2023 Water Quality Report, Foxborough, Massachusetts

Prepared by Sean McCanty, Ph.D.
River Restoration Director
Neponset River Watershed Assocation

06/30/2024

Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data both in Foxborough and throughout the Neponset River watershed since 1996. As part of the Community Water Monitoring Network (CWMN), volunteers collect monthly water samples annually from May to October. Data gathered by the CWMN volunteers are used to track the health of the Neponset River and its tributaries, inform the public about threats to human health and wildlife, and to locate pollution sources (hot spots) for follow-up sampling. There is one permanent CWMN station within the town of Foxborough on the Neponset River on Crackrock Pond (Figure 1), which is tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, temperature, ortho-phosphate, and ammonia once per month between May and October. The following report summarizes the findings for the 2023 season, with raw water quality data available upon request. The parameters discussed in this report are limited to those that have state standards, namely *E. coli*, total phosphorus, pH, and dissolved oxygen.

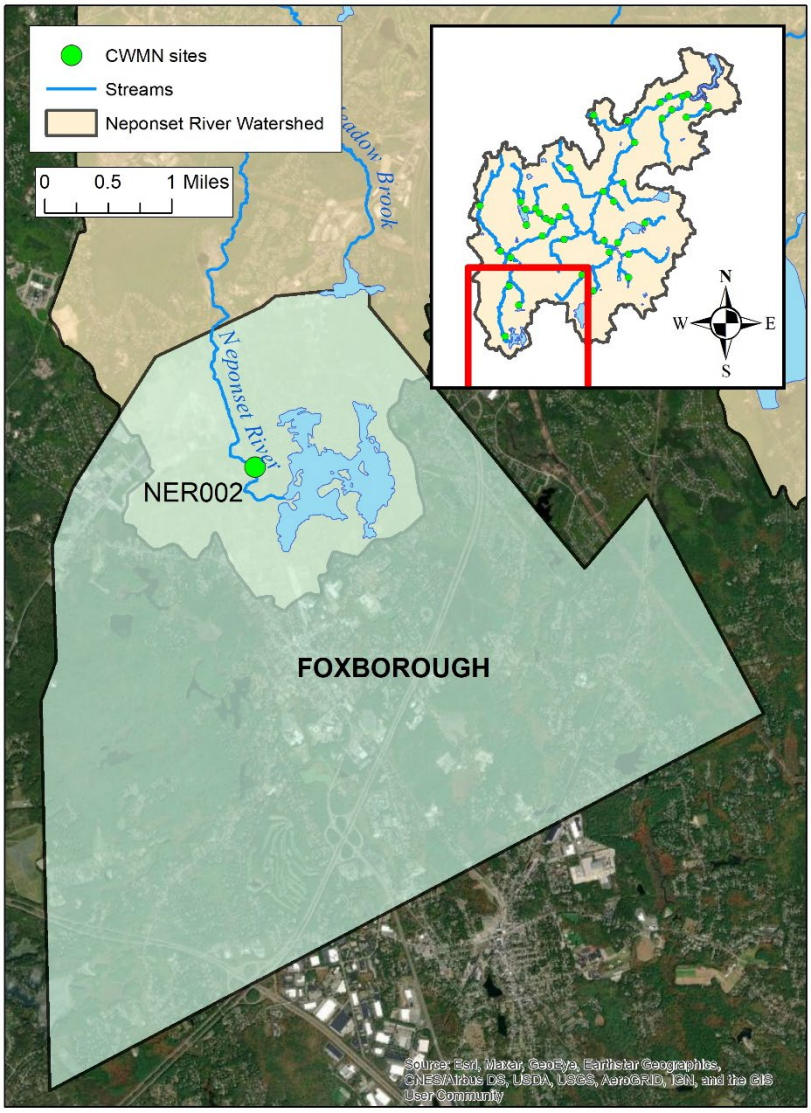

Figure 1: Map of the CWMN site in Foxborough, Massachusetts.

