Section 5-4
Kennebunk River (Mousam and Kennebunk Rivers Alliance)

Kennebunk River

Kennebunk River is 15 miles long and originates at Kennebunk Pond in Lyman. The East Outlet becomes Lords Brook which joins Carlise Brook to form the Kennebunk River. The river continues flowing through Arundel and Kennebunk before discharging to the Gulf of Maine in Kennebunkport at Goochs Beach. Other major tributaries include Duck Brook and Ward Brook.

The statutory class of the Kennebunk River and tributaries is Class B. Below head of tide, the river is Class SB. The primary impacts to the river are from development, recreational use, and agriculture. Kennebunk River is listed by the Department of Environmental Protection (DEP) as impaired for bacteria.

Monitoring History

• The Maine DEP Biological Monitoring Program has been monitoring the river since 1995. Monitoring data has been collected on the mainstem as well as Carlise Brook, Lords Brook and Ward Brook. This data is available on DEP's website.

• The Mousam and Kennebunk River Alliance (MKA) began in 2009 with assistance from the Wells National Estuarine Research Reserve (NERR) and Maine Rivers for the purpose of monitoring the Kennebunk and Mousam rivers. MKA joined the Volunteer River Monitoring Program (VRMP) in 2009.

• Maine DEP's Integrated Water Quality Report lists Kennebunk River (Kennebunk Landing to Goochs Beach) and Duck Brook and tributaries as impaired for Escherichia coli bacteria.

• In 2012, MKA partnered with the DEP TMDL Streams staff to monitor bacteria in Duck Brook. The report is available from DEP.

Methods and Sampling Sites

Volunteers monitor the Kennebunk River at five sites on the mainstem and one site on Ward Brook. Two sites are below head of tide and four are freshwater sites. All of the sites are VRMP approved sites.

Monitoring is conducted biweekly from June to September. Monitors take measurements of water temperature and dissolved oxygen using a YSI meter. Specific conductance is measured using either a YSI meter or an Oakton EC 11+/11 Testr pen and salinity is measured at the tidal sites. Grab samples for *E. coli* are collected at the freshwater sites and Enterococci bacteria at the tidal sites.

