

Water Quality Monitoring in the Upper Winooski River Headwaters

2013

Bacteria and Nutrients

within the towns of Cabot-Marshfield-Plainfield



pearshell mussel in distress at martin bridge 2011

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The Vermont Department of Environmental Conservation**

**The Friends of the Winooski River in Cooperation with
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***E. coli* Bacteria**

Fecal coliform bacteria are a particular group of bacteria primarily found in human and animal intestines and wastes. *Escherichia coli* (*E. coli*) is one of the fecal coliform bacteria widely used as an indicator organism to show the presence of such wastes in water and the possible presence of pathogenic (disease-producing) organisms. When *E. coli* is found in waters, its presence is not the problem of concern itself but is rather an indicator of the presence of fecal contamination (most strains of *E. coli* are not pathogenic) from humans or animals. *E. coli* monitoring is commonly conducted to ensure that the water is safe for swimmers and other contact recreational activities; a relationship can often be established between high bacteria concentrations and its sources such as rainfall runoff from urban streets, waterfowl or other wildlife congregations, pastured animals, and untreated waste (septic) water. Vermont's current Class B water quality standard sets the maximum tolerable *E. coli* level at 77 MPN (most probable number)/100 ml of sampled water. This is a very conservative standard and indicates a potential risk of contracting a gastrointestinal health illness of <4 people in a 1,000 after ingestion of water and is typically below the level of *E. coli* that can originate from wildlife. The federal Environmental Protection Agency (EPA) currently recommends a less stringent standard for geometric mean *E. coli* level of 126 MPN/100mL. This equals a risk factor of about 36 illnesses/1,000 ingestions. The EPA also provides an *E. coli* "Beach Action Value" (BAV) of 235 MPN/mL for single water samples. States can adopt this value and use it to close a recreational water site to the public when *E. coli* levels are above this standard. The State of Vermont is currently reviewing its water quality criteria and is considering the adoption of the 126 mpn/mL geometric mean standard for *E. coli* and a STV (Statistical Threshold Value) standard of 235 MPN/mL that no more than 25% of samples should be above.

***E. coli* Monitoring**

In 2013 the Winooski Headwaters Partnership volunteers concentrated sampling on the main stem locations from Cabot to Plainfield. Twelve locations were on the main stem of the Winooski River, which in 2007-2012 had chronic *E. coli* problems under base flow conditions from below Cabot to Plainfield. In an attempt to identify potential bacteria source sub watersheds, one Winooski River tributary was also sampled in 2013: "Trib B" in Plainfield, because it had periodic high bacteria counts in 2011 and 2012. Samples were collected approximately bi-weekly from June 11th, thru Aug 29th resulting for a total of 6 sampling dates over the summer. **Table 1** below lists all sites sampled in 2013. Maps in **Appendix 1** show the locations of all 2013 *E. coli* sampling locations. The raw *E. coli* data are presented in **Appendix 2**.

Table 1: Headwaters *E. coli* monitoring locations for 2013 in the Cabot-Marshfield-Plainfield, Vt. area. Shaded locations were sampled for the first time in 2013. The remaining sites are longer-term monitoring locations.

River Location	Latitude	Longitude	Description
WIN 86.6	44.4065	72.3104	Above small tributary (Cabot Plains) adjacent to Cabot Recreation Field
WIN 85.5	44.3984	72.3244	By Larry's Ball field below Cabot village.
WIN 84.1	44.3906	72.3307	Immediately above sawmill road bridge at Cabot WWTF
WIN 83.8	44.3829	72.3325	Durant cemetery below Cabot WWTF
WIN 83.4	44.3795	72.3331	Upper Gould flats, below farm road crossing
DRAIN 1	44.3800	72.3335	1 st ditch below 83.4 (agricultural)
WIN 82.8	44.3604	72.3353	Just above GMP generation station.
WIN 82.6	44.3519	72.3470	At Rte. 2 bridge just above Marshfield Village
WIN 81.8	44.3511	72.3547	Above Marshfield WWTP, below Creamery tributary
WIN 81.6	44.3501	72.3566	Below Marshfield WWTF, at flower farm
WIN 72.8	44.2871	72.4090	At Martin Bridge
TRB B 0.1	44.2792	72.4176	Trib B below RR bed crossing, below residential area in Plainfield
WIN 71.4	44.2775	72.4258	Below Bridge and Dam in Plainfield Village
WIN 70.7	44.2733	72.4322	Below Plainfield WWTF at rip rap bank