E. coli bacteria concentration is used by NepRWA and the Commonwealth to assess a waterbody's safety for "contact recreation" through activities such as swimming (primary contact) and boating (secondary contact). The presence of *E. coli* is not necessarily hazardous itself, but it provides evidence of fecal contamination and is an indicator that other, more dangerous, pathogens associated with human and animal waste might be present. The most common source of excess *E. coli* in our watershed is the improper disposal of pet waste in streets, lawns, and catch basins. Additional common sources include sewer or septic system malfunctions and discharges of organic wastes from household or commercial garbage. Wildlife waste also contains *E. coli*, so some amount of *E. coli* in waterbodies is normal. However, elevated concentrations from wildlife are typically due to human activities, such as feeding ducks or large populations of geese. Management interventions to reduce *E. coli* loads can include education on pet waste disposal, proper management of solid waste, frequent cleaning of catch basins, filtration stormwater best management practices (BMPs) to reduce the runoff that reaches a waterbody, and rapid identification and repair of sewage leaks and spills.

Phosphorus is a required plant nutrient that is often the "limiting nutrient" in freshwater ecosystems. This means that plants and algae will grow until the lack of phosphorus limits them. Therefore, the concentration of available phosphorus in a freshwater waterbody will often control the rate of aquatic plant growth (the other required nutrients are typically present at proportionately higher levels). Excess phosphorus creates excess biomass, especially algae, leading to a process called eutrophication. When these excess plants and algae die, the process of decomposition by bacteria and other decomposers consumes dissolved oxygen from the water. In extreme cases, dissolved oxygen levels get too low to support aquatic animals such as fish. Other impacts of eutrophication include unattractive and smelly algal blooms and loss of underwater plant communities due to reduced light penetration in turbid and algae-rich waters. Elevated phosphorus concentrations can also cause harmful algal blooms (HABs), where toxins are produced by the algae. A notable culprit is cyanobacteria, which produce toxins harmful to people and pets as well as wildlife.

Phosphorus sources can include wet (from rain) or dry (from sprinklers) weather runoff from parking lots, streets/gutters, and lawns. These surfaces contain phosphorus from fertilizers, organic matter (leaves, grass clippings), soil, garbage, and pet waste. Interestingly, phosphorus can also accumulate on these surfaces from atmospheric deposition, from fine dust particles and aerosols. Illegal dumping of organic matter, such as leaves in or near waterways or catch basins is a common problem. Poorly maintained septic systems, illicit discharges of sewage, and naturally occurring dead aquatic plant materials are additional sources.

The pH of a waterbody is a measure of how acidic the water is, with low pH meaning the water is more acidic than neutral, and high pH meaning it is more basic or alkaline. Water that is too acidic or too basic can be toxic to aquatic life. The pH is influenced by soil and bedrock characteristics, groundwater seepage, acid rain, carbon dioxide in the atmosphere, or heavy loading of tannin rich leaves/needles.

Adequate concentrations of dissolved oxygen (DO) are necessary to support fish, amphibians, mollusks, aquatic insects, and other invertebrate species. Many environmental drivers impact the DO levels in a water body. For example, cooler water temperatures can sustain higher concentrations of DO, which is why there is often a seasonal trend in DO concentration: low levels in the warm months and higher levels in the colder months. Rapid mixing and turbulence (such as riffles or step pools) also increase levels of DO due to atmospheric mixing. Aquatic plants also generate oxygen via photosynthesis during daytime hours. Alternatively, large amounts of decaying organic matter consume dissolved oxygen as microorganisms degrade the organic matter and lower levels of DO result. Excessive phosphorus that causes eutrophic conditions is also closely associated with low dissolved oxygen levels, because it drives plant growth and subsequent decomposition. In thermally stratified lakes, oxygen deficient conditions can occur in the deeper portions of the water where there is no atmospheric mixing and no photosynthesis (the two sources of DO in aquatic systems). In the summer, ponds and lakes typically have warmer surface waters and thus lower surface DO concentrations. Management interventions that can increase DO levels include increasing riparian shading to maintain lower water temperatures, removing obsolete dams, reducing excessive water diversions, and reducing decaying organic matter though the reduction of phosphorus runoff and other drivers of eutrophication.