Kennebunk River Sampling Sites
Mousam and Kennebunk Rivers Alliance

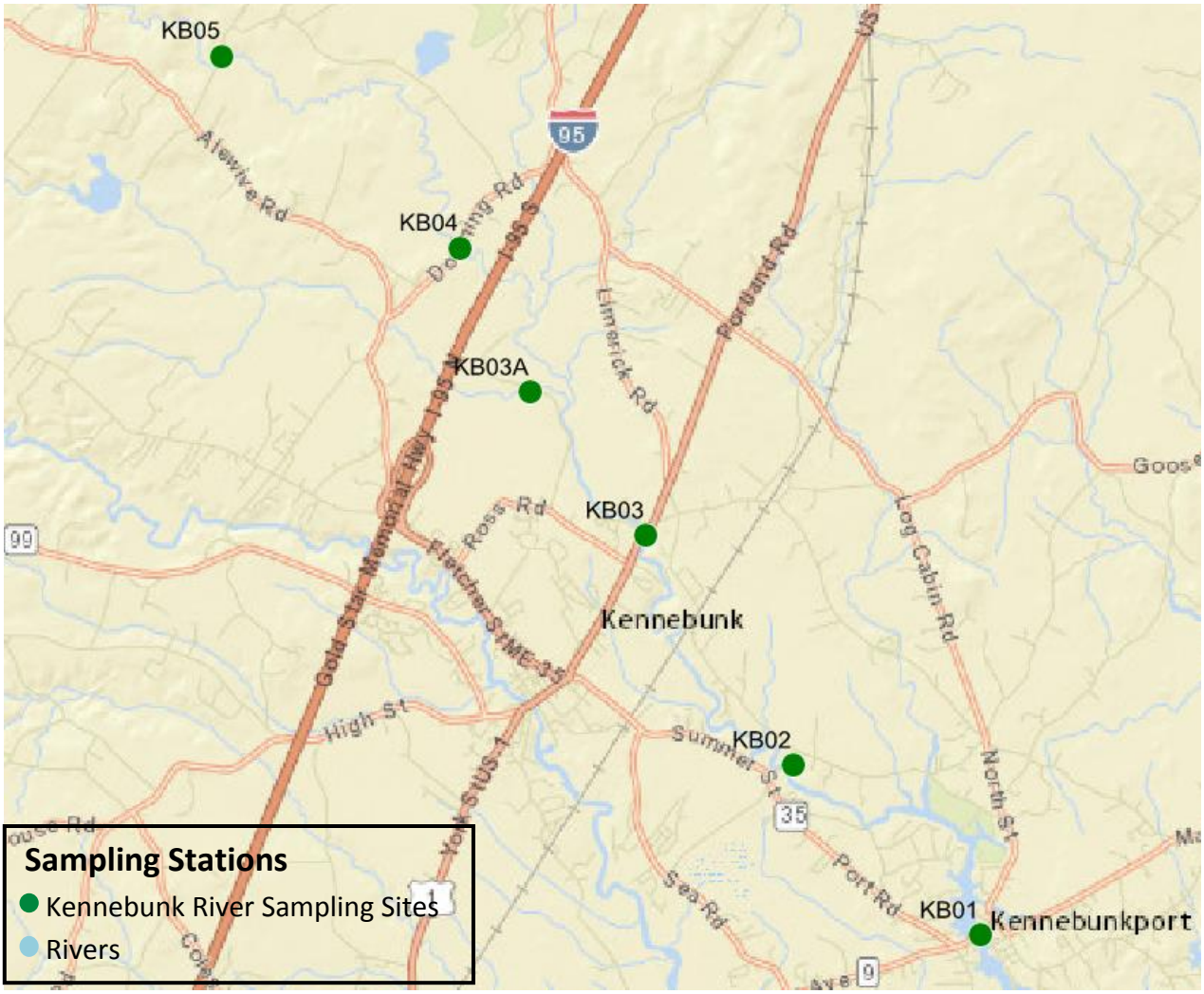


Figure 5-4-1: Map of Mousam and Kennebunk Rivers Alliance sampling sites on the Kennebunk River.

Table 5-4-1: Mousam and Kennebunk Rivers Alliance sampling sites on the Kennebunk River.

VRMP Site ID	Organization Site Code	Sample Location	Class
Kennebunk River - SKE11 - VRMP	KB-01	Route 9 Bridge	SB
Kennebunk River - SKE35 - VRMP	KB-02	Durrell's Bridge	SB
Kennebunk River - SKE66 - VRMP	KB-03	Route 1 Bridge	B
Kennebunk River - SKE103 - VRMP	KB-04	Downing Road	B
Kennebunk River - SKE148 - VRMP	KB-05	Perkins Lane	B
Ward Brook - SKEWD04 - VRMP	KB-03A	Emmons Road	B

Results

Refer to Appendix A for discussion of individual site data and trends.

Dissolved Oxygen

Dissolved oxygen levels are generally lowest early in the morning and then increase during the day, peaking mid to late afternoon. Monitors should try to collect some samples early in the morning. Dissolved oxygen is also affected by flow conditions and temperature. During high flow conditions, more oxygen is added to the river from the atmosphere as the water is more turbulent and there is more opportunity for mixing. If flow during the summer months is higher or lower than normal, this will affect the dissolved oxygen.

Class B criteria for dissolved oxygen are a minimum of 7 mg/l (milligrams/liter) or 75% saturation. To meet water quality criteria, both concentration and saturation criterion must be met. Class SB criterion for dissolved oxygen is 85% saturation.

2016 Results

Dissolved oxygen (DO) was measured seven times at each sampling site. At the freshwater sites, Sites KB-03A and KB-04 did not meet the Class B criterion of 7 mg/l concentration on five sampling dates (July through September). Site KB-04 had one very low reading (3.9 mg/l) in late July. The percent saturation of criterion of 75% also was not met for five dates for these two sites. At the tidal sites, site KB-01 did not meet the Class SB criterion of 85% saturation for one sampling date, while site KB-02 did not meet this criterion on five of seven sampling dates. The values for these five sample dates were slightly depressed, ranging from 67% - 83%.

Overall, dissolved oxygen was fair to excellent for the freshwater sites and fair to good for the tidal sites. The monitors did obtain some early morning measurements (before 8:00 am). However, since one monitoring team does all the sites, it is difficult to get to all the sites early.

Table 5-4-2: A summary of minimum, maximum, and mean dissolved oxygen concentration (mg/l) values at Mousam and Kennebunk Rivers Alliance monitoring sites on the Kennebunk River and tributary.

Site	Class	# Sample Points	Mean	Minimum	Maximum	Criterion	# Not Meeting Criterion
KB-01	SB	7	8.2	6.3	9.5	n/a	n/a
KB-02	SB	7	6.3	5.4	8.1	n/a	n/a
KB-03	B	7	8.4	7.5	9.8	7	0
KB-03A	B	7	6.5	5.7	7.6	7	5
KB-04	B	7	6.2	3.9	8.0	7	5
KB-05	B	7	8.1	7.3	10.0	7	0

Table 5-4-3: A summary of minimum, maximum, and mean dissolved oxygen saturation (%) values at Mousam and Kennebunk Rivers Alliance monitoring sites on the Kennebunk River and tributary.

Site	Class	# Sample Points	Mean	Minimum	Maximum	Criterion	# Not Meeting Criterion
KB-01	SB	7	99.7	81.9	119.0	85	1
KB-02	SB	7	79.2	67.0	91.0	85	5
KB-03	B	7	92.5	81.2	102.4	75	0
KB-03A	B	7	69.0	61.8	81.5	75	5
KB-04	B	7	68.3	55.8	86.7	75	5
KB-05	B	7	87.6	80.7	98.1	75	0

Figure 5-4-2: Graph of dissolved oxygen concentrations.

