Water Quality Sampling of Mid-Winooski Watershed Streams and Rivers

Summer 2019

Volunteers Nancy Munno and Ethan Borland collect samples from the North Branch River in Montpelier

FRIENDS OF THE Winooski

Acknowledgements

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Introduction

The Friends of the Winooski River and its citizen scientist volunteers have been sampling water quality in the Barre-Montpelier area since 2008 as part of our Four Rivers Partnership Program. Sampling efforts initially focused on *E. coli* levels in the area's streams to determine whether river access sites were safe for recreational contact. In 2014 we added sampling for chloride, phosphorus, and turbidity at select sites. Phosphorus, chloride, and turbidity sampling helps determine the quality of aquatic habitat as well as the nutrient load contributed by a stream to Lake Champlain. Engaging local volunteers in the monitoring process brings community members out to the rivers and helps them become more aware of the issues threatening the health of area streams, while sampling for *E. coli* allows us to educate the community about when to avoid local swimming holes, canoe routes, and fishing spots.

In recent years our primary purpose in sampling for *E. coli* has been to identify and address sources of the bacteria in the Winooski River, which is listed by the State of Vermont as impaired for high *E. coli* levels in the reach from the Pioneer Street Bridge in Montpelier downstream to the confluence with the Dog River. In 2018, sampling at the mouth of the North Branch River just above its confluence with the Winooski and near the location of a future riverside park revealed extremely high *E. coli* levels during low-flow, dry weather conditions. Suspected sources of *E. coli* in both the North Branch and the Winooski Rivers include illicit discharge from the sanitary sewer system, failed septic systems, pet waste, the lack of public restrooms for the homeless population, and combined sewer overflows (CSOs). It should be noted that the first two sources would be expected to affect *E. coli* levels during dry weather, whereas the latter two would usually contribute *E. coli* to streams only during rainy conditions when stormwater runoff is generated.

Our 2019 sampling focused on narrowing down the source(s) of *E. coli* to the lower North Branch in Montpelier. A few sites on the Winooski mainstem in order to determine how the North Branch River *E. coli* was affecting the Winooski. Since the Winooski River upstream of Montpelier has also had elevated *E. coli* in past sampling years, we sampled the Stevens Branch upstream of its confluence with the Winooski. Phosphorus and chloride were sampled at a subset of the Montpelier-area sites. In 2019, in partnership with the Vermont River Conservancy (VRC), the Friends of the Winooski River added *E. coli*, phosphorus, and chloride sampling of Joiner Brook in Bolton to our sampling regime. The VRC had recently purchased the Bolton Potholes, a popular swimming area, and was concerned about local reports

of high *E. coli* levels in the brook. Similarly, a few new *E. coli*, phosphorus, and/or chloride sampling sites were added in Northfield on Cox Brook and the Dog River, and in Moretown on Jones Brook due to local concern about water quality and safe recreation.

Methods

In the summer of 2019, Friends of the Winooski River volunteers collected water samples from 24 sites in the mid-Winooski area- five on the Winooski mainstem, nine on the North Branch, two on the Steven's Branch, four on the Dog, and five on smaller tributaries to test for *E. coli*, phosphorus, turbidity, and/or chloride. Sampling occurred on a total of seven dates: June 25th, July 9th, July 25th, August 6th, August 27st (August 20th for Joiner Brook), September 10th, and September 11th. All dates except September 11th were associated with dry weather with little or no rain in the preceding 48 hours. The site IDs, descriptions, and locations for sites are given in Tables 1-4 and are shown on the maps in Figures 1-4.

Table 1. Montpelier area 2019 *E. coli* sampling site locations and descriptions. Sites sampled from bridges are indicated by [b]; all other sites were sampled in-stream.

Site ID	Waterbody	Description	Lat / Long
NBNC02	North Branch	N Branch Nature Center swimming hole (including phosphorus & chloride)	44.28349, -72.57131
MILLPD	North Branch	Mill Pond Park Canoe Access	44.26766, -72.56882
SPRINGST[b]	North Branch	Above Spring Street Bridge	44.26318, -72.57199
Katies (NEW)	North Branch	Behind house at 127 Elm St	44.26291, -72.57344
SCHOOLST[b] (NEW)	North Branch	Above School Street Bridge	44.26156, -72.57506
LANGDONST[b] (NEW)	North Branch	Above Langdon Street Bridge	44.26090, -72.57605
STATEST[b]	North Branch	Above State Street Bridge	44.26044, -72.57645
LOWERNB (NEW)	North Branch	Near concrete platform	44.25969, -72.57698
NBBIKEPATHBR	North Branch	Lower North Branch just above the Bike Path construction site at the rat dam (including phosphorus & chloride)	44.25929, -72.57779
PIONEER[b] (NEW)	Winooski River	Above Pioneer Street Bridge (including phosphorus)	
GRANITE[b]	Winooski River	Above Granite Street Bridge	44.25180, -72.57064
MAINSTBR[b]	Winooski River	Above Main Street Bridge (including phosphorus)	44.25784, -72.57741
TAYLORST[b]	Winooski River	Above Taylor Street Bridge (including phosphorus)	44.25957, -72.57987
MONTHS	Winooski River	Montpelier HS Access (including phosphorus & chloride)	44.26186, -72.58641
JONESBR1	Jones Brook	Fork 1 of Jones Brook behind 2376 Jones Brook Rd (phosphorus only)	44.23978, -72.65888
JONESBR2	Jones Brook trib	Small trib to Jones Brook (phosphorus only)	44.23956, -72.65899

STEVEBMAC	Stevens Branch	Just above confluence with Mac10 trib (*E. coli* and chloride only)	44.21547, -72.53686
Macs10	Unnamed trib	On west side of MacDonalds (chloride and phosphorus)	44.22784, -72.55109
STEVEB[b]	Stevens Branch	Above Partridge Farm Rd Bridge (including chloride)	44.23252, -72.55143

Table 2. 2019 Northfield sampling sites.

Site ID	**Waterbody**	**Description**	**Lat / Long**
DRGOLFABV	Dog River	Above Northfield Country Club (phosphorus only)	44.11012, -72.69103
DRGOLFBEL	Dog River	Below the Northfield Country Club (phosphorus only)	44.11464, -72.67912
WATERST	Dog River	Water Street Park River Access (*E. coli*, phosphorus, and chloride)	44.14656, -72.66169
UNION	Union Brook	Union Brook at mouth (phosphorus and chloride)	44.14919. -72.66060
COXBR3	Cox Brook	Swimming hole at 3rd bridge (*E. coli* and phosphorus)	44.17378, -72.65550
DRATCOX	Dog River	Swimming hole at confluence w/Cox near 1st covered bridge (*E. coli* and phosphorus)	44.17242, - 72.65153

Table 3. 2019 Joiner Brook sampling sites

Site ID	**Waterbody**	**Description**	**Lat / Long**
UVMCAMP	Joiner Brook	Behind UVM Camp (*E. coli*, phosphorus and chloride)	44.39448, -72.87600
HUNTER	Joiner Brook	Behind the Black Barn (*E. coli*)	44.37852, -72.87430
LOWERJB	Joiner Brook	Behind 284 Bolton Valley Access Road (*E. coli*)	44.37566, -72.87420
MOUTHJB	Joiner Brook	Across brook from Smilie School (*E. coli*, phosphorus, and chloride)	44.37386, -72.87830

Figure 1. 2019 Four River Partnership sampling locations on the North Branch and Winooski Rivers in Montpelier VT. See following inset in Figure 2 for the locations along the lower North Branch.

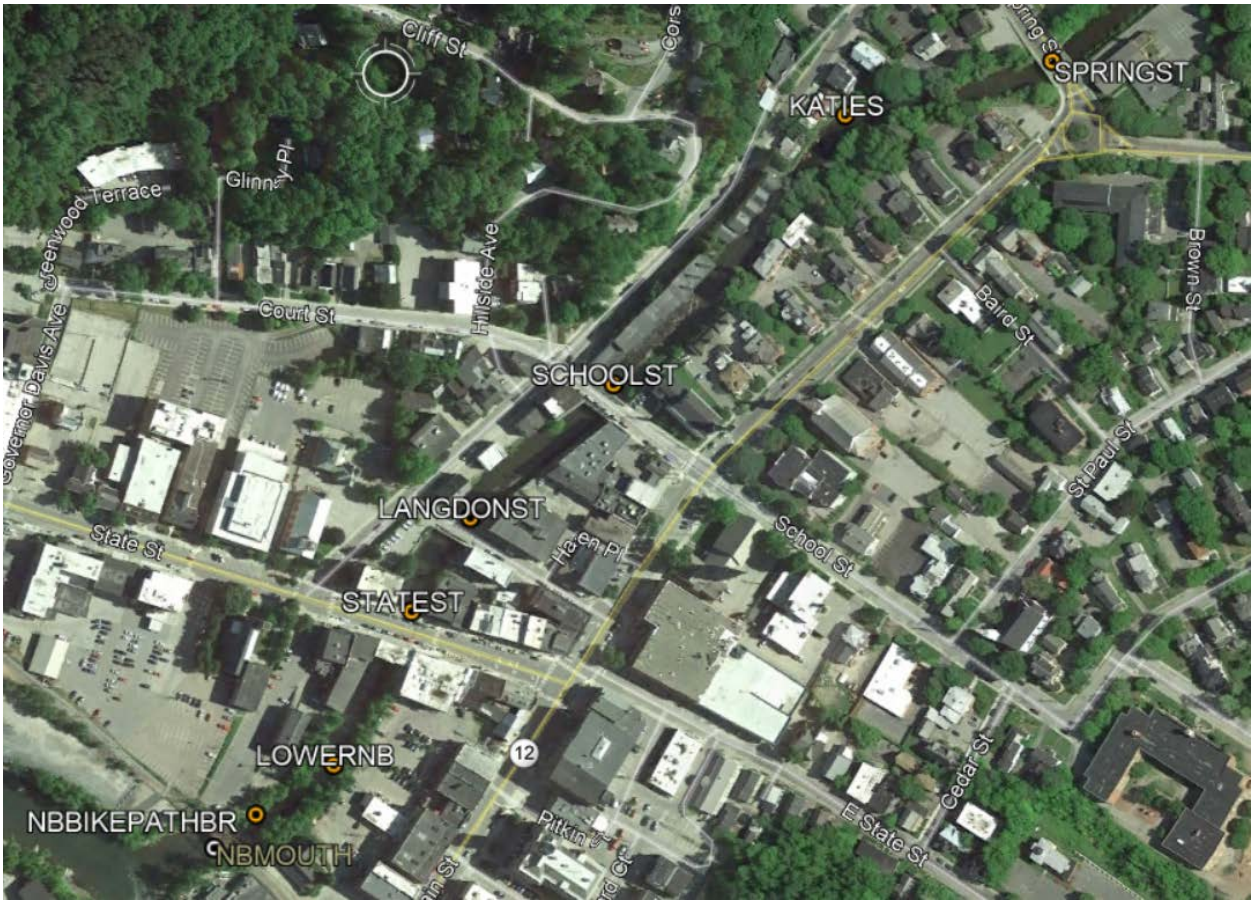

Figure 2. 2019 Four Rivers Partnership sampling locations along the lower North Branch River in Montpelier, Vermont. The NBMOUTH (in gray) sampling site used in 2018 is shown for comparison (see Results & Discussion).

