2021 Water Quality Report, Canton, Massachusetts

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Background

The Neponset River Watershed Association (NepRWA) has been collecting water quality data in Canton 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 eight permanent CWMN stations within and bordering the town of Canton; two on Pequit Brook, one on Pecunit Brook, one on Ponkapoag brook, one on Beaver Meadow Brook, one on Massapoag Brook, one on the East Branch of the Neponset River, and one on the Neponset River (Figure 1). Waterbodies in Canton are tested for *Escherichia coli* (*E.coli*), total phosphorus, pH, dissolved oxygen, and temperature once per month between May and October. Sites EAB010, MPB088, NER125, POB040, and PQB036 are also tested for ortho-phosphate and ammonia. The parameters discussed in this report are limited to those that are tested at

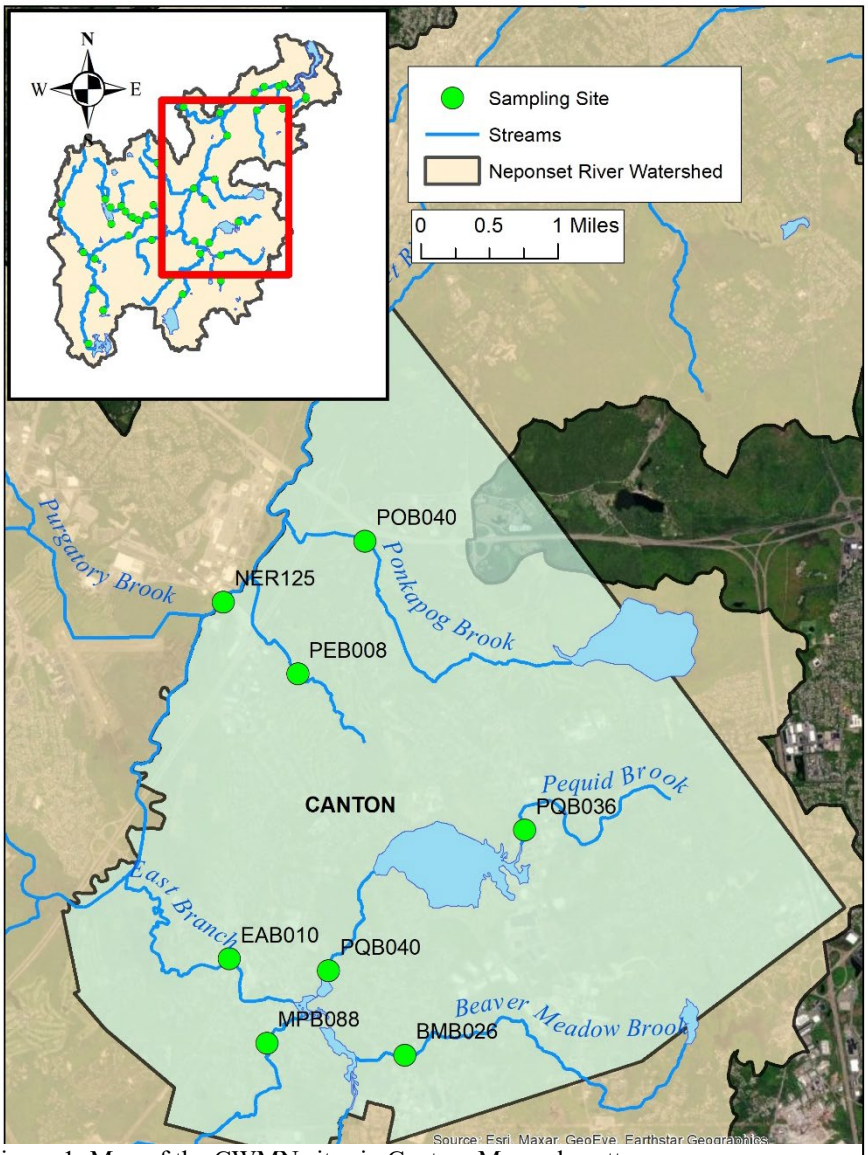

Figure 1: Map of the CWMN sites in Canton, Massachusetts.

every site, namely *E. coli*, total Phosphorus, pH, and dissolved oxygen. The raw water quality data are 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 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. 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 five 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 six sampling events).

