Bell Pond
2022 Water Quality Report

Brought to you by
The City of Worcester Lakes and Ponds Program
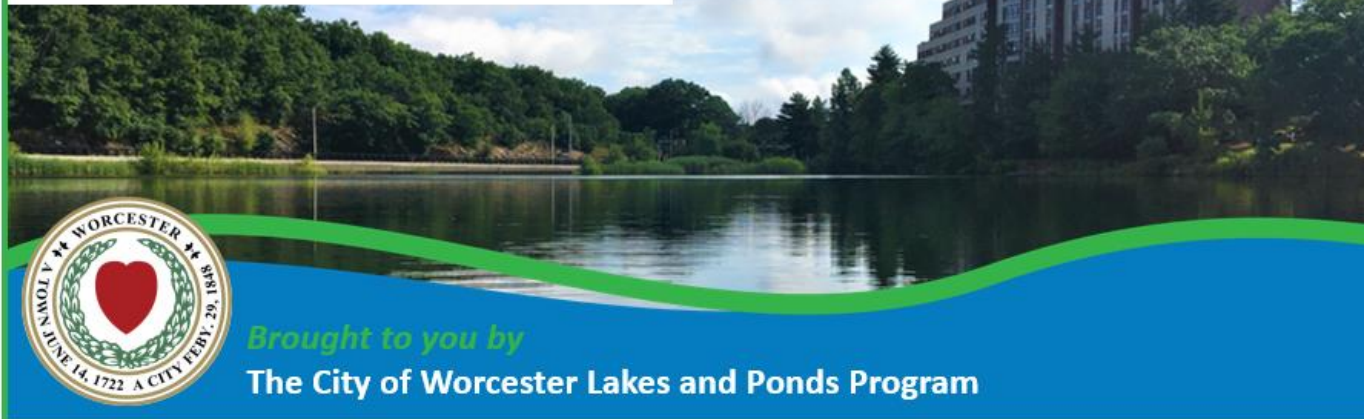
Background

Bell Pond is an 11-acre pond located in the Bell Hill neighborhood of Worcester (see *Figure 1*). Once known as "Bladder Pond", Bell Pond served as a fire suppression and drinking water source for the City of Worcester in the late 1800's. These days, Bell Pond provides ample public access for recreation and continues to have high quality water. The Pond is bordered on the North by Belmont Street, a highly trafficked road to Shrewsbury. To the East is the Seabury Heights retirement housing complex, and to the West there are wooded parklands with footpaths and a fishing platform. There is a small, City-maintained beach on the west side that is well-used in the summer months. Bell Pond is one of the most accessible waterbodies in the city, with pedestrian access around much of the shoreline. Despite its small size, Bell Pond's deepest point is approximately 17 feet, located in the middle of the waterbody. Water to the pond is primarily supplied by underground springs. The pond's main outlet is a catch basin located near the Seabury Heights driveway. There is also a secondary, less defined outlet to the south of the pond in the vicinity of the fishing platform. The pond is stocked in the spring with Rainbow Trout and is a popular local fishing destination.

Figure 1 – Bell Pond is an 11-acre pond located in the Bell Hill neighborhood of Worcester that sports a bathing beach, wooded park land and a popular sport fishery.

The following report details the results of a collection of water quality monitoring programs in 2022, as well as the exciting projects and opportunities the City of Worcester's Lakes and Ponds Program intends on implementing in 2023.

Water Quality Summary

Prior to the Lakes and Ponds Program (L&P), Bell Pond's water quality had not been monitored by the City of Worcester or any other entity. The pond is not listed as impaired on the Massachusetts Section 303(d) List by the Department of Environmental Protection (MassDEP), and since monitoring began in 2017, results have indicated that Bell Pond has few water quality challenges. There was only one beach closure at Bell Pond due to a fecal bacteria exceedance since L&P began monitoring and collecting data in 2017. In past years there have been no cyanobacteria criteria exceedances, water clarity has been high, and no contaminants of concern have been identified. Anecdotal accounts of litter have continued to be a potential threat to wildlife and recreation. Recently, invasive species have become a bigger concern. In 2020, the invasive mollusk, *Corbicula fluminea,* was identified in the pond. While not considered a threat to recreation, its threat to local ecology remains unknown. In 2022, the invasive plant *Phragmites australis* was documented along parts of the shoreline for the first time, although the extent of the infestation remains manageable. Over the past five years, L&P has consistently rated water quality at Bell Pond as "Excellent".

Management Summary

Since 2017, L&P has conducted lake management activities to mitigate invasive aquatic plants, nutrient and sediment loading, cyanobacteria, and fecal bacteria that have threatened waterbodies throughout the City of Worcester. As Bell Pond has not been observed to have any of these challenges, no management in these areas has been necessary. Based on 2022 findings, the L&P is developing a plan to eradicate the invasive *Phragmites australis*. The Lakes and Ponds Program continues to evaluate potential threats posed by the invasive mollusk, *Corbicula fluminea*, as well as litter, and investigate management methods to mitigate these threats.