Figure 3. 2019 Four Rivers sampling locations on the Stevens Branch and an unnamed tributary in Berlin, VT

Figure 4. 2019 Four Rivers Partnership sampling locations on the Dog River and Cox Brook in Northfield, VT

Figure 5. 2019 Four Rivers Partnership sampling locations on Joiner Brook in Bolton, VT

Samples were collected either as midstream grab samples using sterile bottles or, in cases where steep banks prevented safe access to the river, by a bucket-sampling method. Bucket sampling involved lowering a small plastic bucket (not sterile) into the deepest section of the stream channel four times – the first three to rinse the bucket with the river water, and the fourth to fill sampling bottles with the water collected. All samples were put on ice directly after sampling, and transported to the Vermont Agricultural and Environmental Laboratory in Randolph, VT, where they were analyzed by VAEL staff. Quality assurance measures during sampling included taking 1 blank (negative control) and 1 duplicate sample per every ten samples collected. Field sheets required volunteers to not only record site IDs, but to give a written description of the site to avoid site ID mix-ups. Sample numbers were recorded on the

field sheets when the bottles were filled so bottle mix-ups could be identified and corrected, and the results were screened for possible errors. The reproducibility of the sampling results was determined by calculating the relative percent difference (RPD) between the field duplicates (see Appendix B). The RPDs for the samples collected during the 2019 season were 3.2% for chloride, 21.8% for *E. coli*, 10.0% for total phosphorus. All RPD values fall well within the expected range of field duplicates for each parameter, but the variability between samples should still be taken into account when interpreting the results.

Rainfall prior to sampling

Rainfall and the resulting stormwater runoff carrying pollutants to streams in a major factor influencing a waterbody's water quality. The Friends' sampling plan for 2019 included almost exclusively dry-weather sampling to investigate the effects of factors such as improper sewer discharge, septic-system failures, and contaminated ground water. We also sampled during a moderate rain event 9/11/2019 at the Northfield sites to begin to determine the effects of stormwater runoff on water quality such as improper sewer discharge, septic-system failures, and contaminated ground water. Tables 4-6 below show the rainfall amounts recorded in Montpelier, Northfield, and Bolton for the morning of the sampling and the cumulative precipitation for 1, 2, and 3 days prior to the sampling dates. None of the dry-weather sampling dates had significant rain the morning of or the day prior to sampling. A single rain event sampling was attempted at the Northfield sites on 9/11, but a forecasted storm only yielded 0.18 inches of precipitation.

Table 4. Montpelier area rainfall (in inches) on the sampling dates and 1-3 days before sampling. 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) in Berlin, VT. The total daily amounts used to calculate the cumulative rainfall on the days prior to sampling were downloaded from the National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/) for the KMPV station.

Date	rainfall the day of sampling before 8 am	rainfall on the day prior to sampling (day 1)	cumulative rainfall 2 days before sampling (days 1+2)	cumulative rainfall 3 days before sampling (days 1+2+3)
6/25/19	0	0	0	0
7/9/19	0	0	0	0.75
7/25/19	0	0	0.06	0.26
8/6/19	0	0	0	0
8/20/19	0	0	0.04	0.84
8/27/19	0	0	0	0
9/10/19	0	0	0.01	0.25

Table 5. Northfield area rainfall (in inches) on the sampling dates and 1-3 days before sampling. 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) in Berlin, VT. The total daily amounts used to calculate the cumulative rainfall amounts at the Northfield 1.5 N station on the days prior to sampling were downloaded from the National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/). The rain event date is shaded. Data was not available for 8/26, 8/25, or 8/24, but see Montpelier rainfall, above.

Date	rainfall the day of sampling before 8 am	rainfall on the day prior to sampling (day 1)	cumulative rainfall 2 days before sampling (days 1+2)	cumulative rainfall 3 days before sampling (days 1+2+3)
6/25/19	0	0	0	0.1
7/9/19	0	0	0.91	0.91
7/25/19	0	0	0.29	0.37
8/6/19	0	0	0	0
8/27/19	0	Not available	Not available	Not available
9/10/19	0	0	0.18	0.18
9/11/19	0.2	0	0	0.18

Table 6. Bolton area rainfall (in inches) on the sampling dates and 1-3 days before sampling. 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) in Berlin, VT. The total daily amounts used to calculate the cumulative rainfall amounts at the Waterbury 3.0 NW, VT station on the days prior to sampling were downloaded from the National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/).

Date	rainfall the day of sampling before 8 am	rainfall on the day prior to sampling (day 1)	cumulative rainfall 2 days before sampling (days 1+2)	cumulative rainfall 3 days before sampling (days 1+2+3)
6/25/19	0	0	0	0
7/9/19	0	0	1.02	1.23
7/25/19	0	0	0.2	0.21
8/6/19	0	0	0	0
8/20/19	0	0	0.23	0.3
9/10/19	0	0	0	0

Discharge and Flow Levels

Discharge and flow levels can also affect water quality, and several water quality standards are based on flow level at the time of sampling. According to the Vermont Department of Environmental Conservation's "Guidance on Streamflow Observations at time of Water Quality Sampling of Rivers and Streams", low flow conditions are defined as the lowest quartile of all flows experienced at a site (Q25) while flow between the Q25 and Q75 quartiles are considered medium, and flow above the 75th percentile is considered high.

The daily discharge measured on each sampling date at the USGS stream gauges on the Winooski River downstream of Montpelier (USGS gauge 0428600) is shown in Table 7. Comparing these values to historical observations can help determine relative flow levels occurring on the sampling dates. For example, the flow level on 6/25 (1020 cuft/sec) was above the 75th quartile (693 cuft/sec), and so would be considered high. Flow levels on both July sampling dates were between the 25the and 75th quartile, and would be considered medium, and the August and September flow levels would be considered low since they fell below the 25th quartile. Figure 6 shows a hydrograph of the discharge on the Winooski River downstream of Montpelier for the summer 2019 season, with the flow levels on the day of sampling indicated.

Table 7. Winooski River daily discharge at the USGS stream gauge downstream of Montpelier (USGS 04286000) on the six 2019 sampling dates, with corresponding quartiles and flow levels. Daily flow data 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 cuft/s: Min=17.0, 25th %=198.0, Mean = 618.24, 75th % = 693.0, Max = 12,200 as retrieved from: https://waterwatch.usgs.gov/index.php?sno=Winooski+&ds=dv01d_por&btnGo=GO&m=sitempnn) on April 3, 2020.

Date	Daily discharge (cuft/s)	Quartile	Corresponding flow level based on quartile
6/25/19	1020	>Q25	high
7/09/19	325	Q25-75	medium
7/25/19	201	Q25-75	medium
8/06/19	178	<Q25	low
8/27/19	128	<Q25	low
9/10/19	167	<Q25	low

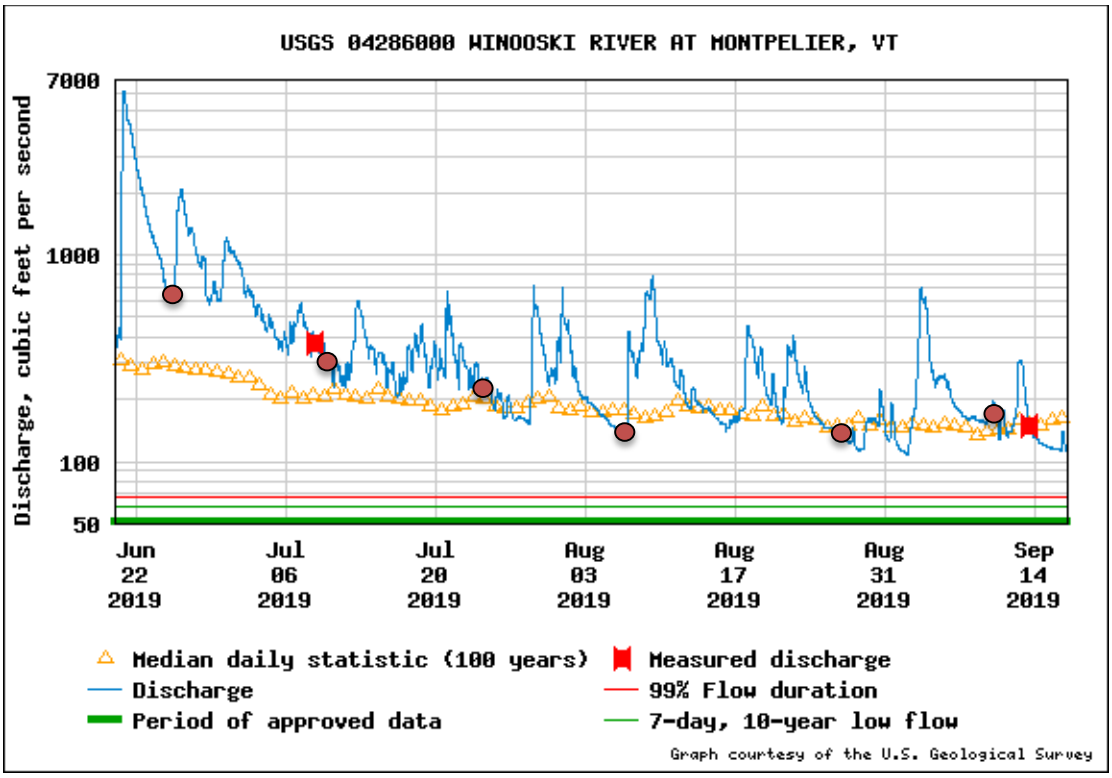

Figure 6. Discharge at the Winooski River gauge at Montpelier, VT during the summer of 2019. The discharge on the regular sampling dates and the rain event dates is indicated by the red circles.