Results and Discussion

Monthly sampling events occur rain or shine on the second Thursday of the month during the sampling season. This means that weather is not a criterion in determining when to collect water quality data. This allows our sampling program to address the different conditions that occur in our waterbodies in wet vs. dry weather. Rain events result in significant increases in street runoff via stormwater and overland flow into our rivers, which can significantly alter the concentrations of bacteria, nutrients, and other chemicals. In 2023, two sampling days occurred during wet periods and four sampling days occurred during dry periods, matching the 10-year average, while overall the region experienced above average precipitation. A wet period is defined as greater than 0.1 inches of precipitation within the 48-hour period preceding a sampling event. As shown in Table 1, the wet/dry ratio of sampling events can vary substantially year-to-year, and may not always reflect drought or flood years. For example, 2021 and 2020 had all but one sampling event occur in dry weather, despite being a drought and flood year respectively. This variability in wet weather sampling suggests we should be cautious in any improvements or changes in parameters, especially for *E. coli*, as the relative improvement may reflect wet vs. dry dynamics more than real improvements to water quality or changes in the frequency of sewage spills. As climate change shifts precipitation patterns, a change in sample collection or weighting may be needed to track water quality changes.

Table 1: The number of water quality sampling days that occurred during dry or wet weather since year 2013.

Year	Dry (days)	Wet (days)
2013	5	1
2014	4	2
2015	4	2
2016	6	0
2017	4	2
2018	3	3
2019	3	3
2020	5	1
2021	5	1
2022	2	4
2023	4	2

Escherichia coli (E. coli)

In Massachusetts, the criteria that defines acceptable levels of *E.coli* in Class B waterbodies (waterbodies that support wildlife, swimming, and boating, but not drinking) was formerly set by a single sample maximum (235 Colony Forming Units (CFU) per 100 mL) and geometric mean calculation (not to exceed 126 CFU/100mL). State level assessment of bacterial impairment now have criteria set by both a statistical value threshold (<10% of samples should exceed 410 CFU/100mL) and a rolling geometric mean calculation (not to exceed 126 CFU/100mL in 20% of windows). Because NepRWA's sampling is performed monthly rather than weekly, and the purpose of these reports is to provide meaningful historic comparison, the new criteria will not be applied in this report. For Crackrock Pond, this means no single sample should exceed 235 CFU/100 mL (the single sample standard), nor should the geometric mean of at least 3 sequential samples taken within the same season exceed 126 CFU/100mL (the seasonal standard). For ease of interpretation and for historic comparison, NepRWA calculates the geometric mean on the whole sampling season (6 sampling events).

In 2023 *E. coli* levels in Crackrock Pond were greater than the single sample maximum threshold in one sample and the geometric mean of samples was below the state criteria (Table 2), similar to 2022. Although the maximum was higher, 2023 actually represents a decrease over the last wet year (2021)'s relatively elevated geometric average for *E. coli*. The geomean is relatively consistent across the last 10 years and demonstrates that *E. coli* is not a persistent concern at this site. However, 5 years have had samples above the single sample maximum, suggesting there are occasional issues with *E. coli*, all tied to wet weather events.

Table 2: Concentrations of *E. coli* at the Crackrock pond site from 2013 through 2023. Unit are in cfu/100ml. N = 6 each year. Bolded values represent a measure above the state criteria, bolded years represent failure of either single sample maximum or season geometric mean.

Year	Maximum	Mean	Minimum	Geometric mean
2013	226	45	5	13
2014	**1860**	**324**	5	32
2015	41	17	5	13
2016	175	48	10	22
2017	**301**	87	10	47
2018	**496**	146	10	56
2019	189	78	10	52
2020	63	33	10	25

2021	156	82	20	62
2022	**259**	67	10	33
2023	**644**	135	10	43

Wet weather concentrations are generally higher than dry weather concentration, and in 2014, 2017, and 2018, 2022, and 2023 wet weather concentrations exceeded the single sample threshold (Figure 2). Dry weather concentrations since 2013 have been less than the single sample threshold. In 2023 the maximum concentration during dry weather (63 CFU/100mL) was significantly lower compared to the maximum of 644 CFU/100mL during wet weather.

