Summary Report: 2016 Sampling Results
Addison County River Watch Collaborative

13 March 2017

Prepared by:
Kristen Underwood
South Mountain Research & Consulting and
Addison County River Watch Collaborative

Prepared for:
Jim Kellogg
VTDEC Water Quality Division

Digital copy of this report available for download at:
www.acrpc.org/acrwc

TABLE OF CONTENTS

1.0 Introduction

This report provides a summary of the 2016 sampling results for the Addison County River Watch Collaborative (ACRWC). Sampling was carried out by a network of volunteers, with logistical and technical support 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 were provided by the LaRosa Analytical Laboratory in Burlington, VT, through an analytical services partnership grant.

2.0 Background

The ACRWC has been monitoring water quality (including sediment, phosphorus, nitrates, and *E.coli*) in six watersheds in Addison County (Figure 1) 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

Beginning with the 2016 sampling season, 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. Table 2 displays the schedule of sampling sites and parameters for the 2016 season; “R” denotes a rotational site, “S” for a sentinel site. 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.

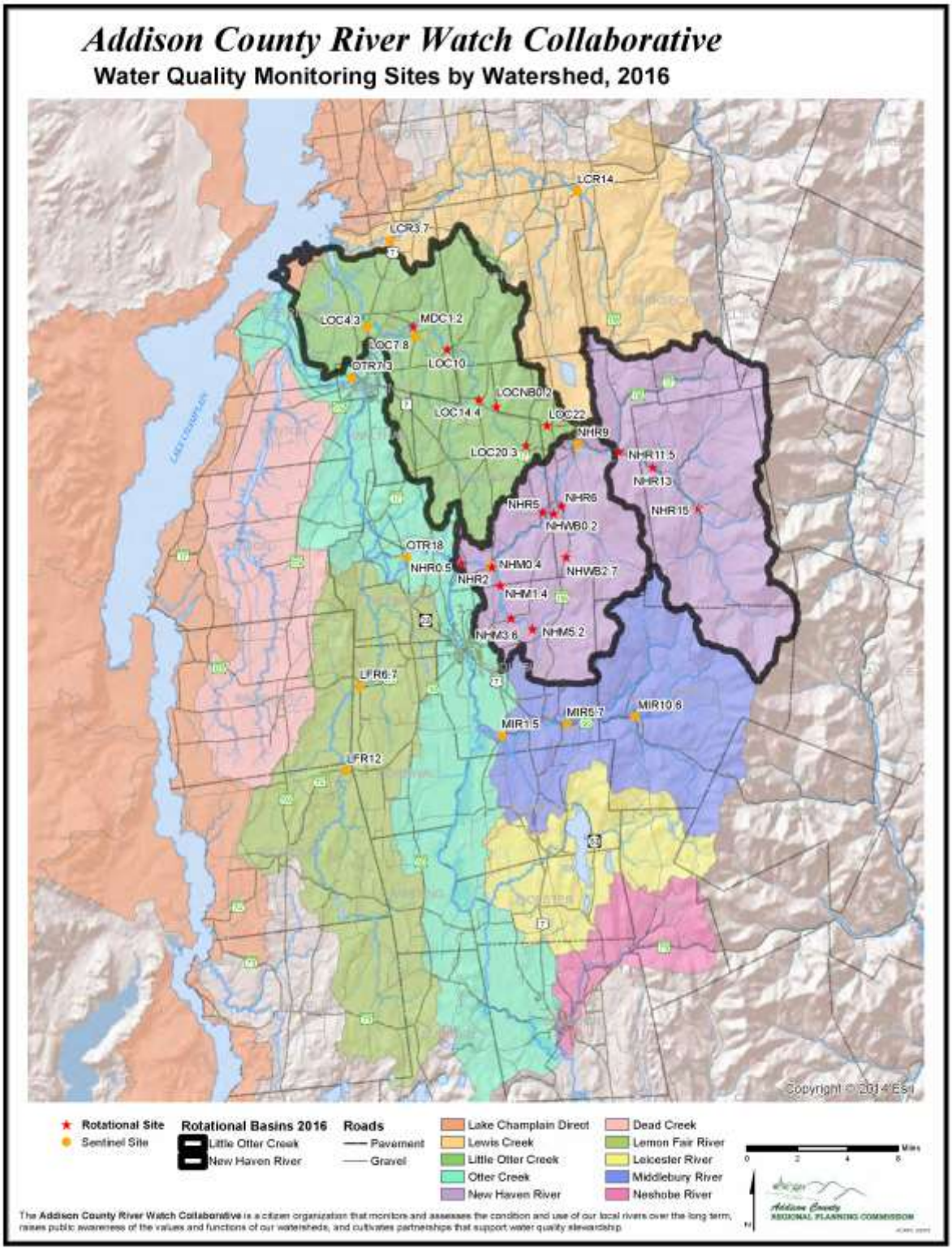


Figure 1. Location of ACRWC monitoring stations for 2016

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 2016 sampling data is provided as Appendix D. Samples were delivered to the LaRosa Analytical Laboratory housed in the Hills Building in the University of Vermont campus in Burlington, Vermont.

During 2016, ACRWC volunteers collected grab samples in these six watersheds at 31 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:

- April 6
- May 4
- June 1
- July 6
- August 3
- September 7

4.0 Precipitation Data

Precipitation data were compiled from existing weather stations in vicinity of the ACRWC watersheds (Table B-1). Overall, calendar year 2016 was a **below-normal precipitation year**, as recorded at regional weather stations in South Burlington (Airport) and Rutland. The region was in a **moderate drought condition** for much of the year (US Drought Monitor, 2017). All sampling months (April – September) saw lower than normal precipitation. Snowfall in the winter of 2015–2016 was far below normal at the Burlington airport and Rutland stations (Table B-2).

5.0 Hydrologic Data

Flow data were compiled from available USGS gaging stations in vicinity of the ACRWC watersheds. Four of the six watersheds sampled by the ACRWC have USGS gaging stations which record instantaneous flow at fifteen minute intervals. Gages on Lewis Creek, Little Otter Creek, and New Haven River are near the downstream end of the main stem. A nearby gage on Otter Creek (at Middlebury) is located mid-basin, recording conditions at 66.5 % of this 944 square mile basin.

