Water Quality Monitoring in the Barre-Montpelier area
2017

a report on the Four Rivers Partnership
Volunteer Water Quality Monitoring program
compiled by Shawn White, Project Manager, Friends of the Winooski River

FRIENDS OF THE Winooski

Background

The Four Rivers Partnership is an affiliation of nonprofit organizations, state and local government entities, citizens, and schools focused on Winooski River watershed projects including water quality monitoring. The partnership is named after the four major rivers in the Barre-Montpelier region of central Vermont: the Steven's Branch, North Branch, Dog, and Winooski Rivers. Water quality monitoring by the Four Rivers Partnership on these rivers and their tributaries is managed by the Friends of the Winooski River. Volunteer members of the Four Rivers Partnership have been collecting *E. coli* data since 2008. Starting in 2014, chloride, phosphorus, and turbidity levels have also been tested. Laboratory services were provided by the Vermont Department of Environmental Conservation's VAEL lab via the La Rosa Volunteer Water Quality Monitoring Program.

2017 Water Quality Monitoring Results

In the summer of 2017, the Four Rivers Partnership volunteers collected samples for *E. coli*, phosphorus, and turbidity testing at eighteen sites on the Winooski, Steven's Branch, North Branch, and Dog Rivers (**Table 1** & **Appendix A**), and performed chloride testing at four sites on an unnamed tributary to the Steven's Branch (**Table 2** & **Appendix A**).

Table 1. Four Rivers biweekly *E. coli*, phosphorus, & turbidity sampling sites, 2017

Site ID	Description	Waterbody	Lat / Long	Parameters
WORDAM	Worcester Dam Swimming Hole	North Branch	44.373441, -72.5453	*E. coli,* TP, Turbidity
NBMAIN	Mill Road Swimming Hole	North Branch	44.385342, -72.55088	*E. coli,* TP, Turbidity
NBNC02	North Branch Nature Center Bridge	North Branch	44.28355, -72.57133	*E. coli,* TP, Turbidity
CUMMINGS	Cummings Street Bridge	North Branch	44.27157, -72.57064	*E. coli*
391ELMST	Behind 391 Elm Street	North Branch	44.26937, -72.56917	*E. coli*
MILLPOND	Mill Pond Park Canoe Access	North Branch	44.26766, -72.56882	*E. coli,* TP, Turbidity
PEDBRID	Pedestrian Bridge between Vine and Mechanic Streets	North Branch	44.26527, -72.56904	*E. coli,* TP, Turbidity
SPRINGST	Spring Street Bridge	North Branch	44.26318, -72.5719	*E. coli,* TP, Turbidity
GRANITE	Granite St Bridge	Winooski	44.25180, -72.57064	*E. coli,* TP, Turbidity
MAINSTBR	Main Street Bridge	Winooski	44.25784, -72.57741	*E. coli,* TP, Turbidity
TAYLORBR	Taylor Street Bridge	Winooski	44.25957, -72.57987	*E. coli,* TP, Turbidity
BIKEBR	Montpelier Rail Trail Bridge	Winooski	44.26013, -72.58123	*E. coli,* TP, Turbidity
MONTSTATE	VSECU parking lot	Winooski	44.260668, -72.58317	*E. coli,* TP, Turbidity
MONTHS	Montpelier High School Canoe Access	Winooski	44.261859, -72.58641	*E. coli,* TP, Turbidity
DRMONTREC	Montpelier Recreation Fields	Dog River	44.25188, -72.60126	*E. coli,* TP, Turbidity
DRRIVERTON	Riverton canoe access	Dog River	44.1994, -72.6338	*E. coli,* TP, Turbidity
STEVEB	Partridge Farm Rd Bridge	Stevens Branch	44.232522, -72.551431	*E. coli,* TP, Turbidity
SPAULD	Spaulding Falls	Jail Branch	44.111917, -72.48998	*E. coli,* TP, Turbidity

Table 2. Four Rivers Partnership chloride sampling sites, 2017

KOHLS	Above CVMH on west branch of trib to Steven's Branch	Unnamed Tributary to the Steven's Branch	44.21979 / -72.56205	chloride
KOHLS2	Above CVMH on west branch of unnamed trib to Steven's Branch	Unnamed Tributary to the Steven's Branch	44.21979 / -72.56205	chloride
CVMH-East	Below CVMH on east branch of unnamed trib to Steven's Branch	Unnamed Tributary to the Steven's Branch	44.22103 / -72.55881	chloride
WOODBR	Below CVMH on west branch of unnamed trib to Steven's Branch	Unnamed Tributary to the Steven's Branch	44.22469 / -72.56191	chloride
Macs10	Trib to Steven's Branch behind MacDo's	Unnamed Tributary to the Steven's Branch	44.227861/ -72.550924	chloride

Sampling occurred between 6:00 and 8:00 am on a total of six dates: June 27th, July 11th, July 25th, August 8th (or 9th, in the case of the WORDAM and NBMAIN sites), August 22nd, and September 5th. Samples were kept on ice and immediately transported to the Vermont Environmental and Agricultural Laboratory for laboratory analysis.

Since rainfall can wash pollutants into streams, it is important to consider the rainfall amounts on and just before the sampling date. Two of the sampling dates, July 25 and Aug 8, occurred the day after rain events, when 0.75 inches and 0.35 inches of rain were recorded at the nearby Barre-Montpelier Knapp State Airport, respectively. **Table 3** below shows the cumulative rainfall amounts for the 4 days prior to each sampling date. Rainfall on the morning of the sampling was limited to light rain on 7/11/17, 7/25/17, and 8/8/17.

Table 3. Rainfall on the sampling date and 1-4 days before sampling.

Date	rainfall the day of sampling before 8 am	rainfall on the day prior to sampling (1 day before)	cumulative rainfall 2 days before sampling (days 1+2)	cumulative rainfall 3 days before sampling (days 1+2+3)	cumulative rainfall 4 days before sampling (days 1+2+3+4)
6/27/17	0	0	0.07	0.86	2.11
7/11/17	0.03	0	0	0.41	0.51
7/25/17	0.04	0.75	0.75	0.75	0.76
8/8/17	0.08	0.35	0.35	0.65	0.65
8/9/17	0	0.08	0.42	0.42	0.72
8/22/17	0	0	0	0.01	0.8
9/5/17	0	0	1.01	1.01	1.01

Rainfall amounts for the day of sampling were obtained using the hourly weather observations listed on the Weather Underground Weather History webpage (https://www.wunderground.com/history/) for the Edward Knapp State Airport weather station (KMPV) near Montpelier. The total daily amounts used to calculate the 1- 4-day rainfall amounts were downloaded from the National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/).

Weather conditions on and in the few days prior to the sampling dates meant most sampling occurred during medium to high flow levels, as confirmed by samplers' observations in the field and the nearby USGS stream gauges on the North Branch and Winooski Rivers (see **Appendix D**). The discharges measured at the USGS stream gauges on the Winooski River downtown of Montpelier, the North Branch River downstream of the Wrightsville dam, and on the Dog River at Northfield Falls are shown in **Tables 4**, **5** and **6**. None of the flow levels were extremely high or

low and most of the flow levels on the sampling dates came fairly close to falling in the middle 50% of historical flows (the Q25-Q75 range).

Table 4. Winooski River daily discharge at the USGS stream gauge downstream of Montpelier

Date	Daily discharge (cuft3/s)	Quartile	Corresponding flow level based on quartile
6/27/17	854	>Q75	high
7/11/17	820	>Q75	high
7/25/17	762	>Q75	high
8/8/17	396	Q25-75	medium
8/22/17	251	Q25-75	medium
9/5/17	499	Q25-75	medium

Daily discharge at the Winooski at Montpelier stream gauge (USGS 04286000) on the six 2017 sampling dates, with corresponding quartiles and flow levels. Daily flow data was retrieved from the National Water Information System Web Interface: https://waterdata.usgs.gov/nwis/dv/?site_no=04286000&agency_cd=USGS&referred_module=sw
USGS discharge statistics for this gauge in cuft3/s: Min=17.0, 25th %=196.0, Mean = 615.7, 75th % = 690.0, Max = 12,200 as retrieved from https://waterwatch.usgs.gov/index.php?sno=Winooski+&ds=dv01d_por&btnGo=GO&m=sitempnn) on January 24, 2018.

