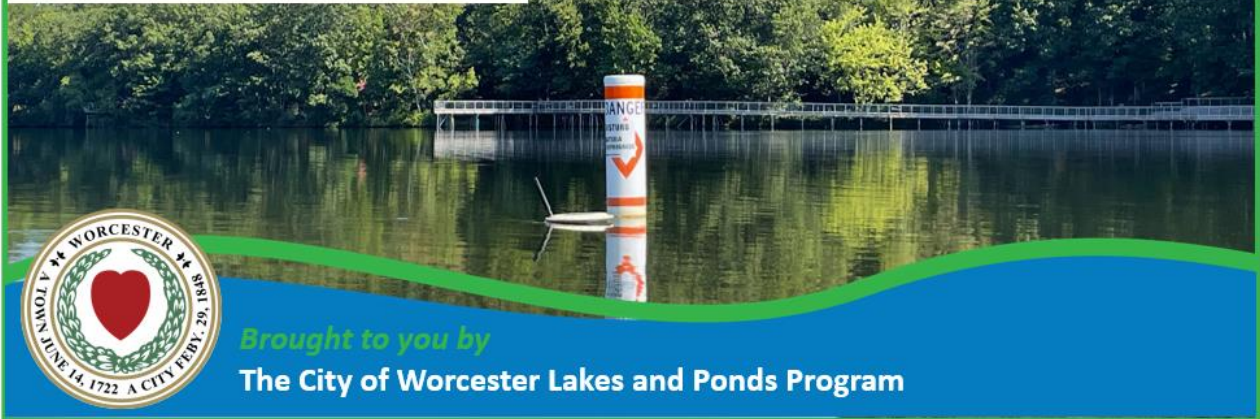


# Coes Reservoir

## 2023 Water Quality Report



### Summary

The following report is presented by the City of Worcester Department of Sustainability and Resilience (DSR), Lakes and Ponds Program (L&P). It details the program's water quality monitoring results, management activities and outreach efforts at Coes Reservoir in 2023. The "State of the Lake" will be rated "Excellent", "Good", "Fair", or "Poor" based on the results' implications on water quality and recreational value. This report will also outline projects and opportunities the City of Worcester's Lakes and Ponds Program (L&P) intends to implement at Coes Reservoir in 2024.

As an urban lake, Coes Reservoir feels many of the pressures of the city. Coes faces challenges including invasive aquatic plants, lake closures due to cyanobacteria and fecal bacteria, and low water clarity. However, management by community groups, and more recently, the City of Worcester Lakes and Ponds Program, has led to water quality that supports a healthy ecosystem and a wide variety of recreational opportunities. ***In 2023, Coes Reservoir received a score of "Good"***, an upgrade from last season's score of "Fair". Continue reading to learn more about this rating and L&P's work on Coes Reservoir!

### Background

Coes Reservoir is a 90-acre impoundment of Tatnuck Brook, located between the Columbus Park and Webster Square neighborhoods of western Worcester. It is about 15 feet deep at its deepest point, which is located in the southern portion of the lake. Coes Reservoir is bordered on the west side by Mill Street, a highly trafficked roadway. The northern end of the lakeshore is largely residential, with commercial zoning along Mill Street on the western side. The southern portion has a public beach, playground, and access to a trail system around the eastern side of the lake.

Coes Reservoir is located at the end of a chain of mill ponds along Tatnuck Brook, which extends south from Holden. Tatnuck Brook exits Worcester's drinking water supply at the Holden 2 Reservoir and is designated a Coldwater Fish Resource (CFR) by MassWildlife. Flowing south into Worcester, Tatnuck Brook is impounded several times as the watershed becomes more developed. Coes Reservoir was created when Tatnuck Brook was dammed in the mid 1800's in order to supply waterpower to the Coes Knife Factory. Due to its long industrial history, the area had a legacy of industrial pollutants that led to remediation and reconstruction of the dam site in 2006.



*Figure 1 – A recently constructed boardwalk provides universal access to the Eastern shore of Coes Reservoir.*

Due to efforts of the City of Worcester and various community groups, Coes Reservoir has become a valuable recreational resource. There is ample public access around much of the lake, including a public beach, a universal access park and playground, a nature viewing boardwalk (see *Figure 1*), a fishing pier, as well as a new kayak launch at the Mill Street Beach that will host kayak and paddleboard rentals. Coes Reservoir boasts a popular fishery, where anglers can catch largemouth bass, chain pickerel, yellow perch, black crappie, bullhead, bluegill, and carp.

The following report details the results of water quality monitoring programs in 2023, as well as the exciting projects and opportunities the City of Worcester's Lakes and Ponds Program (L&P) intends to implement in 2024.

As an urban lake, Coes Reservoir feels many of the pressures of the city. However, management by community groups, and more recently, the Lakes and Ponds Program, has led to water quality that supports a healthy ecosystem and a wide variety of recreational opportunities. In 2022, Coes Reservoir received a score of "Fair" for the first time since L&P began monitoring, being downgraded from "Good". There were no beach closures due to fecal bacteria exceedances. The adaptable aquatic plant management plan has continued to be effective at keeping the reservoir generally free of invasive plants in the lower portion of the reservoir, and seasonally controlling them in the northern portion. However, surface water temperatures were considerably higher than in 2021. Because of the state-wide drought, tributary water inputs were greatly reduced, and the outlet of the reservoir stopped spilling, meaning no water was exiting the lake. Nutrients that entered the lake had a longer residence time, and nutrient sampling results indicated an increasing concentration of phosphorus in the reservoir throughout the season. In 2022, despite monitoring and management by the Lakes and Ponds Program, Coes Reservoir was closed for a total of 78 days due to cyanobacteria blooms. Luckily, only five of these days were during the swimming season. Unfortunately, this was during a heat wave when demand for swimming was high. Also in 2022, L&P conducted periodic monitoring for industrial and emerging contaminants, which did not yield results of concern to public health.

## Management Summary

Coes Reservoir has had management plans for cyanobacteria and invasive aquatic plants since 2018. Additionally, in 2021 a plan was implemented to address the increased number of closures due to *E. coli* bacteria that the public beach experienced in recent seasons.

In contrast to 2022, cyanobacteria were not problematic in 2023, never passing the recreational threshold that would necessitate lake closure. However, in late June, results from cell counts indicated that populations may be growing to potential bloom levels and the decision was made to treat with copper sulfate. A sample collected on the day of the treatment indicated the cell counts had fallen naturally. Through the rest of the season, despite population fluctuations, cyanobacteria concentration never reached bloom levels and the reservoir remained open.