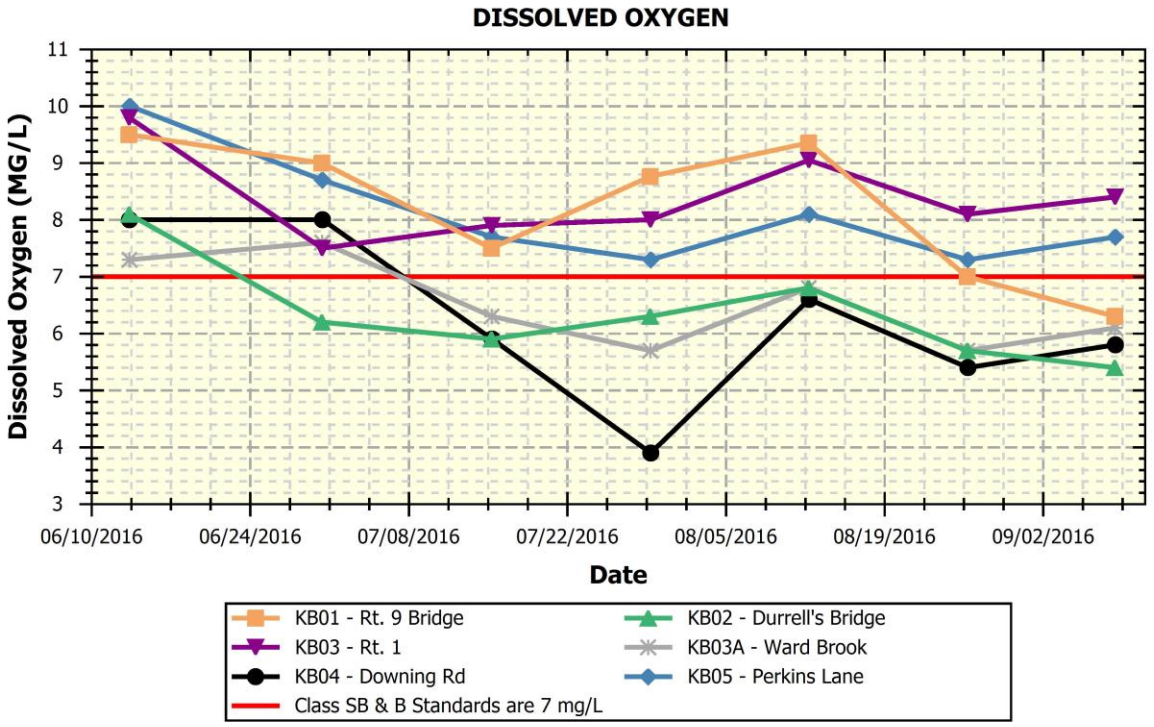
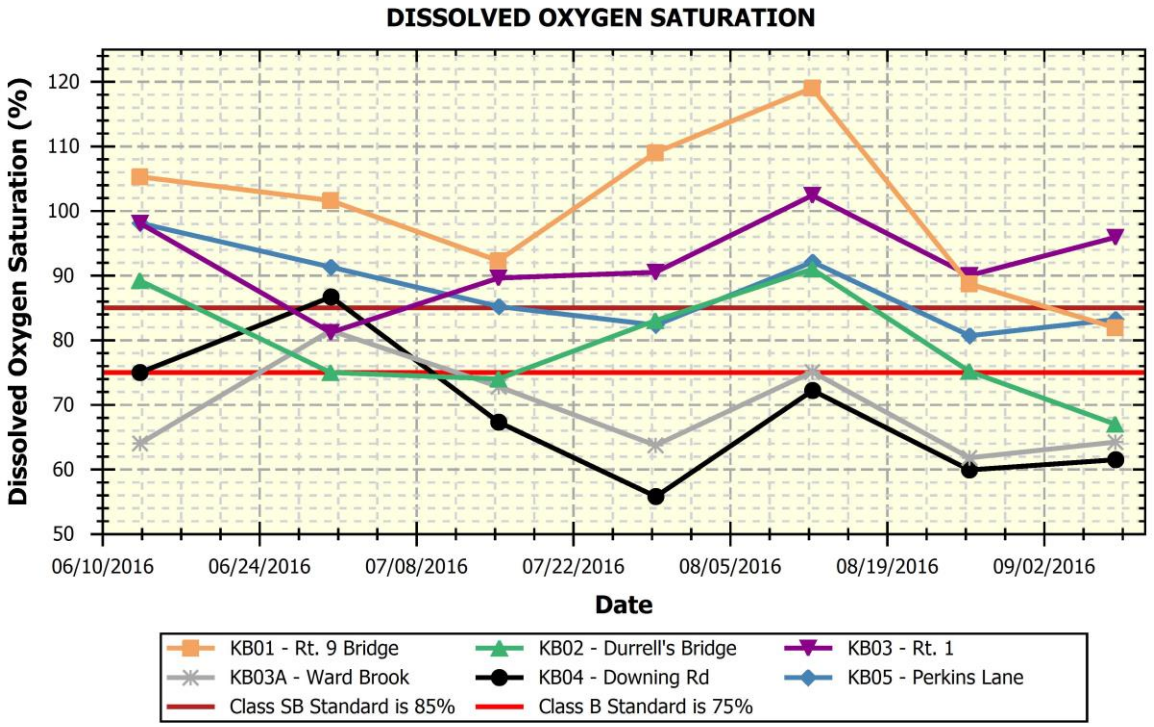


Figure 5-4-3: Graph of dissolved oxygen saturation.



