2011 Kezar Lake Water Quality Report

A REPORT ON THE WATER QUALITY OF KEZAR LAKE,
2 KEZAR LAKE TRIBUTARIES, AND 6 KLWA PONDS

December 2011

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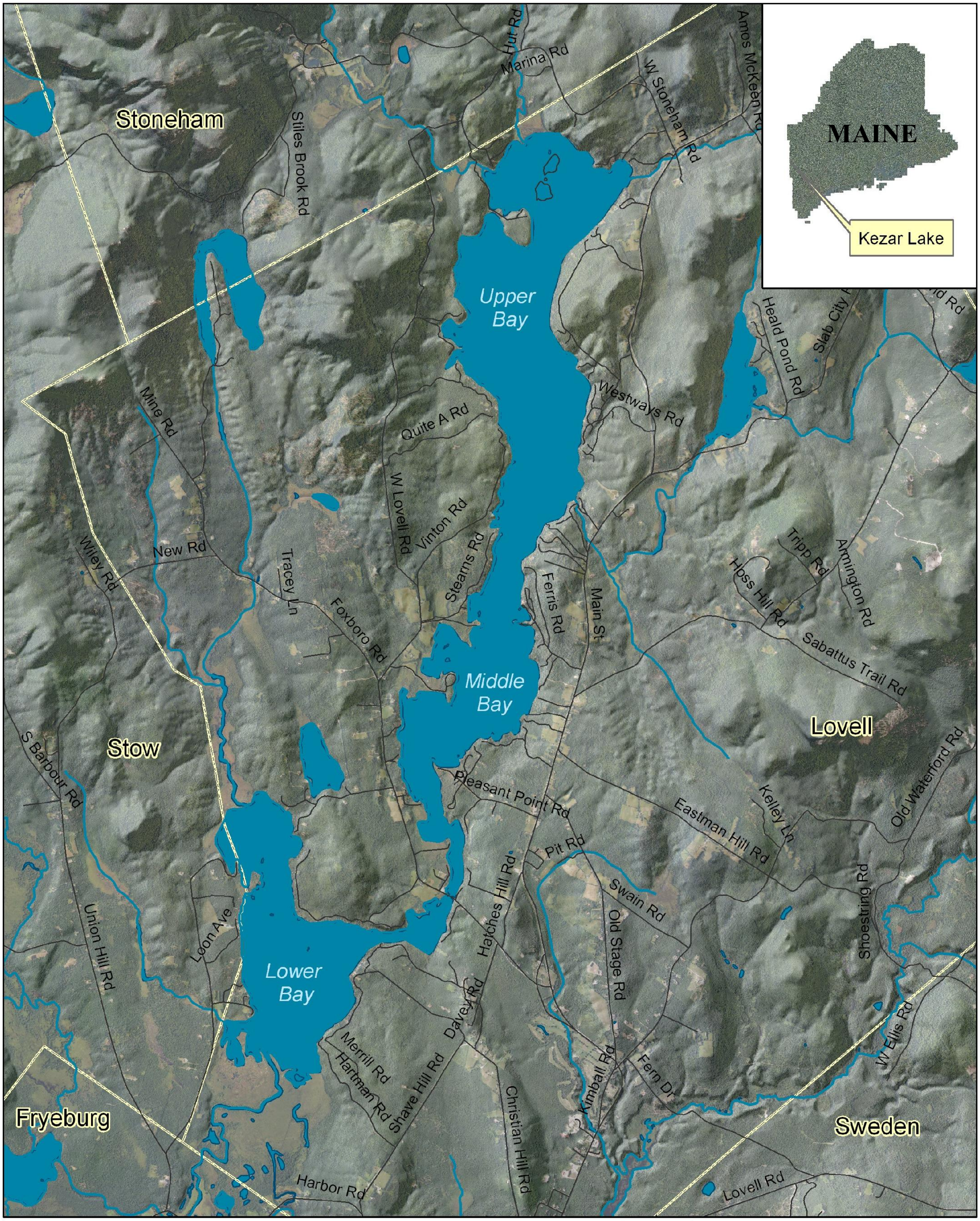
Portland, Maine 04101



Kezar Lake
Lovell, ME

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

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1. Background and Historical Information

Kezar Lake Facts

- **Watershed:** Saco River
- **Surrounding Towns:** Lovell, Stow
- **County:** Oxford
- **Watershed Area:** 35,732 acres (56 sq.mi)
- **Mean Depth:** 34 feet
- **Max Depth:** 155 feet
- **Surface Area:** 2,510 acres (3 sq.mi)
- **Watershed Group:** Kezar Lake Watershed Association

Kezar Lake (Midas #0097) is a non-colored waterbody located in the Town of Lovell, Oxford County, Maine. The lake stretches 9 miles from north to south, covering 2,510 acres (3 square miles) and has a maximum depth of 155 feet (FBE recorded 162 feet on 9/19/2011 at the upper basin) and a mean depth of 34 feet. Kezar Lake lies within the larger Saco River **watershed**.

Located in the foothills of the White Mountains and covering 35,732 acres (56 square miles) in the southwestern Maine towns of Lovell, Stoneham, and Stow, the Kezar Lake watershed encompasses nine smaller ponds and numerous streams. These waterbodies are home to a variety of fish, including landlocked salmon, large and small-mouth bass, lake trout, white perch, pickerel, and smelt. Kezar Lake itself is a mixed warm- and cold-water fishery.

Upper Bay

Water quality monitoring data for Kezar Lake's upper basin (Station 1) has been collected since 1970, and includes 36 years of basic chemical information, and 41 years of **Secchi disk transparencies (SDT)**. The water quality of Kezar Lake's upper basin is considered to be excellent based on measures of SDT, **total phosphorus (TP)**, and **chlorophyll-a (Chl-a)**. The potential for nuisance algae blooms in the upper basin is very low.

Key Terms

- **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.
- **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.
- **Total phosphorus (TP)**: one of the major nutrients needed for plant growth. It is naturally present in small amounts and limits plant growth in lakes. As phosphorus increases, the amount of algae generally increases. TP refers to the total concentration of phosphorus found in the water, including organic and inorganic forms.

A clear lake with small algal populations results in deep Secchi disk readings and low levels of chlorophyll-a and TP.

Kezar Lake's upper basin averages 11.2 Standard Platinum Units (SPU) for **color** and 7.63 m (25.03 ft) for SDT. The range of water column TP for the upper basin is 2 to 19 parts per billion (ppb) with an average of 5.9 ppb, while Chl-a ranges from 0.8 to 9.5 ppb with an average of 2.8 ppb. Recent **dissolved oxygen (DO)** profiles show little to no DO depletion in deep areas of the upper basin.

Middle Bay

Water quality monitoring data for Kezar Lake's middle basin (Station 2) has been collected since 1976, and includes 12 years of basic chemical information and 35 years of SDT readings. In summary, the water quality of Kezar Lake's middle basin is considered to be excellent based on measures of SDT and TP. The potential for nuisance algae blooms in the middle basin is low.

