

Four Rivers Partnership Volunteer Water Quality Monitoring 2013

Background:

The Four Rivers Partnership is an affiliation of nonprofit organizations, state and local government entities, and schools focused on Winooski River watershed projects including water quality monitoring. It includes the area of the Winooski River that is bounded on the upstream edge by the confluence of the Kingsbury River and on the downstream end by the confluence with the Dog River. The Stevens Branch and North Branch join the Winooski River between the Kingsbury and Dog River.

Goals:

As stated in the 2013 Four Rivers Partnership (4RP) water quality monitoring project application, there were three main goals:

1. Bacterial testing: Continue monitoring *E. coli* levels at common recreational sites (9) for bacteria that could present a health risk; begin to determine the source of the high *E. coli* levels at one site.
2. Rain Event Sampling: Gather data on chloride, turbidity, and phosphorus concentration with the goal of identifying and reducing pollutant and sediment sources at seven sites in Barre, Berlin, and Montpelier;
3. Engage and educate the public through the monitoring process and provide water quality information based on monitoring data.

2013 *E. coli* Monitoring Results

Volunteer members of the Four Rivers Partnership have been collecting bacterial data at recreational sites in the Four Rivers area since 2008. We have focused on sampling for *Escherichia coli* (*E. coli*) - a species of bacteria found in the fecal matter of mammals that is used as an indicator of fecal contamination in rivers, streams, lakes, and oceans. While most strains of *E. coli* do not cause disease, their presence may be associated with other bacteria and viruses that may be pathogenic. *E. coli* amounts are often given as “most probable number” or “colony forming units” - reflections of the laboratory tests used to measure *E. coli* levels. US EPA standards for *E. coli* are based on single sample measurements and/or the geometric mean of samples taken over a period of time. The EPA standard for the geometric mean is 126 mpn or cfu/100mL. This corresponds to a level in which there is a probability that 32-36 individuals/1000 would get sick from water contact.

In 2013, the Four Rivers Partnership recruited and trained volunteers to collect samples for *E. coli* testing at nine sites where levels had exceeded State and Federal standards in the past and/or sites that have a high level of recreational contact. A list of these nine sites and their locations is shown in Table 1. Once collected, these water samples were submitted to the La Rosa State laboratory for analysis. The results for these sites are summarized in Figures 1, 2, and 3, and quality assurance data is presented in Appendix A. This data will be posted on the Friends of the Winooski website, presented to the Montpelier Conservation Commission, and will be used to educate the public about possible microbiological contamination of certain sites.

Table 1. Four Rivers Partnership Water Quality Testing Sites, 2013

<u>Location</u>	<u>Waterbody</u>	<u>Site ID</u>	<u>Lat / Long</u>
Mill Road Swimming Hole	North Branch	NBMAIN	44.385342 / -72.550879
Worcester Dam Swimming Hole	North Branch	WORDAM	44.373441 / -72.5453
North Branch Nature Center Bridge	North Branch	NBNC02	44.28355 / -72.57133
Mill Pond Park Canoe Access	North Branch	MILLPOND	44.26766 / -72.56882
VSECU parking lot	Winooski River	MONTSTATE	44.260668 / -72.583174
Montpelier High School Access	Winooski River	MONTHS	44.261859 / -72.586412
Montpelier Recreation Fields	Dog River	DRMONTREC	44.25188 / -72.60126
Riverton canoe access	Dog River	DRRIVERTON	44.1994 / -72.6338
Spaulding Falls	Jail Branch	SPAULD	44.111917 / -72.489982

Geometric mean *E. coli* levels - Low flow conditions

Since *E. coli* counts vary considerably with rainfall amounts, the data were analyzed in two ways: one using only those samples taken under dry conditions, and one using all the samples. “Dry conditions” are defined here somewhat arbitrarily as sample dates when there had been less than a total of 0.25 inches of rain during the preceding 2 days based on Barre/Montpelier rainfall data. Rainfall data was obtained from the National Climate Data Center Climate Data Online website. Two out of the five 2013 sampling dates qualified as dry weather conditions under this criterion. Figure 1 displays the geometric mean *E. coli* counts for all sites under dry conditions only.

