Summary Report: 2017 Sampling Results
Addison County River Watch Collaborative

15 March 2018

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Executive Summary

This report provides a summary of the 2017 water quality results for six rivers monitored by the Addison County River Watch Collaborative (ACRWC). Sediment, phosphorus, nitrogen, and *E.coli* were monitored at 36 stations in Lemon Fair, Lewis Creek, Little Otter Creek, Middlebury River, New Haven River and the lower Otter Creek watersheds. Sampling events occurred on the first Wednesday of each month for two spring dates (April and May) and four summer dates (June, July, August and September). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall.

E.coli counts in all six rivers exceeded the health-based standard of 235 organisms/ 100mL at one or more stations during one or more summer sampling dates (29 out of 36 stations monitored) in 2017. Generally, elevated *E.coli* detections were associated with developed land uses including nearby agriculture and livestock with direct access to the river. Human sources (e.g., failed septic systems) and wildlife sources of *E.coli* also exist in these rivers, including beaver, deer, and waterfowl. Periodic sewage overflows from wastewater treatment systems may have contributed to elevated *E.coli* levels in the Otter Creek. At the most frequented swimming holes (Bartlett's Falls and Sycamore Park on the New Haven River and the Middlebury River Gorge), *E.coli* values were below the health-based standard on all sample dates.

Two to three sentinel stations in each watershed are monitored every year to track long-term trends in water quality. The geometric mean of E.coli counts for all four summer sampling dates exceeded the Vermont water-quality standard of 126 org/100mL at one or both sentinel stations in each of the six watersheds. These results are consistent with historic patterns; segments of the Little Otter Creek, Lewis Creek, Middlebury River, and Otter Creek are listed as impaired and included in a state-wide Total Maximum Daily Load plan for Bacteria. During the one low-flow, baseflow event encountered during scheduled sample dates in 2017, Turbidity and Total Phosphorus concentrations exceeded the respective Vermont water quality standards at sentinel stations in Lemon Fair and Little Otter Creek. Each of the watersheds contributes phosphorus and sediment to Lake Champlain, either directly (Lewis Creek, Little Otter Creek) or via Otter Creek (Middlebury River, New Haven River, Lemon Fair). In the mountainous watersheds of Lewis Creek, Middlebury River, and New Haven River, turbidity and sediment-bound phosphorus concentrations tend to become elevated during high flows. In the valley watersheds (Little Otter Creek, Lemon Fair and Otter Creek), the turbidity and phosphorus concentrations tend to be elevated on a more frequent basis, in a wider range of flow conditions. The most substantial loading occurs during high flow events – typically occurring in the spring or fall months.

In New Haven River and Little Otter Creek, 2017 marked the second year of a two-year focus study, where additional sites were monitored for an expanded list of parameters, in order to better define the spatial extent and magnitude of sediment and nutrient concentrations in these watersheds. New sites were established to bracket potential sources of elevated nutrients, turbidity and pathogens in Muddy Branch and West Brook tributaries in the New Haven River watershed and along the upper main stem of the Litter Otter Creek. These 2016-2017 focus monitoring efforts have expanded the spatial resolution of water quality data in these catchments, to include more information about headwater areas.

- New Haven River watershed: The Muddy Branch and West Brook tributaries are disproportionate loaders of phosphorus, nitrogen and suspended sediment to the New Haven River, under both high-flow and low-flow conditions. For example, while the Muddy Branch sub-watershed represents only 15% of the watershed in area, it was responsible for approximately 71% of the overall load of phosphorus during low-flow conditions in the months of April through September of 2016. Turbidity, *E.coli* and phosphorus concentrations in Muddy Branch and nitrate-nitrogen concentrations in the West Brook tributary exceeded relevant Vermont Water Quality Standards. Restoration and mitigation actions should be focused in these tributaries, including Best Management Practices and stormwater management measures to reduce nutrient, sediment and pathogen inputs.

- Little Otter Creek watershed: Highest nitrogen concentrations were detected along the upper main stem, at two stations which have incremental drainage areas characterized by 42% and 65% agricultural land use, respectively. Nitrate-nitrogen detected at the uppermost station exceeded the VT Water Quality Standard. Nitrogen sources may include wastewater, stormwater, and manure and fertilizer applied to crop and hay fields. For phosphorus and turbidity, on the other hand, middle and lower portions of the watershed appear to be high loaders of phosphorus and turbidity, as each constituent exhibited an increasing trend in concentration with distance downstream along the main stem. Under wet-weather high-flow conditions, phosphorus was also elevated in the upper main stem. Nutrient management planning and other best management practices should target nitrogen sources in the uppermost reaches of the watershed as well as Mud Creek, and phosphorus and sediment sources across the watershed. In a future focus year, finer-scale bracket-monitoring is warranted along the Mud Creek to identify sources of nutrient runoff measured at the mouth of that tributary. Baseline monitoring of the Slang areas downstream of Route 7 is also proposed.

ACRWC relies on partner agencies to identify projects for implementation and ongoing monitoring. Monitoring results have been shared with partner agencies including the VT Agency of Agriculture, UVM Extension, USDA Farm Service Agency, and the Otter Creek Natural Resource Conservation District to support outreach to landowners and farmers in these watersheds and the design of Best Management Practices. ACRWC also shares its data with conservation commissions and planning boards in the Addison County towns to inform Town Plans.

A more intensive monitoring focus rotates back to the Lemon Fair and Lewis Creek for a two-year period beginning in the year 2018. In the Lemon Fair, new bracket monitoring stations will be established on the Beaver Branch, Bascom Brook and Perry Brook tributaries to further define sources of elevated nutrients and sediment detected along the main stem between established stations at Shacksboro Road in Shoreham and Route 125 in Cornwall. In the Lewis Creek, ACRWC will continue with bracket monitoring at stations in vicinity of the Tyler Bridge Road crossing to gain a better understanding of water quality patterns and potential sources of elevated pathogens, nutrients and sediments in this segment which is listed as impaired. ACRWC is seeking grant funding to perform a DNA source tracking study to discriminate sources of fecal bacteria in this watershed.

Acknowledgements

Sampling in six Addison County rivers is carried out by a network of trained volunteers operating under the Addison County River Watch Collaborative (fiscal agent, Lewis Creek Association). Logistical and technical support are provided by Ethan Swift of the VTDEC Monitoring, Assessment and Planning Program, Kevin Behm of the Addison County Regional Planning Commission and Kristen Underwood of South Mountain Research & Consulting. Analytical services are provided by the Vermont Agricultural & Environmental Laboratory (previously, LaRosa Laboratory) in Burlington, VT, under direction of Guy Roberts, through an analytical services partnership grant under the coordination of Jim Kellogg.

Operational support is provided to ACRWC through annual contributions from 12 Addison County towns as well as private and corporate donations and in-kind services. Partial support for statistical and data analysis and reporting in 2017 has also been provided to ACRWC by a LaRosa Organizational Support grant from the VTDEC.

1.0 Introduction

This report provides a summary of the 2017 sampling results for six rivers monitored by the Addison County River Watch Collaborative (ACRWC).

2.0 Background

The ACRWC has been monitoring water quality (including sediment, phosphorus, nitrogen, and *E.coli*) in six watersheds in Addison County for two decades, with the earliest monitoring efforts beginning in 1992:

- Lemon Fair River (2003 – present)
- Lewis Creek (1992 – present)
- Little Otter Creek (1997 – present)
- Middlebury River (1993 – present)
- New Haven River (1993 – present)
- Otter Creek (1992 – present)

Since several years of baseline data now exist for the six ACRWC watersheds, the sampling schedule was revised, beginning with the 2010 season, to include longer-term temporal trend monitoring at a reduced number of key sites in each watershed (sentinel sites) with a reduced number of water quality parameters. These sentinel sites are combined with a more focused monitoring effort in two of the six watersheds that rotate for a period of two years on and four years off (Table 1). The focused evaluation typically involves a greater number of sites (and testing parameters) than the sentinel sites, and is conducted to meet specific data needs of relevance to the chosen watershed.

Table 1. Rotational Schedule for Focused Monitoring

2016 – 2017	2018 - 2019	2020 - 2021
Little Otter Creek	Lewis Creek	Middlebury River
New Haven River	Lemon Fair	Otter Creek

For the 2016 and 2017 sampling seasons, Little Otter Creek and the New Haven River were selected to be focus watersheds (Figure 1, watersheds in bold outline). Therefore, rotational sites were scheduled for sampling in addition to the sentinel sites in these two watersheds during this second focus year. Table 2 displays the schedule of sampling sites and parameters for the 2017 season; “R” denotes a rotational site, “S” for a sentinel site, and “O” for other. A slightly different schedule of sampling parameters is indicated for spring versus summer months – i.e., *E. coli* was added to the list for summer events. Additional fall sampling was conducted at select sites in Lewis Creek watershed as part of a special project to bracket known or suspected sources of pathogens (see Methods).

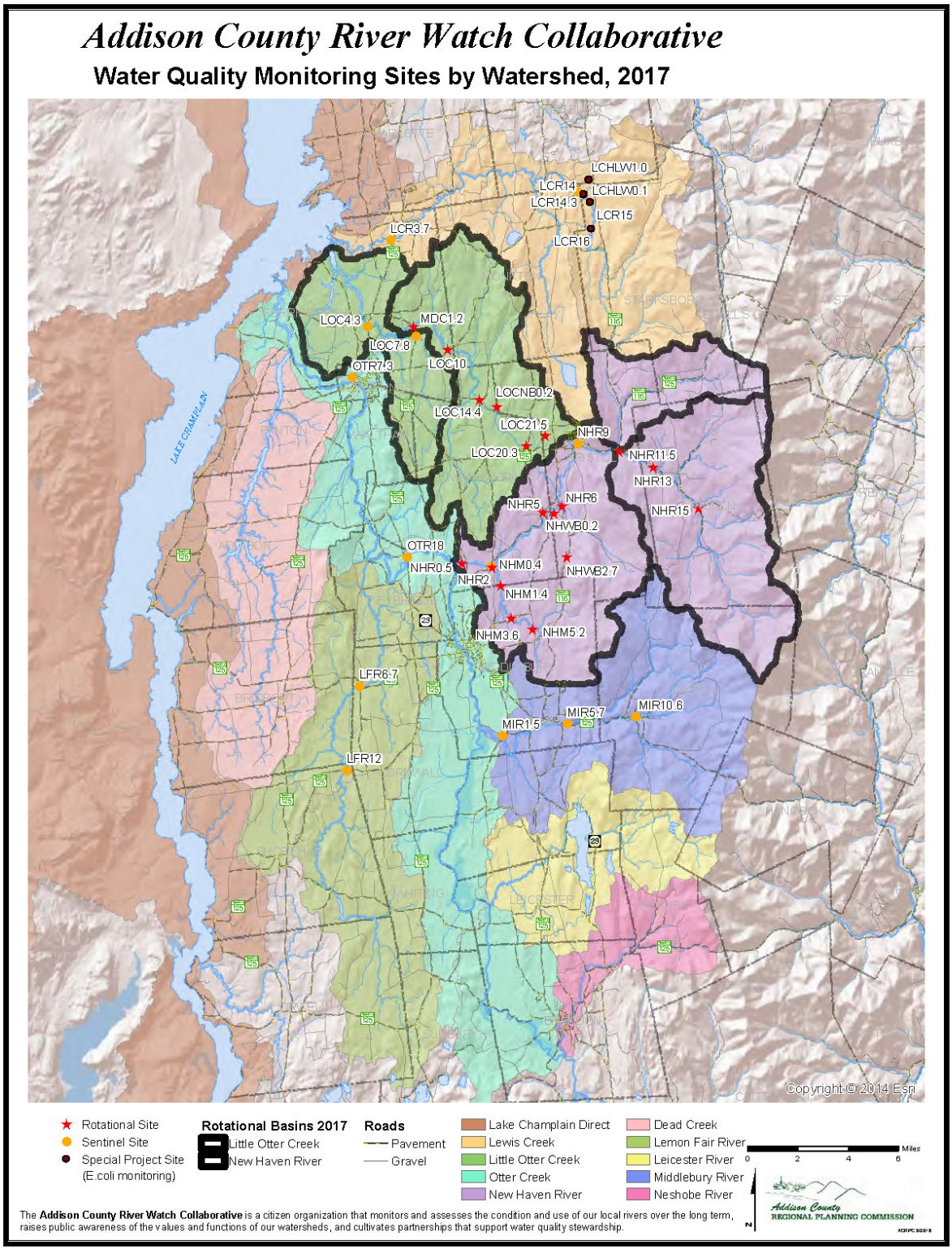

Figure 1. Location of ACRWC monitoring stations for 2017.

Table 2. 2017 Schedule of Sites / Parameters – Spring, Summer and Fall

Project Name: Addison County River Watch Collaborative

Project Number: **137-01**

Sample Year: **2017**

				Spring Schedule (Apr, May)						Summer Schedule (Jun, Jul, Aug, Sep)							Fall Schedule (pending flow events)						
				PARAMETERS						PARAMETERS							PARAMETERS						
Type	**River Name**	**Site ID**	**Site Location**	**TP**	**DP**	**TN**	**NOX**	**Turbidity**	**TSS**	***E.coli***	**TP**	**DP**	**TN**	**NOX**	**Turbidity**	**TSS**	***E.coli***	**TP**	**DP**	**TN**	**NOX**	**Turbidity**	**TSS**
S	Lewis Creek	LCR3.7	Old Route 7 Bridge	X				X		X	X				X								
S	Lewis Creek	LCR14	Tyler Bridge	X	X	X		X		X	X	X	X		X		X	X				X	
O	Hollow Bk (Lewis Ck)	LCHLW1.0	Tyler Bridge Rd Xg of Hollow Bk	X	X	X		X		X	X	X	X		X		X	X				X	
O	Hollow Bk (Lewis Ck)	LCHLW0.1	Hollow Brook at Confl w/ Lewis	X	X	X		X		X	X	X	X		X		X	X				X	
O	Lewis Creek	LCR14.3	Just above confluence of Hollow Bk	X	X	X		X		X	X	X	X		X		X	X				X	
O	Lewis Creek	LCR15	Just above Clifford stabilized crossing	X	X	X		X		X	X	X	X		X		X	X				X	
O	Lewis Creek	LCR16	LaRue bridge crossing	X	X	X		X		X	X	X	X		X		X	X				X	
S	Lemon Fair River	LFR6.7	Route 125 bridge.	X	X			X	X	X	X	X			X	X							
S	Lemon Fair River	LFR12	Downstream of Route 74 bridge	X	X			X	X	X	X	X			X	X							
S	Little Otter Creek	LOC4.3	Route 7 Bridge	X	X	X		X	X	X	X	X	X		X	X							
R	Little Otter Creek	LOC7.8	Middlebrook Rd (North)	X	X	X		X	X	X	X	X	X		X	X							
R	Little Otter Creek	LOC10	Monkton Road	X	X	X		X	X	X	X	X	X		X	X							
R	Little Otter Creek	LOC14.4	Plank Rd.	X	X	X		X	X	X	X	X	X		X	X							
R	Norton Brook	LOCNB0.2	Norton Brook	X	X	X		X	X	X	X	X	X		X	X							
R	Little Otter Creek	LOC20.3	Sawyer Road Bridge	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	Little Otter Creek	LOC21.5	Kilbourn property	X	X	X	X	X	X	X	X	X	X	X	X	X							
S	Mud Creek	MDC1.2	Wing Rd./Middlebrook Rd. (South)	X	X	X		X	X	X	X	X	X		X	X							
S	Middlebury River	MIR1.5	Shard Villa Road Bridge	X				X		X	X				X								
S	Middlebury River	MIR5.7	Midd. Gorge @ Rte 125 Bridge	X				X		X	X				X								
S	Middlebury River (Midd Br)	MIR10.6	Natural Turnpike Road	X				X		X	X				X								
R	New Haven River	NHR0.5	Dog Team Tavern	X				X		X	X				X								
S	New Haven River	NHR2	Muddy Branch confluence (just below)	X				X		X	X				X								
R	Muddy Branch	NHM0.4	Just above confluence at Nash Fm	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	Muddy Branch	NHM1.4	Halpin Covered Bridge Rd	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	Muddy Branch	NHM3.6	Painter Road crossing	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	Muddy Branch	NHM5.2	Munger Road crossing	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	New Haven River	NHR5	New Haven Mills / Munger St Bridge	X				X		X	X				X								
R	West Brook	NHWB0.2	Cove Road crossing	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	West Brook	NHWB2.7	Rt 116 below Elephant Mtn Campground	X	X	X	X	X	X	X	X	X	X	X	X	X							
R	New Haven River	NHR6	Route 116 Bridge, Sycamore Park	X				X		X	X				X								
S	New Haven River	NHR9	South St. Bridge	X				X		X	X				X								
R	New Haven River	NHR11.5	Bartlett's Falls Pool	X				X		X	X				X								
R	New Haven River	NHR13	York Hill Rd Bridge	X				X		X	X				X								
R	New Haven River	NHR15	Garland's Bridge - Gap Road	X				X		X	X				X								
S	Otter Creek	OTR7.3	Vergennes Falls / below outfall	X				X		X	X				X								
S	Otter Creek	OTR18	Twin Bridges Picnic Area	X				X		X	X				X								

Site Types: R = Rotational; S = Sentinel; O = Other (special project).

3.0 Methods

Water quality samples were collected by ACRWC volunteers in accordance with quality assurance procedures outlined in the EPA-approved Generic Quality Assurance Project Plan prepared by VTDEC. A Quality Assurance Summary report for the 2017 sampling data is provided as Appendix D. Samples were delivered to the Vermont Agricultural & Environmental Laboratory (VAEL) housed in the Hills Building at the University of Vermont campus in Burlington, Vermont.

During 2017, ACRWC volunteers collected grab samples in these six watersheds at 36 sites during two Spring events (April and May) and four Summer events (June, July, August and September). Sampling dates were pre-determined as the first Wednesday of each month, and were not designed to capture any specific flow condition:

Scheduled Monthly Sampling – sentinel, rotational, and bracket sites

- April 5
- May 3
- June 7
- July 5
- August 2
- September 6

In addition, a special bracket-monitoring study was carried out in the vicinity of the Tyler Bridge Road in Lewis Creek watershed. A total of six stations was monitored, including sentinel station LCR14 and five temporary stations established upstream of this station. The purpose of this study was to more closely bracket potential or suspected source(s) of pathogens that have been detected consistently at high levels at LCR14 over several years. The objective of this monitoring was to measure both dry-weather and wet-weather conditions. Since scheduled events on the first Wednesday of the month during spring and summer months happened to coincide mostly with wet-weather, high flow conditions, additional dry-weather base flow events were carried out in the fall of 2017 at these bracket stations. No additional storm events were able to be captured during the fall of 2017. The few significant storm events that did occur either occurred during overnight hours, or fell on days which would not permit sufficient lead time for sample processing at the VAEL within a customary work week.

Additional Dry-Weather Sampling – bracket sites only

- September 27
- October 3
- October 25

4.0 Precipitation Data

Precipitation data were compiled from existing weather stations in vicinity of the ACRWC watersheds

(Table B-1). Overall, calendar year 2017 was a near-normal precipitation year, as recorded at regional weather stations in South Burlington (Airport) and Rutland. Higher-than-normal snowfall during the winter of 2016-2017 (Table B-2) helped the region recover from moderate drought conditions experienced in the previous year (US Drought Monitor, 2017). While precipitation was near normal for the year on average, spring and early summer months were wetter than normal, leading to delays in planting corn and harvesting first-cut hay (UVM Extension, 2017). Months of August through December then saw lower-than-normal precipitation (Table B-1). A series of rain events in July impacted southwestern Addison County (drained by Lemon Fair and Otter Creek) and eastern Addison County (in the headwaters of Middlebury River and New Haven River). These were localized areas of rainfall (Figure 2) that were not reflected in precipitation totals recorded at the South Burlington and Rutland weather stations (Table B-1; NWS, 2017).