Table 2. 2016 Schedule of Sites / Parameters – Spring and Summer

Project Name: Addison County River Watch Collaborative														
Project Number: **137-01**				Spring Schedule (Apr, May)					Summer Schedule (Jun, Jul, Aug, Sep)					
Sample Year: **2016**									**PARAMETERS**					
Type	**River Name**	**Site ID**	**Site Location**	**TP**	**DP**	**TN**	**Turbidity**	**TSS**	***E.coli***	***ALK***	**TP**	**DP**	**TN**	**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	
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
R	Little Otter Creek	LOC21.5	Kilbourn property	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
R	Muddy Branch	NHM1.4	Halpin Covered Bridge Rd	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
R	Muddy Branch	NHM5.2	Munger Road crossing	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
R	West Brook	NHWB2.7	Rt 116 below Elephant Mtn Campground	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 (formerly named S.Lincoln Rd)	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	
			Total # sites per event	31	16	14	31	16	31	0	31	16	14	31	16

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

Flow records are available for the past 26 years at Little Otter Creek, New Haven River, and Lewis Creek gaging stations. Mean annual flows recorded at these stations over that time period are summarized in Table 3, along with data from the Otter Creek at Middlebury station. Data are summarized by water year – which begins October 1st of the previous calendar year and extends through September 30th of the indicated year. Based on 26 years of record, mean annual flows in these ACRWC watersheds for water year 2016 were **below normal.**

Table 3. Mean Annual Flows, 1991 – 2016, ACRWC watersheds.

Watershed	Little Otter Creek		New Haven River		Lewis Creek		Otter Creek at Middlebury	
Drainage Area (sq mi)		73		116		81		944
Gaged Area (sq mi)		57.1		115		77.2		628
Min (1991-2016)	*2002*	27	*1995*	129	*1995*	54	*1995*	672
Max (1991-2016)	*2011*	145	*2011*	378	*2011*	214	*2011*	1912
Mean (1991-2016)		**N/A**		**217**		**N/A**		**N/A**
Water Year 2016		**N/A**		**171**		**N/A**		**N/A**

Source: USGS, 2017, on-line surface water data, <http://waterdata.usgs.gov/vt/nwis>.
Note: As of 2/28/2017, water year 2016 MAF data were unavailable for highlighted watersheds.

Appendix B presents graphs of the instantaneous discharge record (provisional data) from calendar year 2016 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 February, but then trended below normal for the remainder of the year – given the warm temperatures and lower-than-average precipitation.

Peak flows in each watershed for water year 2016 were associated with warming temperatures, rain and snowmelt in late February when New Haven River, Lewis Creek and Little Otter Creek met or exceeded their respective 2-year storm magnitude (Olson, 2014). Flows in these four rivers reached their lowest point for the year in August (LOC, NHR), September (OTT) or October (LEW). Except for isolated storm events, flows in all four rivers were below the Low Median Monthly flow for most of July through October (Table B-3). Flows in the Little Otter Creek dropped below the 7-day 10-year low flow stage (7Q10) in early August, and Otter Creek flows measured at Middlebury persisted below the 7Q10 for multiple days in August, September and October.

Table B-3 presents a summary of flow conditions for each sample date following VTDEC *Guidance on Streamflow Observations at time of Water Quality Sampling of Rivers and Streams*. A flow duration curve is also presented in Appendix B for each gaged watershed based on daily mean flows recorded over 25 years from water years 1991 through 2015. High flow levels are defined as those flow conditions which are equaled or exceeded only 25% of the time. Moderate flows are equaled or exceeded

between 25 and 75% of the time. All six sample dates in all four watersheds occurred during low-flow conditions which are equaled or exceeded more than 75% of the time. On each date, flow conditions exhibited base-flow characteristics (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event).

6.0 Sample Results

Appendix C contains quality-assured sample results for the 2016 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 2016. Therefore, sample results are presented for sentinel as well as rotational sites in these two watersheds.

The Vermont Agency of Natural Resources (VTANR) updated the Vermont Water Quality Criteria, effective October 2014. There is now a revised standard for *E.coli* "for the protection of waters for swimming for consistency with the U.S. Environmental Protection Agency's (EPA) guidance under Section 304(a) of the federal Clean Water Act (CWA)" (VWMD, 2014). A new standard has been approved for phosphorus in wadeable streams "to comply with EPA's National Strategy for the Development of Regional Nutrient Criteria promulgated under Section 304(a) of the CWA" (VWMD, 2014). The turbidity standard was clarified to apply to "an annual average under dry weather base-flow conditions" (VWMD, 2014). Updated water quality standards relevant to each watershed are detailed in the footnotes in Appendix C.

In general, water quality results for 2016 were consistent with historic results and trends summarized in the 2009 Draft Water Quality Reports for each watershed (Hoadley, 2009). Reported concentrations were generally on the low end of historic ranges, likely due to consistent low-flow conditions encountered this year. Expanded information has been gathered for newly-established stations in focus watersheds, New Haven River and Little Otter Creek. 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-five years later, measuring and publicizing *E.coli* data continues to be a principal goal of the Collaborative. Historic data from the Collaborative has informed the *Vermont Statewide TMDL for Bacteria-impaired Waters* (VTDEC, 2011) that addresses impaired segments of the Little Otter Creek, Lewis Creek, Middlebury River, and Otter Creek.

This year, *E.coli* counts in five of the six rivers exceeded the health-based standard of 235 organisms/ 100 mL at one or more stations during one or more summer sampling dates (14 out of 31 stations monitored). Generally, elevated *E.coli* detections were associated with developed land uses including nearby agriculture and livestock with direct access to the river. Wildlife sources of *E.coli* also exist in these rivers, including beaver, deer, and waterfowl. During the dry-weather conditions encountered in 2016, some of the region's popular swimming sites had one or more detections of *E. coli* above the standard during the four dates sampled this past summer (Table 4). 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.

Table 4. Number of E.coli detections above health-based standard at recreation sites and swimming holes in Summer of 2016
(Four sample dates: June 1, July 6, August 3, September 7)

River Name	Site ID	Site Location	Town	# Detections
Lewis Creek	LCR3.7	Old Route 7 Bridge	Ferrisburg	0
	LCR14	Tyler Bridge	Monkton	3
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	1
	NHR2	Muddy Branch confluence (just below)	New Haven	0
	NHR5	Munger Street Bridge	New Haven	0
	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, in part, depending on temporal factors including year-to-year variations in climate, seasonal fluctuations in weather and vegetation, and variations in flow stage. The sentinel stations, typically two or three stations in each watershed, have been established to track long-term annual 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, they are located further upstream on our six rivers to examine long-term trends at this sub-watershed scale. The Collaborative plans to conduct an analysis of long-term trends at select sentinel stations in the coming year, with support from a VTANR LaRosa grant.

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. For example, in the mountainous watersheds of Lewis Creek, Middlebury River, and New Haven River (shaded yellow in Table A-1), 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, shaded light blue in Table A-1), 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).

Focus monitoring was carried out this season 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 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. Monitoring results will be 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.