Water Temperature

Maine's Regulations Relating to Temperature (06-096 CMR Chapter 582) require that discharge of pollutants not raise the temperature of any river and stream above the EPA criteria for indigenous species (23 °C maximum and 19 °C weekly average) or 0.3 °C (0.5 °F) above the temperature that would naturally occur outside a mixing zone established by the Board of Environmental Protection. Pollutant is defined in statute as many things including dirt and heat. For tidal waters, discharge of pollutants may not raise the temperature more than 4 °F (2.2 °C) or more than 1.5 °F (0.8 °C) from June 1 to September 1, and may not cause the temperature of any tidal waters to exceed 85 °F (29 °C) at any point outside a mixing zone established by the Board of Environmental Protection.

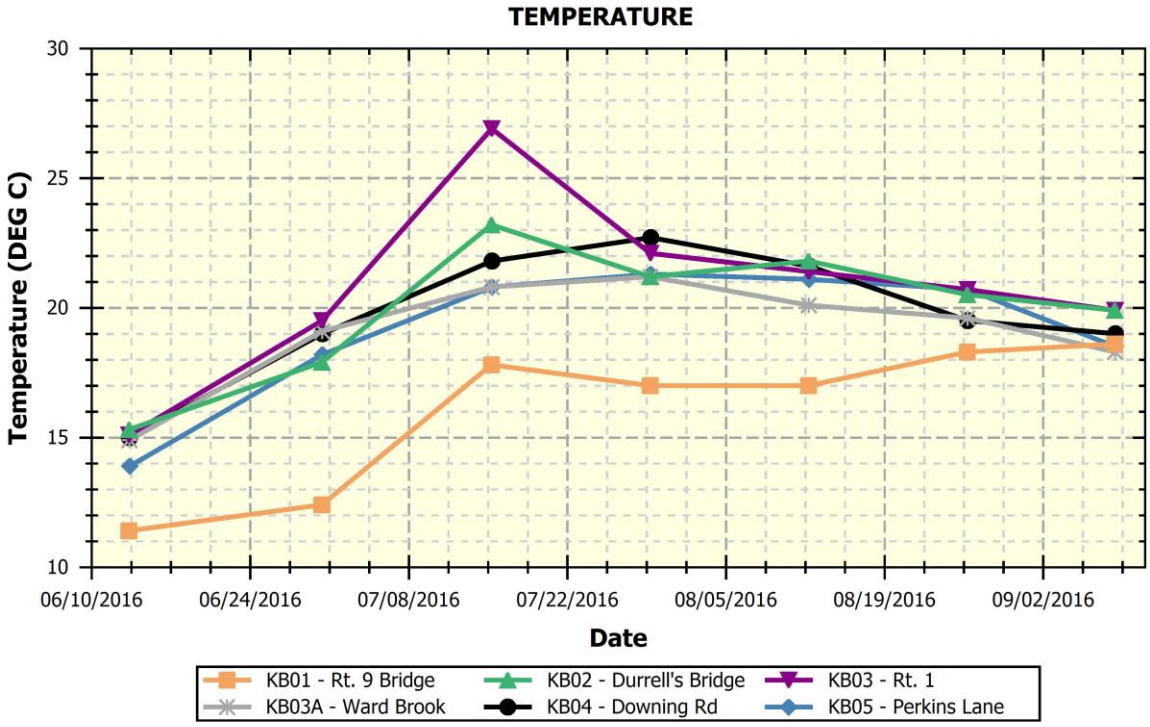
2016 Results

Temperatures at the freshwater sites were all similar and followed the same pattern. Overall, temperatures are slightly elevated in July and August. The tidal sites were quite different with site KB-01 being the coldest site overall (mean temperature 16.1 ˚C) and site KB-02 being the warmest overall (mean temperature of 20.0 ˚C). Temperature at the freshwater sites is good and temperature is good to excellent at the tidal sites.

Table 5-4-4: A summary of minimum, maximum, and mean water temperature (°C) values at Mousam and Kennebunk Rivers Alliance monitoring sites on the Kennebunk River and tributary.

Site	Class	# Sample Points	Mean	Minimum	Maximum	Criterion	# Exceeding Criterion
KB-01	SB	7	16.1	11.4	18.6	n/a	n/a
KB-02	SB	7	20.0	15.3	23.2	n/a	n/a
KB-03	B	7	20.8	15.1	26.9	n/a	n/a
KB-03A	B	7	19.1	14.9	21.2	n/a	n/a
KB-04	B	7	19.8	15.0	22.7	n/a	n/a
KB-05	B	7	19.2	13.9	21.3	n/a	n/a

Figure 5-4-4: Graph of water temperature



Specific Conductance

Specific conductance is related to the amount of dissolved materials in the water. While there are no numerical standards, a relationship exists between conductivity and chloride which has numerical criteria. In general, streams located in urban areas tend to have high specific conductance due to polluted urban stormwater runoff. This may also in large part be due to salt buildup in surface and groundwater from road maintenance practices.