The 2013 summer's geometric mean from all locations at low-flow conditions is presented in **Table 2** along with the geomean results from years 2007, 2008, and 2010-2012. The table illustrates where *E. coli* levels are chronically high along the main stem. Geometric mean *E. coli* counts above the current, very conservative Vermont standard of 77 mpn/ml were recorded starting at the WIN84.1 site below the Cabot wastewater treatment facility on Sawmill Road and downstream from there at all Winooski main stem sites. Chronically high counts above the less stringent EPA geometric mean standard of 126 mpn/ml were present at several sites along the main stem in Marshfield (above and below the hydropower generating station and at Martin Bridge, the location of the endangered pearl shell mussel population) and Plainfield (below the dam and below the waste water treatment facility). Site WIN82.8 above the Marshfield hydropower station and site WIN 71.4 below the Plainfield dam had particularly high geometric mean *E. coli* levels, both exceeding 200 mpn/ml. These two sites have had consistently high *E. coli* levels in every year they have been tested since 2007. Sites downstream from these two sites had consistently lower geometric mean *E. coli* levels during dry weather, suggesting that the bacteria is diluted by incoming tributaries, and/or the bacteria degrade over time and distance in the water.

Table 2: Geometric Mean *E. coli* during dry conditions at Headwaters monitoring sites on the upper Winooski River and one tributary in years 2007, 2008, and 2010-2013. Dry conditions are defined here as dates when there had been less than 0.25" of rain during the preceding 48 hours. Site locations are listed from upstream in Cabot (top) to downstream in Plainfield Village (bottom). *E. coli* counts above the EPA standard of 126 MPN/ml are highlighted in red, and counts above the current Vermont standard of 77 MPN/ml are highlighted in orange. No monitoring was performed in 2009.

Site ID	Description	<i>E. coli</i> Geometric Mean Under Dry Conditions (mpn/ml)						
		2007	2008	2010	2011	2012	2013	All Years
WIN86.6	Cabot Rec Fields						48.2	48.2
WIN85.5	Larry's Ball field below Cabot			51.5	78.2	94.3	73.9	72.2
WIN84.1	Above Sawmill Rd at Cabot WWTF			117.8	84.3	123.7	112.9	109.4
WIN83.8	Durrant Cemetery	187.5	82.5	127.8	175.2	142.9	110.3	131.7
WIN83.4	Winooski R at confluence of tributary					219.3	97.0	173.7
WIN82.8	Marshfield above hydro station				171.3	540.6	128.1	274.0
WIN82.6	Marshfld @ Rt 2 below hydro station		41.01	236.3	55.8	441.8	213.6	128.8
WIN81.8	Above Marshfield WWTF		154.33	184.0		316.7	109.2	190.4
WIN81.6	Marshfield Flower Farm	256.5	133.85	149.6		222.7	119.9	174.8
WIN72.8	Marshfield Martin Bridge			161.7	214.1	167.6	149.9	173.8
WIN71.4	Below Plainfield dam	191.9	171.75	370.8	533.2	432.2	260.6	283.5
WIN70.7	Below the Plainfield WWTF		148.64	267.8		244.9	159.0	202.6

The left-most column in Table 2 lists the geometric mean *E. coli* values calculated using the dry-weather data from all the years a site has been monitored. These multi-year *E. coli* levels were above the EPA geometric mean standard at all Winooski River sites downstream from WIN84.1. Sites WIN82.8, 72.8, and 71.4 exceeded the EPA standard in the past three or more consecutive years. The *E. coli* levels at WIN71.4 have exceeded EPA standards for the past six years. Geometric mean *E. coli* calculated over all years is highest at WIN82.8 and WIN71.4. *E. coli* levels at WIN82.8 increase significantly from the nearest upstream site (WIN83.4) suggesting a significant source or sources of bacteria occur between these locations. While the all-year geometric mean *E. coli* level at sites downstream from WIN82.8 are also high, they are lower than the WIN82.8 value until the WIN71.4 site, where another spike in *E. coli* appears to be happening regularly in all monitoring years. The locations where *E. coli* levels appear to be spiking (WIN82.8 and WIN71.4) can be seen when geometric mean *E. coli* are graphed versus Winooski river mile (**Figure 1**).