Kezar Lake's middle basin averages 11.7 SPU for color and 6.9 m (22.6 ft) for SDT. The range of water column TP is 2 to 10 ppb with an average of 5 ppb (compared to the Maine average of 12 ppb), while Chl-a ranges from 1.7 to 2.8 ppb with an average of 2.1 ppb. Recent DO profiles show little to no DO depletion in deep areas of the middle basin.

Lower Bay

Water quality monitoring data for Kezar Lake's lower basin (Station 3) has been collected since 1976, and includes 26 years of basic chemical information and 35 years of SDT readings. Kezar Lake's lower basin averages 14 SPU for color and 3.2 m (10.5 ft) for SDT. Most of these readings are limited by the depth of the water at this station (~ 3 m) and are thus an underestimate of water quality compared to state-wide averages. The range of water column TP for the lower basin is 3 to 29 ppb with an average of 8.9 ppb, while Chl-a ranges from 0.8 to 6.2 ppb with an average of 2.4 ppb. Current DO profiles show no DO depletion at the deep hole of the lower basin. The potential for TP to leave the bottom sediments and become available to algae in the water column is low. Oxygen levels remained above 8.2 ppm throughout the summer months in 2011.

Key Terms

- **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.
- **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.
- **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 have an SPU greater than 25 and cause diminished transparency readings and increased TP.

2. Water Quality Monitoring – Methods and Parameters

In 2011, FB Environmental collected water samples in Kezar Lake, six ponds in the Kezar Lake watershed, and two tributaries to Kezar Lake. Sampling sites and dates are shown below:

Table 2.1: Sampling Dates, Weather, and Sampling Sites

Date	Weather			Sampling Sites
	Prior 24 hr Precip (in)*	Prior 48 hr Precip (in)*	Sampling Day Weather Conditions	
22-Jun-11	0.00	0.00	cloudy, no rainfall	Kezar Lake, Kezar Lake tributaries (2), Kezar Lake Watershed Ponds (Farrington, Horseshoe)
23-Jun-11	0.06	0.06	light rain, drizzle, mist	Kezar Lake Watershed Ponds (Trout, Cushman, Bradley, Heald)
17-Aug-11	0.18	1.22	fog in early morning, sunny, warm	Kezar Lake, Kezar Lake Watershed Ponds (Bradley, Cushman, Farrington, Horseshoe, Trout)
22-Aug-11	0.67	0.68	fog, rain	Kezar Lake Watershed Ponds (Heald)
19-Sep-11	0.00	0.00	fog in early morning, sunny, warm	Kezar Lake, Kezar Lake tributaries (2)

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

2011 Kezar Lake Sampling

The upper, middle, and lower basins of Kezar Lake were individually assessed during each sampling event. Sampling was conducted in accordance with standard methods and procedures for lake monitoring established by the Maine Department of Environmental Protection, the US EPA, and the Maine Volunteer Lake Monitoring Program. 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: "Trophic state" indicators, or indicators of biological productivity in the lake ecosystem, help determine the extent of and effects of eutrophication in lakes. The upper basin of Kezar Lake is classified as unproductive, and the middle and lower basins are moderately productive. Unproductive lakes have below average TP and Chl-a, and SDT of >7 m. Moderately productive lakes have average TP and Chl-a, and SDT of 4-7 m. The "trophic state" indicators measured in Kezar Lake include:

- SDT (water clarity)
- TP
- Chl-a

Dissolved oxygen: In addition to the above parameters, DO and water temperature were also measured. 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. Oxygen is vital to fish, algae, macrophytes, and chemical reactions that support lake functioning.

DO concentrations may change dramatically with lake depth. Oxygen is produced in the top portion of a lake (where sunlight drives photosynthesis), and oxygen consumption is greatest near the bottom of a lake (where organic matter accumulates and decomposes). In stratified lakes, such as Kezar Lake, this difference may be dramatic - with high oxygen near the surface and virtually no oxygen near the bottom. As mentioned earlier, some species of fish are particularly sensitive to loss of oxygen.

Additional parameters: Indicators of lake water quality measured in addition to trophic state and DO data include:

- natural color
- total alkalinity

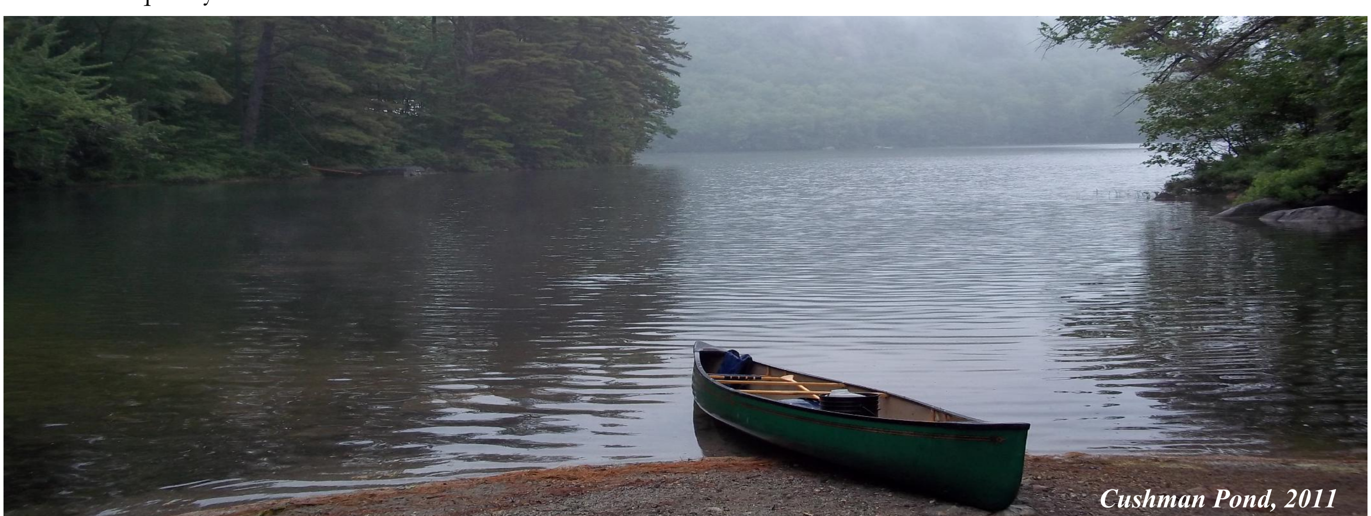
An "integrated epilimnetic core" method was used to collect samples at the "deep hole" of each of Kezar Lake's three basins and the smaller watershed ponds. With this method, a core of water is collected from the water surface to the upper part of the thermocline. Sampling results reflect the "average"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

2011 Kezar Lake Tributary Monitoring

Monitoring inflowing streams for potential problems is also important for protecting the Kezar Lake Watershed. Great Brook and Boulder Brook were selected because they are important tributaries to Kezar Lake. Great Brook drains into the north part of the upper basin, and the outlet of Boulder Brook is situated between the middle and upper basins on the east side of Kezar Lake. Sampling was conducted on June 22nd and September 19th upstream of the Adams Road crossing off Hut Road at Great Brook, and at 3 locations on Boulder Brook: the outlet of Boulder Brook to Kezar Lake, and upstream and downstream of Boulder Brook Route 5 crossing. Parameters measured included DO, temperature, TP, and *E. coli* bacteria. *E. coli* bacteria is 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. The source of this contamination can be from point sources such as wastewater treatment plant discharges and/or stormwater overflows. Bacteria can also originate from polluted non-point runoff sources such as pet waste, livestock, and/or failing septic systems, or from nonhuman-associated sources such as wildlife.