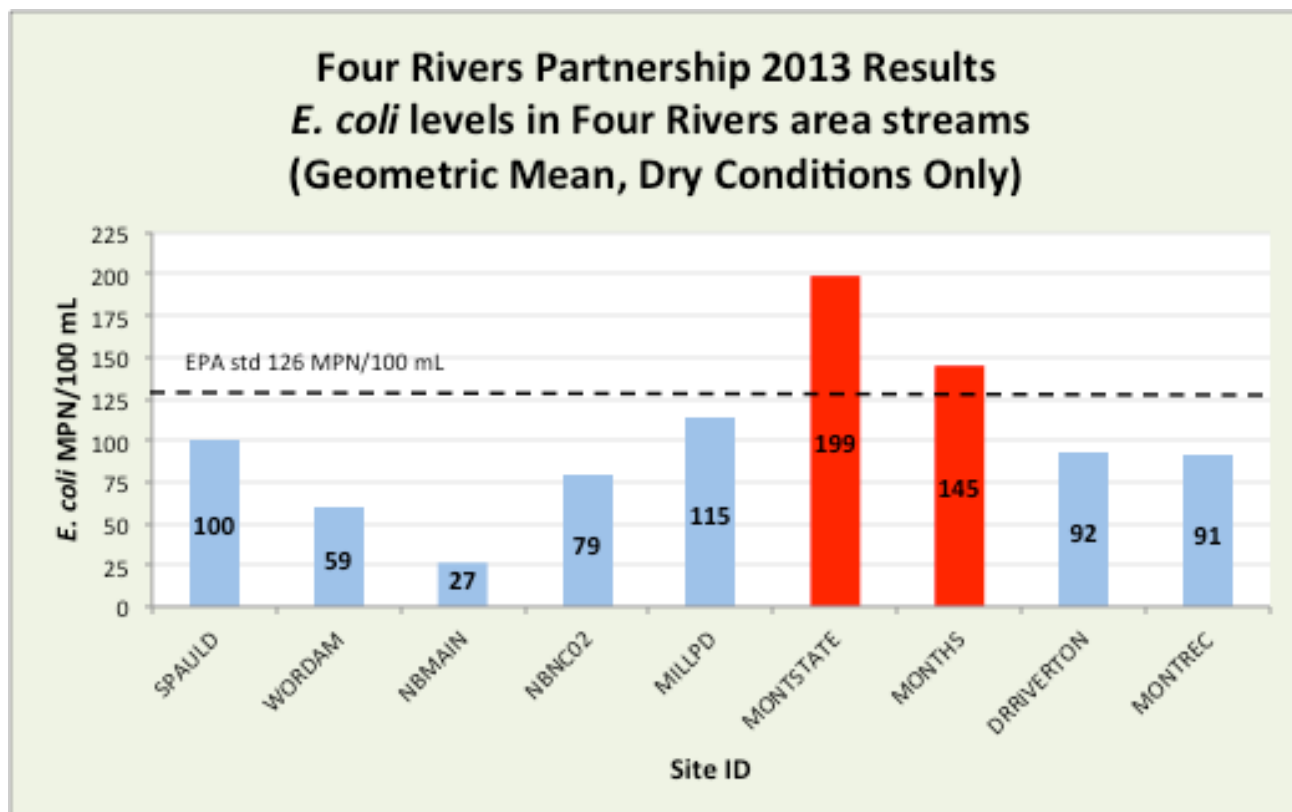


Figure 1. *E. coli* levels at nine sites monitored by the Four Rivers Partnership in 2013. Values shown are geometric mean *E. coli* levels calculated for low flow conditions only. The EPA standard for the geometric mean (126 MPN/mL) is shown by the dotted line. Sites that had geometric mean *E. coli* levels higher than the EPA standard are shown in red.

The geometric mean *E. coli* count in low flow conditions exceeded the EPA standard of 126 MPN/100 mL at the two Winooski River sites: the site near the Vermont State Employee Credit Union (MONTSTATE), and the Montpelier High School river access point (MONTHS). The geometric mean *E. coli* levels for the remaining seven monitoring sites were below the EPA standard when only the samples collected during dry conditions are included.

Geometric mean *E. coli* levels -All flow conditions

Figure 2 shows the geometric mean levels of *E. coli* at our nine sampling sites when calculated using all samples taken in 2013 regardless of flow conditions. When all samples are included, the geometric mean *E. coli* levels at all but two sites exceeded the EPA standard of 126 MPN/mL. The two sites on the Winooski (MONTSTATE and MONTHS) had particularly high geometric mean *E. coli* levels when all flow conditions were considered.