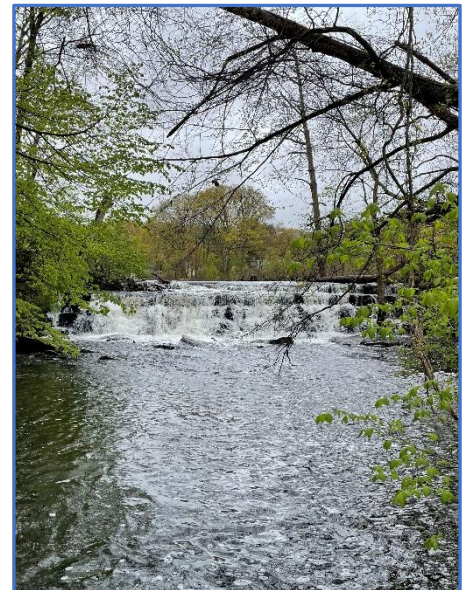
Coes Reservoir's invasive aquatic plant management plan continued in 2023. On July 7<sup>th</sup> and August 2<sup>nd</sup> Imazamox (trade name: Clearcast) was applied to the northern portion of the lake on to address the ongoing Water Chestnut infestation. In addition, Tatnuck Brook Watershed Association (TBWA) organized a community hand pulling event in late July to remove remaining plants along the southern shoreline.

Following high *E. coli* results in 2020 and a suspected relation to goose activity, goose fencing was developed for use at the beach. Fencing was implemented in 2021 and 2022 and appeared to reduce goose activity on the beach. Due to lifeguard staffing shortages the fencing was not implemented consistently in 2023. However, L&P will look to continue to implement fencing in 2024.

## Sampling Analysis and Overview

Sampling from multiple locations within a waterbody and its watershed leads to better understanding of the water that enters the lake, how it is transformed within, and the water leaving the lake. To account for these changes over space and time, L&P samples at sites in tributaries, at the surface and bottom of mid-lake sites, and the outlet.

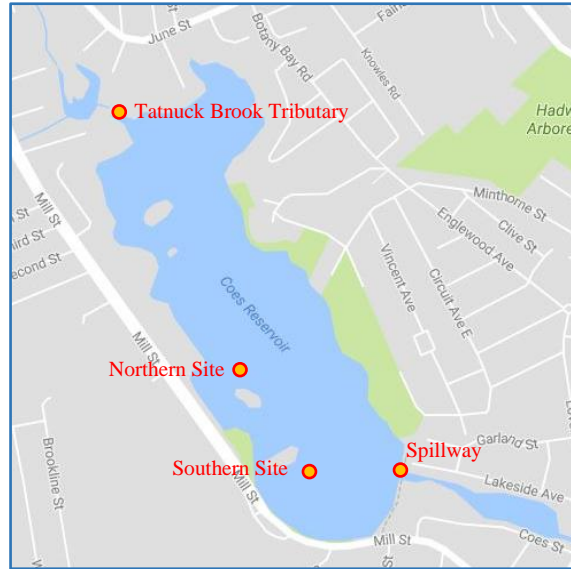
Tributaries are streams that flow into a lake or pond (see *Figure 2*). They collect surface runoff from rain or snowmelt along with some groundwater and carry it through the stream channel to the waterbody. In some cases, tributaries make up a large portion of the water going into the lake, and the quality of the water in these tributaries can give insight into where certain impairments in the lake originate. Outlets are the major exits for water in the lake. Most of the L&P program water quality parameters are measured at the major natural tributaries and outlets of the lakes.



**Figure 2** - Coes Reservoir's sole tributary, Tatnuck Brook exhibited periods of high flow through the 2023 sampling season.



Coes Reservoir was visited semimonthly in 2023 from May through October and sampled at four locations: the major aboveground tributary, Tatnuck Brook; the two deepest parts of the reservoir (the northern is about 13 feet deep and the southern is about 15 feet deep); and the outlet at the spillway located at the southern end of the reservoir (see *Figure 3*). At the in-lake locations, probe measurements and water samples were collected one 1 foot below the surface of the water (“surface”), and two 2 feet from the bottom of the lake (“bottom”). Parameters evaluated included: Secchi transparency, temperature, dissolved oxygen (DO), pH, total phosphorus (TP), total dissolved phosphorus (TDP), and *E. coli*. Samples analyzed for total suspended solids (TSS), ammonia (NH<sub>3</sub>), and nitrate (NO<sub>3</sub>) were collected on a monthly basis. Altogether, there were 12 sampling events. Although Worcester experienced its second wettest summer on record in 2023, none of the sampling days were considered “wet weather” with 24-hour rainfall totals exceeding 0.25 inches.



**Figure 3** - Coes Reservoir map and approximate sampling locations.

Samples for cyanobacteria cell density were collected by a contractor as needed. Additionally, Worcester Department of Inspectional Services tested for *E. coli* as an indicator of harmful bacteria on a weekly basis during the summer months at the Mill Street Beach.

Raw data are displayed and explained below. No statistical analysis has been performed. Subsequent ratings of “Excellent”, “Good”, “Fair”, and “Poor” for reported values are based on the Massachusetts Department of Environmental Protection’s SMART Monitoring Watershed Report Card Criteria.

### **Quality Assurance/Quality Control**

The Lakes and Ponds Program uses Quality Assurance/Quality Control (QAQC) checks to ensure that our data are representative of local conditions and meet precision and accuracy standards. QAQC check results identify data that need to be flagged and/or censored before they are shared and can highlight issues that affect data quality. When data fail to meet acceptable criteria for these checks, they are either flagged as being slightly less robust or censored entirely. Flagged data points are marked with a red flag and censored data are not included in this report. For more information on L&P’s data quality, please contact [greenworcester@worcesterma.gov](mailto:greenworcester@worcesterma.gov).

## Fecal Bacteria

Recreational contact with water contaminated by certain fecal bacteria may cause illness. *Escherichia coli*, or *E. coli* are a type of bacteria found in the digestive tract of warm-blooded animals including geese, pets, and humans. While most strains are harmless, some can make you very sick. These bacteria enter the water in many ways, including direct contact with animal waste, runoff from the shoreline and impervious surfaces like paved roadways during rainstorms, leaking septic tanks, and illicit sewer connections that empty sewage to the stormwater system. The Commonwealth of Massachusetts has strict regulations for bathing beaches, and Worcester Inspectional Services collects samples for *E. coli* weekly at public beaches during the swimming season to ensure that the water is safe for direct contact, closing beaches if the results are above the recreational threshold of 235 cfu/100 mL. In past seasons L&P has collected samples for *E. coli* at the surface of certain in-lake sites to assess *E. coli* conditions in open water. As in-lake *E. coli* results never indicated concern, L&P ceased collecting them in 2023. However, L&P continues to collect *E. coli* samples at select tributaries, and beach testing by Inspectional Services continues.

**Fecal Bacteria at Coes Reservoir.** In 2023, Binienda (Mill St.) Beach was closed for two days, 3-Jul to 5-Jul due to fecal bacteria exceedances. Results from beach testing conducted by Inspectional Services ranged between <4 and 360 CFU/100mL, with only one result exceeding the recreational limit (see Tables 1 & 2). For the first time, in 2023 L&P began collecting samples for *E. coli* in the tributary, Tatnuck Brook. Results ranged from 62 to 579 CFU/100 mL. Six of 12 results were above 235 CFU/100mL or in the range considered "Fair". *E. coli* presence tends to be highly localized, and conditions in the tributary and the beach may be quite different as the data show. In 2023, Binienda (Mill St) beach experienced one closure due to *E. coli*, and tributary results were often considered "Fair". However, *E. coli* did not significantly reduce recreational opportunities. Because of this, Coes Reservoir received a rating of "Good" for *E. coli* in 2023.

