

Portland Water District
Sebago Lake Watershed Monitoring Programs
Crooked River Monitoring (1977 to 2016)
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Introduction

Sebago Lake is the primary drinking water supply for 200,000 people in 11 Greater Portland communities. Lake water was first pumped to Portland in 1869, from an intake located in the southernmost part of the lake, referred to as Lower Bay. In 1908, the Portland Water District was chartered by the Maine Legislature to provide water and wastewater services to the region. Since its inception, the District has been actively monitoring and working to protect Sebago Lake.

In 1993, the District was granted a waiver to the filtration requirements of the federal Safe Drinking Water Act based in part on the purity of the water and the effectiveness of watershed protection efforts. This waiver agreement requires ongoing monitoring of lake water quality. The District maintains more than 10 monitoring and surveillance programs throughout the watershed and lake. In general, as one moves closer to the intakes, more samples are collected and tested for more parameters.

The Crooked River originates at the southern end of Songo Pond in Bethel and meanders southward for approximately 38 miles to its junction with the Songo River near the State Park in Naples, Maine. The two rivers then wind two more miles to their outlet in the northernmost part of Sebago Lake. The District has monitored the Crooked River for over 30 years. Since the Crooked contributes nearly 40% of the surface inflow to the lake, it is the most important tributary we monitor.

Methods

The Crooked River is monitored four times a year from the Sebago Lake State Park in Naples to a bridge on Rt. 35 in Albany for the following analytes: turbidity, total phosphorus, and *E. coli* bacteria. A total of seven sites are monitored as part of the program. These sites listed from North to South are as follows: Route 35, North Waterford, Hunt's Corner, East Waterford, Bolster's Mills, Old Rt. 302, and State Park (see Figure 1). Of these sites, the southern-most sampling point (State Park) has been monitored for the longest period of time, and at the highest frequency. This is due in part to the fact that this site is also included in the Tributary Monitoring Program (see the 2016 Tributary Monitoring Report). For the purposes of this report, data from the State Park site will be used to characterize the Crooked River's overall contribution to Sebago Lake. All data collected from this site are presented.

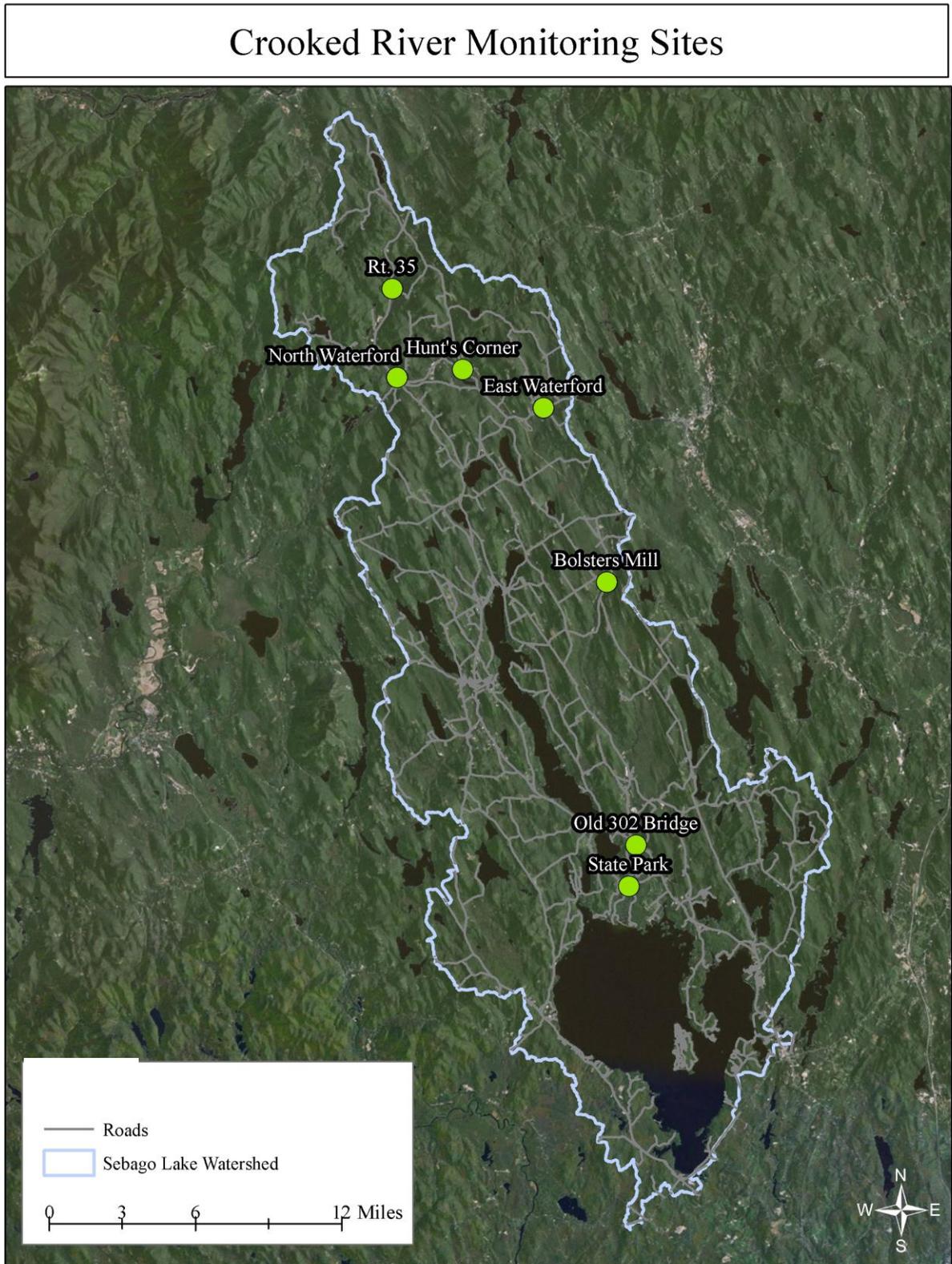
Sampling is performed using a "dipper" to lower acid-washed total phosphorus collection flasks and sterilized bacteria collection bottles into the water, usually from a bridge over the river. Total phosphorous samples are analyzed using the ascorbic acid method and a spectrophotometer in the District's water quality laboratory. *E. coli* samples are analyzed using the Colilert method and are incubated at 35 degrees Celsius for 24 hours. Turbidity is measured using a benchtop Hach 2100N Turbidimeter.