Sampling Analysis and Overview

Bell Pond was visited semimonthly from May through October and sampled at the deepest point, located approximately in the center of the pond (see *Figure 2*). As no aboveground tributary exists, no tributary sample was taken. Probe measurements and water samples were collected 1 foot below the surface of the water ("surface"), and two feet from the bottom of the lake ("bottom"). During every sampling event L&P evaluated Secchi transparency, dissolved oxygen (DO), pH, total phosphorus (TP), total dissolved phosphorus (TDP), and *Escherichia coli* (*E. coli*). Samples were also collected for total suspended solids (TSS), ammonia (NH_3), and nitrate (NO_3) monthly. This year, L&P also collected samples to be analyzed for industrial contaminants and emerging contaminants of concern on two occasions. Altogether, the L&P visited Bell Pond 12 times. For 10 of these events, there were less than 0.25 inches of rainfall in the 24 hours prior to data collection. However, on 14-Jul there were 0.88 inches of rain in the 24 hours prior to

sampling, on 27-Oct there were 0.49 inches. These days are categorized as "wet weather" sampling events and denoted with the symbol 🌧 . Volunteers from the Worcester Cyanobacteria Monitoring Collaborative (WCMC) collected samples from the city beach area for phycocyanin and relative cyanobacteria density analysis to assess bloom risk. Samples were taken twice monthly between May and October, on 21-May, 6-Jun, 18-Jun, 5-Jul, 16-Jul, 1-Aug, 12-Sep, 24-Sep, and 3-Oct. Additionally, the Worcester Department of Inspectional Services tested the beach area for *E. coli* as an indicator for harmful bacteria on a weekly basis during the summer months. In September, a L&P contractor visited Bell Pond to do an aquatic plant survey.

Figure 2 – Bell Pond location and sampling site.

Raw data are displayed and explained in this report. No statistical analysis has been performed. Subsequent ratings of "Excellent", "Good", "Fair", and "Poor" for reported values are based on the MassDEP SMART Monitoring Watershed Report Card Criteria.

Quality Assurance/Quality Control

The Lakes and Ponds Program strives to have a robust data set. L&P therefore uses Quality Assurance/Quality Control checks to ensure that data are representative of local conditions and meet precision and accuracy standards. Review of QAQC check results identifies data that need to be flagged and/or censored before they are shared and can highlight issues that affect data quality. When data failed to meet acceptable criteria for these checks, they were 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.

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 collected 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 were above the recreational threshold. L&P collected samples for *E. coli* at

the surface of certain in-lake sites during all sampling events to assess *E. coli* conditions in open water. Samples were sent to an external lab for analysis.

Fecal Bacteria at Bell Pond. There were no beach closures at Bell Pond in 2022 (see *Table 1 & 2*). Results of beach *E. coli* testing by Worcester Inspectional Services ranged between 4 and 160 cells/ 100ml, falling within ranges considered "Excellent" and "Good" by DEP. Similarly, *E. coli* results from open water sampling by L&P continued to be low, with all but one result below 24 colonies/100ml and indicated conditions considered "Excellent". Bell Pond therefore did not have any challenges with fecal bacteria.

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 were 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 were taken monthly and submitted to an external lab for analysis.

Table 1 & 2 – There were no beach closures at Bell Pond in 2022. Results from beach and open water E. coli *testing fell in the ranges considered "Excellent" and "Good" all season.*

2021 OPEN	
DATE	RESULT
13-May	4.09
26-May	6.32
16-Jun	8.52
30-Jun	13.5
14-Jul	5.21
28-Jul	<1.00
11-Aug	3.06
25-Aug	6.26
15-Sep	24.05
29-Sep	5.21
13-Oct	4.13
27-Oct	8.60

2021 BEACH	
DATE	RESULT
27-Jun	72
5-Jul	16
11-Jul	4
18-Jul	4
25-Jul	8
1-Aug	40
9-Aug	160
15-Aug	8
22-Aug	4

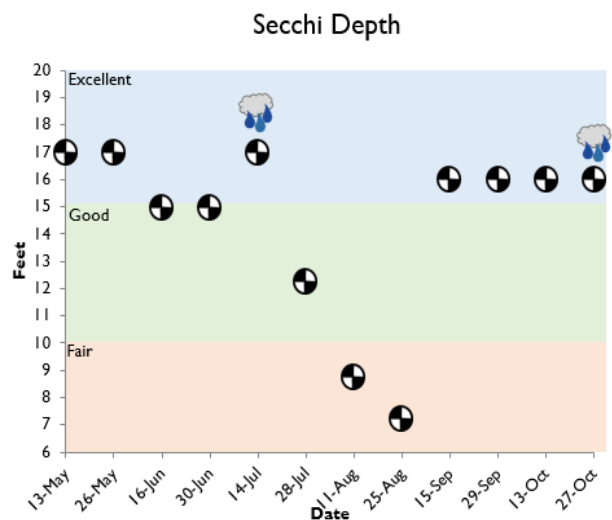| Excellent	Good	**Beach**
Fair	Poor	**closure**
Results in colonies/100 ml		

Secchi Depth

Figure 3 - Secchi depth was categorized as "Excellent" to "Good" except for two dates in August when it decreased to the "Fair" category.