The discharge measured at the USGS stream gauges on the North Branch River downstream of the Wrightsville dam and upstream of the sampling site NCNB02 (US04285500) on the 2019 sampling dates relative to the Q25 and Q75 quartiles are shown in Table 8. Based on the VT DEC's Guidance on stream flows, the flow level on June 25 would be considered high, the levels on the July dates would be considered medium, and the levels on the August and September sampling dates would be considered low. Figure 7 shows a hydrograph of the discharge on the North Branch for the summer 2019 season, with the flow levels on the day of sampling indicated.

Table 8. North Branch River daily discharge at the USGS stream gauge downstream from Wrightsville dam (USGS 0428550) on the six 2017 sampling dates, with corresponding quartiles and flow levels. Daily flow data retrieved from the National Water Information System Web Interface: https://waterdata.usgs.gov/nwis/dv/?site_no=04285500&agency_cd=USGS&referred_module=sw USGS discharge statistics for this gauge in cuft/s: Min=0.2, 25th %=31.0, Mean = 141.15, 75th % = 154.0, Max = 1620 as retrieved from: https://waterwatch.usgs.gov/index.php?sno=North+Branch+Winooski&ds=dv01d_por&btnGo=GO&m=sitempnn on April 3, 2020.

Date	Daily discharge (cuft/s)	Quartile	Flow level
6/25/19	188	>Q25	high
7/09/19	34.8	Q25-75	medium
7/25/19	32.5	Q25-75	medium
8/06/19	15.4	<Q25	low
8/27/19	11.4	<Q25	low
9/10/19	20.6	<Q25	low

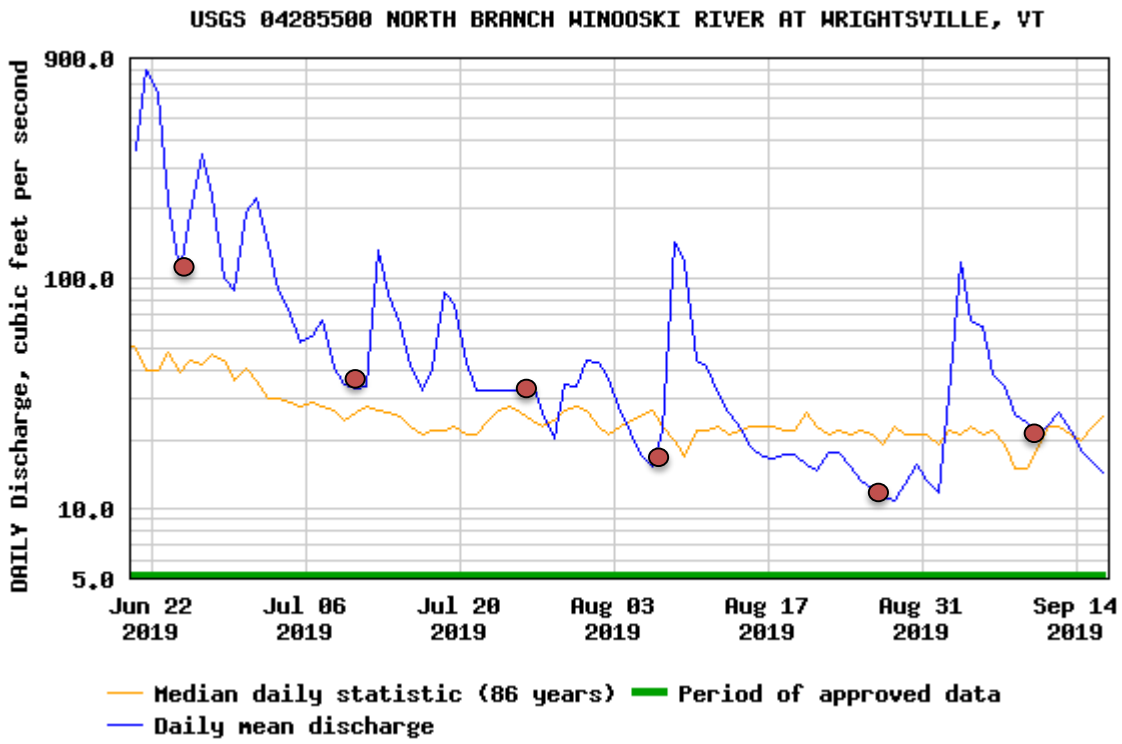

Figure 7. Discharge at the North Branch River gauge at Wrightsville Dam, VT during the summer of 2019. The discharge on the sampling dates is indicated by the red dots.

Since the *E. coli* samples collected during the 2019 season were taken during dry weather conditions, the results were probably not influenced by surface runoff. Furthermore, based on the hydrographs of the North Branch and Winooski Rivers (Figures 6 & 7) samples were taken during base flows and when no hydroelectric power plant releases would have affected the sampling results. Any *E. coli* present in the samples collected are more likely due to failing septic systems, illicit sewer connections to the stormdrain system, in-stream wild or domesticated animals, or free-living bacteria.

Results and Discussion

E. coli sampling results

Escherichia coli (*E. coli*) is a species of bacteria found in the lower digestive tract of mammals and is commonly used as an indicator 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 standard, less than 10% of the single sample measurements should have *E. coli* levels above the single sample maximum (SSM) value of 235 mpn/100mL.

Montpelier-Berlin *E. coli* results:

E. coli levels in the Winooski River in Montpelier have been high for many years. The river has consequently been listed as impaired by the State of Vermont for the reach from Pioneer Street Bridge to its confluence with the Dog River. Beginning in 2015, the Friends of the Winooski River has attempted to track down *E. coli* sources in the city. In 2017, a concerted sampling regime on the Winooski mainstem revealed an uptick of the bacteria between Main Street and Taylor Street bridges, near the confluence of the North Branch with the Winooski. To determine whether the North Branch might be contributing *E. coli* to the Winooski, we sampled the mouth of the North Branch River (just below the railroad bridge and the "rat dam") in 2018. *E. coli* levels at this new NBMOUTH site were extremely high on all 6 dates sampled compared to upstream sites (Figure 8).

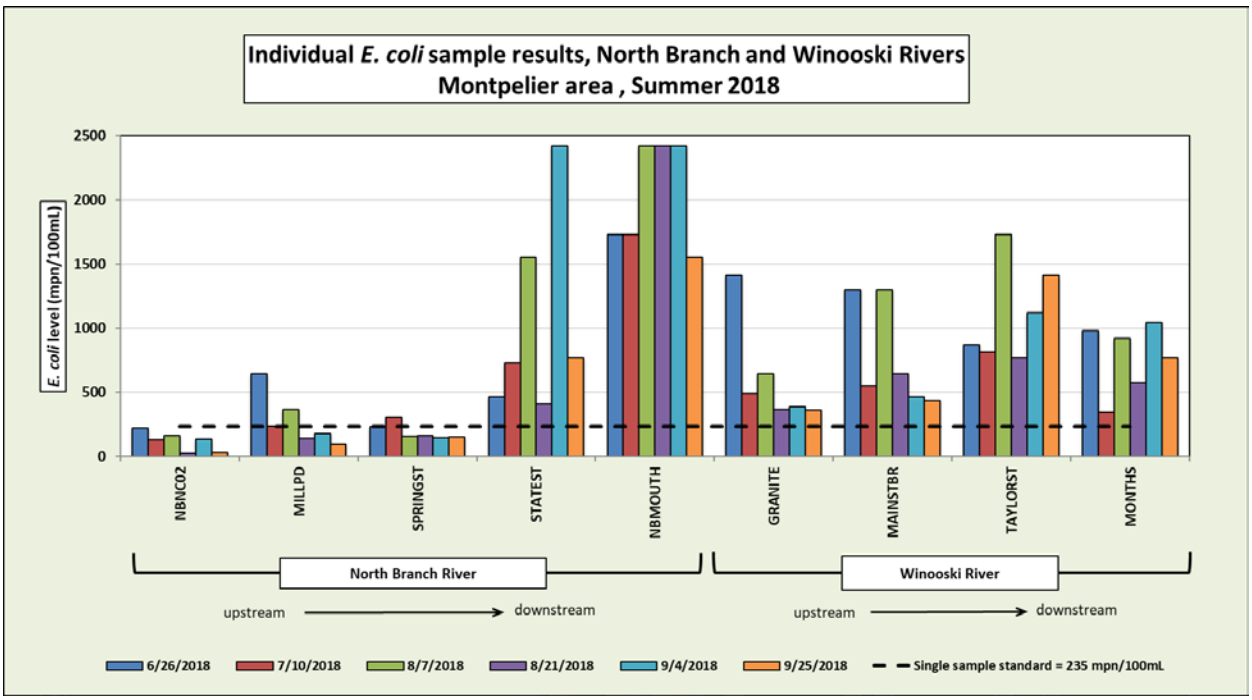

Figure 8. Individual *E. coli* sample results for 6 dry-weather 2018 sampling dates in the Montpelier area at five sampling locations on the North Branch River and four locations on the Winooski. The EPA standard for individual samples (235 mpn/100mL) is shown by the dotted line.

Since there appeared to be a significant source of *E. coli* entering the lower North Branch in 2018, we focused our 2019 *E. coli* sampling in Montpelier on narrowing down the location of this source. Four more sampling sites were added on the North Branch between Spring Street and the mouth of the river: three above State Street (KATIES, SCHOOLST, and LANGDONST) and one between State Street and the mouth (LOWERNB). The sampling site at the mouth of the North Branch had to be moved

upstream slightly to NBBIKEPATHBR due the construction of a pedestrian/rail-trail bridge over the lower section of the river which made the 2018 site inaccessible (see Figure 2).

