2021 Water Quality Report, Westwood, Massachusetts

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11/01/2022

Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data both in Westwood 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 are three permanent CWMN stations within and bordering the town of Westwood: on Mill Brook, Purgatory Brook, and the Neponset River (Figure 1). Waterbodies in Westwood are tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature. Sites PUB022 and NER125 are also tested for ortho-phosphate and ammonia. The parameters discussed in this report are limited to those that are tested at every site and have state guidelines for acceptable levels: *E. coli*, total Phosphorus, pH, and dissolved oxygen. The raw water quality data are available upon request.

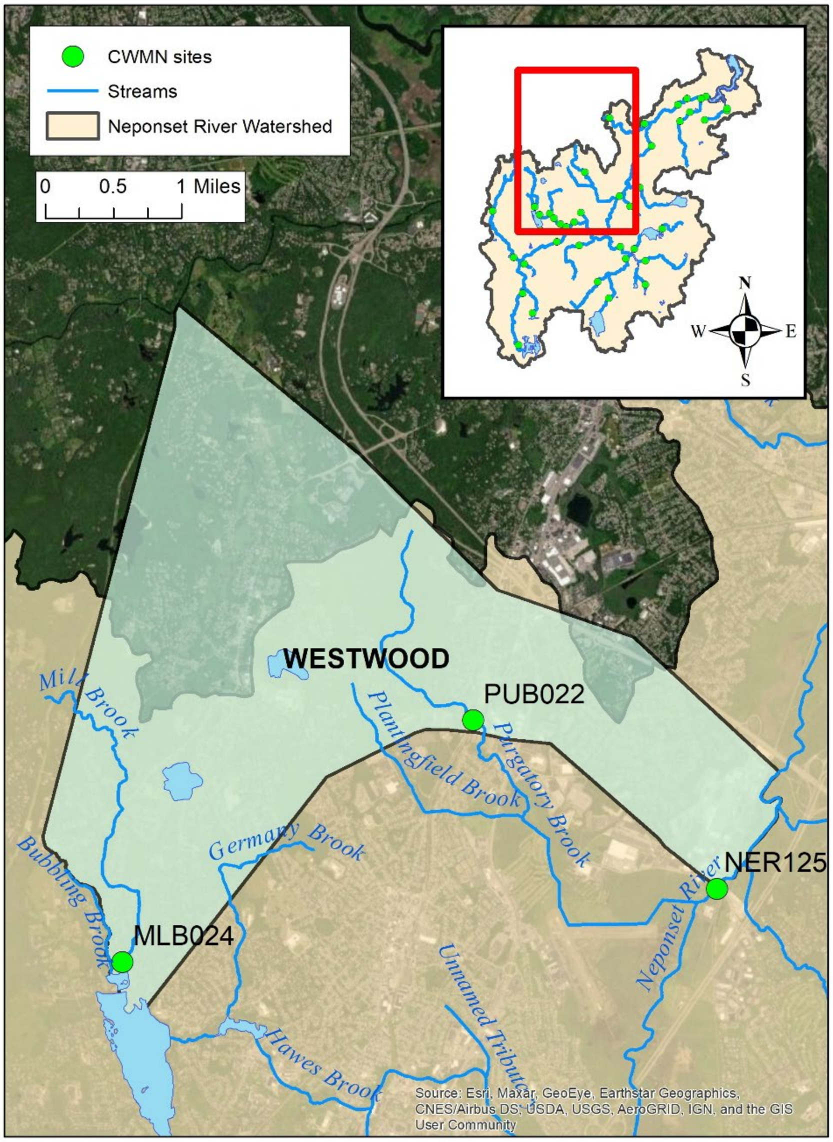

Figure 1: Map of the CWMN sites in Westwood, Massachusetts.

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 phosphorous 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 phosphorous 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 2021, five sampling days occurred during dry periods and just one sampling date occurred during a wet period. 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, both 2021 and 2020 had more sampling events occur during dry weather than any year since 2016, when all six sampling events occurred during dry weather. This lack of additional data during wet weather suggests we should be cautious in any improvements in parameters, especially for *E. coli*, as the relative improvement may reflect wet vs. dry dynamics rather than real improvements to water quality or changes in the frequency of sewage spills.

Table 1: The number of water quality sampling days that occurred during dry or wet weather since year 2011.

