

2021 Water Quality Report, Dedham, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data both in Dedham 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

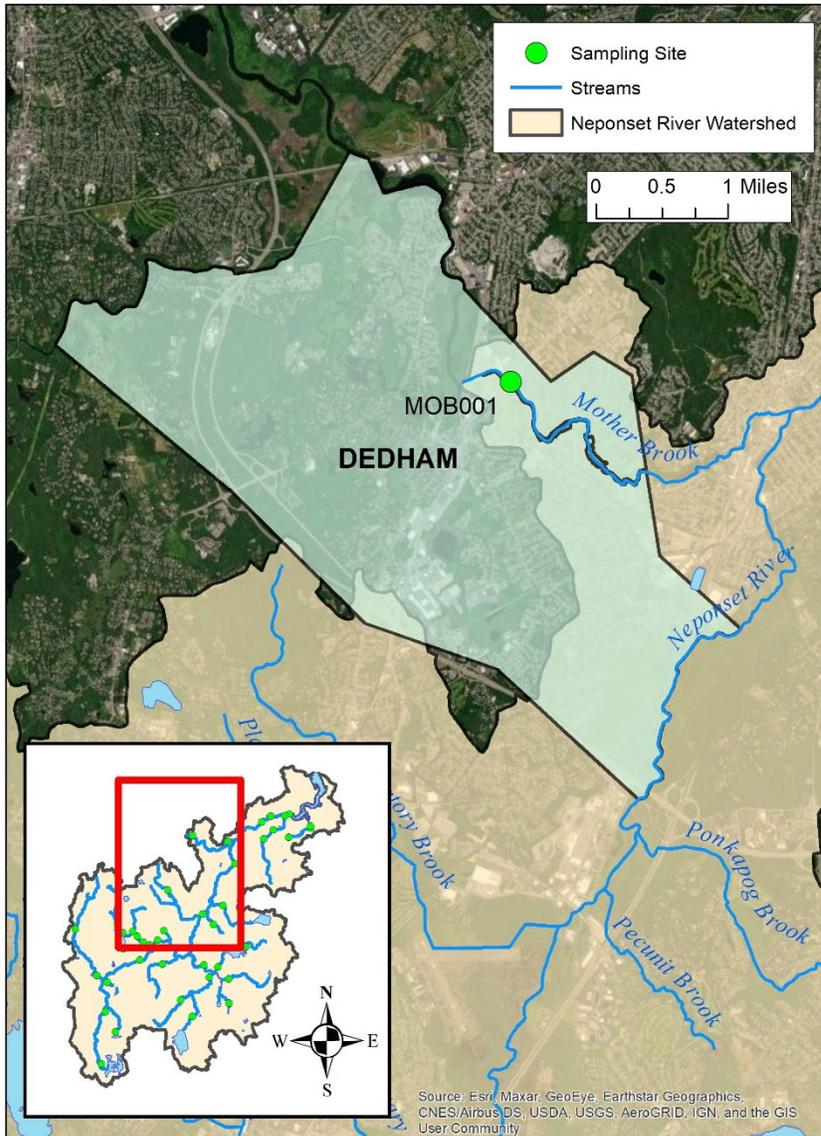


Figure 1: Map of the CWMN sites in Dedham, Massachusetts.

and wildlife, and to locate pollution sources (hot spots) for follow-up sampling. There is one permanent CWMN station within the town of Dedham, located on Mother Brook (Figure 1), which is tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature. The following report summarizes the findings for the 2021 season, with raw water quality data available upon request.

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 or infiltration 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, particularly in overnight hours when decomposition is not offset by active photosynthesis. 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 withdrawals / diversions, and reducing decaying organic matter through 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 Mother Brook, 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 (generally 6 sampling events).