Table 5. North Branch River daily discharge at the USGS stream gauge downstream from Wrightsville Dam

Date	Daily discharge (cuft3/s)	Quartile	Corresponding flow level based on quartile
6/27/17	136	Q25-75	medium
7/11/17	121	Q25-75	medium
7/25/17	158	>Q75	high
8/8/17	38.6	Q25-75	medium
8/22/17	30.0	<Q25	low
9/5/17	66.6	Q25-75	medium

Daily discharge at the North Branch below Wrightsville Dam stream gauge (USGS 0428550) on the six 2017 sampling dates, with corresponding quartiles and flow levels. Daily flow data was retrieved from the National Water Information System Web Interface: https://waterdata.usgs.gov/nwis/dv/?site_no=04286000&agency_cd=USGS&referred_module=sw
USGS discharge statistics for this gauge in cuft3/s: Min=0.2, 25th %=31.0, Mean = 140.4, 75th % = 153.0, Max = 1620 as retrieved from https://waterwatch.usgs.gov/index.php?sno=Winooski+&ds=dv01d_por&btnGo=GO&m=sitempnn) on January 24, 2018.

Table 6. Dog River daily discharge at the USGS stream gauge downstream from Wrightsville Dam

Date	Daily discharge (cuft3/s)	Quartile	Corresponding flow level based on quartile
6/27/17	139	>Q75	high
7/11/17	164	>Q75	high
7/25/17	182	>Q75	high
8/8/17	67.6	Q25-75	medium
8/22/17	51.2	Q25-75	medium
9/5/17	77.3	Q25-75	medium

Daily discharge at the Dog River stream gauge (USGS 04287000) on the six 2017 sampling dates, with corresponding quartiles and flow levels. Daily flow data was retrieved from the National Water Information System Web Interface: https://waterdata.usgs.gov/vt/nwis/dv?referred_module=sw&site_no=04287000
USGS discharge statistics for this gauge in cuft3/s: Min=4.3, 25th %=33, Mean = 129.7, 75th % = 138, Max = 6070 as retrieved from https://waterwatch.usgs.gov/index.php?sno=Dog+River+at+Northfield&ds=dv01d_por&btnGo=GO&m=sitempnn on March 5, 2018.

2017 *E. coli* results

Escherichia coli (*E. coli*) is a species of bacteria found in the lower digestive tract of mammals and is commonly used as an indictor of fecal contamination in rivers, streams, lakes, and oceans. While most strains of *E. coli* do not themselves cause disease, their presence may be associated with other bacteria and viruses that are pathogenic. *E. coli* amounts are often given in units of most probable number (mpn) - a reflection of the laboratory test used to measure the number of *E. coli* cells in a sample. Both the Vermont and US EPA standards for *E. coli* are based on the geometric mean of samples taken over a period of time and/or single sample measurements. The Vermont and EPA standards for the geometric mean *E. coli* level for Class B waters is 126 mpn /100mL. This corresponds to a level in which there is a probability that 32-36 individuals/1000 would get sick from water contact. To meet the single sample measurement standards, less than 10% of the single sample measurements can have *E. coli* levels above the single sample maximum (SSM) value of 235 mpn/100mL.

A summary of the results for each site relative to the geometric mean and single sample maximum standards are shown as a box plot in **Figure 1**. Geometric mean *E. coli* numbers along the North Branch River were consistently low at the North Branch Nature Center and hovered just above the EPA standard at the sites downstream of the CUMMINGS Street Bridge location. Two sites (CIMMINGSST and MILLPD) saw one single sample value above the 235 mpn/100mL standard; since only 6 samples were taken from each site in the sampling season, this translates to 16% of the samples taken.

The geometric mean, median, maximum, and minimum values on the Winooski River, in contrast, were more variable than on North Branch and were well above both the geometric mean and single sample standards, particularly downstream of the MAINST bridge. The sharp increase in the *E. coli* between Main Street and Taylor Street is striking, especially since the two bridges are not very far from each other. This uptick seems to suggest a fecal matter source somewhere between the two sites.

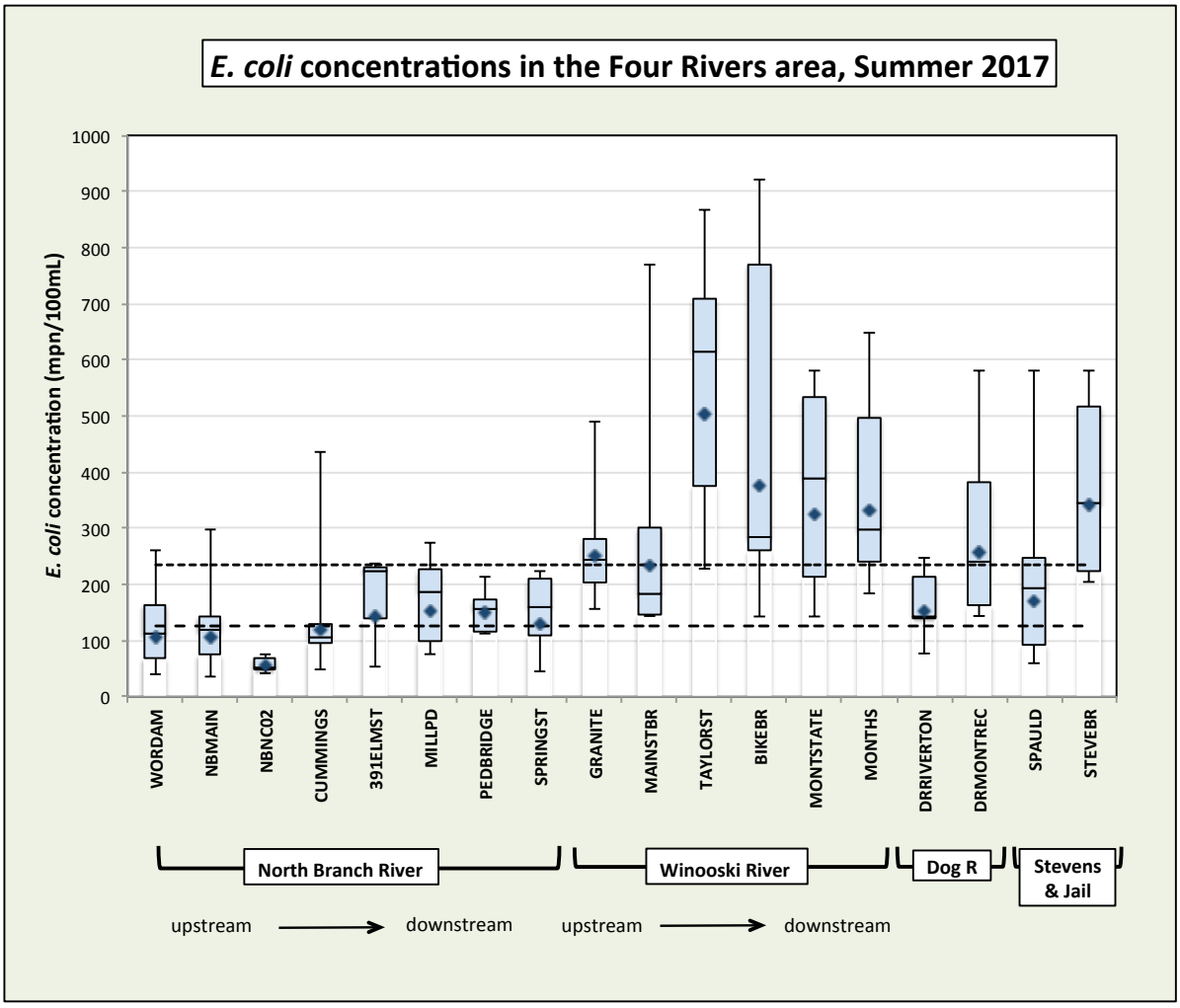

Figure 1. Box and whisker plot of 2017 *E. coli* concentrations at Montpelier, VT water quality sampling locations on the North Branch and Winooski Rivers. The geometric mean values for each site are shown by the blue diamonds (♦), the single sample maximum standard by the short-dotted line (-----), and the geometric mean by the longer-dotted line (— — —). First and third quartiles are shown by the light blue boxes, separated by the median value. Minimum and maximum values are shown by the whiskers.