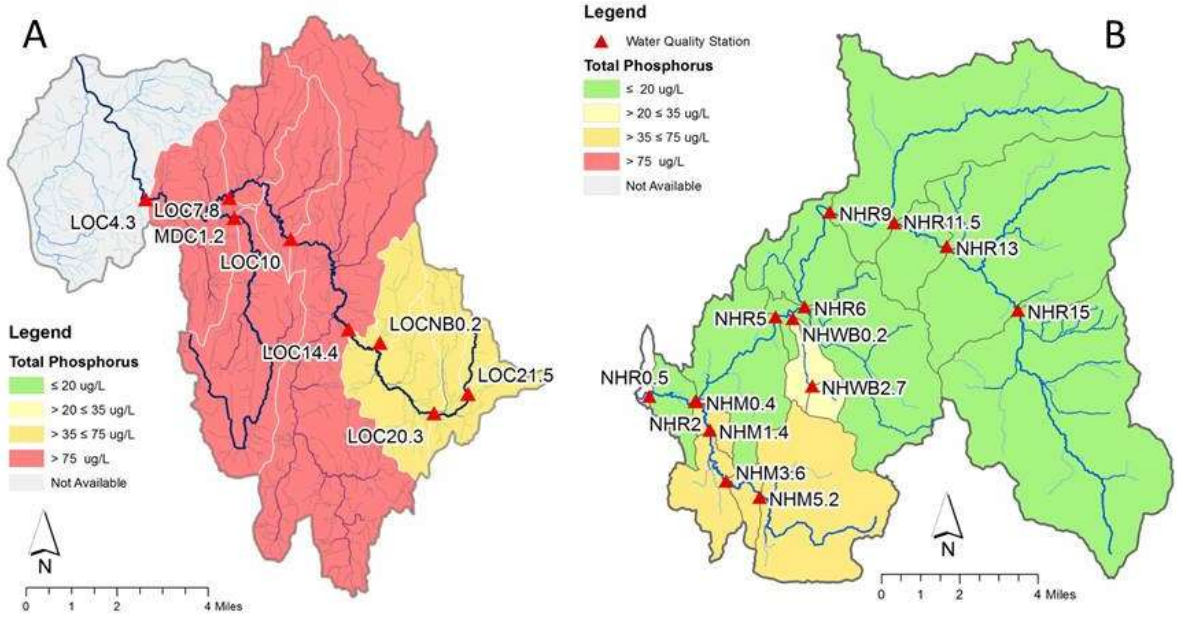


Figure 2. Mean value of Total Phosphorus detected in July, August and September (2016) during low flow conditions at or below the Low-Median-Monthly Flow in (A) Little Otter Creek and (B) New Haven River.

The Little Otter Creek and New Haven River will continue to be focus watersheds in 2017, with the same sentinel and rotational sites monitored for *E.coli*, total and dissolved phosphorus, total nitrogen, and turbidity. Given elevated nitrogen concentrations detected at upper main stem sites in Little Otter Creek and at tributary sites in the New Haven River, an additional lab analysis has been scheduled to detect nitrite and nitrate forms of nitrogen.

6.4 Treatment Effectiveness

In the coming year, with support from a VTANR LaRosa grant, the Collaborative will be reviewing historic data from sites which bracket pastures where cows were previously fenced out of the Lewis Creek and Little Otter Creek, to determine effectiveness of this livestock exclusion practice in terms of its water quality benefits. Data will be shared with landowners, as well as resources agencies such as the UVM Extension, Vermont Agency of Agriculture, Otter Creek Natural Resources Conservation District, and USDA Farm Service Agency.

6.5 Loading Estimates

Another reason to monitor for sediment and nutrients at the subwatershed 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 the Collaborative 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. In 2010 and 2011, the Collaborative carried out a flow / loading study in the Little Otter Creek through its member organization and fiscal agent, Lewis Creek Association. A similar study was completed by Lewis Creek Association in 2012 on the Pond Brook tributary of Lewis Creek. Results are reported separately and are available at www.lewiscreek.org.

7.0 Project Implementation

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.

In 2015, ACRWC began posting monthly provisional *E.coli* results at popular recreation sites on the New Haven River, using funding from a Maple Run grant and volunteer services. These physical postings at existing kiosks in three Bristol town parks (Eagle Park, Saunders River Access and Sycamore Park) were supplementary to notices posted electronically on *Front Porch Forum* (www.frontporchforum.com). In 2016, posting was expanded to six additional recreation sites on the Middlebury River, Lewis Creek and Otter Creek and at Bartlett's Falls on the New Haven River, using sign posts (Figure 3). This expansion was underwritten in part by grant funding from the Lake Champlain Basin Program.

Figure 3. Newly-installed signs for posting monthly *E.coli* results at popular swimming holes

The Vermont Agency of Natural Resources has published EPA-approved Total Maximum Daily Load (TMDL) plans for the Lewis Creek (and Pond Brook), Little Otter Creek, Middlebury River, and Otter Creek (VTDEC, 2011). These TMDL plans include recommendations for further assessment and mitigation of *E.coli* sources in these waters. In 2017, ACRWC will be conducting bracket monitoring in the Lewis Creek in vicinity of the Hollow Brook confluence to focus in on potential source(s) of elevated pathogens in these waters. In addition, statistical analyses will be conducted to examine the effectiveness of historic livestock exclusion projects undertaken by farmers elsewhere in the Lewis Creek and Little Otter Creek. This work has been supported by grant funding from the VANR and ACRPC, as well as private and municipal donations.

8.0 References

Addison County River Watch Collaborative and South Mountain Research & Consulting, 2016, *Workshops and Analysis to Enhance Flood Resiliency of Headwater Forests*, Final Grant Summary Report, Grant Award #: WG224-16.

Olson, S.A., 2014, Estimation of flood discharges at selected annual exceedance probabilities for unregulated, rural streams in Vermont, *with a section on* Vermont regional skew regression, by Veilleux, A.G.: U.S. Geological Survey Scientific Investigations Report 2014–5078, 27 p. plus appendixes, *http://dx.doi.org/10.3133/sir20145078*.

NOAA Online Weather Data: Daily Almanac accessed in February 2017 at: http://www.weather.gov/climate/xmacis.php?wfo=btv

US Drought Monitor, accessed 16 January 2017, http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?VT

USGS, 2017, on-line surface water data, <http://waterdata.usgs.gov/vt/nwis>.

VTDEC, 2011, *Vermont Statewide Total Maximum Daily Load (TMDL) for Bacteria Impaired Waters*, prepared by FB Environmental Associates, Inc., Portland, ME. Including Appendices 2, 3, 4, 5 and 6.