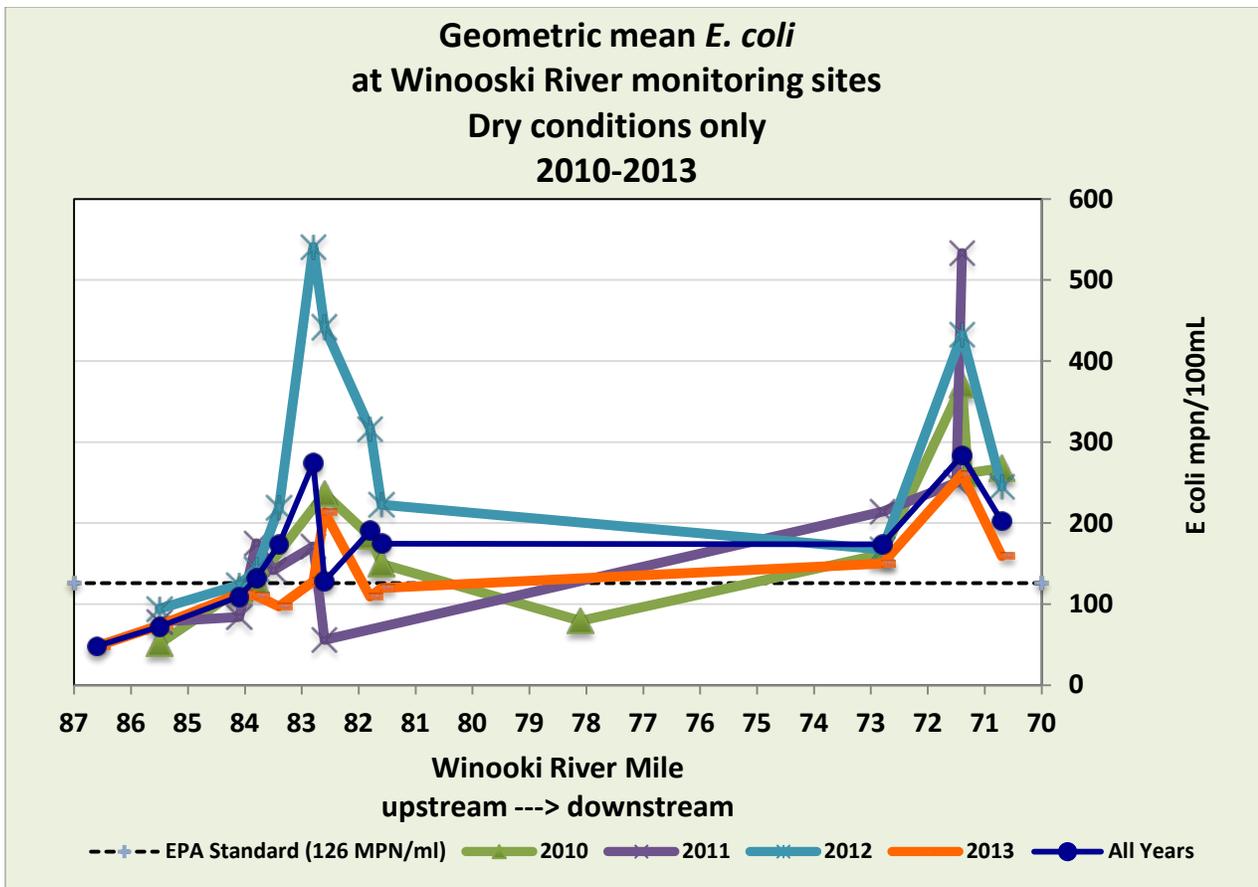


Figure 1. Geometric mean *E. coli* levels at Winooski River main stem monitoring sites. Geometric mean values were calculated using data from dry-weather dates from all years 2007 – 2013. Not all sites were monitored every year (see Table 2 above). Only years 2010 – 2013 are shown since WIN 82.8 was not monitored in previous years. The EPA standard for geometric mean *E. coli* levels (126 mpn/ml) is shown by the dotted line.

Geometric mean multi-year *E. coli* levels were above the EPA standard from WIN 83.8 to the most downstream site, WIN70.7. This stretch of river from includes the site where the dam in Marshfield village was removed in 2012. The removal of this dam opens up a potential kayaking run from about the WIN83.6 location down to the Marshfield town community center and Creamery Book confluence. High bacteria levels through this reach of stream will expose kayakers and other contact recreational users of the river to a greater risk of exposure and contracting gastrointestinal related sickness. This stretch of river also includes two private river-side campgrounds, the Martin Bridge Park, the location of a population of the endangered pearl shell mussel (also at Martin Bridge), and the Plainfield Recreation Fields where there is easy public access to the river just below the WIN71.4 monitoring site where the highest *E. coli* counts are measured.

The data presented above included only the measurements made during dry conditions where there had been less than 0.25 inches of rain in the preceding 48 hours. This data allows the identification of chronic *E. coli* problems. When *E. coli* levels at all conditions regardless of flow are considered, one can get an idea of how stormwater runoff affects the water quality of the river. Table 3 illustrates how the mean *E. coli* numbers increase when all flow conditions are included.