Figure 2 shows the individual sample results for each site relative to the EPA's 235 mpn/100mL single sample maximum (SSM) standard. Most of the individual samples taken on the North Branch River had *E. coli* concentrations below 235 mpn/100mL maximum while levels in the Winooski River often exceeded this standard, especially on the last four sampling dates and at TAYLORST, BIKEBR, MONTSTATE, and MONTHS. Early-season samples taken on the first two sampling dates (6/27 and 7/11) were generally lower than later in the season. Samples collected on 7/25, 8/22, and 9/5 dates generally had the highest levels.

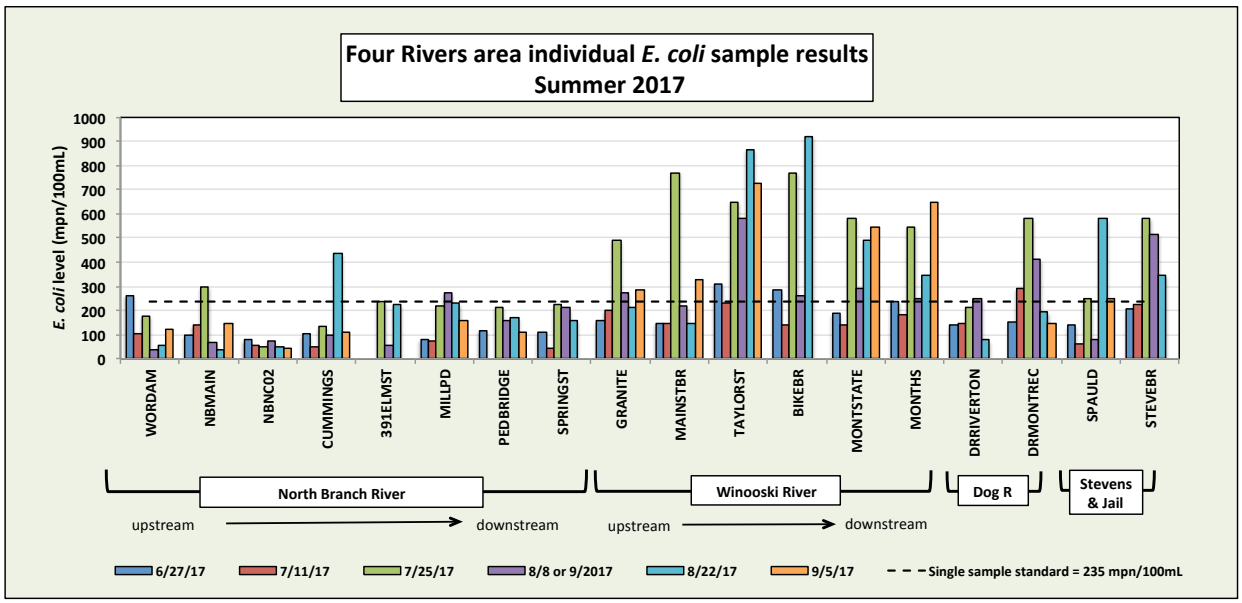

Figure 2. Individual *E. coli* sample results for 6 sampling dates at 20 sampling locations on the North Branch and Winooski Rivers in Montpelier, VT. The EPA standard for individual samples is shown by the dotted line. The WORDAM and NBMAIN sites were sampled on 8/9/17, while the remaining sites were sampled on 8/8/17.

Based on our sampling in previous years, we have found that *E. coli* levels typically show a spike during an approximately 2-day period after moderate to heavy rainfall since stormwater runoff carries animal waste from livestock, pets, manure, and wildlife to streams. Conversely, *E. coli* levels are usually lowest during dry periods when flows are low. In 2017, however, this pattern does not seem to hold completely. While results on 7/25 and 9/5/17 were predictably somewhat elevated due to > 0.5 inches of rainfall within 48 hours before sampling, they were lowest on the 6/27 and 7/11 dates despite high flows on both rivers. The relatively high *E. coli* results for CUMMINGS, TAYLOR/BIKEBR, and SPAULD on 8/22/17 are particularly interesting since the *E. coli* were higher on this date than for any other despite both dry weather and lower flow levels.

The month of June in 2017 was very wet, with a total of 8.6 inches of rain reported at the nearby Knapp State Airport weather station in Berlin, VT. Groundwater levels were therefore probably high, and groundwater flow to the rivers would likely have diluted the *E. coli* concentrations. In addition, very little rain fell within 48 hours of the sampling, so the effects of stormwater runoff were probably minimal. Taken together, the dry weather and high groundwater contribution to flow probably account for the low levels of *E. coli* observed on 6/27 and 7/11.

High *E. coli* levels at CUMMINGS, TAYLORST/BIKEBR, and SPAULD on 8/22/17 may have been due to sampling error or a chance occurrence that introduced fecal matter directly into the water upstream of these sites just before sampling. However, either of these explanations would have had to affect all three sites, which seems unlikely. There is also a chance that a combined sewer overflow event on 8/18/17 at a nearby CSO structure immediately downstream from the Taylor Street Bridge may have influenced the 8/22/17 results at TAYLORST and the downstream BIKEBR location. This also seems unlikely since we sampled from the upstream side of the Taylor

Street Bridge, well away from the CSO point and *E. coli* cells usually do not remain viable that long. Finally, the high levels of *E. coli* at CUMMINGS, TAYLORST/BIKEBR, and SPAULD may reveal illicit sewer connections or leaks that were diluted or masked by higher flows on the other dates. We have suspected *E. coli* sources to exist between NCNB02 and MILLPD on the North Branch, and between GRANITE and MONTSTATE on the Winooski based on our results from previous years (see Figure 4, below). The 8/22 results, therefore, may help us hone in on the locations of these sources, one of which appears to be between the Main Street and Taylor Street bridges, and one upstream of the Cummings Street bridge. Clearly, more investigation is needed, and we plan to include further sampling of these three areas in our 2018 sampling season.

2017 Phosphorus results

Phosphorus is the main pollutant of concern in Lake Champlain and can cause problems in rivers and streams as well. As a nutrient limiting the growth of algae, any increases in its concentration can result in algal blooms that discourage recreation and are sometimes toxic. Furthermore, when the algal cells die, their decomposition depletes the water of oxygen needed by fish and other aquatic organisms, causing a reduction in the quality of aquatic habitat. Phosphorus sources include fertilizers, manure, pet waste, and organic matter. Sediment from erosion of soils, streambeds, or streambanks also contributes to phosphorus levels since phosphorus tends to adhere to soil particles.

The Vermont standard for phosphorus in streams is based on concentrations during low flow conditions and depends on the class, gradient, size, and average temperature of the stream. With the exception of the 8/22/17 sampling at the North Branch River sites, the 2017 sampling did not coincide with dates when area rivers had low flow. The total phosphorus concentrations of individual samples collected in the Four Rivers area in 2017 is shown in **Figure 3**.