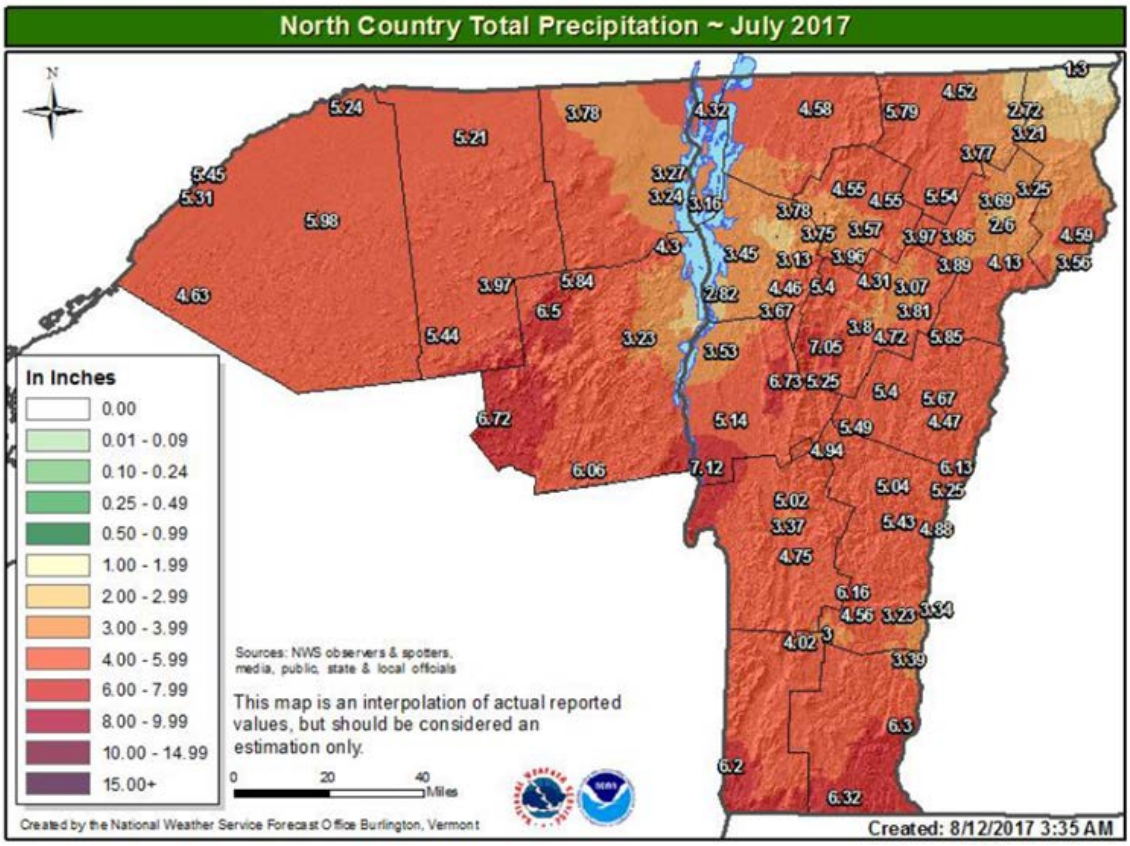

Figure 2. July 2017 precipitation recorded in Vermont and northern NY by National Weather Service (excerpted from http://www.weather.gov/media/btv/e5/E5_BTV_2017-07.pdf)

5.0 Hydrologic Data

5.1 Seasonal Trends

Appendix B presents graphs of the instantaneous discharge record (provisional data) from calendar year 2017 for USGS flow gaging stations on the New Haven River, Lewis Creek, Little Otter Creek, and the Otter Creek at Middlebury stations. Flows in these watersheds were somewhat elevated above normal

in July and August, but then trended below normal for October given the warm temperatures and lower-than-average precipitation for those fall months.

Ice-out conditions in the mountain watersheds came during the last days of February with warming temperatures, rain and snowmelt when New Haven River, Lewis Creek and Little Otter Creek experienced a flow approaching or meeting the 2-year storm magnitude (Olson, 2014). Peak flows for the year in Lewis Creek and New Haven River exceeded the 2-year storm on June 30 and July 1, respectively, when intense rains fell on saturated ground. Minor flood damages and road closures occurred in the upper New Haven River watershed (Figure 3). Flooding on those days also led to local and state road closures in the Middlebury River and Lemon Fair River watersheds. Flows in these four rivers reached their lowest point for the year in late September (Otter) and October (Little Otter Creek, New Haven , Lewis).

New Haven River at Eagle Park (above NHR11.5) – July 1, 2017

New Haven River at Sycamore Park (NHR6) – July 1, 2017

Figure 3. Localized flooding on 1 July 2017 in the New Haven River watershed.

5.2 Flow Conditions During Sampling

During scheduled monthly sample dates - except for the August 2 event - volunteers encountered moderate to high-flow conditions in which water was actively rising or falling in response to recent rainfall – i.e., freshet flows (Table B-3). High flow levels are defined as those flow conditions which are equaled or exceeded only 25% of the time; while, moderate flows are equaled or exceeded between 25 and 75% of the time[1]. The August 2 event represented low-flow, baseflow conditions in Little Otter and New Haven; moderate-flow, baseflow conditions in Lewis Creek; and a low-flow, freshet-flow event (from slowly receding water) in the Otter Creek. Low-flow conditions are equaled or exceeded more than 75% of the time, based on a flow duration curve of daily mean flows (Appendix B). Baseflow conditions represent relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event.[1]

Figure 4 presents daily mean flows recorded at the USGS gage in Lewis Creek during the 2017 season. Sample dates are superimposed as orange diamonds for the six scheduled monthly sampling dates, as well as the three additional dry-weather bracket monitoring events. During the dry-weather sampling

[1] VTDEC *Guidance on Streamflow Observations at time of Water Quality Sampling of Rivers and Streams*

events carried out in late September and October, flow in the Lewis Creek exhibited base-flow characteristics at or near the Low Median Monthly flow (Table B-3).

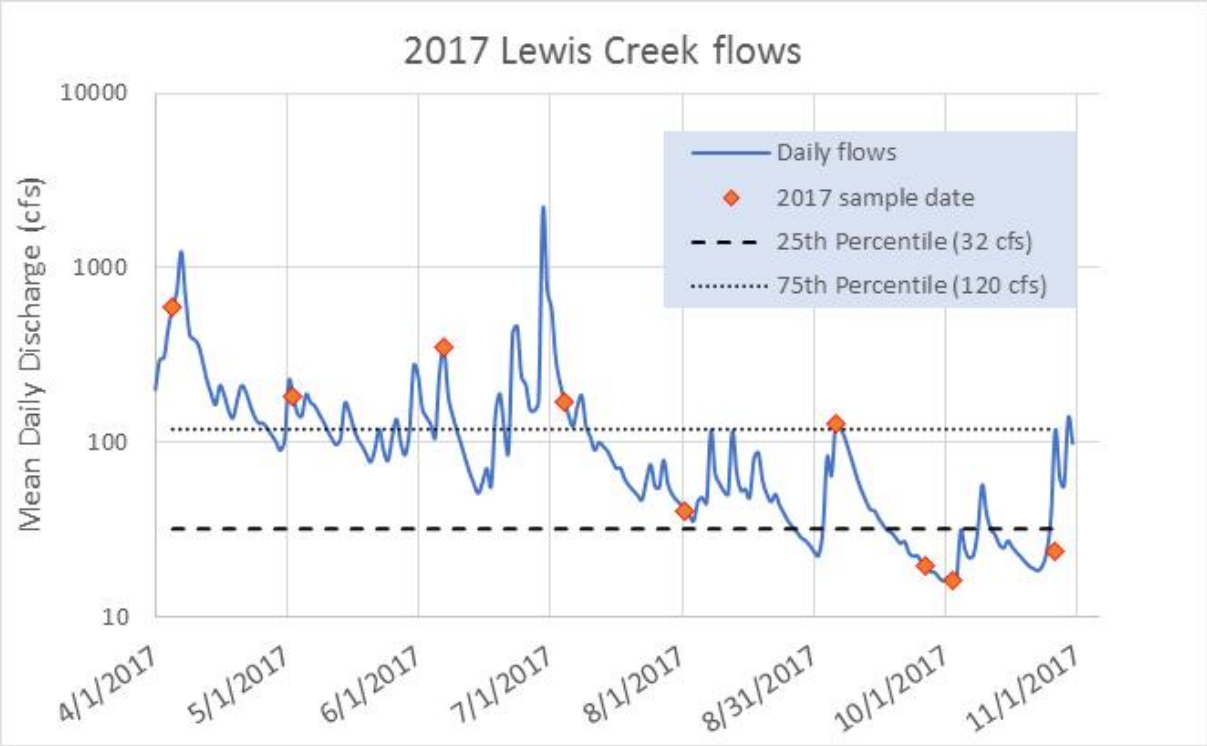

Figure 4. Daily mean flows measured at the USGS streamflow gaging station on Lewis Creek during the 2017 sampling season.

6.0 Monitoring Results

Appendix C contains quality-assured sample results for the 2017 season for the ACRWC watersheds. Attachments 1 through 6 summarize these results for each watershed. These attachments have been designed to serve as a handout for use in future outreach events to watershed stakeholders and relevant town boards. As discussed in Section 2.0, the Little Otter Creek and the New Haven River were chosen as focus watersheds for 2017. Therefore, sample results are presented for sentinel as well as rotational sites in these two watersheds, and data are summarized for the two-year focus period.

In general, water quality results for 2017 were consistent with historic results and trends summarized in the 2009 Draft Water Quality Reports for each watershed (Hoadley, 2009). Expanded information has been gathered for newly-established stations in focus watersheds, New Haven River and Little Otter Creek. The Vermont Agency of Natural Resources (VTANR) updated the Vermont Water Quality Standards, effective January 2017 (VWMD, 2016). Water quality standards relevant to each watershed are detailed in the footnotes in Appendix C.

ACRWC stations are monitored to meet several objectives, including: (1) to evaluate health and safety at swimming holes and recreation sites; (2) to track temporal trends in key constituents; (3) to investigate spatial trends in constituents; (4) to build data sets for assessing the effectiveness of implemented treatments or management practices; and (5) to compute coarse estimates of pollutant loads.

6.1 Health and Safety at Swimming Holes and Recreation Sites

The original sampling motivation for many member groups of the Collaborative was to monitor for pathogens at swimming holes and other popular recreation sites on our Addison County rivers. Twenty-six years later, measuring and publicizing *E.coli* data continues to be a principal goal of the ACRWC. Historic data from ACRWC has informed the *Vermont Statewide TMDL for Bacteria-impaired Waters* (VTDEC, 2011) which addresses impaired segments of the Little Otter Creek, Lewis Creek, Middlebury River, and Otter Creek.

This year, *E.coli* counts in all six rivers exceeded the health-based standard of 235 organisms/ 100 mL at one or more stations during one or more summer sampling dates (29 out of 36 stations monitored). Generally, elevated *E.coli* detections were associated with developed land uses including nearby agriculture and livestock with direct access to the river. Human sources (e.g., failed septic systems) and wildlife sources of *E.coli* also exist in these rivers, including beaver, deer, and waterfowl. Periodic sewage overflows from wastewater treatment systems and combined stormwater / sewer systems may have contributed to elevated *E.coli* levels in the Otter Creek.

During the wet-weather conditions encountered in the summer of 2017, some of the region's popular recreation sites had one or more detections of *E. coli* above the standard during the four dates sampled (Table 3). At the most frequented swimming holes (Bartlett's Falls and Sycamore Park on the New Haven River and the Middlebury River Gorge), *E.coli* values were below the health-based standard on all sample dates. Based on historic monitoring in these Addison County rivers, *E.coli* counts can become elevated during high flow conditions following heavy rains or snow melt, and they can also be associated with low-flow conditions and very warm temperatures.

ACRWC posts monthly provisional *E.coli* results at popular recreation sites on the New Haven River, Middlebury River, Lewis Creek and Otter Creek. Notices are also posted electronically on *Front Porch Forum* (www.frontporchforum.com). Look for our signage at your favorite swimming hole (Figure 5), or contact Matt Witten, Managing Director, mwitten@gmavt.net, for *E.coli* posting information.

Figure 5. Provisional E.coli results are posted monthly at popular swimming holes, including Middlebury Gorge in East Middlebury and Bartlett's Falls on the New Haven River in Bristol, VT.

Table 3. Number of E.coli detections above health-based standard at recreation sites and swimming holes in Summer of 2017
(Four sample dates: June 7, July 5, August 2, September 6)

River Name	Site ID	Site Location	Town	# Detections
Lewis Creek	LCR3.7	Old Route 7 Bridge	Ferrisburg	2
	LCR14	Tyler Bridge	Monkton	2
Middlebury River	MIR1.5	Shard Villa Rd. Bridge	Middlebury	2
	MIR5.7	Midd. Gorge @ Rte 125 Bridge	Middlebury	0
New Haven River	NHR0.5	Dog Team Tavern (former)	New Haven	2
	NHR2	Muddy Branch confluence (just below)	New Haven	2
	NHR5	Munger Street Bridge	New Haven	1
	NHR6	Route 116 Bridge, Sycamore Park	Bristol	0
	NHR9	South St. Bridge	Bristol	0
	NHR11.5	Bartlett's Falls Pool	Bristol	0
	NHR15	S. Lincoln Bridge (Gap Rd.)	Lincoln	0

6.2 Trend Monitoring - Temporal

Water quality in the ACRWC watersheds varies over time, in response to year-to-year variations in climate, seasonal fluctuations in weather and vegetation, and daily to seasonal variations in flow stage. Sentinel stations (typically two or three stations in each watershed) have been established to track long-term annual-scale variations in water quality resulting from naturally-fluctuating weather and vegetation, but also human-influenced factors such as shifting land use or changes in management practices. Sentinel stations are positioned at locations which offer a finer-scale assessment than the single long-term monitoring stations maintained by VTDEC at the mouth of the Lewis Creek, Little Otter Creek and Otter Creek. In other words, ACRWC sentinel stations are located further upstream on our six rivers to examine long-term trends at a sub-watershed scale, as a complement to the Lake Champlain Longterm Tributary Monitoring Program[2]. The ACRWC reviews longterm trends at its sentinel stations on an approximate six- to ten-year cycle, depending on the availability of funding.

6.3 Trend Monitoring – Spatial

Water quality in the ACRWC watersheds also varies in space, depending on the geologic setting and soil types present in the catchment areas draining to each station, as well as variation in land use and land cover characteristics (see Appendix A). Focus monitoring was carried out during 2016 and 2017 in the Little Otter Creek and New Haven River watersheds, to better define the spatial extent and magnitude of sediment and nutrient concentrations in these watersheds. New sites were established to bracket

[2] https://anrweb.vermont.gov/dec/_dec/LongTermMonitoringTributary.aspx

potential sources of elevated nutrients, turbidity and pathogens in Muddy Branch and West Brook tributaries in the New Haven River watershed and along the upper main stem of the Litter Otter Creek. Detailed results for these two focus watersheds are provided in Attachments 3 and 5. The following paragraphs highlight results which have helped to better define spatial patterns of phosphorus and nitrogen in these watersheds.

Figure 6 illustrates stations sampled on the New Haven River and tributaries during base-flow conditions in 2016. The mean of Total Phosphorus (TP) results available for three summer-time base-flow sampling dates exceeded the water-quality standard at all four stations on the Muddy Branch. These exceedances of the standard will be considered by VTDEC alongside other indicators, including biomonitoring data, to determine if these waters should be listed as impaired. Mean TP concentrations are illustrated in Figure 6 by color-coding the incremental subwatershed draining to each station. Under these base-flow, summer conditions, the Muddy Branch (NHM sites) and West Brook (NHWB sites) tributaries are disproportionate loaders of TP to the New Haven River. A similar spatial pattern was evident for mean TP concentrations at high flows. Nitrogen was also elevated in these two tributaries (see Attachment 5).

Agricultural and developed land uses are more concentrated in this southwestern part of the watershed, as compared to the headwaters. Each of these tributaries is also underlain by fine-grained silt and clay soils derived from glacial lake deposits, which have an affinity for phosphorus and which are easily eroded and transported by a range of flows. These are areas where restoration and mitigation actions should be focused, including nutrient management to reduce phosphorus and nitrogen inputs.

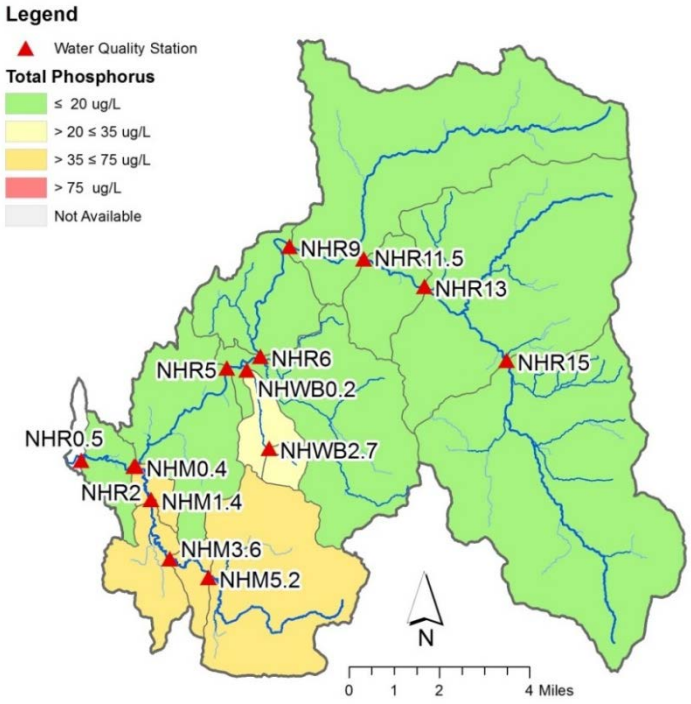

Figure 6. Mean value of Total Phosphorus detected in July, August and September (2016) during base flow conditions at or below the Low-Median-Monthly Flow in the New Haven River watershed.

Figure 7a depicts mean Total Nitrogen concentrations detected during six sampling events in 2017 in the Little Otter Creek watershed. These six events occurred during flows that exceeded the Low Monthly Median flow: five high-flow events, and one low-flow, baseflow event. Highest nitrogen concentrations were detected in the two headwaters stations, LOC20.3 and LOC21.5, which have incremental drainage

areas characterized by 42% and 65% agricultural land use, respectively. According to Vermont Water Quality Standards, nitrogen as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the Low Median Monthly discharge. In order to evaluate nitrogen levels in the Little Otter Creek with respect to this standard, a more specific lab test was scheduled for these stations in 2017 to detect nitrate and nitrite (NO2) forms of nitrogen, or NO3-NO2 Nitrogen (Figure 7b). Based on the separate analysis for NO3-NO2-nitrogen, nitrates make up between 80 and 100 % of the total nitrogen detected during these 6 events at station LOC21.5. (Note that the NO3-NO2-nitrogen analysis tests for both nitrite and nitrate forms of nitrogen. However, nitrite is relatively rare in waters draining sparsely developed landscapes. Results of this test are therefore interpreted by VAEL to represent nitrogen in the form of nitrates (personal communication, Jim Kellogg, VWMD, 3/17/17).

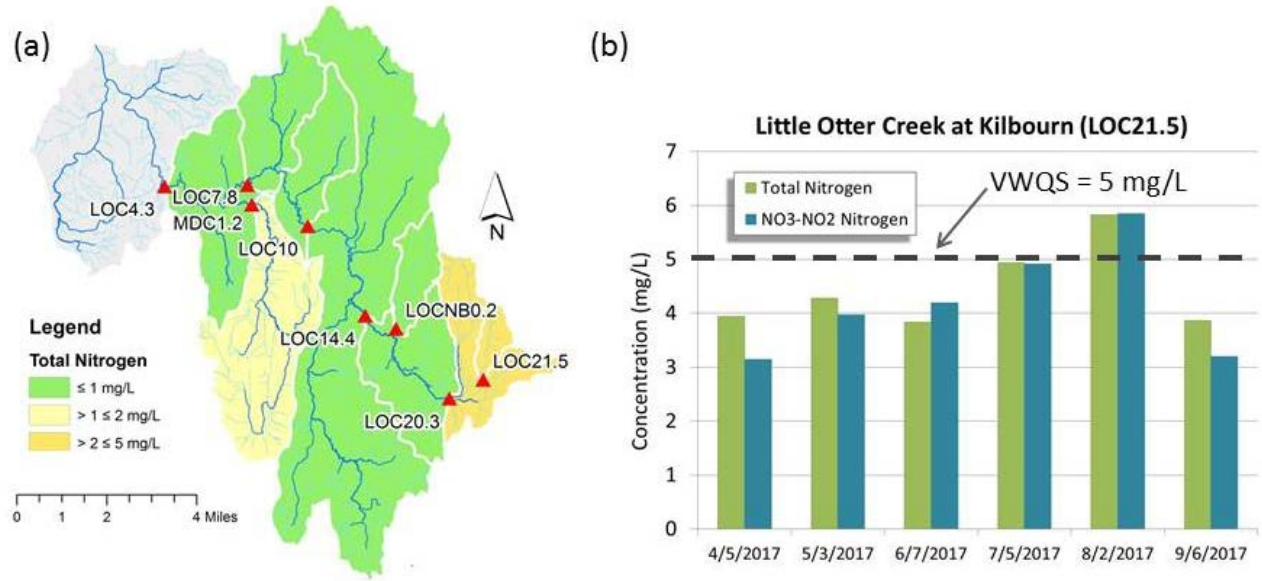

Figure 7. Nitrogen monitoring results for Little Otter Creek focus stations during 2017 including: (a) mean total nitrogen (TN) by water-quality subwatershed and (b) NO3-N02 and TN by sample date for station LOC21.5, relative to the Vermont Water Quality Standard of 5 mg/L for nitrogen as nitrate.

Nitrogen sources may include wastewater, stormwater, and manure and fertilizer applied to crop and hay fields. The wetter-than-normal spring and early summer months in 2017 may also have contributed to nitrogen loss from fields as a result of leaching (UVM Extension, 2017). Given the prevalence of agricultural uses in those sub-watersheds of the Little Otter Creek which demonstrated elevated concentrations of nitrate-N, and the Bristol village contributions to the uppermost subwatershed, nutrient management planning and other best management practices to reduce N runoff should be prioritized in these headwater areas of the watershed, as well as Mud Creek. Finer-scale bracket-monitoring is warranted in the Mud Creek tributary watershed in future years to identify sources of nutrient runoff. Monitoring of the Slang areas of the watershed downstream of Route 7 is also warranted. These areas have traditionally not been monitored due to backwater effects from Lake Champlain. Nevertheless, there is a potential for nutrient and sediment loading to the lake from agricultural and developed uses which are densely concentrated in this region.