In 2020 *E. coli* levels at the Mother Brook site were consistently below the single sample standard and the seasonal geometric mean for the first time in since 2013 (Table 2). In our 2020 report, we noted this potentially pointed to improvements following the closure of the Dedham Transfer Station in 2019. The 2021 season showed a slight increase in *E. coli* levels, with 2 samples failing the single sample maximum standard, 437 CFU/100mL (a wet event) and 354 CFU/100mL (a dry event). However, even this increase is well below the maximum and average values from 2017 – 2019, suggesting that the improvements seen since 2020 represent a marked improvement (Figure 2).

Table 2: The maximum, average, minimum, and geometric mean *E. coli* concentrations at the site on Mother Brook (MOB001) in Dedham, MA, since year 2011. N=6. Units are in cfu/100ml. Bolded values represent a measure above the state criteria, bolded years represent failure of either single sample maximum or season geometric mean.

Year	Maximum	Average	Minimum	Geometric Mean
2011	3450	653	5	94
2012	19900	3538	5	261
2013	288	100	10	60
2014	1200	337	109	191
2015	1940	735	98	457
2016	591	235	52	161
2017	3260	1327	74	569
2018	24200	9237	62	2160
2019	3870	716	20	132
2020	199	116	20	93
2021	437	200	30	142

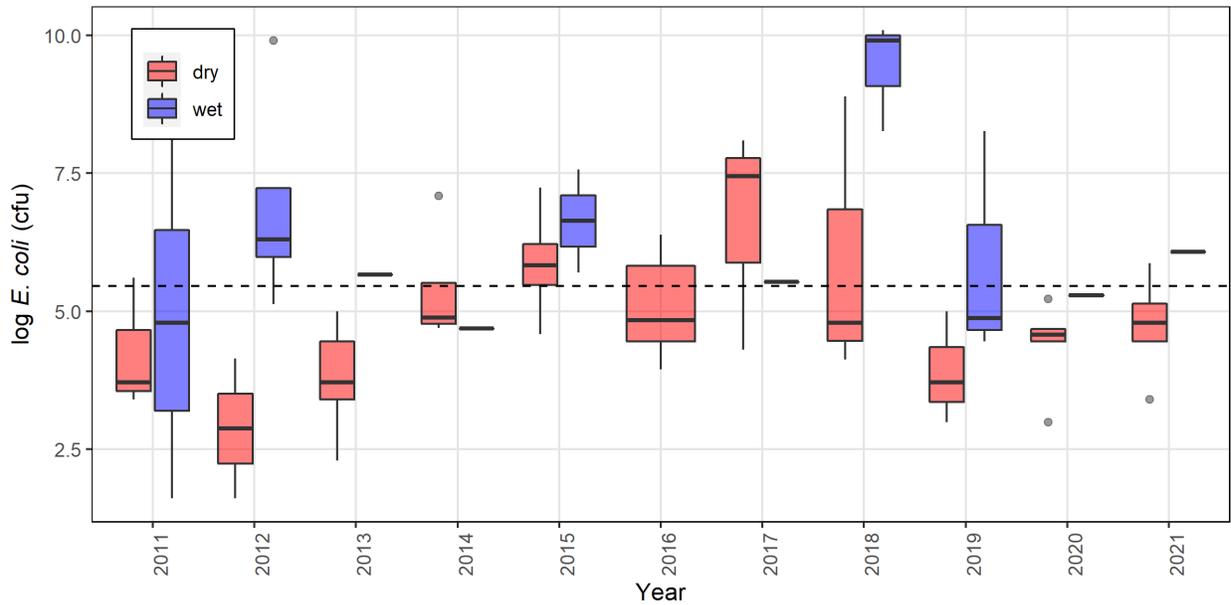


Figure 2: *E. coli* levels at Mother Brook in Dedham, MA from years 2011 to 2021 – note the log scale. The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed line shows the single sample maximum acceptable threshold (235 CFU/100mL). The lower and upper bounds of each box correspond 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 and 0.05mg/L for streams entering a lake/reservoir. We considered the Mother Brook site in Dedham to be entering a lake or reservoir due to the Mill Pond downstream. 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 seasonal average total Phosphorus level in 2021 was 0.08 mg/l, which is above the threshold for waters entering a lake or reservoir (Table 3). Since 2010, seasonal averages have ranged from 0.05mg/l to 0.08 mg/l in 2018 due to a large outlying value (Figure 3). In 2021 however, there was no large outlier, but higher values in almost all months, suggesting

phosphorus is becoming more of an issue. Future data will tell whether this represents a new normal, or aberrant findings for 2021.