Table 3: Geometric mean *E. coli* during all flow and weather conditions at Headwaters monitoring sites on the upper Winooski River in years 2007, 2008, and 2010-2013. Dry conditions are defined here as dates when there had been less than 0.25” of rain during the preceding 48 hours. Site locations are listed from upstream in Cabot (top) to downstream in Plainfield Village (bottom). *E. coli* counts above the EPA standard of 126 MPN/ml are highlighted in red, and counts above the current Vermont standard of 77 MPN/ml are highlighted in orange. No monitoring was performed in 2009.

Site ID	Description	<i>E. coli</i> Geometric Mean Under All Conditions (mpn/ml)						
		2007	2008	2010	2011	2012	2013	All Years
WIN86.6	Cabot Rec Fields						208.3	208.3
WIN85.5	Larry’s Ball field below Cabot			97.8	107.1	94.3	218.2	123.3
WIN84.1	Above Sawmill Rd at Cabot WWTF			195.0	117.0	123.7	284.7	173.6
WIN83.8	Durrant Cemetery	230.7	101.2	208.7	222.6	142.9	332.6	191.3
WIN83.4	Winooski R at confluence of trib					219.3	244.8	232.8
WIN82.8	Marshfield above hydro station				231.4	540.6	379.0	363.0
WIN82.6	Marshfld @ Rt 2 below hydro station		101.1	348.2	95.4	441.8	405.8	222.3
WIN81.8	Above Marshfield WWTF		191.0	282.7		316.7	318.4	266.0
WIN81.6	Marshfld Flower Farm	370.1	174.8	149.6		222.7	289.3	252.0
WIN72.8	Marshfld Martin Bridge			246.4	228.9	167.6	327.0	239.8
WIN71.4	Below Plainfield dam	323.6	253.5	506.9	488.4	432.2	358.5	372.9
WIN70.7	Below the Plainfield WWTF		202.6	386.5		244.9	456.6	303.5

The geometric mean *E. coli* levels for 2013 were well above the EPA standard of 126 mpn/ml at all sites, and all sites but one had *E. coli* levels above the standard when the geometric mean was calculated using data from all years available for each site. As seen with the dry conditions data, the two sites with the highest *E. coli* levels in the all-year average were WIN82.8 in Marshfield and WIN71.4 below the dam in Plainfield. This was not the case with the 2013 data alone, however, since WIN82.6 levels were higher than WIN82.8.

Tributaries: 2011 Headwaters monitoring on Tributary B above the Plainfield dam suggested it was a potential source of *E. coli* in the main stem Winooski. This unnamed tributary was resampled in 2012 and 2013. The 2012 monitoring did not show this tributary to be a significant source of *E. coli* bacteria since geometric mean *E. coli* levels at this site were below both the EPA and the Vermont standards. However, most of the monitoring dates in 2012 were on dry days when there had been little rain during the previous 48 hours. The 2013 monitoring season was much wetter, however, and while the geometric mean *E. coli* level for Trib B was quite low, when samples taken in all weather conditions are included, the geometric mean *E. coli* level for this site rises well above 126 mpn/ml (see **Table 3**). The *E. coli* levels in this tributary were only high during heavy rain where over 1 inch of precipitation fell (**Table 4**), and were extremely high in those instances.

Table 3. *E. coli* levels in two tributaries of the Winooski River in 2013. The Drain 1 value is based on only one sample that was taken during a rainstorm. Values above the EPA standard of 126 mpn/ml are highlighted in red. No sample was taken from Drain 1 during dry conditions.

Tributary/Site ID	Description	Geo mean <i>E. coli</i> (mpn/ml) dry conditions	Geo mean <i>E. coli</i> (mpn/ml) all conditions
Trib B	Tributary below RR bed crossing	18.73	190.69
Drain 1	1st ditch in ag field below 83.4	na	> 2419.6

A potential source of *E. coli* above the Marshfield hydropower generating station, “Drain 1” on Route 215 in Cabot, was sampled once in 2013 when flow was high due to heavy rain. The *E. coli* levels in this sample were extremely high (>2419.6 mpn/ml). This ditch was not sampled again in 2013, however, because of landowner objections.

Table 4. *E. coli* levels in Tributary B on all 2013 sampling dates, showing rainfall amounts for the sampling day and the previous day. *E. coli* values above the EPA standard of 126 mpn/ml are highlighted in red.