6.4 Treatment Effectiveness

Within the past year, ACRWC conducted statistical analyses to document the effectiveness of a historic livestock exclusion project at the Rublee Farm along the upper reaches of Lewis Creek in Starksboro (detailed results reported separately). Livestock exclusion in 1998 resulted in a notable, and statistically-significant, drop in mean *E.coli* concentrations, such that a majority of the post-treatment values detected at a nearby downstream station, were below the health-based standard of 235 MPN/100 mL.

The 2017 bracket monitoring of *E.coli*, phosphorus and turbidity in vicinity of Tyler Bridge Road on the Lewis Creek will continue in 2018. Current monitoring will serve as a baseline for future monitoring to quantify effectiveness of anticipated livestock exclusion measures upstream of the bridge.

6.5 Loading Estimates

Another reason to monitor for sediment and nutrients at the sub-watershed level in Addison County watersheds is to evaluate relative contributions of sediment and nutrients to Lake Champlain in the context of the Lake Champlain Total Maximum Daily Load for phosphorus. Each of the watersheds monitored by ACRWC contributes significant phosphorus to the lake, either directly (Lewis Creek, Little Otter Creek) or via Otter Creek (Middlebury River, New Haven River, Lemon Fair). The most substantial loading occurs during high flow events – typically occurring in the spring or fall months.

Consider an example coarse-loading calculation for the Muddy Branch tributary to New Haven River depicted in Figure 6. A coarse estimate can be made of the contribution of this tributary to overall loading in the watershed, relying on mean concentration data for the monitored spring and summer months (April through September) and the daily mean discharge measured at the USGS gage near station NHR0.5 as detailed in Table 4. While the Muddy Branch sub-watershed represents only 15% of the watershed in area, it was responsible for approximately 71% of the overall load of phosphorus during baseflow conditions in the months of April through September of 2016. This finding would underscore the need for nutrient reduction strategies focused on the Muddy Branch. This coarse-loading estimation method is approximate only, and does not account for the complex dynamics of nutrient and sediment cycling in rivers, and effects of variable discharge. However, the method does provide an estimate of relative pollutant load contributions from sub-regions of a watershed – that may compel action on the part of landowners or towns, and help to prioritize resources for mitigation efforts.

Table 4. Coarse-level estimate of TP loading from Muddy Branch tributary of the New Haven River.

		NHR0.5 Former Dog Team Tavern	NHM0.4 Muddy Branch near confluence
Upstream Drainage Area	sq miles	115.8	17.0
Proportion of USGS Gaged Area	[-]	1.01	0.15
Spring/Summer 2016 Base-Flow Mean TP Concentration	ug/L	11.6	56.3
Average Daily Spring/Summer 2016 Water Flux	million liters	294	43
Spring/Summer 2016 Base-flow TP Load	kg	620	440

7.0 Project Implementation

ACRWC relies on partner agencies to identify projects for implementation and ongoing monitoring. Monitoring results have been shared with partner agencies including the VT Agency of Agriculture, UVM Extension, USDA Farm Service Agency, and the Otter Creek NRCD to support outreach to landowners and farmers in these watersheds and the design of Best Management Practices.

Water quality monitoring data have been used to inform and develop priority implementation projects in watersheds monitored by the Collaborative. Sediment and nutrient concentration data (and coarse estimates of phosphorus yields, where available) have been used to communicate land use impacts on water quality and encourage landowner and municipal participation in watershed restoration. In cooperation with local, state and federal partners, projects have been prioritized within the context of River Corridor Plans and the Otter Creek Basin Plan. Some have been implemented over the years, and with landowner willingness, others will be developed to achieve reductions in nutrient and sediment loading from these catchments. Projects have included wetland restoration & conservation, livestock exclusion, riparian buffer plantings, alternate tillage and crop rotation practices, gully stabilization, improved forest management techniques, and improved road maintenance practices. Water quality data are also being shared with VTDEC biomonitoring teams and used to inform municipal level discussions regarding water quality management classification in ongoing basin planning efforts.

8.0 References

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Appendix A

Physical Features of Watersheds
Monitored by Addison County River Watch Collaborative

Table A-1 summarizes the physical characteristics of the ACRWC watersheds and nearby LaPlatte River. A majority of the drainage area for the New Haven River and Middlebury River is positioned in the mountainous terrain of the Northern Green Mountain physiographic province. Lewis Creek also has a significant percentage of its drainage area in this province. LaPlatte River, Little Otter Creek and Lemon Fair River are located further to the west in the broad, low-relief, Champlain Valley physiographic province. Thus, topographic relief and overall gradients of the New Haven River, Middlebury River and Lewis Creek are substantially higher than that of the Champlain Valley watersheds.

The Green Mountain watersheds (New Haven River, Middlebury River, and Lewis Creek; shaded yellow in Table A-1) tend to exhibit flashier flows, than the Champlain Valley watersheds due, in part, to the steeper overall gradients. The lower-gradient watersheds of the Champlain Valley (shaded blue in Table A-1) tend to be characterized by higher percentages of hydric soils derived from lacustrine and marine lake sediments, and have higher percentages of wetlands. These conditions offer temporary surface water storage and lagged flows, resulting in broader, lower-magnitude storm peaks, longer times to peak, and gradual hydrograph recessions.

In general, the Green Mountain watersheds tend to have higher percentages of forest cover, while the Champlain Valley watersheds have higher percentages of agricultural land use.

The geophysical setting of these watersheds influences water quality. For example, in the mountainous watersheds of Lewis Creek, Middlebury River, and New Haven River, turbidity and sediment-bound phosphorus concentrations tend to become elevated and exceed the water quality standard during high flows. In the valley watersheds (Little Otter Creek and Lemon Fair), the turbidity and phosphorus standards tend to be exceeded on a more frequent basis, in a wider range of flow conditions. As noted in Table A-1 the valley watersheds have a much higher percentage of fine-grained silt and clay soils derived from glacial lake sediments. A separate study recently completed by ACRWC found a strong, and statistically-significant, positive correlation between mean water quality concentrations (for Total Phosphorus, *E. coli* and Turbidity) and both the percentage of these fine-grained glacial lake soils and the percentage of agricultural land use in the catchments draining to water quality stations in these two watersheds (ACRWC & SMRC, 2016).

Table A-1. Physical Features of Watersheds.

Watershed	Physical Characteristics										
	Geologic Province (1)		Soils (2) (% Lake Sediments)	% Hydric Soils	% Wetlands (VSWI)	Topography		Major Land Cover/ Land Use			Stream Classification (Class B) (3)
	NGM	CV				Relief (ft)	Gradient (ft / mile)	Forest	Agric	Urban	
Middlebury River 63 sq mi	71%	29%	10%	15.2%	3.2%	1,758	111	81%	11%	3%	Cold Water Fish
New Haven River 116 sq mi	63%	37%	14%	9.8%	2.5%	2,720	106	76%	15%	4%	Cold Water Fish
Lewis Creek 81 sq mi	31%	69%	24%	18.6%	6.5%	1,676	52	60%	26%	5%	Cold Water Fish
LaPlatte River 53 sq mi	5%	95%	45%	25.3%	6.1%	960	49	38%	39%	16%	Warm Water Fish
Little Otter Creek 73 sq mi	--	100%	62%	30.3%	9.7%	416	18	35%	45%	4%	Cold Water Fish
Lemon Fair River 91 sq mi	--	91%	63%	19.3%	7.3%	256	8	25%	63%	6%	Warm Water Fish
Lower Otter Creek 498 sq mi (of 944 sq mi basin)	29%	69%	38%	20.8%	8.9%	NM	NM	67%	21%	6%	Warm Water Fish

Notes:

(1) NGM = Northern Green Mountains; CV = Champlain Valley; geologic province after Stewart & MacClintock (1969) or biophysical province after the VT Biodiversity Project.

(2) Soils of glaciolacustrine parent material, Natural Resource Conservation Service County Soil Survey Data.

(3) As per VT Water Quality Standards, effective Jan 1, 2008.

Appendix B

Precipitation and Flow Data

Table B-1. Monthly / Annual Precipitation at climate stations located in vicinity of Addison County.

	Data Source	Time Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Burlington, VT (Airport)	*1*	1971-2000	2.22	1.67	2.32	2.88	3.32	3.43	3.97	4.01	3.83	3.12	3.06	2.22	36.05
	2	1981-2010	2.05	1.76	2.21	2.82	3.45	3.69	4.15	3.91	3.64	3.60	3.12	2.37	36.77
330 ft amsl	*2*	2009	1.76	1.81	1.90	1.86	5.25	5.25	4.62	2.32	3.67	2.98	2.98	3.02	37.42
	2	2010	2.41	2.13	2.85	3.08	1.52	5.87	2.25	3.51	4.17	6.24	3.10	3.60	40.73
330 ft amsl	*2*	2011	1.44	3.02	3.39	7.88	8.67	3.52	3.68	6.11	6.06	3.49	1.43	2.23	50.92
20 miles N	*2*	2012	1.96	0.89	0.98	2.84	4.41	3.22	3.78	2.92	5.36	5.04	1.24	3.30	35.94
	2	2013	1.11	1.32	2.05	2.05	8.74	9.86	4.49	3.07	4.74	2.59	2.43	2.54	44.99
	2	2014	2.45	1.83	1.88	3.66	3.94	4.35	5.54	2.05	1.63	4.17	1.98	2.85	36.33
	2	2015	1.29	1.09	0.90	2.64	2.92	8.67	4.67	1.98	4.86	3.17	1.21	4.44	37.84
	2	2016	1.19	3.14	2.26	1.80	2.46	3.05	3.05	2.25	1.39	2.66	2.13	2.35	27.73
	2	2017	2.00	2.67	3.27	3.83	4.91	7.17	3.45	2.40	2.79	3.55	1.68	2.18	39.90
Rutland, VT	*1*	1971-2000	2.70	1.97	2.59	2.80	3.52	3.85	4.58	4.18	3.91	3.21	3.08	2.73	39.12
	2	1981-2010	2.44	2.15	2.77	2.88	3.71	4.00	4.77	4.10	3.78	3.83	3.25	2.96	40.64
620 ft amsl	*2*	2011	2.93	3.76	3.61	5.69	4.40	4.38	4.88	11.24	4.88	3.48	1.29	2.80	53.34
40 miles SSE	*2*	2012	1.69	0.69	1.12	3.32	5.26	3.66	3.62	3.42	4.58	4.57	0.71	4.08	36.72
	2	2013	1.85	0.78	1.51	2.58	5.60	5.93	5.59	3.30	3.25	1.36	2.58	2.55	36.88
	2	2014	3.61	3.42	2.56	2.05	4.14	4.44	5.19	2.69	1.54	4.30	2.12	3.77	39.83
	2	2015	2.50	1.66	0.84	2.26	2.94	7.13	3.11	1.69	3.72	3.34	1.22	3.91	34.32
	2	2016	1.06	4.25	2.88	1.97	2.85	3.67	2.44	3.62	2.48	3.87	2.62	3.00	34.71
	2	2017	1.69	2.26	2.91	2.87	5.79	4.17	3.37	2.45	2.35	4.10	1.21	3.06	36.23

Total precipitation in inches, including liquid equivalent of snow, sleet. M = Missing
Values for 1971-2000 and 1981-2010 periods reflect averages for the time period. Values for individual years are totals.

Data Sources: [1] National Climatic Data Center, 2002, Climatography of the United States No. 81 - 43 (Vermont), Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days: 1971-2000

[2] NOAA Online Weather Data, http://www.weather.gov/climate/index.php?wfo=btv

Table B-2. Monthly / Seasonal Snowfall Totals at climate stations located in vicinity of Addison County.

	Time Period	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Season
So. Burlington, VT (Airport)	1971-2000	0.0	0.0	0.0	0.3	7.2	17.1	20.9	15.3	15.4	5.8	0.0	0.0	81.9
	1981-2011	0.0	0.0	0.0	0.3	5.1	19.1	21.9	16.9	15.6	4.6	0.0	0.0	83.6
	2011-2012	0.0	0.0	0.0	0.1	5.0	6.9	13.4	6.4	5.9	0.0	0.0	0.0	37.7
	2012-2013	0.0	0.0	0.0	0.0	3.8	30.7	14.6	16.6	16.2	1.0	0.0	0.0	82.9
	2013-2014	0.0	0.0	0.0	Tr	6.4	15.3	12.5	24.1	25.4	2.8	0.0	0.0	86.5
	2014-2015	0.0	0.0	0.0	0.0	10.6	21.9	20.7	22.7	4.4	3.1	0.0	0.0	83.4
	2015-2016	0.0	0.0	0.0	Tr	0.2	7.1	13.1	8.6	1.8	3.5	Tr	0.0	34.3
	2016-2017	0.0	0.0	0.0	Tr	4.3	16.7	7.6	30.6	36.8	4.4	0.0	0.0	100.4
Rutland, VT	1971-2000	0.0	0.0	0.0	0.3	5.6	13.5	16.7	13.9	12.4	3.6	0.0	0.0	66.0
	1981-2011	0.0	0.0	0.0	0.5	4.4	16.7	17.3	14.7	12.6	3.3	0.0	0.0	69.3
	2011-2012	0.0	0.0	0.0	6.5	2.9	5.0	8.9	2.7	4.2	0.0	0.0	0.0	30.2
	2012-2013	0.0	0.0	0.0	0.0	0.4	23.9	8.1	8.5	10.9	0.2	0.0	0.0	52.0
	2013-2014	0.0	0.0	0.0	0.3	4.5	18.9	14.5	30.4	20.5	1.7	0.0	0.0	90.8
	2014-2015	0.0	0.0	0.0	0.0	10.3	14.7	19.8	31.6	4.1	3.1	0.0	0.0	83.6
	2015-2016	0.0	0.0	0.0	Tr	0.0	4.1	9.6	5.8	0.4	2.8	0.0	0.0	22.7
	2016-2017	0.0	0.0	0.0	Tr	3.4	19.4	9.3	19.2	17.3	6.2	Tr	0.0	74.8

Total snowfall in inches. Values for 1971-2000 and 1981-2011 periods reflect averages for the time period. Values for seasons are totals.
Source: http://www.weather.gov/climate/xmacis.php?wfo=btv data available as of Jan 2017
Tr = Trace; M - Missing data

Table B-3. 2017 Daily Mean Flows recorded in Addison County rivers on sample dates, with reference to estimated peak flows and low median monthly flows.

	River	Little Otter Ck			Lewis Creek			New Haven River			Otter Ck MB		
	USGS Gage #	#04282650			#04282780			#04282525			#04282500		
	Drainage Area (sq mi)	57.1			77.4			115			630		
Sample Dates	4/5/2017	406	H	FF	595	H	FF	955	H	FF	2,240	H	FF
(Daily Mean Flows)	5/3/2017	103	H	FF	182	H	FF	545	H	FF	1,710	H	FF
(cfs)	6/7/2017	162	H	FF	347	H	FF	530	H	FF	1,390	M	FF
* incidates	7/5/2017	149	H	FF	172	H	FF	294	H	FF	2,690	H	FF
flow < LMM	8/2/2017	12	L	BF	41	M	BF	81	L	BF	419	L	FF
	9/6/2017	93	H	FF	129	H	FF	391	H	FF	741	M	FF
	9/27/2017				19.4 *	L	BF						
	10/3/2017				16.2 *	L	BF						
	10/25/2017				23.6	L	BF						
Peak Flows	Q2	890			1,750			4,550			4,310		
(Olson, 2014; App 3)	Q5	1,370			2,910			7,330			5,880		
(Weighted)	Q10	1,740			3,820			9,540			7,030		
	Q25	2,270			5,110			12,700			8,660		
	Q50	2,720			6,160			15,300			10,000		
	Q100	3,200			7,270			18,200			11,500		
	Q500	4,520			10,400			26,400			15,400		
Low Median Monthly Flow		6.6 (Sept)			21.2 (Sept)			65.0 (Sept)			325 (Aug)		
7Q10 Flow		1.4			5.8			19.4			148		

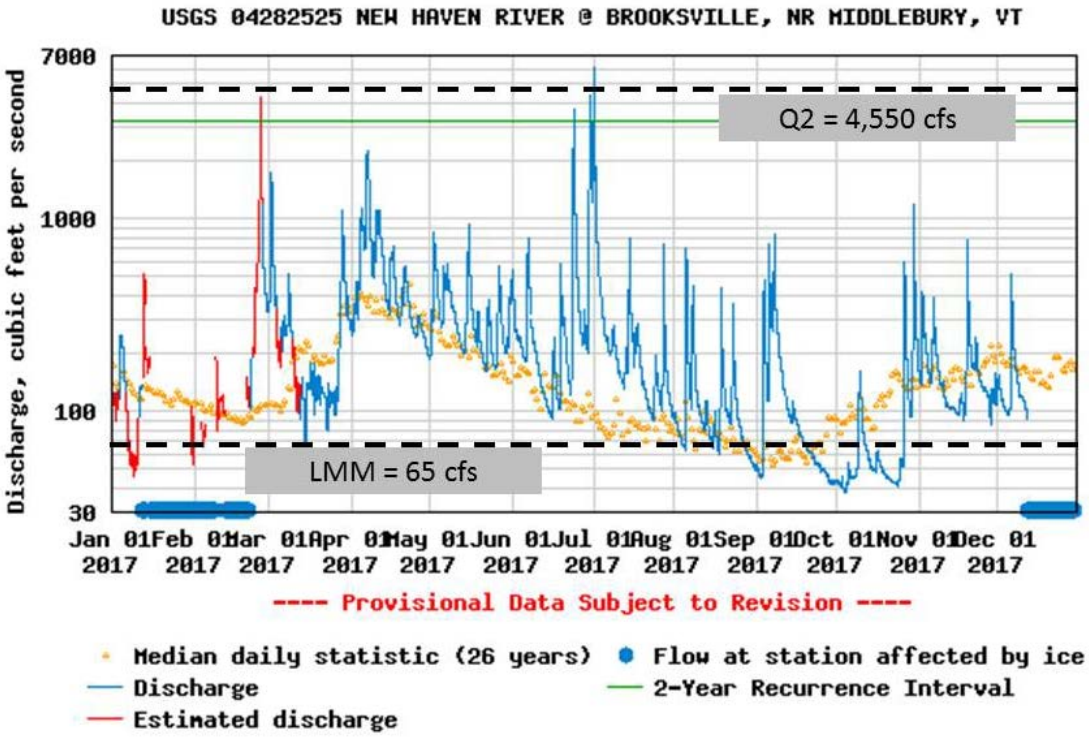
(Blaine Hastings, VWMD, Jan 2014; based on gaging records of variable lengths through water year 2012)

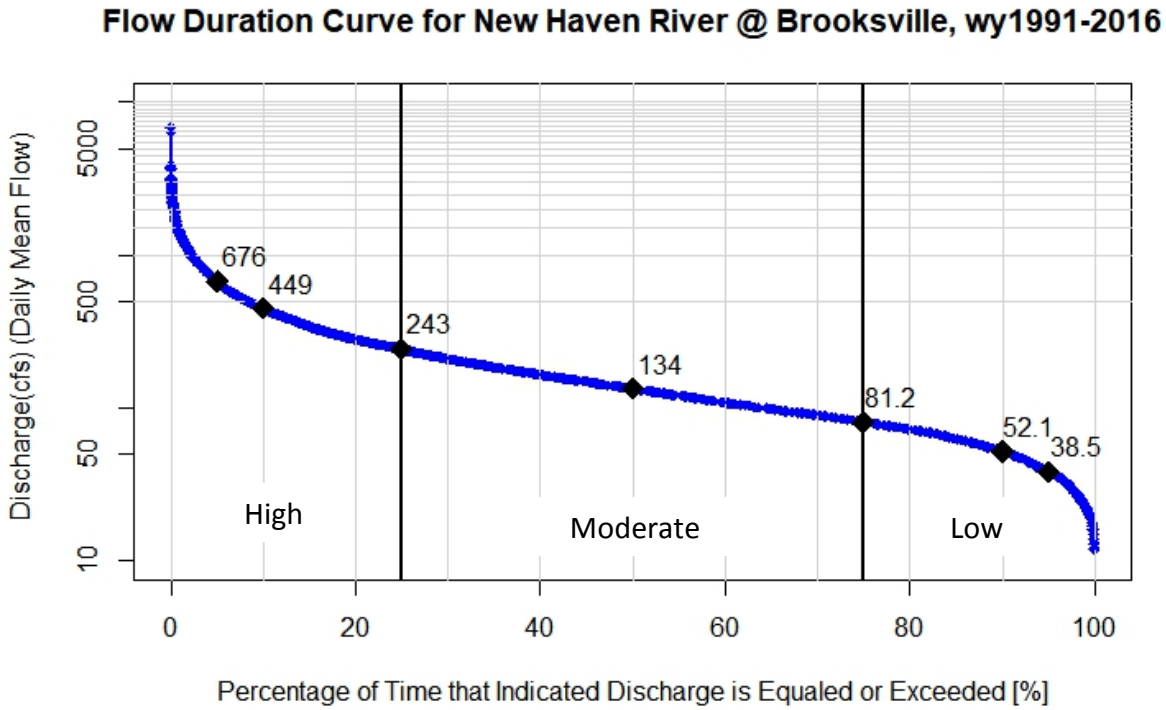
Source: USGS National Water Information System, https://waterdata.usgs.gov/vt/nwis, downloaded 1/3/2018