Year	Dry (days)	Wet (days)
2011	3	3
2012	2	4
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

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) is set by both single sample maximum and a geometric mean. For sites in Westwood, no single sample should exceed 235 Colony Forming Units (CFU) per 100 mL (the single sample standard), nor should the geometric mean of at least 5 samples taken within the same season exceed 126 CFU/100mL (the seasonal standard). For ease of interpretation, NepRWA calculates the geometric mean on the whole sampling season (6 sampling events).

In 2021 maximum *E. coli* levels at the three sites in Westwood were greater than the single sample maximum (maximum values in Table 2) but the seasonal limit water sample levels were within the criteria for the site on the Neponset River (geometric mean values in Table 2). Interestingly, at Mill Brook, the maximum *E. coli* levels was greatest during dry weather, while the other two sites had their highest values during the single wet weather sampling event. While Mill Brook in 2021 had a worse than average year with respect to *E. coli*, both the Neponset River and Purgatory Brook showed significant improvement, with geometric means below the average for the sites (Tables 2 and 3).

In past years, particularly 2019 and 2018, large concentrations of *E. coli* occurred during wet weather suggesting that the excess runoff during precipitation was contaminated with *E. coli* (Figure 2). Purgatory Brook, since 2013 has showed dry weather E. coli levels similar to wet weather, suggesting a problem with *E. coli* contamination less related to stormwater. This appears to have shifted since 2020, with falling values for dry weather samples, which may indicate the problem is improving. In 2021, Purgatory Brook was close to passing the seasonal limit, at levels lower than it has been since 2011. This improvement merits investigation to see if additional gains can be made, or replicated at other sites in Westwood.

Table 2: The maximum, average, minimum, and geometric mean levels of *E. coli* at the sites in Westwood, MA, in 2021. N=6. Units are in cfu/100ml. Bolded rows represent levels over the state standards for *E. coli*.

CWMN Site	Maximum	Average	Minimum	Geometric Mean
MLB024	**9210**	2025	97	**501**
NER125	**464**	162	52	118
PUB022	**1230**	365	52	**173**

Table 3: The maximum, average, minimum, and geometric mean levels of *E. coli* at the sites in Westwood, MA, for 2011-2020. N=60. Units are in cfu/100ml. Average and Average Geometric Mean are both calculated by averaging across the 9 years, not all 60 samples, which reflects a more accurate value for what is typical in these sites.

CWMN Site	Maximum	Average	Minimum	Avg. Geo. Mean
MLB024	**15500**	867	5	**201**
NER125	**14100**	827	5	**305**
PUB022	**19900**	1570	10	**528**