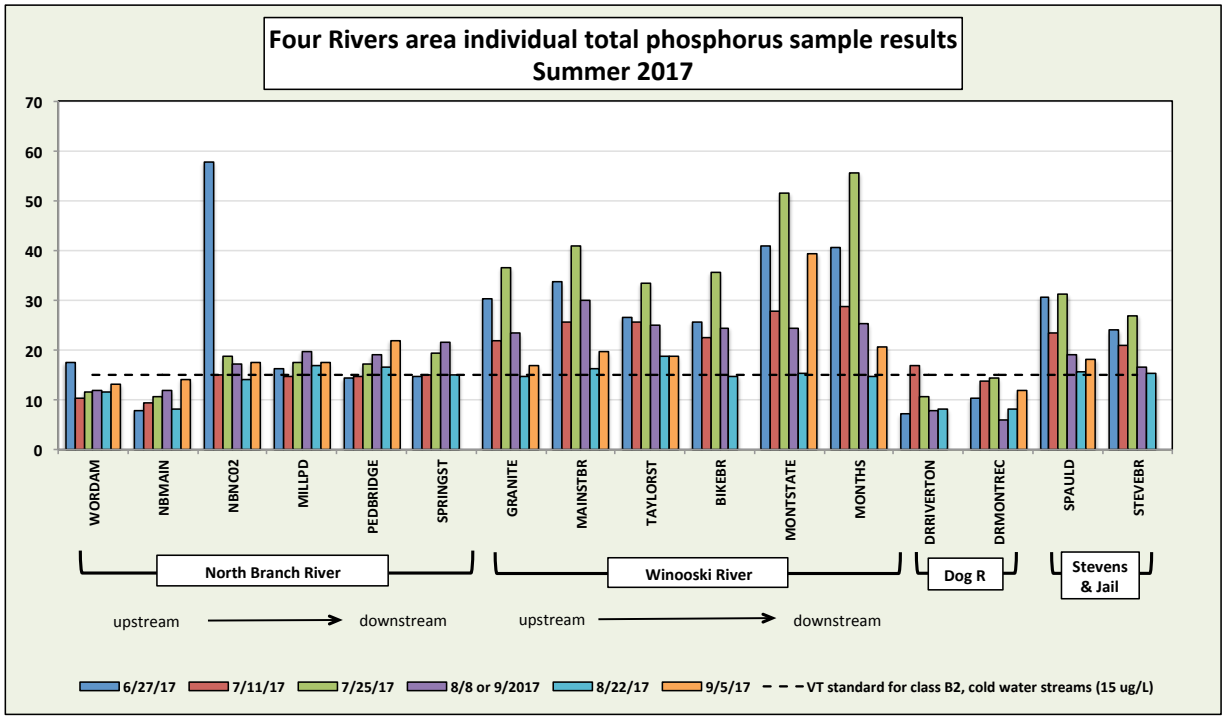

Figure 3. Total phosphorus results for each sample collected in the Four Rivers area in 2017. The Vermont standard (at low-flow) for Class B2, cold, medium, high-gradient streams of 15 ug/L is indicated by the dotted line.

Phosphorus levels were highest and most variable on the Winooski River, where concentrations were highest on 7/25/17, the day after a 0.75" rainstorm, and on 6/27/17, during highest flow of the season. Stormwater runoff therefore appears to be bringing phosphorus into the Winooski, while high flow alone (as on 6/27) may be eroding streambeds and banks, thereby increasing total phosphorus levels. The Steven's Branch and Jail Branch Rivers also seem to be affected by runoff and high flow. The Dog and North Branch River sites, on the other hand, had lower phosphorus levels and seem to have been relatively unaffected by both high flow and stormwater runoff. All sites had phosphorus levels that met or just exceed the VT standard on 8/22/17, when conditions were closest to low flow.

2017 Turbidity Results

The 2017 results of each individual turbidity sample are shown in **Figure 4**. For all sites on the North Branch, Stevens, and Dog Rivers, turbidity levels were consistently below the average annual turbidity standard of 10 nephelometric units (NTU) for cold-water habitat regardless of flow levels. Turbidity levels at the sites on the Winooski River, however, often exceeded the standard, but only when flow levels were high (as on 6/27/17), or the day after significant rainfall (7/25/17 and 8/8/17). Since the Vermont standard for turbidity is based on the average annual results under dry weather base-flow conditions, the only dates the standard can be applied to the results from sites on the Winooski River were those toward the end of the season 8/22/17, and 9/5/17, when no rain

had fallen the day prior to sampling and samplers reported base flow conditions. On these two dates turbidity levels met the Vermont standard at all sites.

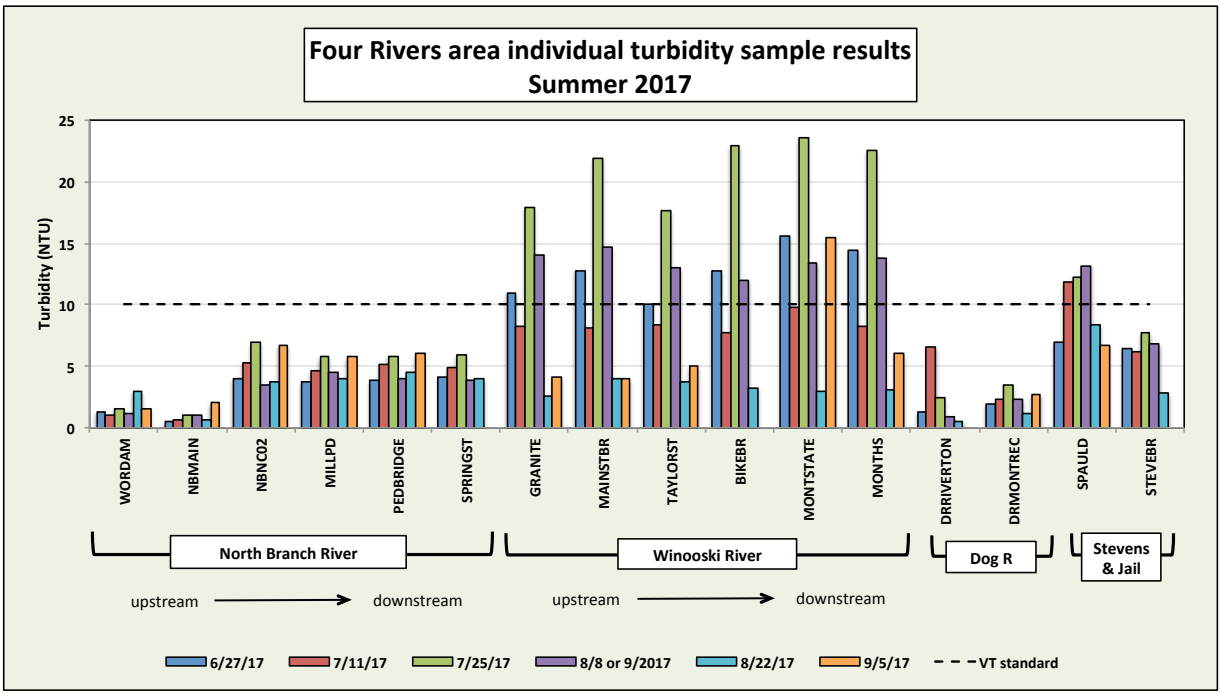

Figure 4. Turbidity results for each sample collected in the Four Rivers area in 2017. The Vermont standard for annual average turbidity in Class B2, cold, medium, high-gradient streams under dry weather base-flow conditions (10 NTU) is indicated by the dotted line.

2016 Chloride Results

According to the Vermont Surface Water Management Strategy, chloride levels above 230 mg/L can lead to poor health and reduced reproduction in aquatic species and may increase stratification in ponds and lakes, thereby inhibiting natural mixing and limiting oxygen availability. Chloride levels in streams tend to be higher during dry times of the year when ground water contributes a larger proportion of water than in wetter times of the year, when rainfall has a diluting effect. Chloride sources include road deicing salts, wastewater, and leachate from landfills. Predictably, chloride levels tend to spike in the spring when road salts are washed into streams during spring rains and snowmelt.