The individual sample results of the Montpelier-area *E. coli* monitoring are shown in Figure 9. *E. coli* levels at all sites in all three rivers sampled were almost uniformly lower in 2019 than in 2018. This may be due at least in part to the fact that 2018 was a somewhat drier year than 2019, with river flow providing less of a diluting effect on illicit discharges. Base flow discharge in the Winooski River during June and July of 2018 were approximately 100-150 cuft/sec, for example, whereas the discharge during the same period of 2019 were 250 to 600 cuft/sec.

Most samples had *E. coli* levels below the single-sample maximum of 235 mpn/ml except for the two downstream-most sites on the North Branch and the two sites on the Steven's Branch, where all the samples taken exceeded the single-sample maximum. On one date, 8/27/2019, all North Branch sites except the most upstream site had extremely high *E. coli* readings. On August 28, Friends of the Winooski River staff observed what appeared to be a leaky sewer manhole cover discharging onto Cummings Street near its bridge over the North Branch. This was reported to the Montpelier Department of Public Works, who fixed the issue. The subsequent samples taken from the North Branch on had levels similar to the first four sampling dates. Individual samples from the extreme lower North Branch at LOWERNB and NBBIKEPATH contained higher concentrations of *E. coli* than those from upstream sites by a factor of 2 or more. 2019 levels at these lower North Branch River sites were not as high as 2018 levels at the North Branch mouth, however, when all samples taken during the sampling season had *E. coli* concentrations over 1500 mpn/100mL.

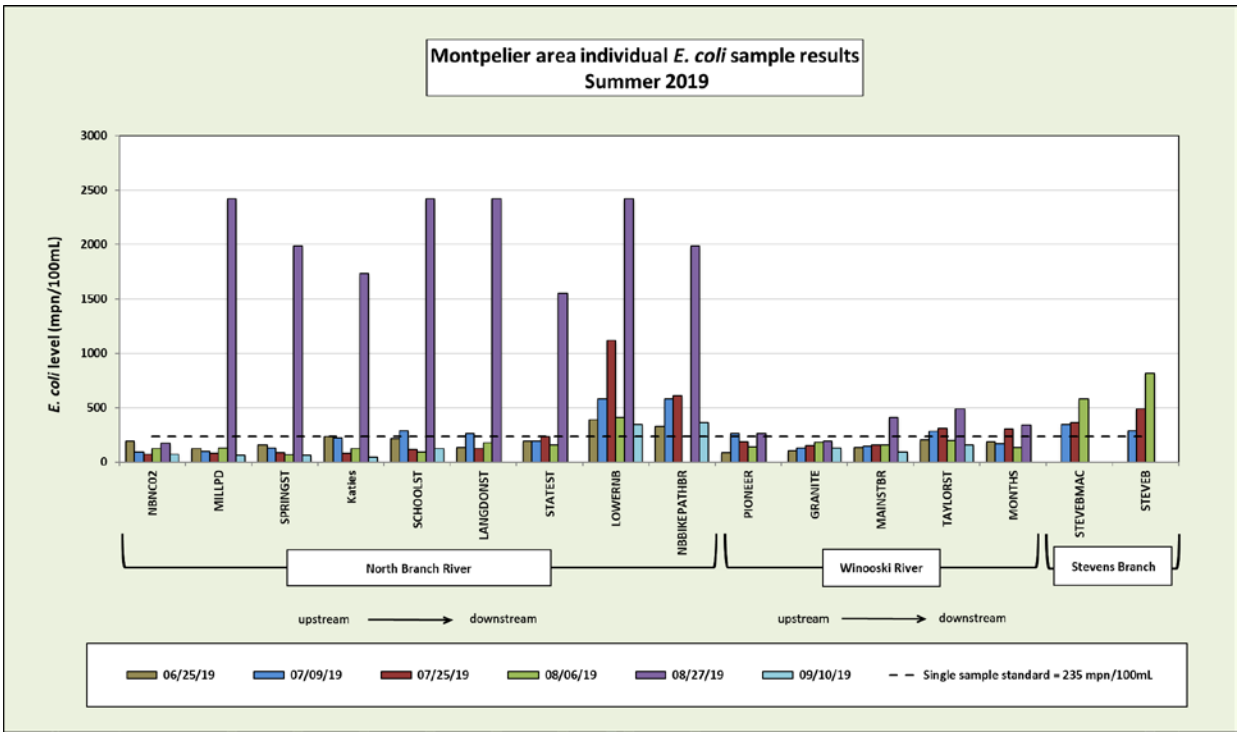

Figure 9. Individual *E. coli* sample results for 16 sampling locations on the North Branch, Winooski Stevens Branch Rivers in the Barre-Montpelier area. The EPA standard for individual samples (235 mpn/100mL) is shown by the dotted line.

A summary of the *E. coli* results for each site relative to the geometric mean standard (126 mpn/100mL) is shown as a box plot in Figure 10. The 8/27 results were eliminated from most North Branch sites for this graph since the high *E. coli* readings that day seemed to be due to an isolated sewer leak incident that was soon eliminated. On the North Branch, geometric mean *E. coli* values met the Vermont water quality standard from the North Branch Nature Center (NBNC02) downstream to 127 Elm Street (Katies). Levels at the School Street Bridge (SCHOOLST), Langdon Street Bridge (LANGDON) and State Street Bridge (STATEST) exceeded the standard somewhat and inched up from upstream to downstream.

A significant jump in geometric mean *E. coli* levels appears on the North Branch between the STATEST (192.8 mpn/100mL) and the two downstream sites LOWERNB and NBBIKEPATH (513.2 and 453.4 mpn/100mL, respectively). While these values were much lower than those recorded at the nearby NBMOUTH site in 2018, when the geometric mean value for *E. coli* at the NBMOUTH site was 2010 mpn/100mL), the data suggests that there is a source of *E. coli* to the lower North Branch is located downstream of the State Street bridge. Note, however, that since the NBBIKEPATH site sampled in 2019 in place of the NBMOUTH site where extremely high *E. coli* levels were observed in 2018, it is possible an additional source is present between NBBIKEPATH and NBMOUTH (see Figure 2).

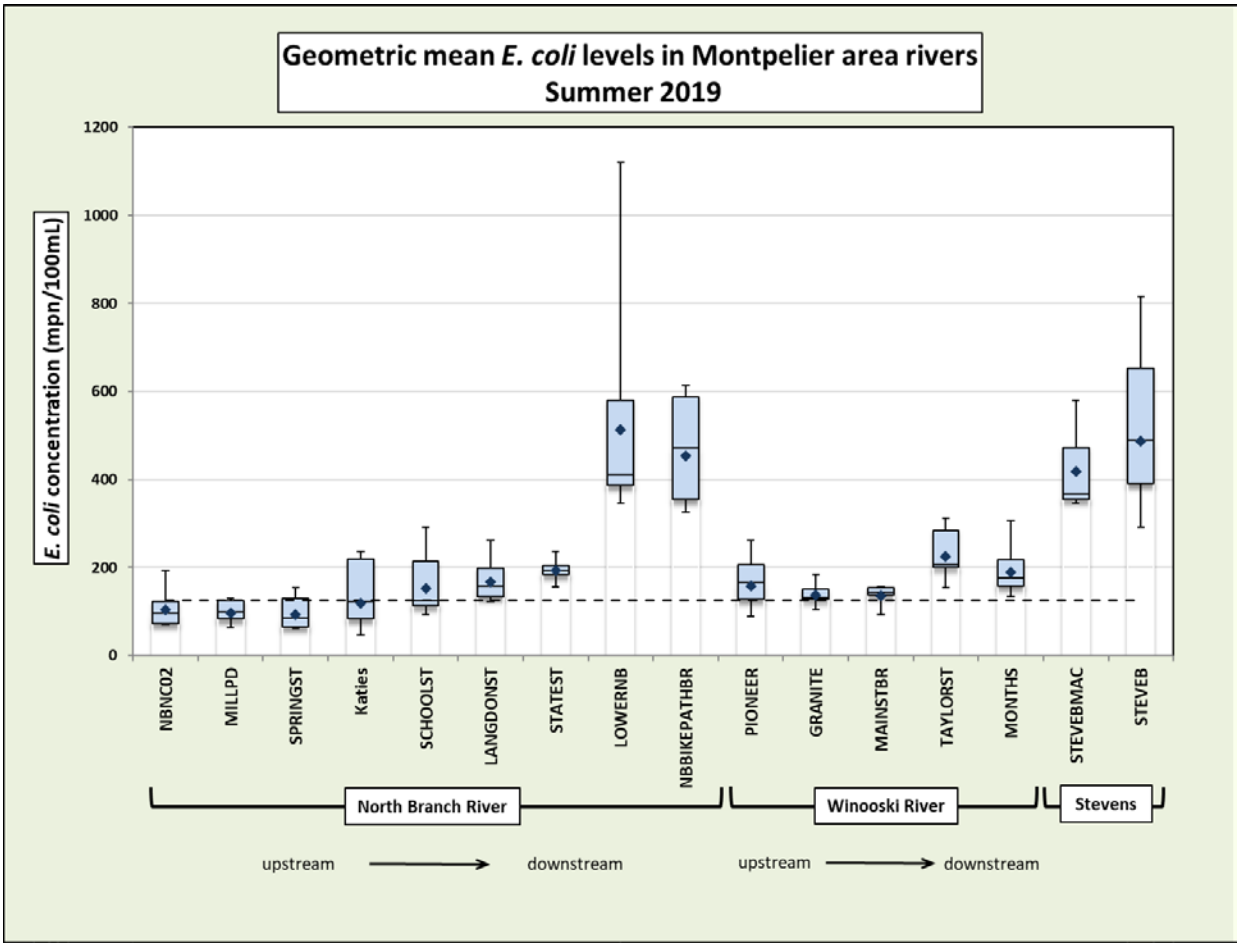

Figure 10. Box and whisker plot of 2019 *E. coli* concentrations at sampling locations on the North Branch and Winooski Rivers. The geometric mean values for each site are shown by the blue diamonds, and the geometric mean standard of 126 mpn/100mL by the dashed line. First and third quartiles are shown by the light blue boxes, separated by the median value. Minimum and maximum values are shown by the whiskers. 8/27 sampling results were eliminated from the analysis since high *E. coli* levels on that date seemed to be due to an isolated incidence of a sewer line leak that was repaired soon after sampling.