Water Clarity at Bell Pond. Historically, water clarity at Bell Pond has been high in comparison to other Program lakes. In 2022, this trend continued with clarity readings falling between 15 and 17 feet for much of the spring, early summer and fall (see *Figure 3*). However, this year, several low Secchi readings were recorded in July and August. Following a downward trend, on 25-Aug Secchi depth was 7 feet, the lowest reading observed in Bell Pond by L&P to date. The next reading returned to the range considered "Excellent", where it remained for rest of the sampling season. This drop in clarity occurred concurrently with the warmest days of the year, and despite these lows, Bell Pond continues to have exceptional clarity compared to other local lakes. At the surface, TSS results were below the detection limit except for on 25-Aug, when it as 2.3 mg/L. TSS results at the bottom were similar with only two results above the detection limit. All detected readings were considered in the "Excellent" range. Despite several lower readings, overall clarity at Bell Pond continued to be "Excellent".

Temperature

Water temperature is important for 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 experienced throughout the water body, affecting the distribution of oxygen, nutrients, and organic matter throughout the lake. Temperature was measured using a temperature sensor on a handheld probe at the water's surface, and two feet from the bottom at the in-lake locations during every sampling event.
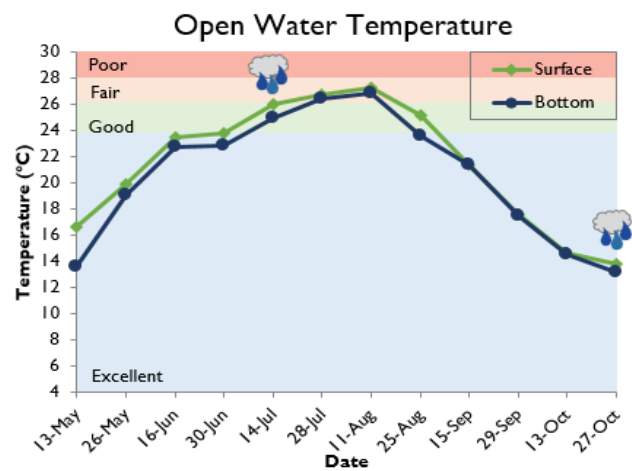

Figure 4- Surface and bottom temperatures were in the "Excellent" to "Good" categories for most of the season, they reached the "Fair" category for two weeks at the end of July.

Temperature at Bell Pond. Temperature readings in Bell Pond in 2022 are similar to those of years past, with surface and bottom temperature below 23.8° C, or considered "Excellent" in spring, early summer and fall (see *Figure 4*). Surface and bottom temperatures rose as expected throughout the summer and peaked at 27.3° C on 11-Aug. This result tied the record for the highest temperature reading taken by L&P at this site. In 2022, temperature at Bell Pond continued to be rated overall as "Excellent".

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, which is 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. Increased algal growth followed by excessive decomposition of organic material can also lead to low oxygen conditions, and 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 during every sampling event.

Dissolved Oxygen at Bell Pond. At Bell Pond, surface readings consistently showed ample dissolved oxygen, ranging between 6.0 mg/L and 9.5 mg/L. On the bottom, DO fluctuated more (see *Figure 5*). Most notably, DO dropped below 4.0 mg/L, into the range considered "Poor" on 11-Aug and 25-Aug, coinciding with the days of lowest Secchi clarity. To better understand the extent to which oxygen depletion occurred in the water column, monthly depth profiles were taken. These included DO readings at the water's surface and at 5 ft increments until the bottom was reached. Low DO readings were rare and only occurred within the last two feet of the water column leaving ample space for aquatic organisms to thrive. DO at Bell Pond in 2022 continued to be "Excellent".
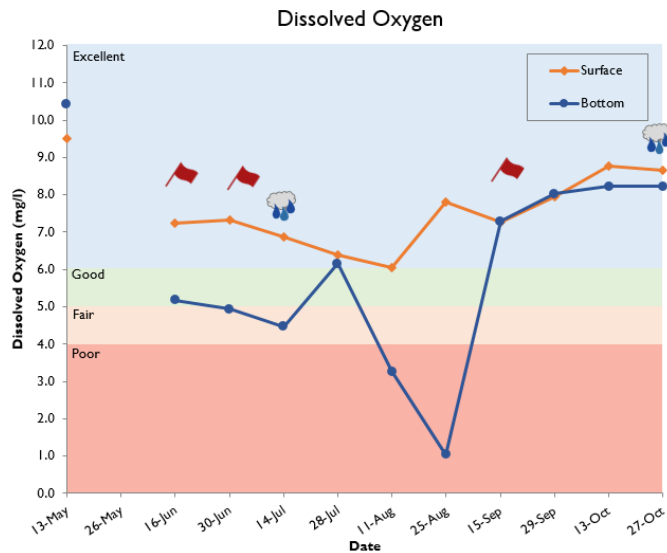
Figure 5 - *Surface dissolved oxygen was rated "Excellent" throughout the season. Bottom dissolved oxygen was in the "Good" to "Fair" categories until August when it dipped to "Poor" before returning to "Excellent".*