VTDEC Water Quality Division, 2009 (August 18), *Proposed Nutrient Criteria for Vermont's Lakes and Wadeable Streams*. http://www.anr.state.vt.us/dec/waterq/lakes/docs/lp_2009nutrientcriteria.pdf

Vermont Watershed Management Division, 2014. *Vermont Water Quality Standards*. Effective 30 October 2014. Montpelier, VT. http://www.watershedmanagement.vt.gov/rulemaking/docs/wrprules/wsmd_wqs2014.pdf

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.

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*	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	M	2.13	2.35	25.07
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	M	31.71

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
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

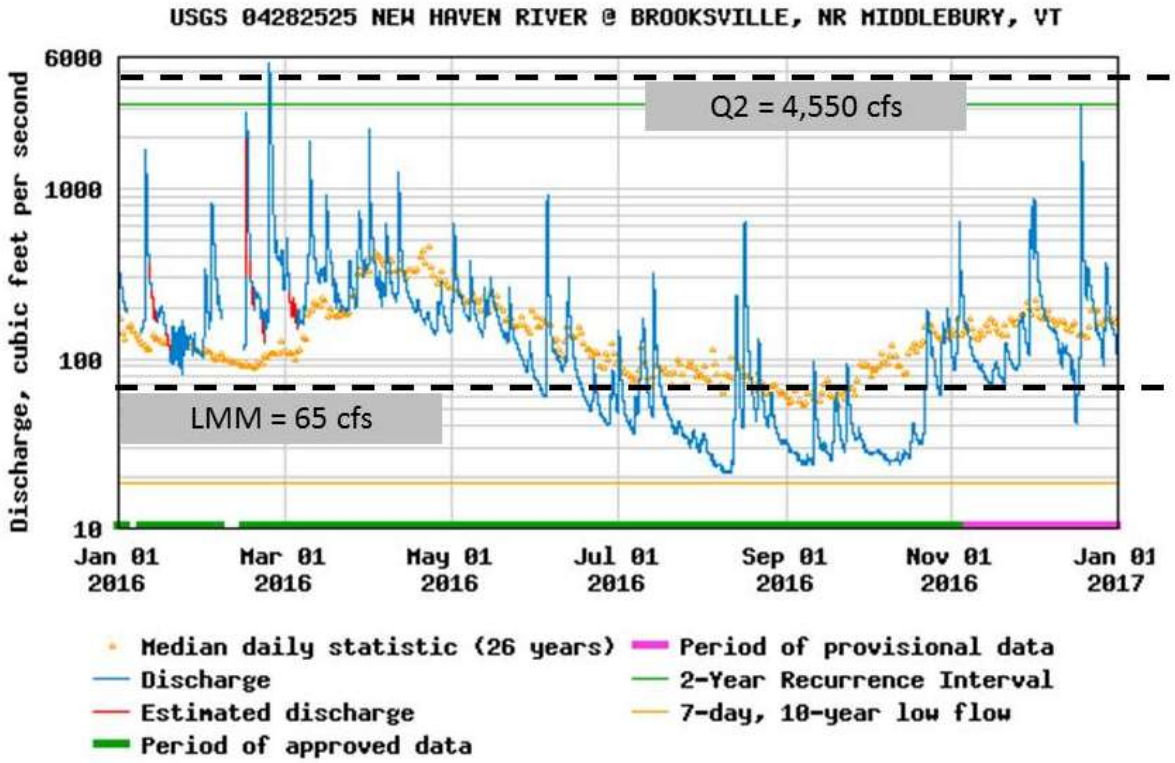
Total snowfall in inches. Values for 1971-2000 and 1981-2011 periods reflect averages for the time period. Values for seasons are totals.
Source: http://www.weather.gov/climate/xmacis.php?wfo=btv data available as of Jan 2017
Tr = Trace; M - Missing data

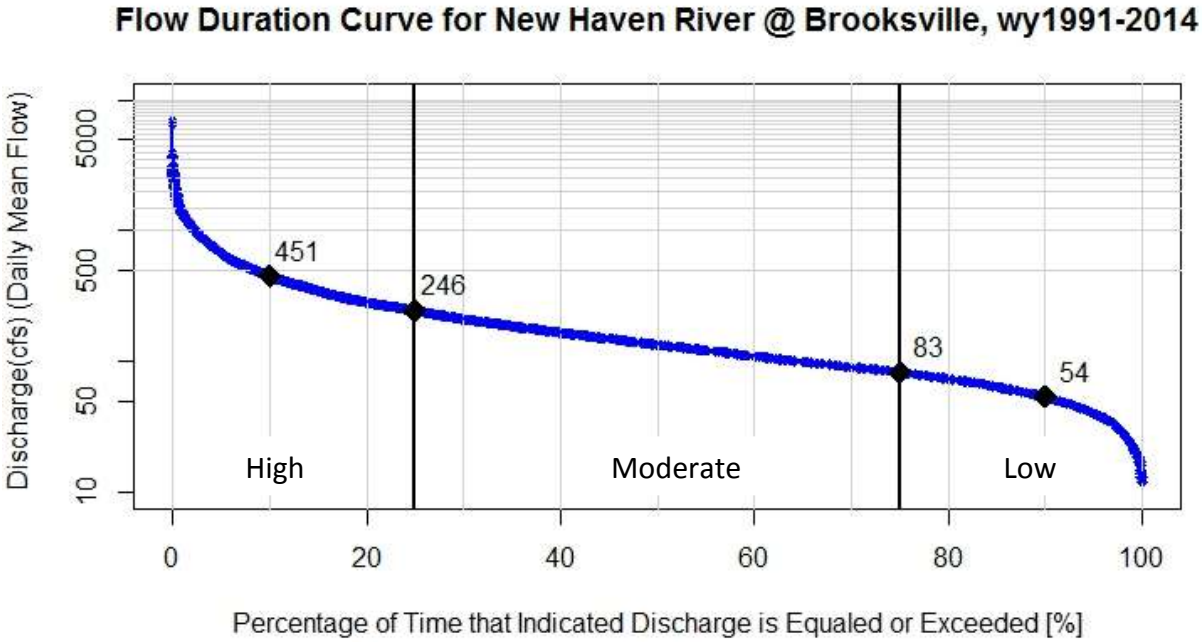
Table B-3. 2016 Daily Mean Flows recorded in Addison County rivers on sample dates, with reference to estimated peak flows and low median monthly flows.