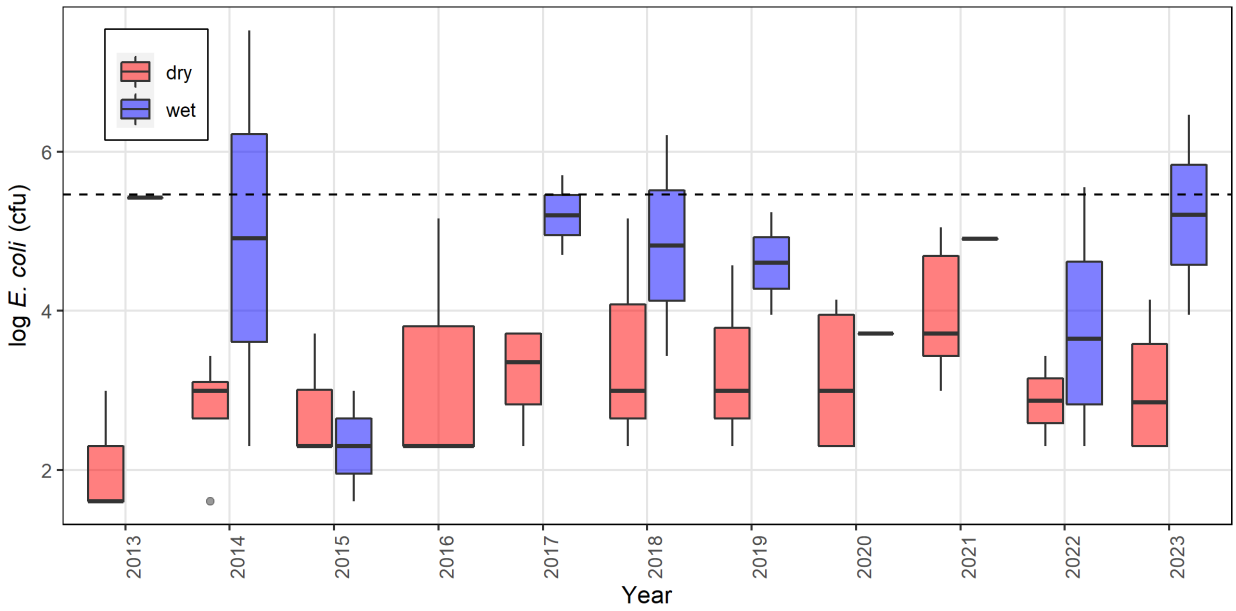

Figure 2: *E. coli* levels at Crackrock pond in Foxborough, MA from years 2013 to 2023 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed line shows the single sample maximum acceptable threshold (235 CFU/100mL). The lower and upper bounds of each box correspond to the first and third quartiles (the 25th and 75th percentiles). The upper whisker extends to the largest value or no further than 1.5 * the range between these two quartiles. Similarly, the lower whisker extends from the hinge to the smallest value or 1.5 * this interquartile range. Data beyond the end of the whiskers are “outlying" points and are plotted individually.

Phosphorus

The Commonwealth of Massachusetts does not currently provide numerical standards for classification of water quality impairments by phosphorus alone. Instead, the Massachusetts Department of Environmental Protection (MassDEP) uses a narrative standard that considers the EPA gold book standard for phosphorus alongside dissolved oxygen levels and excessive

primary producer growth. The EPA gold book standard identifies an average of at least three samples exceeding 0.1mg/L as the upper threshold for flowing waters, 0.05mg/L for streams entering a lake/reservoir, and 0.025mg/L for water within a lake/reservoir. We consider this site to be a lake site. Dissolved oxygen and excess primary producer growth like algal blooms are used as evidence that the phosphorus levels are causing an impact to the stream ecology.

The average total phosphorus levels at Crackrock pond in 2022 were almost five times the allowable concentrations at a lake or pond site (Table 3). However, the maximum and average value of total phosphorus in 2023 was the lowest it has been since 2017, when phosphorus levels became extremely elevated (> 5 times higher than EPA recommendations).

Table 3: The maximum, average, and minimum values of total phosphorus recorded from 2013-2023 at Crackrock pond. N=6. Values above the lake/pond standard are in bold. Extremely high values (>5 times standard) are marked with an asterisk.

Year	Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	Standard (mg/L)
2013	**0.04**	**0.08**	0.02	0.025
2014	**0.04**	**0.07**	0.02	0.025
2015	**0.03**	**0.06**	**0.03**	0.025
2016	**0.03**	**0.04**	0.02	0.025
2017	**0.13***	**0.28***	**0.03**	0.025
2018	**0.23***	**0.32***	**0.11**	0.025
2019	**0.72***	**2.48***	**0.15***	0.025
2020	**0.27***	**0.43***	**0.04**	0.025
2021	**0.38***	**0.59***	**0.26***	0.025
2022	**0.12**	**0.27***	**0.04**	0.025
2023	**0.12**	**0.2***	**0.04**	0.025

High concentrations of total phosphorus have been observed since 2017 and they appear to have peaked in 2019 (Figure 3). Concentrations have decreased substantially from 2019 but are still above the allowable levels. Both 2020 and 2022 demonstrated lower values than other recent years, while both occurred during substantial drought. It is conceivable that water restrictions or the lack of benefit in fertilizing lawns during these years lowered the inflow of phosphorus, and more awareness to communities could yield these positive results even in the absence of drought. However, the maintained reduction in the high rainfall of 2023 suggest a

more systemic positive change may have occurred, potentially successful fertilizer or other outreach campaigns.