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 lakes in our area have a pH between 6.5 and 8.5. pH was measured using an ion-
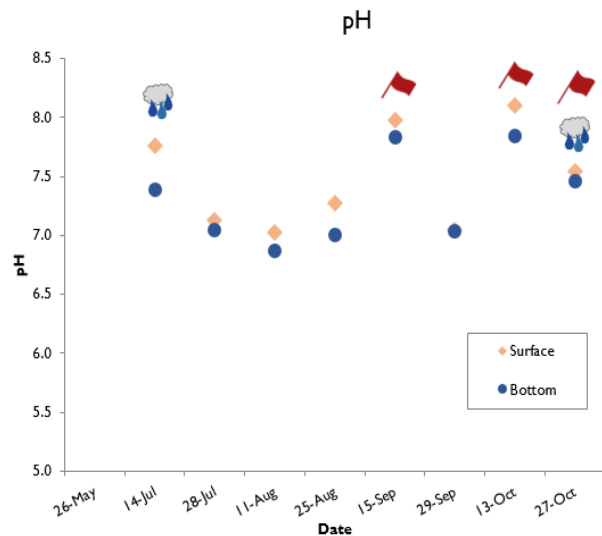
Figure 6 - *pH fluctuated between 6.87 and 7.84 at the lake bottom and 7.0 and 8.1 at the surface at Bell Pond.*

selective electrode (ISE) pH sensor on a handheld monitoring probe. Readings were taken at the water's surface and two feet from the bottom.

pH at Bell Pond. pH readings taken on the surface and bottom of Bell Pond were higher than expected based on past seasons' results. In 2022, the maximum pH reading (8.1) was the highest recorded by L&P (see *Figure 6*). The lowest pH reading of 2022 was also the highest on record (7.0). The cause of this shift is unclear. As elevated pH creates conditions favorable for cyanobacteria growth, L&P will continue to monitor pH in relation to other parameters closely.

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 collected samples for several compounds and submits them to an external lab for analysis. To measure N, samples were collected for nitrate (NO_3) and ammonia (NH_3) at all sites monthly. As extensive issues were noted with QAQC checks performed by the laboratory, the data collected for NH_3 were not considered suitable for inclusion in this report. To measure P, samples were collected for total phosphorus (TP) twice a month at all sites, and total dissolved phosphorus (TDP) twice a month at all bottom sites. TDP was also analyzed to understand how much P is dissolved in the water and available for use by aquatic organisms.

Nutrients at Bell Pond. In 2022, total phosphorus results were like those of past years, ranging between below the reporting limit and 0.016 mg/L on the surface and between below the reporting limit and 0.020 mg/l on the bottom (see *Figure 7*). All results recorded were in the range considered "Excellent" by DEP. The same was true for total soluble phosphorus. All but one result were below the reporting limits for the lab (<0.010mg/l), and the remaining result was 0.010mg/l. As in previous years, results suggest that phosphorus inputs in Bell Pond are low and do not pose a significant risk to water quality. Three of the six nitrate sample results taken this year were censored due to lab QAQC issues. All results passing QAQC
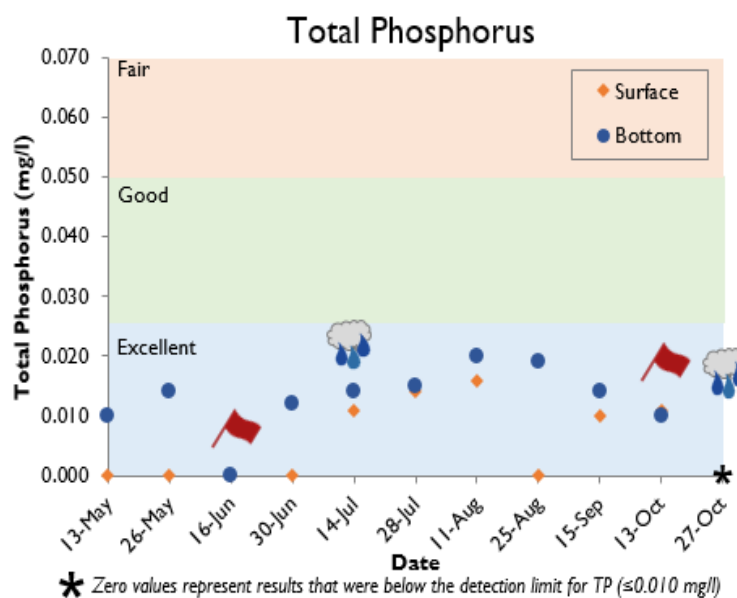

Figure 7 - Total phosphorus remained in the "Excellent" category throughout the 2022 season at the surface and bottom of Bell Pond.

checks were below the detection limit or in the range considered "Excellent". As extensive issues were noted with QAQC checks performed by the contracted laboratory, we did not find the data collected for ammonia suitable for inclusion in this report. Based on available data, nutrient results in Bell Pond remain low and were overall considered "Excellent" in 2022.

Cyanobacteria

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

To understand the abundance of cyanobacteria and make decisions regarding lake management and safe access, L&P utilized the data collected by the Worcester Cyanobacteria Monitoring Collaborative (WCMC) to measure cyanobacteria indicators and estimate toxin exposure risk. The WCMC is a group of community science volunteers that collected water quality samples twice monthly between May and October at 24 waterbodies in and around Worcester, including Bell Pond. Parameters examined included phycocyanin and the relative abundance of cyanobacteria taxa. Like chlorophyll, the pigment phycocyanin is used by cyanobacteria to harness the sun's energy, converting carbon dioxide to sugars for growth and reproduction. Because phycocyanin is unique to cyanobacteria, it can be used as an indicator of cyanobacteria's relative abundance in a waterbody. Cyanobacteria taxa and their comparative abundance helps determine what toxins may be present. The WCMC was also able to determine relative density of cyanobacteria genera in samples using a high-powered microscope. Using both phycocyanin and comparative cyanobacteria density the WCMC began to assign bloom risk at each participating waterbody. For more information on the WCMC and their results, visit WorcesterMA.gov/WCMC.