In 2021 maximum *E. coli* levels at all eight sampling sites exceeded the 235 cfu/100mL single sample limit (Table 2). The highest levels were observed at the Beaver Meadow Brook. Minimum *E. coli* levels were acceptable at all eight sites. The seasonal standard was below the criteria for only two sites: NER125 and EAB010, both on the "mainstem" of the river (Table 2). This suggests an issue with the tributaries in Canton. Additionally, during dry weather only, when *E. coli* levels tend to be lower due to less stormwater runoff, all six tributary sites still exceeded the state criteria, while the mainstem sites did not (Table 3). Despite there only being one wet weather event in 2021, this suggests that the tributaries in Canton are experiencing some bacteria related issues not attributable to stormwater.

Table 2: The maximum, average, minimum, and geometric mean levels of *E. coli* at the eight sampling sites in Canton, MA, year 2021. N=6 for each site (except PQB036, N=5). Units are in cfu/100ml. Bold rows and values were sites with *E. coli* levels that failed the single sample limit at least once. An * means the seasonal sample limit was surpassed.

CWMN Site	Maximum	Average	Minimum	Geometric Mean
BMB026*	**4880**	1030	52	**341**
EAB010	**2010**	408	31	125
MPB088*	**1380**	468	10	**133**
NER125	**464**	162	52	118
PEB008*	**1610**	392	74	**192**
POB040*	**1620**	390	31	**171**
PQB036*	**1860**	740	52	**437**
PQB040*	**1050**	445	10	**213**

Table 3: The maximum *E. coli* levels from samples in 2021 in wet and dry weather. N = 1 for wet weather and N = 5 for dry weather. Bolded values indicate *E. coli* levels above state criteria, and bolded sites names reflect sites above the criteria even in dry conditions.

Site	Dry	Wet
BMB026	**432**	**4880**
EAB010	145	**2010**
MPB088	**886**	**1380**
NER125	183	**464**
PEB008	**305**	**1610**
POB040	**345**	**1620**
PQB036	**1860**	**717**
PQB040	**907**	**1050**

Wet weather events were generally associated with higher *E. coli* levels in past years at all the sampling sites in Canton, with the exception of 2020 (Figure 2). While this is unusual, because of the low sample size of wet weather that year (N=1), it may represent outlier data. For the 2021 data, the wet/dry patterns follow the typical trends for most sites, with the notable exception or PQB036.

Pequit Brook and Beaver Meadow Brook appear to have the greatest problem with *E. coli* for the streams in Canton in 2021. In particular, site PQB036 had elevated *E. coli* levels, with two dry weather sampling values above its wet weather value. Both Pequit Brook and Beaver Meadow Brook had four sampling events above the state criteria for single station maximums, suggesting a systemic problem at these sites with *E. coli* even in dry weather. Because we only sampled once during wet weather, we cannot say if there is a systemic problem during rain events. At these sites in 2018 and 2019, wet weather sampling did result in high *E. coli* levels, which suggests a systemic problem during rain events. The other tributary sites (Ponkapoag Brook, Pecunit Brook, and Massapoag Brook) all also had dry sampling events above the single station maximum. This is an increase relative to last year's results, and raises concerns about the health of these tributaries.