2011 Kezar Lake Watershed Pond Sampling

On June 22nd, June 23rd, August 17th, and August 22nd, monitoring was conducted at the deepest parts of Bradley, Cushman, Farrington, Heald, Horseshoe, and Trout Ponds. The parameters measured were the same as those described above for Kezar Lake. Several of the six ponds are hydrologically connected, and they all drain into Kezar Lake. Determining baseline water quality conditions can identify potential threats to the water quality of Kezar Lake watershed.



Cushman Pond, 2011

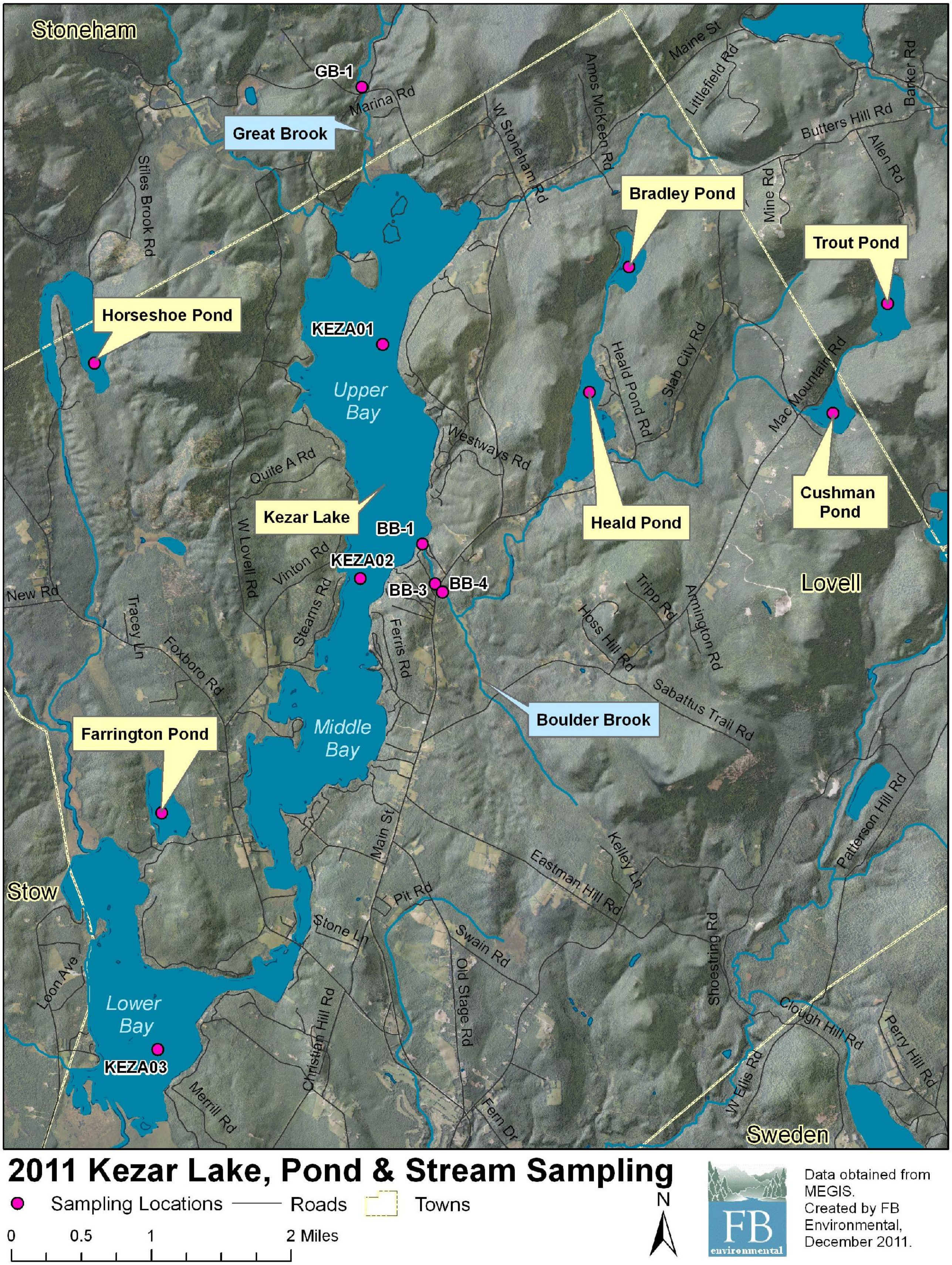


Figure 2.1: Kezar Lake 2011 sampling locations

3. Kezar Lake Water Quality Monitoring Results

3.1 Water Clarity

Measuring Secchi Disk Transparency (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 is usually the most common factor, transparency is an indirect measure of algal populations.

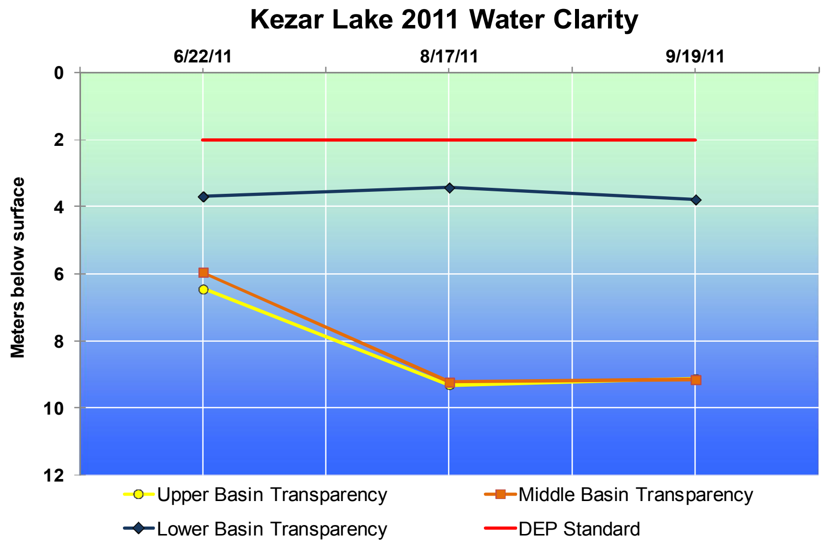


Figure 3.1: Water clarity in the upper and middle basins of Kezar Lake was much better than the Maine DEP standard of 2 meters. Note that readings at the lower basin are limited by the shallow depth and that secchi readings represent the lake bottom.

Transparency values in Maine vary from 0.5 m to 15.5 m, with the average being 4.8 m. Generally, a transparency of 2 m or less indicates a water quality problem and possible algae bloom.