Cyanobacteria at Bell Pond. Over the course of the 2022 season, phycocyanin was not detected in any results from fluorometry analysis conducted by the WCMC (see *Figure 8*), and cyanobacteria density was either rated "none" or "low". Only two genera of cyanobacteria were observed, *Dolichospermum sp.* and *Microcystis sp.* Which were observed in small numbers and on few occasions. The combination of cyanobacteria data collected by the WCMC, and high clarity and low nutrient results indicates that Bell Pond is not at significant risk for harmful cyanobacteria blooms. Bell Pond in 2022 continued to be considered low risk for a cyanobacteria bloom.
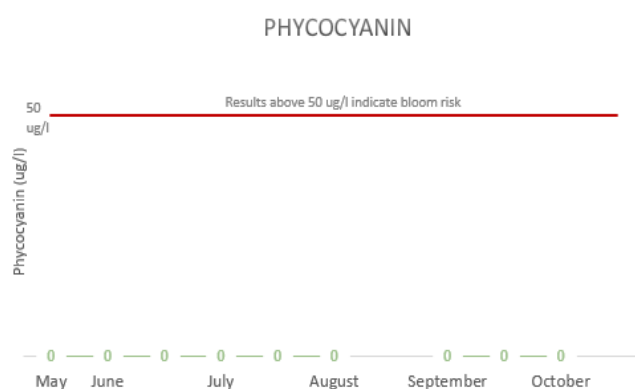

Figure 8 – Phycocyanin was not detected in samples collected by the WCMC at Bell Pond, indicating that cyanobacteria were not prevalent here in 2022.

Invasive Aquatic Plants and Animals

Plants and animals are vital parts of any lake ecosystem. Plants provide food, shelter, and oxygen to other aquatic organisms. Their uptake of nutrients reduces the likelihood of algal blooms, and their root systems stabilize sediments. Animals play invaluable roles in food webs and their removal can disrupt the ecology of a system. 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 by hitching a ride on boats, pets, or boots to get to a new location. 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.
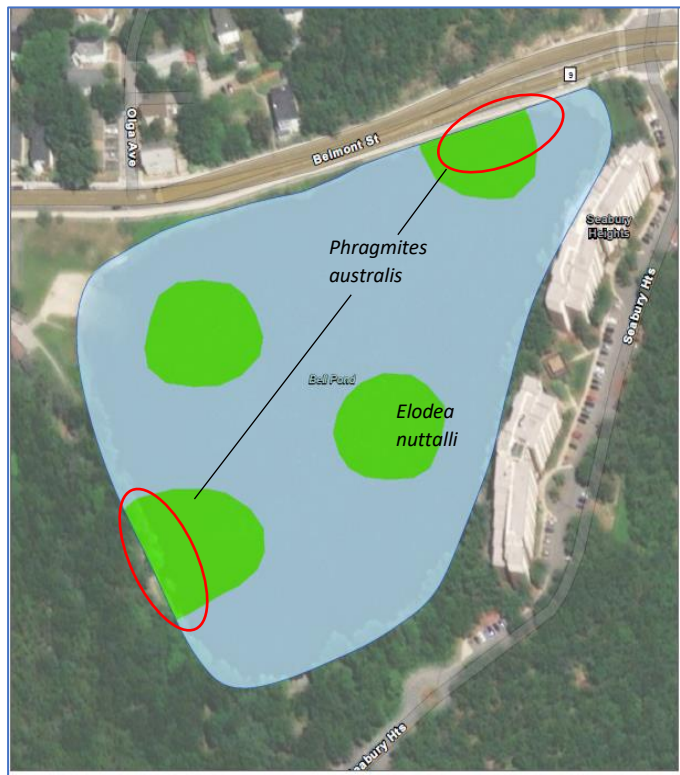

Figure 9 – Plant mapping contracted by L&P in 2022 indicated the presence of the invasive plant Phragmites australis along parts of the shoreline for the first time (circled in red), and the native plant Elodea nuttalli (shaded green).

Invasive Aquatic Plants and Animals at Bell Pond. Past plant surveys and monitoring have indicated that invasive aquatic plants have not previously been a challenge at Bell Pond. However, in 2022, plant mapping contracted by L&P indicated the presence the invasive plant *Phragmites australis* along parts of the shoreline for the first time (see *Figure 9*). At this time, the extent of the infestation remains manageable. The native plant *Elodea nuttalli* was also observed in the lake. Additionally, in 2020 the Lakes and Ponds Program found evidence of the invasive mollusk, *Corbicula fluminea.* Although it is not known how long it has been residing in Bell Pond, it does not appear to be impeding lake health or recreation at this point. Moving forward, the Lakes and Ponds Program will continue to monitor changes in the population of this and other mollusks in Bell Pond.