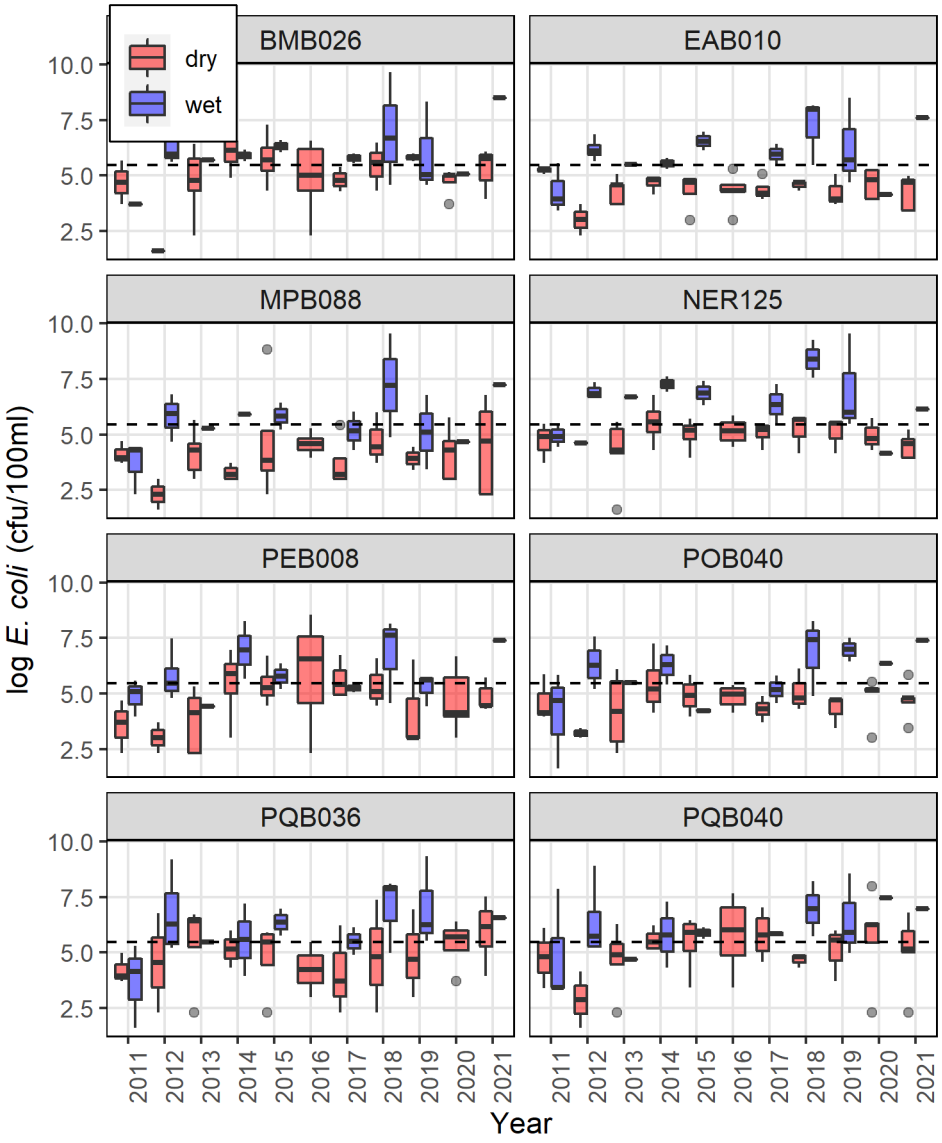

Figure 2: *E. coli* levels at the eight sampling sites in Canton from years 2011 to 2021 – note the log scale, which allows exponential data to be viewed more easily. The plot shows levels grouped by weather (blue = wet, red = dry). The black dashed line shows the single sample maximum acceptable threshold (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 four sites in Canton to be flowing waters and four sites to be entering a lake or reservoir (Table 4). Dissolved oxygen and excess primary producer growth, like algal blooms, are used as evidence that phosphorus levels are causing an impact to the stream ecology.

In 2021, three sites in Canton had seasonal averages that were above the EPA standard: BMB026, PQB036, and MPB088. These three sites where the stream is entering a lake or reservoir, requiring the 0.05mg/l threshold (Table 4). The remaining site in this category did not exceed the threshold, but its maximum sample did equal the criteria. The other four sampling sites, all flowing waters, were below the threshold.

Table 4: The maximum, average, and minimum values of total phosphorus recorded during 2021 at the 8 sampling sites in Canton. Sites broken out into flowing waters or those entering a lake or reservoir. Bolded rows have a seasonal average that exceed the EPA gold book standard for total phosphorus. N=6 for each site except PQB036 where N = 5.