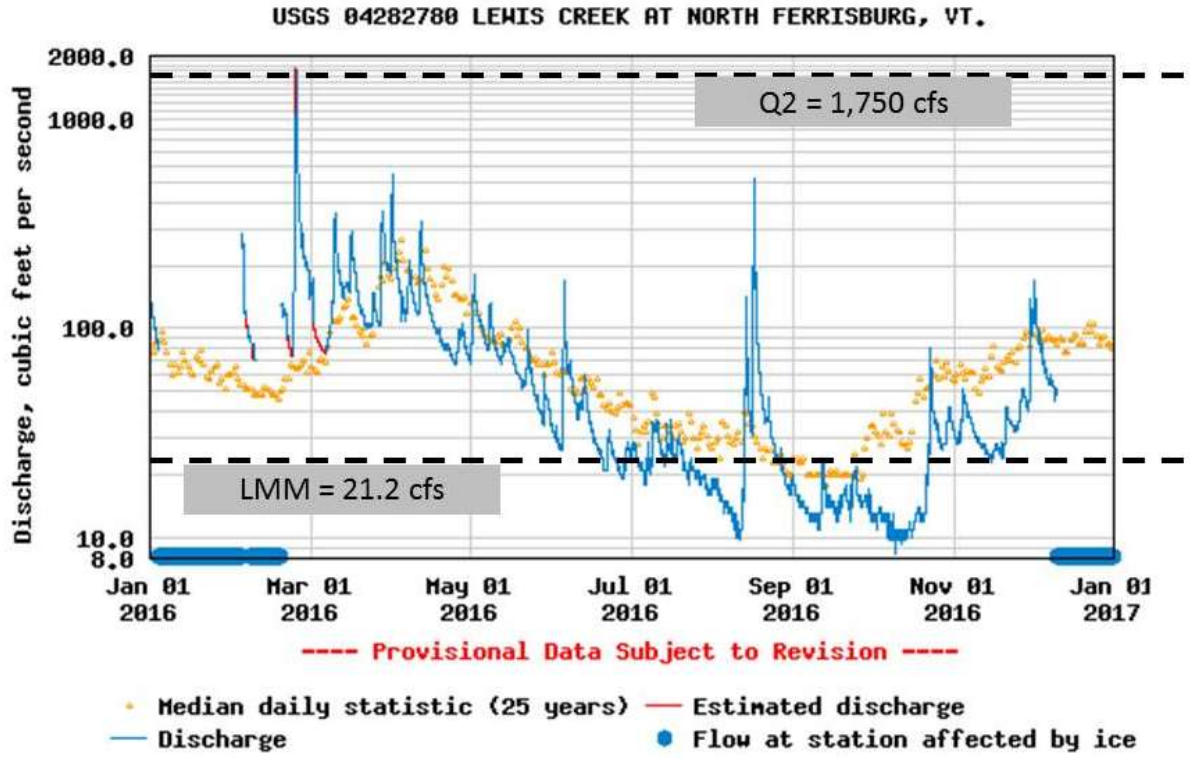
	River	Little Otter Ck		Lewis Creek		New Haven River		Otter Ck MB	
	USGS Gage #	#04282650		#04282780		#04282525		#04282500	
	Drainage Area (sq mi)	57.1		77.4		115		630	
Sample Dates	4/6/2016	55	L-BF	123	L-BF	245	L-BF	1,540	L-BF
(Daily Mean Flows)	5/4/2016	78	L-BF	116	L-BF	245	L-BF	1,220	L-BF
(cfs)	6/1/2016	9.4	L-BF	35	L-BF	77	L-BF	470	L-BF
* incidates	7/6/2016	2.8	L-BF	20	L-BF	40	L-BF	274	L-BF
flow < 7Q10	8/3/2016	2.0	L-BF	18	L-BF	30	L-BF	224	L-BF
	9/7/2016	2.3	L-BF	13	L-BF	25	L-BF	126	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 (Sept)		325 (Aug)	
7Q10 Flow		1.4		5.8		19.4		148	

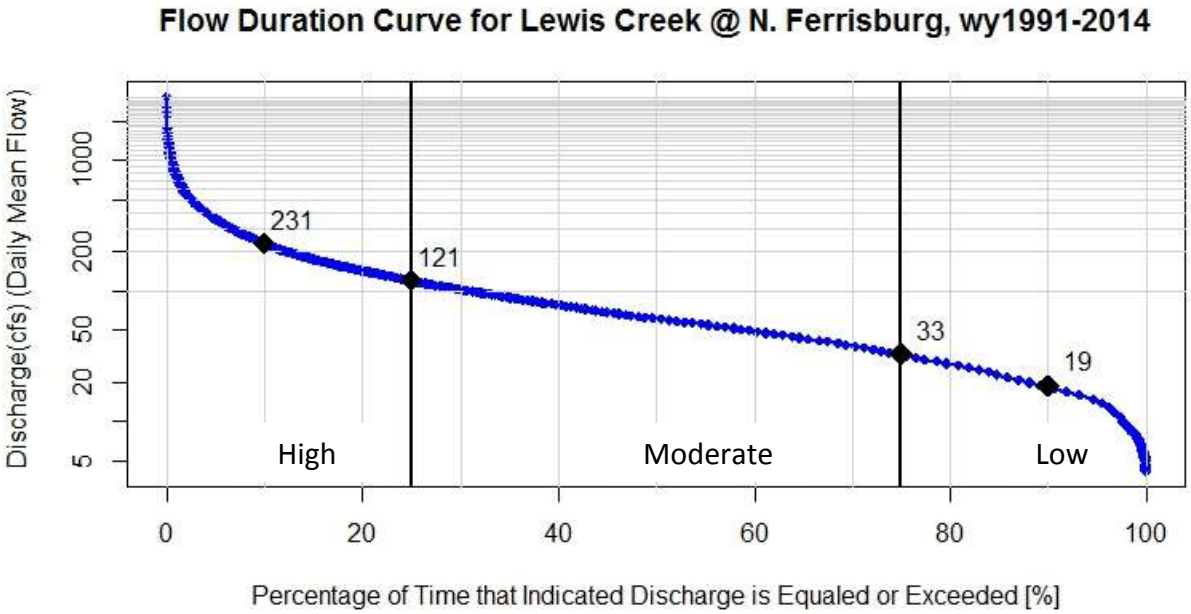
(Blaine Hastings, VWMD, Jan 2014; based on gaging records of variable lengths through water year 2012)