Data presented in this report pertain to data collected at the State Park sample site as a measure of the overall contribution of total phosphorus, *E. coli* bacteria, and turbidity from the Crooked River to Sebago Lake. Data from all seven sample sites for 2016 are included in the appendix of this report.

In 2016, the tributaries were sampled for an expanded set of water quality parameters to compare to historical baseline data. The sampling occurred in June, 2016 and is referred to as the "expanded" Crooked River run in this report. The parameters included: temperature, dissolved oxygen, pH, conductivity, alkalinity, total dissolved solids, total suspended solids, color, nitrate, hardness, iron, and chloride. Temperature, dissolved oxygen, pH, conductivity, and total dissolved solids were measured

using field meters. Alkalinity, total suspended solids, color, hardness, iron, nitrate, and chloride were analyzed in the PWD laboratory.

Figure 1.



Results and Discussion

Total Phosphorus

Phosphorus is one of the major nutrients needed for plant growth. It is generally present in relatively small amounts in temperate lakes. Phosphorous is often the limiting nutrient for algal growth in the system, meaning that as phosphorus increases, the amount of algae also increases. Phosphorus levels are generally higher in flowing tributaries than in a lake. When tributary waters enter a lake, phosphorus becomes diluted and sediments with phosphorus attached settle out on the lake bottom. Total phosphorus includes phosphates attached to sediment as well as dissolved forms of phosphorus and is measured in parts per billion (ppb). A reading of 35 ppb is the action level established by the District. Sampling events that result in total phosphorus levels above 35 ppb are reviewed and appropriate corrective measures are taken if possible.

Total phosphorus has been monitored at the State Park sampling site since 1977, at Bolster's Mills, East Waterford, Hunt's Corner, North Waterford, and Route 35 since 1993, and at the Old Route 302 site since 1995.

Total phosphorus concentrations did not exceed the action level at the State Park or any other site in 2016. All samples were under the action level, with the highest reading on the river of 24.5 ppb being taken at the State Park on 10/27/16. During the time period of 1977 to 2016, total phosphorus levels at the State Park ranged from 5 ppb to 126 ppb. In 2016, State Park total phosphorus levels ranged from 5.8 ppb to 24.5 ppb (Table 1). This range in the data can often be attributed to the presence or absence of precipitation events that cause erosion of river banks and runoff from developed areas to enter the river.

Table 1. 2016 Total phosphorus (ppb) results for the State Park site on the Crooked River, Naples, ME. No total phosphorus samples exceeded the action level in 2016.