Site	Maximum (mg/l)	Average (mg/l)	Minimum (mg/l)	Standard (mg/l)
Flowing				
EAB010	0.06	0.04	0.02	0.1
NER125	0.08	0.06	0.03	0.1
PEB008	0.1	0.07	0.04	0.1
POB040	0.1	0.07	0.03	0.1
Entering Reservoir				
BMB026	**0.07**	**0.05**	**0.03**	**0.05**
MPB088	**0.1**	**0.05**	**0.02**	**0.05**
PQB036	**0.07**	**0.05**	**0.02**	**0.05**
PQB040	0.05	0.03	0.02	0.05

The levels of total phosphorus in 2021 at the flowing water sites do not appear to be concerning (Figure 3). However, in the past few years, site POB040 has had total phosphorus levels above the threshold multiple times. While they remained below concern this year, further monitoring is needed to see if the problem has truly resolved.

In contrast, the levels of total phosphorus at the sites with the more stringent standard did not comply with the standard at three of the four sites. Pequit Brook appears to have the largest problem with total phosphorus levels, although 2021 showed a large decline relative to previous years (Figure 4). Site PQB036 water samples have had levels greater than the standard at a majority of sampling events since 2012. At site PQB040 total phosphorus levels appear to be increasing annually since 2017, again with the exception of 2021. Total phosphorus levels for Beaver Meadow Brook were above the threshold during the majority of sampling events in both 2020 and 2021, a concerning increase relative to previous years.