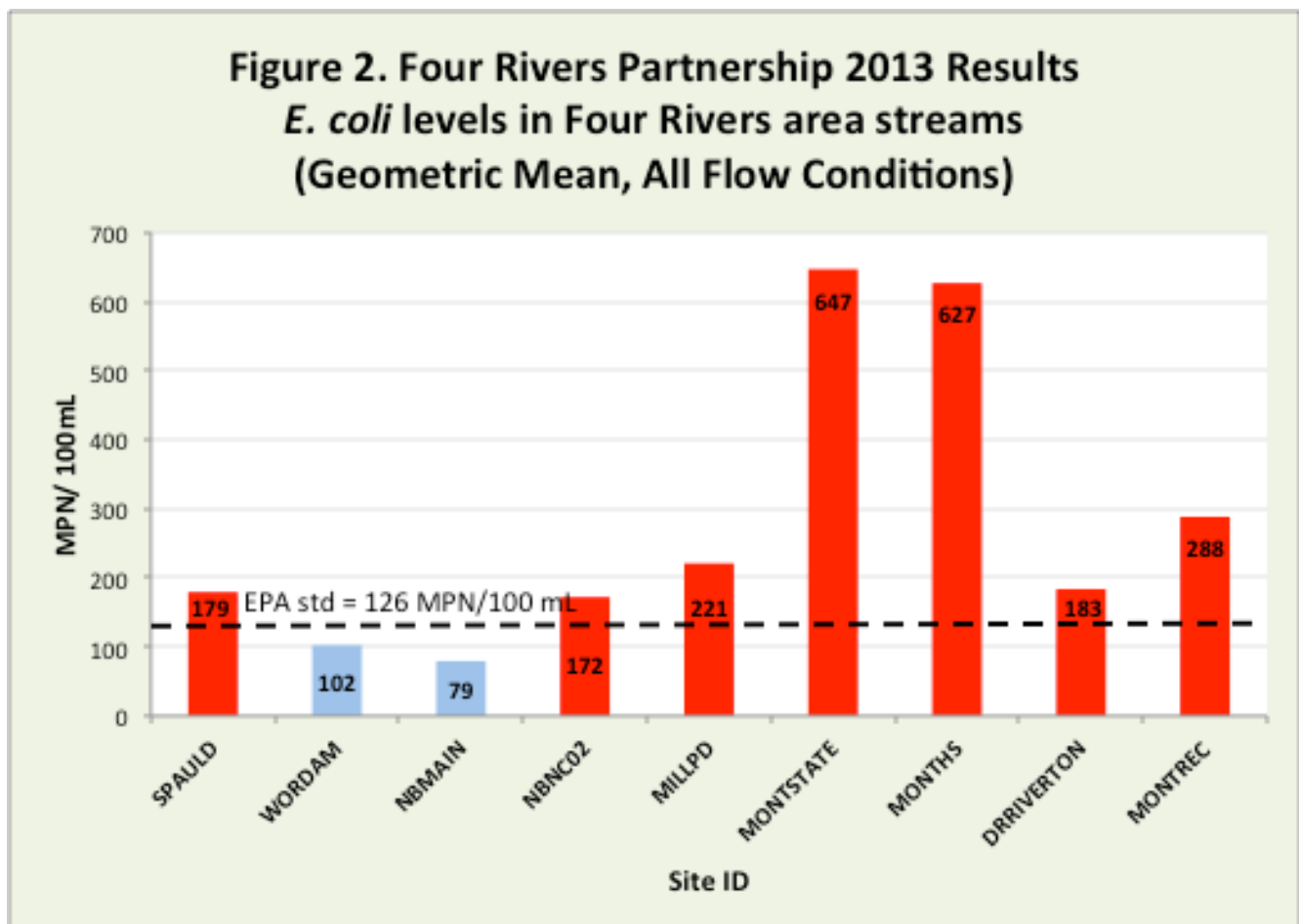


Figure 2. *E. coli* levels at nine sites monitored by the Four Rivers Partnership in 2013. Values shown are geometric mean *E. coli* levels calculated using samples collected during all flow conditions. The EPA standard for the geometric mean at low flow (126 MPN/mL) is shown by the dotted line. Sites that had geometric mean *E. coli* levels higher than the EPA standard are shown in red.