2023 TATNUCK BROOK E.COLI RESULTS		2023 BEACH E.COLI RESULTS	
DATE	RESULT	DATE	RESULT
4-May	62	26-Jun	40
18-May	579	<b>3-Jul</b>	<b>360</b> 🦠
8-Jun	326	5-Jul	<4 🦠
22-Jun	291	10-Jul	40
6-Jul	205	17-Jul	100 🦠
19-Jul	291	24-Jul	60
3-Aug	219	31-Jul	64
17-Aug	238	7-Aug	<4
7-Sep	173	14-Aug	16
21-Sep	155	21-Aug	88
5-Oct	365		
19-Oct	145		

Excellent	Good
Fair	Poor
Red Text = Beach Closure	

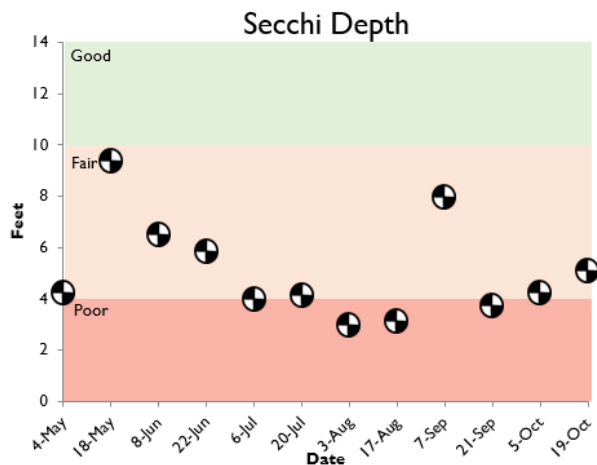
**Table 1 & 2** - In 2023, Binienda Beach was closed for two days, 3-Jul to 5-Jul due to fecal bacteria exceedances. *E. coli* results in Tatnuck Brook ranged between 62 and 579 CFU/100 mL, and were considered "good" and "fair".

## Water Clarity

Water clarity is a measure of the transparency of water. Algae, microscopic organisms, eroded particles, and re-suspended bottom sediments are factors that interfere with light penetration and reduce water transparency. Clear water allows sunlight to penetrate the depths of a waterbody, supporting growth of aquatic plants, which provide food, shelter, and oxygen to aquatic organisms. Clear water is also pleasant to the eye and safer for recreational contact. Turbid water, or water filled with particles, absorbs more heat from sunlight. This reduces the water's capacity to hold oxygen, creating favorable conditions for algal and cyanobacteria blooms, which further reduce clarity. Water clarity can be measured with a Secchi

disk or by quantifying Total Suspended Solids (TSS). A Secchi disk is a weighted black and white disk on a calibrated line that is lowered into the water until it is no longer visible. Secchi readings are collected on each lake visit by L&P. TSS is a measure of the dry weight of suspended particles in a given amount of water. TSS samples are taken on a monthly basis and submitted to a lab for analysis.

**Water Clarity at Coes Reservoir.** Secchi clarity at the two in-lake sites in Coes Reservoir ranged between 3 ft and 9.5 ft (see *Figure 4*). Most readings fell between 4 and 10 ft, or in the range considered “Fair” although several results were lower than 4 ft, or in the range considered “Poor”. Clarity readings were highest at the beginning of the season and lowest in August and September. Surface TSS at Coes Reservoir ranged between 2.5 and 6.0 mg/L, consistently falling below 10 mg/L, or in the range considered “Excellent”. Results at the bottom ranged between 3.3 and 11 mg/L, and were generally lower than 10 mg/L. In Tatnuck Brook, TSS results were lower, ranging between 2.2 and 3.9 mg/L. At the outlet, TSS ranged between 2.9 and 5.9 mg/L, with all results falling below 10 mg/L. In 2023, the majority of Secchi depth readings were considered "Fair". Because of this, water clarity in Coes Reservoir received a rating of “Fair” in 2023.



**Figure 4** - Secchi depth was ranged from the "poor" to "fair" categories throughout the season. "Poor" secchi depth was seen generally later in the season.

## Temperature

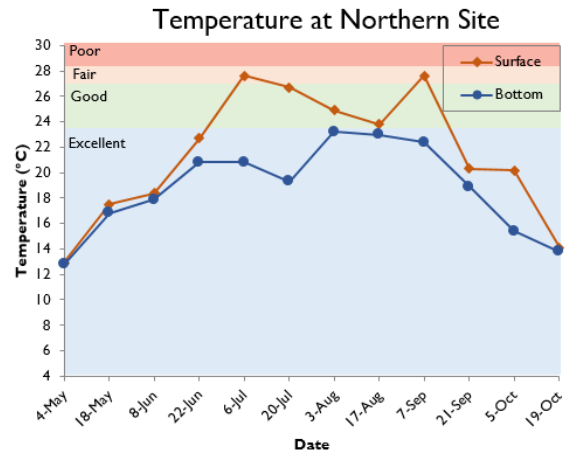
Water temperature is important to understanding both the biology and chemistry of aquatic ecosystems. Because many organisms prefer to live in a narrow temperature range, understanding temperature across the area and depth of a water body is essential. Temperature is also a determining factor in the speed of chemical reactions and the ability of water to hold oxygen. As temperature increases, water can hold less dissolved oxygen. Temperature dynamics in lakes can also determine the level of mixing occurring in the waterbody, affecting the distribution of oxygen, nutrients, and organic matter throughout the lake. Temperature was measured with a thermometer on a handheld probe at the water’s surface at all sites and at the bottom for in-lake sites. To form a more complete picture of how temperature changes through the water column, depth profiles were created by taking measurements at 1-ft increments through the water column.

**Temperature at Coes Reservoir.** Surface water temperature at the in-lake sites rose at the beginning of the season, reaching the maximum recorded temperature on 6-Jul and generally decreasing into the fall, with one abnormally warm day on 7-Sep (see *Figures 5 and 6*). Maximum recorded surface temperatures in 2023 were on par with the last few years; 27.6°C at the Northern Site and 27.7° in the Southern Site. As expected, bottom temperature at the Northern and Southern Sites were always lower than the surface but followed the same seasonal fluctuations. This season L&P rates temperature in Coes Reservoir as "Good".