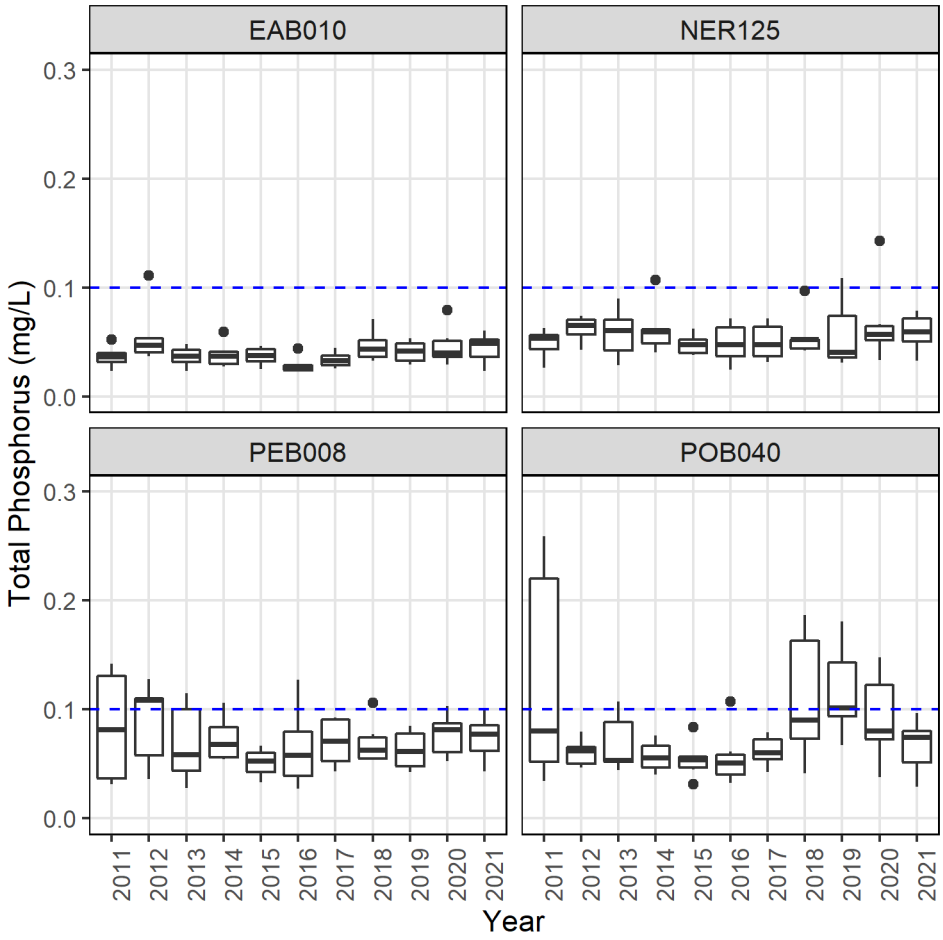

Figure 3: Total phosphorus levels at the four flowing water sites in Canton from year 2011 to 2021. The blue dashed line is at 0.1mg/l. Boxplot statistics are the same as Figure 2.

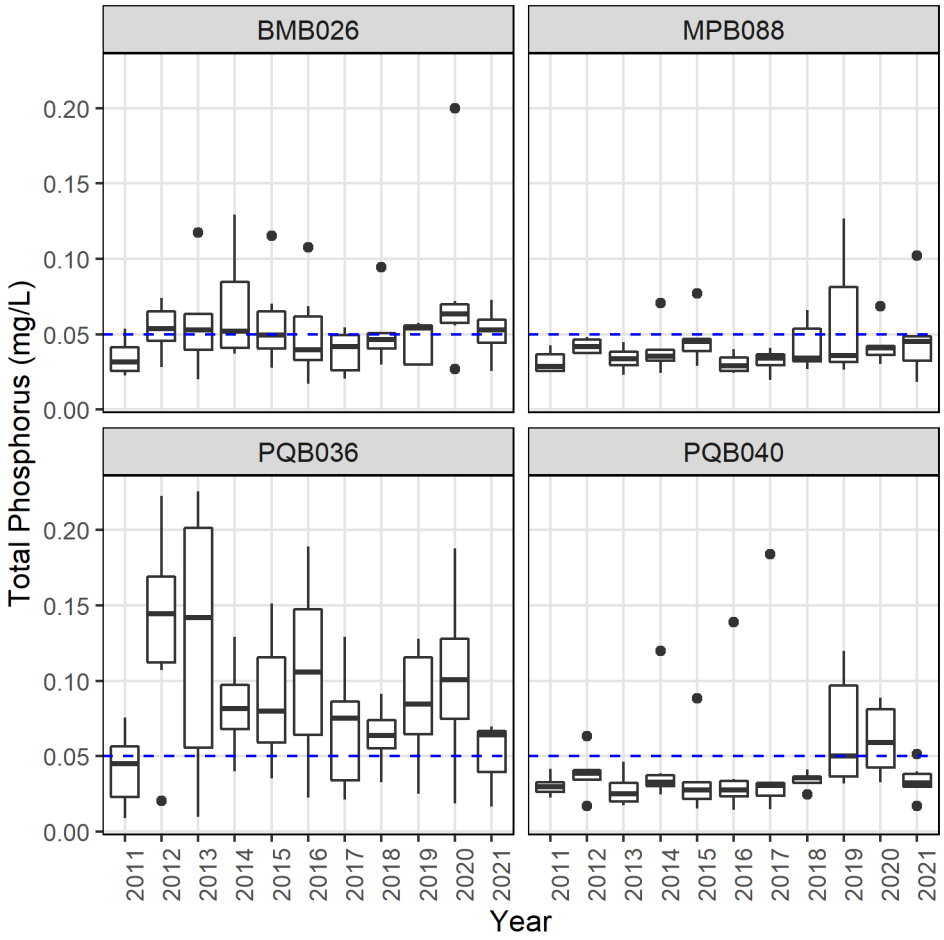

Figure 4: Total phosphorus levels at the four stream sites that are entering a lake or reservoir in Canton from year 2011 to 2021. The blue dashed line is at 0.05mg/l. Boxplot statistics are the same as Figure 2. Note that the y-axis range is different than Figure 3.