Sites exceeding the proposed Statistical Threshold Value standard

In addition to the geometric mean standard, the state of Vermont is considering adoption of the EPA's "Statistical Threshold Value" or "STV" of 235 MPN/mL that no more than 25% percent of the individual samples exceed. Six of the nine monitoring sites, NBMAIN, NCNB02, MILLPD, MONTSTATE, MONTHS, and MONTREC exceeded the proposed STV in more than 25% of the samples collected. The NBMAIN, NCNB02, and MONTREC sites are swimming holes; the MILLPD and MONTHS sites are boat access points. MONTSTATE was a site we added to determine the source of chronically high *E. coli* levels at the Montpelier High School river access point (MONTHS).

Table 2. Percentage of 2013 samples with *E. coli* counts greater than 235 MPN/100 mL and the number of samples collected at each site.

Site ID	# of samples collected	% of samples > 235 MPN/ml
SPAULD	4	25%
WORDAM	5	20%
NBMAIN	5	40%
NBNC02	5	40%
MILLPD	5	40%
MONTSTATE	3	67%
MONTHS	4	75%
DRRIVERTON	4	25%
MONTREC	4	50%

Discussion

The Four Rivers Partnership has been collecting *E. coli* data on a number of sites in the central Winooski watershed since 2008, including eight of the sites sampled in 2013. In order to identify any chronically high *E. coli* levels, the geometric mean *E. coli* values were compared across years. Figure 3 below shows the geometric mean values for all six years under all flow conditions.