The 2019 geometric mean *E. coli* values for the Winooski mainstem, while exceeding the VT & EPA water quality standard slightly, were also consistently lower than the values obtained from our 2018 sampling. In 2018, all the Winooski River sites in Montpelier had geometric mean *E. coli* of over 500 mpn/100mL. In 2019 these values were all below 250 mpn/100mL.

Geometric mean *E. coli* values at sites the Pioneer Street Bridge was somewhat above the chronic standard, while levels at the Granite Street and Main Street bridges were only slightly above the standard. Sites downstream of the confluence with the North Branch River had higher *E. coli* levels. This uptick in the *E. coli* between the Main Street and Taylor Street bridges, observed in 2017, 2018, and 2019 is likely due at least in part to the influx of fecal matter from the North Branch River, which flows into the Winooski between the two bridges. Another source of *E. coli* must exist upstream of the Granite Street Bridge (GRANITE) as well, since levels at that site, upstream of all Montpelier CSOs and the North

Branch River, has consistently exceeded geometric mean standards in 2018 and previous years. In 2019 the Pioneer Bridge (PIONEER) site was added to begin to determine the location of this source. Levels at this site were slightly higher than at GRANITE, and may indicate the source is further upstream.

The geometric mean value for *E. coli* at the Stevens Branch sites (STEVEB and STEVEBMAC), like those of the North Branch and Winooski sites, was lower in 2019 than in 2018. Levels were again well above the standard, however, perhaps due to several illicit sewer discharges upstream in Barre City and Barre Town stormdrain system identified during an outfall monitoring effort conducted by the Friends of the Winooski River and Stone Environmental in 2016. Many of these have yet to be corrected and may be responsible for the high *E. coli* in the Stevens Branch.

In an attempt to locate the suspected source of *E. coli* entering the lower North Branch, in the fall of 2019 Dave Braun (Stone Environmental) and Shawn White (Friends of the Winooski River) dye tested every toilet in a building adjacent to the western, downstream side of the State Street Bridge. Outfalls along this stretch of the river were also visually inspected. No evidence of any illicit discharge was found. The owner of the building on the eastern, downstream side of the State Street Bridge did not respond to requests for permission to do dye-testing there.

Northfield and Joiner Brook *E. coli* results

The Friends of the Winooski River expanded our 2019 sampling to include several sites in the Dog River watershed in Northfield and Joiner Brook in Bolton after being contacted by Northfield community members interested in learning more about the water quality of their local streams and the Vermont River Conservancy, which was interested in learning more about suspected water quality problems affecting the Bolton Potholes, which it had acquired in 2018. *E. coli* sampling at three sites in Northfield were added – two on the Dog River and one on Cox Brook (Figure 4 and Table 2), and four on Joiner Brook –three above Bolton Potholes, and one at the mouth of Joiner Brook (Figure 5).

The *E. coli* levels in each individual sample taken in Northfield and from Joiner Brook is shown in Figure 11. All samples at all sites had *E. coli* levels well below the single-sample maximum standard except for those collected at DRATCOX, a swimming hole on the Dog River at the confluence of Cox Brook. Two out of four samples taken at this site had levels that exceeded the standard. Likewise, the geometric mean *E. coli* levels (Figure 12) at all sites except DRATCOX met the geometric mean *E. coli* standard, while levels at DRATCOX did not. It appears, therefore, that a fecal matter source exists somewhere between the DRATCOX and the WATERST site further upstream on the Dog River.

Joiner Brook samples were particularly low in *E. coli*, allaying fears that a failing septic system observed along the brook could be making the Bolton Potholes unsafe for swimming. It should be remembered, however, that all sampling occurred during dry stretches of weather, when the effects of run-off would be minimal. *E. coli* level could increase dramatically after rainfall.

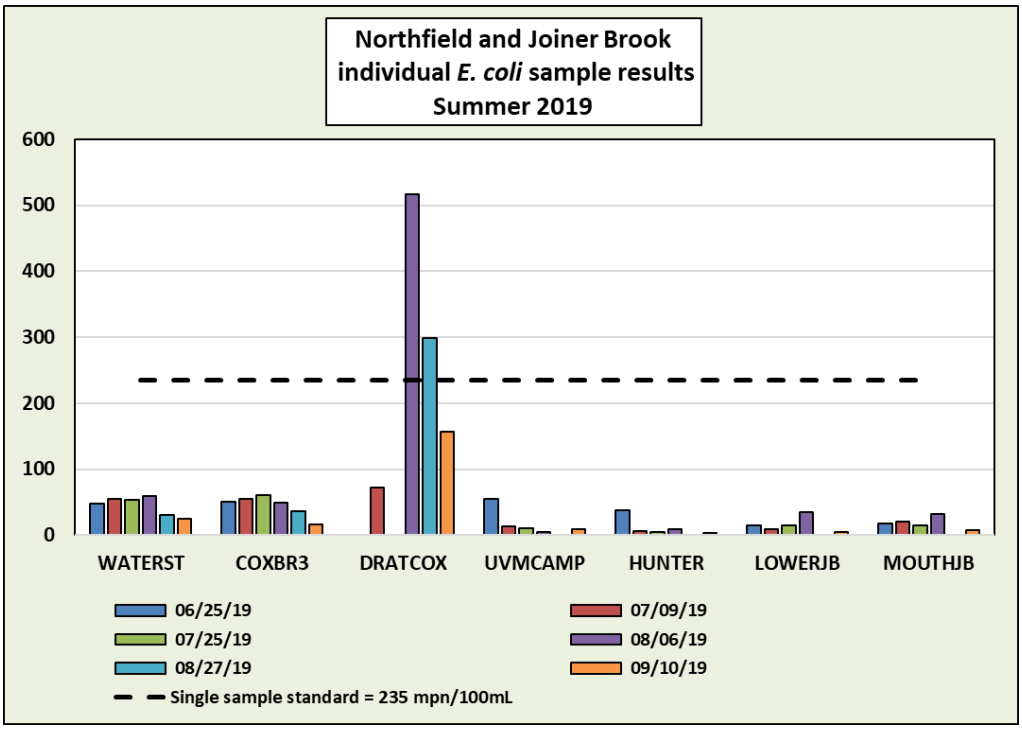

Figure 11. Individual *E. coli* sample results for sampling locations in Northfield and on Joiner Brook in Bolton. The EPA standard for individual samples (235 mpn/100mL) is shown by the dotted line.

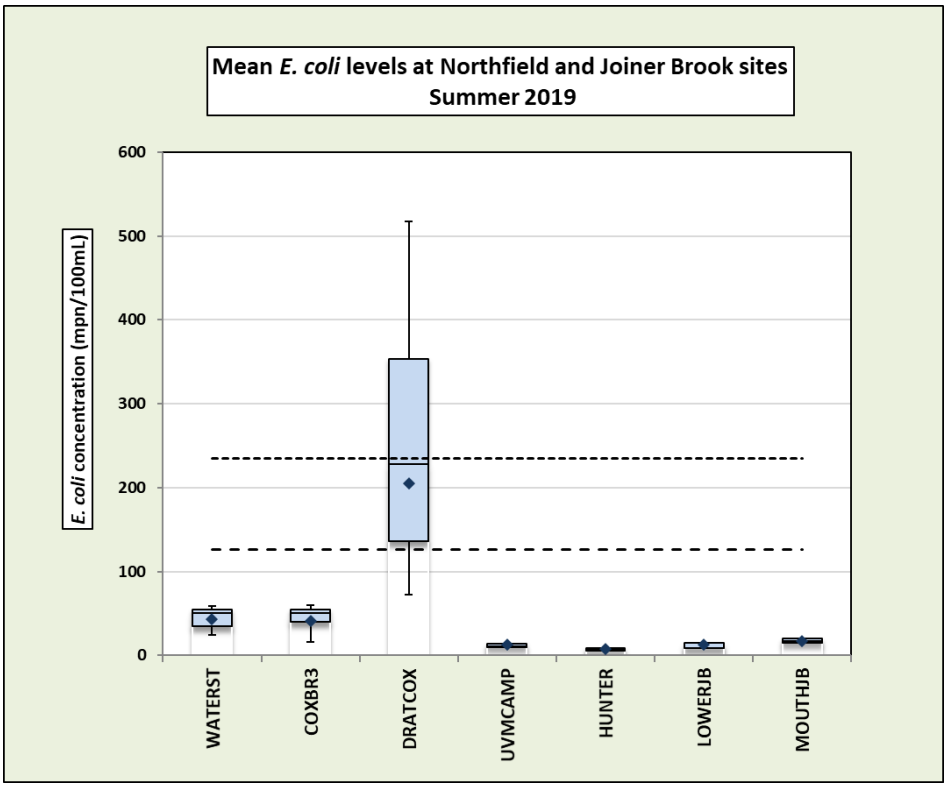

Figure 12. Box and whisker plot of 2019 *E. coli* concentrations at sampling locations on the North Branch and Winooski Rivers. The geometric mean values for each site are shown by the blue diamonds, and the geometric mean standard of 126 mpn/100mL by the dashed line. First and third quartiles are shown by the light blue boxes, separated by the median value. Minimum and maximum values are shown by the whiskers. 8/27 sampling results were eliminated from the analysis since high *E. coli* levels on that date seemed to be due to an isolated incidence of a sewer line leak that was repaired soon after sampling.

Chloride results – all locations

According to the Vermont Surface Water Management Strategy, chloride levels above 230 mg/L, the Vermont "chronic" standard for chloride, 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 the water in streams 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 also tend to spike in the spring when road salts are washed into streams during spring rains and snowmelt.

The Friends of the Winooski River sampled for chloride at ten sites in 2019, three in Berlin in the Stevens Branch subwatershed, two on the North Branch River, one on the Winooski River downstream from Montpelier, two on Joiner Brook, and three in the Northfield area. Chloride levels were fairly low at all sites except at Macs10, a site at the mouth of a tributary to the Stevens Branch (Figure 13). The two sites on the Stevens Branch mainstem also had elevated chloride levels, but were lower than the 230mg/L standard. Levels on the Winooski River at MONTHS were also slightly elevated.