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. 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. Detected parameters are shown below. To see a full list of contaminants tested for, contact greenworcester@worcesterma.gov.

Industrial Contaminants at Bell Pond. All results for VOCs, SVOCs, PCBs, TPH, pesticides, and herbicides were below reporting limits, indicating an extremely low to no concentration. Eleven metals were detected including aluminum, arsenic, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc. These metals are naturally occurring in New England soil and are not present in the water in quantities that would negatively affect human health. Overall, metal results decreased from 2019 testing (*see Table 3*). PFAS is a class of emerging contaminants of concern, however, there are no regulations on PFAS for recreational waterways. There are drinking water regulations for six species of PFAS. The PFAS drinking water limit (also known as an MCL) is total of 20 ng/l, as a sum of the 6 regulated species. The combined total of regulated PFAS species in Bell Pond for each day was 7.16 and 7.23 ug/l (see *Table 4*) which is below the drinking water standard and an overall decrease from 2019 results. As drinking water standards are generally much stricter than those of recreational waterways, we can assume that PFAS is not a concern for recreational users of Bell Pond.

Table 3 – Eleven metals were detected in 2019 and 2022. These metals are naturally occurring in regional soils and are not present in quantities that could affect human health. "ND" signifies that the compound's concentration was not detected by the lab.

Parameter	Wet Result	Dry Result	Wet Result	Dry Result	units
Metals	**9/7/2022**	**10/20/2022**	**7/12/2019**	**9/12/2019**	
Aluminum, Total	0.0109	0.0229	0.0118	0.011	mg/l
Arsenic, Total	0.01245	0.01338	0.00588	0.0105	mg/l
Barium, Total	0.02714	0.02033	0.01047	0.01806	mg/l
Calcium, Total	11.5	11.1	12.6	12.6	mg/l
Copper, Total	0.00463	0.00145	0.00103	0.00121	mg/l
Iron, Total	0.685	0.485	0.29	0.487	mg/l
Magnesium, Total	1.76	1.81	1.84	1.8	mg/l
Manganese, Total	0.5336	0.1859	0.05917	0.3313	mg/l
Potassium, Total	3.21	3.34	3.01	2.98	mg/l
Sodium, Total	49.7	44.4	47.3	46.8	mg/l
Zinc, Total	ND	0.01206	0.01037	ND	mg/l

Table 4 – Several PFAS compounds were detected at Bell Pond in 2019 and 2022. The totals of regulated compounds were very low and not of concern for recreational contact. "ND" signifies that the compound's concentration was not detected by the lab. "NT" signified that the compound was not tested for, as the analysis was not yet available.

Parameter	Wet Result	Dry Result	Dry Result	Wet Result	Unit
Non-Regulated Perfluorinated Alkyl Acids	**9/20/2022**	**7/25/2022**	**7/22/2019**	**6/13/2019**	
Perfluorohexanoic Acid (PFHxA)	2.81	3.09	NT	NT	ng/l
Perfluoropentanoic Acid (PFPeA)	3.2	3.17	NT	NT	ng/l
Perfluorobutanoic Acid (PFBA)	3.95	2.75	NT	NT	ng/l
Perfluorobutanesulfonic Acid (PFBS)	ND	ND	1.83	1.87	ng/l
Regulated Perfluorinated Alkyl Acids	**9/20/2022**	**7/25/2022**	**7/22/2019**	**6/13/2019**	
Perfluorooctanesulfonic Acid (PFOS)	1.93	1.84	2.02	1.92	ng/l
Perfluoroheptanoic Acid (PFHpA)	2.16	2.14	2.45	2.36	ng/l
Perfluorooctanoic Acid (PFOA)	3.07	3.25	4.64	5.29	ng/l
Total Regulated	**7.16**	**7.23**	**9.11**	**9.57**	**ng/l**

Litter

Litter, or inappropriately disposed waste, is harmful to the ecological, aesthetic, and recreational value of lakes and ponds. Improperly discarded plastic and Styrofoam products can be mistaken as food by aquatic organisms and can kill them. Mounds of trash and rotting organic material can cause infestation by disease-carrying vermin. Additionally, they look and can smell unpleasant to beachgoers and hikers. Finally, sharp objects like syringes, broken metal, or glass can pose a threat to swimmers and other beach visitors.

Litter at Bell Pond. Litter is a difficult parameter to measure in a quantitative way, although litter has been determined to be the largest concern for lake water quality at Bell Pond. A study at Bell Pond in 2021 found that, of the categories examined, "small items", "tobacco products", "bags", and "food packaging and containers" were the most prominent classes of litter. See *Figure 10* for the relative rankings of the different classes of litter examined. Another common observation was that most of the litter gathers in the reeds along the shore. Cigarette butts and other small items commonly accumulated in the parking area but were not severe on the grass at the park.