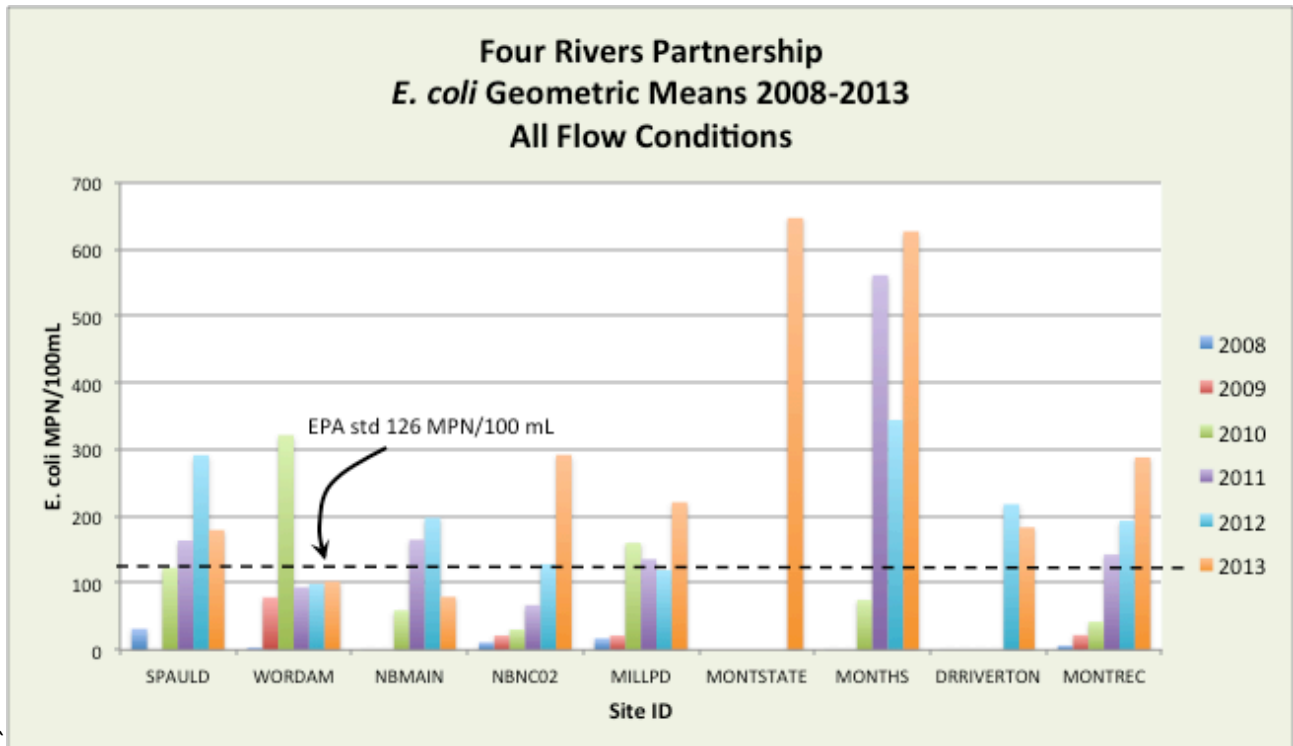


Figure 3. *E. coli* geometric mean levels at all flow conditions, 2008 to 2013. The EPA standard of 126 MPN is shown by the dotted line.

All nine sites had at least one year where the geometric mean *E. coli* for all flow conditions exceeded the EPA standard, and most sites had multiple years where the standard for *E. coli* was exceeded. Three sites, Spaulding Falls on the Jail Branch (SPAULD), the Montpelier High School river access point (MONTHS), and the Montpelier Recreation Fields on the Dog River (MONTREC) have had geometric mean values above the EPA standard for the past three consecutive years. The *E. coli* geometric mean values at the Montpelier High School site for the past three years were particularly high, surpassing 300 MPN/mL each year (see below for more discussion about this site).

Figure 4 shows the comparison of the geometric mean values when only samples taken in low-flow conditions are included in the analysis. In this analysis, six of the sites have a geometric mean above the EPA standard in at least one of the sampling years (SPAULD, WORDAM, NBMAIN, MONTSTATE, MONTHS, and MONTREC). The WORDAM 2008 value, however, was based on only one sample, and so may not have been representative. The MONTHS site has had a low-flow geometric mean values above the standard for the past three consecutive years.

