2012

Kezar Lake Water Quality Report

A Report on the Water Quality of Kezar Lake, Two Tributaries, and Six Watershed Ponds

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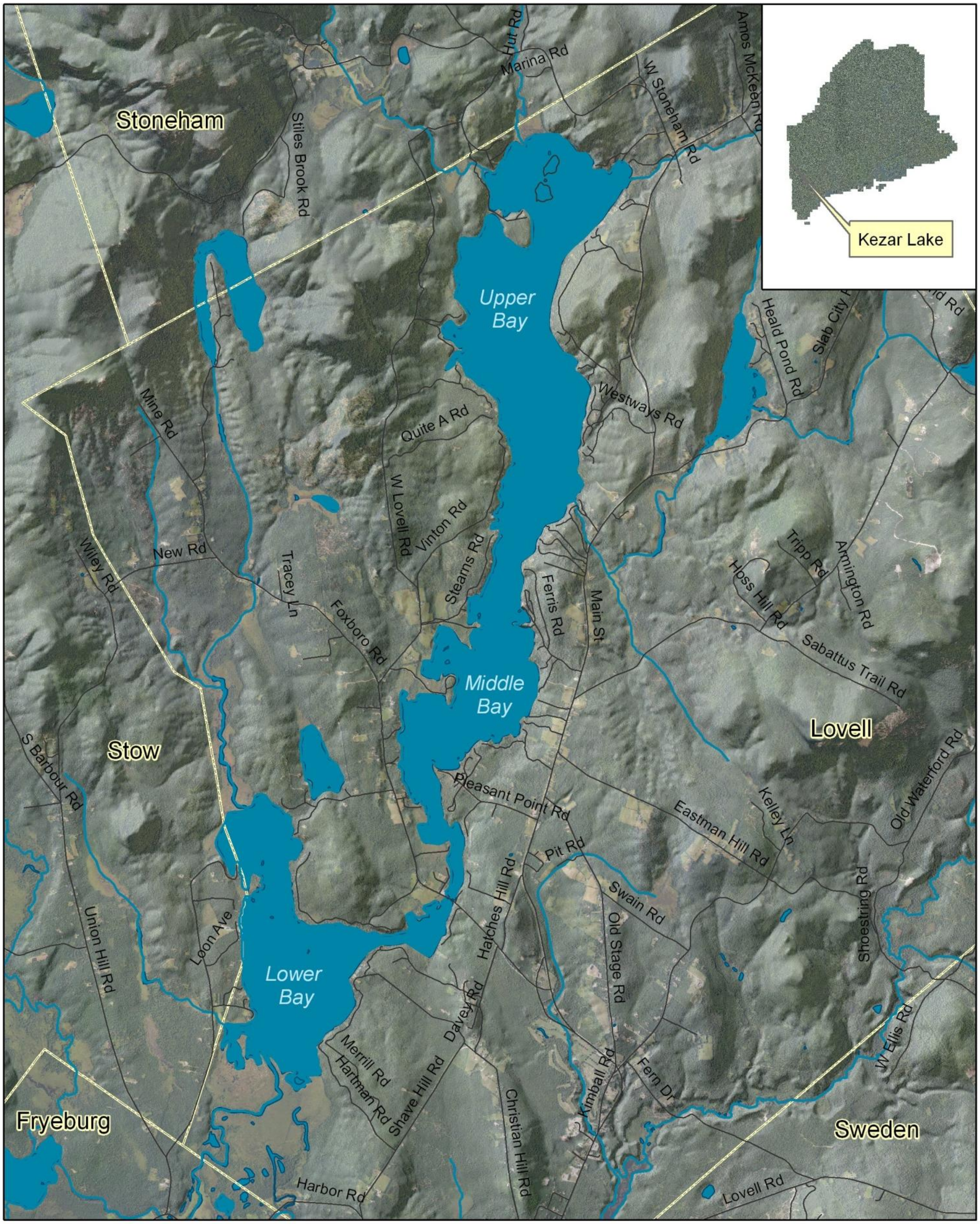

Kezar Lake
Lovell, ME

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Data obtained from MEGIS.
Created by FB Environmental,
December 2011.

2012
Kezar Lake
Water Quality Report

A Report on the Water Quality of Kezar Lake,

Two Tributaries and Six Watershed Ponds

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Glossary of Key Terms Used in this Report

Chlorophyll-a: a measurement of the green pigment found in all plants, including microscopic plants such as algae. It is used as an estimate of algal biomass; higher Chl-a equates to greater amount of algae in the lake.

Color: the influence of suspended and dissolved particles in the water as measured by Standard Platinum Units (SPU). A variety of sources contribute to the types and amount of suspended material in lake water, including weathered geologic material, vegetation cover, and land use activity. Colored lakes (>25 SPU) can have reduced transparency readings and increased TP values. When lakes are highly colored, the best indicator of algal growth is chlorophyll-a.

Dissolved Oxygen: the concentration of oxygen that is dissolved in the water. DO is critical to the healthy metabolism of many creatures that reside in the water. DO levels in lake water are influenced by a number of factors, including water temperature, concentration of algae and other plants in the water, and amount of nutrients and organic matter that flow into the water body from the watershed. Too little oxygen severely reduces the diversity and abundance of aquatic communities. DO concentrations may change dramatically with lake depth. Oxygen is produced in the top portion of a lake (where sunlight drive s photosynthesis), and oxygen consumption is greatest near the bottom of a lake (where organic matter accumulates and decomposes).

Epilimnion: the top layer of lake water that is directly affected by seasonal air temperature and wind. This layer is well oxygenated by wind and wave action except times when the lake is covered by ice.

Escherichia coli (E. coli): an indicator of the presence of fecal contamination in the watershed. By itself, *E. coli* is generally not a threat to human health, but it can be associated with disease-causing organisms.

Eutrophic: refers to lakes with high productivity, high levels of phosphorus and chlorophyll, low Secchi disk readings, and abundant biomass with a lot of accumulated organic matter on the bottom. Eutrophic lakes are susceptible to algal blooms and oxygen depletion in the hypolimnion.

Integrated Epilimnetic Core:

pH: the standard measure of the acidity or alkalinity of a solution on a scale of 0-14. Most aquatic species require a pH between 6.5 and 8. As the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. pH is influenced by bedrock, acid rain deposition, wastewater discharge, and natural carbon dioxide fluctuations.

Sample Station: location where water quality readings and samples are taken. Some of the larger lakes or basins are sampled at more than one location, resulting in multiple station numbers. In lakes with more than one basin, at least one station is usually located in each basin.

Glossary of Key Terms Continued…

Secchi disk transparency (SDT): a vertical measure of water transparency (ability of light to penetrate water) obtained by lowering a black and white disk into the water until it is no longer visible. Measuring SDT is one of the most useful ways to show whether a lake is changing from year to year. Changes in transparency may be due to increased or decreased algal growth, or the amount of dissolved or particulate materials in a lake, resulting from human disturbance or other impacts to the lake watershed area. Factors that affect transparency include algae, water color, and sediment. Since algae are usually the most common factor, transparency is an indirect measure of algal populations.

Standard Platinum Units (SPU): a unit of measurement used to determine the color of lake water. Lake water with 30 SPU color will look slightly brown or tea-colored.