In previous years, the Four Rivers Partnership sampled chloride in several area tributaries. One site, Macs 10, located at the mouth of a small tributary to Steven's Branch, had chloride concentrations well above Vermont's average allowable concentration standard of 230 mg/L in 2012, 2015, and 2016 (**Figure 5**). The average allowable concentration standard is the highest concentration of the pollutant to which aquatic life can be exposed for an extended period of time (4 days) once every three years without deleterious effects. All six samples taken during dry weather at Macs 10 have had levels above 428 mg/L. There is a high likelihood, therefore, that the chloride levels tend to exceed 230 mg/L for more than 4 days at a time. All samples taken at this site,

however, had chloride levels below the VT "acute" maximum allowable concentration (MAC) standard for chloride of 860 mg/L. Rain events have a diluting effect on the chloride levels at this site (data not shown).

Table 7. Chloride levels during dry, low flow conditions in at Macs 10, a site on an unnamed tributary to the Steven's Branch, in mg/L.

Site ID	Date	Chloride (mg/L)
Macs 10	8/12/12	555
Macs 10	8/4/15	571
Macs 10	8/18/15	541
Macs 10	9/1/15	596
Macs 10	7/5/16	485
Macs 10	8/30/16	428
Macs 10	7/11/17	465
Macs 10	8/22/17	400
Macs 10	10/14/17	414

A potential source of the high chloride levels at Macs 10 may have been located during stormwater outfall monitoring done by the Friends of the Winooski River in Berlin in 2015. High conductivity readings were detected in the discharge from three outfalls adjacent to the Central Vermont Medical Center parking lots. The discharges from these outfalls feed into two branches of the Macs 10 site tributary. It appears that groundwater contaminated with chloride-containing road salts may be entering the stormwater system somehow, resulting in the high conductivity readings.

To better document the chloride source, the Four Rivers partnership sampled chloride levels above and below the CVMC parking lots in 2016 and 2017 on the two tributary branches that flow on either side of the medical center (see map, **Figure 5**). The results of the 2016 and 2017 chloride sampling in the area around the CVMC and at the Macs10 site are shown in **Figure 6**. Levels upstream of the medical center at the KOHLS site, were lower than at the downstream CVMH-EAST and WOODBR sites, but were nevertheless usually elevated beyond the Vermont average allowable chloride standard. Chloride concentrations downstream of the medical center on both branches of the tributary were significantly higher, with highest readings on the eastern branch of the stream. Chloride levels were lower after rainfall of 0.21" on 8/1/16 and 0.75" on 7/25/17 at the Macs 10 site, but were generally unaffected by rainfall at the other sites. These results are consistent with road salt use on the CVMH parking lots having contaminated the area's groundwater, which in turn carries the chloride into the nearby streams.

Figure 5. Chloride sampling sites on the unnamed tributary to the Steven's Branch, Berlin, VT.

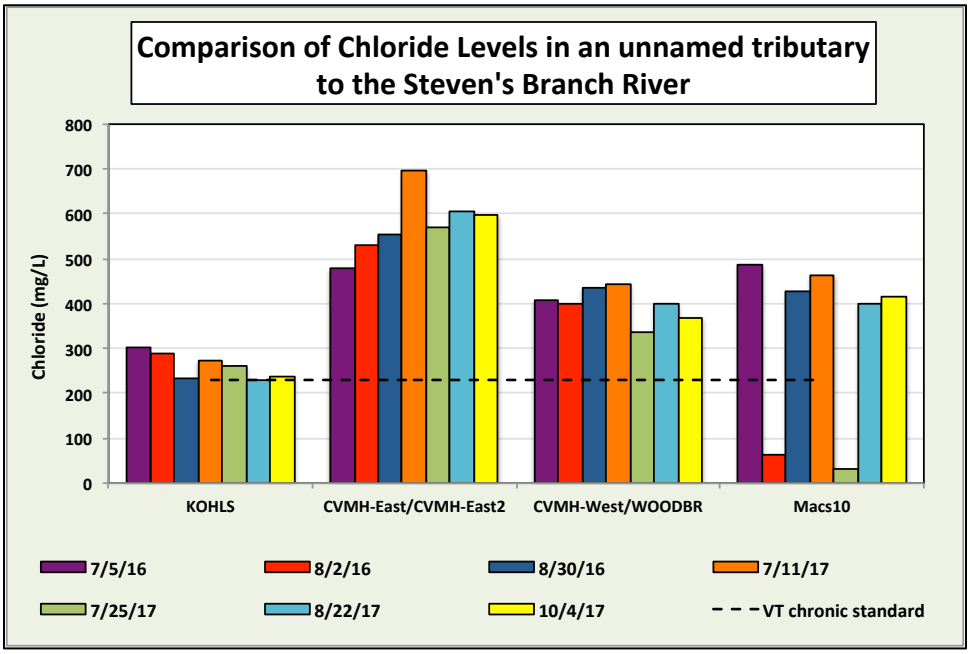

Figure 6. 2016 and 2017 chloride results for four sites on an unnamed tributary to the Steven's Branch. The sites on the eastern and western branches of the tributary were moved slightly further downstream from CVMH-East to CVMH-East2 and CVMH-West to WOODBR, respectively, after the 7/5/16 sampling due to accessibility problems.

Appendix A. Sampling Site Location Maps

Figure 1. The locations of the upper North Branch sampling sites in Worcester, VT, where samples for *E. coli*, total phosphorus, and turbidity were collected.

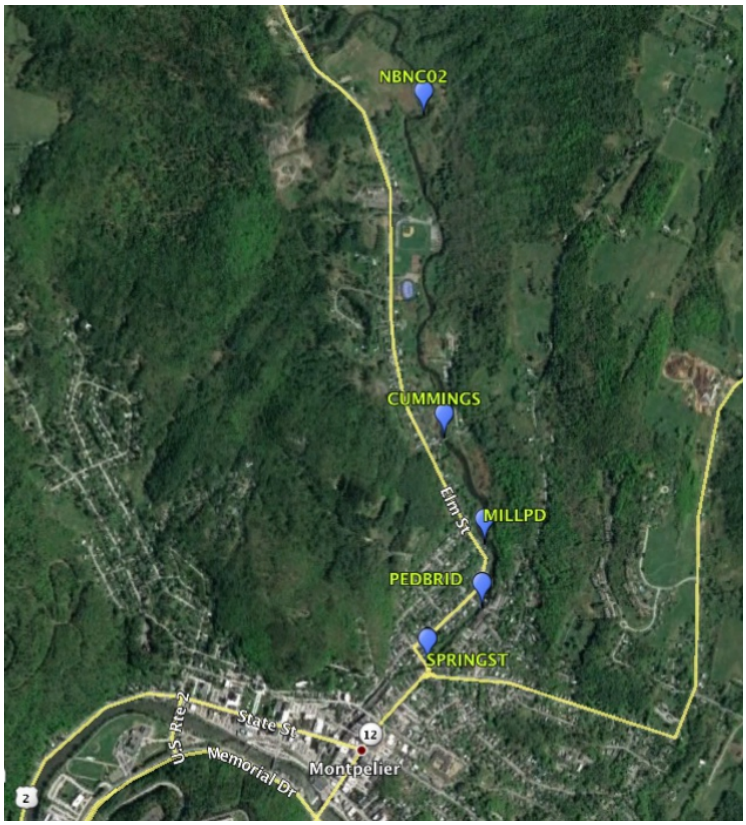

Figure 2. Map showing the locations of the lower North Branch River 2017 sampling sites in Montpelier, VT. *E. coli*, total phosphorus, and turbidity samples were collected at all sites except CUMMINGS and 391ELMST, where only E. *coli* samples were collected.