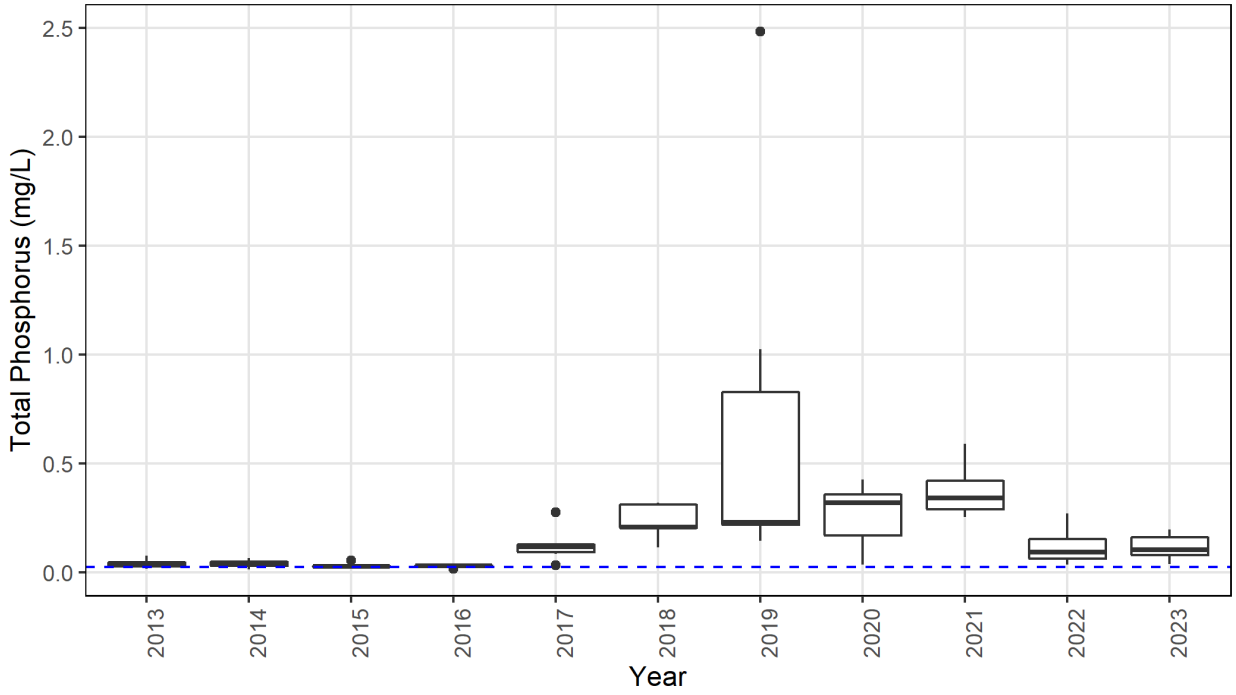

Figure 3: Total phosphorus levels at Crackrock pond from year 2013 to 2023. The blue dashed line is at 0.025mg/l. Boxplot statistics are the same as Figure 2.

Phosphorus loading into the pond was lower over the course of 2023, with June and July showing reduced total phosphorus when compared to the 10 year average (Figure 4). Dissolved oxygen levels are dangerously low at this site, as shown in Figure 4, despite 2023 demonstrating a better dissolved oxygen concentration in June. Both of these points provide evidence that phosphorus concentrations may be impacting conditions for aquatic animals through eutrophic algal growth. Anecdotally, since 2019, volunteers at this site have noted complete coverage in aquatic plants by the end of the summer. Water samplers have also noted that the water odor was earthy and smelling of rotten eggs on multiple occasions, which suggests the presence of anaerobic bacteria decomposing organic matter and producing hydrogen sulfide. A more quantitative survey of plant coverage would assist in having this site's phosphorus impairment be better understood and managed.