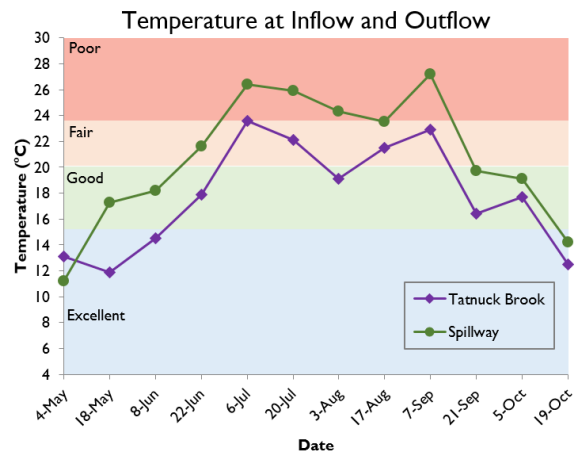
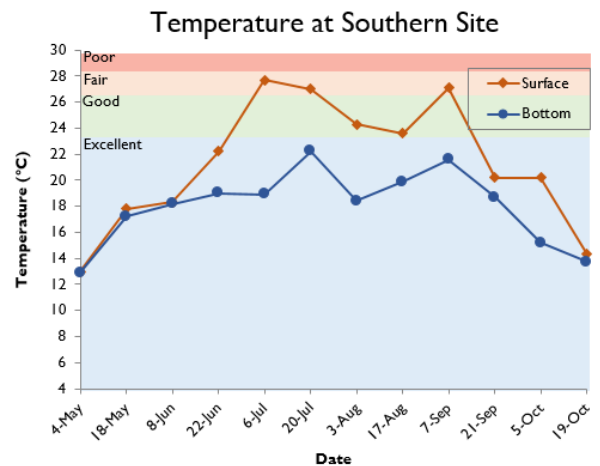
Tatnuck Brook is the major tributary to Coes Reservoir. It is a designated Coldwater Fisheries Resource, a special designation given to waterways that support cold water fish species such as trout. These fish require higher quality water than warm water species. The outlet of Coes Reservoir is the spillway at its southern end. Water temperature in Tatnuck Brook was warmer than ideal (see *Figure 7*). Most temperature readings were above 15°C, and during the warmest parts of summer the brook entered the "Fair" category for temperature. Four readings were recorded above 20°C, the upper avoidance limit for cold water fish. The temperature at the lake outlet was on average 3°C higher than in Tatnuck Brook, demonstrating how much the brook warms after passing through Coes Reservoir.

## Dissolved Oxygen

Oxygen dissolved in water is essential to aquatic life just as it is to life on land. Dissolved Oxygen (DO) is a highly variable parameter that is controlled by many factors, including temperature, pressure, aeration, diffusion, rate of photosynthesis, rate of respiration and more. When water temperature rises, water can hold less dissolved oxygen, potentially causing stress to aquatic organisms. Thermal stratification, or layering in the water column based on temperature, can also create a barrier to waterbody mixing, creating areas with depleted DO in some deeper portions of waterbodies.



**Figures 5 and 6** - Bottom temperatures were considered "excellent" all season. Surface temperatures were in the "good" to "excellent" categories except for three dates that were considered "fair".

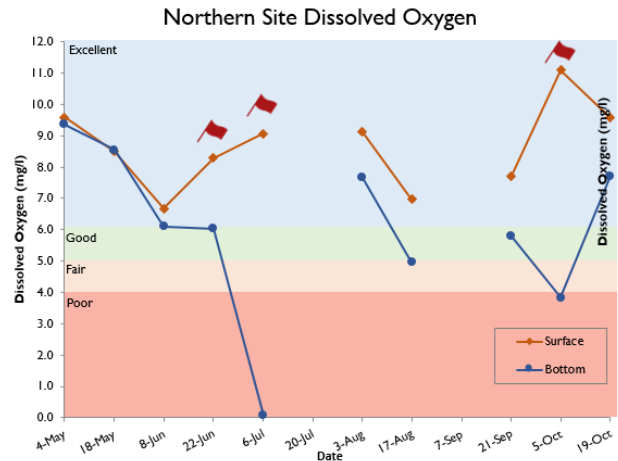


**Figure 7** - The temperature at the lake outlet was on average 3°C higher than in Tatnuck Brook, demonstrating how much the brook warms after passing through Coes Reservoir

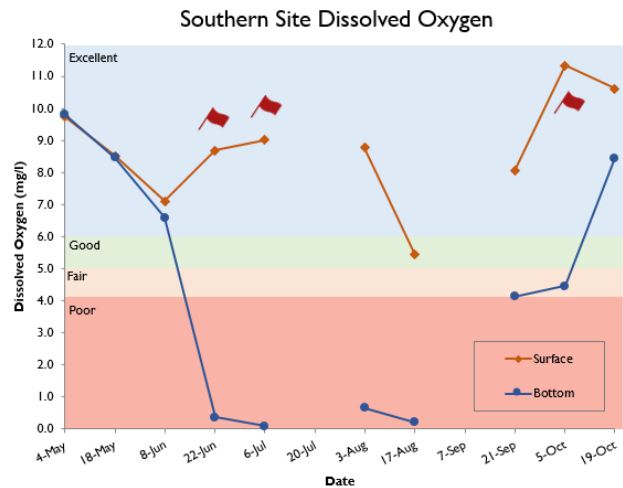
Increased algal growth followed by excessive decomposition of organic material can also lead to low oxygen (hypoxic) conditions, potentially causing fish kills. DO was measured using a galvanic DO sensor on a handheld probe at the water's surface, and two feet from the bottom at the in-lake locations. To form a more complete picture of how DO changes through the water column, depth profiles were created by taking measurements at 1-ft increments through the water column.

**Dissolved Oxygen at Coes Reservoir.** Surface DO at the in-lake sites was above 6 mg/L, or in the range considered "Excellent", in all but one instance (see Figures 8 and 9). Other than one low outlier reading on 17-Aug (5.43 mg/L), surface DO ranged between 6.68 and 11.33 mg/L and followed a similar pattern throughout the season at the Northern and Southern Sites. Measurements on the bottom had a large range, between 0.07 and 9.80 mg/L. At the Northern and Southern Sites, DO was highest at the beginning and end of the season. In the southern site DO was below 4 mg/L, considered "Poor" between 22-Jun and 17-Aug. Due to censored data points on 20-Jul and 7-Sep, it is difficult to determine a clear pattern in bottom DO at the Northern Site.

DO in Tatnuck Brook ranged between 6.96 and 9.67 mg/L, with most readings in the range considered "Good" (see Figure 10). In the spillway, ranged between 5.79 and 12.16 mg/L, with all but one reading above 6 mg/L, or in the range considered "Excellent".



**Figure 8** - Dissolved oxygen at the surface was categorized as "excellent" throughout the season. Bottom dissolved oxygen ranged from the "excellent" to "poor" categories, "poor" conditions were seen mid-summer.



**Figure 9** - Dissolved oxygen at the surface was categorized as "excellent" except for one day when it was "good". Bottom dissolved oxygen ranged from the "excellent" to "poor" categories, "poor" conditions were seen mid-summer.