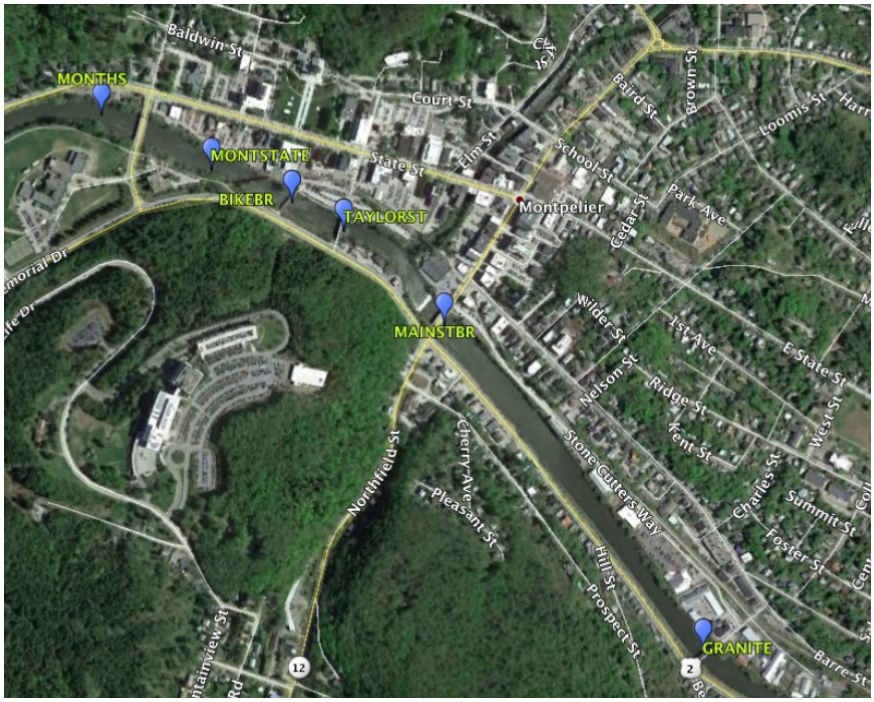

Figure 3. Map showing the locations of the sites on the main stem of the Winooski River in Montpelier, VT where *E. coli*, phosphorus, and turbidity samples were collected in 2017.

Figure 4. Map showing the locations of the sites on the Dog River in Berlin and Montpelier, VT where *E. coli*, phosphorus, and turbidity samples were collected in 2017.

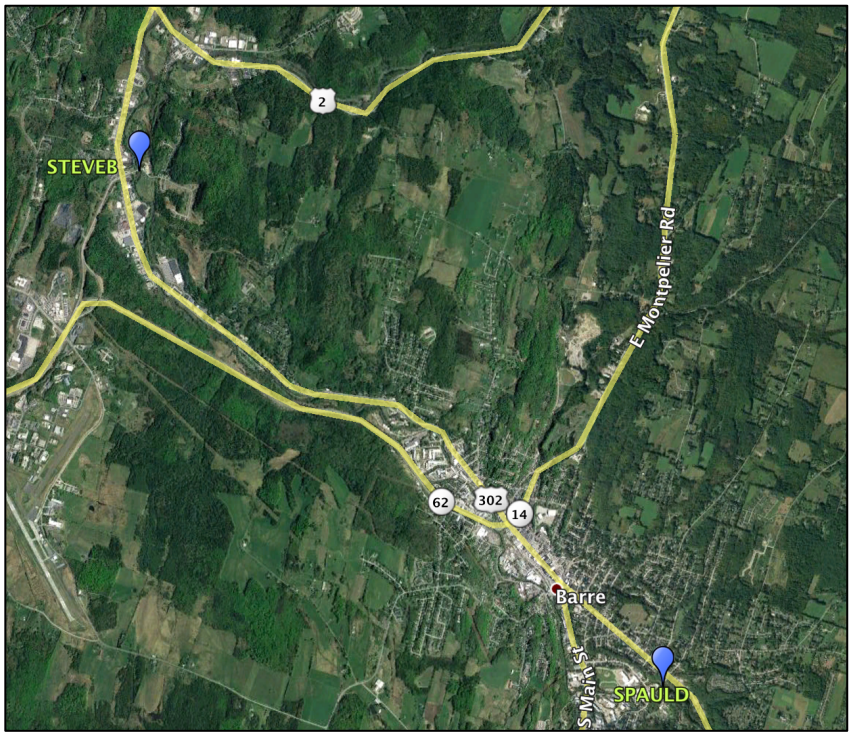

Figure 5. Map showing the locations of the sites on the Stevens and Jail Branches in Berlin and Barre, VT where *E. coli*, phosphorus, and turbidity samples were collected in 2017.

Figure 6. Map showing the locations of the sites on the small unnamed tributary to the Stevens Branch where chloride samples were collected in 2017.

Appendix B. Quality assurance measures for chloride, *E. coli*, total phosphorus, and turbidity sampling in 2017

Test	Site	Date	A	D	B	Relative % Difference
Chloride	CMVH-East	7/25/17	570	595	<2	4.2
	Macs 10	6/27/17	35.7	35.7	<2	0
	KOHLS	8/30/17	238	243	<2	2.0
Chloride Mean Relative % Difference						**2.1**
Chloride Mean Blank Concentration					**<2**	
E. coli	BIKEBR	8/22/17	920.84	547.5	<1	50.8
	DRMONTREC	8/22/17	193.49	108.07	<1	56.6
	GRANITE	7/11/17	201.42	128.09	<1	44.5
	GRANITE	8/8/17	275.51	365.4	<1	28.0
	MILLPD	7/11/17	75.89	69.07	<1	9.4
	MONTHS	8/8/17	248.9	344.8	<1	32.3
	NBMAIN	6/27/17	98.67	107.58	<1	8.6
	NBNC02	6/27/17	77.12	86	<1	10.9
	PEDBRID	7/25/17	214.26	344.8	<1	46.7
	SPAULD	9/5/17	248.09	165.76	<1	39.8
	TAYLORST	7/25/17	648.82	648.82	<1	0
***E. coli* Mean RPD**						**29.8**
***E. coli* Mean Blank Concentration**					**<1**	
Total P	BIKEBR	8/22/17	14.7	15.5	< 5	5.3
	DRMONTREC	8/22/17	7.99	8.99	< 5	11.8
	GRANITE	7/11/17	21.9	22.1	< 5	0.9
	GRANITE	8/8/17	23.3	26.7	<5	13.6
	MILLPD	7/11/17	14.8	15.5	< 5	4.6
	MONTHS	8/8/17	25.2	24.1	< 5	4.5
	NBMAIN	6/27/17	7.97	8.31	< 5	4.2
	NCNB02	6/27/17	57.7	56.2	*77.1	2.6
	PEDBRID	7/25/17	17.1	18.4	< 5	7.3
	SPAULD	9/5/17	18.2	18.9	< 5	3.8
	TAYLORST	7/25/17	33.4	37.9	< 5	12.6
Total Phosphorus Mean RPD						**6.5**
Total Phosphorus Mean Blank Concentration					***<5**	
Turbidity	BIKEBR	8/22/17	3.2	2.81	<0.2	13.0
	DRMONTREC	8/22/17	1.16	0.99	<0.2	15.8
	GRANITE	7/11/17	8.23	8.17	< 0.2	0.7
	GRANITE	8/8/17	14.1	13.4	< 0.2	5.1
	MILLPD	7/11/17	4.7	4.46	< 0.2	5.2

	MONTHS	8/8/17	13.8	14.1	< 0.2	2.2
	NBMAIN	6/27/17	0.52	0.52	< 0.2	0
	NBNC02	6/27/17	3.97	4.24	< 0.2	6.6
	PEDBRID	7/25/17	5.85	6.22	0.97	6.1
	SPAULD	9/5/17	6.76	7.55	< 0.2	11.0
	TAYLORST	7/25/17	17.6	16	< 0.2	9.5
11Turbidity Mean RPD						**6.8**
Turbidity Mean Blank Concentration				**0.26**		

Appendix C. Project Completeness

Table 7c – Project Completeness

Parameter	Number of Samples Anticipated	Number of Valid Samples Collected & Analyzed	Percent Complete *
Chloride	30	19	63%
Total and Dissolved Phosphorus	100	60	60%
E. coli	80	61	75%
Turbidity	100	61	60%

[1]These numbers include the blanks and duplicates

* Percent Complete = # of Valid Samples Collected and Analyzed / # of Samples Anticipated

Low percentage complete numbers were due to a lack of 2017 rain events that coincided with volunteer availability, which prevented us from collecting some of our anticipated samples. In addition, we decided to only collect chloride during dry weather (due to a lack of volunteers willing to sample at these sites), so no samples were collected on two of our regular sampling dates.

