Four Rivers Partnership
Volunteer Water Quality Monitoring 2016

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 River, and Winooski Rivers. Water quality monitoring by the Four Rivers Partnership has focused on these rivers and their tributaries and 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 were also tested. Laboratory services were provided by the Vermont Department of Environmental Conservation's VAEL lab via the La Rosa Volunteer Water Quality Monitoring Program. This report was compiled by Shawn White, Project Manager of the Friends of the Winooski River.

2016 Water Quality Monitoring Results

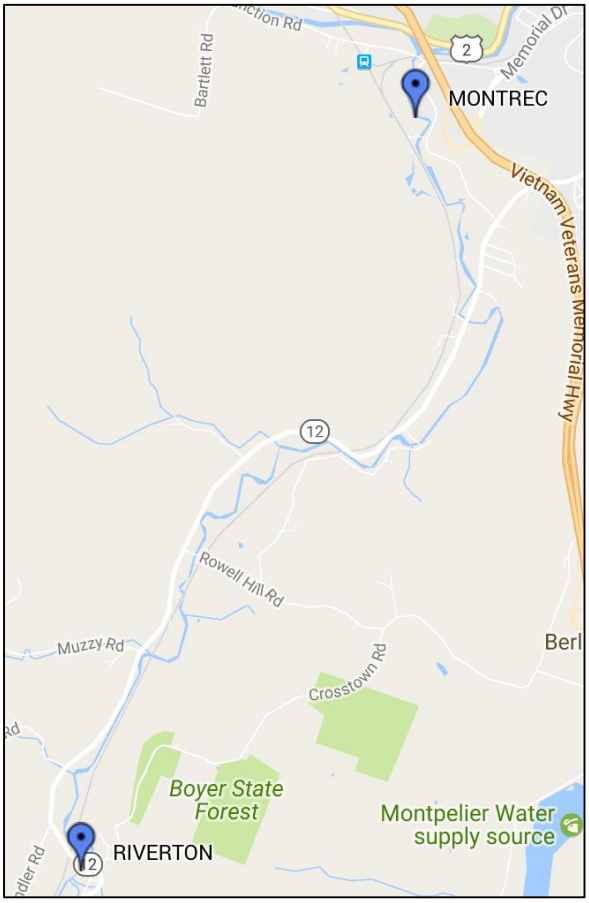
In the summer of 2016, the Four Rivers Partnership volunteers collected samples for *E. coli*, phosphorus, and turbidity testing at eleven sites (Table 1 & Figure 1), and chloride testing at four sites (Table 2 & Figure 2) in the Barre-Montpelier-Riverton area. Sampling occurred biweekly on five dates: July 5, July 19, Aug 2, Aug 17, and Aug 30. Two of these dates, July 19 and Aug 17, occurred directly after rain events, when 0.26 inches and 2.03 inches, respectively, of rain were recorded at the nearby Barre-Montpelier Knapp State Airport. These dates are considered "rain events" for the purposes of this analysis.

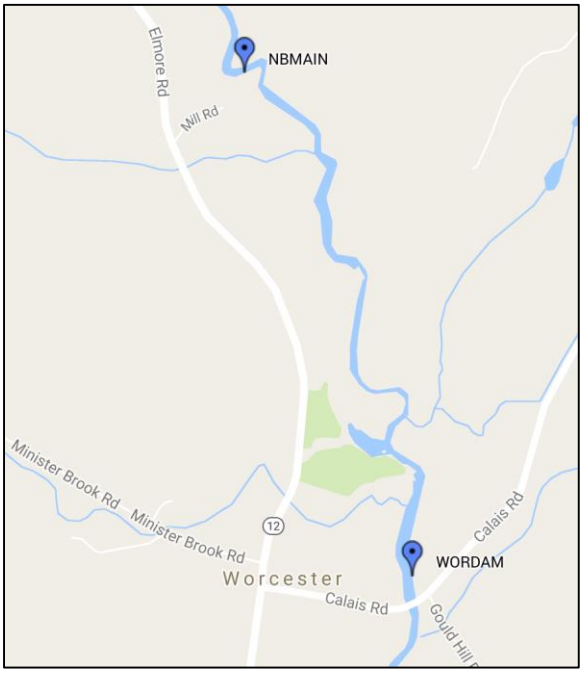
Table 1. Four Rivers Partnership biweekly *E. coli*, phosphorus, & turbidity sampling sites, 2016

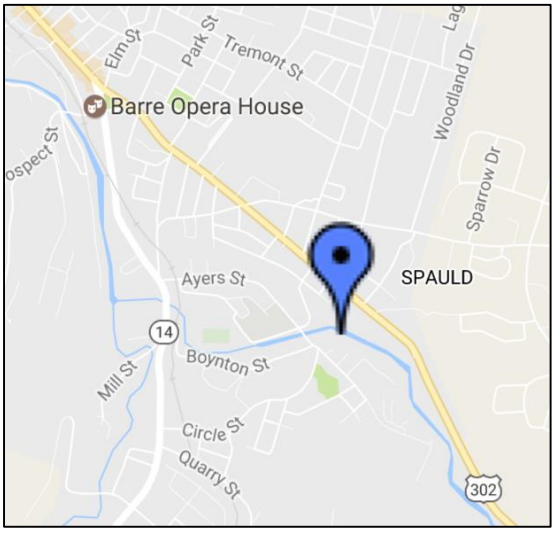
Site ID	Description	Waterbody	Lat / Long	Parameters monitored
NBMAIN	Mill Road Swimming Hole	North Branch	44.385342 / -72.550879	*E. coli*, TP, Turbidity
WORDAM	Worcester Dam Swimming Hole	North Branch	44.373441 / -72.5453	*E. coli*, TP, Turbidity
NBNC02	North Branch Nature Center Bridge	North Branch	44.28355 / -72.57133	*E. coli*, TP, Turbidity
MILLPOND	Mill Pond Park Canoe Access	North Branch	44.26766 / -72.56882	*E. coli*, TP, Turbidity
GRANITE	Granite St Bridge	Winooski River	44.25180 / -72.57064	*E. coli*, TP, Turbidity
MONTSTATE	VSECU parking lot	Winooski River	44.260668 / -72.583174	*E. coli*, TP, Turbidity
MONTHS	Montpelier High School Access	Winooski River	44.261859 / -72.586412	*E. coli*, TP, Turbidity
WINDOG	Winooski / Dog River confluence	Winooski River	44.25652, -72.60119	*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
SPAULD	Spaulding Falls	Jail Branch	44.111917 / -72.489982	*E. coli*, TP, Turbidity