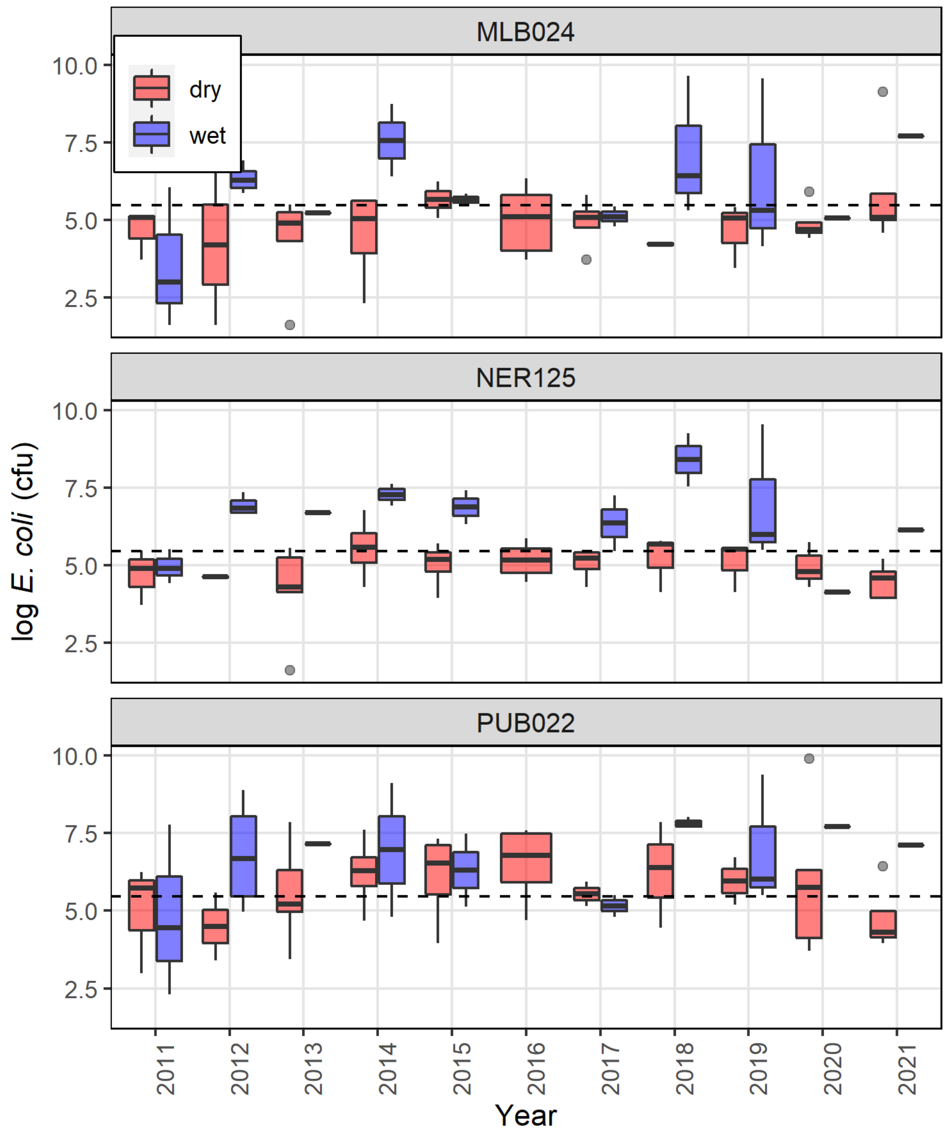

Figure 2: *E. coli* levels at the sites in Westwood, MA from years 2011 to 2021 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed 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. 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 and 0.05mg/L for streams entering a lake/reservoir. 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 sampling site on Mill Brook is directly upstream of Pettee Pond, so we apply the 0.05mg/L threshold. The other two sites do not empty directly into a pond or lake, so we apply the 0.1mg/L threshold for flowing waters. The seasonal average total Phosphorus concentration in 2021 was in compliance for the sites on the Neponset River and Purgatory Brook but was above the threshold for the site on Mill Brook, due to the stricter standard for waters entering an impoundment (Table 4). The high concentrations of total Phosphorus observed in 2020 on Mill Brook were reduced in 2021, but still above average for the last 10 years (Figure 3).

Mill Brook phosphorus levels in 2021 were above average across the summer months, returning to roughly average values in August. This suggests there may have been some summer related reason for elevated phosphorus this year on Mill Brook. In contrast, the Neponset and Purgatory Brook experienced generally an average year, with the notable exception of the September spike in phosphorus for Purgatory Brook (Figure 4). With that exception, both Purgatory and the Neponset remained below the state guidance on phosphorus.

Table 4: The maximum, average, and minimum values of total phosphorus recorded during 2021 at the three sites in Westwood, MA. N=6.

Site	Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
MLB024	0.11	0.07	0.03	0.05
NER125	0.08	0.06	0.03	0.1
PUB022	0.18	0.08	0.03	0.1