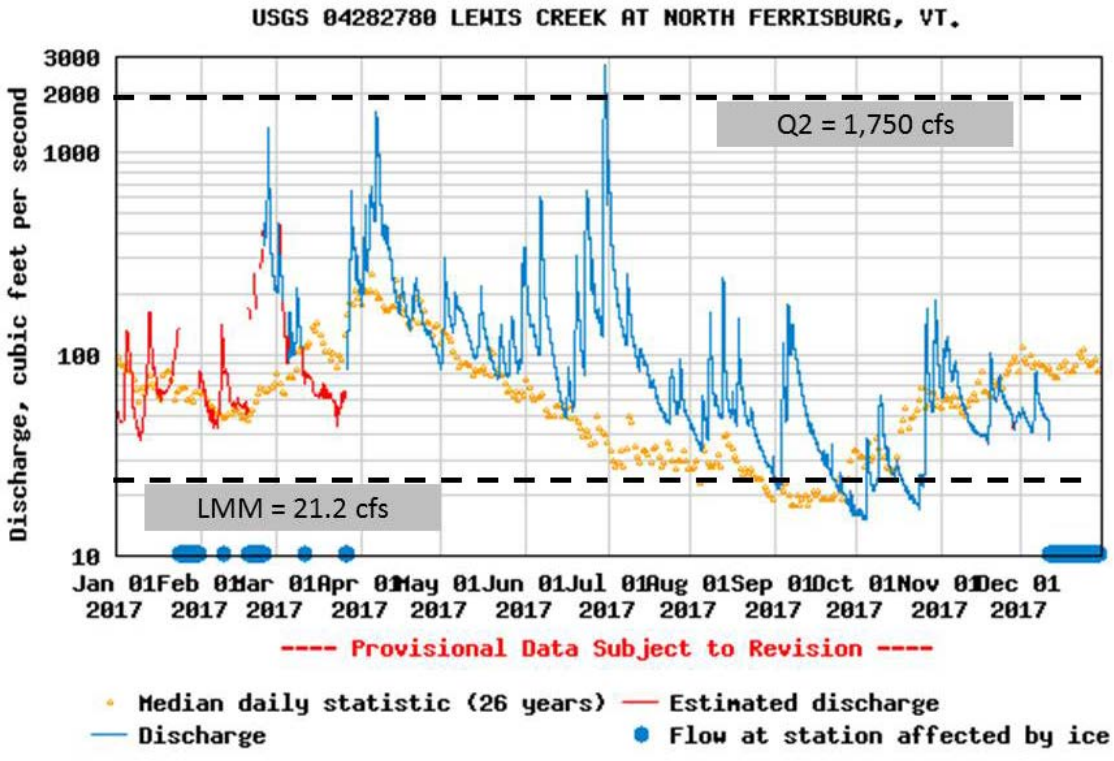
Abbreviations: Flow condition follows VTDEC Guidance:

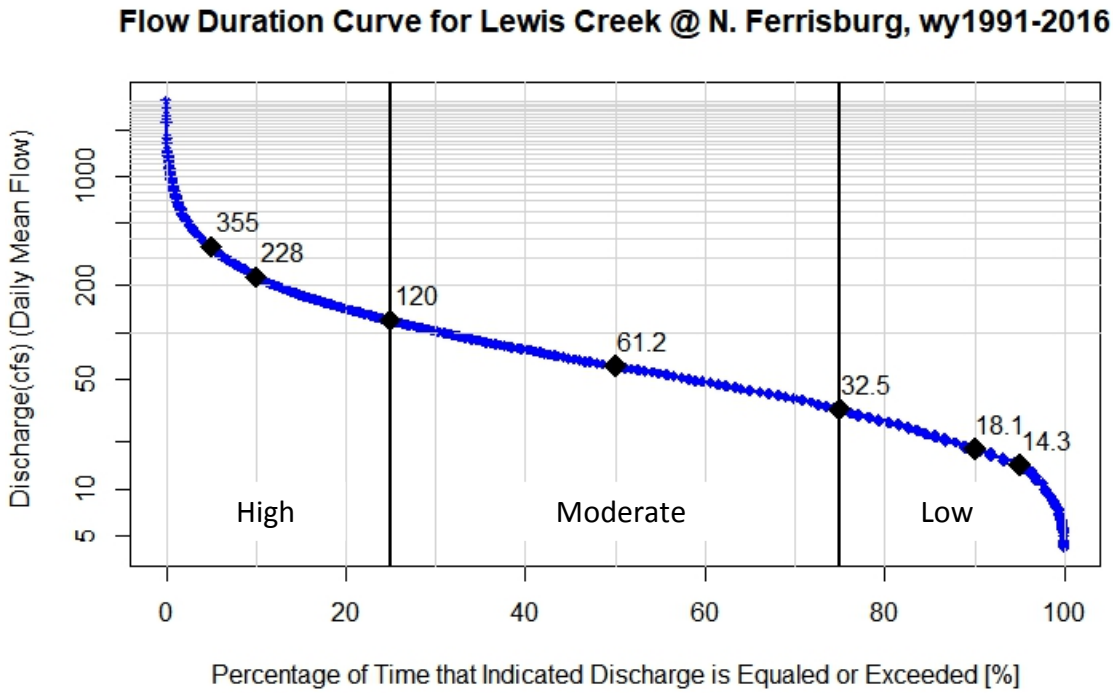
Flow Level: Fd - Flood (>bankfull flow), H - High (>p.75), M - Moderate (>p.25 ≤p.75), L - Low (≤ p.25), where p = percentile

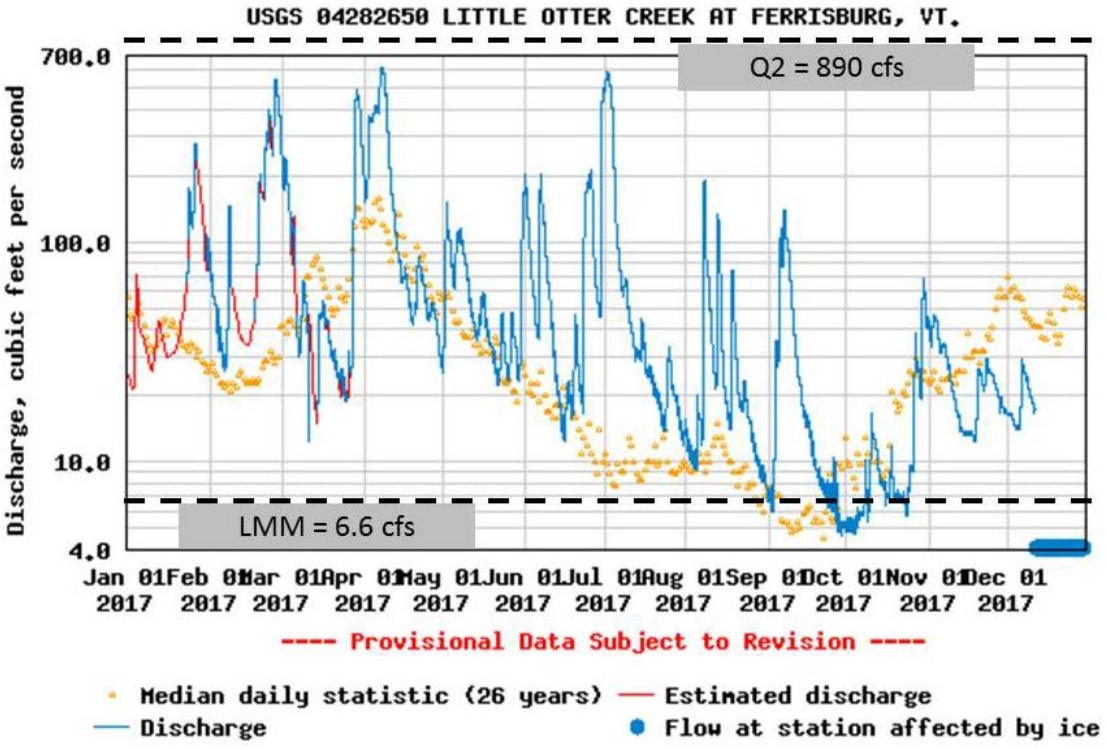
Flow Category: BF - Base Flow, FF - Freshet Flow, HF - Hydro Flow

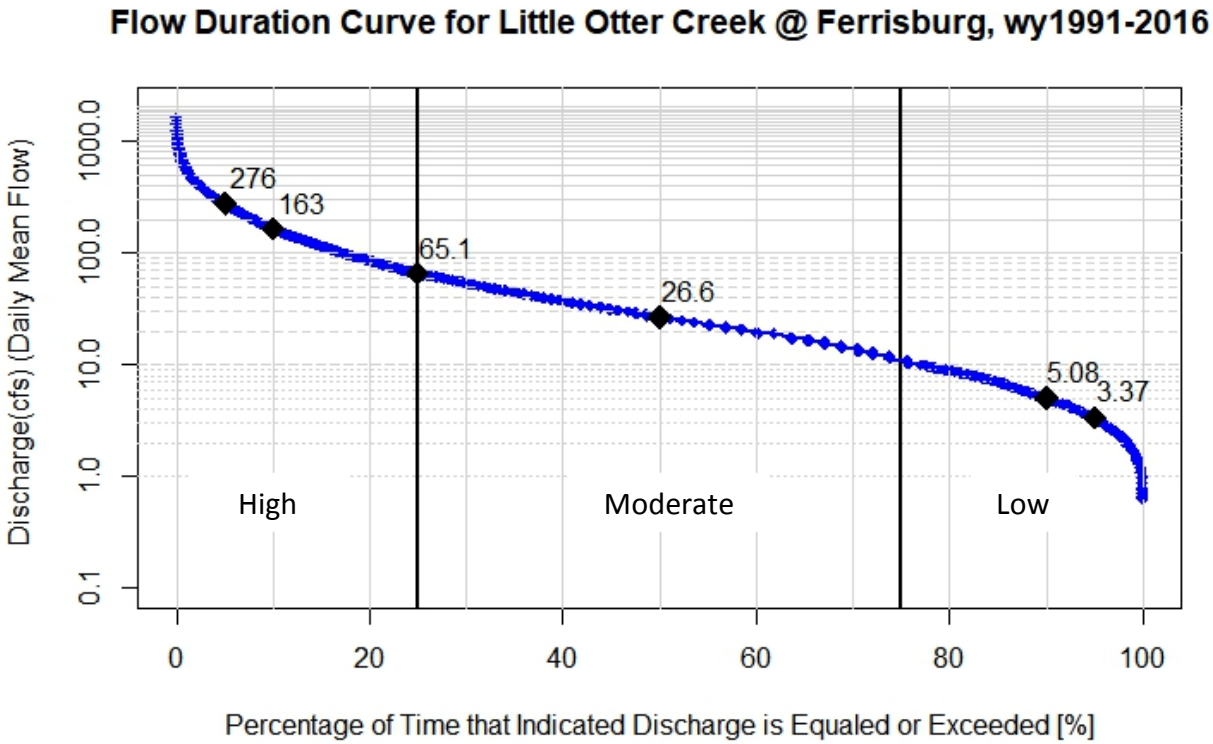

USGS 04282525 NEW HAVEN RIVER @ BROOKSVILLE, NR MIDDLEBURY, VT
Discharge, cubic feet per second
7000
1000
100
30
Q2 = 4,550 cfs
LMM = 65 cfs
Jan 01 2017
Feb 01 2017
Mar 01 2017
Apr 01 2017
May 01 2017
Jun 01 2017
Jul 01 2017
Aug 01 2017
Sep 01 2017
Oct 01 2017
Nov 01 2017
Dec 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (26 years)
Flow at station affected by ice
Discharge
2-Year Recurrence Interval
Estimated discharge

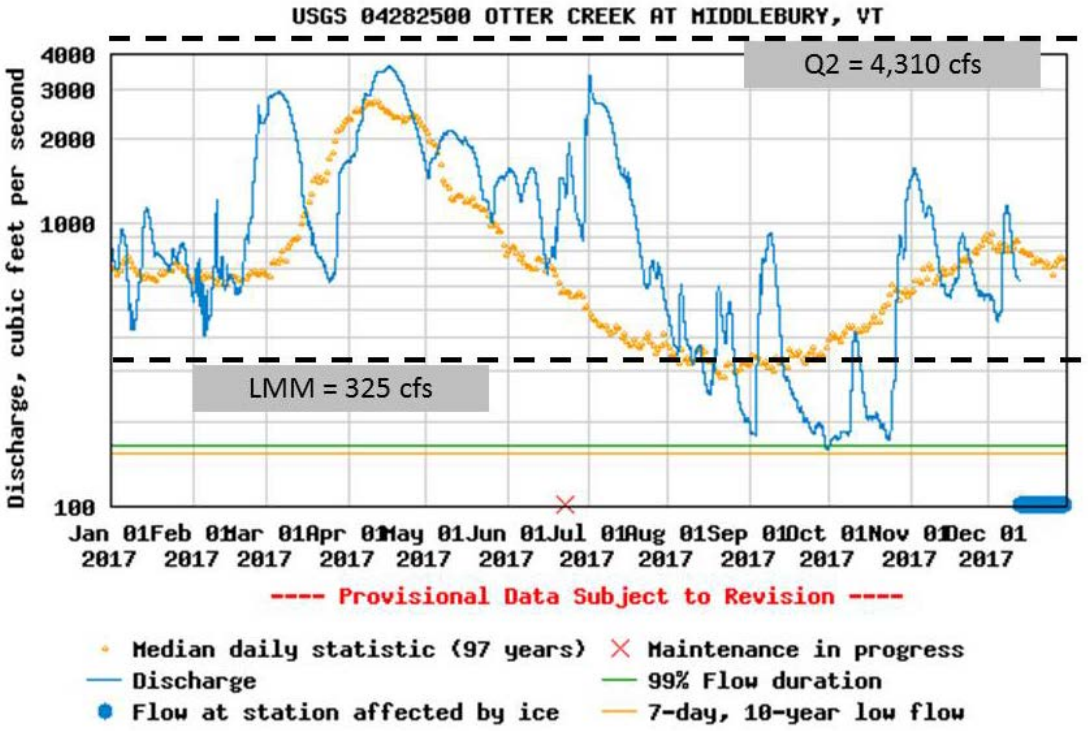

Flow Duration Curve for New Haven River @ Brooksville, wy1991-2016
Discharge(cfs) (Daily Mean Flow)
5000
500
50
10
676
449
243
134
81.2
52.1
38.5
High
Moderate
Low
0
20
40
60
80
100
Percentage of Time that Indicated Discharge is Equaled or Exceeded [%]

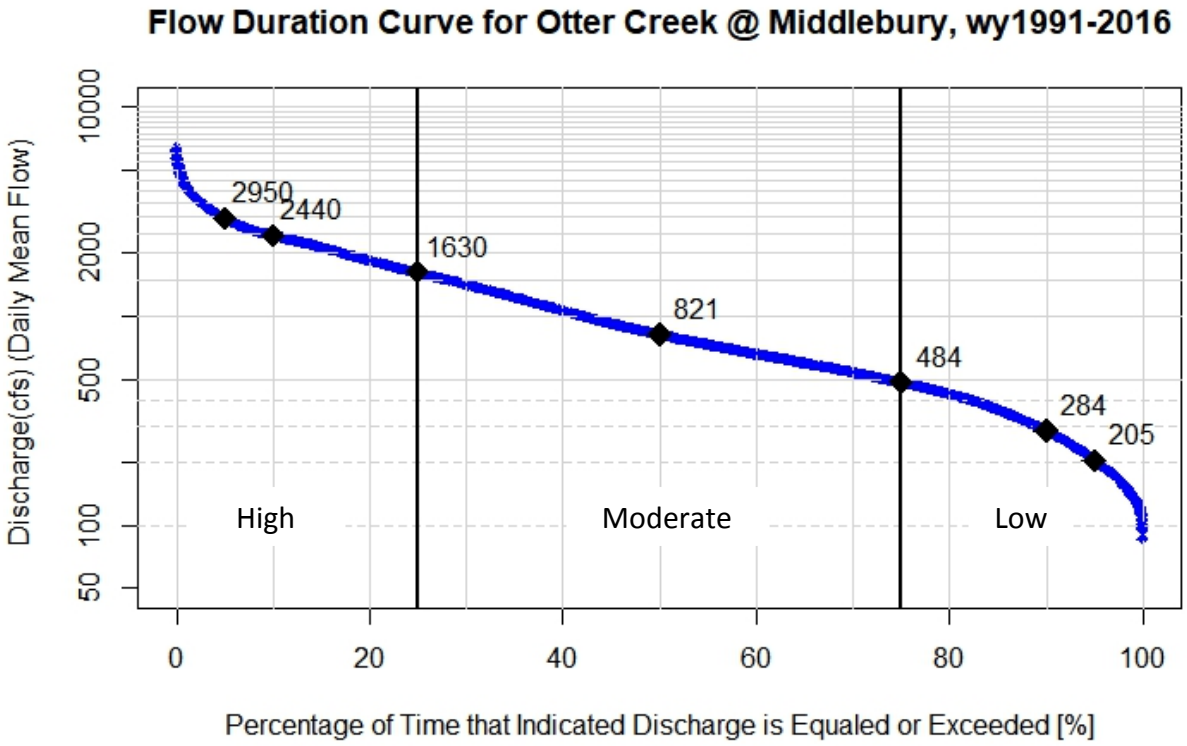

USGS 04282780 LEWIS CREEK AT NORTH FERRISBURG, VT.
Discharge, cubic feet per second
3000
2000
1000
100
10
Q2 = 1,750 cfs
LMM = 21.2 cfs
Jan 01 2017
Feb 01 2017
Mar 01 2017
Apr 01 2017
May 01 2017
Jun 01 2017
Jul 01 2017
Aug 01 2017
Sep 01 2017
Oct 01 2017
Nov 01 2017
Dec 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (26 years)
Estimated discharge
Discharge
Flow at station affected by ice


Flow Duration Curve for Lewis Creek @ N. Ferrisburg, wy1991-2016
Discharge(cfs) (Daily Mean Flow)
1000
200
50
10
5
355
228
120
61.2
32.5
18.1
14.3
High
Moderate
Low
0
20
40
60
80
100
Percentage of Time that Indicated Discharge is Equaled or Exceeded [%]


USGS 04282650 LITTLE OTTER CREEK AT FERRISBURG, VT.
Discharge, cubic feet per second
700.0
100.0
10.0
4.0
Q2 = 890 cfs
LMM = 6.6 cfs
Jan 01 2017
Feb 01 2017
Mar 01 2017
Apr 01 2017
May 01 2017
Jun 01 2017
Jul 01 2017
Aug 01 2017
Sep 01 2017
Oct 01 2017
Nov 01 2017
Dec 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (26 years)
Estimated discharge
Discharge
Flow at station affected by ice


Flow Duration Curve for Little Otter Creek @ Ferrisburg, wy1991-2016
Discharge(cfs) (Daily Mean Flow)
1000.0
100.0
10.0
1.0
0.1
276
163
65.1
26.6
5.08
3.37
High
Moderate
Low
0
20
40
60
80
100
Percentage of Time that Indicated Discharge is Equaled or Exceeded [%]


USGS 04282500 OTTER CREEK AT MIDDLEBURY, VT
Q2 = 4,310 cfs
LMM = 325 cfs
Discharge, cubic feet per second
4000
3000
2000
1000
100
Jan 01 2017
Feb 01 2017
Mar 01 2017
Apr 01 2017
May 01 2017
Jun 01 2017
Jul 01 2017
Aug 01 2017
Sep 01 2017
Oct 01 2017
Nov 01 2017
Dec 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (97 years)
Discharge
Flow at station affected by ice
Maintenance in progress
99% Flow duration
7-day, 10-year low flow


Flow Duration Curve for Otter Creek @ Middlebury, wy1991-2016
Discharge(cfs) (Daily Mean Flow)
10000
2000
500
100
50
2950
2440
1630
821
484
284
205
High
Moderate
Low
0
20
40
60
80
100
Percentage of Time that Indicated Discharge is Equaled or Exceeded [%]

Appendix C

Water Quality Data Tables by Watershed

Abbreviations:

TN = Total Nitrogen
NO2-NO3-Nitrogen = nitrite and nitrate forms of nitrogen (also abbreviated, NOX)
TP = Total Phosphorus
DP = Dissolved Phosphorus
TSS = Total Suspended Sediments

MPN/100 mL = organisms per 100 milliliters
mg/L = milligrams per liter
ug/ L = micrograms per liter
NTU = Nephelometric Turbidity Units

-- = No Data
NS = Not Sampled
NA = Not Analyzed (e.g., insufficient sample volume; vial broken in transit)
NM = Not Measured

JB = estimated value; constituent was present in an associated field blank

JD = estimated value; Relative Percent Difference (RPD) of primary and field duplicate sample values exceeded the QAPP RPD goal for that constituent

Note: QA/QC issues further detailed in separate QA Summary Report

Lemon Fair River

Location	Date	E. Coli. (mpn/100ml)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
LFR6.7	4/5/2017		118	58.8	24.8	94.5
LFR12	4/5/2017		183	70	103	195.8
LFR6.7	5/3/2017		116	42.8	47.7	67
LFR12	5/3/2017		98.9	34.8	45.3	54.6
LFR6.7	6/7/2017	1732.9	157	50	71	107.4
LFR12	6/7/2017	> 2419.6	212	78	87.9	137.4
LFR6.7	7/5/2017	613.1	398	234	41.1	68.6
LFR12	7/5/2017	248.9	232	119	32.1	59.7
LFR6.7	8/2/2017	163.1	231	71.8	120	161.6
LFR12	8/2/2017	214.2	205	83.1	102.5	144.8
LFR6.7	9/6/2017	> 2419.6	227	84.2	131.3	109.6
LFR12	9/6/2017	> 2419.6	322	162	106	108

VT Water Quality Standards (effective January 2017):

- **Turbidity** (warm water Class B) = **25 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.