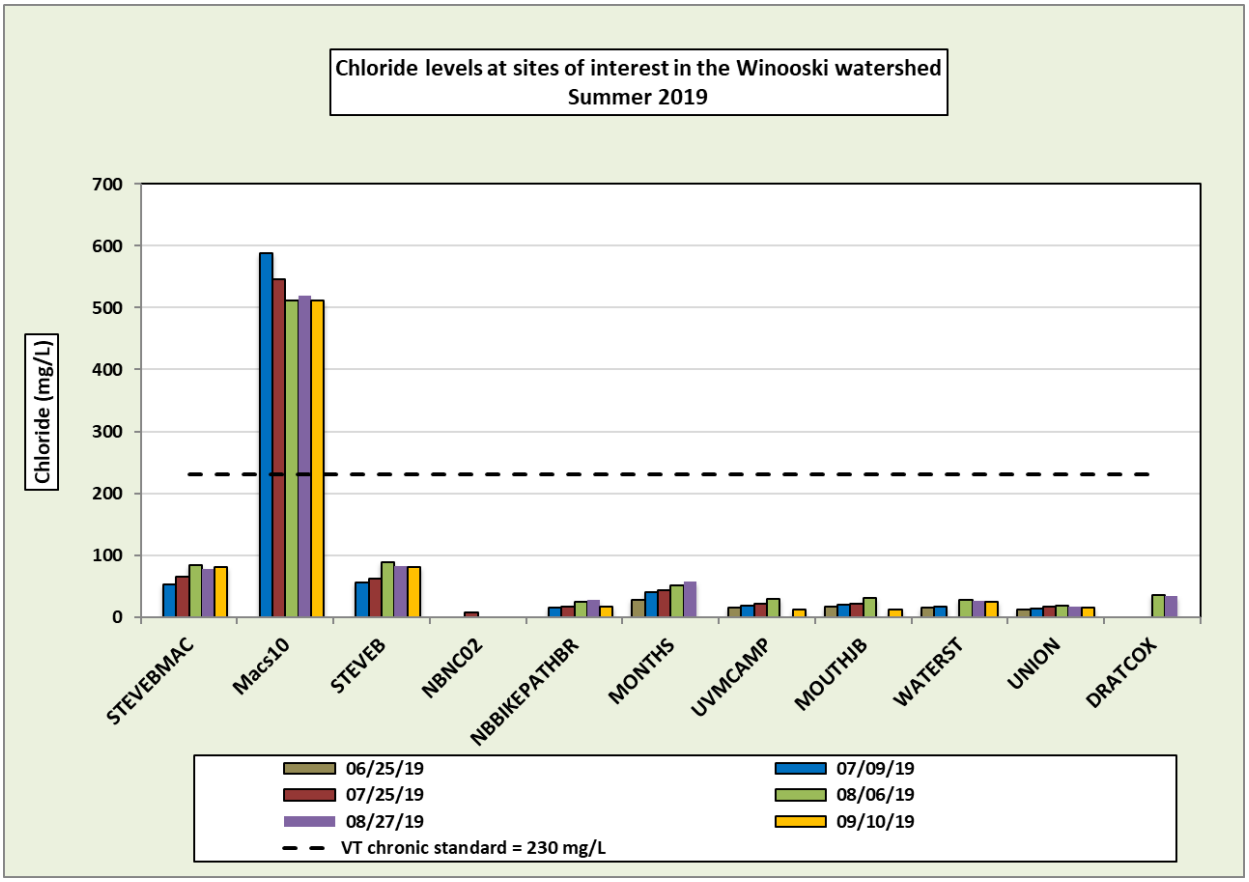

Figure 13. Chloride levels at 11 sites in the Winooski River watershed during the summer of 2019.

As in previous years, chloride levels at Macs 10 were consistently very high. Prior stormwater outfall monitoring and stream sampling further up in this stream's watershed strongly suggests that road salt use on the parking lots of the Central Vermont Medical Center has contaminated the groundwater feeding this stream. The Friends of the Winooski River have been in communication with the facilities manager at the medical center to help the facility get information on updated de-icing techniques and will continue to monitor this site. The Friends have not heard from CVMC whether any changes have been made regarding salt use on parking lots, despite requests for that information.

Phosphorus results – all locations

Phosphorus is a main pollutant of concern in Lake Champlain and can also cause problems in rivers and streams. 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, wastewater, 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 Friends of the Winooski River sampled for phosphorus at 17 sites in the Winooski watershed – nine in the Berlin-Montpelier area, six in Northfield, and two on Joiner Brook.

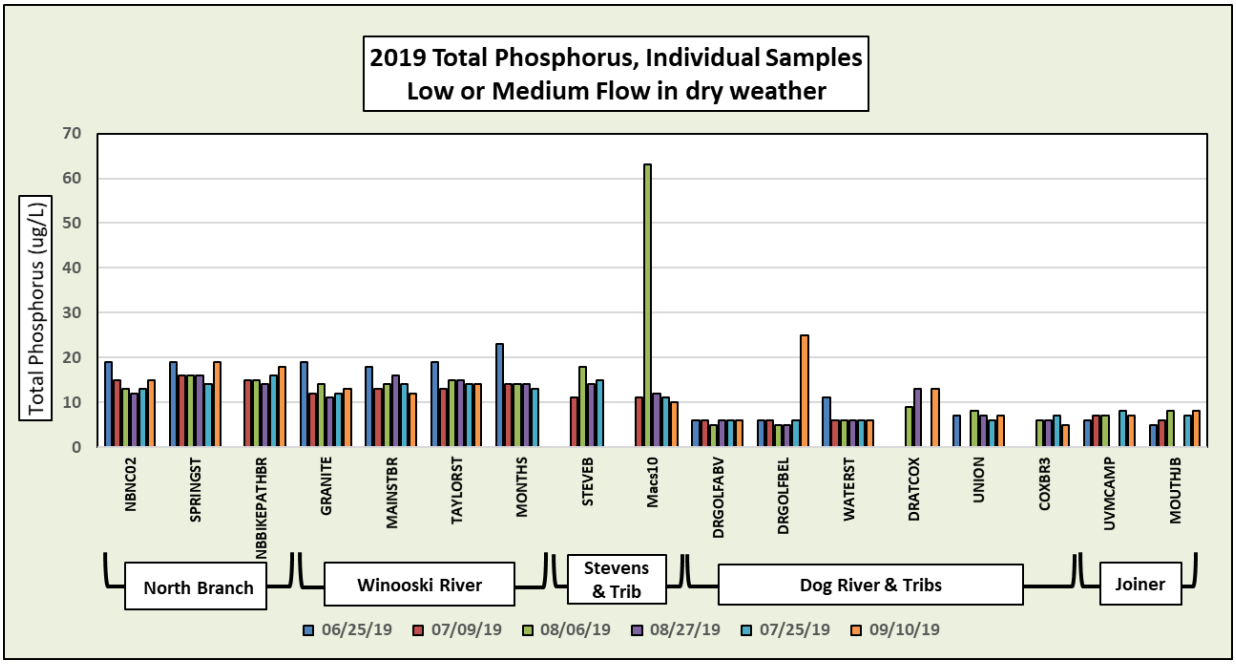

Figure 14. Total phosphorus levels for individual samples collected during low to medium flow in Montpelier, Berlin, Northfield, and Bolton in 2019.

Total phosphorus levels in individual samples at these sites where generally under 20 ug/mL except for occasional higher readings. The phosphorus concentration at the North Branch, Winooski River, and Stevens Branch sites were higher overall than at sites on the Dog River, Cox Brook, Union Brook, and Joiner Brook. Two samples, one from a site (Macs10) on the unnamed tributary to the Stevens Branch, and one taken from the Dog River below the Northfield Country Club golf course (DRGOLFBEL), had relatively high readings. Since these samples were taken during a period of dry weather, stormwater run-off could not have been a factor. These higher readings must therefore have been due to some other event such as recent application of fertilizer upstream. Note there is no standard in Vermont for phosphorus concentrations in single samples.

Figure 15 shows the mean total phosphorus for the 2019 June-September season for low to medium flows. The mean total phosphorus criteria for aquatic biota in Vermont is based on the stream type. Class B, medium-sized high-gradient streams have a standard of 15 ug/L, while larger, slower Class B streams have a standard of 27 ug/L. The dotted line in the Figure 15 corresponds to the 15 ug/L criterion. Another way of thinking about phosphorus concentrations is to ask whether a particular waterway contributes phosphorus to Lake Champlain or has a diluting effect. Since the target goal for phosphorus levels in the Main Lake of Lake Champlain is 10 ug/L, the North Branch, Winooski (in the Montpelier area), and Steven's Branch Rivers – which all have mean total phosphorus concentrations above 10 ug/L - area would be expected to be contributing to the phosphorus in the lake, while the Dog (in Northfield), its tributaries, and Joiner Brook would be expected to have a diluting affect.

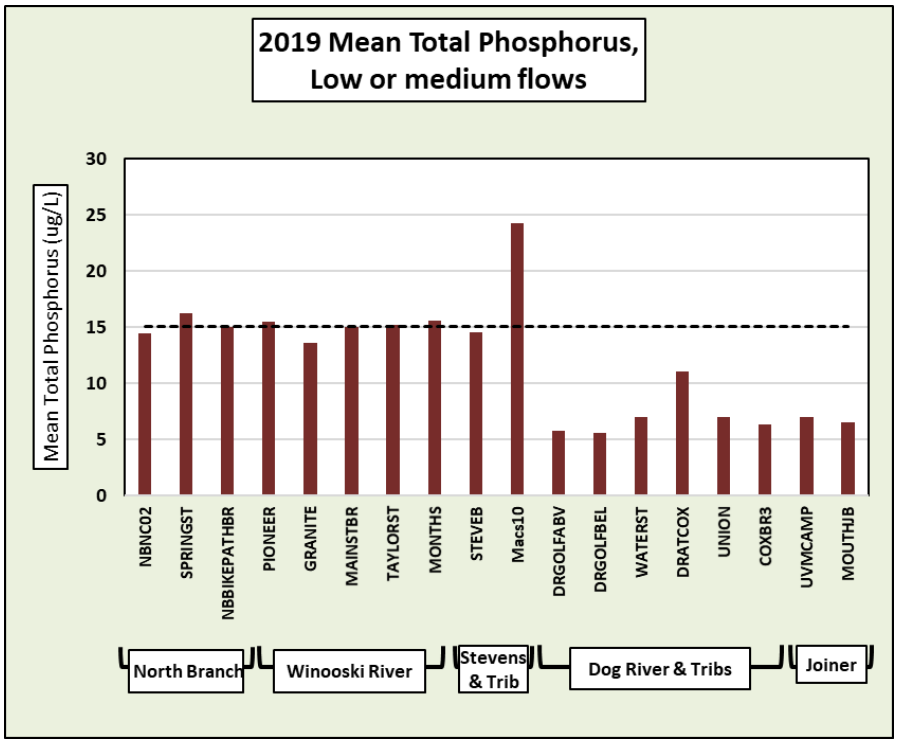

Figure 15. Mean total phosphorus at sampling sites in Montpelier, Berlin, Northfield, and Bolton in 2019. The dotted line shows the VT mean total phosphorus criteria for aquatic biota for Class B, medium high-gradient streams.