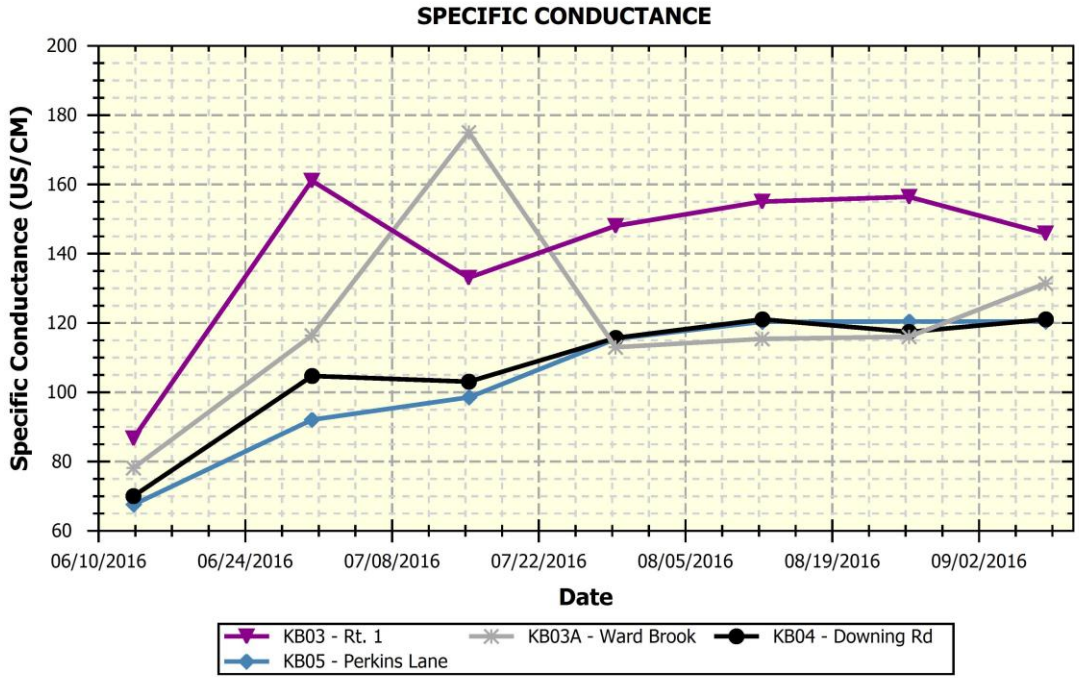
2016 Results

Specific conductance at the freshwater sites KB-03A, KB-04 and KB-05 was low overall. Site KB-03 was the highest overall with a mean value of 141 µS/cm, which was lower than in 2015. Site KB-03A had one slightly elevated value. Overall, specific conductance at the freshwater sites is good-excellent.

Table 5-4-5: A summary of minimum, maximum, and mean specific conductance (µS/cm) values at Mousam and Kennebunk Rivers Alliance monitoring sites on the Kennebunk River and tributary.

Site	Class	# Sample Points	Mean	Minimum	Maximum	Criterion	# Exceeding Criterion
KB-01	SB	n/a	-	-	-	n/a	-
KB-02	SB	n/a	-	-	-	n/a	-
KB-03	B	7	141	87	161	n/a	n/a
KB-03A	B	7	121	78	175	n/a	n/a
KB-04	B	7	108	70	121	n/a	n/a
KB-05	B	7	105	68	120	n/a	n/a

Figure 5-4-5: Graph of specific conductance.



Bacteria

Enterococci bacteria are used as the indicator organism for marine waters and *E. coli* bacteria are used for freshwaters. While these types of bacteria are not pathogens, their presence in the water may indicate the presence of other organisms including bacteria and viruses that can cause gastrointestinal illnesses. Monitoring should include at least six samples and include a mix of dry and storm event sampling.

Class B criteria for bacteria are as follows: "Between May 15th and Sept 30th, *E. coli* of human and domestic origin shall not exceed a geometric mean of 64/100 ml (milliliters) or an instantaneous level of 236/100 ml." Class SB criteria are as follows: "Between May 15th and September 30th, the numbers of Enterococcus bacteria of human and domestic animal origin in these waters may not exceed a geometric mean of 8 per 100 milliliters or an instantaneous level of 54 per 100 milliliters." Geometric means are calculated instead of average because it is more appropriate to use this calculation for something like bacteria where there may be one or more very high or low values that can skew the mean

2016 Results

The freshwater sites exceeded the Class B instantaneous criterion of 236 MPN/100 ml on 2-3 sampling dates. The geometric mean criterion of 64 MPN/100 ml was exceeded at all freshwater sites. Sites KB-03A and KB-05 had some particularly high values. Rain events occurred prior to the 6/30/16 (0.66" rain) and 7/29/16 (0.44" rain) sampling dates. The tidal site KB-01 did not exceed the Class SB instantaneous criterion of 54 MPN/100 ml and KB-02 exceeded this criterion on 3 sampling dates. The geometric mean criterion of 8 MPN/ml was exceeded at both tidal sites. The highest values for KB-02 occurred in June and July. Two of these dates coincided with rain events. Overall, bacteria at all the sites was poor-fair, except for site KB-01 which was good. Overall, bacteria levels were better in 2016 than the previous year, probably due to much lower rainfall levels in 2016. Further investigation of bacteria sources is warranted.

Table 5-4-6: A summary of minimum, maximum, and geometric means for bacteria (MPN/100 mL) values at Mousam and Kennebunk Rivers Alliance monitoring sites on the Kennebunk River and tributary.