Thermocline: the uppermost point in the water column where the temperature drops at least a degree Celsius per meter of depth.

Total Alkalinity: a measure of the buffering capacity of a lake, or the capacity of water to neutralize acids. It is a measure of naturally-available bicarbonate, carbonate, and hydroxide ions in the water, which is largely determined by the geology of soils and rocks surrounding the lake. Alkalinity is important to aquatic life because it buffers against changes in pH that could have drastic effects on animals and plants.

Total Phosphorus (TP): the total concentration of phosphorus found in the water, including organic and inorganic forms. TP is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits plant growth in freshwater ecosystems. As phosphorus increases, the amount of algae generally increases. Humans can add phosphorous to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or poorly maintained septic tanks.

Trophic State Indicators: a scale from 0 to 100+, which ranks lakes for productivity. The low (zero) end of the scale supports very little algae, has excellent water quality (oligotrophic) and the high end 100+ is eutrophic and very productive. TSI can be calculated from the Secchi disk, Chl-a or total phosphorus results and requires at least five months of data per year. Lakes with TSI values greater than 65 may support algal blooms while values over 100 indicate extreme productivity and annual algae blooms. TSI values can be used to compare lakes with similar water color and track water quality trends within a lake.

Watershed: a drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

1. Background and Historical Information

Kezar Lake Facts:
Watershed: Saco River
Surrounding Towns: Lovell, Stow, Stoneham
County: Oxford
Watershed Area: 35,732 acres (56 mi^2)
Mean Depth: 34 feet
Max Depth: 155 feet
Surface Area: 2,510 acres (3 mi^2)
Watershed Group: Kezar Lake Watershed Association
Midas Number: 0097
Fishery: Mixed warm and cold-water fishery

Kezar Lake is a non-colored waterbody located in the Town of Lovell in Oxford County, Maine. The lake stretches nine miles from north to south. The Kezar Lake watershed also encompasses nine smaller ponds and numerous streams.

This report documents the results of water quality monitoring conducted by FB Environmental Associates (FBE) for the Kezar Lake Watershed Association (KLWA) in 2012. In addition to monitoring water quality in the three basins of Kezar Lake, FBE also collected water quality data at six ponds in the Kezar Lake watershed: Bradley, Cushman, Farrington, Heald, Horseshoe and Trout ponds. Several of the six ponds are hydrologically connected, and they all ultimately drain into Kezar Lake. Additionally, FBE monitored two tributaries to Kezar Lake: Great Brook and Boulder Brook. Great Brook drains into the upper basin at the north end of Kezar Lake, and Boulder Brook flows into Kezar Lake between the middle and upper basins on the east side of the lake.

Background and historical information about Kezar Lake, Great Brook, Boulder Brook and the six ponds has been presented in detail in previous reports. Please refer to the following reports on the KLWA website for more information (http://klwa.us/reports/):

- Kezar Lake 2011 Water Quality Report (December 2011) - *Summarizes the results of the 2011 water quality monitoring for Kezar Lake, Boulder Brook, Great Brook, and the six ponds.*
- Historical Trend Analysis: Kezar Lake and Ponds (July 2012) - *Summarizes major trends and observations made from an in-depth analysis of the historical water quality data for Kezar Lake and the six ponds.*

2. Water Quality Monitoring Methods and Parameters

Sampling locations, dates, and weather conditions of water samples collected by FBE in 2012 are listed in Table 1 (below):

Table 1: 2012 Sampling Dates, Weather and Locations.

Date	Weather			Sampling Sites
	Prior 24 hr Precip (in)*	Prior 48 hr Precip (in)*	Sampling Day Weather Conditions	
20-Jun-12	0.00	0.00	Clear, with a short period of light rain	Kezar Lake, Kezar Lake tributaries (2), Kezar Lake Watershed Ponds (Trout, Cushman, Bradley, Heald, Farrington, Horseshoe)
13-Aug-12	0.29	0.31	Clear, with some periods of partly to mostly cloudy skies	Kezar Lake, Kezar Lake Watershed Ponds (Trout, Cushman, Bradley, Heald, Farrington, Horseshoe)
18-Sep-12	0.08	0.08	Fog in early morning, periods of light rain and rain in late morning to early afternoon. Windy at times in early afternoon	Kezar Lake, Kezar Lake tributaries (2)

**Source: Weather Underground, Fryeburg Airport Weather Station (KIZG)*

Kezar Lake Monitoring

The three basins of Kezar Lake were sampled on June 20, August 13 and September 18, 2012 (Table 1). Sampling was conducted in accordance with standard methods and procedures for lake monitoring established by the Maine Department of Environmental Protection (Maine DEP), the US Environmental Protection Agency, and the Maine Volunteer Lake Monitoring Program (VLMP). All lab samples were analyzed at the Health and Environmental Testing Lab (HETL) in Augusta unless otherwise noted. The following parameters were measured:

Trophic State Indicators: Maine DEP defines trophic state as the ability of a waterbody to produce algae and other aquatic plants; the trophic state of a waterbody is a function of its nutrient content. Water clarity (measured by **Secchi disk transparency (SDT)** readings), **Total Phosphorus (TP)**, and **Chlorophyll-a (Chl-a)** are trophic state indicators, or indicators of biological productivity in lake ecosystems. The combination of these parameters helps determine the extent of and effects of eutrophication in lakes.

Additional indicators of lake water quality measured in 2012 include **dissolved oxygen (DO)**, **temperature**, **natural color**, **total alkalinity** and **pH**.

An integrated epilimnetic core method was used to collect samples at the deep hole of each of Kezar Lake's three basins and the smaller watershed ponds. With this method, a core of water is collected from the water surface to the upper part of the thermocline. Sampling results reflect the average concentration for each of the measured parameters.

Kezar Lake Tributary Monitoring

Tributary sampling was conducted on June 20 and September 18, 2012 upstream of the Adams Road crossing off Hut Road at Great Brook (GB-1), and at three locations on Boulder Brook: at the outlet to Kezar Lake on the Boulder Brook Club property (BB-1), and upstream (BB-4) and downstream (BB-3) of the Route 5 crossing (Table 1). Water quality parameters measured included **DO**, **temperature**, **TP**, and ***E. coli***.

Kezar Lake Watershed Pond Monitoring

On June 20 and August 13, 2012, monitoring was conducted at the deep hole of Bradley, Cushman, Farrington, Heald, Horseshoe, and Trout Ponds (Table 1). Water quality parameters measured were the same as those described above for Kezar Lake.

KLWA volunteers Sara Cope and Charlie Dattelbaum (above) and FBE scientist Emily DiFranco (right) collecting water quality samples in Kezar Lake in August 2012.