Date	<i>E. coli</i> (mpn/ml)	Same day rainfall (inches)	Previous day's rainfall (inches)
6/11/13	2419.6	1.6	0.32
6/25/13	150	0.81	0.22
7/9/13	156	0	0.91
7/23/13	2419.6	1.23	0.01
8/13/13	27	0.16	0
8/27/13	13	0	0.11

In summary, the *E. coli* bacterial monitoring on the main stem of the upper Winooski River showed a similar trend as that of 2011 and 2012. *E. coli* levels were high at most sites at both low and high flows, but were higher after rain events. The highest levels of the bacteria were found in the same two reaches in all three years. One reach is in Marshfield from just below the Cabot flats at the Green Mountain Power hydropower generation station through Marshfield village to about Creamery Brook, and the other in Plainfield village below the dam. The *E. coli* counts in these reaches are significantly above the VT and EPA contact recreation standards. The source(s) of *E. coli* for the Marshfield village reach appear to be located between the generating station and Gould Flats Road. This reach of the watershed should be explored to help identify potential non-point sources and ways to mitigate them. The high counts in the Plainfield village area are potentially from stormwater or poor municipal hookups and infrastructure leaks. Stormwater outfalls were monitored during dry weather in both Marshfield and Plainfield by the Friends of the Winooski River in the summer of 2013. This monitoring revealed only one potential problem outfall downstream from both these reaches, however, and no obvious problems in upstream areas (see **Stormwater Outfall Monitoring** section below). One outfall right at the Plainfield dam, however, was not accessible for assessment and could be a potential source of the *E. coli* contamination. For both the Marshfield and Plainfield reaches, *E. coli* could be reaching the river during storm events via stormwater runoff, either through the storm drain system or as surface runoff into tributaries-situations that would not have been detected in the monitoring process.

The two tributaries that were monitored by the Headwaters during the 2013 season, one in Plainfield upstream from WIN74.1, and one in Marshfield upstream from WIN82.8, showed evidence of high *E. coli* during rain events. The Plainfield tributary had low *E. coli* during dry, low-flow periods, however. The Marshfield tributary was not sampled during dry conditions. It appears that at least one source of *E. coli* may be surface runoff, whereas illicit discharge from stormwater outfalls seems a less likely source. Due to the chronically elevated *E. coli* levels in the main stem it is recommended that this monitoring continue, and that the *E. coli*

sources continue to be tracked down. Results for the 2013 Headwaters monitoring has been presented at the Marshfield town meeting and will be posted on the Friends of the Winooski website. Links to this site will be distributed to Cabot, Marshfield and Plainfield residents via Front Porch forum.

Water Quality Monitoring Results

The five Winooski River tributaries in **Table 5** were sampled in 2013 for nutrients (total nitrogen and phosphorus) and chloride. The samples were all collected once pre month June through September regardless of flow conditions for a total of four sampling dates. The results are presented in **Appendix 3** and average concentrations at low and all flows are shown in **Table 4** below.

Chloride concentrations were well below Vermont’s proposed standard for chloride of 230 mg/l at all sites and below the detection level of 2 mg/l at two of the tributary streams. Chloride concentrations in Vermont are primarily a reflection on the level of road salt accumulation in the groundwater. These chloride levels are low and do not pose a threat to the aquatic life.

Nitrogen concentrations were also low and below the Vermont standard of 5 mg/L. Mean total phosphorus was relatively low during dry periods, with the exception of the WIN72.8 site, where total phosphorus averaged above the State’s proposed 15 µg/L for medium, high gradient streams at low flow. Phosphorus levels increased significantly in all streams during high flow after rain events, especially on South Walden Tributary, Jug Brook, and Great Brook, as seen in the average phosphorus values for all conditions.

Table 3: Locations of water quality monitoring stream reaches sampled in 2013.

River Location	Latitude	Longitude	Description
SWT 0.2	44.419325	72.312587	South Walden Tributary at Houston Hill Road
JB 0.1	44.3923	72.3310	Jug Brook immediately below Rt 215 in lower Cabot.
NAB 2.6	44.2776	72.37728	Naismith Brook at Holt Road bridge
WIN 72.8	44.2871	72.4090	Winooski River at Martin Bridge
GB 0.1	44.2767	72.4267	Great Brook at mouth