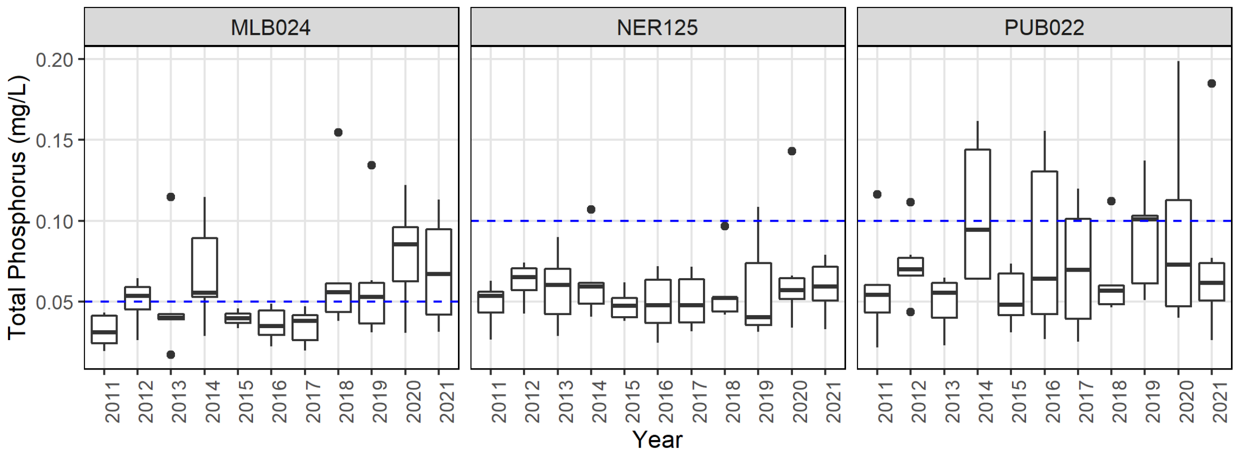

Figure 3: Total phosphorus levels at the three sites in Westwood, MA from year 2011 to 2021. The blue dashed line is at 0.05mg/l for Mill Brook (entering a pond) and at 0.1mg/l (for flowing waters) for the sites on the Neponset River and Purgatory Brook. Boxplot statistics are the same as Figure 2.

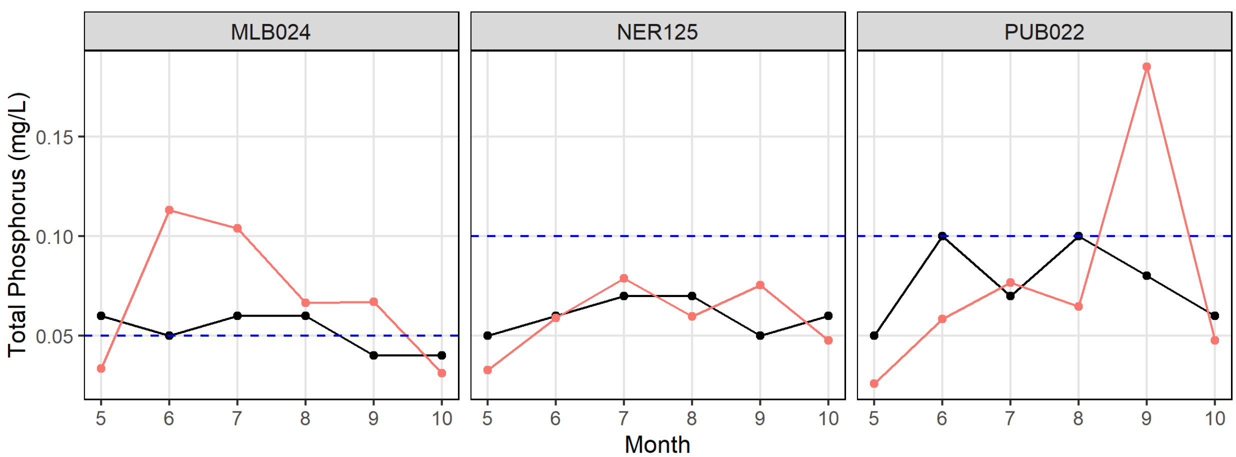

Figure 4: Monthly total Phosphorus concentrations at the three sites in Westwood, MA. The black line shows the mean monthly value from 2011 to 2020 and the red line shows the 2021 values. The blue dashed line is at 0.05mg/l for Mill Brook and at 0.1mg/l for the sites on the Neponset River and Purgatory Brook.

It is important to note that the Massachusetts DEP asks for additional information to help identify problems with total phosphorus, as high values alone are insufficient without documented issued in primary production and eutrophication. While we do not have primary producer data at these sites, there are negative correlations between total phosphorus levels and dissolved oxygen levels for Purgatory Brook, but not strong relationships at Mill Brook or the Neponset (R^2 = -0.21, R^2 = -0.36, R^2 = -0.42 at MLB024, NER125, and PUB022, respectively). This negative relationship at Purgatory Brook could demonstrate ongoing eutrophication.

pH

The Commonwealth of Massachusetts considers a pH range between 6.5 and 8.3 to be healthy for waterbodies in the state. Since 2011, pH has been within acceptable range at both Mill Brook and Purgatory Brook (Figure 5). However, the Neponset site showed more acidic values than in the previous decade, which may suggest some new issue related to acidity in the mainstem. Over the last few years, the variability in pH has increased at all 3 sites, but with the exception of the Neponset site, it has not substantially changed the average value.