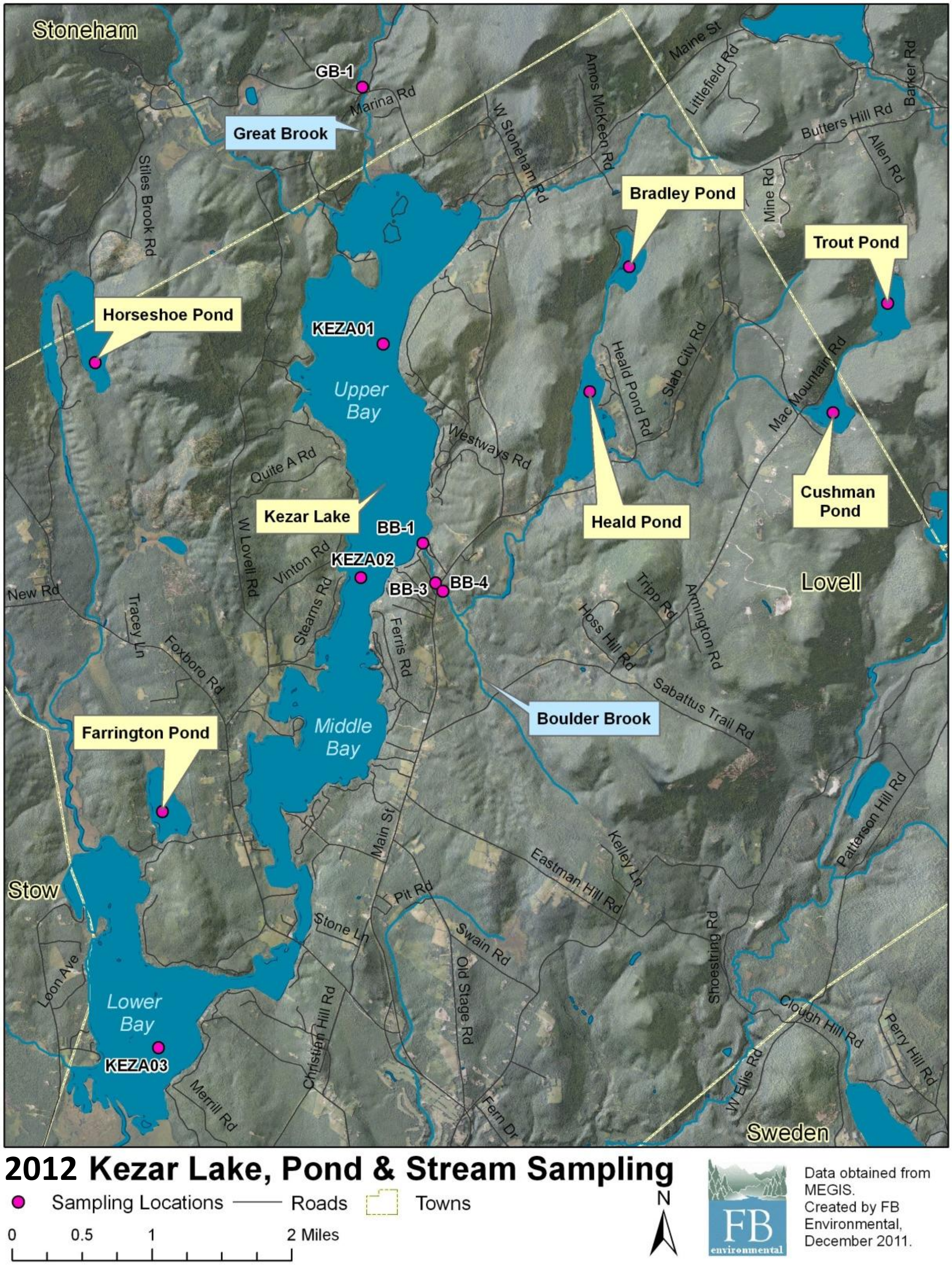


Figure 1: Map of 2012 Sampling Locations.

3. Kezar Lake Water Quality Monitoring Results

Water Clarity

In 2012, average Secchi Disk Transparency (SDT) readings for the upper, middle, and lower basins of Kezar Lake were 7.3, 6.5, and 3.5 m, respectively (Figure 2). When compared to the other basins, water clarity in the lower basin appears to be less than at the other basins. Yet, water clarity at the lower basin is limited by depth, and the Secchi disk touches the bottom of the lake before disappearing from view. Water clarity in the upper and middle basins of Kezar Lake decreased compared to 2011 in that clarity in the upper basin decreased by 1 m, while clarity in the middle basin decreased by 1.6 m. Annual fluctuations in clarity are common, and often result from variable weather patterns from year to year. 2012 was no exception, with increased rainfall (compared to 2011) in June and September (see annual distribution of precipitation, Fig. 6, p. 10). Historically, water clarity in Kezar Lake has been variable on an annual basis, yet remains consistent over the historical sampling period (Figure 3).

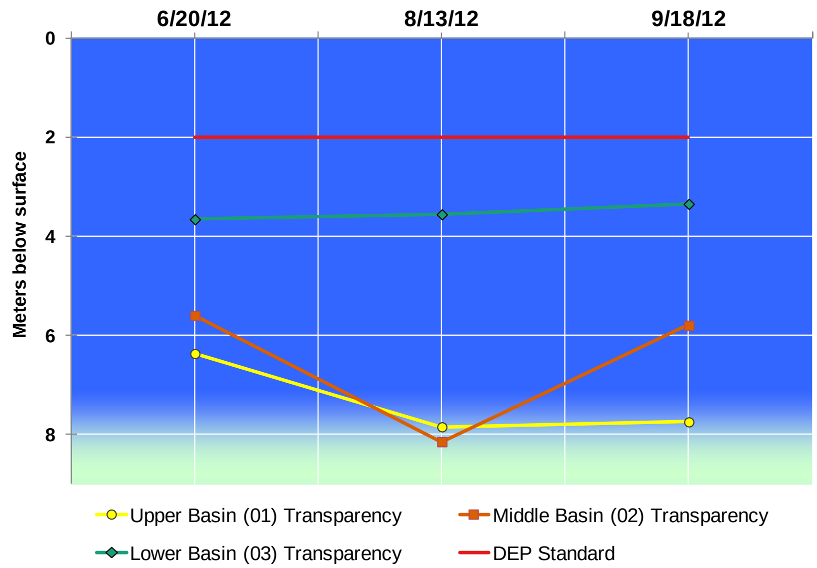


Figure 2: Kezar Lake 2012 Water Clarity.

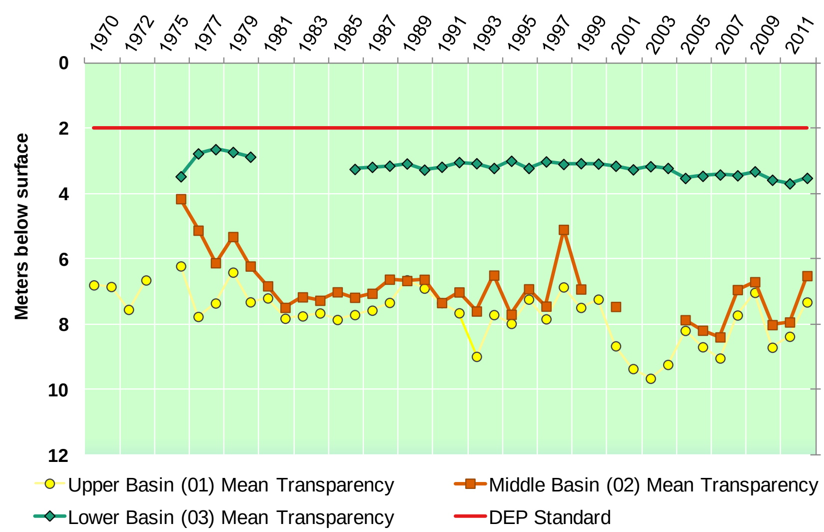


Figure 3: Kezar Lake Historical Water Clarity, 1970-2012.