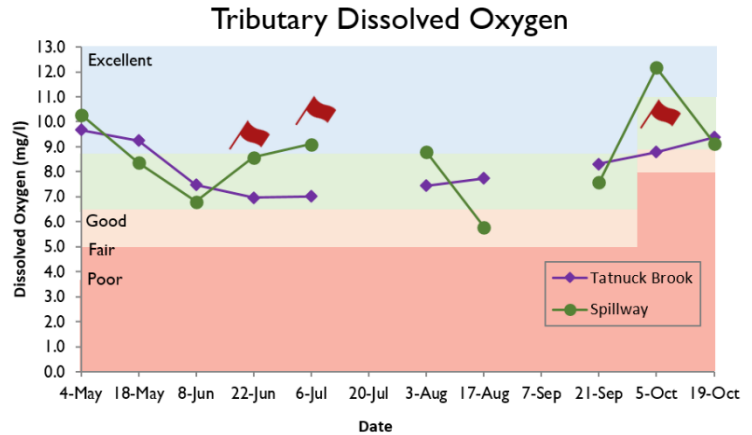




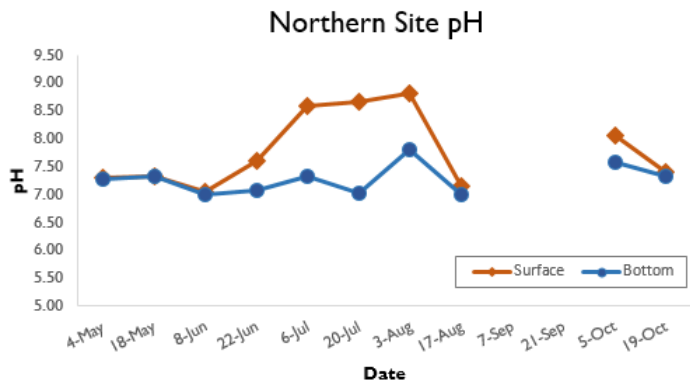
To determine whether oxygen depletion occurs in the water column, lake profiles were taken in which DO readings were measured at 1 ft intervals. The water column was uniformly oxygenated during the first sampling session (see Appendix). Beginning in the end of June, a distinct oxycline developed in which DO concentration fell below 4 mg/L, at 8 ft and below. From July through early September, a clear oxycline was observed in which water above 8 ft was fully oxygenated, and water below was hypoxic. By the end of September, the water column was fully oxygenated to the end of the season. In 2023, L&P observed more extreme hypoxia than in the past. Additional seasonal depth profiles are needed to determine whether this is a unique case or indicative of a trend. Though surface DO was consistently considered "Excellent", depth profiles indicated that notable portions of the water column were hypoxic between late June and early September. However, as the surface was always fully oxygenated, there was space for aquatic organisms to find refuge. This season L&P rates DO in Coes Reservoir as "Fair".

## pH

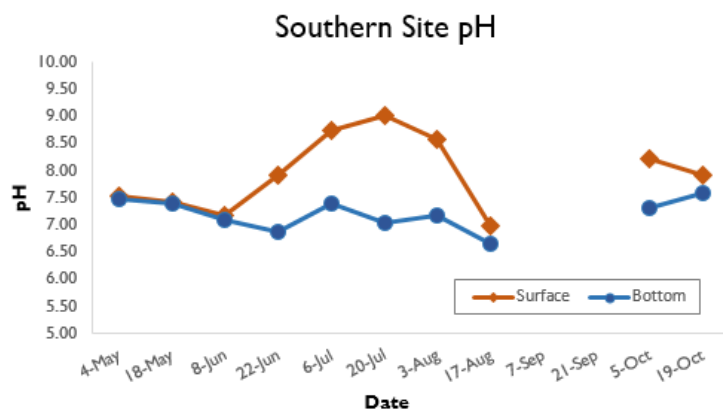
pH is the concentration of hydrogen ions (H+) in a solution. The more H+ ions that are present, the more acidic the solution. On a scale of 0-14 units, 7 is a neutral pH. As pH increases from 7, the solution is more basic, and as pH decreases from 7, it becomes more acidic. In aquatic ecosystems, pH affects most chemical and biological processes including species distribution, growth rate, reproductive success, and nutrient dynamics in lakes. A high pH can promote chemical reactions that release phosphorus from lake sediments. Healthy



**Figure 10** – DO in Tatnuck Brook ranged between 6.96 and 9.67 mg/L, with most readings in the range considered "Good". In the spillway, ranged between 5.79 and 12.16 mg/L, with all but one reading above 6 mg/L, or in the range considered "Excellent".



**Figure 11**- North Site: pH ranged from 7.05 - 8.82 at the surface and 6.99 - 7.79 at the bottom.



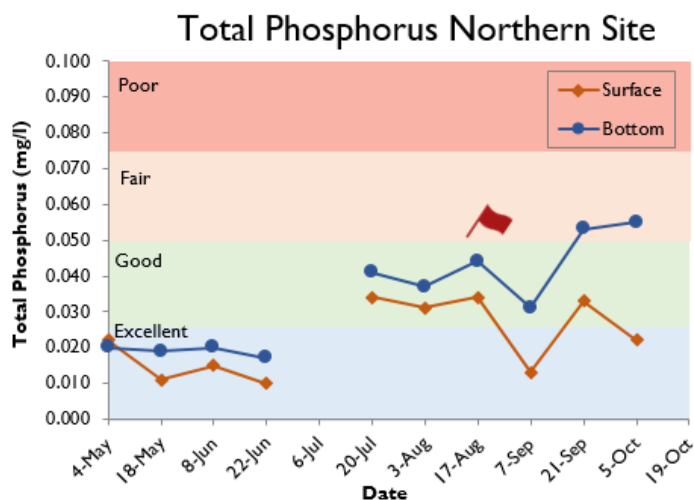
**Figure 12**- South Site: pH ranged from 6.97 - 9.01 at the surface and 6.65 - 7.58 at the bottom.

lakes in our area have a pH between 6.5 and 8.5. pH was measured using an ion-selective electrode (ISE) pH sensor on a handheld monitoring probe. Readings are taken at the water's surface and two feet from the bottom.

**pH at Coes Reservoir.** Surface pH at the in-lake sites ranged between 7.40 and 8.21 over the course of the season (see Figures 11 and 12). The highest recorded pH at the Northern and Southern Sites was recorded on 20-Jul and 3-Aug, concurrent with some of the season's highest cyanobacteria counts. Bottom pH readings at each site had a smaller range, 6.65 to 7.79, with no discernible pattern throughout the season. At Tatnuck Brook, pH ranged between 6.67 and 8.64, also not showing a pattern through the season. At the outlet, pH between 7.11 and 8.75, and more closely followed the in-lake distribution.

## Nutrients

Nutrients, primarily nitrogen (N) and phosphorus (P), are food sources for aquatic plants and algae. Although plants and algae are the basis of aquatic food chains and necessary for a healthy lake ecosystem, an overabundance of nutrients can lead to issues such as harmful algal blooms and excessive plant growth. Common nutrient inputs to urban lakes and ponds include fertilizers, pet and goose waste, illicit sewer connections to the stormwater system, and runoff that flows over land into the stormwater system. Additionally, under the right conditions, P can be released from the sediments at the bottom of the lake, becoming more available for uptake by organisms. To examine the nutrients present in program lakes, L&P collects samples for several compounds and submits them to an external lab for analysis. To measure N, samples are collected for Nitrate (NO<sub>3</sub>) and Ammonia (NH<sub>3</sub>) at all sites monthly. To measure P, samples are collected for total phosphorus (TP) twice a month at all sites, and total dissolved phosphorus (TDP) twice a month at all bottom sites. TDP is analyzed to understand how much P is dissolved in the water and available for use by aquatic organisms.