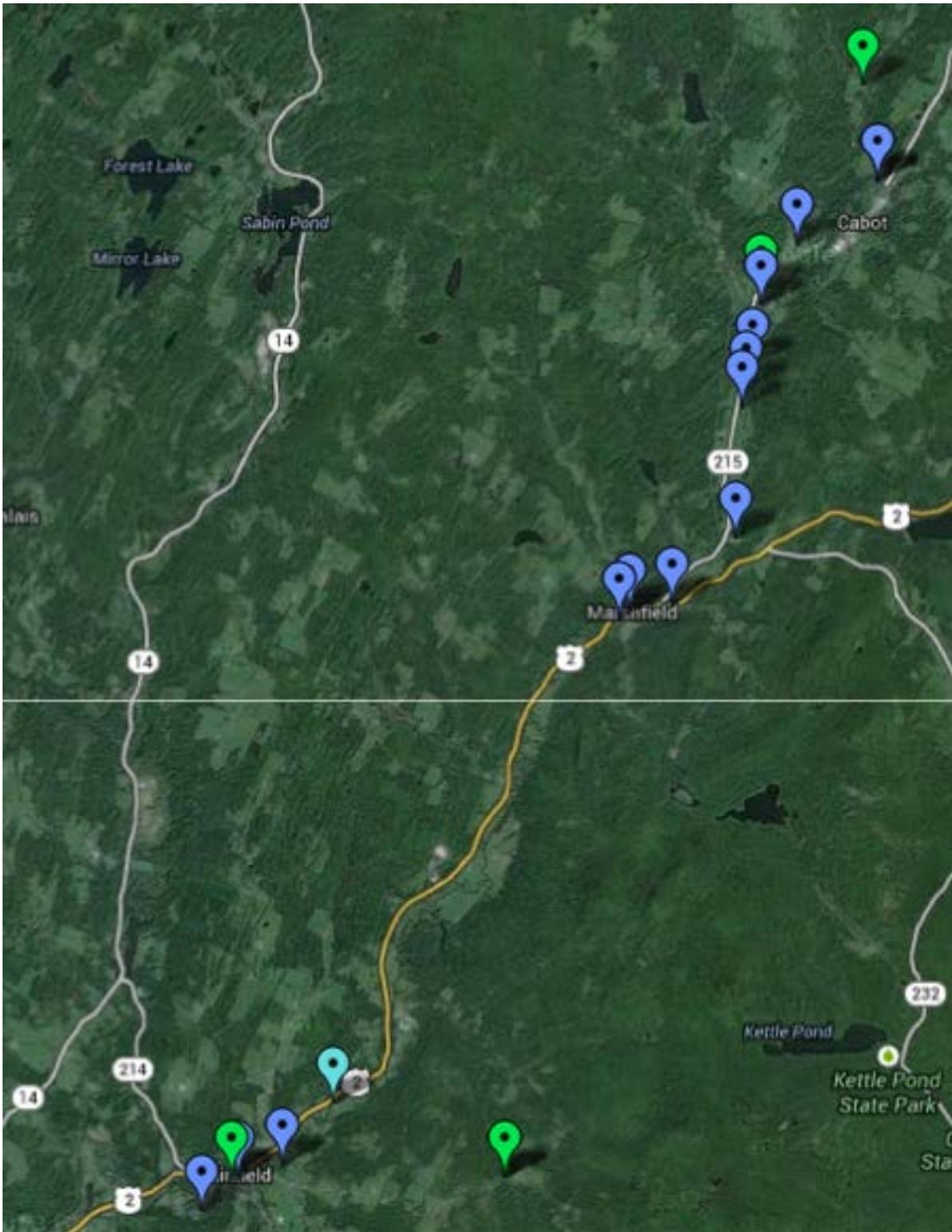
Table 4: Average (n=4) concentration of chloride, total nitrogen, and total phosphorus in four small tributaries of the upper Winooski River and the Winooski River at Martin Bridge (site WIN 72.8) during dry conditions or all conditions. Dry conditions were defined as sampling times when there had been less than 0.25 inches of rain in the previous 48 hours. There were two dates that qualified as dry based on this criterion. The current Vermont standard for nitrogen in class B streams is 5mg/L. There is no current standard for chloride and phosphorus, but the state is considering the adoption of a 230 mg/ml standard for mean chloride and a 15 ug/L standard for mean phosphorus at low flow in class B medium, high-gradient streams. Values above these standards are highlighted.