Lewis Creek

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
LCR3.7	4/5/2017			277.5			91.6
LCR3.7	5/3/2017			53.2			12.4
LCR3.7	6/7/2017	1299.7		150			56.1
LCR3.7	7/5/2017	101.7		76.1			22.3
LCR3.7	8/2/2017	35.0		22.1			4.72
LCR3.7	9/6/2017	> 2419.6		188.4			77.2
LCR14	4/5/2017		0.49	193	16.3		46.1
LCR14	5/3/2017		0.39	36.1	10.1		9.3
LCR14	6/7/2017	365.4	0.29	41.7	8.2		11.5
LCR14	7/5/2017	117.8	0.54	31.6	12		6.3
LCR14	8/2/2017	179.3	0.73	13.1	8.0		2.7
LCR14	9/6/2017	1203.3	0.5	59.4	14.4		13.3
LCR14	9/27/2017	325.5		17			4.1
LCR14	10/3/2017	142.1		12.2			2.1
LCR14	10/25/2017	488.4		19.7			3.7
LCR14.3	4/5/2017		0.5	177	15.9		49.6
LCR14.3	5/3/2017		0.42	37.5	10.6		8.4
LCR14.3	6/7/2017	344.8	0.3	55.5	9.9		15.7
LCR14.3	7/5/2017	209.8	0.53	32.7	12.3		8.4
LCR14.3	8/2/2017	186	0.78	16.4	8.1		3.7
LCR14.3	9/6/2017	1732.9	0.47	55.8	16.1		13.1
LCR14.3	9/27/2017	344.8		14.6			2.4
LCR14.3	10/3/2017	209.8		14.9			3.9
LCR14.3	10/25/2017	648.8		22.9			2.6
LCR15	4/5/2017		0.44	177	12.7		38.5
LCR15	5/3/2017		0.38	23.8	8.7		7.2
LCR15	6/7/2017	325.5	0.27	56.7	6.6		12.5
LCR15	7/5/2017	108.6	0.56	30.8	11.4		7.6
LCR15	8/2/2017	365.4	0.81	13.5	7.3		1.8
LCR15	9/6/2017	1299.7	0.46	53.7	12.3		10.2
LCR15	9/27/2017	307.6		13.7			2.4
LCR15	10/3/2017	135.4		11.4			1.9
LCR15	10/25/2017	387.3		12.9			1.9

Lewis Creek (continued)

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
LCR16	4/5/2017		0.41	141	13.5		23.6
LCR16	5/3/2017		0.39	21.2	8.8		5.2
LCR16	6/7/2017	121.1	0.24	53.9	5.2		9.7
LCR16	7/5/2017	40.4	0.55	35.6	11.1		7.0
LCR16	8/2/2017	141.4	0.8	11.1	8.3		0.9
LCR16	9/6/2017	770.1	0.45	40.6	9.5		7.2
LCR16	9/27/2017	104.6		17.5			5.6
LCR16	10/3/2017	52.0		13.4			2.2
LCR16	10/25/2017	82.3		11.9			1.3
LCHLW0.1	4/5/2017		0.45	41.1	9.86		13.6
LCHLW0.1	5/3/2017		0.38	13.1	7.01		1.22
LCHLW0.1	6/7/2017	248.1	0.28	20.5	< 5		4.24
LCHLW0.1	7/5/2017	62.4	0.49	13.8	9.62		1.63
LCHLW0.1	8/2/2017	67.0	0.65	8.1	5.65		0.78
LCHLW0.1	9/6/2017	648.8	0.48	25.6	14		7.49
LCHLW0.1	9/27/2017	123.4		11.3			1.39
LCHLW0.1	10/3/2017	32.8		10.4			2.01
LCHLW0.1	10/25/2017	61.3		11.7			2.21
LCHLW1.0	4/5/2017		0.37	32	8.5		9.9
LCHLW1.0	5/3/2017		0.36	10	7.2		0.9
LCHLW1.0	6/7/2017	118.7	0.24	17.1	< 5		3.5
LCHLW1.0	7/5/2017	34.5	0.51	11.8	10.2		1.2
LCHLW1.0	8/2/2017	13.5	0.73	5.5	5.8		0.3
LCHLW1.0	9/6/2017	579.4	0.5	19	10.1		3.5
LCHLW1.0	9/27/2017	37.4		7.6			0.2
LCHLW1.0	10/3/2017	38.9		5.7			0.2
LCHLW1.0	10/25/2017	58.3		6.6			0.4

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.
- **Nitrogen** as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. Total nitrogen includes organic and inorganic forms of nitrogen. A test of NO3-NO2 inorganic forms of nitrogen is required to evaluate water quality relative to the VWQS.

Little Otter Creek

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	NO2-NO3 Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
LOC4.3	4/5/2017		1.41		124	62.9	44	82.5
LOC4.3	5/3/2017		0.89		94.3	48.1	30	40.5
LOC4.3	6/7/2017	1732.9	1.05		210	108	59.2	83.4
LOC4.3	7/5/2017	79.8	0.78		222	133	35	43.7
LOC4.3	8/2/2017	106.7	0.58		102.9	55.2	27	50.2
LOC4.3	9/6/2017	> 2419.6	1.19		294	141	118.3	130.4
LOC7.8	4/5/2017		1.17		104	46.7	36.4	63
LOC7.8	5/3/2017		0.79		90.1	47.8	25.3	34.7
LOC7.8	6/7/2017	2419.6	0.84		135	53.5	38.6	63.5
LOC7.8	7/5/2017	79.8	0.72		183	111	39.4	44
LOC7.8	8/2/2017	95.9	0.52		89.1	37.3	42.6	64.3
LOC7.8	9/6/2017	> 2419.6	1.24		291	153	96	112
LOC10	4/5/2017		1.07		83.3	47.6	20	37.6
LOC10	5/3/2017		0.76		82.1	50.7	15	18.2
LOC10	6/7/2017	980.4	1.06		120	63	21.3	29.2
LOC10	7/5/2017	86	0.75		170	122	16.6	18.3
LOC10	8/2/2017	157.6	0.69		116.7	58.6	36.3	51.9
LOC10	9/6/2017	1986.3	1.21		232	142	47.5	62.3
LOC14.4	4/5/2017		1.47		81.2	56.4	13.8	19
LOC14.4	5/3/2017		0.69		60.4	41.8	6.8	6.4
LOC14.4	6/7/2017	435.2	0.81		104	57	16.8	14.1
LOC14.4	7/5/2017	41.4	0.57		94	63.1	12.2	13.4
LOC14.4	8/2/2017	48.7	0.64		60.4	42.9	7.3	8.5
LOC14.4	9/6/2017	410.6	0.68		107.1	70.4	21.5	18.4
LOC20.3	4/5/2017		2.53	1.73	96.5	64.5	20.3	17.7
LOC20.3	5/3/2017		2.58	2.1	46.4	33.5	6.8	4.7
LOC20.3	6/7/2017	186	2.21	1.83	96.9	62	12.3	8.8
LOC20.3	7/5/2017	866.4	2.98	2.8	72.1	39.2	13.5	9.1
LOC20.3	8/2/2017	248.1	3.83	4.13	50.9	37.5	6	4.0
LOC20.3	9/6/2017	517.2	2.41	1.98	87.5	67.3	8	5.9

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.
- **Nitrogen** as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. Total nitrogen includes organic and inorganic forms of nitrogen. A test of NO3-NO2 inorganic forms of nitrogen is required to evaluate water quality relative to the VWQS.

Little Otter Creek (continued)

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	NO2-NO3 Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
LOC21.5	4/5/2017		3.94	3.15	113	68.7	10.4	14.3
LOC21.5	5/3/2017		4.28	3.97	46.8	27.2	1.4	1.1
LOC21.5	6/7/2017	186	3.83	4.19	74.3	55.8	3.6	3.4
LOC21.5	7/5/2017	96.0	4.94	4.92	66	59.3	< 1	1.8
LOC21.5	8/2/2017	81.3	5.83	5.85	47.2	45.6	< 1	0.8
LOC21.5	9/6/2017	461.1	3.87	3.2	106	91.5	4.9	3.3
MDC1.2	4/5/2017		1.99		130	79.4	18.4	59.3
MDC1.2	5/3/2017		0.84		134	104	11.2	14.3
MDC1.2	6/7/2017	2419.6	2.29		404	327.2	12.8	24.5
MDC1.2	7/5/2017	80.1	1.04		440	354	7.4	7.1
MDC1.2	8/2/2017	686.7	1.03		157	123	< 1	9.1
MDC1.2	9/6/2017	2419.6	1.69		223.5	158	20	26.6
LOCNB0.2	4/5/2017		0.28		27.8	15.2	6.9	12.8
LOCNB0.2	5/3/2017		0.19		22.7	11	4.6	5.8
LOCNB0.2	6/7/2017	206.4	0.24		26.3	10.2	4.2	4.8
LOCNB0.2	7/5/2017	82.0	0.17		33.2	17.5	9.6	7.9
LOCNB0.2	8/2/2017	238.2	0.26		38.4	15	24.1	18.7
LOCNB0.2	9/6/2017	866.4	0.29		42.8	15.7	21.5	16.6

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.
- **Nitrogen** as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. Total nitrogen includes organic and inorganic forms of nitrogen. A test of NO3-NO2 inorganic forms of nitrogen is required to evaluate water quality relative to the VWQS.

Middlebury River

Location	Date	E. Coli. (mpn/100ml)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
MIR1.5	4/5/2017		81.9			42.1
MIR1.5	5/3/2017		37.7			6.1
MIR1.5	6/7/2017	488.4	45.9			7.1
MIR1.5	7/5/2017	63.7	43.8			13.7
MIR1.5	8/2/2017	101.7	20.2			3.8
MIR1.5	9/6/2017	1553.1	133			19.6
MIR5.7	4/5/2017		19.6			3.3
MIR5.7	5/3/2017		14.2			1.5
MIR5.7	6/7/2017	18.7	13.8			1.4
MIR5.7	7/5/2017	24.1	11.5			1.3
MIR5.7	8/2/2017	6.3	7.3			0.2
MIR5.7	9/6/2017	156.5	14.6			1.9
MIR10.6	4/5/2017		16.8			1.8
MIR10.6	5/3/2017		13.3			0.6
MIR10.6	6/7/2017	21.8	13.1			1.2
MIR10.6	7/5/2017	7.5	10.7			0.8
MIR10.6	8/2/2017	14.8	9.6			0.3
MIR10.6	9/6/2017	37.3	13			0.4

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.

New Haven River

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	NO2-NO3 Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
NHR0.5	4/5/2017				60.1			32.2
NHR0.5	5/3/2017				21.9			4.5
NHR0.5	6/7/2017	866.4			40.4			11.9
NHR0.5	7/5/2017	63.1			20.3			4.6
NHR0.5	8/2/2017	121.1			11.9			2.3
NHR0.5	9/6/2017	1986.3			60.4			15.8
NHR2	4/5/2017				58.7			30
NHR2	5/3/2017				26.4			6.1
NHR2	6/7/2017	456.9			41.8			10.6
NHR2	7/5/2017	35.0			20.5			5.7
NHR2	8/2/2017	151.5			18.4			4.7
NHR2	9/6/2017	1732.9			74.5			18.5
NHR5	4/5/2017					10.5		11.5
NHR5	5/3/2017				16.2			2.2
NHR5	6/7/2017	172.3			20.7			3.5
NHR5	7/5/2017	23.1			12.8			2.0
NHR5	8/2/2017	48.7			5.71			0.8
NHR5	9/6/2017	461.1			23.9			5.8
NHR6	4/5/2017				**NS**			**NS**
NHR6	5/3/2017				12.9			1.3
NHR6	6/7/2017	67.7			15.3			2.5
NHR6	7/5/2017	22.1			10.5			0.9
NHR6	8/2/2017	77.1			6.87			0.6
NHR6	9/6/2017	218.7			18.2			3.0
NHR9	4/5/2017				20.6			4.6
NHR9	5/3/2017				12.7			1.1
NHR9	6/7/2017	49.5			14.9			3.3
NHR9	7/5/2017	25.3			9.6			0.7
NHR9	8/2/2017	24.3			5.67			0.5
NHR9	9/6/2017	139.1			14.3			2.2
NHR11.5	4/5/2017				17.4			3.2
NHR11.5	5/3/2017				12.6			1.1
NHR11.5	6/7/2017	27.5			10.9			1.0
NHR11.5	7/5/2017	35.5			8.27			0.6
NHR11.5	8/2/2017	32.7			5.31			0.5
NHR11.5	9/6/2017	201.4			15.1			1.8

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**.
  In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.

New Haven River (continued)

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	NO2-NO3 Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
NHR13	4/5/2017				18.7			2.9
NHR13	5/3/2017				10.3			1.0
NHR13	6/7/2017	123.6			11.8			1.3
NHR13	7/5/2017	19.5			9.2			1.0
NHR13	8/2/2017	37.9			< 5			0.9
NHR13	9/6/2017	160.7			12.7			1.8
NHR15	4/5/2017				15.3			2.5
NHR15	5/3/2017				10.7			1.0
NHR15	6/7/2017	21.6			10.6			3.3
NHR15	7/5/2017	35.9			8.5			0.9
NHR15	8/2/2017	9.7			< 5			0.3
NHR15	9/6/2017	**NA**			12.5			1.1
NHM0.4	4/5/2017		0.9	0.4	130	36.5	84.5	94.3
NHM0.4	5/3/2017		0.67	0.18	74.3	30.3	19.8	20.6
NHM0.4	6/7/2017	> 2419.6	1.11	0.31	164	60.1	45.7	52.0
NHM0.4	7/5/2017	88.2	0.38	0.1	74.8	36.6	22.2	25.2
NHM0.4	8/2/2017	980.4	0.38	0.12	43.5	21.3	16.4	20.5
NHM0.4	9/6/2017	> 2419.6	1.1	0.11	168.5	109	57.0	56.8
NHM1.4	4/5/2017		0.92	0.43	114	37.1	74.0	73.0
NHM1.4	5/3/2017		0.6	0.15	72.2	30.3	17.7	17.3
NHM1.4	6/7/2017	> 2419.6	1.07	0.34	155	64.7	39.4	46.0
NHM1.4	7/5/2017	129.6	0.37	0.1	67.8	38.1	16.4	21.4
NHM1.4	8/2/2017	435.2	0.35	0.13	37.3	20.7	10.4	11.6
NHM1.4	9/6/2017	> 2419.6	1.07	0.21	154	92.4	53.0	49.1
NHM3.6	4/5/2017		0.92	0.46	88.2	34.4	46.0	47.6
NHM3.6	5/3/2017		0.56	0.12	62.1	27.9	10.6	11.2
NHM3.6	6/7/2017	1413.6	0.92	0.31	121	61.4	18.2	27.7
NHM3.6	7/5/2017	70.3	0.38	0.11	61.1	35.9	14.0	16.1
NHM3.6	8/2/2017	93.3	0.41	0.21	42.9	22.1	11.7	15.1
NHM3.6	9/6/2017	> 2419.6	1.08	0.25	146.1	107	23	24.9

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.
- **Nitrogen** as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. Total nitrogen includes organic and inorganic forms of nitrogen. A test of NO3-NO2 inorganic forms of nitrogen is required to evaluate water quality relative to the VWQS.

New Haven River (continued)

Location	Date	E. Coli. (mpn/100ml)	Total Nitrogen (mg/L)	NO2-NO3 Nitrogen (mg/L)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
NHM5.2	4/5/2017		0.93	0.47	70.7	34.9	26	31.9
NHM5.2	5/3/2017		0.58	0.16	67.4	33.6	7.4	8.2
NHM5.2	6/7/2017	686.7	0.92	0.29	113	62.7	15.8	19.4
NHM5.2	7/5/2017	115.3	0.37	0.12	60	36.3	10.4	10.8
NHM5.2	8/2/2017	142.1	0.47	0.27	37.7	21	10.2	11.5
NHM5.2	9/6/2017	> 2419.6	1.29	0.35	177	131	20	19.4
NHWB0.2	4/5/2017		1.03	0.87	448	43	536	178.2
NHWB0.2	5/3/2017		2.96	2.92	48	18.4	14.8	14.3
NHWB0.2	6/7/2017	> 2419.6	2.29	1.48	148	67.6	22.6	29.8
NHWB0.2	7/5/2017	193.5	5.9	5.55	61.4	29.5	16.4	18.4
NHWB0.2	8/2/2017	410.6	5.03	4.71	21.9	17.6	< 1	1.2
NHWB0.2	9/6/2017	> 2419.6	2.45	1.84	268	119.0	52.7	62.4
NHWB2.7	4/5/2017		0.36	0.18	166	8.4	118	25
NHWB2.7	5/3/2017		0.27	0.18	14	5.1	2.2	1.3
NHWB2.7	6/7/2017	204.6	0.18	0.08	16.6	< 5	5	3.0
NHWB2.7	7/5/2017	38.8	0.22	0.07	13.6	10.4	3.9	1.7
NHWB2.7	8/2/2017	172.3	0.3	0.2	13.2	9.5	< 1	1.6
NHWB2.7	9/6/2017	235.9	0.38	0.28	30.2	16.3	3.8	4.8

VT Water Quality Standards (effective January 2017):

- **Turbidity** (cold water Class B) = **10 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.
- **Nitrogen** as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. Total nitrogen includes organic and inorganic forms of nitrogen. A test of NO3-NO2 inorganic forms of nitrogen is required to evaluate water quality relative to the VWQS.

Otter Creek (Lower)

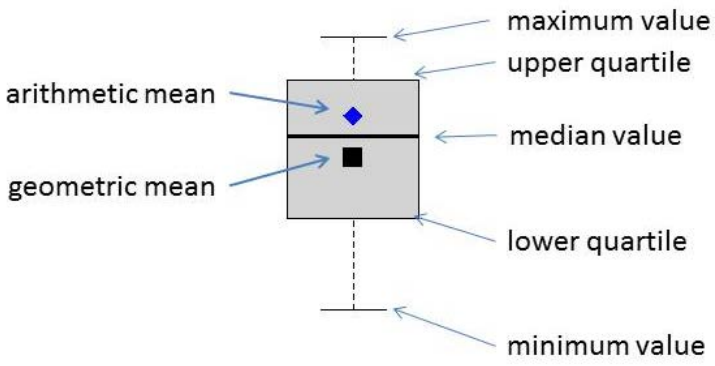
Location	Date	E. Coli. (mpn/100ml)	Total Phosphorus (ug/L)	Dissolved Phosphorus (ug/L)	Total Suspended Solids (mg/L)	Turbidity (NTU)
OTR7.3	4/5/2017		79			43
OTR7.3	5/3/2017		49			11.8
OTR7.3	6/7/2017	547.5	48.9			9.4
OTR7.3	7/5/2017	133.3	140			46
OTR7.3	8/2/2017	42.8	34.8			8.3
OTR7.3	9/6/2017	770.1	57.3			14.7
OTR18	4/5/2017		77.7			32.4
OTR18	5/3/2017		35			6.1
OTR18	6/7/2017	410.6	40.8			8.0
OTR18	7/5/2017	101.7	85.5			23.3
OTR18	8/2/2017	16.9	27.4			3.5
OTR18	9/6/2017	1119.9	55.9			11.8

VT Water Quality Standards (effective January 2017):

- **Turbidity** (warm water Class B) = **25 NTUs** as an annual average under dry weather base-flow conditions.
- **E. coli** (Class B): Not to exceed a geometric mean of 126 organisms /100ml obtained over a representative period of 60 days, and no more than 10% of samples above **235 organisms/100 ml**. In waters receiving combined sewer overflows, the representative period shall be 30 days.
- **Phosphorus** (Class B, Warm-water Medium Gradient): Not to exceed **27 ug/L** at low median monthly flow during June through October in a section of the stream representative of well-mixed flow.