Massachusetts DEP asks for additional information to help identify a problem with total Phosphorus, such as primary producer data. While we do not have primary producer data at these sites, many sites in Canton have a strong negative correlation between total phosphorus levels and dissolved oxygen levels (Table 5), which can be a symptom of eutrophication. The strongest correlations are observed at PQB036, followed by BMB026 and NER125.

Data from CWMN sampling shows that dissolved oxygen levels are dangerously low in past years and in 2020 at PQB036 (Figure 6), which makes it a more likely candidate as a stream impaired by total Phosphorus.

Table 5: Correlation coefficient (R^2) between total Phosphorus levels and dissolved oxygen levels at the eight sites in Canton, MA using data from 2010 - 2020.

Site	R^2
PQB036	-0.52
BMB026	-0.45
NER125	-0.36
POB040	-0.24
PQB040	-0.24
PEB008	-0.18
MPB088	-0.15
EAB010	0.01

pH

The Commonwealth of Massachusetts considers a pH range between 6.5 and 8.3 to be healthy for waterbodies in the state. All sampling events in Canton met the pH standard in 2021 for between one and two sampling events, which were slightly more acidic than the standard allows (Figure 5). In past years, PQB036 is the only site that has low pH levels (all samples in 2015 and 2017) in past years, but levels improved since. No sites had any water samples that were above the upper threshold. With the exception of a few more acidic samples, pH does not appear to be a large concern for Canton sites.