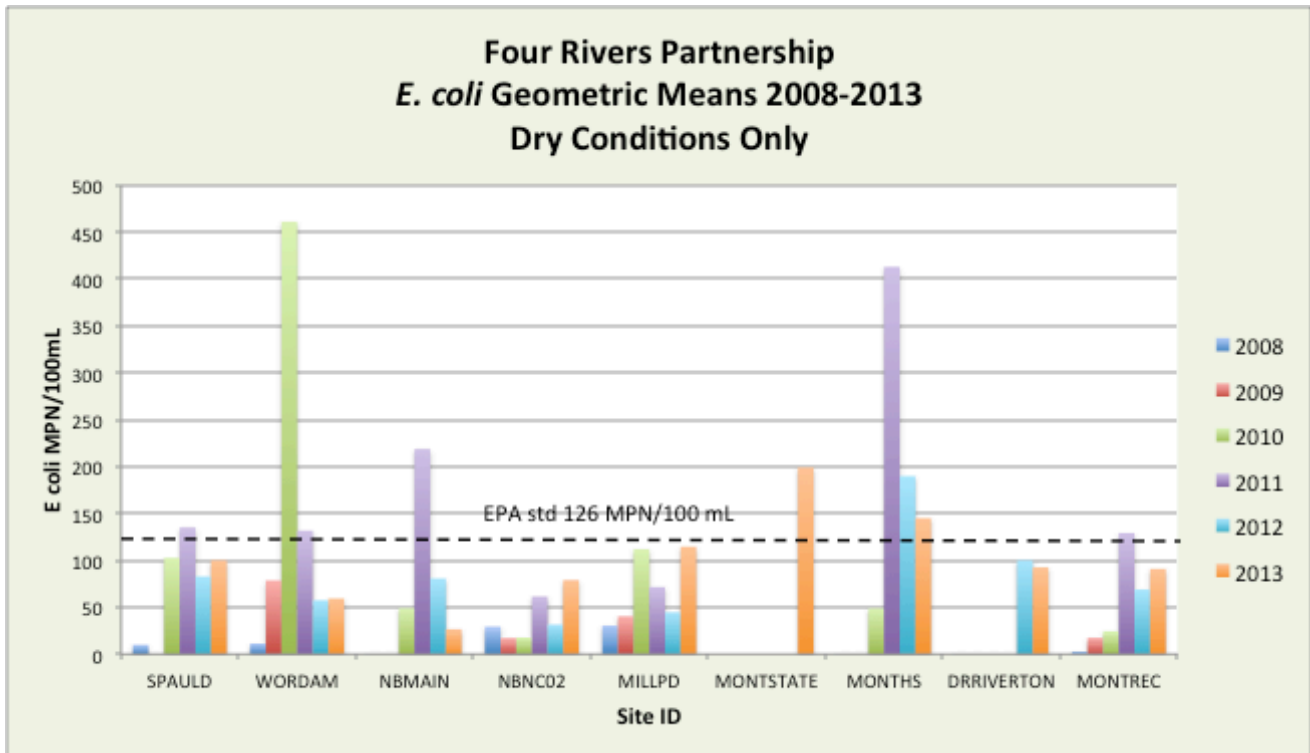


Figure 4. *E. coli* geometric mean levels during low-flow conditions, 2008 to 2013. The EPA standard of 126 MPN is shown by the dotted line.

The Montpelier High School river access point (MONTHS) is within a stretch of the Winooski River from Pioneer Street Bridge in Montpelier to I-89 that has been designated as impaired by the Water Management Division of the Vermont Department of Environmental Conservation. Chronically high *E. coli* at this site is likely due to one or more combined sewer overflow (CSO) points upstream. Combined sewers, in which domestic sewage and stormwater are transported via the same pipe system to a waste water treatment plant, were designed with overflow points that keep the treatment plant from becoming overloaded during heavy rain storms or sudden snow melts. In storm situations, the system discharges a mixture of raw sewage and stormwater directly into streams. While the sewer and stormwater lines have been mostly separated in Montpelier, there remain six known CSO points along the Winooski and North Branch Rivers upstream from the MONTHS site.

In 2013, we added the MONTSTATE monitoring site to help pinpoint the source of *E. coli* at the MONTHS high school site and to test the idea that a CSO at Bailey Avenue was the primary source of *E. coli* at the MONTHS site.

E. coli levels were consistently higher at MONTSTATE than at MONTHS in 2013, suggesting that: 1) there is an *E. coli* source upstream from MONTSTATE, and 2) the CSO at Bailey Avenue between MONTSTATE and MONTHS is not the only source of the bacterium and may not be a major source. The Friends plan to do further investigation of this issue in 2014 and future years.

Urban Water Quality Parameters: In 2012 and 2013, the Four Rivers Partnership sampled small Winooski River and Stevens Brook tributaries during rainstorm events to get an idea of how stormwater runoff is affecting the Winooski. These streams drain watersheds of varying land use composition in the Barre-Montpelier area. The locations of the monitoring sites used are given in Table 3.

Table 3. Four Rivers Partnership Urban Water Quality 2013 Test Sites

<u>Site ID</u>	<u>Tributary</u>	<u>Description</u>	<u>Watershed land use</u>	<u>Lat /Long</u>
Macs 10	Unnamed	Trib behind MacDos on 302	Commercial development	44.134000/-72.330374
Gunner 10	Gunners Brook	@ Blackwell St & 302	Rural and urban residential	44.121391/-72.303450
Bailey 10	Unnamed	Bailey & State, Montpelier	Suburban residential	44.154318/-72.351288
VTRANS 10	Pond Brook	Below footbridge at VTRANS bldg.	Wetlands; some commercial development	44.135739/-72.331140
Sabin 10	Blanchard Brook	@ mouth	Suburban residential	44.150259/-72.334766
MONTSTATE	Winooski River	VSECU parking lot	Varied	44.260668/-72.583174
MONTHS	Winooski River	Montpelier HS access	Varied	44.261859 /-72.586412

Samples were collected at five sites in 2012 and seven sites in 2013. Five separate tributaries and the Winooski River were sampled for chloride, phosphorous, and turbidity on a baseline dry day (8/21/12), during one rain event on 9/5/12, and another on 9/10/13. A summary of the results of this sampling is shown in Table 4. Baseline dry weather sampling was not done in 2013 due to a combination of persistent wet weather and a lack of volunteer availability on rarer dry days.

Table 4. Chloride, phosphorous, and turbidity in five Winooski River tributaries and the Winooski main stem during rainstorm events on 9/5/2012 and 9/10/13 using 8/21/2012 as a baseline. Values above current or proposed standards for mean chloride (230 mg/L), phosphorus (27 ug/L for medium-gradient, warm-water streams), and turbidity (25 NTU) are highlighted.