4/19/16	8.9
4/27/16	8.0
6/21/16	14.7
6/29/16	9.0
8/8/16	5.8
8/15/16	8.2
10/18/16	12.7
10/27/16	24.5

***Escherichia coli* Bacteria**

E. coli bacteria is a type of fecal coliform bacteria found in the gastrointestinal tracts of warm-blooded animals. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. Sewage may also contain many other types of disease-causing organisms such as Giardia, Cryptosporidium, typhoid, viral and bacterial gastroenteritis, and hepatitis A. Natural occurrences can cause elevated *E. coli* levels. Examples include significant precipitation events that wash pollution from impervious surfaces and areas of development (animal feces, etc.) into the river, and the erosion of soil into the river since a small percentage of fecal bacteria is associated with soil. *E. coli* levels tend to be higher in the tributaries but become diluted when the tributary water enters the lake. The District's action level for *E. coli* is 235 MPN/100 mL in accordance with the Maine Healthy Beaches Program. Sampling events that result in *E. coli* levels above 235 MPN/100mL are reviewed or re-sampled if the cause is unknown.

E. coli levels did not exceed the action level at the State Park or any other site on the River in 2016. During the time period of 2009-2016 *E. coli* levels ranged from 2 MPN/100 mL to 613 MPN/100 mL at the State Park. In 2016, *E. coli* levels ranged from 5 MPN/100 mL to 61 MPN/100 mL at the State Park (Table 2). Even the highest reading taken all year (61 MPN/100 mL taken on 8/15/16) was well below the action level.

Table 2. 2016 *E. coli* (MPN/100 mL) results for the State Park site on the Crooked River, Naples, ME. No *E. coli* samples from the State Park exceeded the action level in 2016.

3/24/16	6
4/19/16	9
4/27/16	5
5/17/16	22
6/21/16	17
6/29/16	5
7/27/16	22
8/8/16	17
8/15/16	61
9/27/16	41
10/18/16	9
10/27/16	16
11/15/16	27

Turbidity

Turbidity refers to the amount of suspended particulate matter in the water. Turbidity measurements are performed through the use of a turbidimeter, in which a beam of light is passed through a water sample and the light output is measured on the other side. The greater the amount of suspended particulate matter in the water, the more the light beam is refracted and blocked, and the higher the turbidity. In streams, the three major types of suspended particulates that contribute to turbidity are algae, detritus (dead organic material), and silt (inorganic or mineral suspended sediment). High turbidity decreases light penetration and facilitates eutrophication of rivers and lakes. Particulates also provide attachment sites for heavy metals such as cadmium, mercury and lead, and many toxic organic contaminants such as PCBs and many

pesticides. Turbidity is measured in NTU (nephelometric units). Generally, readings below 1 NTU indicate water that appears “clear” to the naked eye. Readings greater than 4 NTU indicate water that would appear cloudy or murky. A reading of 4.0 NTU or greater is the action level determined by the District’s Environmental Services Department. Values of 4.0 NTU or higher are reviewed, the site is resampled, and appropriate corrective measures are taken if possible.

In 2016 turbidity values ranged from 0.7 to 1.3 NTU at the State Park site (Table 3). There were no turbidity readings above the action level at any site on the Crooked River in 2016. Even the highest readings taken all year (1.4 NTU at E. Waterford and Rte. 35 on 6/21/16) were well below the action level.

Table 3. 2016 Turbidity (NTU) results for the State Park site on the Crooked River, Naples, ME. No turbidity samples from the State Park exceeded the action level in 2016.

3/24/16	0.9
4/19/16	0.8
4/27/16	0.7
5/17/16	0.9
6/21/16	1.2
6/29/16	1.2
7/27/16	1.3
8/8/16	1.2
8/15/16	1.2
9/27/16	1.2
10/18/16	1.0
10/27/16	1.1
11/15/16	1.1

“Expanded” Crooked River Run

Historically, the expanded set of parameters (listed in the Methods section of this report) was sampled on every run. PWD determined, however, that these parameters were not needed as indicators of stream health four times a year because they did not vary much over time. The expanded set of parameters is now monitored every 5 years to determine whether the water quality has changed in comparison to historical data. The results of the expanded sampling can be found below in Table 4. Results from the 2016 sampling fell within the historical range for all parameters.