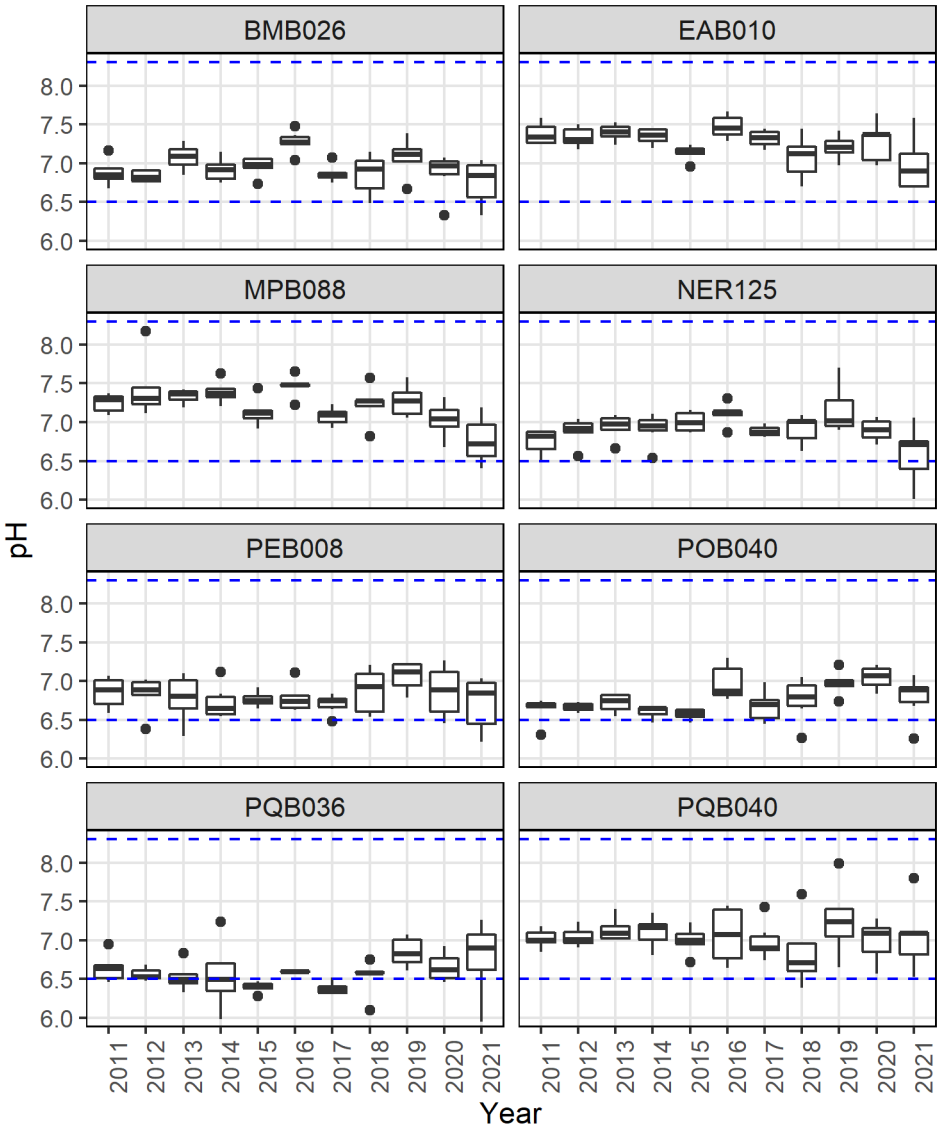

Figure 5: The pH levels at the eight sites in Canton for years 2011 through 2021. Boxplots statistics are the same as Figure 2. The blue dashed lines are at pH = 6.5 and pH=8.3, the criteria range for pH level in Massachusetts.

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

Levels of DO at five sites were lower than the thresholds at some point during the sampling season, with only EAB010, MPB088, and PQB040 consistently meeting standards (Figure 6). Beaver Meadow Brook had only 1 sampling event below the criteria, in October. Typically, DO levels are lowest in the summer, so this may be an outlier event or sampling error. PQB036 experienced the worst dissolved oxygen values, followed by NER125. It is not surprising that these two sites also had some of the strongest correlations between phosphorus levels and dissolved oxygen decreases, suggesting eutrophication may be playing a role here. The largest single month drop in DO was at site NER125, which had hypoxic conditions in June of 2021 (DO = 1.62mg/L) compared to the ten year mean value of DO = 4.84mg/L. Hypoxic waters have low oxygen levels (less than 2mg/l) and cannot support many aquatic species. Additionally, levels of DO at site NER125 were at or below the 5mg/l threshold for most of the sampling season except in May and October.

Dissolved oxygen levels at site PQB036 (the upstream site on Pequit Brook) have been very low in past years and were again in 2021. DO levels at this site in 2021 started at 3.50mg/L in May, but ranged from 0.97mg/L to 3.22mg/L for the remainder of the sampling season, which suggests hypoxic conditions for the duration of the summer and early fall. In general, however, DO levels were above or close to the ten year averages in almost all sites and months.