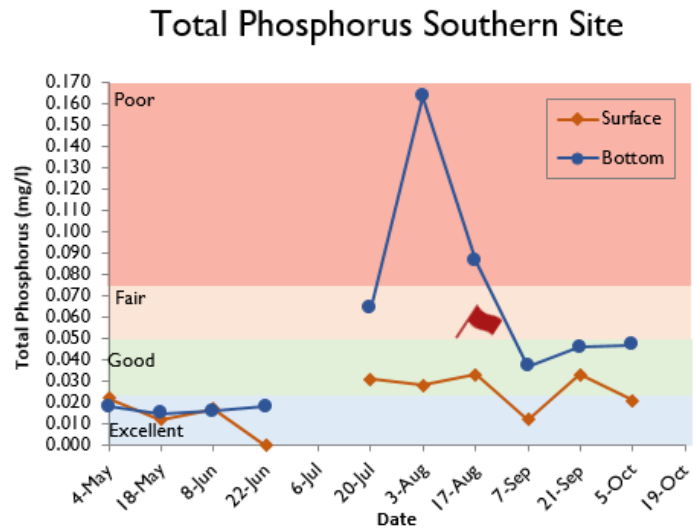
**Figure 13** - Surface total phosphorus in the Northern site was considered "excellent" at the beginning of the season and end of the season, with several results in the "good" category between July and September. Bottom Total Phosphorus started in the "excellent" category, with more results in the "good" and "fair" categories as the season went on.

**Nutrients at Coes Reservoir.** At the in-lake sites, TP on the surface ranged from 0.010 to 0.034 mg/L, with some results considered “Excellent” and most within the “Good” range (see *Figures 13 and 14*). Recorded surface TP generally increased over the course of the season at both sites. Bottom TP was almost always higher and ranged from 0.015 to 0.163 mg/L, generally increasing as the season went on. Samples were also collected for TDP at the bottom in the Northern and Southern Sites. Results were generally in the ranges considered “Excellent” and “Good”, however on 17-Aug the result from the Southern Site was 0.153 mg/L, in the category considered “Poor”.

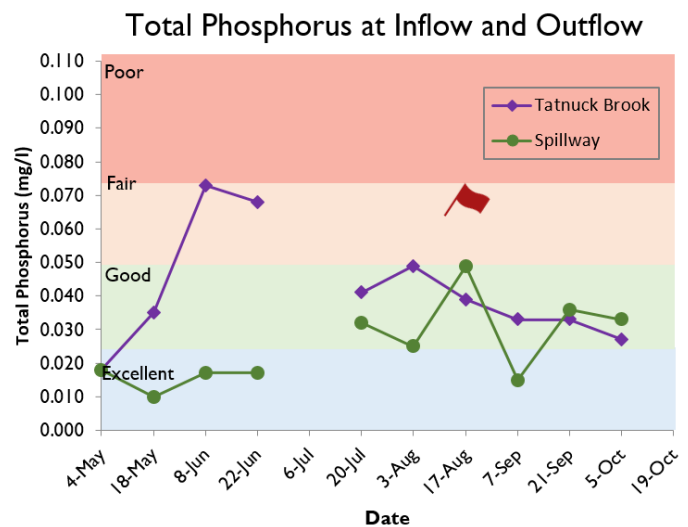
TP results in Tatnuck Brook ranged between 0.018 and 0.073 mg/L, although most results were between 0.025 mg/L and 0.050 mg/L, the range considered “Good” (see *Figure 15*). The “Fair” results did not occur on wet weather days. At the outflow results were generally lower, ranging between 0.010 and 0.049 mg/L, with results in the categories considered “Excellent” and “Good”.

At the in-lake sites, NO<sub>3</sub> results from surface and bottom samples indicated low concentrations, with all results below 0.6 mg/L and in the range considered “Excellent”. As surface concentrations were generally in categories considered “Excellent” and “Good”, nutrients in Coes Reservoir received a rating of “Good” in 2023. However, based on observations in past seasons, it is possible that Coes Reservoir is susceptible to cyanobacteria blooms at lower phosphorus concentrations than indicated by the SMART criteria.

NO<sub>3</sub> results from Ararat Brook were below 0.6 mg/L but considerably higher than in-lake results, ranging between 0.197 and 0.254 mg/L. NH<sub>3</sub> results from Ararat Brook and the outlet were either not detected or below 0.15 mg/L.



**Figure 14** - Surface total phosphorus in the Southern site was considered “excellent” at the beginning of the season and end of the season, with several results in the “good” category between July and September. Bottom Total Phosphorous started in the “excellent” category, with more results in the “good”, “fair”, and poor categories as the season went on.



**Figure 15** - Total phosphorus results in Tatnuck Brook were in the “good” and “fair” categories. Total phosphorus measured at the spillway was considered “excellent” to “good”.

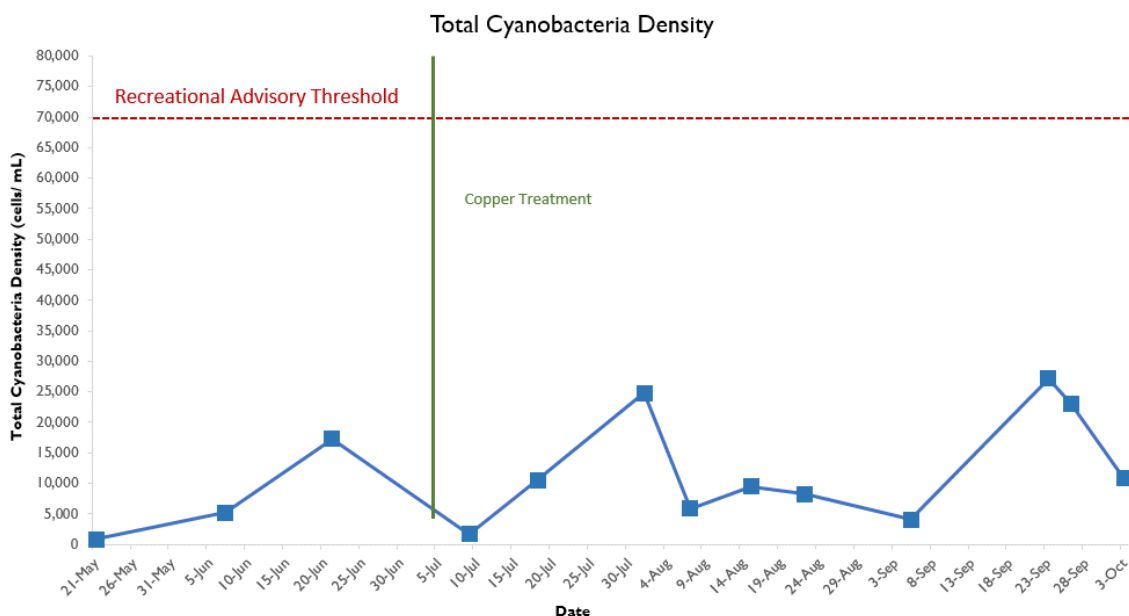


## Cyanobacteria

Cyanobacteria are naturally occurring microorganisms in lakes and ponds. Using sunlight and nutrients such as N and P, cyanobacteria use photosynthesis to gain energy similarly to plants. While normal at low densities in healthy ecosystems, under the right conditions some species of cyanobacteria can reproduce quickly and cause potentially harmful blooms. In addition to being unsightly and smelly, cyanobacteria blooms can produce toxins that are harmful to humans and pets. Blooms also have the potential to create hypoxic conditions that can cause fish kills.