Location	Chloride (mg/L)		TN (mg/L)		TP (µg/L)	
	dry	all	dry	all	dry	all
SWT 0.2	18.55	16.0	0.36	0.8	9.06	158.2
JB 0.1	<2	<2	0.29	0.69	9.0	125.9
NAB 2.6	<2	<2	0.32	0.33	14.8	24.0
WIN 72.8	5.8	5.3	0.37	0.41	20.0	46.4
GB 0.1	5.7	2.4	0.54	0.68	6.3	247.7

Storm water outfall monitoring: In the summer and fall of 2013, The Friends of the Winooski River and Stone Environmental conducted a comprehensive storm water outfall monitoring and assessment in the towns of Plainfield, Marshfield, and Cabot. In this assessment, we visited all mapped stormwater outfall locations for each town during dry weather when the outfalls would be expected to be dry. Flowing outfalls were flagged as possible problem outfalls, and water quality testing was done in the field for ammonia, chlorine, and detergents. Optical brightener test pads were left in these flowing outfalls for approximately one week. Optical brighteners are present in laundry detergents and are added to “brighten” fabric. They bind to cotton, fluoresce under UV (black) light, and can be used as an indicator of domestic sewage.

This effort identified one stormwater outfall in Plainfield that was flowing during dry weather conditions and had a discharge that tested positive for optical brighteners. The outfall empties onto the bank of the Winooski between monitoring sites WIN71.4 and WIN70.7. Closer inspection of the catchbasin above this outfall revealed a suspicious, unmapped connection entering into this basin located at the corner of Martin Meadow Road and Towne Avenue. The flow from this connection also tested strongly positive for optical brighteners, indicating it contained laundry detergent and probably originated from one or more of the homes in the surrounding residential neighborhood. A sample of the discharge from this connection was sent to the La Rosa laboratory for *E. coli* testing to determine whether fecal matter was also present in the discharge. The results of this testing was negative (<1 mpn/ml). The Friends plan to follow up this problem outfall with the town of Plainfield’s Department of Water and Waste Water in the spring of 2014.

Appendix 1: Maps showing locations of *E. coli* sampling sites in the Upper Winooski River 2013. Blue icons indicate *E. coli* monitoring sites; green icons indicate water quality parameter monitoring sites. The teal marker indicates the location of WIN72.8, where both *E. coli* and the other water quality parameters were monitored.



Appendix 2: 2013 *E. coli* counts by station location and date, and the geometric mean

Location	Date	flow	Final E. Coli. (mpn/100ml)
TRB B 0.1	6/11/13	high	>2419.6
TRB B 0.1	6/25/13	high	150
TRB B 0.1	7/9/13	high	156
TRB B 0.1	7/23/13	high	>2419.6
TRB B 0.1	8/13/13	low	27
TRB B 0.1	8/27/13	low	13
TRB B 0.1	geo mean	low	18.73
TRB B 0.1	geo mean	all	190.69
WIN 70.7	6/11/13	high	579
WIN 70.7	6/25/13	high	261
WIN 70.7	7/9/13	high	980
WIN 70.7	7/23/13	high	>2419.6
WIN 70.7	8/13/13	low	93
WIN 70.7	8/27/13	low	272
WIN 70.7	geo mean	dry	159.0
WIN 70.7	geo mean	all	456.6
WIN 71.4	6/11/13	high	291
WIN 71.4	6/25/13	high	193
WIN 71.4	7/9/13	high	816
WIN 71.4	7/23/13	high	>2419.6
WIN 71.4	8/13/13	low	84
WIN 71.4	8/27/13	low	228
WIN 71.4	geo mean	dry	138.39
WIN 72.8	geo mean	all	358.52
WIN 72.8	6/11/13	high	214
WIN 72.8	6/25/13	high	172
WIN 72.8	7/9/13	high	1046
WIN 72.8	7/23/13	high	1414
WIN 72.8	8/13/13	low	105
WIN 72.8	8/27/13	low	214
WIN 72.8	geo mean	dry	149.9
WIN 72.8	geo mean	all	327.03

Location	Date	flow	Final E. Coli. (mpn/100ml)
WIN 81.6	6/11/13	high	308
WIN 81.6	6/25/13	high	228
WIN 81.6	7/9/13	high	240
WIN 81.6	7/23/13	high	>2419.6
WIN 81.6	8/13/13	low	124
WIN 81.6	8/27/13	low	116
WIN 81.6	geo mean	dry	119.93
WIN 81.6	geo mean	all	289.33
WIN 81.8	6/11/13	high	411
WIN 81.8	6/25/13	high	411
WIN 81.8	7/9/13	high	214
WIN 81.8	7/23/13	high	>2419.6
WIN 81.8	8/13/13	low	91
WIN 81.8	8/27/13	low	131
WIN 81.8	geo mean	dry	109.18
WIN 81.8	geo mean	all	318.44
WIN 82.6	6/11/13	high	687
WIN 82.6	6/25/13	high	387
WIN 82.6	7/9/13	high	152
WIN 82.6	7/23/13	high	>2419.6
WIN 82.6	8/13/13	low	140
WIN 82.6	8/27/13	low	326
WIN 82.6	geo mean	dry	213.64
WIN 82.6	geo mean	all	405.76
WIN 82.8	6/11/13	high	488
WIN 82.8	6/25/13	high	461
WIN 82.8	7/9/13	high	517
WIN 82.8	7/23/13	high	1553
WIN 82.8	8/13/13	low	108
WIN 82.8	8/27/13	low	152
WIN 82.8	geo mean	dry	128.12
WIN 82.8	geo mean	all	379.03