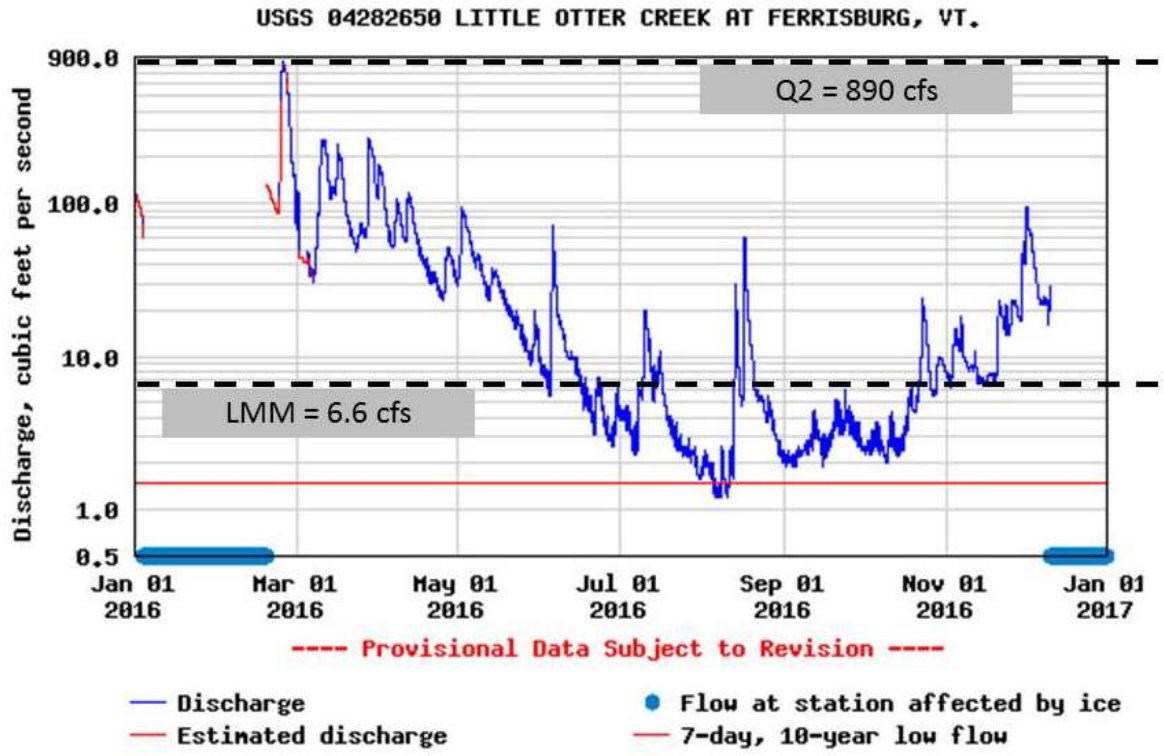
Abbreviations: Flow condition follows VTDEC Guidance:
Flow Level: Fd - Flood (>bankfull flow), H - High (>p.75), M - Moderate (>p.25 ≤p.75), L - Low (≤ p.25), where p = percentile
Flow Category: BF - Base Flow, FF - Freshet Flow, HF - Hydro Flow

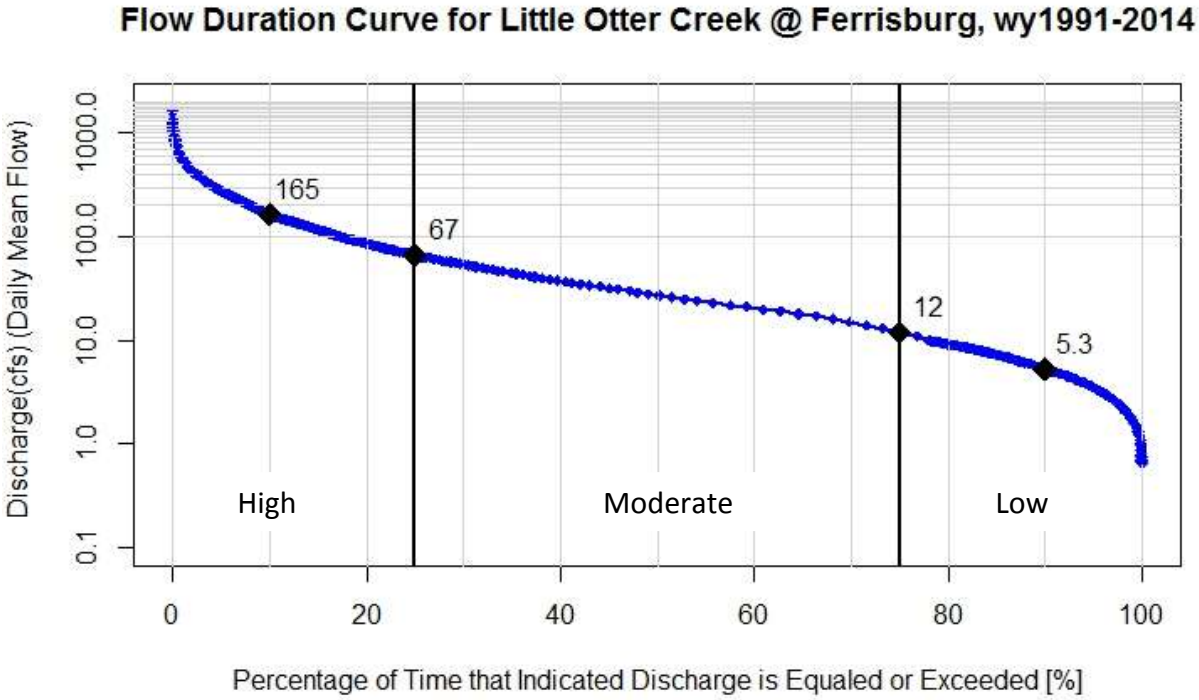

USGS 04282525 NEW HAVEN RIVER @ BROOKSVILLE, NR MIDDLEBURY, VT
Discharge, cubic feet per second
6000
1000
100
10
Q2 = 4,550 cfs
LMM = 65 cfs
Jan 01 2016
Mar 01 2016
May 01 2016
Jul 01 2016
Sep 01 2016
Nov 01 2016
Jan 01 2017
Median daily statistic (26 years)
Discharge
Estimated discharge
Period of approved data
Period of provisional data
2-Year Recurrence Interval
7-day, 10-year low flow