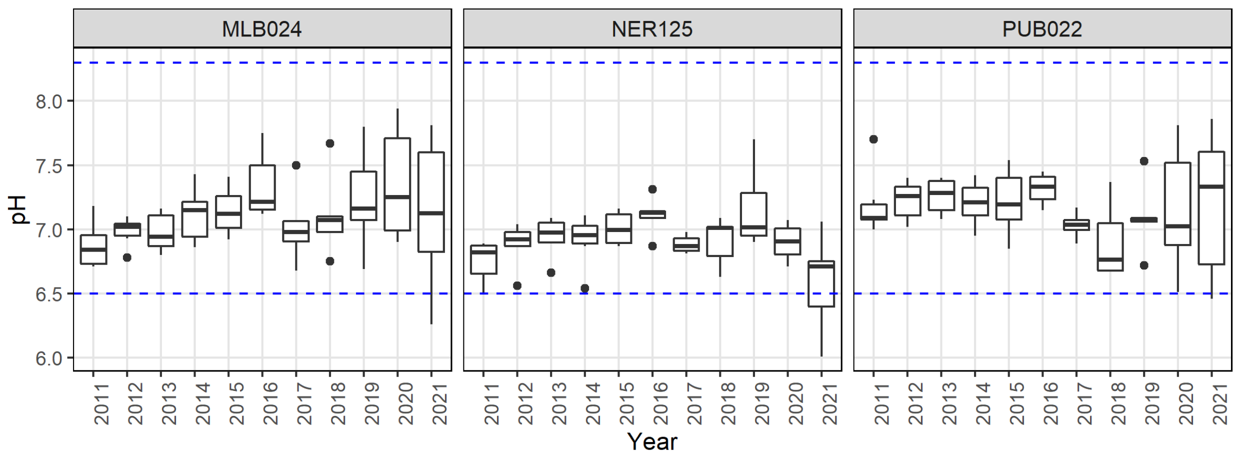

Figure 5: The pH levels at the three sites in Westwood for years 2011 through 2021. Boxplots statistics are the same as Figure 2. The blue dashed lines represent the recommended range for pH within Massachusetts.

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. Purgatory Brook and Mill Brook are listed as a Coldwater Fish Resource by the Massachusetts Division of Fisheries and Wildlife so we apply the 6 mg/l threshold for those two sites and the 5mg/l threshold for the site on the Neponset River. However, it is important to note that the Massachusetts DEP does not recognize Purgatory Brook and Mill Brook as cold-water fishery streams and they are therefore not regulated as such under the Surface Water Quality Standards.

Dissolved oxygen concentrations in 2021 were very similar to the 10-year average levels at all 3 sites, with the exception of the Neponset site's June sample. Both Mill Brook and Purgatory Brook had DO levels well above the coldwater fishery standard. This is interesting because Mill Brook has consistently higher than recommended total phosphorus (Figure 4). Because of this, Mill Brook may not be experiencing meaningful eutrophication, a condition we would like to maintain. The site on the Neponset River experiences DO concentrations in the summer just below the 5mg/l threshold based on the 10-year average. However, hypoxic conditions were observed in June 2021 (DO = 1.62mg/l) and issues with sampling resulted in no July sample. Thus, it is hard to know if this was a fluke value or a DO issue during the summer.