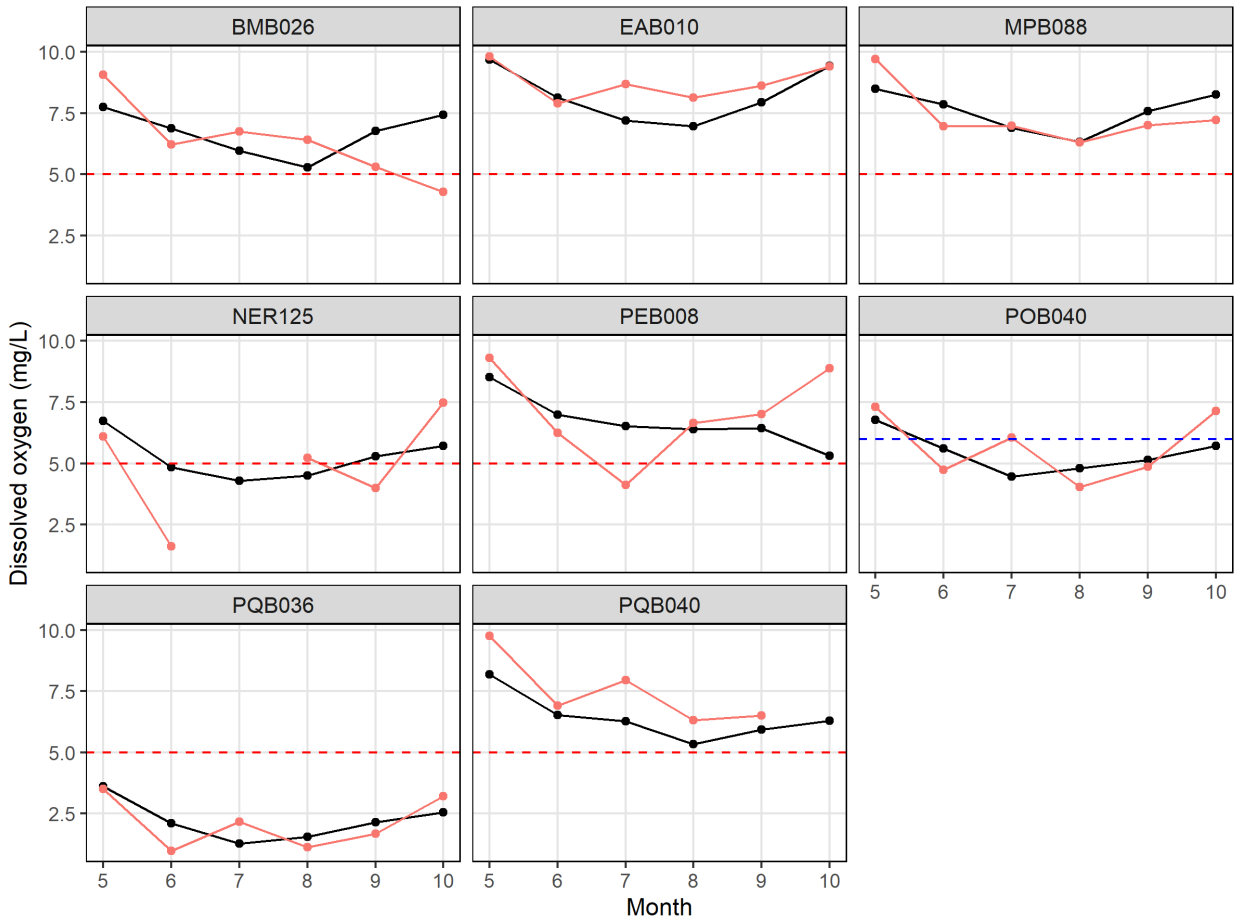

Figure 6: Monthly dissolved oxygen levels at each of the eight sites in Canton. The black line shows the mean monthly value from 2011 to 2020 and the red line shows the 2021 values. The red dashed line is at dissolved oxygen = 5mg/l and the blue dashed line is at dissolved oxygen = 6mg/l (Ponkapoag Brook only).

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

Table 6: Major parameters of concern by site with recommendations on first steps to address the problem. * signifies a critical problem. DO = Dissolved oxygen.

Site	Parameter	Recommendation
PQB036	DO*	• Reduce nutrient loads and organic content • Evaluate flow rates and shading throughout the summer and fall • Consider continuous monitoring of DO with loggers to identify key changes

	TP*	• Sample for primary producers (algae, Chlorophyll-a) and survey for overgrowth of aquatic plants in stream and at Reservoir Pond • Identify sources of TP (runoff or inflows)
	E. coli	• Identify source of persistent issues with bacteria, including during dry weather (sewage contamination) • Conduct bacterial source identification survey
NER125	DO*	• Evaluate flow rates and shading in summer • Evaluate loads of organic matter
POB040	DO	• Reduce nutrient loads • Assess shading and flow rates during the summer months
	TP	• Identify sources and any changes that may have resulted in lower TP this year • Assess aquatic plant growth via survey
PQB040	TP	• Identify sources and cause for increase • Sample for primary producers in Forge Pond
	E. coli	• Identify source of peak levels during dry weather and the consistent high levels during the other dry weather sampling events. • Identify sources of wet weather elevated levels. Sample during more rain events to increase the sample size of wet weather and determine if the elevated levels in 2020 are a continuing issue or a one-time event.
BMB026	TP	• Identify new sources that could have led to increase in 2020 • Sample for primary producers in Bolivar Pond
PEB008	TP	• Identify sources and cause for increases
	E coli	• Source identification tracking • Wet weather runoff interception (BMPs)