Attachments

1 Lemon Fair River – 2017 Water Quality Summary
2 Lewis Creek – 2017 Water Quality Summary
3 Little Otter Creek – 2017 Water Quality Summary
4 Middlebury River – 2017 Water Quality Summary
5 New Haven River – 2017 Water Quality Summary
6 Otter Creek (Lower) – 2017 Water Quality Summary



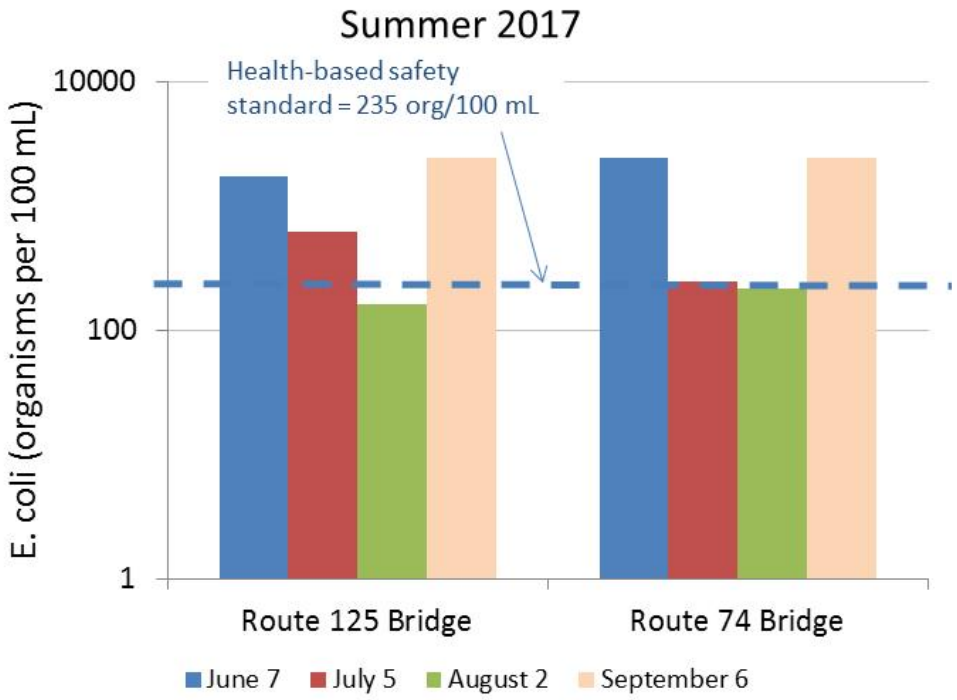
Lemon Fair River - 2017 Water Quality Summary
Addison County River Watch Collaborative

Site	Location	Town
LFR6.7	Route 125 bridge.	Cornwall
LFR12	Downstream of Route 74 bridge	Shoreham

The Addison County River Watch Collaborative has been monitoring water quality in the Lemon Fair River since 2003. For years 2014 through 2017, the number of sampling locations in this watershed has been reduced to two sentinel stations monitored for long-term trends: LFR6.7 and LFR12.

During 2017, sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April through July and September sampling events took place during high flows, either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records for a similar, nearby river (Little Otter Creek). The August event occurred during low flows, representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event).

Samples from the Lemon Fair watershed were tested for *E.coli*, phosphorus (total and dissolved), total suspended solids, and turbidity; *E.coli* was tested only on the summer dates.



E.coli counts at the two Lemon Fair sentinel sites ranged from 163 to >2,420 organisms/100 mL. Vermont Water Quality Criteria (VWMD, 2016) state that *E.coli* is not to exceed a geometric mean of 126 organisms /100mL obtained over a representative period of 60 days, and no more than 10% of

samples should be above 235 organisms/100 mL. *E.coli* counts exceeded the state's health-based standard of 235 organisms/ 100 mL at both sites in June, July and September. The geometric mean of summer sampling results was 805 org/100mL at LFR6.7 and 747 org/100mL at LFR12; both values exceeded the state's geomean standard of 126 organisms/ 100 mL. Detected *E.coli* counts were largely consistent with historic monitoring results which indicate chronic exceedances of the water quality standard at these two sites.

Turbidity levels at the Lemon Fair stations ranged from 55 to 196 NTUs. The Vermont state standard of 25 NTUs (for Class B warm-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to only the August 2 event. Detected concentrations were above the standard at both sites on this date: 162 NTUs (at LFR6.7) and 145 NTUs (at LFR12).

Phosphorus was detected at moderate to high levels during the six spring and summer sampling dates of 2017. Concentrations ranged from 99 to 398 µg/L. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow during June through October. Flows in the Lemon Fair were at low levels during the August 2 sample date. Based on gaging records for nearby rivers of similar character (Little Otter Creek and Otter Creek), flows in Lemon Fair were likely near the low median monthly flow on this date. The reported Total Phosphorus results for August 2 exceeded the instream phosphorus criterion at each sentinel station: 231 and 205 µg/L at LFR6.7 and LFR12, respectively. It is possible that the Lemon Fair River would instead be classified as a Slow-Winder stream ecotype (not yet determined for the reaches sampled); there is no instream phosphorus criterion yet established for the Slow-Winder ecotype. Dissolved phosphorus (DP) was also tested at each site; DP as a percentage of Total Phosphorus ranged from 31 to 59% during the six sample dates.

2018: A more intensive monitoring focus rotates back to the Lemon Fair for a two-year period beginning in the year 2018. The Addison County River Watch Collaborative will monitor for *E.coli*, phosphorus (total and dissolved), total nitrogen, and turbidity at 13 main stem and tributary sites, and total suspended solids on 7 main stem sites in 2018. New bracket monitoring stations will be established on the Beaver Branch, Bascom Brook and Perry Brook tributaries to further define sources of elevated nutrients and sediment detected along the main stem between established stations at Shacksboro Rd in Shoreham and Route 125 in Cornwall.

For more information, contact the Lemon Fair sampling coordinator:
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Addison County River Watch Collaborative managing director:
Matt Witten, 434-3236, mwitten@gmavt.net
or visit our web page at: www.acrpc.org/acrwc

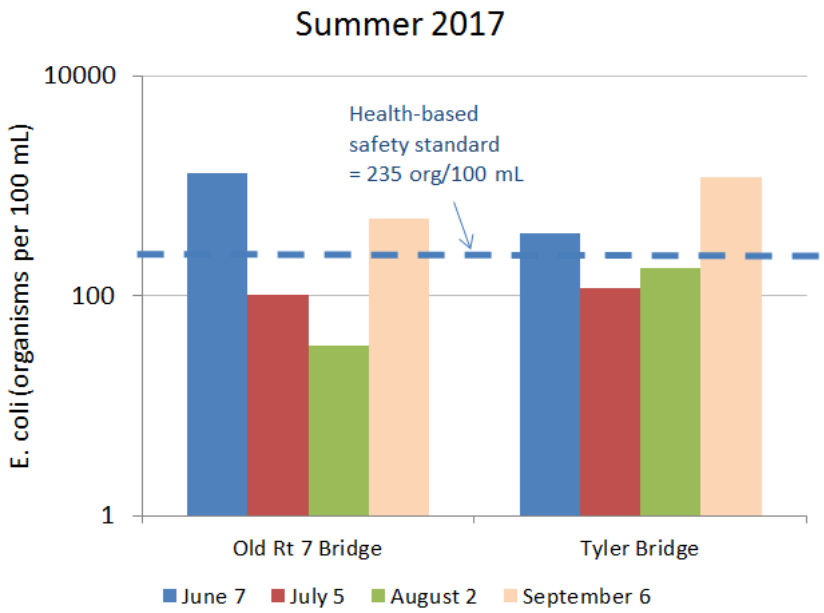
Lewis Creek - 2017 Water Quality Summary
Addison County River Watch Collaborative

Site	Location	Town
LCR3.7	Old Route 7 Bridge	Ferrisburgh
LCR14	Tyler Bridge	Monkton

The Addison County River Watch Collaborative has been monitoring water quality in the Lewis Creek since 1992. For years 2014 through 2017, the number of sampling locations in this watershed has been reduced to two sentinel stations monitored for long-term trends: LCR3.7 and LCR14. This brief watershed summary provides results of sentinel monitoring. A special monitoring project was also conducted in the Lewis Creek watershed in 2017 to bracket known or suspected source regions of bacterial contamination upstream of the Tyler Bridge Road crossing, in support of a Total Maximum Daily Load for Bacteria-impaired waters.[3] Results of this special project are provided under separate cover.

During 2017, sentinel sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April through July and September sampling events took place during high flows, either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records from a USGS streamflow gaging station located on the Lewis Creek at the Route 7 crossing. The August event occurred during moderate flows, representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event).

Samples from the Lewis Creek watershed were tested for *E.coli*, total phosphorus, and turbidity; *E.coli* was tested only on the summer dates.



[3] http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/mp_bacteriatmdl.pdf

E.coli counts in the Lewis Creek at the two sentinel stations ranged from 35 to >2,420 organisms/100 mL. Vermont Water Quality Criteria (VWMD, 2016) state that *E.coli* is not to exceed a geometric mean of 126 organisms /100mL obtained over a representative period of 60 days, and no more than 10% of samples should be above 235 organisms/100 mL. *E.coli* counts exceeded the state's health-based standard of 235 organisms/100 mL on two of the four summer sample dates at each station: Tyler Bridge Rd (LCR14) and the Old Route 7 bridge (LCR3.7). The geometric mean of summer sampling results was 310 org/100mL at LCR14 and 325 org/100mL at LCR3.7; both values exceeded the state's geomean standard of 126 organisms/ 100 mL. Detected *E.coli* counts at this Tyler Bridge station were largely consistent with historic monitoring results which indicate chronic exceedances of the water quality standard for *E.coli.* Station LCR14 is located downstream of a dairy pasture where livestock have direct access to the stream. Beavers are also abundant in segments of the Lewis Creek and Hollow Brook tributary upstream of this station.

Turbidity levels in the Lewis Creek at the sentinel stations ranged from 2.7 to 92 NTUs for the six sample dates. The Vermont state standard of 10 NTUs (for Class B cold-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to only the August event. Detected concentrations were below the standard at both sites on this date: 2.7 NTUs (at LCR14) and 4.7 NTUs (at LCR3.7). Based on past years' sampling results, turbidity can be elevated at times of increased flow – during a summer thunderstorm, or during spring runoff conditions – especially in the lower reaches of the river. An increasing trend in turbidity with distance downstream is generally observed during all flow conditions.

Phosphorus was detected at low to high concentrations during the six Spring and Summer sampling dates, ranging from 13 to 278 µg/L. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow conditions during June through October. Flows in the Lewis Creek during sentinel monitoring were near the low median monthly flow during the August sample date, based on records from the USGS streamflow gage located at the Route 7 crossing. Detected concentrations of phosphorus on this date did not exceed the instream nutrient standard of 27 µg/L at either sentinel station: 13 µg/L (at LCR14) and 22 µg/L (at LCR3.7). Historic results for both sentinel and rotational sites have shown an increasing trend in phosphorus concentration with distance downstream, as well as a tendency for elevated phosphorus concentrations during high flows.

2018: An increased number of parameters and additional monitoring sites will be evaluated when a more intensive monitoring focus rotates back to the Lewis Creek for a two-year period beginning in the year 2018. As part of this focus monitoring, the Collaborative will continue with bracket monitoring at stations in vicinity of the Tyler Bridge Road crossing to gain a better understanding of water quality patterns and potential sources of elevated pathogens, nutrients and sediments in this region.

Water quality data from the previous focus period (2012-2013) are being used by VTDEC biomonitoring teams to evaluate the health of several headwaters reaches. These data will inform ongoing municipal-level discussions and basin-planning efforts regarding water quality management and classification.

For more information, contact the Lewis Creek sampling coordinator:
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Lewis Creek Association Program Coordinator:
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Addison County River Watch Collaborative managing director:
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or visit our web page at: www.acrpc.org/acrwc

Focus watershed:
2016 and 2017

Little Otter Creek – 2016 and 2017 Water Quality Summary

Addison County River Watch Collaborative

Site	Location	Town
LOC4.3	Route 7 Bridge	Ferrisburgh
LOC7.8	Middlebrook Rd (North)	Ferrisburgh
LOC10	Monkton Road	Ferrisburgh
LOC14.4	Plank Rd.	New Haven
LOC20.3	Sawyer Road Bridge	New Haven
LOC21.5	Kilbourn property	Bristol
MDC1.2	Wing Rd./Middlebrook Rd. (South)	Ferrisburgh
LOCNB0.2	Norton Brook	Bristol

The Addison County River Watch Collaborative has been monitoring water quality in the Little Otter Creek since 1997. For the 2016 and 2017 seasons, the Little Otter Creek was the subject of a more intensive monitoring focus, where rotational as well as sentinel stations were monitored and additional parameters were tested to better define spatial variability in pathogen, sediment and nutrient concentrations. Sentinel station LOC4.3 is located within a river segment that is listed as impaired (303D list, Part D) for contact recreation use due to *E.coli* from agricultural runoff (VTDEC, 2016). Sentinel station MDC1.2 is located on Mud Creek tributary within a segment that is considered stressed by *E.coli* from agricultural runoff that may be impacting contact recreation uses of these waters (VTDEC, 2016). Three new water quality monitoring stations were established in the watershed to complement two existing sentinel stations (LOC4.3 and MDC1.2) and three stations monitored during a previous focus effort in 2010 and 2011 (stations LOC7.8, LOC10, and LOC14.4). Station LOC20.3 was established at the Sawyer Road Bridge crossing of the upper Little Otter Creek. A one-mile segment of the river spanning this station is listed as impaired (303D List, Part A) for aquatic life support uses due to nutrients and sediment resulting from agricultural runoff, and for contact recreation uses due to pathogens (303D List, Part D; VTDEC, 2016). An additional station was established at LOC21.5, approximately one mile upstream of this station and west of Burpee Road. A third new station was set up at the Plank Road crossing of Norton Brook a tributary to Little Otter Creek draining The Watershed Center and adjacent agricultural lands in northwest Bristol.

During 2017, sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April through July and September sampling events took place during high flows, with water levels either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records from a USGS streamflow gaging station located on at the Route 7 crossing. The August event occurred during low flows, representative of base-flow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event). Flow conditions in 2017 contrasted with the previous year, in which flows were dominated by low-flow, base-flow conditions during a drier-than-normal year.

Samples were tested for *E.coli*, phosphorus (total and dissolved), nitrogen, total suspended solids, and turbidity; *E.coli* was tested only on the summer dates.

E.coli counts at Little Otter Creek stations ranged from 41 to >2420 organisms/100 mL during 2017. Vermont Water Quality Criteria (October 2016) state that *E.coli* is not to exceed a geometric mean of 126 org/100mL obtained over a representative period of 60 days, and no more than 10% of samples should be above 235 org/100 mL. *E. coli* counts at six of the stations exceeded the state's health-based standard of 235 org/100 mL

on at least one of the four summer sampling dates (Figure 1). The geometric mean of *E.coli* counts for all 2016 and 2017 sample dates exceeded the state's water quality standard of 126 org/ 100 mL at all stations except for the Route 7 Bridge (LOC4.3) and Plank Road crossing (LOC14.4). Geomean concentrations for baseflow versus freshet flow conditions are displayed in Figure 2.

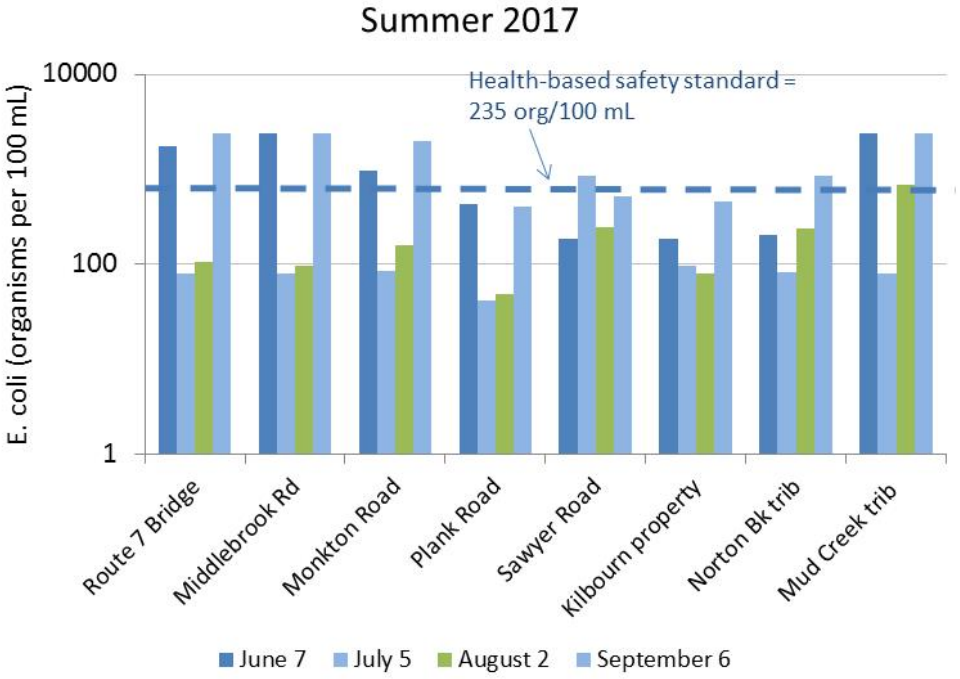


Figure 1. E.coli measured at Little Otter Creek stations on four summer dates in 2017. Blue-shaded dates were freshet flows at high flow stage; green-shaded date was a base-flow event during low flow.

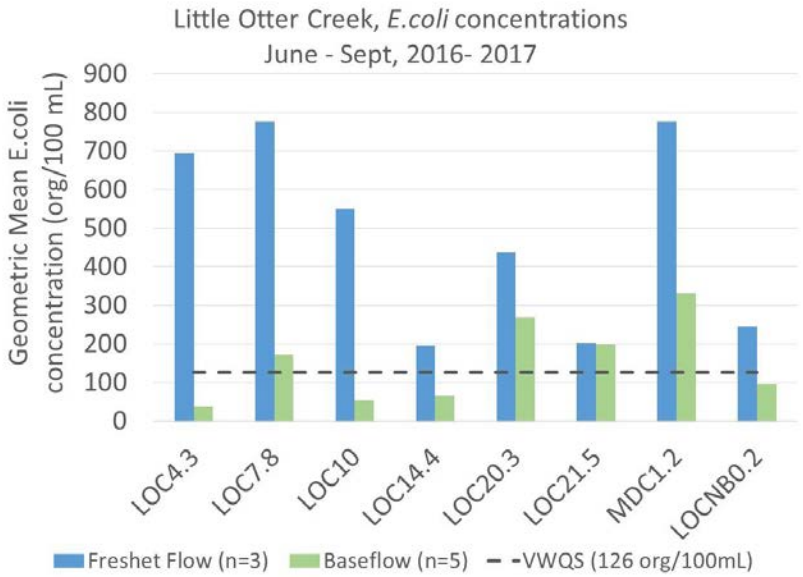


Figure 2. Geometric mean of E.coli monitoring results for Little Otter Creek focus stations during wet-weather, freshet flow events (in blue) versus dry-weather, baseflow events (in green) during focus monitoring years 2016 and 2017.

Turbidity levels reported for the Little Otter Creek stations ranged from 0.8 to 130 NTUs for the six sample dates in 2017. The distribution of Turbidity results for both focus years, 2016 and 2017, is displayed in the box-and-whisker plot below (Figure 3). The Vermont state standard of 10 NTUs (for Class B cold-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to six sample dates over the two years. The mean of baseflow Turbidity concentrations exceeded the water quality standard at all stations except LOC14.4, LOC20.3, and LOC21.5. Turbidity values tend to increase with distance downstream along the main stem, consistent with historic monitoring patterns. Turbidity can also become elevated at times of increased flow – during a Summer thunderstorm, or during Spring runoff conditions. These lower reaches of the Little Otter Creek drain regions underlain by fine-grained silt and clay soils derived from glacial lake deposits, which are easily eroded and transported by a range of flows.

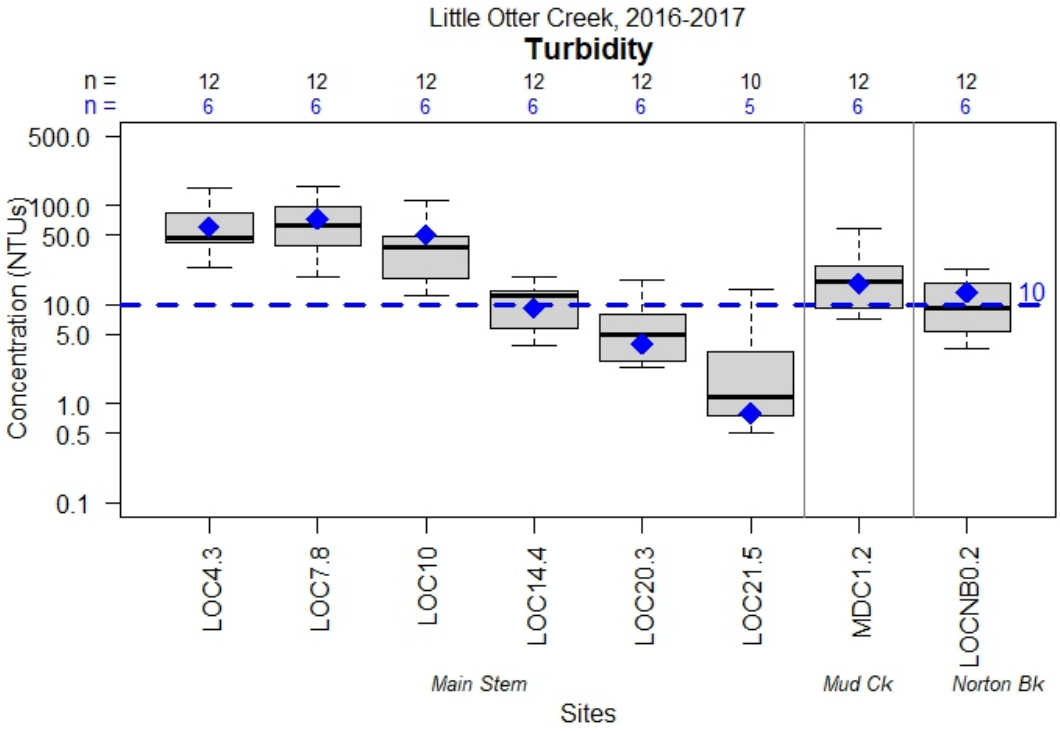


Figure 3. Summary of Turbidity Results for Little Otter Creek, 2016 and 2017. The whiskers extend to the maximum and minimum values detected over twelve sampling events, while the gray-shaded box represents the middle 50% of values. The median value is marked by the dark horizontal line. The blue diamond marks the mean of that subset of samples collected during base-flow conditions, with the corresponding number of samples (n) indicated in blue along the top of the chart.