To understand the abundance of cyanobacteria and make decisions regarding lake management and safe access, L&P contracts samples for cyanobacteria cell counts on a weekly basis at Coes to determine bloom risk. When results are above the recreational threshold of 70,000 cells/mL the waterbody must be closed to recreation until cell counts fall. During cyanobacteria blooms L&P also contracts samples for cyanotoxins to establish whether they are present in concentrations that could be harmful. When possible, L&P uses preventative lake treatments, such as algaecide, to stop blooms from occurring before cell counts exceed the recreational threshold.

**Cyanobacteria at Coes Reservoir.** There were no closures due to cyanobacteria exceedances at Coes Reservoir in 2023. Cyanobacteria cell counts remained low in the early season, beginning to increase in late June (see *Figure 16*). Due to a count of 17,300 indicating potential exponential growth, a preventative algaecide treatment was conducted on 7-Jul. Results from a test on the same day indicated that numbers had naturally fallen on their own. Though cell count results rose and fell two more times, no more treatments were required to avoid bloom conditions. Despite the implementation of a copper sulfate treatment on 7-Jul in response to rising cyanobacteria cell counts, Coes Reservoir was never closed due



**Figure 16** – Cyanobacteria cell density over the course of 2023 at Coes Reservoir. Results over 70,000 cells/ml trigger a recreational advisory and lake closure.



to cyanobacteria bloom conditions in 2023. Because of this, Coes Reservoir received a rating of “Good” for cyanobacteria.

## ***Invasive Aquatic Plants and Animals***



**Figure 17** – Invasive Water Chestnut in Coes Reservoir’s Northern cove.

An invasive plant or animal is an organism that is not native to the region and outcompetes local flora and fauna. The absence of natural constraints, like predators or environmental limitations, allows invasive plants and animals to reproduce at a rapid rate. When invasive aquatic plants and animals become too numerous or dominant, they can overtake all available space, disrupting local ecosystems and making recreation more difficult. Invasive organisms can arrive at new locations by hitching a ride on boats, pets, or boots. Some are released with good intentions as a beautiful addition to a landscape or sport fishing opportunity. Professional surveys and visual inspections from Lakes and Ponds Program staff are used to make management decisions regarding invasive species.

***Invasive Aquatic Plants and Animals at Coes Reservoir.*** Coes Reservoir is managed for three invasive aquatic plants: Water Chestnut (*Trapa natans*) (see Figure 17), Fanwort (*Cabomba caroliniana*), and Eurasian Milfoil (*Microphyllum spicatum*). Before the utilization of chemical treatments, milfoil and water chestnut threatened to overtake the entire reservoir. To address populations of these plants, the Lakes and Ponds Program uses a combination of physical removal and herbicide strategies. A successful systemic herbicide treatment of Fluoridone (trade name: Sonar) took place in 2019 and significantly reduced the fanwort and milfoil density through the present. As in 2022, plant management in 2023 focused on continuing to eradicate water chestnut. Imazamox (trade name: Clearcast) was applied to the northern portion of the lake on 7-Jul and 2-Aug of 2023. To address water chestnut plants that were not covered by herbicide treatment, Tatnuck Brook Watershed Association (TBWA) organized a volunteer hand pulling event in early August, in which community members collected plants and trash in kayaks over the course of a morning. Together, these activities were successful in reducing the density of the invasive plant during the season. Unfortunately, due to its unique reproductive strategy, it may be many more years before the water chestnut will be completely eradicated.

A plant survey conducted in September of 2022 indicated water chestnut as the only invasive species in Coes Reservoir, among a number of native aquatic plants. The survey showed the distribution of water chestnut to be generally limited to the northern end of the lake. Although it is likely that remnant populations of fanwort and Eurasian Milfoil exist, populations were small enough to evade detection by the survey.

## ***Industrial Contaminants***

As a post-industrial urban center, legacy pollutants and emerging contaminants of concern from industrial processes may be present in Worcester’s recreational waters. These contaminants may cause negative health and environmental effects. Every three years, L&P tests for a range of these compounds on both a wet and dry weather event in our lakes. Because most industrial contaminants are legacy pollutants, contamination levels are not expected to change much year to year. In 2022, L&P tested for 74 volatile organic compounds (VOCs), 72 semi volatile organic compounds (SVOCs), 9 polychlorinated biphenyls (PCBs), petroleum hydrocarbons (TPH), 23 perfluoroalkyl substances (PFAS), 21 pesticides, 10 herbicides, and 22 heavy metals. No results of concern were detected. See the [2022 Coes Reservoir Water Quality Report](#) or contact [greenworchester@worcesterma.gov](mailto:greenworchester@worcesterma.gov) for more information.

## ***State of the Lake***

**In 2023, Coes Reservoir received a score of “Good”**, an upgrade from last season’s score of “Fair”. There were no closures due to cyanobacteria exceedances, though one preventative lake treatment was contracted to ensure safety and recreational access. There was only one instance of beach closure due to a fecal bacteria exceedance, in which Binienda (Mill St.) Beach was closed for two days, 3-Jul to 5-Jul. With a cooler, wetter year, surface water temperatures were generally lower than in 2023. As in 2022, L&P continued to observe increasing Phosphorous concentrations over the season. The adaptable aquatic plant management plan has continued to be effective at keeping the reservoir generally free of invasive plants in the lower portion of the reservoir, and seasonally controlling them in the northern portion.

## ***Ongoing Projects and Plan for 2024***

### ***Water Quality Monitoring***

In 2023, the Lakes and Ponds Program will continue to monitor Coes Reservoir in order to track changes in water quality and implement its cyanobacteria and invasive aquatic plant management plans. L&P will continue to contract cyanobacteria enumeration to better understand cyanobacteria population dynamics and inform management and public health decisions.