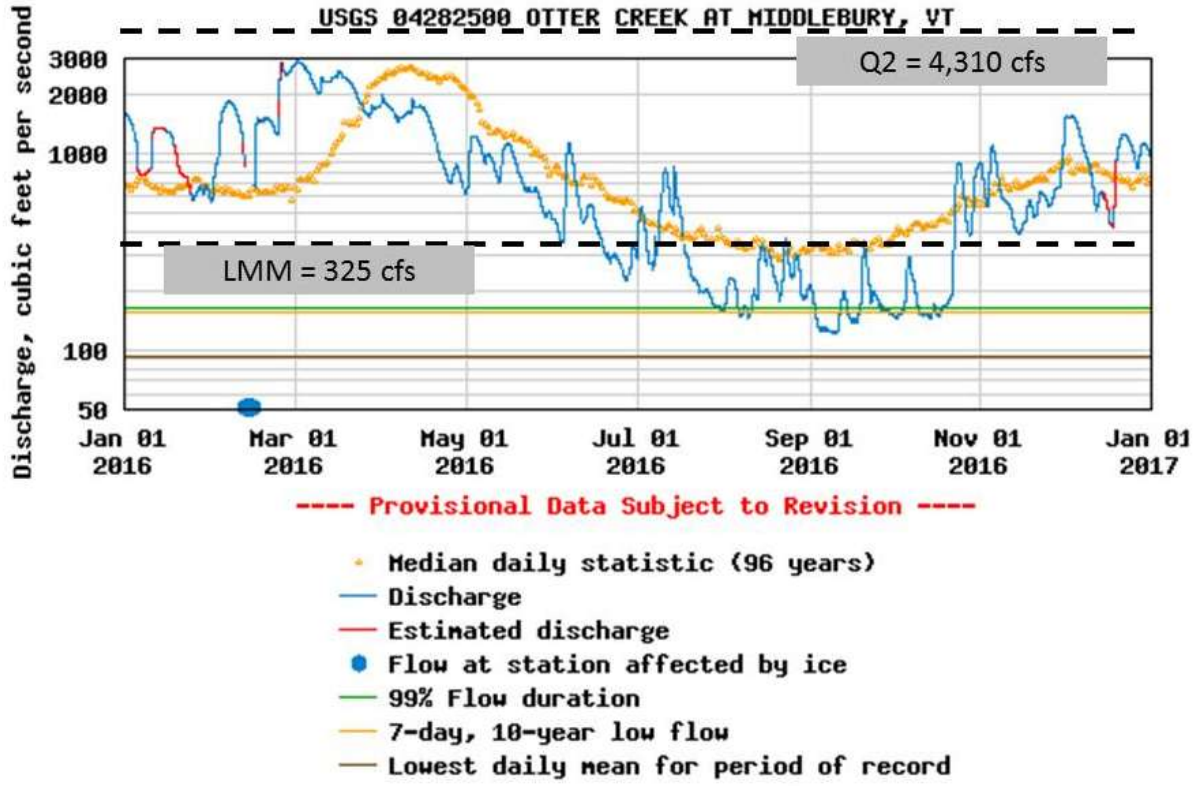

Flow Duration Curve for New Haven River @ Brooksville, wy1991-2014
Discharge(cfs) (Daily Mean Flow)
5000
500
50
10
451
246
83
54
High
Moderate
Low
0
20
40
60
80
100
Percentage of Time that Indicated Discharge is Equaled or Exceeded [%]

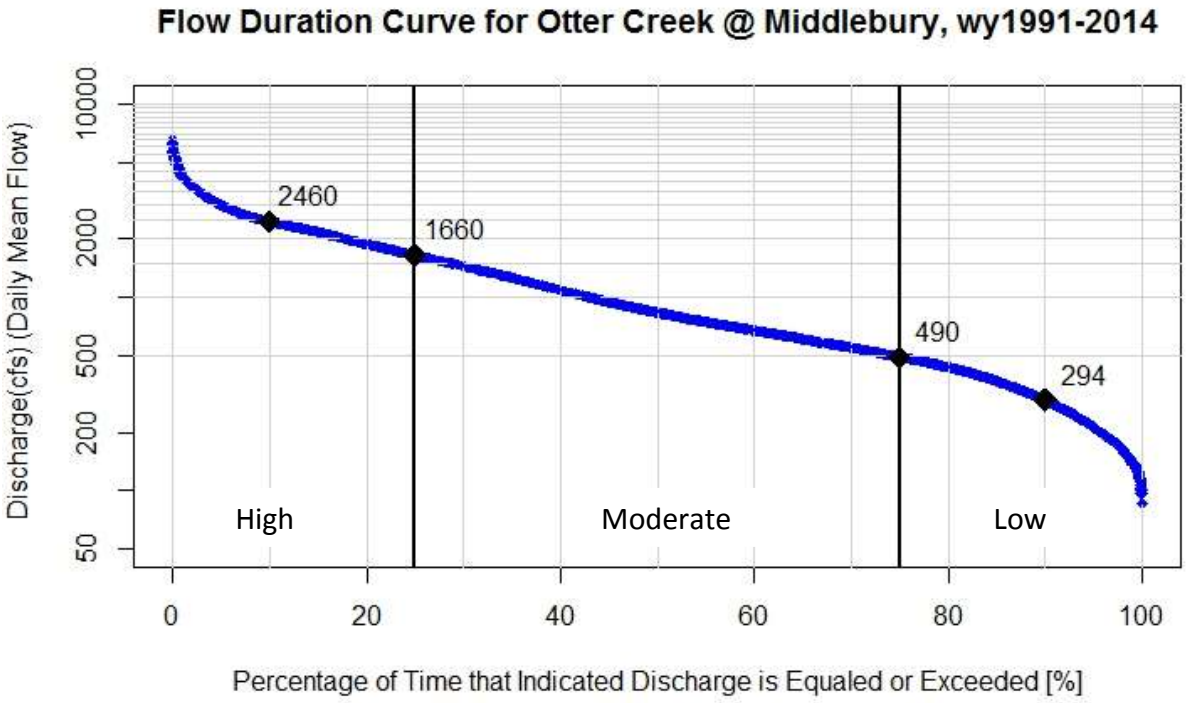

USGS 04282780 LEWIS CREEK AT NORTH FERRISBURG, VT.
Discharge, cubic feet per second
2000.0
1000.0
100.0
10.0
8.0
Q2 = 1,750 cfs
LMM = 21.2 cfs
Jan 01 2016
Mar 01 2016
May 01 2016
Jul 01 2016
Sep 01 2016
Nov 01 2016
Jan 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (25 years)
Estimated discharge
Discharge
Flow at station affected by ice


Flow Duration Curve for Lewis Creek @ N. Ferrisburg, wy1991-2014
Discharge(cfs) (Daily Mean Flow)
5
20
50
200
1000
231
121
33
19
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
900.0
100.0
10.0
1.0
0.5
Q2 = 890 cfs
LMM = 6.6 cfs
Jan 01 2016
Mar 01 2016
May 01 2016
Jul 01 2016
Sep 01 2016
Nov 01 2016
Jan 01 2017
---- Provisional Data Subject to Revision ----
Discharge
Estimated discharge
Flow at station affected by ice
7-day, 10-year low flow