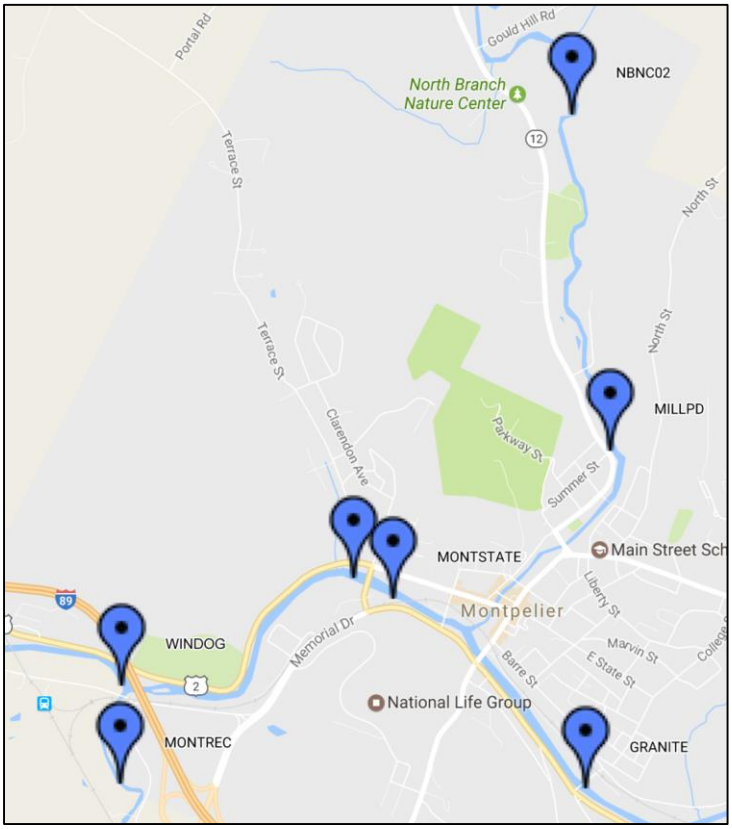
Table 2. Four Rivers Partnership chloride sampling sites, 2016

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


MONTREC
Bartlett Rd
Memorial Dr
Vietnam Veterans Memorial Hwy
Rowell Hill Rd
Muzzy Rd
Crosstown Rd
Boyer State Forest
Montpelier Water supply source
RIVERTON
2
12


NBMAIN
Elmore Rd
Mill Rd
Minister Brook Rd
Minister Brook Rd
Worcester
Calais Rd
Calais Rd
WORDAM
12


Barre Opera House
Elm St
Park St
Tremont St
Woodland Dr
Sparrow Dr
Ayers St
SPAULD
Boynton St
Mill St
Circle St
Quarry St
14
302


Portal Rd
Gould Hill Rd
NBNC02
North Branch Nature Center
Terrace St
North St
MILLPD
Clarendon Ave
Parkway St
Summer St
MONTSTATE
Main Street Sch
Montpelier
Liberty St
Marvin St
E State St
Barre St
Memorial Dr
WINDOG
National Life Group
MONTREC
GRANITE
12
89
2

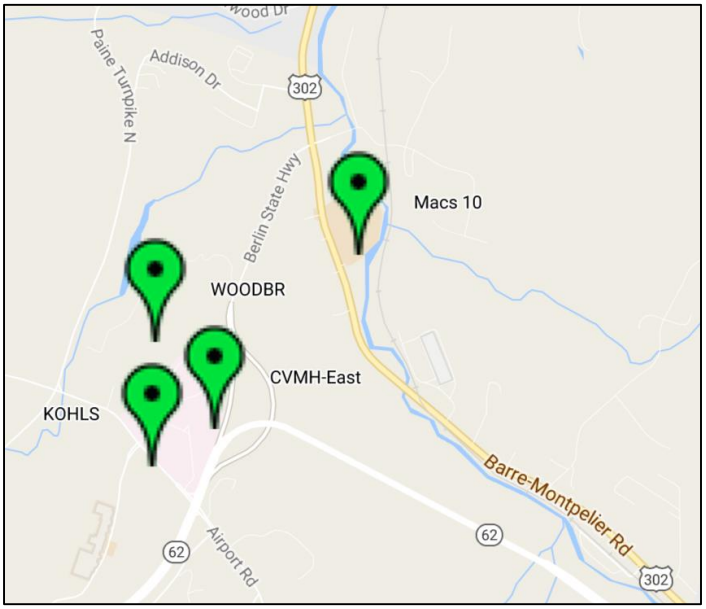


Figure 1. Maps showing the locations of the eleven sites where samples for *E. coli*, phosphorus, and turbidity were collected (blue markers), and the four sites where chloride was collected (green markers) in 2016. The MONTHS site, just west of the MONTSTATE site in Montpelier, is not labeled.

2016 *E. coli* results

Escherichia coli is a species of bacteria found in the fecal matter of mammals warm-blooded animals and is commonly used as an indictor of fecal contamination in rivers, streams, lakes, and oceans. While most strains of *E. coli* do not cause disease, they may be associated with other bacteria and viruses that are pathogenic. *E. coli* amounts are often given as "most probable number" – a reflection of the laboratory test used to measure *E. coli* levels. The Vermont and US EPA standards for *E. coli* are similar and are based on single sample measurements and/or the geometric mean of samples taken over a representative period of time. The Vermont standard for the geometric mean *E. coli* for Class B waters is 126 mpn /100mL, and corresponds to a level in which there is a probability that 8 individuals/1000 would get sick after water contact. To meet both the geometric mean and single sample measurement standards, less than 10% of the single sample measurements should have *E. coli* levels above 235 mpn/100mL.

The results of the Four River Partnership 2016 *E. coli* sampling is shown in Figure 2. During dry conditions when less than 0.25 inches of rain had fallen in the 24 hours prior to sampling, the VT standard for geometric mean *E. coli* (126 mpn/100mL) was exceeded at seven sites out of eleven sites sampled. Highest dry-weather levels were observed on the Winooski mainstem in Montpelier at the MONTSTATE, MONTHS, and DRMOUTH sites, at the Mill Pond Park on the North Branch in Montpelier (MILLPD), and on the lower Dog (DRMONTREC). The dry-weather *E. coli* levels at the remaining sites were either at or lower than standard; lowest levels were observed at the North Branch Nature Center swimming hole on the North Branch River. Dry weather results are arguably more important since it is during dry weather that most recreational contact would occur.

As in previous years, 2016 *E. coli* levels are highly dependent on rainfall. Figure 2 shows a comparison of *E. coli* results for dry conditions (July 5, Aug 2, and Aug 30) versus rainy

conditions (July 19 and Aug 17)). After moderate to heavy rainfall, all sites showed increased *E. coli* levels, and five sites had levels above 2419.6 mpn/mL- the maximum concentration that can be measured by the VAEL lab's standard testing protocol for *E. coli*. Three of these five sites (GRANITE, MONTSTATE, and MONTHS) are on the Winooski mainstem where it flows through Montpelier, one is at a swimming hole on the North Branch in Worcester (WORDAM), and one is at the canoe access and swimming hole on the Dog River in Riverton (DRRIVERTON).

