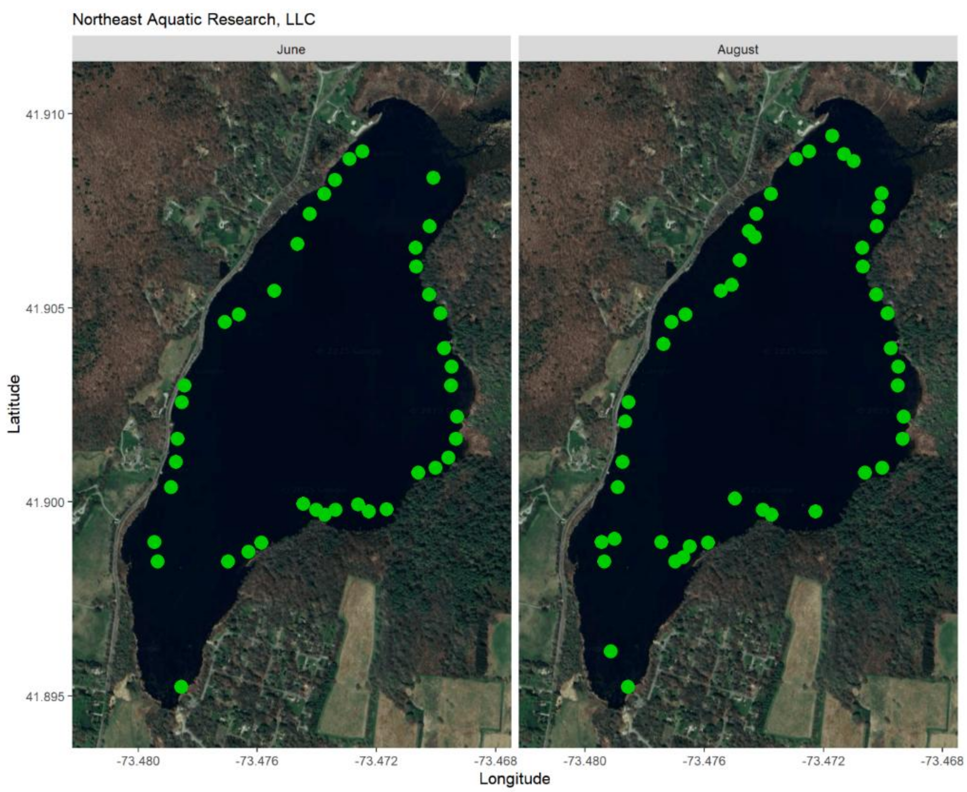
*Map 4. Locations of Curly-leaf Pondweed in June and August 2024.*


*Map 5. Locations of Water Chestnut in June and August 2024. Water Chestnut was difficult to find in August due to the extreme water lily growth making areas inaccessible.*



*Map 6. Locations of Brittle Naiad in August 2024. No Brittle Naiad present in June 2024.*


*Map 7. Locations of native floating leaf plants in June and August 2024.*



## Recommendations for 2025

Plant growth in Mudge Pond is profuse and the pond contains a large number of invasive species. Eurasian Milfoil and Fanwort are the most abundant of the invasives. A Fluridone or ProcellaCOR treatment would be beneficial for reducing growth of Eurasian Milfoil. However, these herbicides are not as effective vs. Fanwort or Curly-leaf Pondweed. Fanwort requires the herbicide Clipper, while Curly-leaf Pondweed requires yet another herbicide, typically Diquat, because this plant needs to be killed quickly. Curly-leaf Pondweed needs to be treated in the spring—May usually, Eurasian Milfoil can be treated effectively in June-July, and Fanwort is best treated in September. However, any and all treatments using herbicides will need to be approved by the State of CT pesticide department.

Water Chestnut was found at only a few locations, but this species can spread rampantly. Water Chestnut develops nutlets (winter buds), which drop to the lake bottom and can lie dormant in the sediment over winter and up to multiple years. This makes it very difficult to eradicate the species once it has become established. Multiple years of management are required to deplete the seed bank. We recommend beginning management of this species as soon as possible to avoid further spread and establishment. Due to the small number of plants currently in the lake, hand-pulling is possible, though herbicide treatment is also an option. It is best to remove Water Chestnut by July. A second removal event should be conducted in October to catch any new growth.

We found that all available littoral habitat from the shore to about 6 feet of water depth is colonized by floating-leaved plant species - Yellow and White Waterlily, and Water Sheild. These plants are succession species in that they transition a lake from open water to wetland. We strongly encourage thinning the water lilies in some areas and removing the water lilies in other areas, where appropriate.

At least two aquatic plant surveys should be conducted in 2025 – the first in late spring/early summer with a focus on assessing the Water Chestnut and Curly-leaf Pondweed populations. This can also act as a pre-treatment survey if plant management efforts are employed. The second survey should be conducted in late summer to assess the Eurasian Milfoil, Brittle Naiad, and Fanwort populations. This will also be the post-treatment survey in the event that a treatment has been conducted.

Internal loading is the biggest water quality concern at this time. The bottom 2.5-3.5 meters of water were anoxic from June through September. For the duration of this time, nutrients were being released from the sediment at the bottom of the lake that was in contact with this anoxic water. Total nitrogen was particularly elevated. The lake is an excellent candidate for artificial aeration. At this time, NEAR doesn't have a recommendation on the type of aeration or vendor for this management option. We expect to have researched the existing state-of-the-art options by the end of 2025, such that this time next year we can present the town with a set of aeration recommendations.

Monthly water quality monitoring should be conducted from April through November in 2025 to track the extent of anoxic water, water clarity, and nutrient concentrations both in the lake and entering the lake via the inlets. We recommend investigating the watershed upstream of Inlet 1 to search for possible sources of elevated nitrogen concentrations in that inlet. This inlet has a large sediment delta, indicating that there are one or more sources of erosion upstream that is causing suspended solids to be washed into the lake. This/these area(s) need to be identified and an erosion control solution implemented.