Table 3: The maximum, average, and minimum values of total phosphorus recorded during 2020 at Mother Brook in Dedham, MA. N=6.

Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
0.10	0.08	0.04	0.05

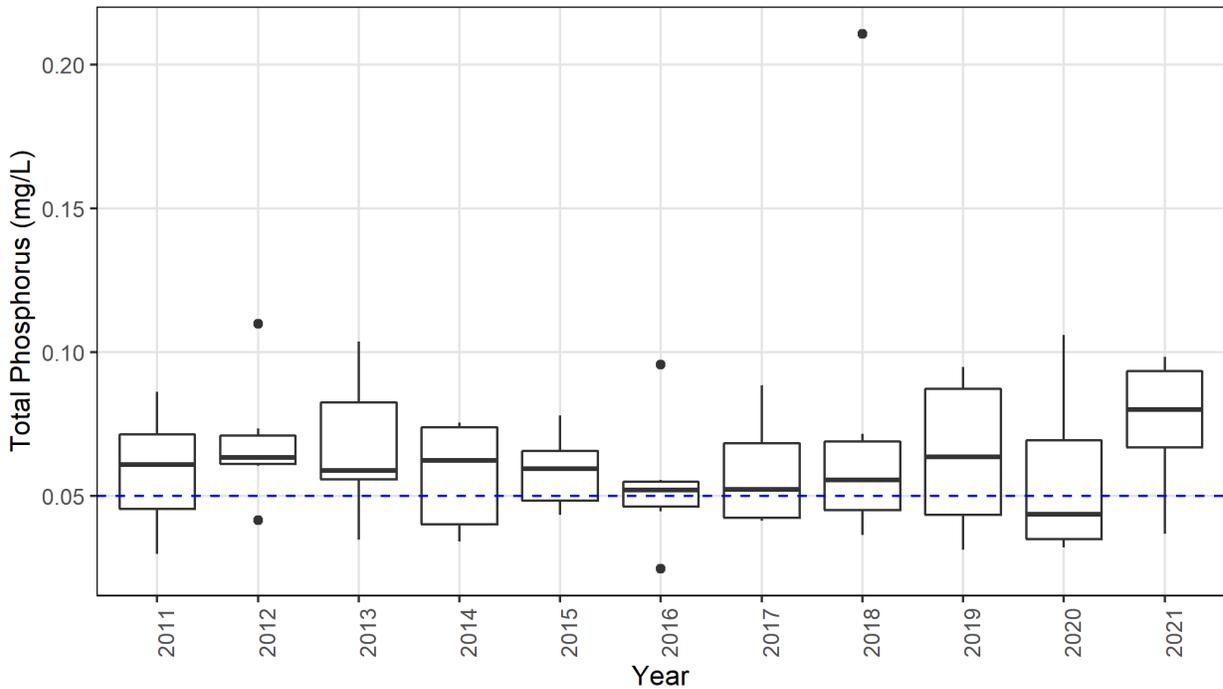


Figure 3: Total phosphorus levels at Mother Brook in Dedham, MA from year 2011 to 2021. The blue dashed line is at 0.05mg/l. Boxplot statistics are the same as in Figure 2.

It is important to note that the Massachusetts DEP asks for additional information to help identify a problem with total Phosphorus, such as algae or other primary producer data. While we do not have primary producer data at this site, there is a strong negative correlation between total Phosphorus levels and dissolved oxygen levels ($R^2 = -0.58$) over the last 10 years, suggests eutrophication may be a concern. While dissolved oxygen levels are not considered low at this site, the strong relationship with total Phosphorus implies that it is important to maintain low nutrient levels.

pH

The Commonwealth of Massachusetts considers a pH range between 6.5 and 8.3 to be healthy for waterbodies in the state. Since 2010 pH levels have been within the acceptable range at the Mother Brook site except during one sampling event in 2020 and 2021 (Figure 4). The October water sample had a pH of 6.26, which is too acidic, but all other samples that year had near neutral values. This coincides with a new pH probe in use at NepRWA and it will depend on future data to determine whether the probe is faulty or more accurate.