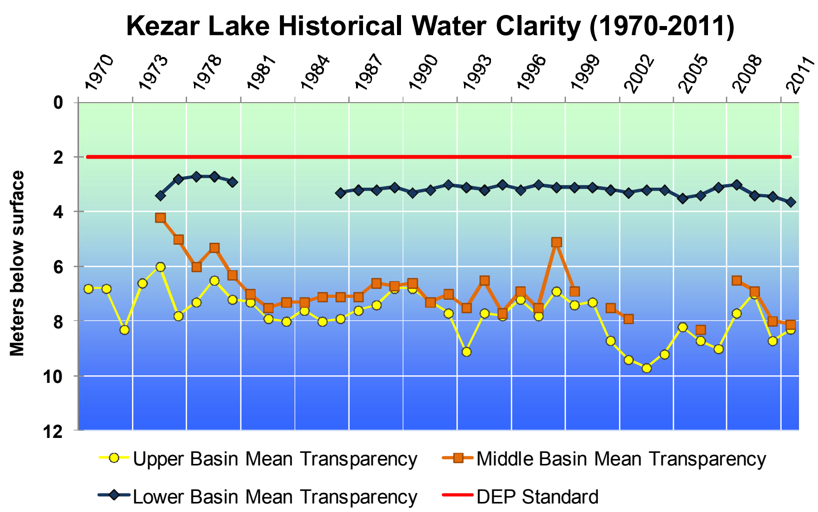


Figure 3.2: The 2011 average water clarity for the upper basin of Kezar Lake is 0.7 m better than the historical average for the lake (1970-2010). Secchi disk readings have been fairly consistent over the years.

In 2011, average SDT for the upper, middle, and lower basins of Kezar Lake were 8.3, 8.1, and 3.6 m, respectively (Figure 3.1). When compared to the other basins, water clarity in the lower basin could be misrepresented. Yet, the water in the lower basin is clear to depth and the Secchi disk touches bottom before disappearing from view. Water clarity in the middle and lower basins of Kezar Lake improved slightly compared to 2010, but water clarity in the upper basin diminished by 0.4 m. Overall water clarity improvement has been maintained since 2009 by close to a meter in the upper and middle basins. A large gain in clarity such as this may be caused by less rain and/or wind during the season. Historically, the basins have slightly fluctuated in clarity (Figure 3.2), but show a consistent trend.

In Maine, average Secchi disk 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. If the lower basin was deep enough, it would likely fall into the moderately productive range.

3.2 Dissolved Oxygen

DO is a measure of the amount of oxygen dissolved in the water. All living organisms, except for certain types of bacteria, need oxygen to survive. Too little oxygen (known as anoxia) severely reduces the diversity and abundance of aquatic communities. Therefore, the amount of DO in the water is very important to aquatic life. 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 and middle basins in August 2011 (Figure 3.3). Typically during the hottest summer months, DO concentration in the middle basin is <5 ppm, as was seen in 2011 and 2009. In August 2010, the middle basin rarely strayed below 8 ppm. The difference in DO between 2009 to 2011 may be influenced by fluctuating levels of precipitation. Overall, Kezar Lake has adequate DO for aquatic life.

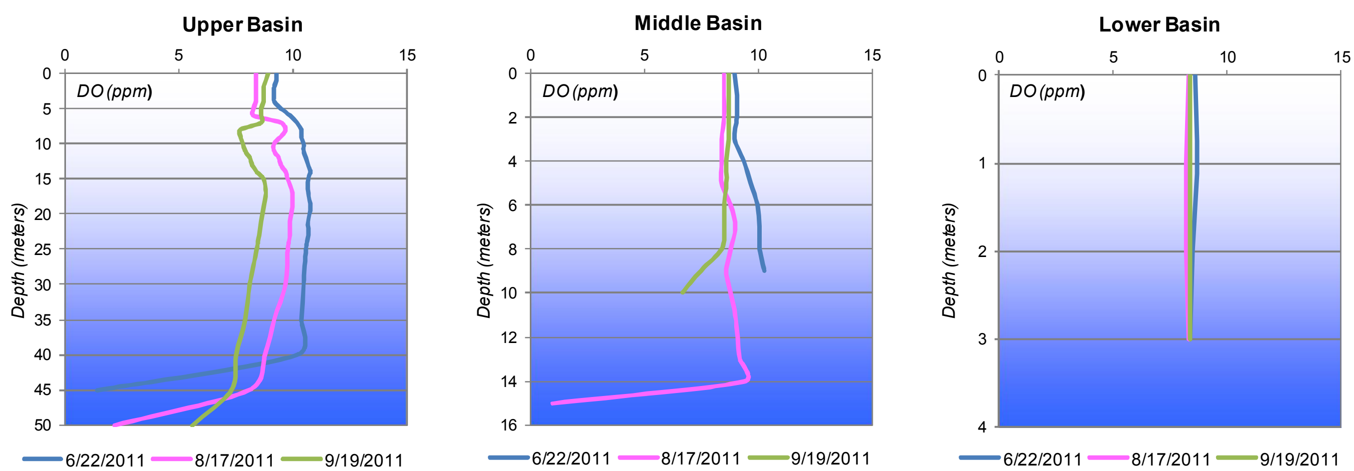


Figure 3.3: Kezar Lake 2011 dissolved oxygen measurements show high DO concentrations throughout the lake.

3.3 Total Phosphorus

TP is one of the major nutrients needed for plant growth. It is generally present in small amounts and limits plant growth in lakes. As TP increases, the amount of algae also increases and may ultimately lead to algal blooms. Humans can add phosphorous to a lake through stormwater runoff, lawn or garden fertilizers, and leaky or poorly maintained septic tanks. In Maine lakes, TP varies from 1 ppb to 158 ppb with an average of 12 ppb.

In 2011, TP averaged 5.3, 5.7, and 8.3 ppb at the upper, middle, and lower basins of Kezar Lake, respectively (Table 3.1). Overall, these values show a decrease compared to 2010 at the upper (9 ppb) and lower (11 ppb) basins, and an increase compared to 2010 at the middle (3 ppb) basin. As in 2009 and 2010, the upper basin TP values decreased as the season progressed. 2011 TP concentrations in the lower basin were

Table 3.1: Kezar Lake TP

Total Phosphorous (ppb)		
6/22/2011	Upper	8.0
	Middle	6.0
	Lower	9.0
8/17/2011	Upper	4.0
	Middle	5.0
	Lower	8.0
9/19/2011	Upper	4.0
	Middle	6.0
	Lower	8.0
2011 Average (Kezar Lake)	Upper	5.3
	Middle	5.7
	Lower	8.3
Maine Lakes Average	12.0	

consistently lower than 2010. Both individual TP samplings and seasonal averages were below the statewide average.

3.4 Color

Color is measured by comparing a sample of the lake water to Standard Platinum Units (SPU). Colored lakes (>25 SPU) can have reduced transparency readings and increased TP values. However, this does not necessarily mean such lakes are more productive. Therefore, Chl-a is the best indicator of productivity in colored lakes. In Maine lakes, color varies from 2 to 481 SPU with an average of 28 SPU. Color was 10.3, 10.7, and 13.7 SPU in the upper, middle, and lower basins of Kezar Lake in 2011, respectively (Table 3.2). For all samples, color increased from 2010 to 2011, but are comparable to historical averages of 11.2, 11.7, and 13.9 SPU for the upper, middle, and lower basins of the lake, respectively.