Nitrogen levels were detected at low to moderate concentrations at most stations during the 2017 spring and summer sampling dates, ranging from 0.2 to 5.8 mg/L. Highest nitrogen concentrations were detected in the two headwaters stations, LOC20.3 and LOC21.5, which have incremental drainage areas characterized by 42% and 65% agricultural land use, respectively. According to Vermont Water Quality Standards, nitrogen as nitrate (NO3) is not to exceed 5.0 mg/L at flows exceeding the low median monthly discharge. In order to evaluate nitrogen levels in the Little Otter Creek with respect to this standard, a more specific lab test was scheduled for these stations in 2017 to detect nitrate and nitrite (NO2) forms of nitrogen, or NO3-NO2 Nitrogen (Figure 4). Based on the separate analysis for NO3-NO2-nitrogen, nitrates make up between 68 and 100% of the total nitrogen detected during these 6 events at these headwater stations. Nitrate-nitrogen detected at LOC21.5 exceeded the VT Water Quality Standard on August 2, during low-flow, base-flow conditions.

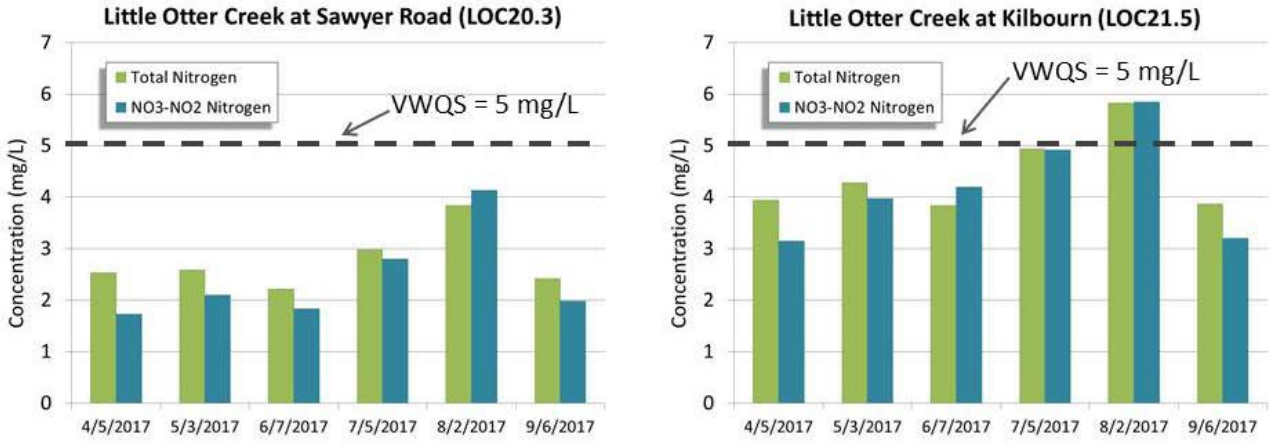


Figure 4. Total Nitrogen and nitrate-Nitrogen Results for stations LOC20.3 and LOC21.5 in 2017.

It should be noted that the NO3-NO2-nitrogen analysis tests for both nitrite and nitrate forms of nitrogen. However, nitrite is relatively rare in waters draining sparsely developed landscapes. Results of this test are therefore interpreted by VT Agricultural & Environmental Lab to represent nitrogen in the form of nitrates (personal communication, Jim Kellogg, VTWMD, 3/17/17).

Phosphorus was detected at low to high concentrations on the Little Otter Creek during the spring and summer sampling dates in 2016 and 2017. Concentrations ranged from 16 to 440 µg/L. Mean TP concentrations are illustrated below for low-flow conditions (Figure 5a) and high-flow conditions (Figure 5b) by color-coding the incremental sub-watershed draining to each station. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow during June through October. Based on gaging records from the Little Otter Creek at Route 7, flows were slightly above the low median monthly flow on the July, August, and September sample dates in 2016. The mean of the phosphorus results available for these three summer sampling dates exceeded the instream nutrient standard of 27 µg/L at all sampled stations (Figure 5a). Exceedances of the instream phosphorus standard will be considered by VTDEC alongside other indicators, including biomonitoring data, to refine impairment status of these waters.

During high-flow, freshet-flow conditions (Figure 5b), these same regions of the watershed yielded higher concentrations of phosphorus, consistent with historic results. Dissolved phosphorus (DP) was also tested at each of the six new sites in 2016 and 2017. As a percentage of Total Phosphorus, DP ranged from 37 to 90% during high-flow conditions and from 20 to 100% during baseflow conditions.

These regions with high concentrations of phosphorus and nitrogen are areas where restoration and mitigation actions should be focused, including nutrient management to reduce phosphorus and nitrogen inputs. Given the prevalence of agricultural uses in those sub-watersheds of the Little Otter Creek which demonstrated elevated concentrations of nitrate-N, and the Bristol village contributions to the uppermost subwatershed, nutrient management planning and other best management practices to reduce N runoff should be prioritized in these headwater areas of the watershed, as well as Mud Creek. Finer-scale bracket-monitoring is warranted in the Mud Creek tributary watershed in future years to identify sources of nutrient runoff. Monitoring of the Slang areas of the watershed downstream of Route 7 is also warranted. These areas have traditionally not been monitored due to backwater effects from Lake Champlain. Nevertheless, there is a potential for nutrient and sediment loading to the lake from agricultural and developed uses which are densely concentrated in this region.

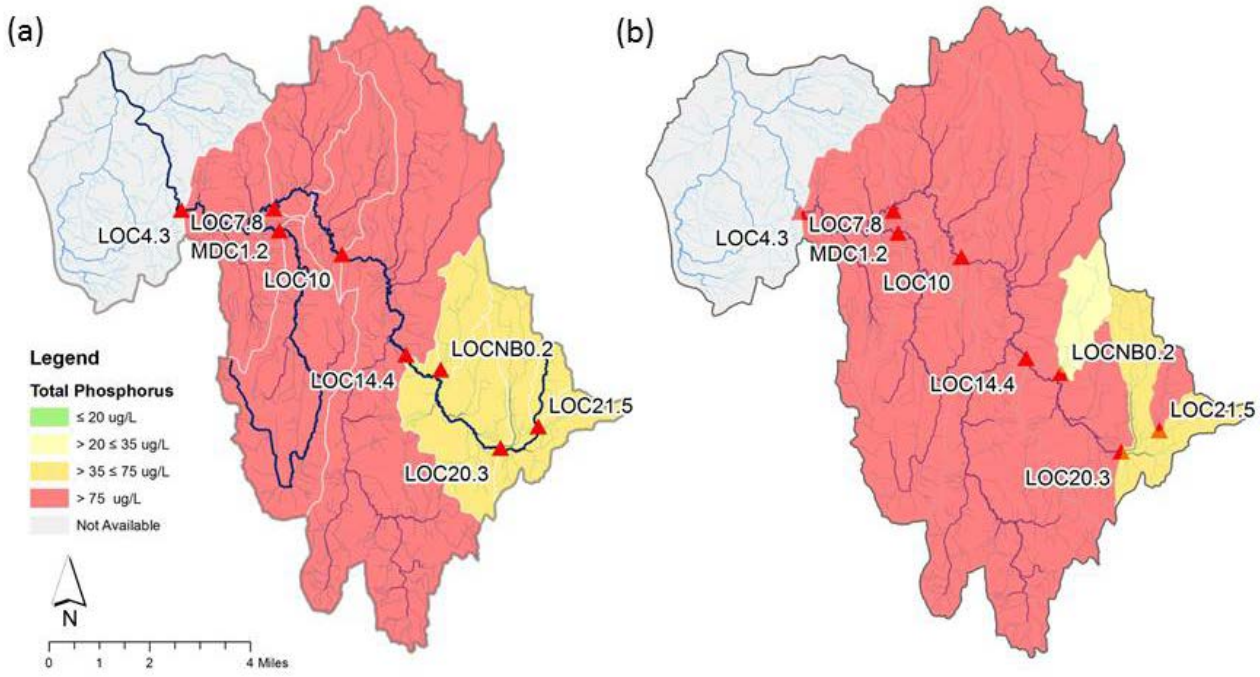


Figure 5. Total Phosphorus monitoring results for Little Otter Creek focus stations during 2016 and 2017, presented as the mean of results for (a) three low-flow baseflow sample dates at or below the Low Median Monthly flow and (b) five high-flow, freshet-flow sample dates.

2018: Beginning in 2018, Little Otter Creek watershed will rotate out of focused monitoring, and sampling will be conducted for a reduced number of parameters at two sentinel stations, LOC4.3 and MDC1.2.

For more information, contact the Little Otter Creek sampling coordinator:
Deb Healey, 475-2944, lumiere@gmavt.net
Addison County River Watch Collaborative managing director:
Matt Witten, 434-3236, mwitten@gmavt.net
or visit our web page at: www.acrpc.org/acrwc

Middlebury River – 2017 Water Quality Summary

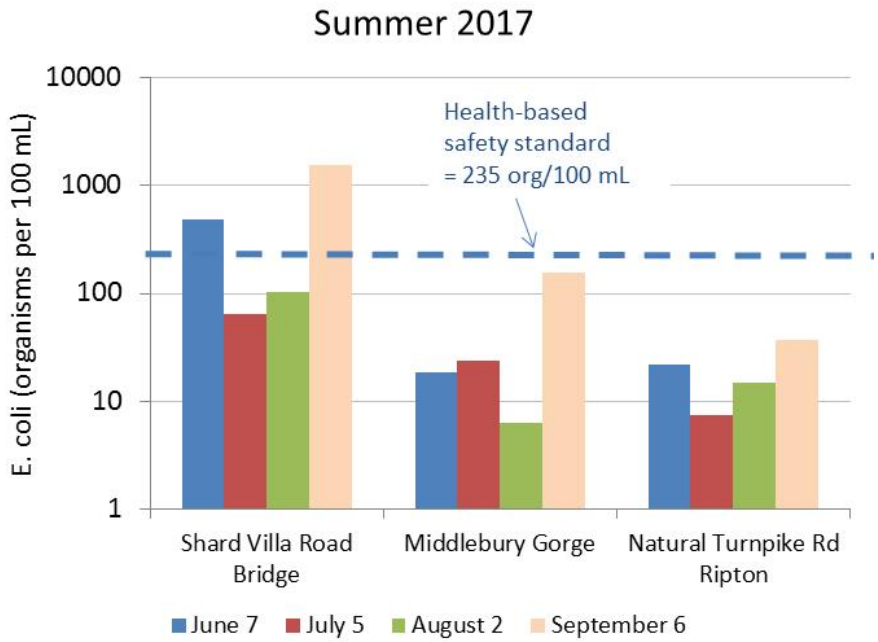
Addison County River Watch Collaborative

Site	Location	Town
MIR1.5	Shard Villa Rd. Bridge	Middlebury
MIR5.7	Midd. Gorge @ Rte 125 Bridge	Middlebury
MIR10.6	Natural Turnpike Road	Ripton

The Addison County River Watch Collaborative has been monitoring water quality in the Middlebury River since 1993. For years 2016 through 2019, the number of sampling locations in this watershed has been reduced to three sentinel stations monitored for long-term trends: MIR1.5, MIR5.7, and MIR10.6.

During 2017, sentinel sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April through July and September sampling events took place during high flows, either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records from the nearby USGS streamflow gage on the New Haven River. The August event occurred during low flows, representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event).

Samples were tested for *E.coli*, total phosphorus, and turbidity; *E.coli* was tested only on the summer dates.



E.coli counts at Middlebury River sites ranged from 6.3 to 1553 organisms/ 100 mL. Vermont Water Quality Criteria (October 2016) state that *E.coli* is not to exceed a geometric mean of 126 organisms /100mL obtained over a representative period of 60 days, and no more than 10% of samples should be above 235 organisms/100 mL. Samples obtained from the Shard Villa Road Bridge site contained *E. coli* in excess of the 235 org/100 mL health-based standard during the June and September events. The geometric mean of

values from this site exceeded the geometric mean standard of 126 org/100 mL. At the popular Middlebury Gorge swimming site (MIR5.7), *E.coli* values were below the health-based standard on all sample dates.

Based on previous years' monitoring results that include additional sites, *E.coli* counts show an increasing trend with distance downstream from the Middlebury Gorge. Developed and agricultural land uses dominate the river corridor in this lower end of the Middlebury River.

Turbidity levels in the Middlebury River during 2017 were relatively low, ranging from 0.2 to 42 NTUs. The Vermont state standard of 10 NTUs (for Class B cold-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to only the August sample date. Detected concentrations were below the standard at all three sentinel sites on this date.

Based on past years' sampling results, turbidity can become elevated at times of increased flow – during a summer thunderstorm, or during spring runoff conditions – especially in the lower reaches of the river below the Route 7 bridge. A slight increasing trend in turbidity with distance downstream is generally observed during all flow conditions. Turbidity can occur as a result of high suspended sediments in the water (during moderate to high flows) and as a result of algae during low-flow conditions.

Phosphorus was detected at relatively low levels during the six spring and summer sampling dates of 2017. Concentrations ranged from 7.3 to 133 µg/L. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow during June through October. Based on gaging records from the nearby New Haven River, flows in the Middlebury River were slightly above the low median monthly flow on the August sample date only. Total phosphorus concentrations were below the instream phosphorus criterion on this date at each site, ranging from 7.3 to 20 ug/L. Past years' sampling results, which include additional sites, show an increasing trend in phosphorus concentrations with distance downstream from the Middlebury Gorge.

2018: The Addison County River Watch Collaborative will continue to monitor for *E.coli*, total phosphorus and turbidity at these three sentinel sites on the Middlebury River in 2018. An increased number of parameters and additional monitoring sites will be evaluated when a more intensive monitoring focus rotates back to the Middlebury River for a two-year period beginning in the year 2020. Look for regular postings of *E.coli* results at new signposts installed at the Middlebury Gorge and at the parking area off Three Mile Bridge Road.

For more information, contact the Middlebury River sampling coordinator:
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Addison County River Watch Collaborative managing director:
Matt Witten, 434-3236, mwitten@gmavt.net
or visit our web page at: www.acrpc.org/acrwc

Focus watershed:
2016 and 2017

New Haven River – 2016 and 2017 Water Quality Summary

Addison County River Watch Collaborative

Site	Location	Town
NHR0.5	Former Dog Team Tavern	New Haven
NHR2	Muddy Branch confluence	New Haven
NHR5	New Haven Mills / Munger St Bridge	New Haven
NHR6	Route 116 Bridge, Sycamore Park	Bristol
NHR9	South St. Bridge	Bristol
NHR11.5	Bartlett's Falls Pool	Bristol
NHR13	York Hill Rd Bridge	Lincoln
NHR15	S. Lincoln Bridge (Gap Rd.)	Lincoln
NHM0.4	Just above confluence at Nash Farm	New Haven
NHM1.4	Halpin Covered Bridge Rd	New Haven
NHM3.6	Painter Road crossing	Middlebury
NHM5.2	Munger Road crossing	Middlebury
NHWB0.2	Cove Road crossing	Bristol
NHWB2.7	Rt 116 below Elephant Mtn Campground	Bristol

The Addison County River Watch Collaborative has been monitoring water quality in the New Haven River since 1993. For the 2016 and 2017 seasons, the New Haven River was the subject of a more intensive monitoring focus, where rotational as well as sentinel stations were monitored and additional parameters were tested to better define spatial variability in pathogen, sediment and nutrient concentrations. New Haven River is listed as a stressed water, with *E.coli* and sediment impacting contact recreation and aquatic habitat uses (VTDEC, 2016).

Monitoring was resumed at four historic water quality stations on the main stem to complement sentinel stations NHR2 and NHR9 and established swimming hole sites NHR6 and NHR11.5. In addition, six new bracket monitoring stations were established on two tributaries of the lower main stem to better define the degree and extent of water quality conditions on these waters. Four new stations were established at road crossings on the Muddy Branch which drains the northeastern third of the town of Middlebury and joins the New Haven River at the former Nash Bridge. Two new stations were set up on the West Brook tributary which drains north along VT Route 116 and joins the New Haven River nearly one mile downstream of Sycamore Park.

During 2017, sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April through July and September sampling events took place during high flows, either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records from a USGS streamflow gaging station located on the New Haven River at Brooksville. The August event occurred during low flows, representative of base-flow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event). Flow conditions in 2017 contrasted with the previous year, in which flows were dominated by low-flow, base-flow conditions during a drier-than-normal year.

Samples were tested for *E.coli*, phosphorus (total and dissolved), nitrogen, total suspended solids, and turbidity; *E. coli* was tested only on the summer dates.

E.coli counts at sites in the New Haven River watershed ranged from 9.7 to >2420 organisms/100 mL in 2017 (Figure 1). Vermont Department of Health guidance identifies a health-based standard for *E.coli* of 235 organisms/100 mL. *E. coli* counts at popular recreational sites (Figure 1) were below this health-based standard on all summer dates except for the September 6 sample from New Haven Mills, and the June 7 and September 6 dates at popular angling sites, Nash Bridge and Dog Team Tavern.

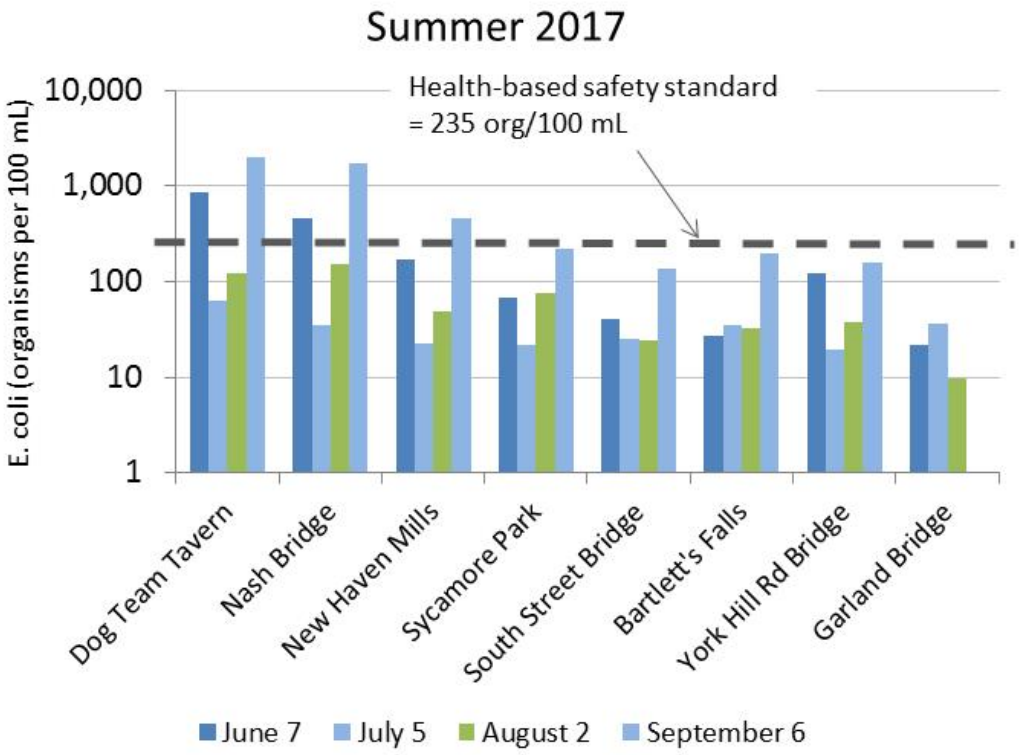

Figure 1. E.coli measured at recreation sites along the New Haven River main stem on four summer dates in 2017. Blue-shaded dates were freshet flows at high flow stage; the green-shaded date was a base-flow event during low flow.

The box-and-whisker chart in Figure 2 summarizes *E. coli* concentrations detected at all stations on summer sampling dates during both focus years. Vermont Water Quality Criteria (October 2016) state that *E.coli* is not to exceed a geometric mean of 126 organisms /100mL obtained over a representative period of 60 days, and no more than 10% of samples should be above 235 organisms/100 mL. Consistent with historic results, an increasing trend in *E.coli* levels is evident with distance downstream along the main stem from station NHR11.5 (Bartlett's Falls) to NHR2 (Nash Bridge). Developed and agricultural land uses are more prevalent in the lower New Haven River watershed. Newly-monitored West Brook joins the main stem nearly one mile downstream of Sycamore Park, between stations NHR6 and NHR5. Muddy Branch joins the main stem at the Nash Bridge just above station NHR2. *E.coli* counts in these tributary stations were elevated above the health-based standard on one or more summer sampling dates, except for the uppermost station on West Brook at the VT Route 116 crossing just downstream of Elephant Mountain campground. The geometric mean of concentrations for all four Muddy Branch stations and the downstream-most West Brook station were also elevated above the 126 org/100mL geomean standard. The incremental drainage areas of these tributary stations are dominated by agricultural (24 to 58%) and developed (1 to 13%) land uses, while the uppermost site on West Brook (NHWB2.7) has a drainage area that is 96% forested.