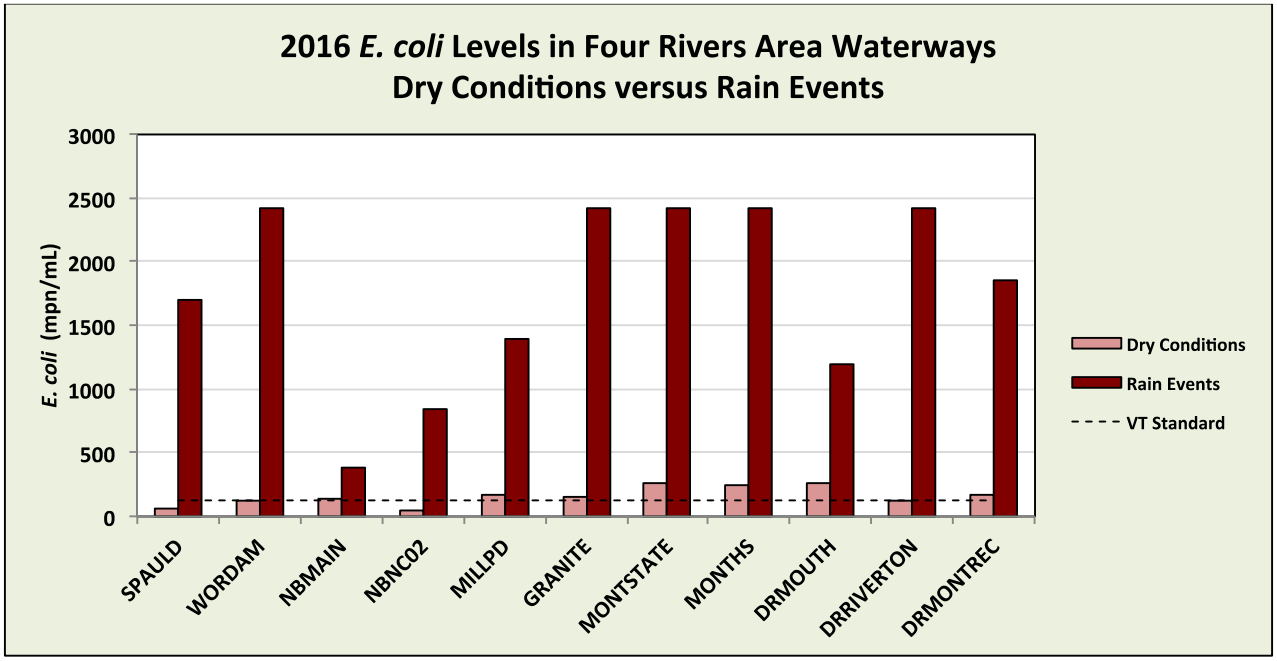


Figure 2. 2016 dry versus rainy weather (base flow versus freshet) geometric mean *E. coli* levels at 11 sites in the Four Rivers area. The Vermont standard of 126 mpn/100 mL is indicated by the dotted line.

E. coli results 2008-2016

Figure 3 shows a comparison of the geometric mean *E. coli* values under dry-weather conditions for monitoring years 2008-2016 for all sites. Despite the fact that *E. coli* concentrations at these sites are fairly variable, some general patterns are beginning to emerge. For example, *E. coli* at the MONTHS site (the Montpelier High School canoe access) has been consistently above the VT/EPA standard for the past six years. This reach of the Winooski River is listed as impaired for *E. coli* by the State of Vermont. Similarly, the MONTSTATE site levels have been above the standard for all four years sampled. Several sites have had *E. coli* levels nearly at or below the standard for several years, such as Spaulding Falls on the Jail Branch in Barre (SPAULD), the Worcester Dam swimming hole (WORDAM, with the exception of 2010, when one single sample skewed the mean), and the North Branch Nature Center swimming hole (NCB02). The *E. coli* levels at two sites, MILLPD and DRMONTREC, met the standard in years 2008 – 2013, but seem to have become elevated during the past three years. Other sites have levels that are quite variable from year to year (NBMAIN and DRRIVERTON).

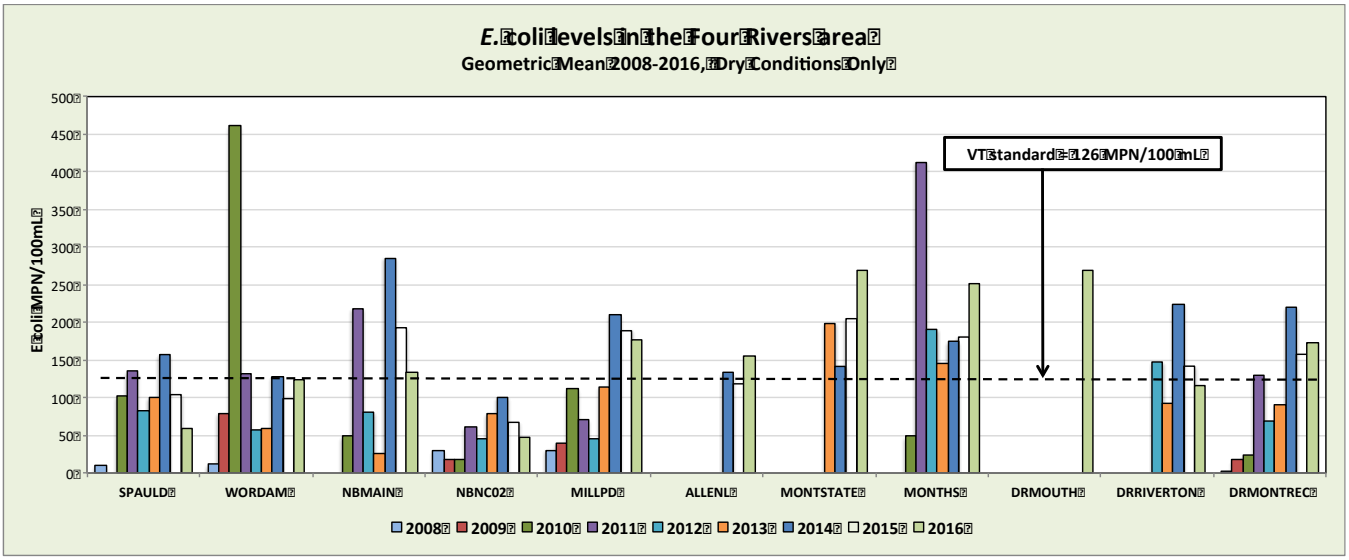


Figure 3. A comparison of geometric mean *E. coli* values in years 2008 – 2016 when only dry-weather (low flow) conditions are considered. Some sites were not sampled in all years.

2016 single sample *E. coli* measurements

The 2016 Vermont Water Quality Standards document states that less than 10% of samples should be have *E. coli* levels greater than 235 mpn/100 mL. Table 3 lists the percentage of single samples with *E. coli* results above this level for each site. Note that since only four or five samples were taken over the course of the sampling season at most sites, however, one sample constitutes 20% to 25% of the total samples taken.

Table 3. Percentage of samples at each site with *E. coli* levels above 235 mpn/ 100 mL.