Out of all the ponds in the Lakes and Ponds Program, Bell Pond has the highest percentage of its perimeter open for public use, and its location in the middle of the city means that it is heavily utilized. The northern end is abutted by a major roadway, and three quarters of the perimeter is lined with walking paths. The last quarter is accessible to the residents of a large apartment complex. While trash receptacles are left out by the City, they are often overturned or not used. While litter was not formally qualified in 2022, the Lakes and Ponds Program is attempting to combat this challenge with collaborations with local organizations and an educational campaign, which you can read more about in the following section.
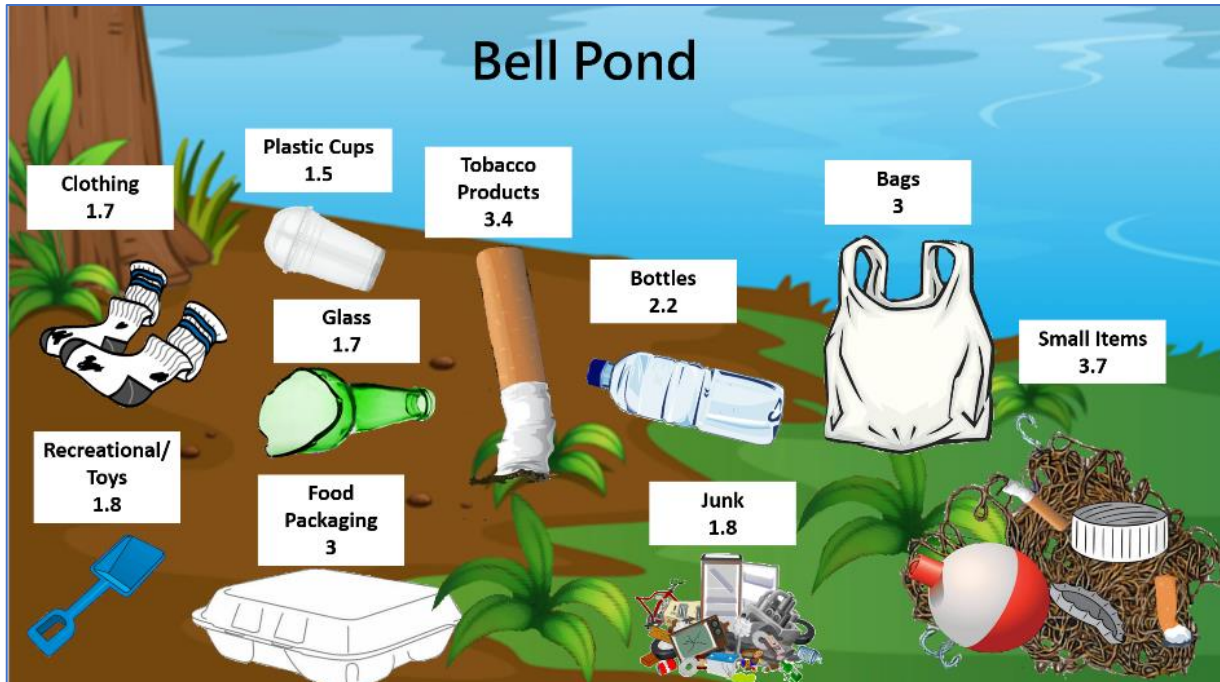
Figure 10 – The relative abundance of different categories of litter were categorized in 2021. A rating of 1 indicates the lowest abundance, and 5 is the highest.

Ongoing Projects

Community Science and Water Storage

Since 2019, Bell Pond has been part of a worldwide scientific study on freshwater storage called "Lake Observations by Citizen Scientists & Satellites" which was spearheaded by the University of North Carolina and funded through NASA. The study relies on community scientists, or ordinary people, to collect lake level observations from a gauge located in the shallow water off of Belmont Street, and text them into the study. Simultaneously, satellites are collecting data on changes to the area of the lake from above. Using both data points, the study can track changes in the volume of water in the lake over time.

Since the study began, the community has texted in about 134 water level observations, with 16 taken during the 2022 season. Results from 2022 are shown in *Figure 11*. As ice conditions in the lake dislodged the gauge over the winter, the gauge was reset to 1 ft in early June. Water depth readings ranged between 0.95 and -0.12 ft. Negative readings occurred when the water level dropped below the zero line on the gauge. Water depth fell consistently between June and late August. Water level rose slowly in the fall but only reached 0.1 ft at the last reading in late November.

As time has passed since the installation of the gauge, the frequency of observations has decreased. To increase engagement, L&P hopes to publish more promotional materials on the study, including an episode of the video series, the "Blue Space Minute". L&P will also begin a gauge maintenance plan, so it is more visible from the road, and add signage on the adjacent railing to call attention to the project. To get involved and see the data in real time, visit *www.locss.org*.
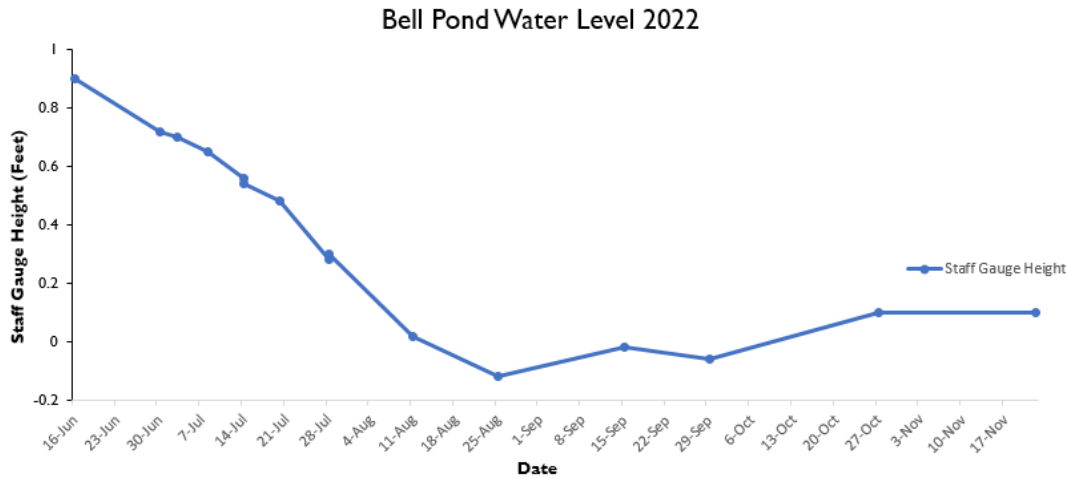
Bell Pond Water Level 2022