Table 3.2: Kezar Lake color

Color (SPU)		
6/22/2011	Upper	12.0
	Middle	12.0
	Lower	14.0
8/17/2011	Upper	8.0
	Middle	8.0
	Lower	10.0
9/19/2011	Upper	11.0
	Middle	12.0
	Lower	17.0
2011 Average (Kezar Lake)	Upper	10.3
	Middle	10.7
	Lower	13.7
Maine Lakes Average	28.0	

3.5 Chlorophyll-a

Chl-a is 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. Chl-a in Maine lakes ranges from 0.7 ppb to 182 ppb, with an average of 5.3 ppb. From 2008 to 2010, Chl-a levels in the upper and middle basins of Kezar Lake decreased by 0.2 and 0.3 ppb, respectively. In 2011, average Chl-a decreased by 0.1 ppb at the upper basin, but increased from 1.8 ppb in 2010 to 2.2 ppb in 2011. As expected, the lower basin Chl-a count averages highest at 2.6 ppb and increased by 0.2 ppb between 2010 and 2011. The lower basin is more at risk to algal growth than other areas of the lake due to its shallow nature. Chl-a concentrations are still roughly half the Maine average of 5.3 ppb (Table 3.3).

Table 3.3: Kezar Lake Chl-a

Chlorophyll-A (ppb)		
6/22/2011	Upper	2.3
	Middle	2.8
	Lower	2.7
8/17/2011	Upper	1.9
	Middle	2.0
	Lower	2.6
9/19/2011	Upper	1.9
	Middle	1.7
	Lower	2.5
2011 Average (Kezar Lake)	Upper	2.0
	Middle	2.2
	Lower	2.6
Maine Lakes Average	5.3	

3.6 Alkalinity

Alkalinity is 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. Kezar Lake has low alkalinity, and all basins averaged between 3 and 4 mg/L over the course of the 2011 season (Table 3.4). These low values indicate that Kezar Lake is susceptible to changes in pH.

Table 3.4: Kezar Lake alkalinity

Alkalinity (ppm)		
6/22/2011	Upper	3.0
	Middle	3.0
	Lower	4.0
8/17/2011	Upper	4.0
	Middle	4.0
	Lower	4.0
9/19/2011	Upper	4.0
	Middle	3.0
	Lower	3.0
2011 Average (Kezar Lake)	Upper	3.7
	Middle	3.3
	Lower	3.7
Maine Lakes Average	12.0	

3.7 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 7.63 m compared to an average of 4.83 m for all Maine lakes. Water clarity in the middle and lower basins is also consistently better than the state average.

Based on measures of SDT, TP, and Chl-a, Kezar Lake water quality improved slightly in 2011 compared to 2010 and 2009 measurements (Table 3.6). Even though Chl-a increased at the lower and middle basins, all 2011 SDT depths and TP results improved compared to historical averages and the upper and lower basins. Further monitoring is needed to assess whether these changes are temporary or suggest a changing trend.

Table 3.5: Summer month precipitation averages, 2009-2011, in inches (Source: Weather Underground, Fryeburg Airport, KIZG)

	2009	2010	2011
June	6.5	4.8	3.0
July	8.2	2.5	2.4
August	4.6	3.9	7.5
September	1.3	3.5	3.9
Totals	**20.6**	**14.7**	**16.8**

Short-term changes in TP and transparency readings (e.g. going from 7 m in 2009 to 8.7 m in 2010 to 8.3 m in 2011 in the upper basin) may be due to weather influences such as calmer winds or decreased rainfall (Table 3.5), which can increase water clarity and decrease TP by decreasing the amount of particles—particularly sand, silt, and clay sediments—suspended in water. 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. As mentioned previously, it is difficult to compare Secchi measurements in the lower basin from year to year, since the Secchi disk hits the lake bottom. As such, TP and Chl-a are better water quality measures for the lower basin.

Table 3.6: Kezar Lake historical and recent water quality averages

Kezar Lake Historical and Recent Water Quality Averages							
Year	Basin	SDT (meters)	TP (ppb)	Chl-a (ppb)	pH	Alkalinity (mg/L)	Color (SPU)
2011 Average (Kezar Lake)	Upper	8.3	5	2.0		3.7	10.3
	Middle	8.1	6	2.2		3.3	10.7
	Lower	3.6	8	2.6		3.7	13.7
2010 Average (Kezar Lake)	Upper	8.7	9	2.1		3.7	8.3
	Middle	8.1	3	1.8		4.0	8.7
	Lower	3.6	11	2.4		4.0	9.0
2009 Average (Kezar Lake)	Upper	7.0	8	2.3		3.3	21.3
	Middle	6.7	5	2.1		3.3	12.7
	Lower	3.3	8	2.3		4.0	16.0
2008 Average (Kezar Lake)	Upper	7.7	10	2.2	6.5	3.0	14.7
	Middle	6.9	4	2.4	6.6	3.0	14.7
	Lower	3.5	9	2.6	6.5	3.0	19.3
2007 Average (Kezar Lake)	Upper	9.0	4	1.8		4.7	9.2
	Middle	8.4					
	Lower	3.4	10	2.5		4.9	11.4
2006 Average (Kezar Lake)	Upper	9.1	5	1.7	6.8	4.8	7
	Middle	8.2					
	Lower	3.5	8	2.3		5.3	8.3
Historical Average (Kezar Lake)*	Upper	7.6	6	2.8	6.7	4.5	11.2
	Middle	6.9	5	2.1	6.5	3.4	11.7
	Lower	3.2	9	2.4	6.7	4.6	13.9
Maine Average		*4.8*	*12*	*5.3*	*6.8*	*12.0*	*28.0*

** The historical average includes all ME DEP and VLMP certified data through 2007, VLMP SDT data collected from 2008 to 2010, and data collected by FBE from 2008 to 2011. Surveying was not conducted every year, and for many years only SDT data is available.*

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, will help us better understand long- and short-term trends and maintain Kezar Lake's water quality in the future.

Given the low levels of DO in the upper and middle basins of Kezar Lake in August, it is recommended that a TP profile grab be collected at the deep hole at various depths through the water column, including one meter off the bottom to assess TP concentrations during periods of anoxia. This information will provide insight to internal phosphorus loading in the lake. In addition, we recommend that a historical trend analysis be conducted to assess changes in water quality parameters over the past 40 years. This information will be valuable to determine how Kezar Lake has changed over the long-term, rather than just the past few years. A third sampling recommendation is to add a July sampling event for Kezar Lake. Currently samples are collected in June, August and September. July is a missing link in assessing long-term water quality, especially during month of the most productive times of the year.

4. Kezar Lake Tributary Sampling Results

Great Brook

Boulder Brook

4.1 Water Quality Results

In 2011, the water quality of two Kezar Lake tributaries, Boulder Brook and Great Brook, was monitored under dry conditions. Great Brook is located on the northwest end of Kezar Lake off West Stoneham Road. Boulder Brook drains a wetland and crosses under Route 5 just north of Center Lovell. Boulder Brook travels through the Boulder Brook Club and flows 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 Adams Road crossing adjacent to Hut Road (GB-1). Water quality parameters, including temperature and DO, were measured each time a grab sample was collected, and both brooks were sampled twice for *E. coli* and TP. DO at both streams tested well above the 7 ppm threshold required by most aquatic species for survival and growth (Great Brook averaged 9.8 ppm and Boulder Brook averaged 8.4 ppm). Boulder Brook average DO has decreased since 2009, while Great Brook average DO has generally increased since 2009. Boulder Brook was also warmer and averaged 16.5 °C (61.7 °F) compared to 12.8 °C (55.0 °F) at Great Brook—both streams were cooler than in 2010.