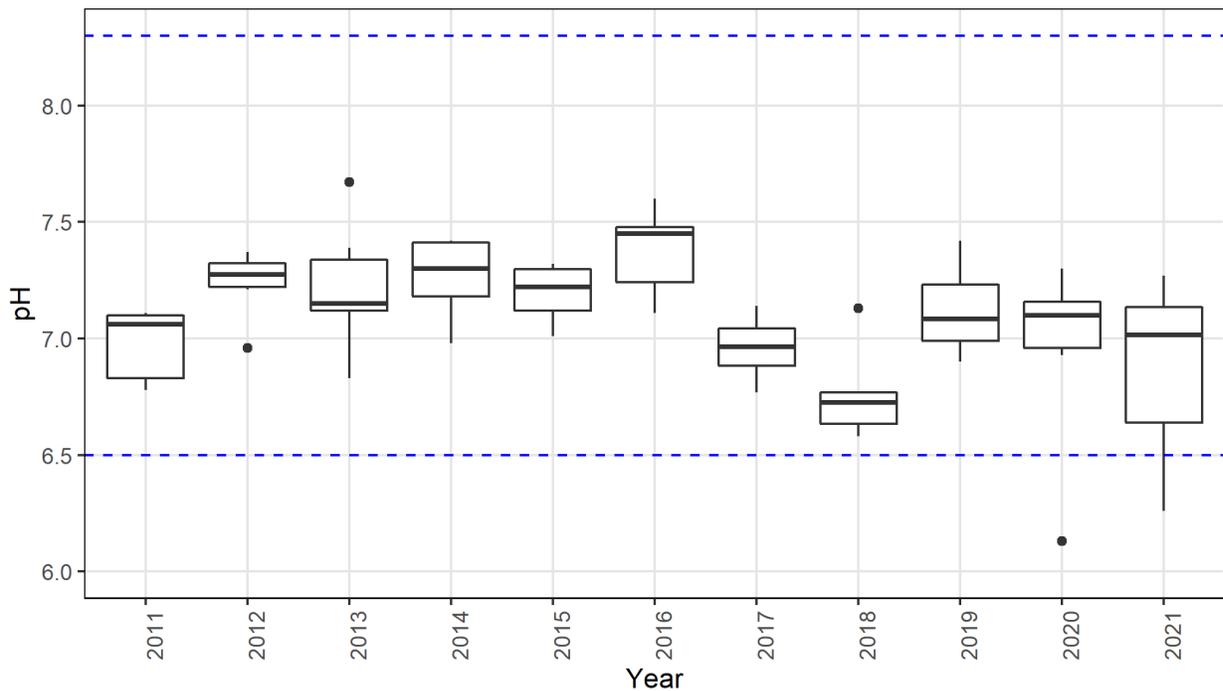


Figure 4: The pH levels at the eight sites in Dedham for years 2011 through 2021. Blue dashed lines represent the Common Boxplots statistics are the same as Figure 2.

Dissolved Oxygen:

The Commonwealth of Massachusetts considers DO levels below 5 mg/L to be stressful to all aquatic organisms and below 6 mg/L to be stressful to certain species of fishes that require colder water. Mother Brook is not a cold-water resource according to the Massachusetts Division of Fisheries and Wildlife, so here we use the 5 mg/l threshold.

Dissolved oxygen levels in 2021 were similar to the 10-year average levels (Figure 5). Trends in seasonal dissolved oxygen are likely driven by stream temperatures and nutrient enrichment. Ten years of data shows that DO levels are typically above the stressful threshold except in 2018 when the June and July levels were DO = 1.7mg/l and DO = 2.3mg/l, respectively (Figure 6). The June 2018 total Phosphorus concentration was 0.21mg/l, which could have fueled plant growth and a subsequent reduction in DO. Considering the 10 years of data shown in Figure 6, the hypoxic conditions in 2018 appear to be an anomalous, but it would be helpful to understand what environmental conditions created the hypoxic stream conditions to prevent that in the future.