In Maine, SDT values vary from 0.5 m to 15.5 m, with the average of 4.8 m. Average SDT readings are related to algal productivity using the following guidelines:

- **4 meters or less = Productive**
- **4 -7 meters = Moderately Productive**
- **7 meters or greater = Non-productive**

According to these guidelines, the upper basin of Kezar Lake is on the lower end of non-productive and the middle basin is moderately productive.

Dissolved Oxygen

A common problem in Maine lakes is the depletion of oxygen in the deepest part of the lake throughout the summer months. This occurs when thermal stratification prevents the oxygenated surface water from mixing with water deep in the lake. As a result, oxygen in deeper areas can become depleted. DO levels below 5 ppm can stress some species of cold-water fish, and over time reduce habitat for sensitive cold-water species. In addition, anoxia at the lake bottom can result in the release of phosphorous from the sediments and become an available food source to algae.

Historically, Kezar Lake has experienced some DO depletion in all three basins. Evidence of DO depletion was documented in the upper basin in August and September 2012 (Figure 4). Typically during the hottest summer months, DO concentrations in the middle basin are <5 ppm, as was seen in 2011 and 2009. However, in August 2012, DO in the middle basin remained high, never measuring below 7.3 ppm. Overall, Kezar Lake has adequate levels of DO for aquatic species.

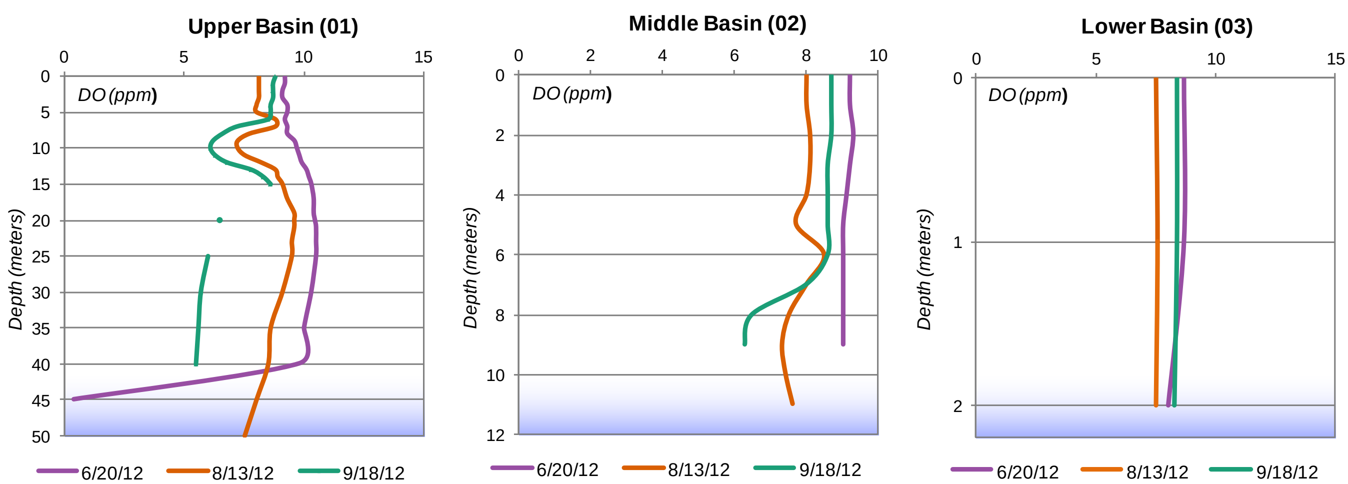


Figure 4: Kezar Lake 2012 Dissolved Oxygen Profiles.

Temperature profiles in 2012 are in line with historic temperature profiles for all stations. Formation of the metalimnion occurred between 5 and 8 meters below the surface at the upper and middle basins. A thermocline cannot develop at the lower basin due to the shallow depth of the water.

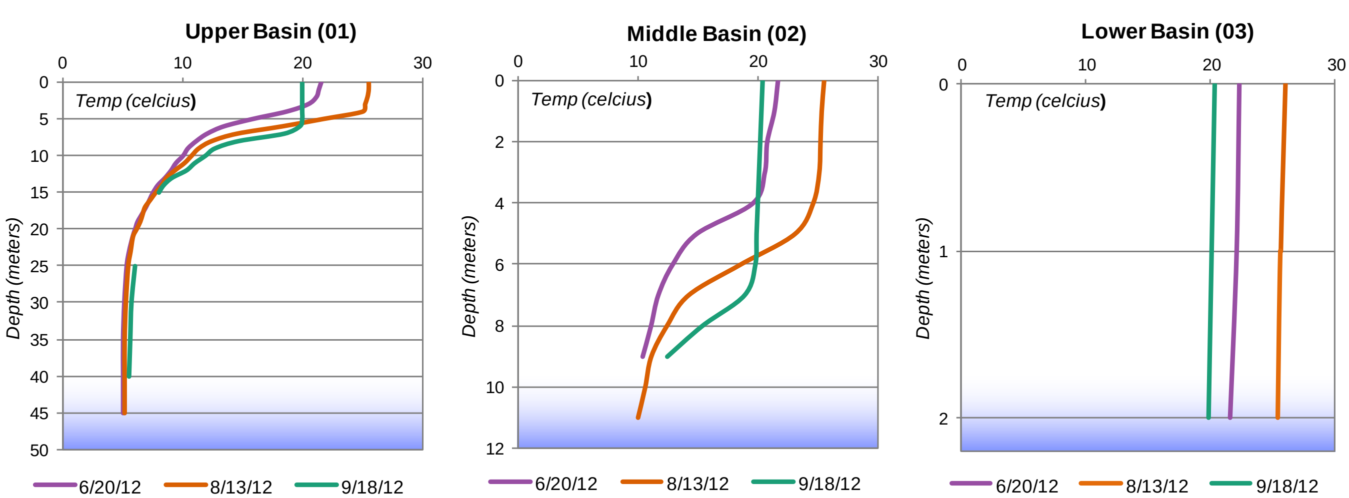


Figure 5: Kezar Lake 2012 Temperature Profiles.

Total Phosphorus

In Maine lakes, TP varies from 1 ppb to 158 ppb with an average of 12 ppb. In 2012, TP averaged 4.9, 4.7, and 9.7 ppb at the upper, middle, and lower basins of Kezar Lake, respectively (Table 2). Overall, these results are lower than 2011 TP results at the upper (5 ppb) and middle (6 ppb) basins, and higher 2011 TP results at the lower (8 ppb) basin. As in 2009, 2010 and 2011, TP concentrations in the upper basin decreased as the season progressed. 2011 TP concentrations in the lower basin were consistently higher than 2011. TP samples collected in 2012, and seasonal averages for all basins were below the statewide average.