Sampling Site	**% of samples with *E. coli* > 235 mpn/100mL**
SPAULD	40 %
WORDAM	50 %
NBMAIN	75 %
NBNC02	50 %
MILLPD	60 %
GRANITE	40 %
MONTSTATE	80 %
MONTHS	80 %
DRRIVERTON	40 %
DRMONTREC	60 %

Finding potential sources of *E. coli* on the Winooski River mainstem

One of the goals of the Four Rivers partnership is to monitor the overall effects of Montpelier's 6 CSOs and locate other potential sources of fecal matter entering local streams, such as failing septic systems or improper connections between sewer lines and stormwater pipes. Locating *E. coli* sources is notoriously difficult due to high variability in *E. coli* levels resulting from fluctuating temperatures and flow, diluting effects of tributaries, multiple point and non-

point sources, and free-living *E. coli* associated with bottom sediments. Consistently high *E. coli* levels at the Montpelier High School canoe access point (MONTHS), however, led us to attempt to locate the upstream source, which had been commonly assumed to be one or both of the two combined sewer overflow structures (CSOs 003 and 023) at the Bailey Street Bridge, just upstream from the school. Since levels at MONTHS are elevated during dry conditions in addition to spiking after rain, and CSO overflows would be expected to contribute fecal matter to receiving streams only during heavy rain events, other sources of *E. coli* not associated with stormwater should be assumed to be present. In 2013, the Four River Partnership added the MONTSTATE sampling site approximately 0.1 mile upstream of Bailey Street Bridge to help determine the effect of the Bailey Street CSOs and begin to locate other sources. MONTSTATE is upstream of CSOs 003 and 023, but downstream from the remaining four Montpelier CSOs (CSOs 001, 007, 008, and 009).

Dry-weather *E. coli* levels at MONTSTATE in 2013-2016 have generally been equal to or higher than those at MONTHS, indicating the Bailey CSOs are not the primary source of dry-weather levels of *E. coli* at MONTHS. However, the two locations had similar *E. coli* measurements after the five rain events sampled during this time frame (albeit the maximum 2419.6 mpn/100mL value in two of those cases). In 2014, consequently, the Friends added another site further upstream, ALLENL, in an attempt to bracket the source(s) of *E. coli* at MONTSTATE and MONTHS. The ALLENL site is upstream from all of the known Montpelier CSOs and most stormwater outfall pipes. Figure 4 shows the locations of the three Winooski mainstem sites relative to CSO structures in Montpelier. Access issues at ALLENL forced us to move this site slightly upstream to the Granite Street Bridge (GRANITE) in 2015.

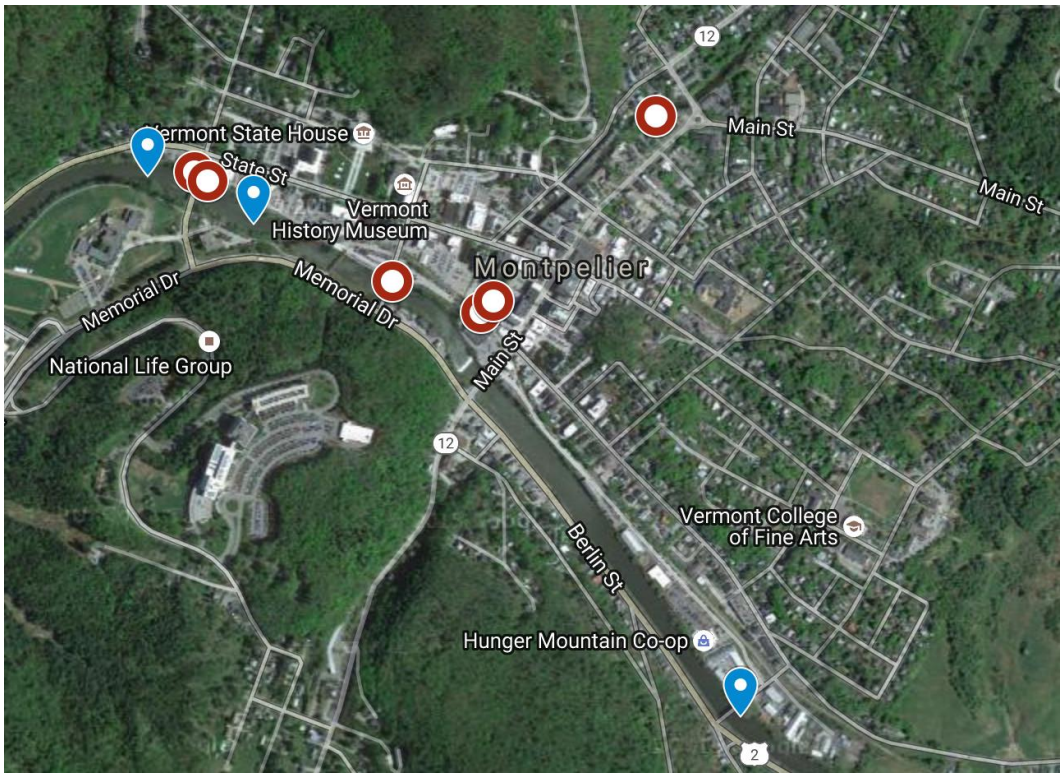


Figure 4. Locations of Montpelier CSO structures relative to the Four Rivers sampling sites on the Winooski River. Blue markers show the sampling sites (MONTHS, MONTSTATE, and ALLENL/GRANITE from left to right), and red markers show the locations of the remaining Montpelier CSOs.

The dry-weather geometric mean *E. coli* levels at ALLENL/GRANITE were similar to those at MONTSTATE and MONTHS in 2014, but lower than the two downstream sites in 2015 and 2016. Higher levels at the downstream sites during dry weather could be due to leaky or improperly connected sewer lines since stormwater runoff should not be a factor. In parallel to the Four Rivers Partnership 2016 sampling, Stone Environmental and the Friends of the Winooski River were engaged in an assessment of Montpelier's stormwater outfall pipes in an effort to locate discharges of raw sewage or other pollutants. This work found at least three improper connections of the wastewater sewer system to stormwater drains pipes, all emptying directly into the Winooski or the North Branch Rivers. The Montpelier Public Works Department eliminated at least one of these connections in the fall of 2016, and the others are slated to be corrected in the near future. The Four Rivers Partnership has received a La Rosa Organizational Support grant to sample these three Winooski mainstem sites along with several additional sites during 2017 in an concentrated effort to determine whether the IDDE fixes will reduce dry-weather *E. coli* levels.

While the improper sewer connections may help explain dry weather *E. coli* levels in the Winooski below Montpelier, *E. coli* levels during freshet flows after rainfall have other additional sources associated with stormwater. Four Rivers Partnership sampling during and after rain events have found that *E. coli* levels at both MONTSTATE and MONTHS spike considerably after rainfall. This would seem to point to the Montpelier CSOs as the source of stormwater-associated E. coli. Interestingly, however, *E. coli* levels at the ALLENL/GRANITE site above downtown Montpelier were as high or higher than at MONTSTATE and MONTHS.

It can be concluded, therefore, that the Montpelier CSOs are not the sole source of *E. coli* in the impaired stretch of the Winooski during rain events, and that there is some alternate/additional source upstream of the GRANITE site. Sampling upstream of GRANITE may help determine the location and identity of that upstream source. It should be noted, however, that water quality monitoring sites in the Headwater region of the Winooski (Plainfield, Marshfield, and Cabot) also experience considerable spikes in *E. coli* after rainfall.