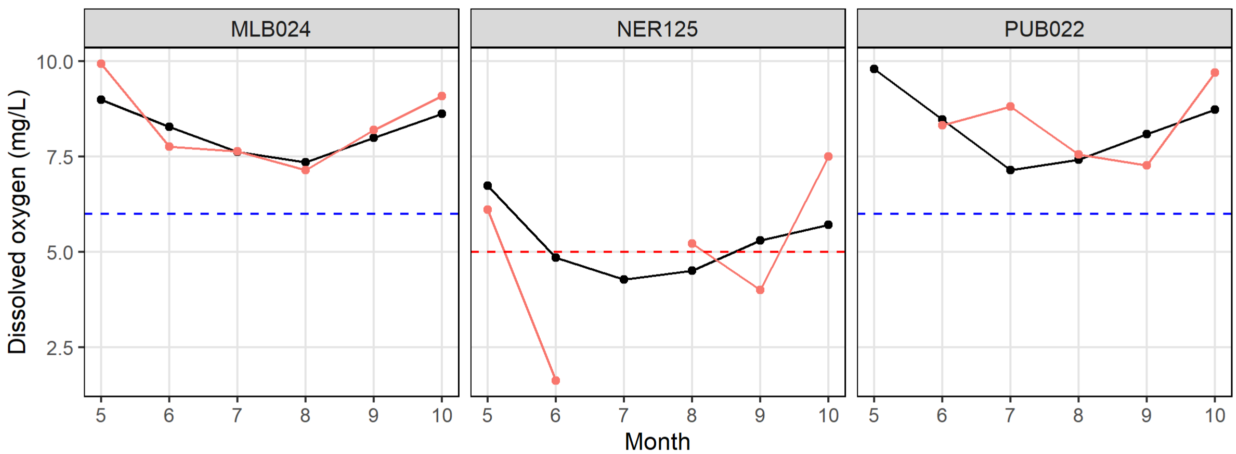

Figure 6: Monthly dissolved oxygen levels at the three sites in Westwood, MA. The black line shows the mean monthly value from 2011 to 2021 and the red line shows the 2021 values. The blue dashed lines are at DO = 6mg/l for MLB024 and PUB022, and the red dashed line is at DO = 5mg/l at NER125.

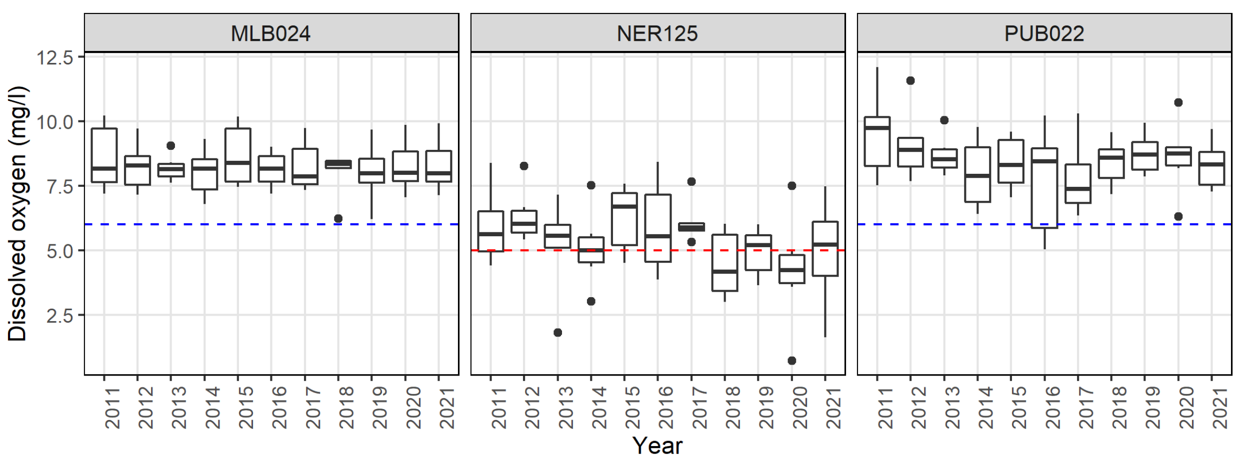

Figure 7: Dissolved oxygen levels at the three sites in Westwood, MA over the last 10 years. The blue dashed lines are at DO = 6mg/l for MLB024 and PUB022, and the red dashed line is at DO = 5mg/l at NER125.

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 5 details our recommendations and items to discuss with the Town.

Table 5: Major parameters of concern by site with recommendations on first steps to address the problem. TP = total phosphorus, DO = dissolved oxygen.

Site	Parameter	Recommendation
MLB024	TP	• Identify sources of Phosphorus that could have contributed to the high concentration in the summer months. • Assess issues with runoff during dry weather. • Assess primary producer growth at this site and at Pettee Pond to identify ecological impacts.
NER125	DO	• Evaluate issues related to June hypoxia, including flow rates and decomposing material.
	pH	• Identify decline in pH values in 2021, see if it remains an issue in 2022.
PUB022	TP	• Identify sources of Phosphorus that could have contributed to the high concentration in September.
	E. coli	• Assess issues with runoff during dry weather. • Identify any changes that resulted in lower levels in 2021 so they can be maintained and replicated elsewhere.