Color

In Maine lakes, color varies from 2 to 481 SPU with an average of 28 SPU. In 2012, color averaged 14.5, 14, and 16.3 SPU at the upper, middle, and lower basins of Kezar Lake, respectively (Table 3). For all samples, color was higher than 2010 and 2011 levels, and was above historical averages of 11.2, 11.7, and 13.9 SPU for the upper, middle, and lower basins, respectively. Historical data indicate that high color values correspond with high precipitation years, as a result of increased runoff (see Fig. 6, p. 10). Kezar lake is a non-colored lake an average color that is less than the average for Maine lakes.

Chlorophyll-a

Chl-a in Maine lakes ranges from 0.7 ppb to 182 ppb, with an average of 5.3 ppb (Table 4). In 2012, Chl-a increased slightly over 2011 values at all three basins in Kezar Lake. In previous years, the lower basin commonly had a higher average Chl-a concentration than the upper and middle basins. In general, this basin is more at risk to algal growth than other areas of the lake due to its shallow nature. However, relatively higher Chl-a values measured in June at the upper and middle basins resulted in higher Chl-a averages overall at these basins for 2012. Chl-a concentrations are still roughly half the Maine average.

Table 4: Kezar Lake 2012 Chlorophyll-a.

Chlorophyll-A (ppb)		
6/20/2012	Upper	2.6
	Middle	3.4
	Lower	1.9
8/13/2012	Upper	1.9
	Middle	1.8
	Lower	2.5
9/18/2012	Upper	2
	Middle	1.7
	Lower	1.8
2011 Average (Kezar Lake)	Upper	2.2
	Middle	2.3
	Lower	2.1
Maine Lakes Average	5.3	

Table 3: Kezar Lake 2012 Total Phosphorus.

Total Phosphorous (ppb)		
6/20/2012	Upper	5.0
	Middle	6.0
	Lower	10.0
8/13/2012	Upper	4.0
	Middle	4.0
	Lower	10.0
9/18/2012	Upper	3.0
	Middle	4.0
	Lower	9.0
2012 Average (Kezar Lake)	Upper	4.0
	Middle	4.7
	Lower	9.7
Maine Lakes Average	12.0	

Table 2: Kezar Lake 2012 Color.

Color (SPU)		
6/20/2012	Upper	18.0
	Middle	19.0
	Lower	24.0
8/13/2012	Upper	14.0
	Middle	14.0
	Lower	13.0
9/18/2012	Upper	11.5
	Middle	9.0
	Lower	12.0
2012 Average (Kezar Lake)	Upper	14.5
	Middle	14.0
	Lower	16.3
Maine Lakes Average	28.0	

Alkalinity

Kezar Lake has low alkalinity (buffering capacity). In 2012, all three basins in Kezar Lake averaged 4 mg/L over the course of the sampling season (Table 5). These low values indicate that Kezar Lake is susceptible to changes in pH. Alkalinity is important to aquatic life because it buffers against changes in pH that could have dramatic effects on aquatic plants and animals. Without a high buffering capacity, the lake is subject to both natural and anthropogenic swings in pH values, which can jeopardize the health of freshwater fish species.

pH

Most aquatic species require a pH between 6.5 and 8. Measurements of pH at all three basins in Kezar Lake ranged from 6.9 - 7 (neutral) in 2012 (Table 6). Acid waters are below 7; alkaline waters are above 7. In Maine pH varies, from 4.23 to 9.70, the average being 6.81.

Table 5: Kezar Lake 2012 Alkalinity.

Alkalinity (ppm)		
6/20/2012	Upper	4.0
	Middle	4.0
	Lower	4.0
8/13/2012	Upper	4.0
	Middle	4.0
	Lower	4.0
9/18/2012	Upper	4.0
	Middle	4.0
	Lower	4.0
2011 Average (Kezar Lake)	Upper	4.0
	Middle	4.0
	Lower	4.0
Maine Lakes Average	12.0	

Table 6: Kezar Lake 2012 pH.

pH		
8/13/2012	Upper	7
	Middle	6.9
	Lower	6.9
9/18/2012	Upper	6.9
	Middle	6.9
	Lower	6.9
2011 Average (Kezar Lake)	Upper	7.0
	Middle	6.9
	Lower	6.9
Maine Lakes Average	6.8	

Kezar Lake, August 2012

Summary

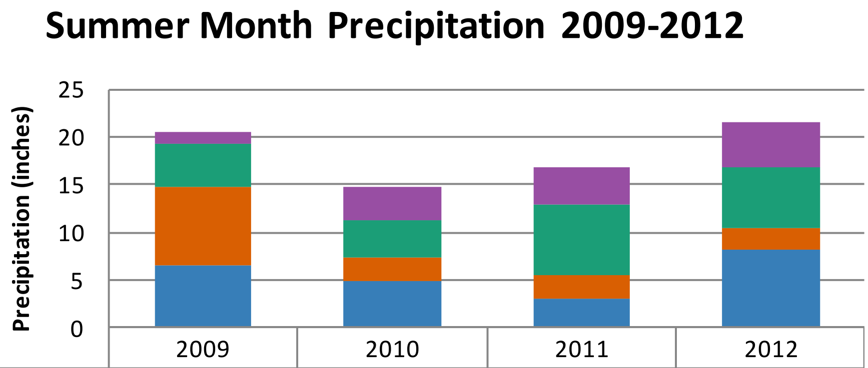
Kezar Lake remains one of Maine's cleanest and clearest lakes, with above average water quality and clarity. Historically, Kezar Lake's TP and Chl-a results have been well below statewide averages. Similarly, the long-term average SDT for the lake's upper basin is 7.7 m compared to an average of 4.8 m for all Maine lakes. Water clarity in the middle basin is also consistently better than the state average (Table 7).

Table 7: Summary of Kezar Lake Historical and Recent Water Quality Averages.

Year	Basin	SDT (meters)	TP (ppb)	Chl-a (ppb)	pH	Alkalinity (mg/L)	Color (SPU)
2012	Upper (01)	7.3	4	2.2	7.0	4.0	14.5
	Middle (02)	6.5	5	2.3	6.9	4.0	14.0
	Lower (03)	3.5	10	2.1	6.9	4.0	16.3
2011	Upper (01)	8.3	5	2.0		3.7	10.3
	Middle (02)	8.1	6	2.2		3.3	10.7
	Lower (03)	3.6	8	2.6		3.7	13.7
2010	Upper (01)	8.7	9	2.1		3.7	8.3
	Middle (02)	8.1	3	1.8		4.0	8.7
	Lower (03)	3.6	11	2.4		4.0	9.0
2009	Upper (01)	7.0	8	2.3		3.3	21.3
	Middle (02)	6.7	5	2.1		3.3	12.7
	Lower (03)	3.3	8	2.3		4.0	16.0
2008	Upper (01)	7.7	10	2.2	6.5	3.0	14.7
	Middle (02)	6.9	4	2.4	6.6	3.0	14.7
	Lower (03)	3.5	9	2.6	6.5	3.0	19.3
2007	Upper (01)	9.0	4	1.8		4.7	9.2
	Middle (02)	8.4					
	Lower (03)	3.4	10	2.5		4.9	11.4
2006	Upper (01)	9.1	5	1.7	6.8	4.8	7
	Middle (02)	8.2					
	Lower (03)	3.5	8	2.3		5.3	8.3
Historical Average[1]	Upper (01)	7.7	6	2.8	6.7	4.5	11.2
	Middle (02)	6.9	5	2.1	6.5	3.4	11.7
	Lower (03)	3.2	9	2.4	6.7	4.6	13.9
Maine Lakes Average [2]		*4.8*	*12*	*5.3*	*6.8*	*11.9*	*28.0*

[1] Includes FBE data from 1970 t0 2012, but does not include 2012 VLMP data.