E. coli results were well below the Maine DEP standard of 194 col/100 mL at both Boulder Brook and Great Brook (Tables 4.1 and 4.2). Great Brook maintained a consistent 21 col/100 mL for 2011, well below the 354 col/100mL average in 2010. The highest *E. coli* reading for 2011 was 99 col/100mL for Boulder Brook on June 22nd at site BB-4 or upstream of Route 5 crossing. Boulder Brook *E. coli* results decreased from June 22nd sampling to September 19th sampling, and averaged well below the 112 col/100mL average in 2010. Further sampling is needed under both dry and wet weather conditions, as wells as during peak summer months (July-August) to refine potential sources.

TP is the most important nutrient to monitor in freshwater ecosystems because it can serve as a direct indicator of algal abundance. TP results for the tributaries ranged from 4 to 24 ppm with an average of 4.5

ppm for Great Brook and 17.5 ppm for Boulder Brook, much less than 11.5 ppm for Great Brook and 51.5 ppm for Boulder Brook in 2010. Boulder Brook is still potentially contributing more TP to Kezar Lake than Great Brook.

The differences between Great Brook and Boulder Brook 2011 water quality monitoring results are minor, but the water quality in Great Brook is better than in Boulder Brook. The *E. coli* exceedances documented in June 2010 were not seen in 2011; however, the sample from 2010 with a high bacteria count was collected during wet weather. Precipitation can effect DO, TP, and bacteria concentrations temporarily. Further sampling, especially with the addition of at least one wet sample, is needed for the 2012 sampling season to confirm these long-term trends.

Table 4.1: Boulder Brook 2011 water quality monitoring results

Date	Site Code	Temp. (C)	DO (ppm)	TP (ppb)	*E. coli* (col/100mL)
6/22/2011	BB-1	19.2	9.3	22	27
	BB-3	19.9	7.9	24	75
	BB-4	20.7	7.8	23	99
9/19/2011	BB-1	15.4	9.3	8	1
	BB-3	12.0	8.1	13	26
	BB-4	11.9	7.8	15	30
2011 Average		**16.5**	**8.4**	**17.5**	**43.0**
2010 Average		*17.4*	*9.1*	*51.5*	*112.3*

No wet weather samples were taken for streams.

Table 4.2: Great Brook 2011 water quality monitoring results

Date	Site Code	Temp. (C)	DO (ppm)	TP (ppb)	*E. coli* (col/100mL)
6/22/2011	GB-1	16.2	8.93	5	21
9/19/2011	GB-1	9.4	10.72	4	21
2011 Average		**12.8**	**9.8**	**4.5**	**21**
2010 Average		*15.8*	*8.3*	*11.5*	*353.8*

No wet weather samples were taken for streams.

Figure 4.1: 2010-2011 Kezar streams total phosphorous comparison

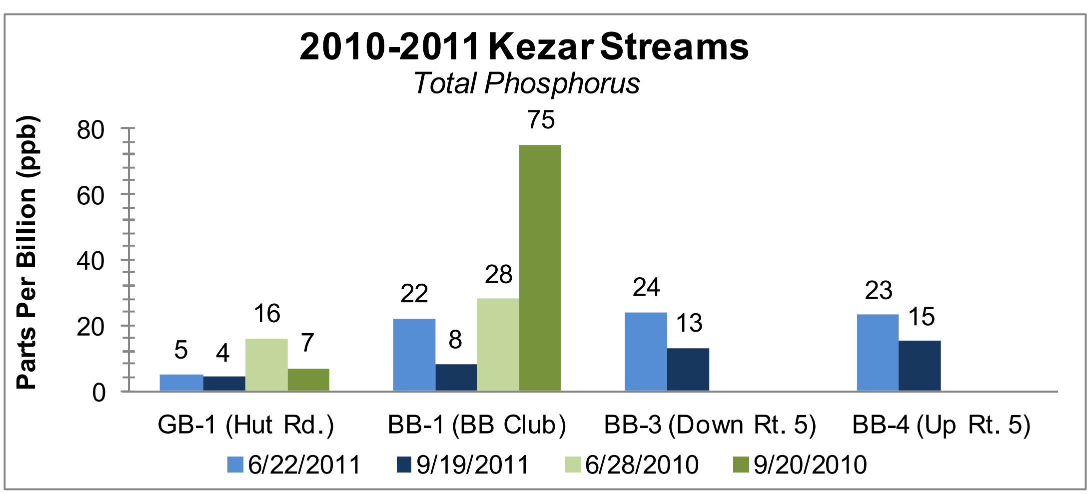
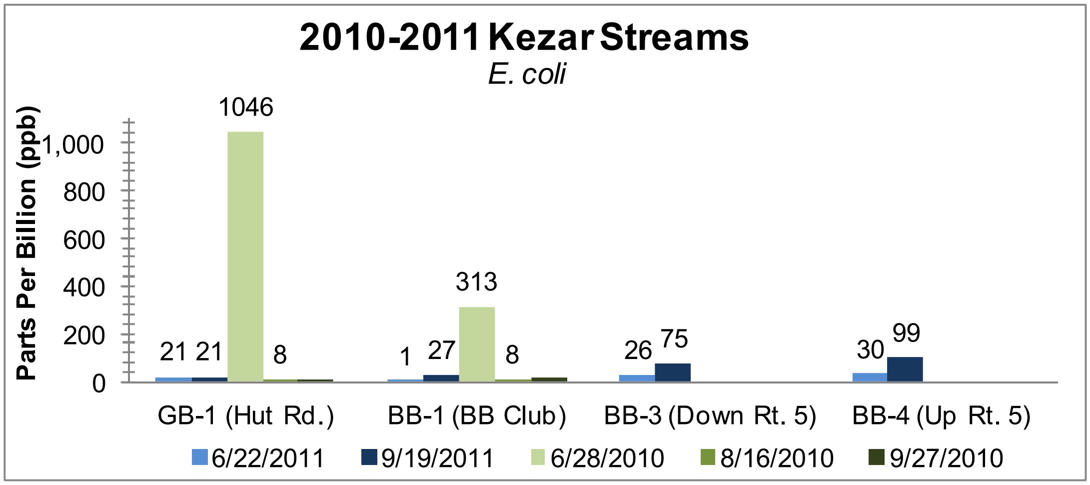


Figure 4.2: 2010-2011 Kezar streams* E. coli *comparison



5. KLWA Ponds Water Quality Results

In 2011, FB Environmental conducted baseline sampling for 6 ponds that drain directly or indirectly into Kezar Lake. Bradley, Cushman, Farrington, Heald, Horseshoe, and Trout Ponds were monitored 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 the most biologically productive and when indications of stress and water quality degradation are most evident.