Finding potential sources of *E. coli* on the North Branch and Dog Rivers

Two other Four River area reaches have exhibited a trend of elevated *E. coli* levels over the past few years. For example, there seems to be a consistent jump in *E. coli* levels in the North Branch between NBNC02 (the North Branch Nature Center swimming hole), where *E. coli* levels are consistently low, and MILLPD (the Mill Park canoe access), where the geometric mean *E. coli* levels were 189 and 177 mpn/100mL in 2105 and 2016 respectively and 60% of single samples had levels above 235 mpn/100 mL in both years. This may be due to illicit discharge of sewage into the stormdrain system or directly to the river. Failing septic systems can also leak raw sewage into waterways via groundwater, and/or pet waste from the residential area between the nature center and Hubbard park may provide a fairly consistent source of *E. coli*. The 2016 Montpelier IDDE stormwater end-of-pipe assessments, however, found no evidence of illicit discharge that would explain the uptick in *E. coli* levels at this site.

The other site where the Four Rivers Partnership has observed elevated *E. coli* is at the Montpelier Recreational Fields on the Dog River (DRMONTREC). This site has had geometric mean *E. coli* levels above the VT standard the past three years.

2016 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. When the algae die, their decomposition depletes the water of oxygen needed by fish and other aquatic organisms. Phosphorus sources include fertilizers, manure, organic matter, and erosion.

Four Rivers 2016 mean phosphorus levels during dry weather, low-flow conditions for each site is shown in Figure 5. The phosphorus levels at most sites were at or below the VT standard for class B medium gradient, cold-water streams (15 ug/L). Levels at the MONTSTATE site just exceeded the standard, and only the MILLPD site exceeded the standard to any extent. Both were under the standard for class B warm-water streams (27 ug/L). The 2016 dry-level phosphorus levels at most sites were about equal to or lower than level in 2017 (data not shown).

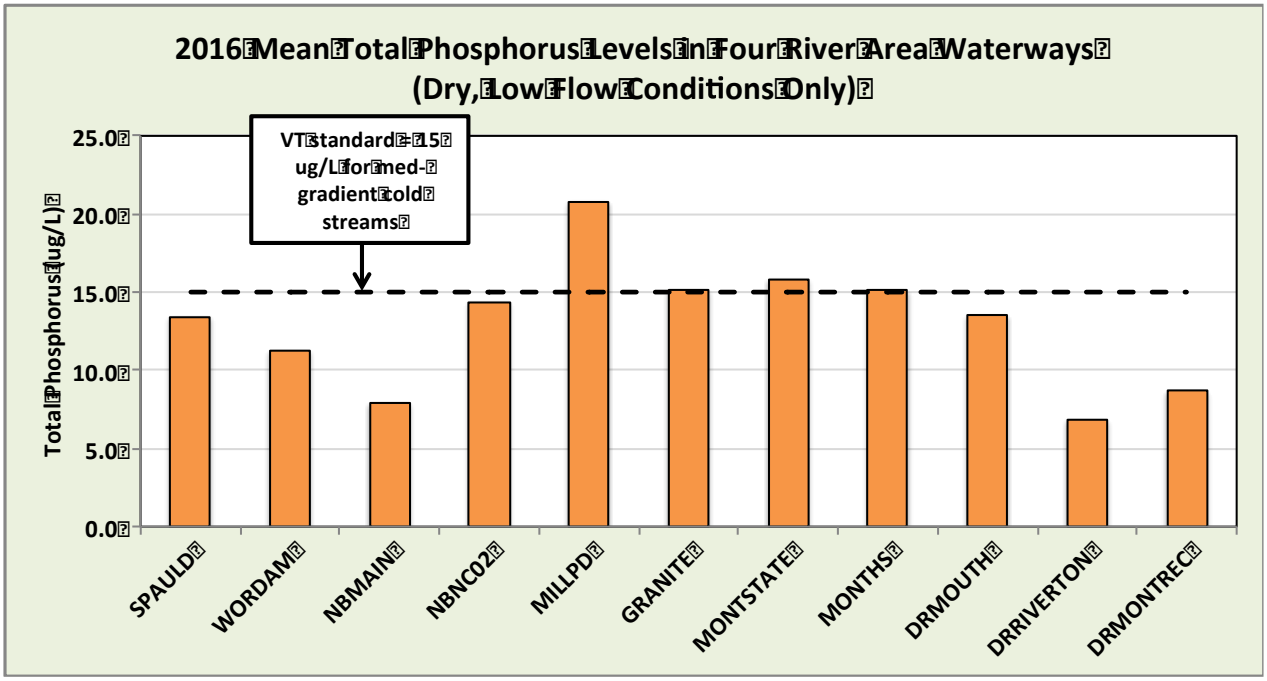


Figure 5. 2016 dry-weather (base-flow) mean phosphorus levels at 11 sites in the Four Rivers area. The Vermont standard for Class B(2), cold, medium, high-gradient streams of 15 ug/L is indicated by the dotted line.

Like *E. coli*, phosphorus levels increase dramatically at most sites during rain events (Figure 6), especially on the mainstem of the Winooski, and to a lesser degree on the Dog and Jail Branch Rivers. Stormwater washes sediment, fertilizers, and organic matter into streams, and higher flows after rain causes streambank erosion and streambed scour – all of which result in elevated phosphorus. Clearly, reducing levels of phosphorus carried by the Winooski to Lake Champlain should involve mitigating the effects of stormwater.

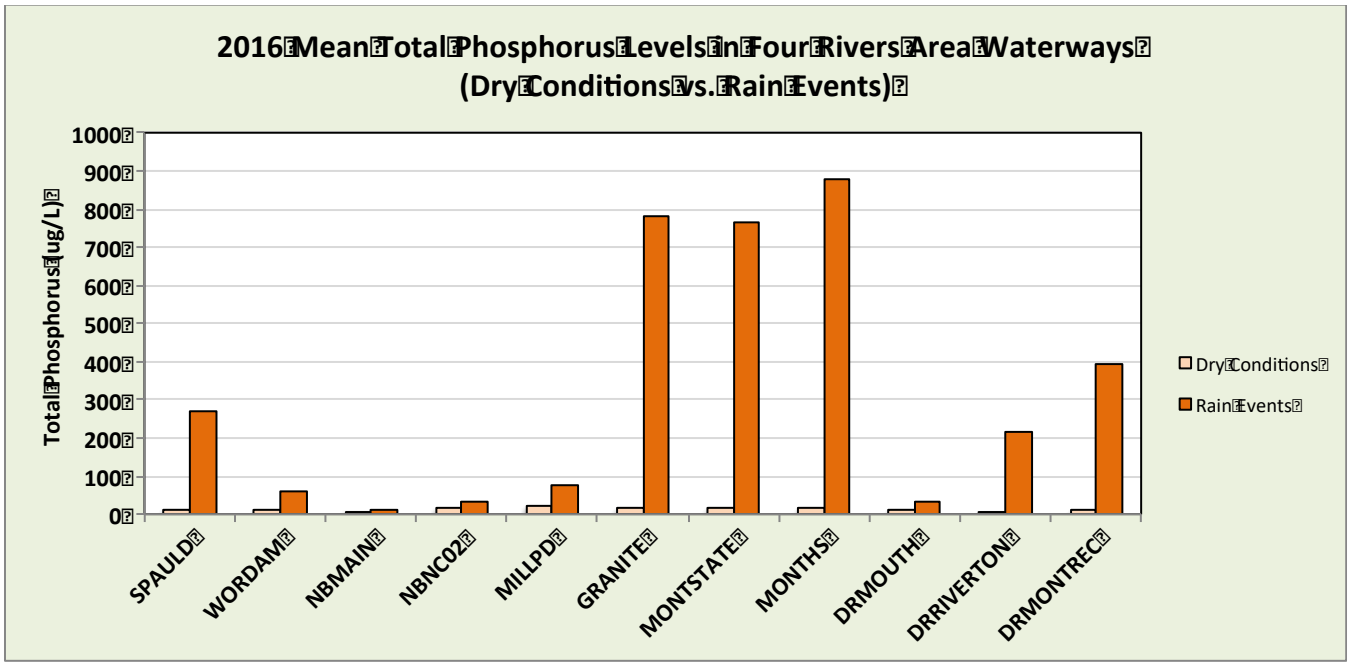


Figure 6. 2016 dry versus rainy weather (base flow versus freshet) mean phosphorus levels at 11 sites in the Four Rivers area. The Vermont standard is 15 ug/L for cold, medium high-gradient class B(2) streams, and 27 ug/L for warm, medium-gradient class B(2) streams.