[2] 2011 Maine Lakes Report (Maine VLMP)



	2009	2010	2011	2012
September	1.3	3.5	3.9	4.8
August	4.6	3.9	7.5	6.3
July	8.2	2.5	2.4	2.3
June	6.5	4.8	3.0	8.3

(Source: Weather Underground, Fryeburg Airport, KIZG)

Figure 6: Summer Precipitation, 2009-2012.

Based on measures of SDT and Chl-a, Kezar Lake water quality declined slightly in 2012 compared to 2010 and 2011 measurements (Table 7). Even though SDT decreased at the upper and middle basins, 2012 TP concentrations in the upper and middle basins improved compared to 2011 and historical averages.

Short-term changes in TP and transparency readings may be due to weather influences such as stronger winds or increased rainfall which can decrease water clarity and increase TP by increasing the amount of particles—particularly sand, silt, and clay sediments—suspended in the water column. A total of 21.6 inches of rain fell in the region during the summer months (June through September) of 2012 (Figure 6), similar to rainfall totals from the summer of 2009 (20.6 inches). In 2010 and 2011, summer rainfall amounts totaled 14.7 and 16.8 inches, respectively (Table 7). This may explain why Kezar Lake SDT readings in 2012 were lower (worse) than in both 2010 and 2011, but were similar to 2009 readings. A similar trend was noted in lake color levels: levels were higher in 2012 and 2009 and lower in 2010 and 2011, corresponding with total summer rainfall. Although 2012 color values in the lake were higher than historical averages, they are still lower than the average for lakes in Maine. Also, Chl-a measurements have remained relatively stable at all basins in recent years.

Long-term changes in transparency and TP, on the other hand, may be due to increased development, or changes in land use in the watershed. Since it is difficult to compare SDT measurements in the lower basin from year to year due to its shallow depth, TP and Chl-a are better indicators of water quality for the lower basin.

While the water quality of Kezar Lake is generally excellent, the lake is sensitive to change. In 2005, the lake was added to Maine's list of Priority Waterbodies. Continuing to monitor all three basins of the lake, as well as the small ponds that drain to Kezar Lake, will help the KLWA better understand long and short-term trends and maintain the high quality of the water in Kezar Lake for future generations.

Supplementing monitoring efforts by adding a July sampling event for Kezar Lake is highly recommended to better assess seasonal (summer) water quality during the most productive time of the year. Currently samples are collected in June, August and September. July is a missing link in assessing long-term water quality.

4. Kezar Lake Tributary Monitoring Results

In 2012, the water quality of two Kezar Lake tributaries, Boulder Brook and Great Brook, was monitored on two dates (June 20 and September 18) under dry weather conditions. Great Brook is located on the northwest end of Kezar Lake off West Stoneham Road. Boulder Brook flows under Route 5 just north of Center Lovell and through the Boulder Brook Club, flowing into Kezar Lake at the swimming area.

Boulder Brook was sampled at the outlet to Kezar Lake on the Boulder Brook Club property (BB-1) as well as upstream (BB-4) and downstream (BB-3) of the Route 5 crossing. Great Brook was sampled upstream of the Adams Road crossing adjacent to Hut Road (GB-1). Temperature, dissolved oxygen (DO), total phosphorus (TP) and *E. coli* were measured at each sampling event.

Average DO concentration in both streams was above 7 ppm, the Maine DEP DO standard for Class A streams, and a threshold required by most aquatic species for survival and growth (Great Brook averaged 10 ppm and Boulder Brook averaged 7.8 ppm). Site BB-4 was the only station that measured below 7 ppm at any point during the season, with a DO reading of 6.8 ppm on September 18 (Table 9). Boulder Brook's average DO concentration has decreased since 2009, while Great Brook's average DO concentration has generally increased since 2009. Boulder Brook was also warmer and averaged 18.5 °C (65.3 °F) compared to 13.9 °C (57.0 °F) at Great Brook—both streams were warmer than in 2011.

Table 8: 2012 Great Brook Water Quality Monitoring Results.

Date	Site Code	Temp. (C)	DO (ppm)	TP (ppb)	*E. coli* (col/100mL)
6/20/2012	GB-1	15.9	10.2	4	34
9/18/2012	GB-1	11.9	9.7	4	4
2012 Average		**13.9**	**10.0**	**4**	**19**
2011 Average		*12.8*	*9.8*	*5*	*21*

Table 9: 2012 Boulder Brook Water Quality Monitoring Results.

Date	Site Code	Temp. (C)	DO (ppm)	TP (ppb)	*E. coli* (col/100mL)
6/20/2012	BB-1	19.0	8.8	11	34
	BB-3	22.6	7.8	12	13
	BB-4	22.8	7.6	12	23
9/18/2012	BB-1	19.1	8.7	3	1
	BB-3	13.6	7.1	15	461
	BB-4	13.7	6.8	15	548
2012 Average		**18.5**	**7.8**	**11**	**180**
2011 Average		*16.5*	*8.4*	*18*	*43*

TP is one of the most important nutrients to monitor in freshwater ecosystems because it can serve as an indirect indicator of algal abundance. TP concentrations in the tributaries ranged from 3 to 15 ppm with an average of 5 ppm for Great Brook, and 11 ppm for Boulder Brook. These values are much lower than results from 2010 (11.5 ppm for Great Brook and 51.5 ppm for Boulder Brook), and slightly lower than concentrations measured in 2011 (5 ppm and 18 ppm, respectively). Boulder Brook is still potentially contributing more TP to Kezar Lake than Great Brook, with the highest concentrations measured at the Route 5 crossing.

E. coli results in the tributaries were well below the Maine DEP standard of 194 col/100 mL at both Great Brook and at Station BB-1 on Boulder Brook (Tables 8 and 9). However, elevated *E. coli* levels were measured at Boulder Brook stations BB-3 (461 col/100mL) and BB-4 (548 col/100mL) on September 18, 2012. Station BB-4 had the highest *E. coli* counts in 2011, with a reading of 99 col/100mL under dry weather conditions. High *E. coli* measurements under dry conditions may indicate fecal contamination from septic systems, wildlife or pets. Further sampling and reconnaissance is needed under both dry and wet weather conditions, as wells as during peak summer months (July-August) to refine potential sources at this site. In general, the water quality in Great Brook is better than in Boulder Brook.

In addition to the two samples collected by FBE in Great Brook and Boulder Brook, FBE also collected in-stream data in the Great Brook watershed. Six sites were monitored over a three week period, with each deployment lasting one week. Monitoring sites included Great Brook upstream and downstream, Beaver Brook upstream and downstream, plus Willard Brook and the Melrose Tributary. Sampling parameters included oxygen, temperature, pH, turbidity, depth, and specific conductivity. Issues of primary concern included pH and turbidity, both of which were strongly affected during rain events. A spawning survey was conducted by Stantec, which documented landlocked salmon and brook trout in several locations. Results from the additional in-stream sampling and the fish survey are summarized in memos provided to KLWA in December, 2012.