Water quality is generally good in the 6 ponds. According to 2011 sampling results (Table 5.1, p.14), half of the 6 KLWA ponds sampled had an average water clarity better than the Maine average of 4.83 meters. All but Horseshoe and Trout Ponds showed increased TP levels compared to 2010. Farrington Pond had a high TP average at 19 ppb, which is greater than the state average of 12 ppb (refer to Farrington Pond, p. 14). All ponds are consistently lower than the state average for alkalinity, making the watershed highly susceptible to changes in pH. Water clarity in all ponds but Horseshoe diminished from 2010 to 2011. Farrington Pond tested above state average for Chl-a by almost triple. Water sampling results during this sampling season were relatively stable from month to month, most likely due to the lack of rainfall and consistently warmer temperatures. Variations in water quality from year to year are common, which is why it is important to continue collecting baseline data for the KLWA ponds to gain a better understanding of water quality trends in the Kezar lake watershed.

Kezar Lake, 2010

5.1 Bradley Pond

Bradley Pond is an undeveloped, 35-acre water-body with a maximum depth of 30 feet, an average depth of 10 feet, and a watershed area of 0.49 square miles. Water from Bradley Pond drains into Heald Pond, and then runs through Boulder Brook into Kezar Lake. The alkalinity of Bradley Pond has remained between 3 and 4 ppm since 2007, which is well below the Maine average of 12 ppm. This indicates that Bradley Pond is susceptible to changes in pH. Bradley is the most colored pond in the Kezar Lake watershed at 22 SPU. In June and August 2011, DO in Bradley Pond dropped below the aquatic life standard of 5 ppm between 4 and 5 meters depth (Figure 5.1). Overall, the water quality of Bradley Pond has improved when compared to 2008 and 2009 DO data. However, from 2010 to 2011, SDT decreased from 5.4 to 4.6 m (2008 clarity was 5.5 m), Chl-a increased from 3.9 to 5.8 ppb, TP increased from 7.5 to 10 ppb, alkalinity decreased from 4 to 3 mg/L, and color increased from 14.5 to 22 SPU. Further monitoring is needed to confirm whether this is becoming a consistent trend.

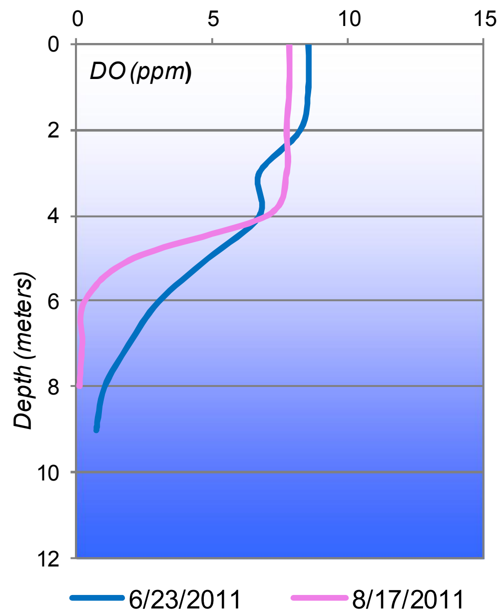


Figure 5.1. Bradley Pond 2011 DO profile

5.2 Cushman Pond

Cushman Pond is notable because of the well marked milfoil infestation site. Cushman has a surface area of 37 acres, an average depth of 15 feet, a maximum depth of 21 feet, and a watershed area of 0.50 square miles. Like Bradley Pond, Cushman drains into Heald Pond, which drains into Kezar Lake through Boulder Brook. In 2011, as in 2009 and 2010, minimal DO depletion was observed at the bottom of the deepest area of the pond (Figure 5.2). This finding is consistent with historical late summer DO profiles. Cushman experienced a similar trend to Bradley from 2010 to 2011 as SDT diminished slightly from 5.86 to 5.51 m, TP increased from 4.5 to 7 ppb, Chl-a increased from 1.8 to 2 ppb, alkalinity decreased from 5 to 4.5 mg/L, and color increased from 8 to 9.5 SPU. This suggests that environmental factors (e.g. weather) are affecting these waterbodies similarly.

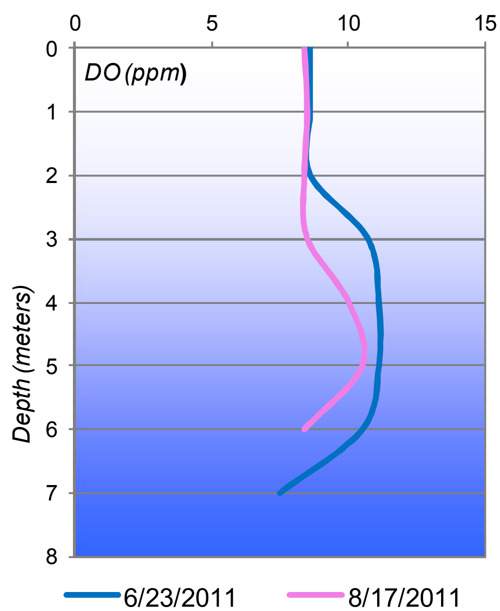


Figure 5.2. Cushman Pond 2011 DO profile

5.3 Farrington Pond

Farrington Pond drains directly into the lower basin of Kezar Lake. It has a surface area of 57 acres, a maximum depth of 15 feet, an average depth of 5 feet, and a watershed area of 0.53 square miles. The once-stable TP concentrations in Farrington Pond increased from 13.5 in 2010 to 19 ppb in 2011. While Chl-a has been on a steady decline in recent years, 2011 testing revealed a spike to 15.5 ppb. Since 2010, alkalinity has increased from 3 to 4.5 mg/L, color has increased from 10 to 16.5 SPU, and SDT had diminished slightly from 4.55 to 4.18 m. DO depletion is not an issue for this pond, primarily because of the pond's shallow depth (Figure 5.3); however, June 2011 DO was less than 5 ppm between 4 and 5 meters, which may partially explain the high algal indicator (26 ppb for Chl-a) for that sampling day. Farrington Pond is particularly sensitive to sediment suspension from either the anchor or the Secchi disk. For this reason, Secchi readings are taken last. The high TP reading in June 2011 may be the result of re-suspension of bottom sediments caused by dropping the anchor.

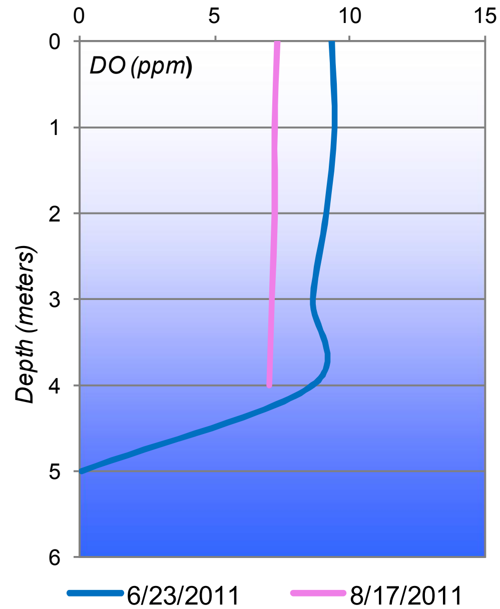


Figure 5.3. Farrington Pond 2011 DO profile

5.4 Heald Pond

Heald Pond drains through Kezar Lake into Boulder Brook. It has a surface area of 101.3 acres, a maximum depth of 19 feet, and a watershed area of 4.24 squaremiles. DO concentrations are low (< 5 ppm) below 4 meters (13.7 feet) in the summer months (Figure 5.4). TP concentrations increased from 8.5 ppb in 2010 to 9.5 ppb in 2011, much higher than the low of 3.5 ppb in 2007. Chl-a decreased from 4.2 ppb in 2010 to 3.5 ppb in 2011. Alkalinity remained at 5 ppm, making Heald one of the most resistant ponds in the watershed to changes in pH. Color increased from 16 to 19 SPU, and water clarity decreased only slightly from 4.88 to 4.72 m.