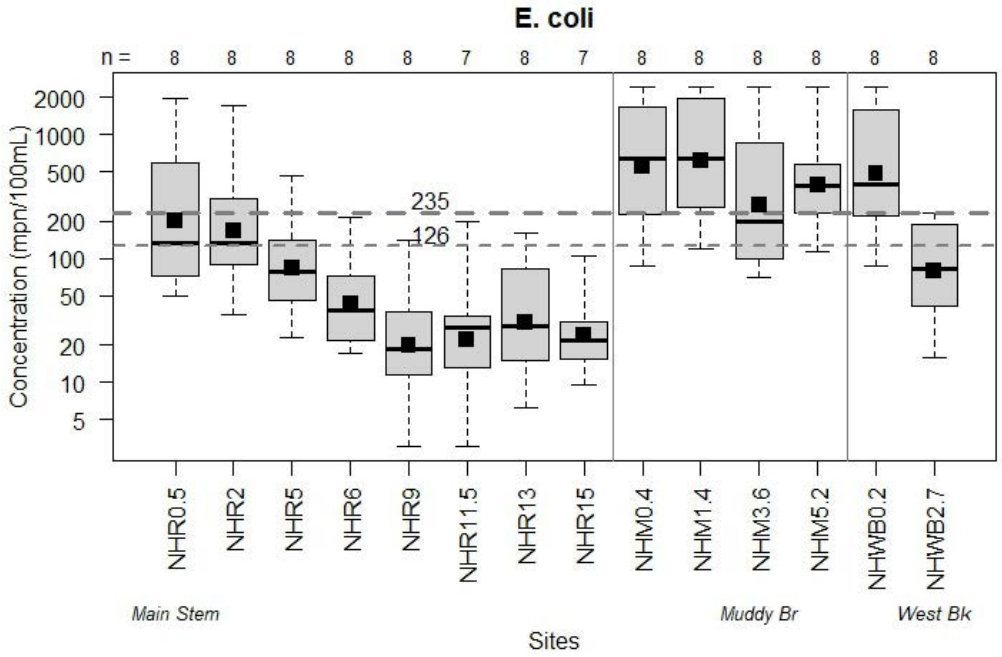

Figure 2. E.coli measured at New Haven River and tributary stations on five dry-weather, low-flow dates and three wet-weather, high-flow dates between June and September in 2016 and 2017. The number of samples (n) represented by each box-and-whisker is displayed across the top of the chart. The whiskers extend to the maximum and minimum values, while the gray-shaded box represents the middle 50% of values. The median value is marked by the dark horizontal line. The geometric mean of all available samples for each station is displayed as the black square symbol. The horizontal, gray dashed lines represent the health-based (235) and geomean (126) standards for E.coli.

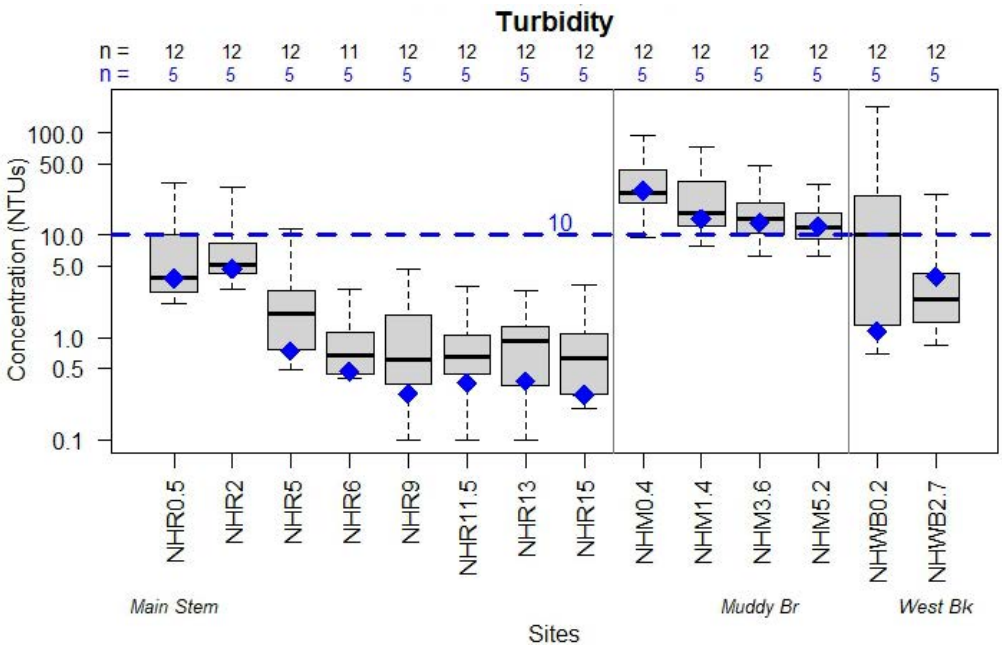

Figure 3. Summary of Turbidity results measured at New Haven River and tributary stations on five dry-weather, low-flow dates and seven medium-to-high-flow dates in 2016 and 2017. The arithmetic mean of the five low-flow/ baseflow samples for each station is displayed as the blue diamond symbol. The horizontal, blue dashed line represents the Turbidity standard for Class B cold-water streams.

Turbidity levels at the New Haven River watershed sites ranged from <0.2 to 178 NTUs for the twelve sample dates in 2016 and 2017. The Vermont state standard of 10 NTUs (for Class B cold-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to five of the sample dates over the 2016-2017 seasons. The blue diamond for each box and whisker in Figure 3 marks the mean of that subset of samples collected during baseflow conditions, with the corresponding number of samples (n) indicated in blue along the top of the chart. Mean Turbidity concentrations were below the standard at all main stem sites in 2016-2017, and the mean of results was below this standard for each of the new stations on West Brook. On the other hand, the Turbidity standard was exceeded by the mean of low-flow sample results for all four of the Muddy Branch stations. Based on past years' monitoring results, turbidity can become elevated at times of increased flow – during a summer thunderstorm, or during spring runoff conditions – especially in the lower reaches of the river below the Bristol Flats. A slight increasing trend in turbidity with distance downstream is generally observed during all flow conditions. These lower reaches of the watershed are dominated by fine-grained soils derived from a glacial lake that previously filled the Champlain Valley. Also, developed and agricultural uses are more prevalent in this lower portion of the watershed. A separate study recently completed by ACRWC found a strong, and statistically-significant, positive correlation between mean Turbidity concentrations and both the percentage of these fine-grained glacial lake soils and the percentage of agricultural land use in the catchments draining to water quality stations in the New Haven River and Little Otter Creek watersheds (ACRWC & SMRC, 2016).

Nitrogen was tested in samples collected only from the new stations established in West Brook and Muddy Branch, and was detected at low to moderate concentrations at these stations during the twelve spring and summer sampling dates in 2016 and 2017, ranging from 0.2 to 5.9 mg/L. Highest nitrogen concentrations were detected at the downstream station on West Brook, which has an incremental drainage area characterized by 58% agricultural land use. According to Vermont Water Quality Standards, nitrogen as nitrate (NO3) should not exceed 5.0 mg/L at flows exceeding the low median monthly discharge. In order to evaluate nitrogen levels in the New Haven River with respect to this standard, a more specific lab test was scheduled for these six tributary stations in 2017 to detect nitrate and nitrite (NO2) forms of nitrogen, or NO3-NO2 Nitrogen. Based on the separate analysis for NO3-NO2-nitrogen, nitrates make up on average 56% of the total nitrogen (TN) detected during these six events in the West Brook station at Route 116, and 85% of the TN detected during these 6 events in the West Brook station at Cove Road (Figure 4). Nitrogen as nitrate exceeded the water quality standard on the July 5 event at Cove Road.

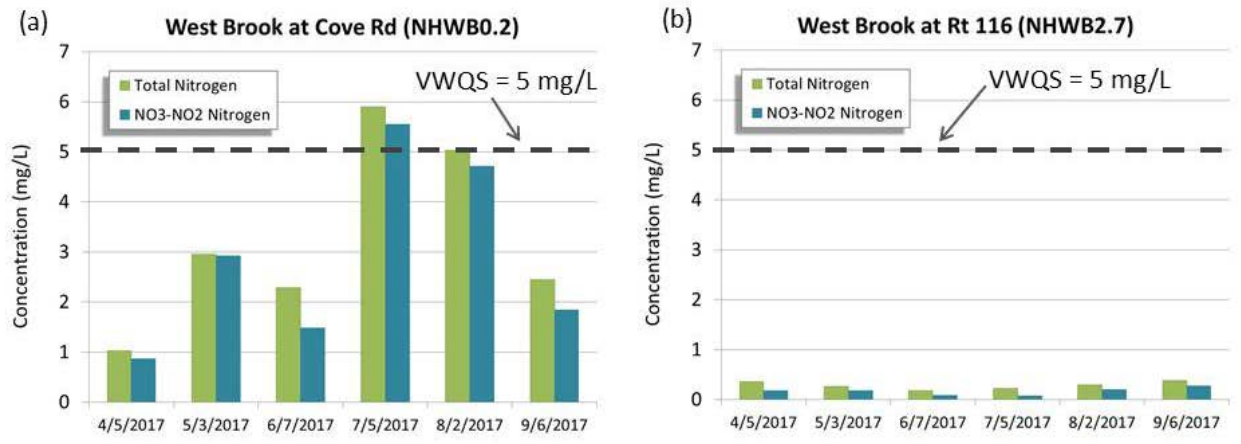

Figure 4. Nitrogen monitoring results for West Brook tributary of the New Haven River focus stations during 2017 including TN and NO3-N02 by sample date for: (a) station NHWB0.2 and (b) NHWB2.7, relative to the Vermont Water Quality Standard of 5 mg/L for nitrogen as nitrate.

In the Muddy Branch, TN concentrations were much lower, ranging from 0.4 to 1.3 mg/L in 2017. NO3-NO2 forms represented between 28 to 38% of the TN, on average, for each Muddy Branch station. It should be noted that the NO3-NO2-nitrogen analysis tests for both nitrite and nitrate forms of nitrogen. However, nitrite is relatively rare in waters draining sparsely developed landscapes. Results of this test are therefore interpreted by VT Agricultural & Environmental Lab to represent nitrogen in the form of nitrates (personal communication, Jim Kellogg, VTWMD, 3/17/17).

Phosphorus was detected at low to high concentrations on the New Haven River during the spring and summer sampling dates in 2016 and 2017. Concentrations ranged from < 5 to 448 µg/L. Mean TP concentrations are illustrated below for low-flow conditions (Figure 5a) and high-flow conditions (Figure 5b) by color-coding the incremental sub-watershed draining to each station. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow during June through October. Based on gaging records from the New Haven River at Brooksville, flows were below the low median monthly flow on the July, August, and September sample dates in 2016. The mean of the results available for these three summer sampling dates exceeded the standard at all four stations on the Muddy Branch (Figure 5a). Exceedances of the instream phosphorus standard will be considered by VTDEC alongside other indicators, including biomonitoring data, to determine if these waters should be listed as impaired.

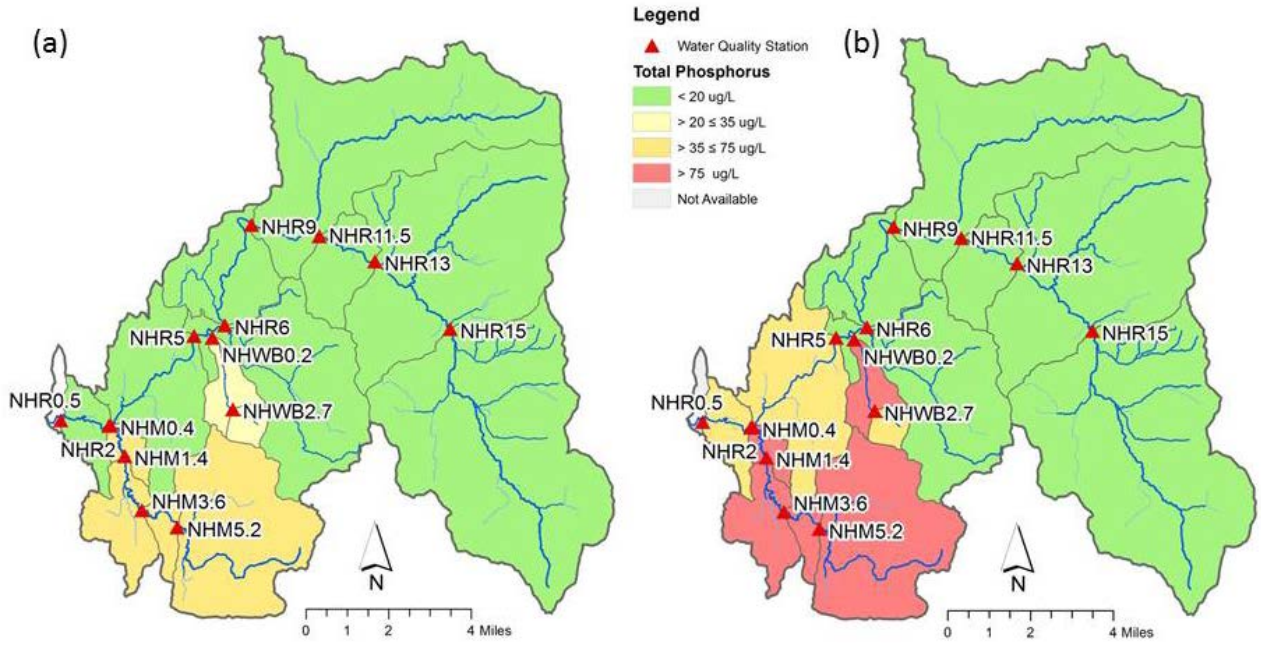

Figure 5. Total Phosphorus monitoring results for New Haven River focus stations during 2016 and 2017, presented as the mean of results for (a) three low-flow baseflow sample dates at or below the Low Median Monthly flow and (b) five high-flow, freshet-flow sample dates.

During high-flow, freshet-flow conditions these same regions of the watershed yielded higher concentrations of phosphorus, consistent with historic results. Dissolved phosphorus (DP) was also tested at each of the six new sites in 2016 and 2017. As a percentage of Total Phosphorus, DP ranged from 5 to 77% during high-flow conditions and from 31 to 100% during baseflow conditions. Under both low- and high-flow conditions, the Muddy Branch (NHM sites) and West Brook (NHWB sites) tributaries are disproportionate loaders of TP to the New Haven River. Agricultural and developed land uses are more concentrated in this southwestern part of the watershed, as compared to the headwaters. Each of these tributaries is also underlain by fine-grained silt and clay soils derived from glacial lake deposits, which have

an affinity for phosphorus and which are easily eroded and transported by a range of flows. These are areas where restoration and mitigation actions should be focused, including nutrient management to reduce phosphorus and nitrogen inputs.

2018: Beginning in 2018, New Haven River watershed will rotate out of focused monitoring, and sampling will be conducted for a reduced number of parameters at two sentinel stations, NHR2 and NHR9, and two swimming hole sites, NHR11.5 and NHR6.

For more information, contact the New Haven River sampling coordinator:
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or visit our web page at: www.acrpc.org/acrwc

Otter Creek – 2017 Water Quality Summary

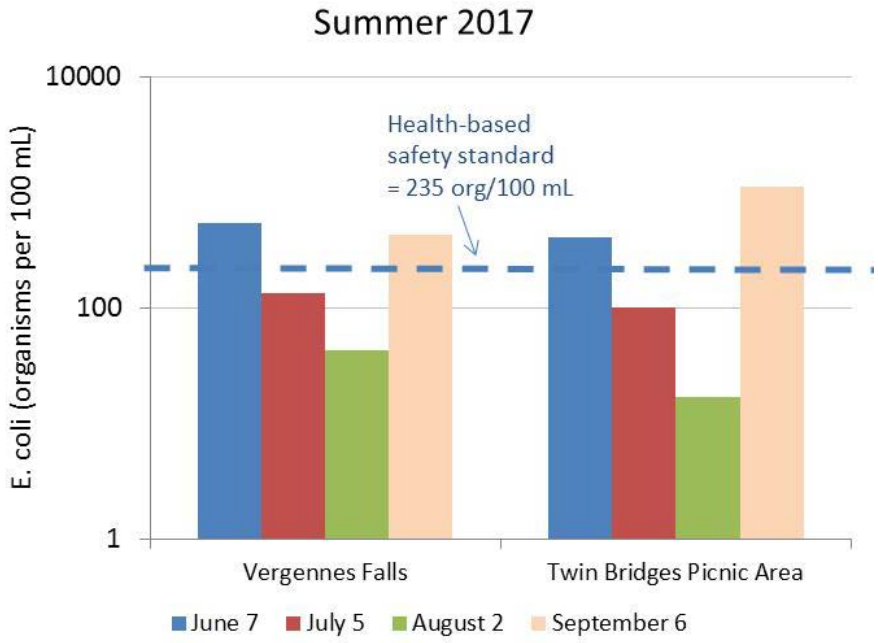
Addison County River Watch Collaborative

Site	Location	Town
OTR18	Twin Bridges Picnic Area	Weybridge
OTR7.3	Vergennes Falls/below outfall	Vergennes

The Addison County River Watch Collaborative has been monitoring water quality in the lower Otter Creek since 1992. For years 2016 through 2019, the number of sampling locations in this watershed has been reduced to two sentinel stations monitored for long-term trends: OTR18 and OTR7.3.

During 2017, sampling occurred on two spring dates (April 5 and May 3) and four summer dates (June 7, July 5, August 2, and September 6). The year was characterized by a wetter-than-normal spring and early summer, followed by a drier-than-normal fall. April, May and July sampling events took place during high flows, either actively rising or declining from recent rainfall and runoff, based on streamflow gaging records from the Otter Creek at Middlebury. The June and September events occurred during moderate-flow conditions, as river stage was rising in response to recent storms. The August sampling date occurred during low flows, with stage slowly declining from recent rainfalls. None of the scheduled sampling events happened to capture baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall event).

Samples were tested for *E.coli*, total phosphorus, and turbidity; *E.coli* was tested only on the summer dates.



E.coli counts at sites on the lower Otter Creek ranged from 17 to 1120 organisms/100 mL. Vermont Water Quality Criteria (October 2016) state that *E.coli* is not to exceed a geometric mean of 126 organisms /100mL obtained over a representative period of 60 days, and no more than 10% of samples should be above 235 organisms/100 mL. *E.coli* concentrations exceeded the health-based standard of 235 org/100mL on the

June and September sampling dates at both sentinel stations. The geometric mean of summer sampling results was 222 org/100mL at OTR7.3 and 168 org/100mL at OTR18; both values exceeded the state's geomean standard of 126 organisms/ 100 mL. Otter Creek receives runoff from the Lemon Fair River between stations OTR18 and OTR7.3. *E.coli* concentrations in the Lemon Fair were elevated relative to concentrations in the Otter Creek on the same sample dates. Periodic sewage overflows from Combined Sewer Overflow stations in Rutland may have contributed to elevated *E.coli* levels in the Otter Creek detected on summer sampling dates (https://anrweb.vt.gov/DEC/WWInventory/SewageOverflows.aspx).

Turbidity levels at the Otter Creek stations ranged from 3.5 to 46 NTUs for the six spring and summer sample dates. The Vermont state standard of 25 NTUs (for Class B warm-water fisheries) is applicable during baseflow conditions which were not captured during the six sample dates. Based on past years' sampling results, turbidity can become elevated at times of increased flow – during a summer thunderstorm, or during spring runoff conditions.

Phosphorus levels at Otter Creek stations ranged from 27 to 140 µg/L. The instream phosphorus criterion of 27 µg/L for warm-water medium gradient (WWMG) wadeable stream ecotypes in Class B waters is applicable at low median monthly flow during June through October. Based on gaging records from the Otter Creek at Middlebury, flows were above the low median monthly flow on all six sample dates; therefore it would be inappropriate to compare sampling results for high-flow conditions to the instream phosphorus standard. Total phosphorus concentrations were positively correlated to Turbidity levels. Based on past years' monitoring of both dissolved and total phosphorus, the percentage of total phosphorus in the dissolved form decreases as turbidity levels increase during moderate to high flows. This suggests that particulate forms of phosphorus (i.e., sorbed to fine sediments) are predominant during wet-weather, freshet-flow conditions.

It is possible that sewer releases in Rutland and Vergennes contributed to elevated phosphorus concentrations on April 5 at stations OTR18 (78 ug/L) and OTR7.3 (79 ug/L). In the early days of April, permitted Combined Sewage Overflow stations in Rutland discharged to the East Creek and Otter Creek. In Vergennes, the Wastewater Treatment Facility reported to VT Department of Environmental Conservation on April 6 that the "Macdonough drive pump station was hydraulically overloaded as a result of consistent sustained rain. As a result area homes were spared sewage backing up into basements." Rains occurred from April 4 through April 7, spanning the April 5 sampling event.
https://anrweb.vt.gov/DEC/WWInventory/SewageOverflows.aspx).

2018: The Addison County River Watch Collaborative will continue to monitor for *E.coli*, total phosphorus and turbidity at these two sentinel sites on the Otter Creek in 2018. An increased number of parameters and additional monitoring sites will be evaluated when a more intensive monitoring focus rotates back to the Otter Creek for a two-year period beginning in the year 2020.

For more information, the Otter Creek sampling coordinator:
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