Appendix D. Individual Sample Data

Sample Number	Location	Date	Chloride (mg/L)	*E. coli* (mpn/100ml)	TP (ug/L)	Turbidity (NTU)	Flow Level Reported by Sampler	Flow Category Reported by Sampler	Flow Level according to USGS gauge discharge and historical data*
170468-01	NBMAIN	6/27/17		98.67	7.97	0.52	medium	baseflow	medium
170468-02	NBMAIN-BLANK	6/27/17		< 1	< 5	< 0.2	medium	baseflow	medium
170468-03	NBMAIN-DUP	6/27/17		107.58	8.31	0.52	medium	baseflow	medium
170468-04	WORDAM	6/27/17		261.25	17.6	1.27	medium	baseflow	medium
170468-05	NBNC02	6/27/17		77.12	57.7	3.97	medium	freshet	medium
170468-06	NBNC02-BLANK	6/27/17		< 1	77.1	< 0.2	medium	freshet	medium
170468-07	NBNC02-DUP	6/27/17		86	56.2	4.24	medium	freshet	medium
170468-08	CUMMINGSBR	6/27/17		101.93	14.3	4.79	high	freshet	medium
170468-09	MILLPD	6/27/17		81.26	16.2	3.68	high	freshet	medium
170468-10	PEDBRID	6/27/17		116.19	14.4	3.85	medium	freshet	medium
170468-11	SPRINGST	6/27/17		109.51	14.6	4.08	medium	baseflow	high
170468-12	GRANITE	6/27/17		155.25	30.3	11	high	baseflow	high
170468-13	MAINSTBR	6/27/17		148.3	33.6	12.8	high	freshet	high
170468-14	TAYLORST	6/27/17		307.59	26.6	10.1	high	freshet	high
170468-15	BIKEBR	6/27/17		285.1	25.6	12.7	medium	baseflow	high
170468-16	MONTSTATE	6/27/17		186	40.8	15.6	medium	baseflow	high
170468-17	MONTHS	6/27/17		238.22	40.7	14.4	medium	baseflow	high
170468-18	SPAULD	6/27/17		137.35	30.7	6.94	medium	freshet	na
170468-19	STEVEBR	6/27/17		204.59	23.9	6.41	high	baseflow	na
170468-20	DRMONTREC	6/27/17		151.52	10.4	1.93	high	baseflow	high
170468-21	DRRIVERTON	6/27/17		139.58	7.28	1.28	medium	baseflow	high
170468-22	Macs10	6/27/17	35.7				high	freshet	na
170468-23	Macs10-BLANK	6/27/17	< 2				high	freshet	na
170468-24	Macs10-DUP	6/27/17	35.7				high	freshet	na
170469-01	NBMAIN	7/11/17		139.58	9.23	0.59	medium	baseflow	medium
170469-02	WORDAM	7/11/17		104.97	10.4	1.09	medium	baseflow	medium
170469-03	NBNC02	7/11/17		53.81	15.1	5.32	medium	baseflow	medium
170469-04	CUMMINGSBR	7/11/17		48.74	14.6	5.41	high	freshet	medium
170469-05	MILLPD	7/11/17		75.89	14.8	4.7	medium	baseflow	medium
170469-06	MILLPD-BLANK	7/11/17		< 1	< 5	< 0.2	medium	baseflow	medium
170469-07	MILLPD-DUP	7/11/17		69.07	15.5	4.46	medium	baseflow	medium
170469-08	PEDBRID	7/11/17			14.7	5.2	high	freshet	medium
170469-09	SPRINGST	7/11/17		44.34	15.1	4.87	medium	baseflow	medium

170469-10	GRANITE	7/11/17		201.42	21.9	8.23	high	freshet	high
170469-11	GRANITE-DUP	7/11/17		128.09	22.1	8.17	high	freshet	high
170469-12	GRANITE-BLANK	7/11/17		< 1	< 5	0.47	high	freshet	high
170469-13	MAINSTBR	7/11/17		143.87	25.5	8.15	medium	freshet	high
170469-14	TAYLORST	7/11/17		228.18	25.7	8.32	medium	freshet	high
170469-15	BIKEBR	7/11/17		142.09	22.5	7.74	medium	baseflow	high
170469-16	MONTSTATE	7/11/17		142.09	27.9	9.83	medium	baseflow	high
170469-17	MONTHS	7/11/17		184.18	28.6	8.25	medium	baseflow	high
170469-18	SPAULD	7/11/17		59.8	23.5	11.8	medium	baseflow	na
170469-19	STEVEBR	7/11/17		222.36	21	6.18	medium	baseflow	na
170469-20	DRMONTREC	7/11/17		290.93	13.7	2.27	high	baseflow	high
170469-21	DRRIVERTON	7/11/17		143.87	16.8	6.58	medium	baseflow	high
170469-22	Macs10	7/11/17	465				medium	baseflow	na
170469-23	WOODBR	7/11/17	445				medium	baseflow	na
170469-25	WOODBR-DUP	7/11/17	434				medium	baseflow	na
170469-26	CMVH-East	7/11/17	696				medium	baseflow	na
170469-27	KOHLS	7/11/17	274				medium	baseflow	na
170910-01	NBMAIN	7/25/17		298.66	10.7	1.02	medium	freshet	high
170910-02	WORDAM	7/25/17		178.53	11.6	1.61	medium	freshet	high
170910-03	NBNC02	7/25/17		50.36	18.6	6.92	medium	freshet	high
170910-04	CUMMINGSBR	7/25/17		135.4	18.3	5.92	high	freshet	high
170910-05	MILLPD	7/25/17		218.72	17.4	5.76	high	freshet	high
170910-06	PEDBRID	7/25/17		214.26	17.1	5.85	medium	freshet	high
170910-07	PEDBRID-BLANK	7/25/17		< 1	< 5	0.97	medium	freshet	high
170910-08	PEDBRID-DUP	7/25/17		344.8	18.4	6.22	medium	freshet	high
170910-09	SPRINGST	7/25/17		224.68	19.4	5.98	medium	freshet	high
170910-10	GRANITE	7/25/17		488.44	36.5	17.9	high	freshet	high
170910-11	MAINSTBR	7/25/17		770.1	40.8	21.9	medium	freshet	high
170910-12	TAYLORST	7/25/17		648.82	33.4	17.6	medium	freshet	high
170910-13	TAYLORST-BLANK	7/25/17		< 1	< 5	< 0.2	medium	freshet	high
170910-14	TAYLORST-DUP	7/25/17		648.82	37.9	16	medium	freshet	high
170910-15	BIKEBR	7/25/17		770.1	35.5	22.9	medium	freshet	high
170910-16	MONTSTATE	7/25/17		579.43	51.4	23.6	medium	freshet	high
170910-17	MONTHS	7/25/17		547.5	55.5	22.5	medium	freshet	high
170910-18	SPAULD	7/25/17		248.9	31.1	12.2	medium	freshet	na
170910-19	STEVEBR	7/25/17		579.43	27	7.67	medium	baseflow	na
170910-20	DRMONTREC	7/25/17		579.43	14.3	3.45	medium/high	freshet	high
170910-21	DRRIVERTON	7/25/17		214.16	10.7	2.45	medium/high	freshet	high
170910-22	Macs10	7/25/17	31.4				medium	baseflow	na
170910-23	WOODBR	7/25/17	338				medium	freshet	na
170910-24	CMVH-East	7/25/17	570				medium	freshet	na
170910-25	CMVH-East-BLANK	7/25/17	< 2				medium	freshet	na