Location	Date	flow	Final E. Coli. (mpn/100ml)
WIN 83.4	6/11/13	high	276
WIN 83.4	6/25/13	high	199
WIN 83.4	7/9/13	high	172
WIN 83.4	7/23/13	high	>2419.6
WIN 83.4	8/13/13	low	64
WIN 83.4	8/27/13	low	147
WIN 83.4	geo mean	dry	96.99
WIN 83.4	geo mean	all	244.77
WIN 83.8	6/11/13	high	488
WIN 83.8	6/25/13	high	172
WIN 83.8	7/9/13	high	548
WIN 83.8	7/23/13	high	>2419.6
WIN 83.8	8/13/13	low	80
WIN 83.8	8/27/13	low	152
WIN 83.8	geo mean	dry	110.27
WIN 83.8	geo mean	all	332.58
WIN 84.1	6/11/13	high	387
WIN 84.1	6/25/13	high	186
WIN 84.1	7/9/13	high	240
WIN 84.1	7/23/13	high	>2419.6
WIN 84.1	8/13/13	low	54
WIN 84.1	8/27/13	low	236
WIN 84.1	geo mean	dry	112.89
WIN 84.1	geo mean	all	284.72

Location	Date	flow	Final E. Coli. (mpn/100ml)
WIN 85.5	6/11/13	high	344
WIN 85.5	6/25/13	high	308
WIN 85.5	7/9/13	high	77
WIN 85.1	7/23/13	high	>2419.6
WIN 85.5	8/13/13	low	42
WIN 85.5	8/27/13	low	130
WIN 85.5	geo mean	dry	73.89
WIN 85.5	geo mean	all	218.15
WIN 86.6	6/11/13	high	1203
WIN 86.6	7/9/13	high	58
WIN 86.6	7/23/13	high	>2419.6
WIN 86.6	8/13/13	low	29
WIN 86.6	8/27/13	low	80
WIN 86.6	geo mean	dry	48.17
WIN 86.6	geo mean	all	208.26

Appendix 3: Water quality results from 2013 locations.

Location	Date	Flow	Chloride (mg/L)	TN (mg-N/l)	TP (ug P/L)
GB 0.1	6/25/13	high	2	0.08	71.4
GB 0.1	7/23/13	high	2.71	1.37	424
GB 0.1	8/27/13	base	7.4	0.64	6.03
GB 0.1	9/17/13	base	3.96	0.43	6.54
GB 0.1	average	base	5.68	0.535	6.285
GB 0.1	average	all	2.4	0.7	247.7
JB 0.1	6/25/13	high	2	na	12.7
JB 0.1	7/23/13	high	2	1.49	473
JB 0.1	8/27/13	base	2	0.26	8.68
JB 0.1	9/17/13	base	2	0.31	9.24
JB 0.1	average	base	2	0.29	8.96
JB 0.1	average	all	2	0.69	125.91
NAB 02.6	6/25/13	high	2		25.8
NAB 02.6	7/23/13	high	2	0.36	40.9
NAB 02.6	8/27/13	base	2	0.25	14.4
NAB 02.6	9/17/13	base	2	0.38	15.1
NAB 02.6	average	base	2	0.315	14.75
NAB 02.6	average	all	2	0.32	21.89
WIN 72.8	6/25/13	high	5.22		29.40
WIN 72.8	7/23/13	high	4.56	0.5	116.00
WIN 72.8	8/27/13	base	5.95	0.44	20.3
WIN 72.8	9/17/13	base	5.59	0.3	19.7
WIN 72.8	average	base	5.77	0.37	20.00
WIN 72.8	average	all	5.33	0.41	46.35
WIN 87.9	6/25/13	high	15.20	0.22	20
WIN 87.9	7/23/13	high	11.7	2.08	595
WIN 87.9	8/27/13	base	16.7	0.35	8.61
WIN 87.9	9/17/13	base	20.4	0.36	9.52
WIN 87.9	average	base	18.55	0.355	9.065
WIN 87.9	average	all	16.0	0.8	158.2