2016 Turbidity Results

The 2016 results of turbidity sampling are shown in Figure 7. Turbidity levels at all sites were well below the Vermont standard of an annual average of 10 nephelometric units (NTU) for cold-water habitat under dry, base-flow conditions. However, turbidity levels jump considerably during rain events (Figure 8) as sediments and pollutants are brought into streams via stormwater and settled bottom sediments are brought into the water column by higher flows. Since both phosphorus and *E. coli* tend to adhere to soil particles, higher turbidity levels are associated with high phosphorus and high *E. coli*.

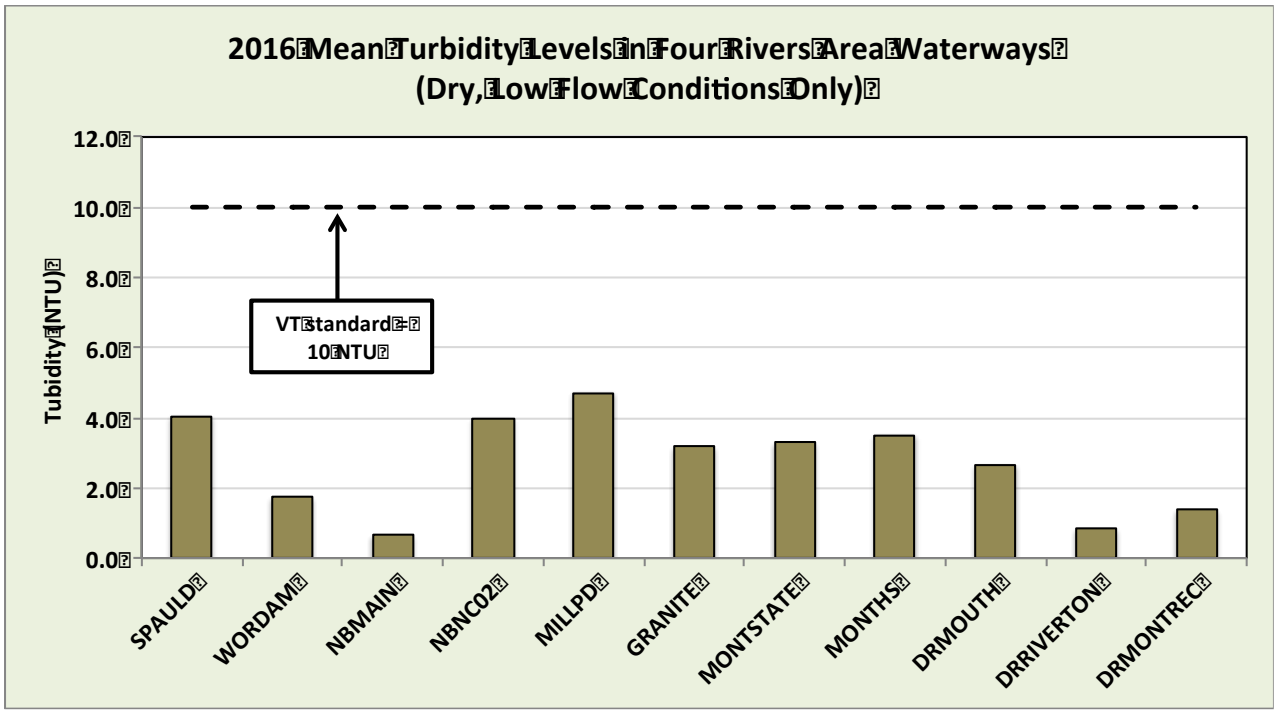


Figure 7. 2016 low-flow turbidity levels in Four Rivers area streams. The Vermont standard for cold-water fish habitat is shown by the dotted line (NTU=nepholometric units). The standard for class B streams without cold-water habitat is 25 NTU.