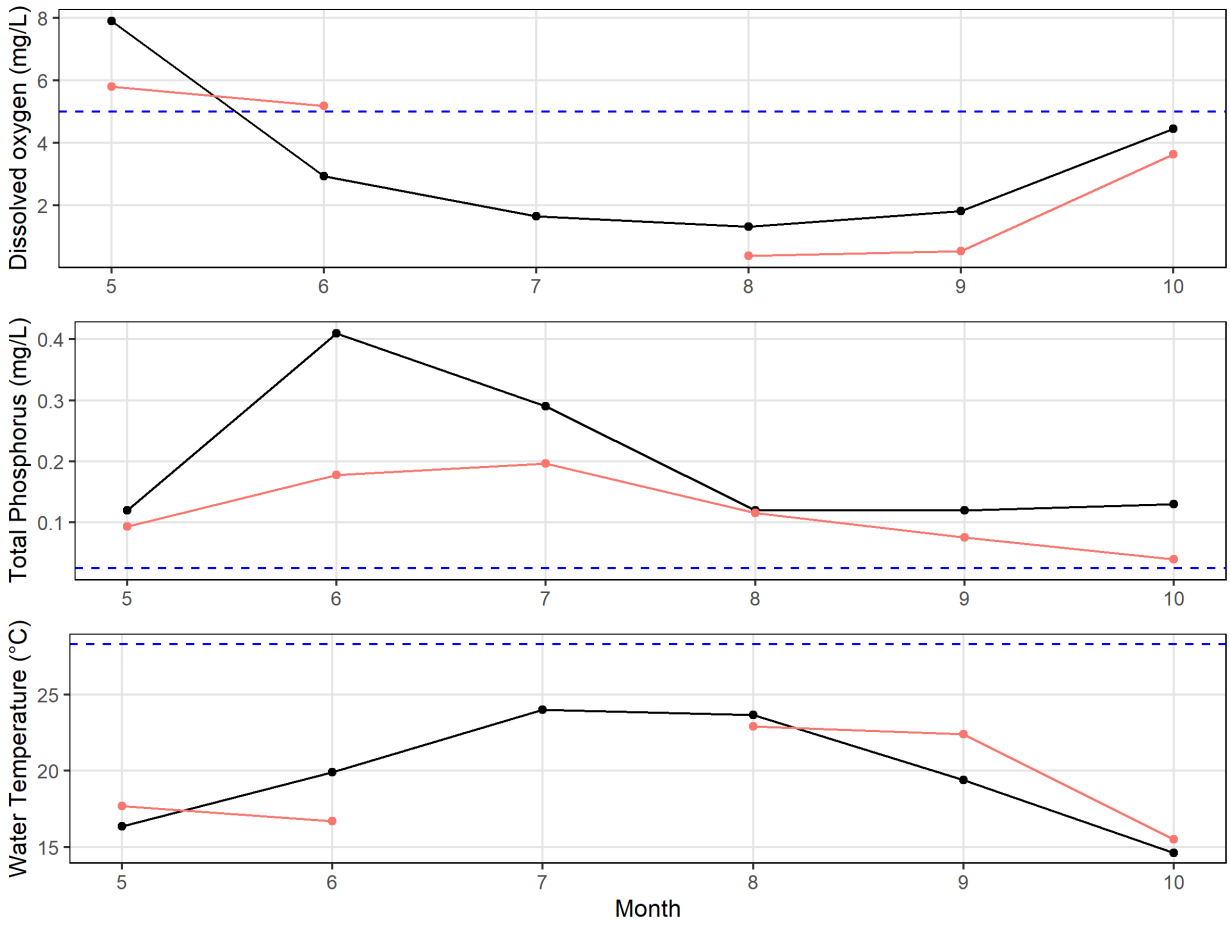

Figure 4: Monthly dissolved oxygen levels (top plot), total phosphorus (middle plot), and water temperature (bottom plot) levels at Crackrock pond. The black line shows the mean monthly value from 2013 to 2023 and the red line shows the 2023 values. The blue dashed line is at 5mg/l in the top plot, 0.025mg/l in the middle plot and 28.3°C in the bottom plot.

pH

The Commonwealth of Massachusetts considers a pH of 6.5 to 8.3 a healthy range for waterbodies in the state. Since 2013, pH has been within the acceptable range at Crackrock pond, except on a few rare occasions where samples register as either too acidic or too basic (Figure 5). Results from 2022 showed a high range in pH values, though the average remained within acceptable range. pH conditions seemingly stabilized in 2023, but should continue to be monitored, including potential problem spots within the pond due to poor water mixing.