Site ID	Date	Chloride (mg/L)	TP (ug P/L)	Turbidity (NTU)
Steven's Branch Tributaries				
Gunner 10 (base)	8/21/12	56.6	6.3	1.42
Gunner 10	9/05/12	25.7	75.2	41.3
Gunner 10	9/10/13	42.7	40.5	9.79
Macs 10 (base)	8/21/12	555	6.3	0.94
Macs 10	9/05/12	231	62.3	43.5
Macs 10	9/10/13	186	110	91.6
VTRANS 10 (base)	8/21/12	64.8	9.75	0.58
VTRANS 10	9/05/12	198	28	3.2
VTRANS 10	9/10/13	72.6	14.4	1.46
Winooski River Tributaries				
Sabin 10 (base)	8/21/12	120	6.05	1.7
Sabin 10	9/05/12	70.7	108	37.4
Sabin 10	9/10/13	78.9	66.3	28
Bailey 10 (base)	8/21/12	85.2	10.6	0.78
Bailey 10	9/05/12	64.4	60.6	7.63
Bailey 10	9/10/13	56.5	35.2	na
Winooski River Main Stem (sampled in 2013 only)				
MONTSTATE	9/10/13	20.3	25.4	4.1
MONTHS	9/10/13	21.7	26.7	4.06

Chloride: 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. The State of Vermont is considering adoption of 230mg/L standard for mean chloride and 860mg chloride /L as an acute standard. 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. Chlorides of potassium, magnesium and calcium have more of an adverse effect on the health of aquatic organisms than sodium chloride, upon which the standard is based.

Our rain event sampling of chloride suggests that chloride levels are generally higher during dry (baseline) conditions than during rain events, perhaps due to evaporation from streams

concentrating the chloride and other dissolved substances (rainwater having a diluting effect). For example, the highest level of chloride measured at any site was from a sample collected from the Mac 10 site on the dry baseline sampling date. All samples had chloride levels below the proposed acute standard of 860 mg/L, and most had levels of chloride that fell below the mean (chronic) standard of 230 mg/L. Two of the three readings at the Mac 10 site, however, were above the chronic standard. More measurements are needed to help establish whether this site has an ongoing chloride problem.

Phosphorous: The VT Water Quality Standards sets no specific standard for phosphorous levels in Class B waters below 2500 feet in elevation. However, as for chloride, the state of Vermont is considering adoption of a base-flow phosphorous standard of 27 ug/L for class B, “warm water medium-gradient streams” and 15 ug/L for “medium high-gradient streams”. The phosphorous levels exceeded the proposed 27 ug/L standard at all sites during both rain events except at VTRANS on 9/10/13, but the base-flow levels were all below 15 ug/L.

Another way of considering the phosphorous levels detected during the storm events is to ask whether the phosphorous levels in a stream are contributing to or diluting the phosphorous that eventually gets transported to Lake Champlain. The target phosphorous standard for the Main Lake of Lake Champlain is 10 ug/mL. Therefore, since the total phosphorous levels in the samples taken during the 9/5/12 and 9/10/13 rain events were all well above 10 ug/L, these tributaries can be considered to have contributed to the phosphorous load during these storms. In contrast, the samples taken as a baseline on 8/21 are generally at or below 10 ug P/L.

Turbidity: The VT Water Quality standard for turbidity is 25 nephelometric units (NTU) for warm-water fish habitat and 10 NTU for cold-water fish habitat -measured as an average annual turbidity under base flow conditions. Turbidity at most sites was well below both these values on the 8/21 baseline sampling date. Samples taken during the storm on 9/5 were relatively high at Macs 10, Gunner 10, and Sabin 10, but remained fairly low at the VTRANS 10 and Bailey 10 sites. A similar pattern is seen with the 2013 rain event sampling, where the VTRANS 10 and Bailey 10 sites had relatively low turbidity levels during the storm. Gunner 10 also had low turbidity during the 2013 freshet. The other two sites, Sabin 10 and Mac 10 had high turbidity levels during the rainstorm. The Winooski River turbidity values measured at MONTSTATE and MONTHS (downstream from all the sites except Bailey 10) were well below the 10 NTU and 25 NTU standards for turbidity.