*Tatnuck Brook Project: Collaboration with Worcester State University.* Coes Reservoir is the last of a chain of lakes along Tatnuck Brook, which stretches from Holden through western Worcester. Other lakes on the brook include Cooks Pond, Patch Reservoir, Patch Pond, and Coes Pond. Previously, consistent water quality monitoring has been restricted to Coes Reservoir due to funding and staffing constraints. However, in 2022, the Lakes and Ponds Program collaborated with Worcester State University (WSU) researchers and students to expand sampling into Patch Reservoir, Cooks Pond, and additional sections of Tatnuck Brook. Collaborators from WSU received a grant to use L&P methodologies to collect samples in these waterbodies on the same days the Lakes and Ponds Program samples in Coes Reservoir. This allows us to directly compare waterbody results to better understand dynamics throughout the watershed and create

more informed management plans in future years. This work continued in 2023 at Patch Reservoir and Cooks Pond. Reports from these investigations have been included alongside the four program lakes and can be found at [WorcesterMA.gov/bluespace](http://WorcesterMA.gov/bluespace). The WSU Tatnuck Brook Project will continue in 2024, subject to funding.

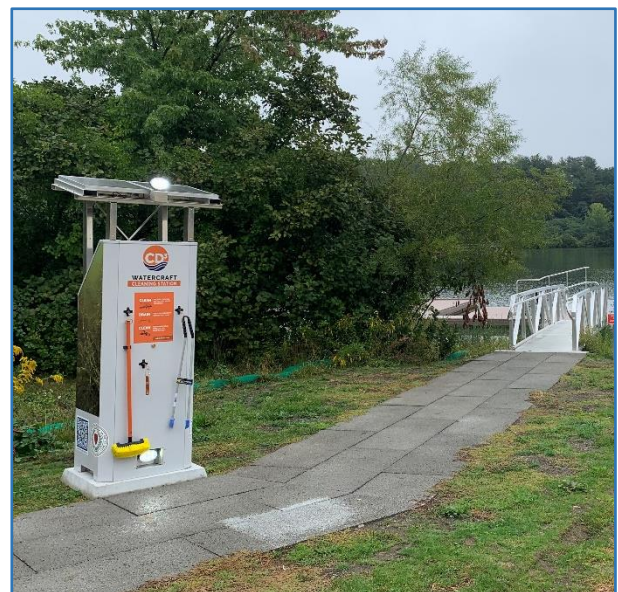
As Coes Reservoir experienced impacts from cyanobacteria in 2022, the Lakes and Ponds Program will continue to refine its monitoring and management approach to avoid prolonged lake closures. The Lakes and Ponds Program has utilized solar powered continuous monitoring buoys (see *Figure 18*) at Lake Quinsigamond since 2021 and at Indian Lake since 2022. These buoys use probes to track the cyanobacteria indicators phycocyanin and chlorophyll, as well as turbidity and temperature, and upload real-time data to an online dashboard. The Lakes and Ponds Program installed a buoy at Coes Reservoir in 2023 to improve responsiveness to cyanobacteria indicators. Though cyanobacteria were not as active at Coes Reservoir in 2023, remote monitoring will continue to provide early indicators of bloom risk in 2024.



**Figure 18** – A continuous monitoring buoy was deployed at Coes Reservoir in 2023 to collect parameters associated with cyanobacteria activity.

### **Lake Management**

**Boat Decontamination Stations.** The Lakes and Ponds Program is committed to monitoring and managing the invasive aquatic plants that can obstruct waterways. However, the best way to curb invasive aquatic plants’ effect on lake ecosystems is to keep them out of the lakes in the first place. The most common way invasive aquatic plants are spread is the accidental introduction as hitchhikers on boats and trailers. In many cases, even a small piece of a plant can re-root and start growing in a waterbody. In the fall of 2021, the Lakes and Ponds Program utilized funds from the American Rescue Plan Act (ARPA) to install solar powered boat decontamination stations at Indian Lake and Coes Reservoir (see *Figure 19*). These stations are free to use and contain instructions on best practices for intercepting invasive aquatic plants before they



**Figure 19** - Solar powered boat decontamination stations were installed at Coes Reservoir to help enable boaters to stop invasive plants at the source by decontaminating watercraft before and after use.



can take root in Worcester’s waterbodies. There are blowers and grabbers to remove weeds in hard-to-reach places, brushes to scrub algae off the sides of boats and tools to drain and dry bilge water. L&P will continue to promote use of the stations and explore further applications in 2024. To learn more about invasive aquatic plants and these decontamination stations see the episode of “The Blue Space Minute” on the City of Worcester YouTube Channel [Blue Space Minute - Boat Cleaning Stations - YouTube](#).

**Goose Fencing.** In 2021, the Lakes and Ponds Program implemented a Goose Fencing Pilot Project that aimed to reduce the number of beach closures at Indian Lake and Coes Reservoir due to fecal bacteria exceedances by humanely keeping geese away from the beach (see Figure 20). Geese usually enter the beach from the water and cannot easily get over low fences. They are uncomfortable when there are barriers between the beach and the water because the water is their escape route from land predators. After City lifeguards erected small fences between the shore and water during the evening hours, L&P found the use of the beach by the geese was significantly reduced, and beach closures due to *E. coli* also seemed to be reduced. In 2023, lifeguard staffing challenges led to minimal implementation of fencing. In 2024, as lifeguard staffing is available, L&P plans to continue the use of goose fencing at the Mill St. beach.



**Figure 20** – Goose fencing at Coes Reservoir was successful in deterring geese from the beach area.

**Education and Outreach:**

**Coes Aquatic Science Day.** As part of the 2021 Blue Space Angler Event Series, the Tatnuck Brook Watershed Association (TBWA) hosted an event at Coes Reservoir called the Family Aquatic Science Day (see Figure 21). In this event participants of all ages discovered the aquatic environment through a series of booths where they took measurements with water quality meters, learned about aquatic macroinvertebrates, looked at cyanobacteria under a microscope, explored a 3-D replica of a watershed, and collected fish with a large seine net. TBWA expanded the event in 2023, engaging 5<sup>th</sup> graders from Columbus



**Figure 21** –Students and volunteers at the 2023 Aquatic Science Day collect fish and other aquatic organisms in a seine net.



Park School. TBWA plans to continue to grow the event in 2024. L&P is excited to continue to support TBWA in this effort.

*Text Message Alert System.* In 2023, the Lakes and Ponds Program launched a text message alert system allowing residents to sign up to receive up-to-date information on lake access to guide upcoming visits. Text messages will alert residents when a beach is closed for fecal bacteria exceedances, or if a boat ramp is closed because a lake is receiving an invasive aquatic plant treatment. Especially since many lakegoers use public transportation to access waterbodies, L&P aims to provide a resource that can help to guide plans before people begin travel. The Lakes and Ponds Program will continue to work with DCR, Inspectional Services, and the Parks Department to establish a flow of information to keep the system up to date.

*Litter.* Inappropriately disposed waste is harmful to the ecological, aesthetic, and recreational value of lakes and ponds. In 2024, DSR will begin work on a Zero Waste Master Plan that will provide a comprehensive strategy for understanding and mitigating the impact of waste in our community. Lakes and Ponds Program will collaborate with DSR staff on ways to reduce impact of waste and litter in our lakes and ponds.

To learn more about Lakes and Ponds Program offerings, please see [WorcesterMA.gov/bluespace](https://WorcesterMA.gov/bluespace).

## Appendix: Depth Profiles