Attempted rain event sampling in Northfield

Only one rain event sampling was attempted in 2019. Total phosphorus was sampled on the morning of 9/11, when a fairly substantial rain event had been forecast. Due the fact that the rain had been predicted to fall early in the morning, the go-ahead to sample was given to volunteers the previous day. The total rain amount that fell that morning, however, was only 0.11 inches. In our experience, this is not enough precipitation to have much influence on phosphorus levels. The results of the 9/11 sampling reflect this, and are discussed further here (but see the Appendix for all the 2019 sampling results, including those of 9/11.)

Summary- Problem sites

The Friends of the Winooski River's 2019 sampling efforts in the Berlin-Montpelier area confirmed several problem areas that had been observed in previous years. In particular, *E. coli* concentrations in the lower North Branch in Montpelier remained high. 2019 and 2018 results indicate the presence of one or more significant sources of fecal matter entering the river somewhere downstream of the Spring Street Bridge. 2019 results further defined the most contaminated area to the reach downstream from the State Street Bridge. Possible sources include improper sewer discharge, a homeless population that frequents the confluence of the two rivers,

and/or a population of mallards that lives between Spring and Langdon Streets. Follow-up efforts by Stone Environmental and the Friends of the Winooski River to find illicit discharge from a building adjacent to the bridge were unsuccessful. The Friends had hoped to do more in-stream and outfall sampling in 2020 to continue to track down any sources. We feel this is of particular importance since the City of Montpelier and the Vermont River Conservancy have recently created a park at the mouth of the North Branch and hope to include a river access point for public use. However, the LaRosa program, which had helped fund our water quality monitoring program, was abruptly and indefinitely cancelled by the Department of Environmental Conservation the spring of 2020, leaving us little time to find alternative funding to do this work. Other sites with high *E. coli* levels are the Stevens Branch sites (STEVEBMAC and STEVEB) and the DRATCOX swimming hole site at the confluence of Cox Brook and the Dog River. As with the lower North Branch, further investigation into the sources of *E. coli* affecting these sites will have to be postponed until funding for water quality monitoring is restored.

Chloride levels at the Macs10 site on an unnamed tributary to the Stevens Branch remained very high at low or medium flows for the ninth consecutive year of sampling. This stream originates on "Hospital Hill" in Berlin, VT. Using outfall monitoring and stream sampling in the upstream part of the stream's drainage, the Friends of the Winooski River found evidence that the majority of the chloride originates around the Central Vermont Medical Center and Woodbridge Nursing Home parking lots. Since chloride levels are highest during dry periods we suspect the groundwater around the hospital is contaminated. The facilities management at the hospital was informed of this problem in 2018, but we are unaware if any changes in salt management have been instituted. Chloride levels on the Stevens Branch just above and well below the confluence with this stream were elevated, as were levels at the MONTHS site downstream of downtown Montpelier.

Phosphorus levels were generally lower than 20 ug/L except for a two individual samples taken at Macs10 on an unnamed tributary to the Stevens Branch and DRGOLFBEL, on the Dog River just below the Northfield Country Club. The phosphorus in the Macs10 sample was particularly high – above 60ug/L. Mean phosphorus levels were higher in the North Branch, Stevens Branch, and Winooski Rivers compared to the Dog River, and Joiner, Union, and Cox Brooks.

Appendix A - Individual sample results for 2019

Sample Number	Location	Date	Chloride (mg/L)	Final E. coli (mpn/100ml)	TP (ug P/L)	Flow Level on field sheet
1900540-032	COXBR3	06/25/19	NA	50.39	NA	
1900572-025	COXBR3	07/09/19	6.8	55.55	NA	
1900598-025	COXBR3	07/25/19	NA	60.15	7	
1900678-027	COXBR3	08/06/19	NA	49.54	6	
1900759-025	COXBR3	08/27/19	NA	36.84	6	
1900883-027	COXBR3	09/10/19	NA	15.96	5	
1901115-004	COXBR3	09/11/19	NA	NA	8	
1900759-029	COXBR3-DUP	08/27/19	NA	30.89	NA	
1900572-033	DRATCOX	07/09/19	NA	72.79	NA	
1900678-028	DRATCOX	08/06/19	35	517.21	9	
1900759-026	DRATCOX	08/27/19	33.6	298.66	13	
1900883-028	DRATCOX	09/10/19	NA	156.48	13	
1900540-024	DRGOLFABV	06/25/19	NA	NA	6	
1900572-022	DRGOLFABV	07/09/19	NA	NA	6	
1900598-022	DRGOLFABV	07/25/19	NA	NA	6	
1900678-023	DRGOLFABV	08/06/19	NA	NA	5	
1900759-021	DRGOLFABV	08/27/19	NA	NA	6	
1900883-023	DRGOLFABV	09/10/19	NA	NA	6	
1901115-001	DRGOLFABV	09/11/19	NA	NA	9	
1900540-025	DRGOLFBEL	06/25/19	NA	NA	6	

1900572-023	DRGOLFBEL	07/09/19	NA	NA	6	
1900598-023	DRGOLFBEL	07/25/19	NA	NA	6	
1900678-024	DRGOLFBEL	08/06/19	NA	NA	5	
1900759-022	DRGOLFBEL	08/27/19	NA	NA	5	
1900883-024	DRGOLFBEL	09/10/19	NA	NA	25	
1901115-002	DRGOLFBEL	09/11/19	NA	NA	9	
1900540-011	GRANITE	06/25/19	NA	104.6	19	
1900572-009	GRANITE	07/09/19	NA	131.69	12	
1900598-011	GRANITE	07/25/19	NA	151.52	12	
1900678-012	GRANITE	08/06/19	NA	185.01	14	
1900759-009	GRANITE	08/27/19	NA	191.79	11	
1900883-012	GRANITE	09/10/19	NA	129.06	13	
1900540-021	HUNTER	06/25/19	NA	37.34	NA	
1900572-019	HUNTER	07/09/19	NA	6.2	NA	
1900598-019	HUNTER	07/25/19	NA	5.16	NA	
1900678-020	HUNTER	08/06/19	NA	8.52	NA	
1900883-020	HUNTER	09/10/19	NA	3.01	NA	
1900572-004	Kaites	07/09/19	NA	218.72	NA	
1900540-004	Katies	06/25/19	NA	235.93	NA	
1900598-004	Katies	07/25/19	NA	83.92	NA	
1900678-004	Katies	08/06/19	NA	123.35	NA	
1900759-004	Katies	08/27/19	NA	1732.89	NA	
1900883-004	Katies	09/10/19	NA	46.54	NA	

1900598-030	Katies-BLANK	07/25/19	NA	<1.000	NA	
1900598-029	Katies-DUP	07/25/19	NA	81.26	NA	
1900678-032	Katies-BLANK	08/06/19	NA	<1.000	NA	
1900678-031	Katies-DUP	08/06/19	NA	93.35	NA	
1900540-006	LANGDONST	06/25/19	NA	137.35	NA	
1900572-006	LANGDONST	07/09/19	NA	261.25	NA	
1900598-006	LANGDONST	07/25/19	NA	123.56	NA	
1900678-006	LANGDONST	08/06/19	NA	178.53	NA	
1900759-006	LANGDONST	08/27/19	NA	2419.57	NA	
1900540-022	LOWERJB	06/25/19	NA	14.64	NA	
1900572-020	LOWERJB	07/09/19	NA	8.52	NA	
1900598-020	LOWERJB	07/25/19	NA	14.64	NA	
1900678-021	LOWERJB	08/06/19	NA	34.51	NA	
1900883-021	LOWERJB	09/10/19	NA	5.16	NA	
1900540-009	LOWERNB	06/25/19	7.61	387.32	19	
1900572-007	LOWERNB	07/09/19	NA	579.43	NA	
1900598-008	LOWERNB	07/25/19	NA	1119.87	NA	
1900678-008	LOWERNB	08/06/19	NA	410.58	NA	
1900759-007	LOWERNB	08/27/19	NA	2419.6	NA	
1900883-008	LOWERNB	09/10/19	NA	344.8	NA	
1900883-034	LOWERNBOUTFALL	09/10/19	NA	<1.000	NA	
1900572-016	Macs10	07/09/19	588	NA	11	
1900598-016	Macs10	07/25/19	546	NA	11	

1900678-016	Macs10	08/06/19	512	NA	63	
1900759-014	Macs10	08/27/19	520	NA	12	
1900883-018	Macs10	09/10/19	512	NA	10	
1900540-012	MAINSTBR	06/25/19	NA	137.35	18	
1900572-010	MAINSTBR	07/09/19	NA	143.87	13	
1900598-012	MAINSTBR	07/25/19	NA	155.25	14	
1900678-013	MAINSTBR	08/06/19	NA	156.48	14	
1900759-010	MAINSTBR	08/27/19	NA	410.58	16	
1900883-013	MAINSTBR	09/10/19	NA	93.31	12	
1900540-005	MILLPD	06/25/19	NA	124.98	NA	
1900572-002	MILLPD	07/09/19	NA	98.95	NA	
1900598-002	MILLPD	07/25/19	NA	83.61	NA	
1900678-002	MILLPD	08/06/19	NA	129.63	NA	
1900759-002	MILLPD	08/27/19	NA	2419.6	NA	
1900883-002	MILLPD	09/10/19	NA	62.44	NA	
1900540-014	MONTHS	06/25/19	27	187.19	23	
1900572-012	MONTHS	07/09/19	39.7	166.4	14	
1900598-014	MONTHS	07/25/19	43.7	307.59	13	
1900678-015	MONTHS	08/06/19	51.6	133.44	14	
1900759-012	MONTHS	08/27/19	57.2	344.11	14	
1900598-028	MONTHS-BLANK	07/25/19	<2.00	<1.000	<5	
1900598-027	MONTHS-DUP	07/25/19	44.5	275.51	15	
1900540-023	MOUTHJB	06/25/19	16.7	17.31	5	