5. Kezar Watershed Ponds Monitoring Results

In 2012, FB Environmental continued baseline monitoring for six ponds that drain directly or indirectly into Kezar Lake. Water quality data for Bradley, Cushman, Farrington, Heald, Horseshoe, and Trout Ponds was collected during the months of June and August. June is the beginning of the “warm” season in Maine lakes, and August is generally the time when Maine lakes are most biologically productive, and therefore, when indications of stress and water quality degradation are most apparent.

Water quality is generally good in the six ponds. According to 2012 sampling results (Table 10), four of the six KLWA ponds had an average water clarity better than the Maine average of 4.83 meters. Only Farrington and Heald Ponds had a SDT below the Maine average. However, SDT are limited by depth on

Table 10: Kezar Watershed Ponds 2011 and 2012 Water Quality Monitoring Results.

Pond	SDT (m)		TP (ppb)		Chl-a (ppb)		pH	Alkalinity (mg/L)		Color (SPU)	
	2011	**2012**	*2011*	**2012**	*2011*	**2012**	**2012**	*2011*	**2012**	*2011*	**2012**
Bradley	*4.6*	5.3	*10.0*	8.5	*5.8*	5.8	6.5	*3.0*	4.0	*22.0*	31.5
Cushman	*5.5*	5.3	*7.0*	9.5	*2.0*	4.1	7.0	*4.5*	4.0	*9.5*	16.0
Farrington	*4.2*	4.6	*19.0*	12.5	*15.5*	5.8	7.1	*4.5*	4.0	*16.5*	18.0
Heald	*4.7*	4.6	*9.5*	10.0	*3.5*	4.5	6.7	*5.0*	4.5	*19.0*	35.0
Horseshoe	*7.0*	6.2	*6.5*	7.5	*3.4*	4.7	6.9	*3.0*	3.5	*9.0*	14.5
Trout	*7.2*	6.2	*6.5*	4.0	*1.8*	2.6	7.0	*3.5*	3.0	*7.0*	14.5
Maine Average	*4.8*		*12.0*		*5.3*		*6.8*	*12.0*		*28.0*	

Farrington, and the Secchi disk hit the bottom of the pond during the August sampling event. None of the six ponds fell below the Maine DEP minimum SDT standard of two meters. However, all but Bradley and Farrington Ponds showed slightly decreased SDT readings compared to 2011. Additionally, all of the ponds showed an increase in color from 2011 to 2012. These results may be related to higher than average summer precipitation in 2012 (as discussed on page 10).

As in 2011, Farrington Pond had the highest TP average at 12.5 ppb, which is slightly greater than the state average of 12 ppb. This, however, was an improvement over Farrington Pond's average TP of 19 ppb in 2011. TP concentrations in Bradley and Trout ponds also decreased in 2012 (compared to 2011).

All ponds are consistently lower than the state average for alkalinity (12 ppm), making these waterbodies highly susceptible to changes in pH. Overall, pH values ranged from 6.5 (Bradley Pond) to 7.1 (Farrington Pond). Annual variability in water quality results is common for freshwater lakes, which is why collection of annual baseline data for the KLWA ponds is important to provide the KLWA with long-term water quality trends in the Kezar Lake watershed.

Bradley Pond

In 2012, SDT and TP concentrations in Bradley Pond improved slightly compared to 2011 levels; SDT increased by 0.6 m and TP decreased by 1.5 ppb. Chl-a levels between 2011 and 2012 remained unchanged. In June and August 2012, DO concentrations in Bradley Pond dropped below the aquatic life standard of 5 ppm between 5 and 6 meters depth (Figure 7). Color increased from 14.5 SPU in 2010 to 22 SPU in 2011 and 31.5 SPU in 2012. From 2011 to 2012, alkalinity increased by 1 mg/L (from 3 to 4 mg/L), and pH levels were 6.5- at the low end of the acceptable range for most aquatic species. As the pH of a lake declines, particularly below 6, the reproductive capacity of fish populations can be greatly impacted as the availability of nutrients and metals changes. As such, pH in Bradley Pond should be continued to be monitored in future years.

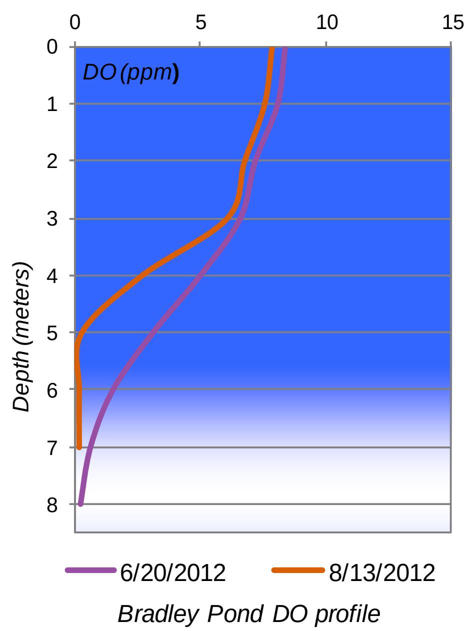


Figure 7: Bradley Pond 2012 Dissolved Oxygen Profile.

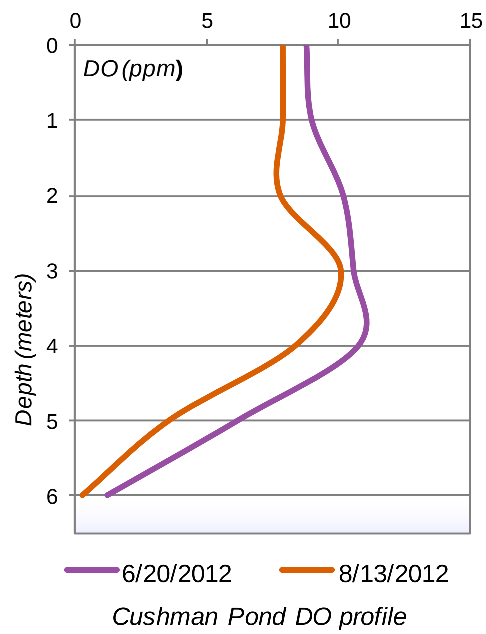


Figure 8: Cushman Pond 2012 Dissolved Oxygen Profile.

Cushman Pond

In 2012, as in 2009 through 2011, minimal DO depletion was observed at the bottom of the deepest area of Cushman Pond between five and six meters (Figure 8). Overall, Cushman Pond water quality declined slightly between 2011 and 2012. SDT decreased slightly from 5.5 m to 5.3 m; TP increased from 7 ppb to 9.5 ppb; Chl-a increased from 2 ppb to 4.1 ppb; and color increased from 9.5 SPU to 16 SPU. Further monitoring is needed to support long-term trends in Cushman Pond to determine if short-term declines in water quality are being affected by environmental factors such as wind and precipitation.