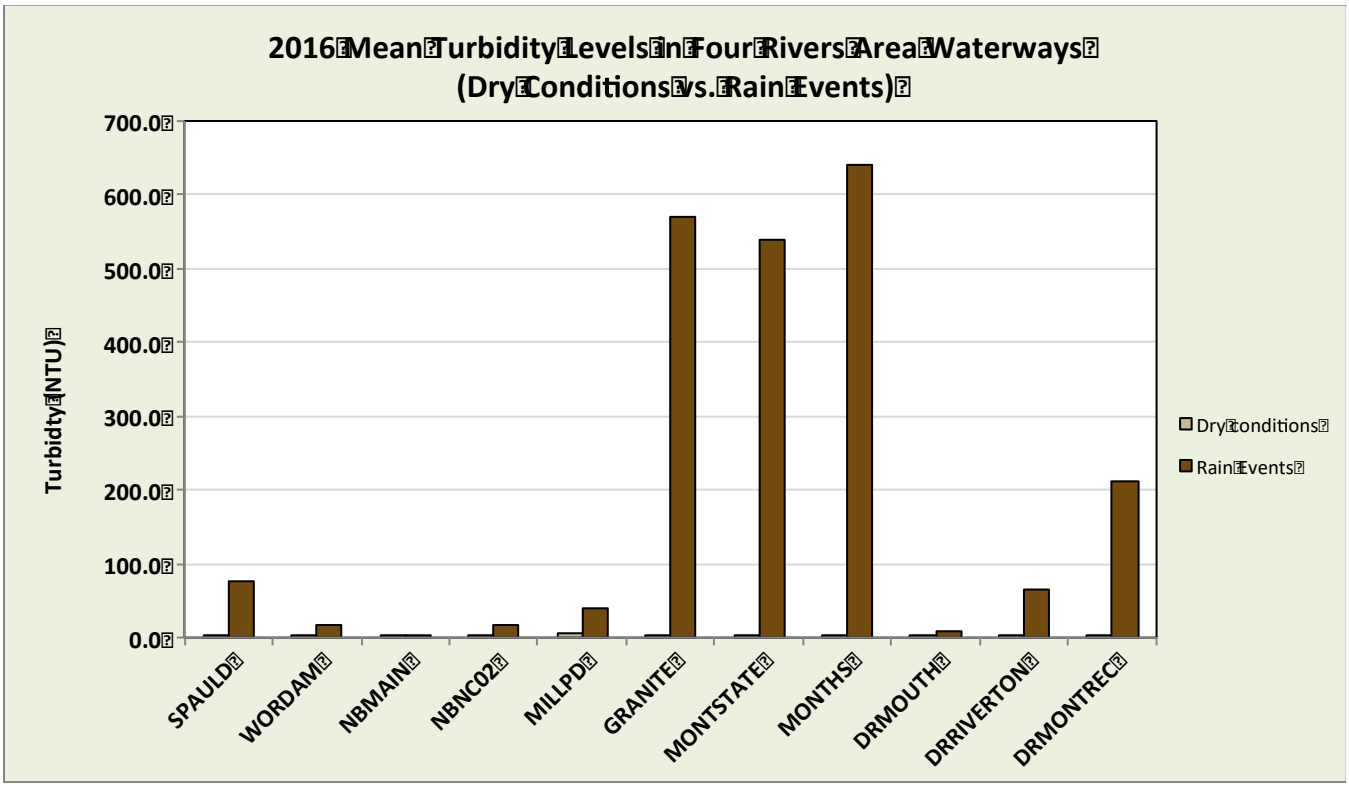


Figure 8. 2016 dry versus rainy weather (base flow versus freshet) mean turbidity levels at 11 sites in the Four Rivers area. The Vermont standard is 10 nephelometric units (NTU) for cold water streams and 25 NTU for warm, medium-gradient class B(2) streams.

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 mean chloride concentrations well above Vermont's average allowable concentration standard of 230 mg/L in 2012 and 2015. Continued sampling at this site in 2016 showed a slight decrease in these levels (Table 4). 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 we have taken during dry weather at Macs 10 have had levels above 425 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 of the individual samples taken at all four sites, 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 4. Chloride levels during dry, low flow conditions 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

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 discharge from these outfalls feeds into two branches of the stream above the Macs 10 site. Groundwater contaminated with chloride-containing road salts may be entering the stormwater system somehow, resulting in the high conductivity readings.

To better document where the chloride source is, the Four Rivers partnership sampled chloride levels above and below the CVMC parking lots on the two stream branches that flow on either side of the medical center (see map, Figure 9). Levels upstream of the medical center at the KOHLS site were lower than levels in the stream downstream from the outfalls draining the parking lots (CVMH-EAST and WOODBR), but were nevertheless elevated beyond the Vermont average allowable chloride standard. Chloride concentrations downstream from the medical center were similar to the levels at Macs10 at the mouth of the stream and were highest during dry periods, suggesting that chloride is not being brought into the stream via stormwater, but rather via contaminated groundwater. Chloride levels were consistently higher on the eastern branch of the stream, on the Hwy 62 side of the medical center.

Figure 9. Chloride sampling sites on the unnamed tributary to the Steven's Branch, Berlin, VT.

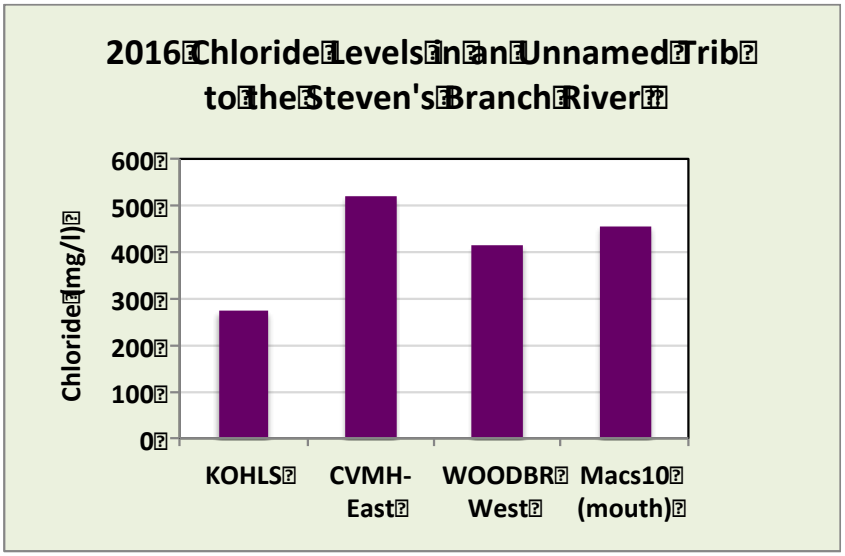


Figure 10. 2016 mean chloride results for four sites on an unnamed tributary to the Steven's Branch. The VT standard for average chloride is 230 mg/L.

General Conclusions

E. coli levels at 7 of 11 Four River sampling sites did not meet the state's standard of 126 mpn100mL, but were only somewhat above the standard at four of these sites. Highest levels were observed at three sites on the Winooski River mainstem where *E. coli* concentrations were approximately twice the allowable amount. Dry weather *E. coli* levels were lower upstream of downtown Montpelier than at three downstream sites. *E. coli* levels after rainfall were very high both above and below Montpelier combined sewer overflow locations (CSOs).

Dry-weather phosphorus levels at most sites met or only slightly exceeded the Vermont standard, with the exception of the Mill Pond Park canoe access site on the lower North Branch. After rain, however, phosphorus levels spiked, especially on the Winooski mainstem but also on the Dog and Jail Branch Rivers. Turbidity was also low during dry weather sampling but increased considerably on the Winooski River after rain. Dog River and Jail Branch River turbidity were also higher after rains, but to a lesser extent. Stormwater runoff, therefore, appears to be a major factor determining water quality in the Four Rivers area of the Winooski watershed, and recreational users of the rivers should avoid contact for approximately 48 hours after moderate to heavy rainfall.

Mean chloride levels on one unnamed tributary of the Steven's Branch are much higher than the Vermont standard for chronic chloride conditions. Sampling on two branches of this stream revealed that chloride levels are similarly high just below the Central Vermont Medical Center. Levels are lower but also elevated above the medical center, and are higher during dry weather than wet weather at all sites sampled. A likely scenario is that road salt used on the parking lots around the medical center has contaminated the groundwater, which is turn feeding the stream.

Quality assurance data and project completeness for the 2016 sampling effort is presented in **Appendices A** and **B**. The data from this report will be summarized in a Friends of the Winooski newsletter article, and the *E. coli* data in particular was presented to the public during Montpelier's WaterFest in the fall of 2016. This report will be posted on the Friends of the Winooski website, sent to the Montpelier Conservation Commission and the North Branch Nature Center, given to the 2016 sampling volunteers, and will be used to educate the public about the water quality conditions of area streams.