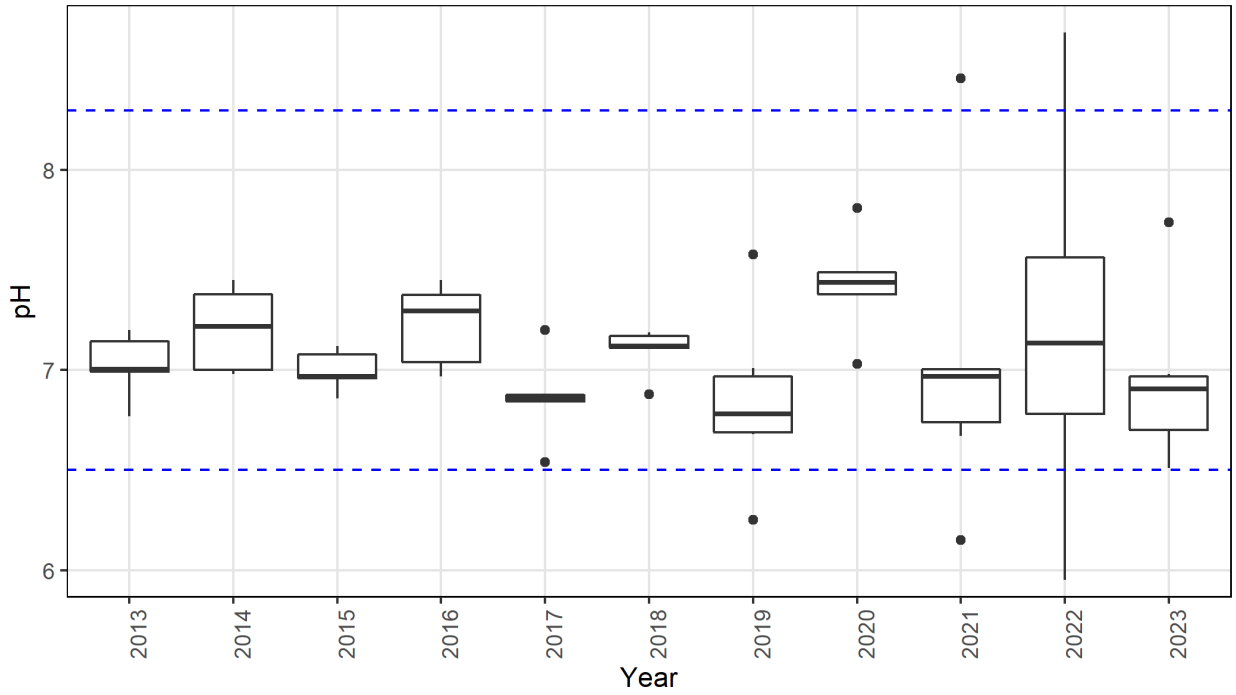

Figure 5: The pH levels at Crackrock pond for years 2013 through 2023. Blue dashed lines represent pH of 6.5 and 8.3 respectively. Boxplots statistics are the same as Figure 2.

Dissolved Oxygen:

The Commonwealth of Massachusetts considers DO levels below 5 mg/L to be stressful to all aquatic organisms and 6 mg/L to be stressful to certain species of fishes that require colder water. At this site, we apply the 5 mg/L threshold, as it has not been designated a Coldwater Fish Resource by the Division of Fish and Game.

Dissolved oxygen concentrations have consistently been lower than 5mg/L at Crackrock pond since 2013 (Figure 6). In 2023, dissolved oxygen concentrations were below 1 mg/L in August and September (data missing in July; DO = 0.39 mg/L, 0.54 mg/L respectively). These values represents anoxic conditions throughout the summer, consistent with eutrophication suggested by the high phosphorus values.

Additionally, water temperatures rose to were higher than average in August, which is a strong heating effect. This both lowers the amount of oxygen capable of being dissolved and creates better growth conditions for algae, which might have fueled the rapid decrease in dissolved

oxygen (Figure 4). Crackrock Pond also has the Neponset Reservoir directly upstream of it, which may be contributing to both low dissolved oxygen and high phosphorus. A study of the inflowing water would likely be informative in developing a management plan for these issues. As noted last year, the strong drought effect in 2022 would typically see worse dissolved oxygen issues, but oxygen levels were even lower this year. The fact that phosphorus levels appear to be improving may be a leading indicator of future dissolved oxygen level improvement as the ecology responds.