170910-26	CMVH-East-DUP	7/25/17	595				medium	freshet	na
170910-27	KOHLS	7/25/17	260				medium	freshet	na
170910-29	ELMST391	7/25/17		235.93			medium	freshet	high
171035-01	NBMAIN	8/9/17		67.66	11.9	1.06	no field sheet	no field sheet	medium
171035-02	WORDAM	8/9/17		40.2	11.9	1.22	no field sheet	no field sheet	medium
171035-03	NBNC02	8/8/17		75.89	17.1	3.48	medium	baseflow	medium
171035-04	CUMMINGSBR	8/8/17		95.9	19.9	3.58	medium	baseflow	medium
171035-05	MILLPD	8/8/17		275.51	19.7	4.45	medium	freshet	medium
171035-06	PEDBRID	8/8/17		156.48	18.9	3.96	low	baseflow	medium
171035-07	SPRINGST	8/8/17		209.82	21.6	3.92	low	baseflow	medium
171035-08	GRANITE	8/8/17		275.51	23.3	14.1	medium	baseflow	medium
171035-09	GRANITE-BLANK	8/8/17		< 1	< 5	< 0.2	medium	baseflow	medium
171035-10	GRANITE-DUP	8/8/17		365.4	26.7	13.4	medium	baseflow	medium
171035-11	MAINSTBR	8/8/17		218.72	30.1	14.7	low/medium	freshet	medium
171035-12	TAYLORST	8/8/17		579.43	24.9	13	low/medium	freshet	medium
171035-13	BIKEBR	8/8/17		260.25	24.5	12	medium	freshet	medium
171035-14	MONTSTATE	8/8/17		290.93	24.4	13.4	medium	freshet	medium
171035-15	MONTHS	8/8/17		248.9	25.2	13.8	medium	freshet	medium
171035-16	MONTHS-BLANK	8/8/17		< 1	< 5	< 0.2	medium	freshet	medium
171035-17	MONTHS-DUP	8/8/17		344.8	24.1	14.1	medium	freshet	medium
171035-18	SPAULD	8/8/17		78.94	19.2	13.2	medium	freshet	na
171035-19	STEVEBR	8/8/17	45.9	517.21	16.4	6.77	low	baseflow	na
171035-20	DRMONTREC	8/8/17		410.58	5.84	2.32	low/medium	freshet	medium
171035-21	DRRIVERTON	8/8/17		248.09	7.77	0.87	medium	freshet	medium
171035-22	Macs10	8/8/17	41.85				medium	baseflow	na
171035-23	ELMST391	8/8/17		53.71			no field sheet	no field sheet	na
171157-01	NBMAIN	8/22/17		35.92	8.25	0.61	medium	baseflow	low
171157-02	WORDAM	8/22/17		57.8	11.7	2.93	medium	baseflow	low
171157-03	NBNC02	8/22/17		46.38	14.2	3.73	low/medium	baseflow	low
171157-04	CUMMINGSBR	8/22/17		435.17	15.4	4.04	medium	baseflow	low
171157-05	MILLPD	8/22/17		228.18	16.8	4.03	medium	baseflow	low
171157-06	PEDBRID	8/22/17		172.47	16.6	4.48	low	baseflow	low
171157-07	SPRINGST	8/22/17		160.71	14.9	4	low	baseflow	low
171157-08	GRANITE	8/22/17		214.26	14.8	2.63	medium	baseflow	medium
171157-09	MAINSTBR	8/22/17		144.97	16.3	3.97	low	baseflow	medium
171157-10	TAYLORST	8/22/17		866.44	18.7	3.69	low	baseflow	medium
171157-11	BIKEBR	8/22/17		920.84	14.7	3.2	low	baseflow	medium
171157-12	BIKEBR-BLANK	8/22/17		< 1	< 5	< 0.2	low	baseflow	medium
171157-13	BIKEBR-DUP	8/22/17		547.5	15.5	2.81	low	baseflow	medium
171157-14	MONTSTATE	8/22/17		488.44	15.3	2.93	low	baseflow	medium
171157-15	MONTHS	8/22/17		344.8	14.7	3.03	low	baseflow	medium
171157-16	SPAULD	8/22/17		579.43	15.6	8.41	medium	baseflow	na
171157-17	STEVEBR	8/22/17		344.8	15.2	2.78	not recorded	not recorded	na

171157-18	DRMONTREC	8/22/17		193.49	7.99	1.16	low/medium	baseflow	medium
171157-19	DRMONTREC-BLANK	8/22/17		< 1	< 5	< 0.2	low/medium	baseflow	medium
171157-20	DRMONTREC-DUP	8/22/17		108.07	8.99	0.99	low/medium	baseflow	medium
171157-21	DRRIVERTON	8/22/17		77.12	8.14	0.5	medium	baseflow	medium
171157-22	Macs10	8/22/17	400				medium	baseflow	na
171157-23	STEVEBR-BLANK	8/22/17	< 2				medium	baseflow	na
171157-24	STEVEBR	8/22/17	55.5				medium	baseflow	na
171157-25	WOODBR	8/22/17	400				medium	baseflow	na
171157-26	CMVH-East	8/22/17	605				medium	baseflow	na
171157-27	KOHLS	8/22/17	230				medium	baseflow	na
171157-28	KOHLS 2	8/22/17	228				medium	baseflow	na
171157-29	ELMST391	8/22/17		224.68			medium	baseflow	low
171262-01	NBMAIN	9/5/17		144.97	14.2	2.01	medium	baseflow	medium
171262-02	WORDAM	9/5/17		121.12	13.2	1.59	medium	baseflow	medium
171262-03	NBNC02	9/5/17		41.35	17.5	6.7	medium		medium
171262-04	CUMMINGSBR	9/5/17		111.23	16.4	5.46	medium	baseflow	medium
171262-05	MILLPD	9/5/17		156.48	17.5	5.78	medium	baseflow	medium
171262-06	PEDBRID	9/5/17		112.64	22	6.06	medium	freshet	medium
171262-08	GRANITE	9/5/17		285.1	16.8	4.13	medium	baseflow	medium
171262-09	MAINSTBR	9/5/17		328.15	19.6	3.95	low	baseflow	medium
171262-10	TAYLORST	9/5/17		726.99	18.7	4.97	low	baseflow	medium
171262-12	MONTSTATE	9/5/17		547.5	39.3	15.4	low	baseflow	medium
171262-13	MONTHS	9/5/17		648.82	20.7	6.05	low	baseflow	medium
171262-14	SPAULD	9/5/17		248.09	18.2	6.76	low	baseflow	na
171262-15	SPAULD-BLANK	9/5/17		< 1	< 5	< 0.2	low	baseflow	na
171262-16	SPAULD-DUP	9/5/17		165.76	18.9	7.55	low	baseflow	na
171262-17	Macs10	9/5/17	41.9	365.4	17.7	3.54	low	baseflow	na
171262-18	DRMONTREC	9/5/17		143.87	11.9	2.71	low	baseflow	medium
171745-01	Macs 10	10/4/17	414				low	baseflow	na
171745-02	WOODBR	10/4/17	370				low	baseflow	na
171745-03	KOHLS	10/4/17	238				low	baseflow	na
171745-06	KOHLS - Blank	10/4/17	<2				low	baseflow	na
171745-07	KOHLS - Dup	10/4/17	243				low	baseflow	na
171745-04	KOHLS2	10/4/17	237				low	baseflow	na
171745-05	CBMH-East	10/4/17	596				low	baseflow	na

*Flow level according to the USGS gauge was determined using the daily discharge recorded by the closest USGS stream gauge on each of the six 2017 sampling dates combined with USGS discharge statistics for the gauge. Discharge amounts falling into the first quartile (<25%) were considered low flow levels, while discharge amounts falling into the second two quartiles (25-75%) were considered medium, and the upper quartile amounts (>75%) were considered high. The Stevens, and Jail Branch Rivers do not have stream gauges.