Appendix A. Quality assurance measures for chloride, *E. coli*, total phosphorus, and turbidity sampling in 2016

Test	Site	Date	A	D	B	Relative % Difference
Chloride	KOHLS	7/5/16	302.5	302.5	<2	0
	Macs 10	8/2/16	64.8	64.5	<2	0.46
	WOODBR	8/30/16	435	437.5	<2	0.57
Chloride Mean Relative % Difference						**0.34**
Chloride Mean Blank Concentration					**<2**	
E. coli	WORDAM	7/5/16	178.21	166.4	<1	6.8
	MONTHS	7/19/16	298.7	435.2	<1	37.2
	MILLPD	8/2/16	178.9	201.42	<1	11.8
	MONTHS	8/17/16	2419.6	2419.6	<1	0
	DRRIVERTON	8/30/16	116.85	103.94	<1	11.7
***E. coli* Mean RPD**						**13.5**
***E. coli* Mean Blank Concentration**					**<1**	
Total P	WORDAM	7/5/16	10.4	11.2	< 5	7.4
	MONTHS	7/19/16	25.5	24.7	< 5	3.2
	MILLPD	8/2/16	14.3	13.6	< 5	5.0
	MONTHS	8/17/16	1570	1340	<5	15.8
	DRRIVERTON	8/30/16	6.78	7.23	< 5	6.4
Total Phosphorus Mean RPD						**7.6**
Total Phosphorus Mean Blank Concentration					**<5**	
Turbidity	WORDAM	7/5/16	1.42	1.08	<0.2	27.2
	MONTHS	7/19/16	10.1	10.3	<0.2	2.0
	MILLPD	8/2/16	4.17	4.39	< 0.2	5.1
	MONTHS	8/17/16	1194	875	< 0.2	30.8
	DRMONTREC	9/1/15	0.84	0.89	< 0.2	5.8
Turbidity Mean RPD						**14.2**
Turbidity Mean Blank Concentration					**<0.2**	

Appendix B. 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 the lack of substantial rain events in 2016, 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 the regular sampling dates.

Appendix C. Individual Sample Data

Sample Number	Location	Date	Chloride (mg/L)	E. coli (mpn/100ml)	TP (ug P/L)	Turbidity (NTU)
160786-18	CVMH-EAST	7/5/16	477.5			
160786-17	CVMH-WEST	7/5/16	407.5			
160786-11	DRMONTREC	7/5/16		344.8	10.2	1.14
160786-12	DRRIVERTON	7/5/16		85.74	7.24	0.87
160786-07	GRANITE	7/5/16		146.72	20.8	4.55
160786-14	KOHLS	7/5/16	302.5			
160786-15	KOHLS-BLANK	7/5/16	< 2			
160786-16	KOHLS-DUP	7/5/16	302.5			
160786-19	Macs10	7/5/16	485			
160786-06	MILLPD	7/5/16		261.25	29.5	4.55
160786-09	MONTHS	7/5/16		209.82	20.1	4.5
160786-08	MONTSTATE	7/5/16		172.16	22.8	3.93
160786-04	NBMAIN	7/5/16		365.4	7.5	0.45
160786-05	NBNCO2	7/5/16		67.66	15.4	4.45
160786-13	SPAULD	7/5/16		160.71	22.8	7.96
160786-01	WORDAM	7/5/16		178.21	10.4	1.42
160786-02	WORDAM-BLANK	7/5/16		< 1	< 5	< 0.2
160786-03	WORDAM-DUP	7/5/16		166.4	11.2	1.08
160787-11	DRMONTREC	7/19/16		1413.61	28.6	10.4
160787-10	WINDOG	7/19/16		1203.33	30.4	7.66
160787-12	DRRIVERTON	7/19/16		> 2419.6	42.7	25.1
160787-07	GRANITE	7/19/16		> 2419.6	159	92.8
160787-19	Macs10	7/19/16	16.8			
160787-06	MILLPD	7/19/16		1986.29	43.5	26.8
160787-09	MONTHS	7/19/16		> 2419.6	182	89.9
160787-08	MONTSTATE	7/19/16		> 2419.6	167	95.7
160787-02	NBMAIN	7/19/16		387.32	10.9	1.62
160787-03	NBNCO2	7/19/16		298.66	25.5	10.1
160787-05	NBNCO2-BLANK	7/19/16		< 1	< 5	< 0.2
160787-04	NBNCO2-DUP	7/19/16		435.17	24.7	10.3
160787-13	SPAULD	7/19/16		> 2419.6	208	80.9
160949-16	CMVH-EAST	8/2/16	530			
160949-11	DRMONTREC	8/2/16		131.35	6.34	1.21
160949-10	WINDOG	8/2/16		435.17	13.5	2.51
160949-12	DRRIVERTON	8/2/16		156.48	6.69	0.82
160949-07	GRANITE	8/2/16		224.68	12.5	2.75
160949-14	KOHLS	8/2/16	288			
160949-19	Mac10-Dup	8/2/16	64.5			
160949-17	Macs10	8/2/16	64.8			

160949-18	Macs10-Blank	8/2/16	< 2			
160949-04	MILLPD	8/2/16		178.9	14.3	4.17
160949-05	MILLPD-BLANK	8/2/16		< 1	< 5	< 0.2
160949-06	MILLPD-DUP	8/2/16		201.42	13.6	4.39
160949-09	MONTHS	8/2/16		307.59	11.4	3.02
160949-08	MONTSTATE	8/2/16		307.59	11.5	2.89
160949-02	NBMAIN	8/2/16		248.9	8.98	0.97
160949-03	NBNC02	8/2/16		33.19	12.3	3.48
160949-13	SPAULD	8/2/16		50.39	8.55	2.41
160949-20	WOODBR	8/2/16	398			
160949-01	WORDAM	8/2/16		325.54	11.2	1.35
161086-11	DRMONTREC	8/16/16		> 2419.6	760	415
161086-12	DRRIVERTON	8/16/16		> 2419.6	384	105
161086-05	GRANITE	8/16/16		> 2419.6	1400	1050
161086-04	MILLPD	8/16/16		980.39	108	53.4
161086-07	MONTHS	8/16/16		> 2419.6	1570	1194
161086-08	MONTHS-BLANK	8/16/16		< 1	< 5	< 0.2
161086-09	MONTHS-DUP	8/16/16		> 2419.6	1340	875
161086-06	MONTSTATE	8/16/16		> 2419.6	1360	980
161086-03	NBNC02	8/16/16		> 2419.6	45.2	24.1
161086-13	SPAULD	8/16/16		1203.33	336	71.3
161086-01	WORDAM	8/16/16		2419.57	58.6	18.2
161229-18	CMVH-EAST2	8/30/16	552.5			
161229-09	DRMONTREC	8/30/16		112.64	9.53	1.75
161229-08	WINDOG	8/30/16		165.76	13.6	2.81
161229-10	DRRIVERTON	8/30/16		116.85	6.78	0.84
161229-11	DRRIVERTON-BLANK	8/30/16		< 1	< 5	< 0.2
161229-12	DRRIVERTON-DUP	8/30/16		103.94	7.23	0.89
161229-05	GRANITE	8/30/16		114.46	12.2	2.18
161229-14	KOHLS	8/30/16	232			
161229-19	Macs10	8/30/16	427.5			
161229-04	MILLPD	8/30/16		117.76	18.5	5.45
161229-07	MONTHS	8/30/16		248.9	13.8	3
161229-06	MONTSTATE	8/30/16		365.4	13.2	3.02
161229-02	NBMAIN	8/30/16		26.86	7.36	0.55
161229-03	NBNCO2	8/30/16			15.5	4
161229-13	SPAULD	8/30/16		26.21	8.99	1.76
161229-15	WOODBR	8/30/16	435			
161229-16	WOODBR-BLANK	8/30/16	< 2			
161229-17	WOODBR-DUP	8/30/16	437.5			
161229-01	WORDAM	8/30/16		32.25	12.3	2.43