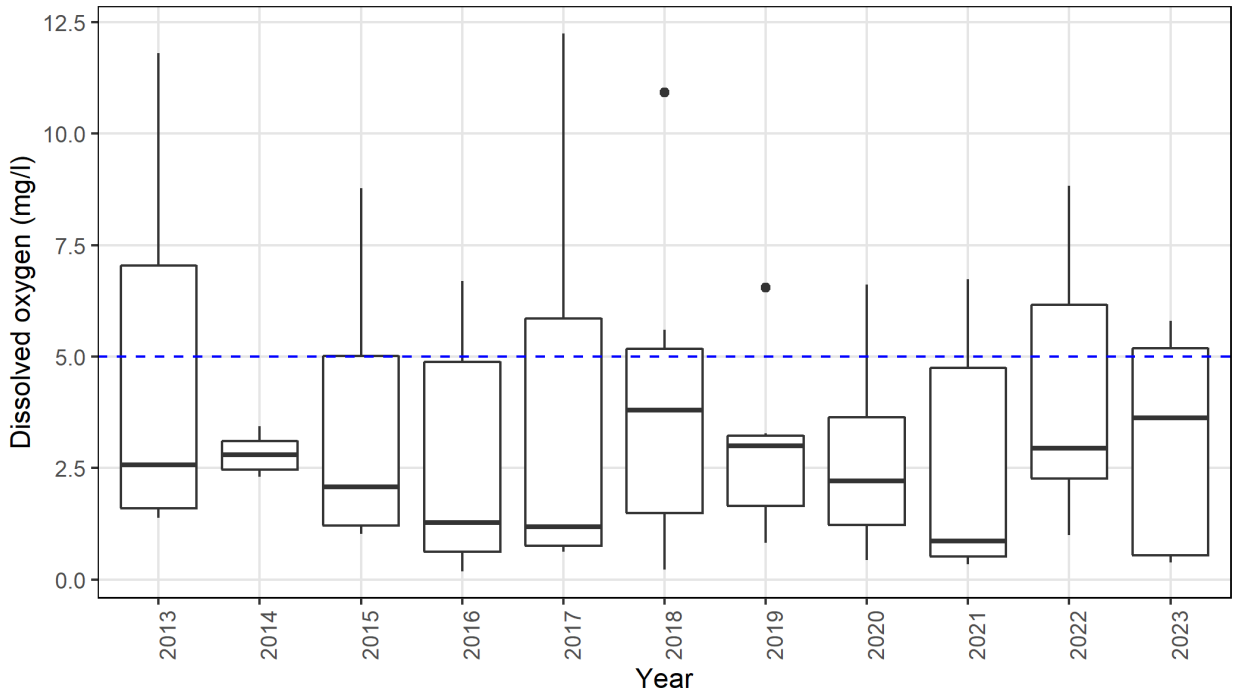

Figure 6: Dissolved oxygen levels at Crackrock pond from 2013-2023. The blue dashed line is at DO = 5mg/L.

Conclusion

The water quality data that we collect through the CWMN program is used to inform our messaging to the public and follow up site visits to sites to investigate problems (hot spot sampling). Table 4 details our recommendations and items to discuss with the Town.

Table 4: Major parameters of concern at Crackrock pond with recommendations on first steps to address the problem. TP = total phosphorus, DO = Dissolved oxygen.

Site	Parameter	Recommendation
NER002 **Crackrock Pond**	TP	• Investigate the new source of phosphorus that is causing high concentrations since 2017. Increased fertilizer awareness and messaging may build on observed successes. • Reduce all know forms of nutrient runoff toward this site, including inflows from Neponset Reservoir • Assess runoff and inflows during dry weather. • Quantitatively monitor for primary producer growth at this site for anticipated DEP phosphorus TMDL.

	DO	• Reduce all forms of nutrient runoff toward this site
		• Consider adding in mechanical aeration at inflow or in other locations.
		• Adjust impoundment dynamics to increase flow and decrease the residence time of water within the pond.
		• Investigate the status of DO in incoming water from the Reservoir
		  o How much water is released?
		  o What is the depth of water that is released?
		  o What is the oxygen and phosphorus concentration?