***Figure 11** - Staff gauge height was .95 feet at the start of the season and progressively decreased to 0.12 feet in August.*

State of the Lake

For the sixth year running, the Lakes and Ponds Program has rated Bell Pond's overall water quality as "Excellent". Since monitoring began in 2017, there was only one beach closure for a fecal bacteria exceedance, and no lake closures due to cyanobacteria. With few exceptions, results for temperature, DO, *E. coli*, TP, NH_3, NO_3 and TSS are considered "Excellent". Despite higher-than-expected surface pH readings and occasional lower clarity readings, Bell Pond remains the clearest waterbody monitored by L&P. In 2022, the invasive plant *Phragmites australis* was documented along parts of the shoreline for the first time, however, the extent of the infestation remains manageable. While an invasive mollusk is present, it does not appear to be impacting recreation.

Plan for 2023

Water Quality Monitoring

In 2023, the Lakes and Ponds Program will continue to monitor Bell Pond to ensure that it is maintaining high water quality. L&P will closely monitor pH and clarity, given that elevated pH can create conditions favorable for cyanobacteria growth. L&P will also develop a plan to monitor for the invasive plant *Phragmites australis* to guide potential management efforts. The WCMC will continue to monitor Bell Pond for cyanobacteria. In addition to collecting phycocyanin and cyanobacteria density data, the WCMC will continue to develop its methods of evaluating toxin exposure risk, with the hopes of creating a cost effective and accurate way to determine toxin exposure risk. As litter in the public park area continues to pose a challenge, L&P will continue to monitor litter quality and quantity throughout the park.

Lake Management

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 Coes Reservoir and Indian Lake by humanely keeping geese away from the beach (see *Figure 12).* Geese usually enter the beach from the water and are not good at getting 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 erecting a small fence between the shore and water during the evening hours, L&P found the use of the beach by the geese was significantly

Figure 12 – Goose fencing at Coes Reservoir was successful in deterring geese from the beach area.

reduced, and beach closures also seemed to be reduced. In 2022, the Lakes and Ponds Program improved the construction of the fencing using higher quality materials and making installation easier to increase usage during the summer.

While beach closures due to fecal bacteria exceedances have not recently occurred at Bell Pond, geese do still sometimes frequent the beach. In 2022, after seeing positive results of fewer goose droppings at Coes Reservoir, lifeguards at Bell Pond requested goose fencing. Because the request came late in the season, fencing was only utilized for a few weeks, but L&P plans to continue its use during the swimming season in 2023 with the hopes that it will improve visitor experience at the pond.

Invasive Aquatic Plants. Following the identification of the invasive plant *Phragmites australis* around the perimeter of Bell Pond, L&P will begin the processing of permitting required for the application of herbicides to control the spread of the plant. If successful, L&P will contract the application of herbicide to curtail the spread of the plant in the fall of 2023.

Education and Outreach

Litter. The Lakes and Ponds Program will work with its partners, including the Department of Public Works & Parks and Worcester Green Corps, to use our data to create litter reduction strategies. L&P will also help to build pride around Bell Pond with videos and signage related to its high-quality water, including the re-release of the Bell Pond "Blue Space Minute" Episode on Litter, which debuted in April of 2022.
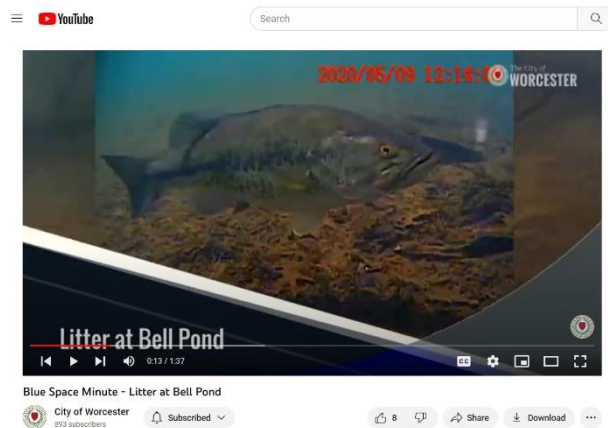

Figure 13 – The "Blue Space Minute" debuted an episode on Litter in 2022 on the City of Worcester YouTube Channel.