Site	Class	Type	# Sample Points	Geometric Mean	Minimum	Maximum	Criterion Inst/Geo	# Exceeding Criterion
KB-01	SB	Entero	7	12*	<10	20	54/8	0
KB-02	SB	Entero	7	48	10	204	54/8	3
KB-03	B	*E. coli*	7	184	84	435	236/64	3
KB-03A	B	*E. coli*	7	303	127	1203	236/64	3
KB-04	B	*E. coli*	7	235	82	1046	236/64	2
KB-05	B	*E. coli*	7	238*	73	>2420	236/64	2

***KB-01 geometric mean calculation includes two samples points below the minimum reporting limit (<10). 10 was used as the value. KB-05 geometric mean calculation includes one sample point over the maximum reporting limit (>2420). 2420 was used as the value.**

Figure 5-4-7: Graph of *E. coli* (MPN/100ml).

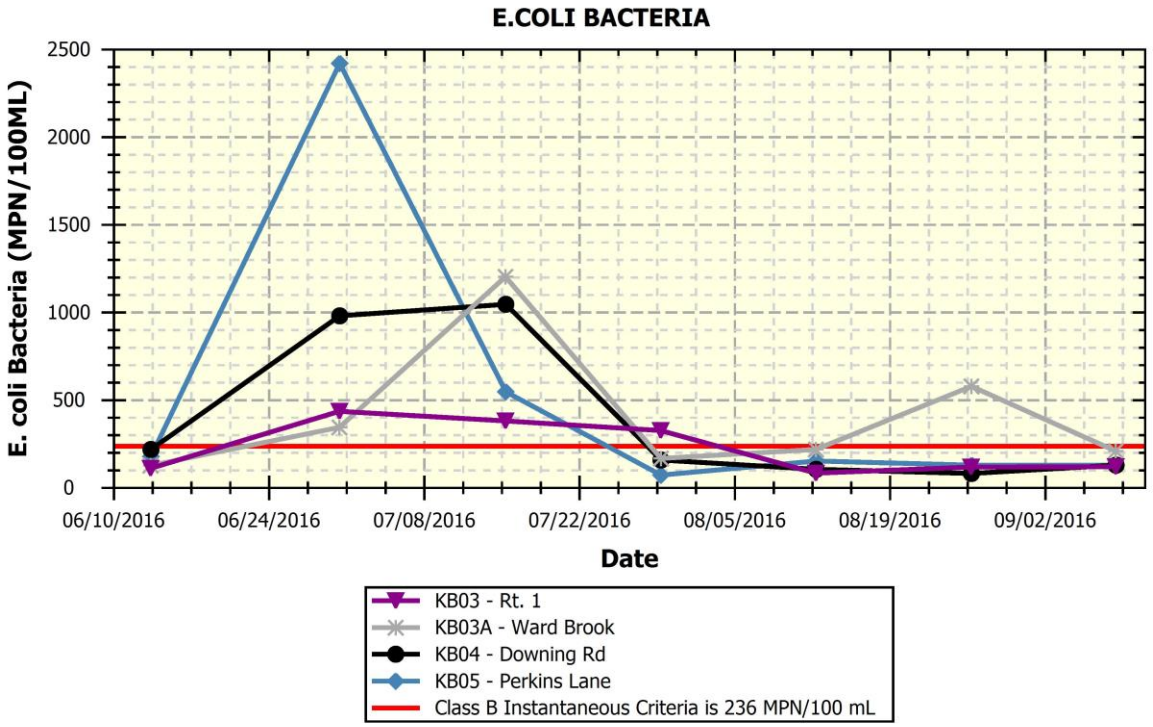
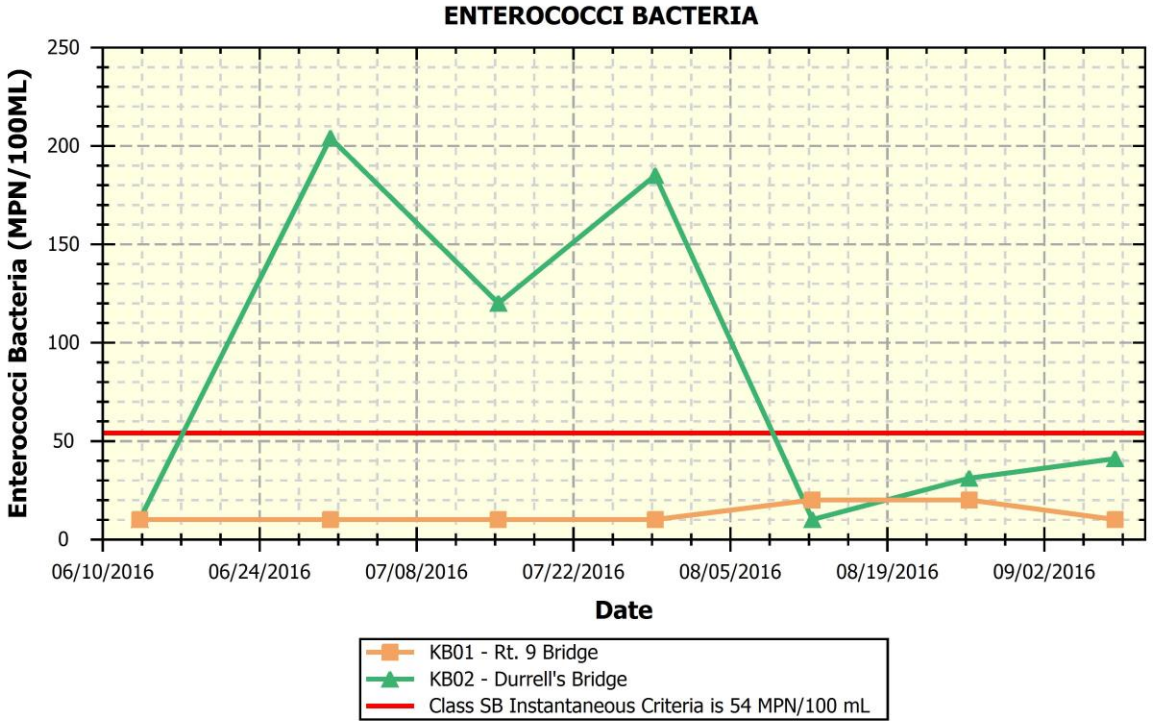