Table 4. Results of expanded Crooked River run sampling on 6/21/16							
	State Park	Old Rte. 302 Bridge	Bolsters Mills	East Waterford	Hunt's corner	North Waterford	Rte. 35
Temperature (°C)	21.4	21	21.4	19.8	20.1	20.5	20.4
Dissolved Oxygen (% saturation)	8	8.4	8.1	8	8.1	8	8.1
pH	6.92	7.02	7.26	7.35	7.36	7.07	7.18
Alkalinity (mg/L)	10.5	10.6	8.8	7.9	8	7.1	6.7
Conductivity (µohms)	66.6	63.5	51.9	50.4	48	42.2	39.9
Total Suspended Solids (mg/L)	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5
Total Dissolved Solids (mg/L)	33.2	31.8	25.9	25.3	24.1	21.1	19.9
Color (SPU)	59	52	59	57	53	61	85
Nitrate (mg/L)	<0.23	0.24	<0.23	<0.23	<0.23	<0.23	0.26
Chloride (mg/L)	9	9	7	7	7	6	5
Hardness (mg/L)	12.5	13.5	10.2	9.6	9.5	9.2	9
Iron (mg/L)	0.04	0.03	0.04	0.04	0.03	0.03	0.04

Conclusion:

This sampling program provides a “snapshot” determination of the health of the Crooked River. Samples that exceed established action levels are investigated and re-sampled if necessary. Because sampling occurs four times a year, it is difficult to determine a continuous water quality trend from the data. Rather, this program reflects the variability of water quality in response to both environmental and human factors.

The total phosphorus levels in 2016 remained within the historical range, with no readings above the 35 ppb action level.

E. coli bacteria levels obtained in 2016 remained consistent with historical fecal coliform bacteria and *E. coli* data, with no readings above the 235 MPN/100 mL action level.

Turbidity levels in the Crooked River in 2016 also remained well within the historical range. No turbidity readings exceeded the action level in 2016.

Overall, the Crooked River appears to have generally stable water quality. The drought that occurred during the 2016 sampling season caused less soil and attached nutrients and bacteria to be washed into the river. While 2016 was a good year for the Crooked River, continued monitoring of the river is necessary.

The Crooked River contributes more surface inflow to Sebago Lake than any other tributary and a reduction in water quality in the Crooked River could reduce water quality in the lake.

Appendix: Crooked River Data 2015

Sample Date	Site	Turbidity (NTU)	Total Phosphours (ppb)	<i>E. coli</i> (MPN/100mL)
3/24/2016	State Park	0.9		6
4/19/2016	State Park	0.8	8.9	9
4/19/2016	Old 302 Bridge	0.9	14.0	16
4/19/2016	Bolster's Mills	0.6	5.7	5
4/19/2016	E. Waterford	1.1	7.8	58
4/19/2016	Hunt's Corner	0.9	8.4	5
4/19/2016	N. Waterford	0.7	8.1	10
4/19/2016	Rte. 35	0.7	10.3	10
4/27/2016	State Park	0.7	8.0	5
5/17/2016	State Park	0.9		22
6/21/2016	State Park	1.2	14.7	17
6/21/2016	Old 302 Bridge	1.1	14.4	41
6/21/2016	Bolster's Mills	1.3	16.2	38
6/21/2016	E. Waterford	1.4	16.3	54
6/21/2016	Hunt's Corner	1.3	12.4	20
6/21/2016	N. Waterford	1.0	13.4	16
6/21/2016	Rte. 35	1.4	16.4	46
6/29/2016	State Park	1.2	9.0	5
7/27/2016	State Park	1.3		22
8/8/2016	State Park	1.2	5.8	17
8/8/2016	Old 302 Bridge	0.9	20.8	74
8/8/2016	Bolster's Mills	1.2	4.6	36
8/8/2016	E. Waterford	1.1	21.6	99
8/8/2016	Hunt's Corner	1.0	10.9	79
8/8/2016	N. Waterford	1.0	11.0	73
8/8/2016	Rte. 35	1.2	20.8	23
8/15/2016	State Park	1.2	8.2	61
9/27/2016	State Park	1.2		41
10/18/2016	State Park	1.0	12.7	9
10/18/2016	Old 302 Bridge	0.6	9.9	26
10/18/2016	Bolster's Mills	1.1	24.2	10
10/18/2016	E. Waterford	1.1	17.7	11
10/18/2016	Hunt's Corner	0.9	15.3	58
10/18/2016	N. Waterford	0.7	2.8	16
10/18/2016	Rte. 35	0.7	13.5	13
10/27/2016	State Park	1.1	24.5	16
11/15/2016	State Park	1.1		27