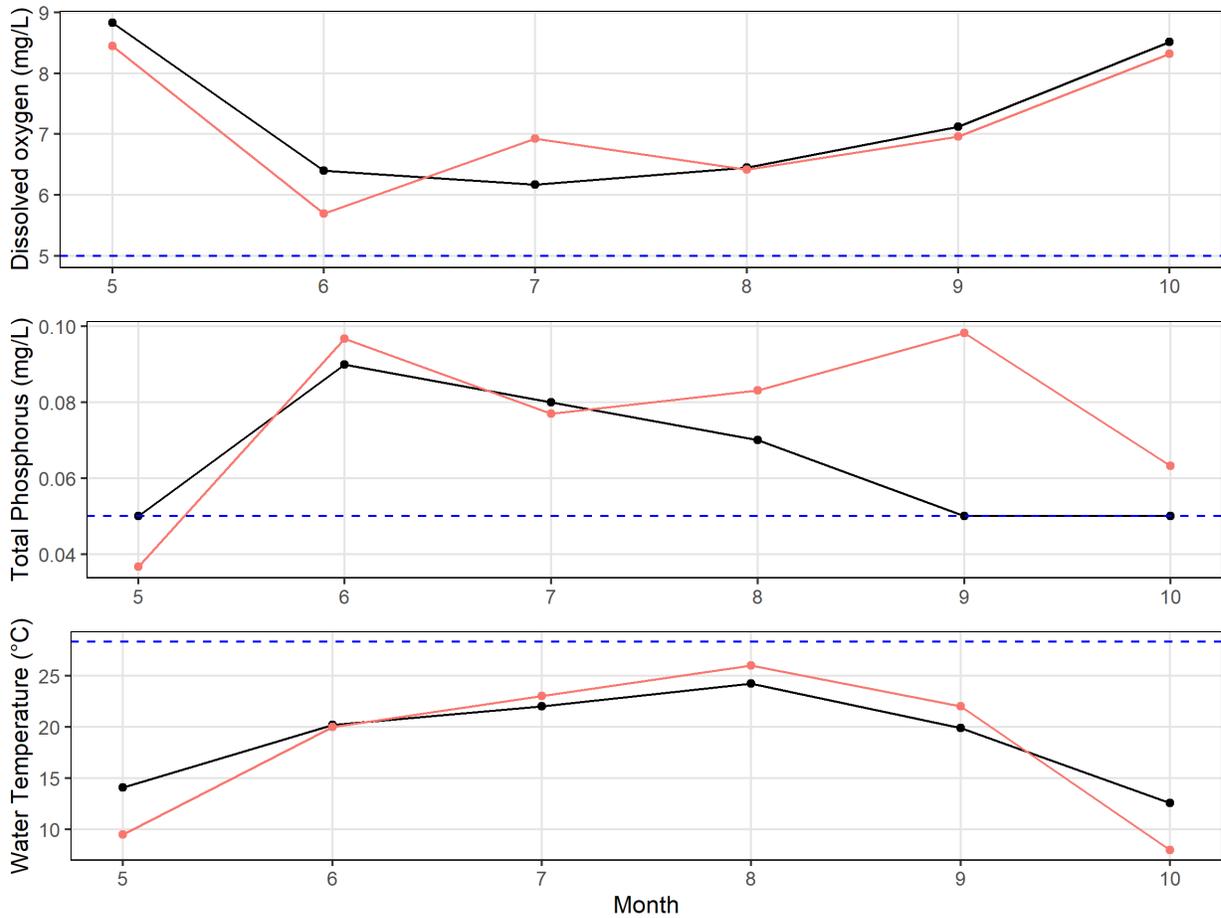


Figure 5: Monthly dissolved oxygen levels (top plot), total phosphorus levels (middle plot) and water temperature levels (bottom plot) at Mother Brook in Dedham. The black line shows the mean monthly value from 2011 to 2021 and the red line shows the 2020 values. The blue dashed lines represent the state criteria, namely 5 mg/L for DO, 0.05mg/L for phosphorus, and 28.3°C for warm water maximum temperature.