Discussion: Water quality and land use

Urban development and industrial activity seem to be affecting the tributaries in the Barre-Montpelier area. One unnamed tributary, on which the Mac 10 monitoring site was located, showed evidence of impairment for all three water quality parameters tested. This stream drains a large section of the area on “Hospital Hill”, including the Berlin Mall, the Central Vermont Medical Center, the Woodbridge Nursing Home, and the Berlin State Highway connector between Routes 62 and 302. It also passes directly through a quarry and what appears to be the quarry’s holding pond. While there are short stretches of this tributary that pass through vegetated areas, most of it is in, under, or along paved areas. The overall amount of impervious surface such as roofs, roads, and parking lots is high. Road salt use is likewise expected to be high.

Nearby Pond Brook has a large watershed and drains Berlin Pond and the area just east of the Edward J Knapp Airport. Much of the Pond Brook watershed is classified as Class 2 wetland, and most of it is forested. Relatively low chloride, phosphorous, and turbidity at the VTRANS 10 site on the lower section of Pond Brook, just upstream from where it enters the Winooski, indicates that pollutants are not finding their way into this stream to the extent they are for the unnamed tributary above.

Water quality parameters were similar at sites Gunner 10 on Blanchard Brook in Barre, Sabin 10 on Blanchard Brook in Montpelier, and Bailey 10 on an unnamed Winooski tributary in Montpelier. Chloride levels were low, while phosphorous levels were somewhat high. Phosphorous and turbidity levels were lower at Bailey 10 than at the other sites. All three streams flow through a combination of residential parcels and open fields. The density of roads and buildings are fairly low in all three watersheds and parking lots and commercial areas are lacking for the most part. Blanchard and Gunners Brooks drain much larger areas than the Bailey 10 tributary. Blanchard Brook drains a residential area with large lots in Montpelier and East Montpelier that includes upper Main Street, Murray Hill, and lower Towne Hill Road of Montpelier. The Gunners Brook watershed is large and includes the southwest part of the Town of Plainfield as well as the northeast section of Barre Town. Most of the Gunners Brook watershed is rural farmland and cleared residential lots. The lower section of Gunners Brook flows past rock quarries, behind Hope Cemetery, and through residential neighborhoods in Barre City before reaching its confluence with Stevens Branch in downtown Barre. The smaller Bailey 10 tributary in Montpelier drains the Park West neighborhood and generally parallels Terrace Avenue. Slightly better water quality parameters at Bailey 10 may be due to the fact that this tributary has a smaller watershed and therefore is less likely to pick up pollutants.

Appendix A. Quality assurance measures for *E. coli* sampling in 2013

Site ID	Date	Relative Percent Difference Between Duplicate Pairs (RPD)	Comments
NBMAIN	6/25/13	10.1%	Blank <1
NBNC02	7/9/13	27.8%	Blank <1
MONTHS	7/23/13	23.2%	Blank <1
MONTREC	8/13/13	55.5%	Blank = 110 (Probably an extra duplicate instead of a blank)
SPAULD	8/27/13	22.5%	Blank <1
Mean Relative Percent Difference (Mean RPD)		28%	
Mean Blank Concentration			<p>22 mpn/mL if the sample that was probably an extra blank taken on 8/13/13 is included in the calculation and <1 is considered 0 mpn/mL.</p> <p>0 mpn/mL if the extra duplicate is not included.</p>

Appendix B. Quality Assurance Measures for Phosphorous, Chloride, and Turbidity Sampling in 2013

Site ID	Date	Sample Type	Relative Percent Difference Between Duplicate Pairs (RPD)	Comments
MONTHS	9/10/13	Phosphorous	1.49%	
	9/10/13	Chloride	1.86%	
	9/10/13	Turbidity	1.71%	
Mean Relative Percent Difference (Mean RPD)		Phosphorous	1.49%	Based on only one RPD pair.
		Chloride	1.86%	
		Turbidity	1.71%	

Appendix C. Project Completeness

Parameter	Number of Samples Anticipated	Number of Valid Samples Collected & Analyzed	Percent Complete *
Chloride	12	14	117%
Total and Dissolved Phosphorus	12	14	117%
<i>E. coli</i>	75	51	68%
Turbidity	12	14	117%

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