Figure 5-4-8: Graph of Enterococcus (MPN/100ml).



Discussion and Recommendations

There are numerous sources of pollution and other stresses to the Kennebunk River sites monitored by the Mousam and Kennebunk Rivers Alliance that could potentially have an impact on water quality. Some of those sources of pollution and stresses may include:

- Non-point source pollution (e.g., septic systems, eroded soil, fertilizers, pesticides, heavy metals, petroleum residues, road salt, wildlife and pet feces) and polluted stormwater originating from urban impervious surfaces (e.g., streets, parking lots, driveways, roofs), agriculture, and forestry.
- Ponds and impoundments (which often create more pond-like aquatic habitat conditions that may have higher water temperatures and lower dissolved oxygen concentrations than free-flowing waters).
- Natural effects of wetlands (such as contributing waters to a stream or river that have low dissolved oxygen levels due to the decomposition of large amounts of organic matter, respiration of abundant plant matter, and low re-aeration rates that is characteristic of many wetlands).

The following are recommendations for future monitoring:

- **The monitors should continue to include early morning measurements for dissolved oxygen. It is important to get some values early in the morning (before 8:00 am), particularly during the warmer summer months. Over a 24-hour period, the lowest readings occur in the early morning and highest readings in mid to late afternoon. This occurs because oxygen is used up during the night due to plant respiration and during the day, plant life is photosynthesizing, producing oxygen.**
- **The VRMP, Healthy Beaches Program staff, DEP monitoring staff, Wells NERR staff and volunteers should continue to work on bacteria monitoring. Efforts should also continue on tracking down potential bacteria sources. Healthy Beaches Program staff should perhaps continue with bacteria sampling at the sites below head of tide to provide some continuity at those locations.**
- **Bacteria sampling should include samples obtained during both baseflow and storm events.**
- **Continue monitoring at all stations to develop a long-term trend database.**

Appendix A-1

* Sampling depths are only reported for Tier 1 VRMP sites.

** "NA" = normal environmental sample ; "D" = field duplicate; "L" = Lab Duplicate; "D.O." = dissolved oxygen; "Spec. Cond" = specific conductance; "TSS" = total suspended solids