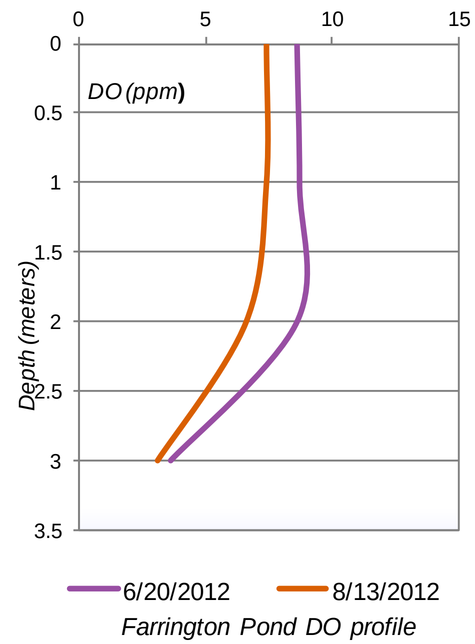


Figure 9: Farrington Pond 2012 Dissolved Oxygen Profile.

Farrington Pond

Farrington Pond drains directly into the lower basin of Kezar Lake. The once stable TP concentrations in Farrington Pond increased from 13.5 in 2010 to 19 ppb in 2011, but decreased to 12.5 ppb in 2012. Overall, Chl-a has been on a steady decline in recent years. Although 2011 Chl-a levels spiked to 15.5 ppb, Chl-a levels dropped to 5.8 ppb in 2012. Since 2011, alkalinity decreased from 4.5 to 4.0 mg/L. Color increased from 10 in 2010 to 16.5 SPU in 2011 and 18 SPU in 2012. SDT increased (improved) slightly from 4.2 in 2011 to 4.6 m in 2012. DO depletion has not been an issue for this pond, primarily due to the pond's shallow depth (Figure 9).

Heald Pond

Heald Pond outlets into Mill Brook, which flows southwest until it meets Boulder Brook. Boulder Brook then flows northwest, into the upper basin of Kezar Lake at the Boulder Brook Club. As described in Section 4 (above), water quality samples were collected at three locations on Boulder Brook in 2012. DO concentrations in Heald Pond are low (< 5 ppm) below 4 meters (13.7 feet) in the summer months (Figure 10). TP concentrations increased from 8.5 ppb in 2010 to 9.5 ppb in 2011, to 10.0 in 2012, much higher than the low of 3.5 ppb in 2007. Chl-a increased from 3.5 ppb in 2011 to 4.5 ppb in 2012. Color increased from 19 to 35 SPU, making Heald Pond the most colored of the six ponds. Water clarity decreased only minimally from 4.7 to 4.6 m between 2011 and 2012.

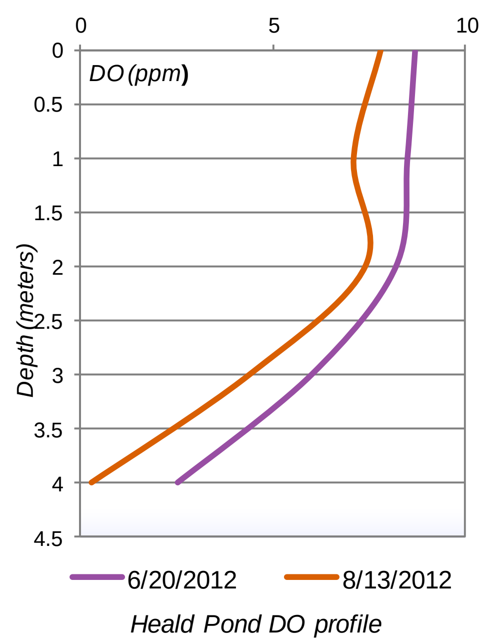


Figure 10: Heald Pond 2012 Dissolved Oxygen Profile.

Horseshoe Pond

Due to volunteer efforts, there is more historical data for Horseshoe Pond than any other small pond in the Kezar Lake watershed. The water quality of Horseshoe Pond has changed little over recent years, and is in line with historical results. Minor declines in water quality were documented between 2011 and 2012. Water clarity decreased from 7.0 to 6.2 m, TP increased from 6.5 to 7 ppb, Chl-a increased from 3.4 to 4.7 ppb, alkalinity increased from 3 to 3.5 mg/L and color increased from 9 to 14.5 SPU. Dissolved oxygen fell below 5 ppm at 7 meters in August and 8 meters in June (Figure 11).

Trout Pond

From 2011 to 2012, average water clarity decreased from 7.2 m to 6.2 m in Trout Pond; a further decrease from the 2010 SDT average of 8.1 m. Average TP decreased from 6.5 ppb to 4.0 ppb, Chl-a increased from 1.8 to 2.6 ppb and alkalinity decreased from 3.5 to 3.0 mg/L. Color decreased from 10 to 7 SPU between 2010 and 2011, but increased to 14.5 SPU in 2012. Based on data from the last six years, Trout Pond has the best water quality of all the small ponds in the Kezar Lake watershed. This may be due to the limited development on the shoreline of this waterbody compared to other developed ponds in the watershed. Overall, Trout Brook has the highest (best) average water clarity compared to the other waterbodies, including Kezar Lake. However, recent trends indicate increasing average annual color, meaning the lake is becoming more "colored", which may be a sign of increasing productivity.

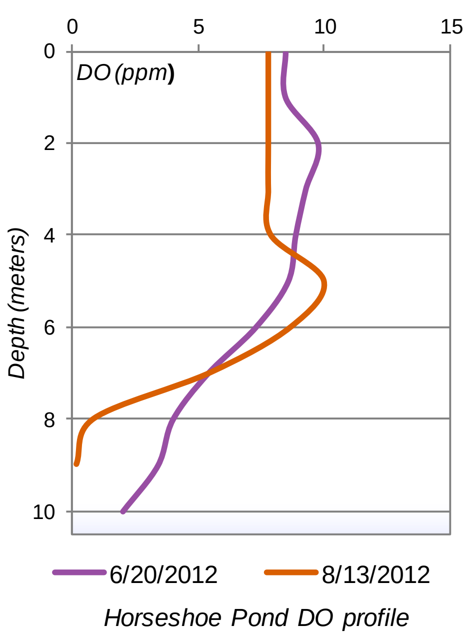


Figure 11: Horseshoe Pond 2012 Dissolved Oxygen Profile.

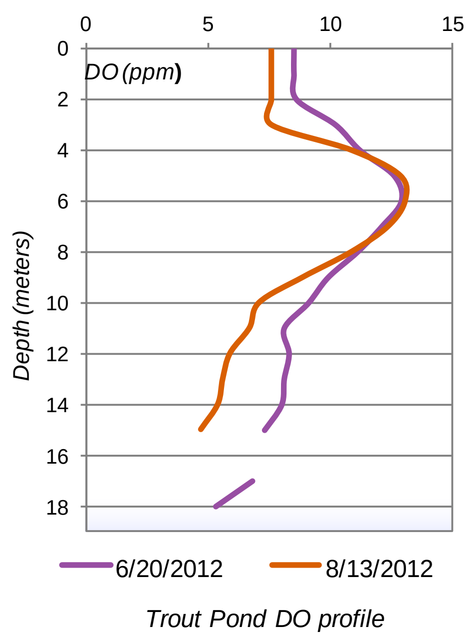


Figure 12: Trout Pond 2012 Dissolved Oxygen Profile.

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