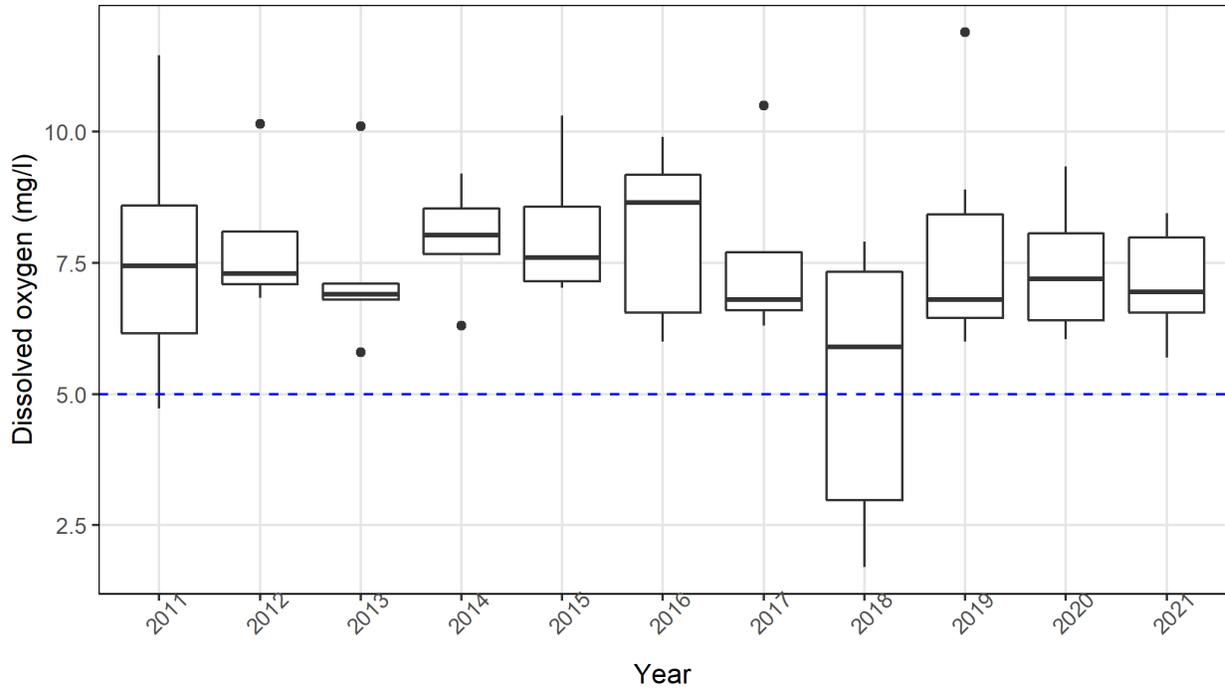


Figure 6: Dissolved oxygen levels at Mother Brook in Dedham, MA, from year 2011 to year 2021. N=6 for each year. The blue dashed line is at 5mg/l.

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 by site with recommendations on first steps to address the problem.

Site	Parameter	Recommendation
MOB001	TP	<ul style="list-style-type: none"> Identify sources of phosphorus and aim to reduce concentrations -including reviewing available Charles River data in an effort to determine whether sources may be upstream rather than on the Brook. Consider a monitoring program for plant and algae growth to identify ecological impacts of the high phosphorus concentrations both at the site and within the downstream impoundments.

MOB001	<i>E. coli</i>	<ul style="list-style-type: none">• Continue to monitor to ensure that the levels remain low following the closure of the Dedham Transfer Station. Identify other, non-sewage sources of <i>E. coli</i> contamination, such as pet waste and consider outreach campaigns to curtail them.
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