1900572-021	MOUTHJB	07/09/19	19.5	20.34	6	
1900598-021	MOUTHJB	07/25/19	21.9	14.64	7	
1900678-022	MOUTHJB	08/06/19	30.5	31.84	8	
1900759-020	MOUTHJB	08/20/19	NA	NA	7	
1900883-022	MOUTHJB	09/10/19	12.6	7.38	8	
1900540-031	MOUTHJB-BLANK	06/25/19	<2.00	<1.000	NA	
1900540-030	MOUTHJB-DUP	06/25/19	16.1	12.11	NA	
1900540-008	NBBIKEPATHBR	06/25/19	NA	325.54	NA	
1900572-008	NBBIKEPATHBR	07/09/19	14.9	579.43	15	
1900598-009	NBBIKEPATHBR	07/25/19	15.9	613.14	16	
1900759-008	NBBIKEPATHBR	08/27/19	27.7	1986.29	14	
1900883-009	NBBIKEPATHBR	09/10/19	16.4	365.4	18	
1900883-032	NBBIKEPATHBR-BLANK	09/10/19	<2.00	<1.000	NA	
1900883-031	NBBIKEPATHBR-DUP	09/10/19	16.6	488.44	NA	
1900540-001	NBNC02	06/25/19	NA	193.49	19	
1900572-001	NBNC02	07/09/19	NA	95.99	15	
1900678-001	NBNC02	08/06/19	NA	123.56	13	
1900759-001	NBNC02	08/27/19	NA	172.33	12	
1900598-001	NCNB02	07/25/19	7.08	73.28	13	
1900883-001	NCNB02	09/10/19	NA	71.16	15	
1900540-029	NCNB02-BLANK	06/25/19	NA	<1.000	<5	

1900540-028	NCNB02-DUP	06/25/19	NA	143.87	24	
1900540-010	PIONEER	06/25/19	NA	88.41	20	
1900572-028	PIONEER	07/09/19	NA	261.25	13	
1900598-031	PIONEER	07/25/19	NA	187.19	NA	
1900678-011	PIONEER	08/06/19	NA	142.09	15	
1900759-016	PIONEER	08/27/19	NA	261.25	14	
1901115-005	PIONEER	09/10/19	35.3	NA	26	
1900540-002	SCHOOLST	06/25/19	NA	214.26	NA	
1900572-005	SCHOOLST	07/09/19	NA	290.93	NA	
1900598-005	SCHOOLST	07/25/19	NA	112.64	NA	
1900678-005	SCHOOLST	08/06/19	NA	93.35	NA	
1900759-005	SCHOOLST	08/27/19	NA	2419.57	NA	
1900883-005	SCHOOLST	09/10/19	NA	124.98	NA	
1900540-003	SPRINGST	06/25/19	NA	155.25	19	
1900572-003	SPRINGST	07/09/19	NA	129.63	16	
1900598-003	SPRINGST	07/25/19	NA	86	14	
1900678-003	SPRINGST	08/06/19	NA	65.65	16	
1900759-003	SPRINGST	08/27/19	NA	1986.29	16	
1900883-003	SPRINGST	09/10/19	NA	61.27	19	
1900572-029	SPRINGST-DUP	07/09/19	NA	139.58	15	
1900572-030	SRPINGST-BLANK	07/09/19	NA	<1.000	<5	
1900540-007	STATEST	06/25/19	NA	193.49	20	
1900572-027	STATEST	07/09/19	NA	193.49	15	

1900598-007	STATEST	07/25/19	NA	235.93	13	
1900678-007	STATEST	08/06/19	NA	156.48	14	
1900759-031	STATEST	08/27/19	NA	1553.12	16	
1900572-014	STEVEB	07/09/19	55.4	290.93	11	
1900598-015	STEVEB	07/25/19	62.6	488.44	15	
1900678-018	STEVEB	08/06/19	88	816.41	18	
1900759-015	STEVEB	08/27/19	83	866.44	14	
1901115-006	STEVEB	09/10/19	80.8	NA	17	
1900678-030	STEVEB-BLANK	08/06/19	<2.00	<1.000	<5	
1900678-029	STEVEB-DUP	08/06/19	82	517.21	17	
1900759-028	STEVEB-BLANK	08/27/19	<2.00	<1.000	<5	
1900759-027	STEVEB-DUP	08/27/19	84.5	686.67	14	
1900572-017	STEVEBMAC	07/09/19	52.4	344.8	12	
1900598-017	STEVEBMAC	07/25/19	64.8	365.4	NA	
1900678-017	STEVEBMAC	08/06/19	83.5	579.43	NA	
1900759-013	STEVEBMAC	08/27/19	77	NA	NA	
1900883-016	STEVEBMAC	09/10/19	81	NA	NA	
1900540-013	TAYLORST	06/25/19	NA	206.35	19	
1900572-011	TAYLORST	07/09/19	NA	285.1	13	
1900598-013	TAYLORST	07/25/19	NA	313.01	14	
1900678-014	TAYLORST	08/06/19	NA	201.42	15	
1900759-011	TAYLORST	08/27/19	NA	488.44	15	
1900883-014	TAYLORST	09/10/19	NA	155.25	14	

1900540-026	UNION	06/25/19	12.5	NA	7	
1900572-024	UNION	07/09/19	13.9	30.13	NA	
1900598-024	UNION	07/25/19	17.2	NA	6	
1900678-025	UNION	08/06/19	18.5	NA	8	
1900759-024	UNION	08/27/19	17.1	NA	7	
1900883-025	UNION	09/10/19	15.4	NA	7	
1901115-003	UNION	09/11/19	NA	NA	12	
1900540-020	UVMCAMP	06/25/19	14.8	54.61	6	
1900572-018	UVMCAMP	07/09/19	17.7	13.5	7	
1900598-018	UVMCAMP	07/25/19	21.5	10.89	8	
1900678-019	UVMCAMP	08/06/19	29.2	4.13	7	
1900759-017	UVMCAMP	08/20/19	NA	NA	8	
1900883-019	UVMCAMP	09/10/19	12.2	9.79	7	
1900572-032	UVMCAMP-BLANK	07/09/19	<2.00	<1.000	NA	
1900572-031	UVMCAMP-DUP	07/09/19	18.3	12.11	NA	
1900540-027	WATERST	06/25/19	15.3	47.11	11	
1900572-026	WATERST	07/09/19	17.2	55.55	6	
1900598-026	WATERST	07/25/19	NA	53.71	6	
1900678-026	WATERST	08/06/19	27.4	58.63	6	
1900759-023	WATERST	08/27/19	26.2	31.29	6	
1900883-026	WATERST	09/10/19	24.1	24.62	6	

Appendix B – Quality Control: Relative Percent Difference between samples and duplicates; blank sample results

Sample Number	Location	Date	Chloride (mg/L)	Final *E. coli* (mpn/100ml)	TP (ug P/L)	RPD Chloride	RPD E. coli	RPD TP
1900759-025	COXBR3	08/27/19	NA	36.84	6			
1900759-029	COXBR3-DUP	08/27/19	NA	30.89	NA			
1900598-004	Katies	07/25/19	NA	83.92	NA			
1900598-030	Katies-BLANK	07/25/19	NA	<1.000	NA			
1900598-029	Katies-DUP	07/25/19	NA	81.26	NA		3.2	
1900678-004	Katies	08/06/19	NA	123.35	NA			
1900678-032	Katies-BLANK	08/06/19	NA	<1.000	NA			
1900678-031	Katies-DUP	08/06/19	NA	93.35	NA		27.7	
1900598-014	MONTHS	07/25/19	43.7	307.59	13			
1900598-028	MONTHS-BLANK	07/25/19	<2.00	<1.000	<5			
1900598-027	MONTHS-DUP	07/25/19	44.5	275.51	15	1.8	11	14.3
1900540-023	MOUTHJB	06/25/19	16.7	17.31	5			
1900540-031	MOUTHJB-BLANK	06/25/19	<2.00	<1.000	NA			
1900540-030	MOUTHJB-DUP	06/25/19	16.1	12.11	NA	3.7	35.4	
1900883-009	NBBIKEPATHBR	09/10/19	16.4	365.4	18			
1900883-032	NBBIKEPATHBR-BLANK	09/10/19	<2.00	<1.000	NA			
1900883-031	NBBIKEPATHBR-DUP	09/10/19	16.6	488.44	NA	1.2	28.8	

1900540-001	NBNC02	06/25/19	NA	193.49	19			
1900540-029	NCNB02-BLANK	06/25/19	NA	<1.000	<5			
1900540-028	NCNB02-DUP	06/25/19	NA	143.87	24		29.4	23.3
1900572-003	SPRINGST	07/09/19	NA	129.63	16			
1900572-029	SPRINGST-DUP	07/09/19	NA	139.58	15		7.4	6.5
1900572-030	SRPINGST-BLANK	07/09/19	NA	<1.000	<5			
1900678-018	STEVEB	08/06/19	88	816.41	18			
1900678-030	STEVEB-BLANK	08/06/19	<2.00	<1.000	<5			
1900678-029	STEVEB-DUP	08/06/19	82	517.21	17	7.1	44.9	5.7
1900759-015	STEVEB	08/27/19	83	866.44	14			
1900759-028	STEVEB-BLANK	08/27/19	<2.00	<1.000	<5			
1900759-027	STEVEB-DUP	08/27/19	84.5	686.67	14	1.8	23.1	0
1900572-018	UVMCAMP	07/09/19	17.7	13.5	7			
1900572-032	UVMCAMP-BLANK	07/09/19	<2.00	<1.000	NA			
1900572-031	UVMCAMP-DUP	07/09/19	18.3	12.11	NA	3.3	10.9	
Average Relative Percent Difference						**3.15**	**22.18**	**9.96**