Organization Site Code	VRMP Site ID	Date	Time	** Sample Type Qualifier	* Sample Depth	Depth Unit	Water Temp (DEG C)	** D.O. Sat. (%)	** D.O. (MG/L)	** Spec. Cond. (US/CM)	Salinity (PPTH)	Turb-idity (NTU)	Total Diss. Solids (MG/L)	** TSS (MG/L)	E. coli Bacteria (MPN/ 100ML)	Entero-cocci (MPN/ 100ML)
Kennebunk River - Mousam and Kennebunk Rivers Alliance: Approved Sites																
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	6/13/2016	7:05 AM	NA			11.4	105.3	9.5		30					10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	6/13/2016	7:05 AM	L												10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	6/30/2016	7:35 AM	NA			12.4	101.6	9.0		28.9					10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	6/30/2016	7:35 AM	L												L 10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	7/15/2016	7:04 AM	NA			17.8	92.3	7.5		28.9					L 10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	7/29/2016	7:15 AM	NA			17.0	109.0	8.8		29.6					L 10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	8/12/2016	7:05 AM	NA			17.0	119.0	9.4		30.7					20
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	8/12/2016	7:05 AM	L												10
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	8/26/2016	7:05 AM	NA			18.3	88.7	7.0		30.7					20
KB-01	KENNEBUNK RIVER - SKE11 - VRMP	9/8/2016	7:52 AM	NA			18.6	81.9	6.3		31.3					10
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	6/13/2016	7:30 AM	NA			15.3	89.2	8.1		16.9					10
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	6/30/2016	7:55 AM	NA			17.9	75.0	6.2		24.2					204
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	7/15/2016	7:22 AM	NA			23.2	74.0	5.9		13.4					120
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	7/29/2016	7:30 AM	NA			21.2	83.0	6.3		27.8					185
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	7/29/2016	7:30 AM	L												197
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	8/12/2016	7:20 AM	NA			21.8	91.0	6.8		26.8					10
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	8/26/2016	7:30 AM	NA			20.5	75.2	5.7		28.1					31
KB-02	KENNEBUNK RIVER - SKE35 - VRMP	9/8/2016	8:07 AM	NA			19.9	67.0	5.4		21.7					41
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	6/13/2016	7:45 AM	NA			15.1	98.1	9.8	86.7	0.1				111	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	6/13/2016	7:45 AM	L											156	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	6/30/2016	8:15 AM	NA			19.5	81.2	7.5	161	0.1				435	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	6/30/2016	8:15 AM	D			19.5	81.2	7.5	161	0.1					
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	6/30/2016	8:20 AM	D											344	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	7/15/2016	7:42 AM	NA			26.9	89.6	7.9	133	0.1				381	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	7/29/2016	7:50 AM	NA			22.1	90.5	8.0	148	0.1				326	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	7/29/2016	7:50 AM	D			22.1	91.5	8.0	147.6	0.1					
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	8/12/2016	7:40 AM	NA			21.4	102.4	9.1	155	0.1				84	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	8/26/2016	7:45 AM	NA			20.7	90.0	8.1	156.4					118	
KB-03	KENNEBUNK RIVER - SKE66 - VRMP	9/8/2016	8:30 AM	NA			19.9	95.9	8.4	145.8	0.1				119	
KB-03A	WARD BROOK - SKEWD04 - VRMP	6/13/2016	8:05 AM	NA			14.9	64.0	7.3	78.1					127	
KB-03A	WARD BROOK - SKEWD04 - VRMP	6/30/2016	8:40 AM	NA			19.1	81.5	7.6	116.3	0.1				344	
KB-03A	WARD BROOK - SKEWD04 - VRMP	7/15/2016	8:00 AM	NA			20.8	72.8	6.3	175					1203	
KB-03A	WARD BROOK - SKEWD04 - VRMP	7/15/2016	8:00 AM	D			20.6	73.2	6.5	173					1120	
KB-03A	WARD BROOK - SKEWD04 - VRMP	7/29/2016	7:50 AM	L											308	
KB-03A	WARD BROOK - SKEWD04 - VRMP	7/29/2016	7:50 AM	D											291	
KB-03A	WARD BROOK - SKEWD04 - VRMP	7/29/2016	8:07 AM	NA			21.2	63.7	5.7	113	0.1				167	
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/12/2016	7:55 AM	NA			20.1	75.1	6.8	115.4					219	
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/12/2016	7:55 AM	D			20.0	73.8	6.5	113.7						
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/12/2016	8:05 AM	D											205	
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/26/2016	8:00 AM	NA			19.6	61.8	5.7	116						

Organization Site Code	VRMP Site ID	Date	Time	** Sample Type Qualifier	* Sample Depth	Depth Unit	Water Temp (DEG C)	** D.O. Sat. (%)	** D.O. (MG/L)	** Spec. Cond. (US/CM)	Salinity (PPTH)	Turb-idity (NTU)	Total Diss. Solids (MG/L)	** TSS (MG/L)	E. coli Bacteria (MPN/ 100ML)	Entero-cocci (MPN/ 100ML)
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/26/2016	8:00 AM	D			19.5	60.1	5.6	116.4						
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/26/2016	8:05 AM	NA											579	
KB-03A	WARD BROOK - SKEWD04 - VRMP	8/26/2016	8:05 AM	D											260	
KB-03A	WARD BROOK - SKEWD04 - VRMP	9/8/2016	8:42 AM	NA			18.3	64.2	6.1	131.4					210	
KB-03A	WARD BROOK - SKEWD04 - VRMP	9/8/2016	8:42 AM	D			18.3	65.1	6.1	131.6						
KB-03A	WARD BROOK - SKEWD04 - VRMP	9/8/2016	8:45 AM	D											249	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	6/13/2016	8:25 AM	NA			15.0	75.0	8.0	70					219	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	6/30/2016	9:00 AM	NA			19.0	86.7	8.0	104.7	0.1				980	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	7/15/2016	8:25 AM	NA			21.8	67.3	5.9	103					1046	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	7/29/2016	8:30 AM	NA			22.7	55.8	3.9	115.6	0.1				158	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	8/12/2016	8:20 AM	NA			21.6	72.2	6.6	121					105	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	8/26/2016	8:25 AM	NA			19.5	59.9	5.4	117.4					82	
KB-04	KENNEBUNK RIVER - SKE103 - VRMP	9/8/2016	9:15 AM	NA			19.0	61.5	5.8	121					128	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	6/13/2016	8:45 AM	NA			13.9	98.1	10.0	67.6					179	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	6/30/2016	9:15 AM	NA			18.2	91.3	8.7	92					>2420	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	7/15/2016	8:42 AM	NA			20.8	85.2	7.7	98.5					548	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	7/29/2016	8:40 AM	NA			21.3	82.3	7.3	115.4					73	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	8/12/2016	8:37 AM	NA			21.1	92.1	8.1	120.3					152	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	8/26/2016	8:40 AM	NA			20.7	80.7	7.3	120.4					128	
KB-05	KENNEBUNK RIVER - SKE148 - VRMP	9/8/2016	9:25 AM	NA			18.5	83.2	7.7	120.4					128	