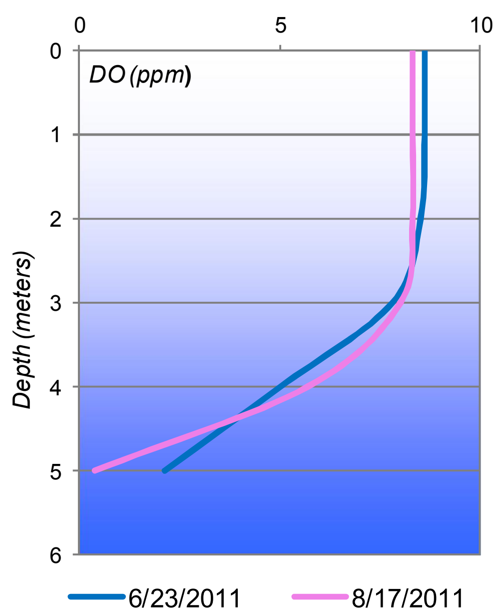


Figure 5.4. Heald Pond 2011 DO profile

5.5 Horseshoe Pond

Horseshoe Pond drains into Moose Pond, which in turn drains into Kezar Lake. This pond has a surface area of 136 acres, a depth of 12 feet, a maximum depth of 40 feet, and a watershed area of 1.64 square miles. Due to volunteer efforts, there is more historical data for this pond than any other small pond in the Kezar Lake Watershed. The water quality of Horseshoe Pond has changed little over the years, and is in line with historical results. Only minor fluctuations were seen from 2010 to 2011: water clarity increased from 6.82 to 7.01 m, TP decreased from 7.0 to 6.5 ppb, Chl-a decreased from 4.4 to 3.4 ppb, alkalinity remained stable at 3 mg/L, and color increased from 8 to 9 SPU. DO depletion was not as prevalent in 2011 as in previous years for Horseshoe, yet fell below 5 ppm after 8 meters in August (Figure 5.5).

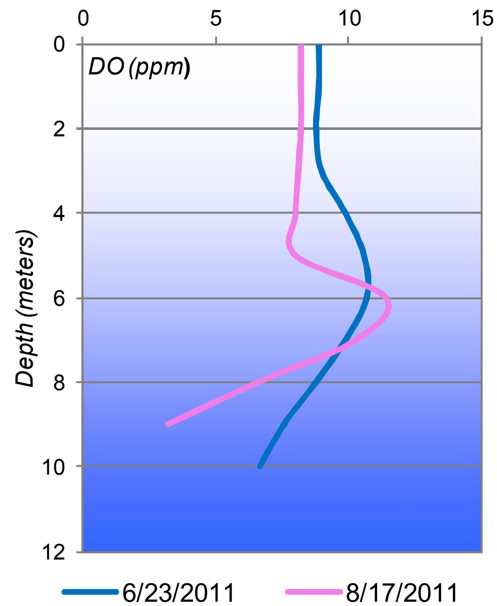


Figure 5.5. Horseshoe Pond 2011 DO profile

5.6 Trout Pond

Water from Trout Pond travels through Cushman Pond, Heald Pond, and Boulder Brook before reaching Kezar Lake. A secluded summer camp is the only development on this pond. Trout Pond's surface area is unknown, but it is slightly larger than Cushman Pond. Based on FB Environmental depth measurements, the maximum depth of the pond is 73 feet. However, a camp employee stated that it may be as deep as 87 feet. From 2010 to 2011, average water clarity decreased from 8.13 m to 7.22 m, and average TP and alkalinity remained stable at 6.5 ppb and 3.5 mg/L, respectively. Chl-a decreased from 3.9 to 1.8 ppb, and color decreased from 10 to 7 SPU between 2010 and 2011. Trout Pond has the best water quality of all the small ponds in the Kezar Lake Watershed. While highly variable chemical results have been a potential issue in previous years, Trout was the most stable pond of the entire Kezar Lake watershed when comparing 2010 to 2011 results. DO was also relatively unchanged through the summer months and comparable to 2009 and 2010 trends. In 2011, DO depletion occurred at depths greater than recorded depths of DO depletion in the previous 2 years.

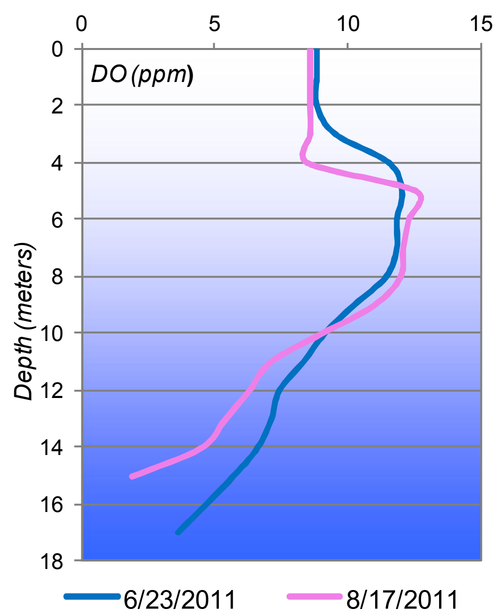


Figure 5.6. Trout Pond 2011 DO profile

Table 5.1: KLWA Ponds 2011 and 2010 water quality monitoring results

Pond	SDT (m)		TP (ppb)		Chl-a (ppb)		Alkalinity (mg/L)		Color (PCU)	
	2010	**2011**	*2010*	**2011**	*2010*	**2011**	*2010*	**2011**	*2010*	**2011**
Bradley	*5.4*	4.6	*7.5*	10.0	*3.9*	5.8	*4.0*	3.0	*14.5*	22.0
Cushman	*5.9*	5.5	*4.5*	7.0	*1.8*	2.0	*5.0*	4.5	*8.0*	9.5
Farrington	*4.6*	4.2	*13.5*	19.0	*3.9*	15.5	*3.0*	4.5	*10.0*	16.5
Heald	*4.9*	4.7	*8.5*	9.5	*4.2*	3.5	*5.0*	5.0	*16.0*	19.0
Horseshoe	*6.8*	7.0	*7.0*	6.5	*4.4*	3.4	*3.0*	3.0	*8.0*	9.0
Trout	*8.1*	7.2	*6.5*	6.5	*3.9*	1.8	*3.5*	3.5	*10.0*	7.0
Maine Average	*4.8*		*12.0*		*5.3*		*12.0*		*28.0*	

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