Flow Duration Curve for Little Otter Creek @ Ferrisburg, wy1991-2014
Discharge(cfs) (Daily Mean Flow)
1000.0
100.0
10.0
1.0
0.1
165
67
12
5.3
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
3000
2000
1000
100
50
Jan 01 2016
Mar 01 2016
May 01 2016
Jul 01 2016
Sep 01 2016
Nov 01 2016
Jan 01 2017
---- Provisional Data Subject to Revision ----
Median daily statistic (96 years)
Discharge
Estimated discharge
Flow at station affected by ice
99% Flow duration
7-day, 10-year low flow
Lowest daily mean for period of record


Flow Duration Curve for Otter Creek @ Middlebury, wy1991-2014
Discharge(cfs) (Daily Mean Flow)
10000
2000
500
200
50
2460
1660
490
294
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
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	Final E. Coli (mpn/100mL)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
LFR6.7	4/6/2016		75.9	26.9	30.2	51.4
LFR12	4/6/2016		59.6	28.5	17.2	43.2
LFR6.7	5/4/2016		85.1	29.1	37.7	37.8
LFR12	5/4/2016		55.5	21.1	17.6	21.7
LFR6.7	6/1/2016	648.82	169	36.3	99	168.4
LFR12	6/1/2016	816.41	165	38.2	90	159.4
LFR6.7	7/6/2016	378.44	186	47.7	112.4	158.8
LFR12	7/6/2016	686.67	351	16	173.6	327.2
LFR6.7	8/3/2016	770.1	357	67.7	328	485
LFR12	8/3/2016	42.5	348	58.1	274	386
LFR6.7	9/7/2016	93.31	197	64.8	112.3	140
LFR12	9/7/2016	18.9	230	56.1	148.2	199.8

VT Water Quality Standards (effective October 2014):

- **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	Final E. Coli (mpn/100mL)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
LCR3.7	4/6/2016		23.6			8.7
LCR14	4/6/2016		19.8			4.1
LCR3.7	5/4/2016		16.6			3.4
LCR14	5/4/2016		13.2			2.3
LCR3.7	6/1/2016	76.7	28.1			5.0
LCR14	6/1/2016	290.9	11			1.8
LCR3.7	7/6/2016	73.3	20.4			5.0
LCR14	7/6/2016	579.4	15.4			2.2
LCR3.7	8/3/2016	44.1	17.9			4.0
LCR14	8/3/2016	193.5	13.2			3.5
LCR3.7	9/7/2016	29.8	19.4			6.4
LCR14	9/7/2016	547.5	13.5			3.3

VT Water Quality Standards (effective October 2014):

- **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.

Little Otter Creek

Location	Date	Final E. Coli (mpn/100mL)	TN (mg/L)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
LOC4.3	4/6/2016		0.54	39.6	19	14.8	23.8
LOC7.8	4/6/2016		0.6	35	15.7	14.8	19.8
LOC10	4/6/2016		0.64	34.5	21.5	8.3	12.3
LOC14.4	4/6/2016		1.56	27	17	3.2	4.3
LOC20.3	4/6/2016		3.81	43	19.1	18	7.1
LOC21.5	4/6/2016		**NS**	**NS**	**NS**	**NS**	**NS**
MDC1.2	4/6/2016		0.54	42.9	30.3	2.1	13.9
LOCNB0.2	4/6/2016		0.15	16.2	12.9	3.1	3.7
LOC4.3	5/4/2016		0.64	42.9	18.9	14.4	23.3
LOC7.8	5/4/2016		0.57	42	18.1	15.4	19.2
LOC10	5/4/2016		0.61	44.9	26.6	10	12.8
LOC14.4	5/4/2016		0.89	28.5	18.5	2.6	3.8
LOC20.3	5/4/2016		3.28	44.4	18.6	9.3	2.6
LOC21.5	5/4/2016		**NS**	**NS**	**NS**	**NS**	**NS**
MDC1.2	5/4/2016		0.7	50.1	36.5	5.8	8.1
LOCNB0.2	5/4/2016		0.21	19.8	10.7	3.2	3.6
LOC4.3	6/1/2016	76.7	1.03	185	59.2	95	149.4
LOC7.8	6/1/2016	117.8	0.95	**NR**	54.7	112	156.2
LOC10	6/1/2016	143.9	0.99	182	61.6	84	110.6
LOC14.4	6/1/2016	37.9	0.84	81.1	54.8	7.3	11.6
LOC20.3	6/1/2016	325.5	4.14	37.4	30.8	1.9	2.3
LOC21.5	6/1/2016	73.3	5.1	64.8	60.1	2	0.8
MDC1.2	6/1/2016	178.5	1	153	123	5.8	9.1
LOCNB0.2	6/1/2016	50.4	0.34	43.4	21.4	11	7.3

VT Water Quality Standards (effective October 2014):

- **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.

Little Otter Creek (continued)

Location	Date	Final E. Coli (mpn/100mL)	TN (mg/L)	TP (ug/L)	DP (ug/L)	TSS (mg/L)		Turbidity (NTU)
LOC4.3	7/6/2016	31.5	0.52	112	45.1	33.8	JD	51.8
LOC7.8	7/6/2016	435.2	0.49	135	46.9	68.9	JD	94.1
LOC10	7/6/2016	30.5	0.54	112	58.7	23.4	JD	39.6
LOC14.4	7/6/2016	54.6	0.65	76.2	47.2	10.8	JD	12.9
LOC20.3	7/6/2016	410.6	4.22	58.1	45.5	7.0	JD	2.8
LOC21.5	7/6/2016	345	5.3	90.7	58.9	19.0	JD	1.3
MDC1.2	7/6/2016	1,414	1.02	122	71.1	20.7	JD	19.7
LOCNB0.2	7/6/2016	122.3	0.32	118	23.4	40.6	JD	16.9
LOC4.3	8/3/2016	14.5	0.7	129	63.1	33.2		44.6
LOC7.8	8/3/2016	231.0	0.65	148	48.5	67		95.8
LOC10	8/3/2016	41.4	0.67	121	46.4	35.3		45.1
LOC14.4	8/3/2016	101.7	0.88	72.2	52.6	13		13.2
LOC20.3	8/3/2016	172.2	4.51	60.3	44.2	102		5.2
LOC21.5	8/3/2016	195.6	5.75	55.5	58.7	< 1		0.6
MDC1.2	8/3/2016	206.4	1.23	146	91.7	22.6		24.2
LOCNB0.2	8/3/2016	44.3	0.38	61.8	29.4	17.7		23.1
LOC4.3	9/7/2016	18.7	0.68	105	41.9	51.7		44.4
LOC7.8	9/7/2016	129.6	0.55	133	41.3	70.8		96.3
LOC10	9/7/2016	16.6	0.76	121	48.6	35.0		45.0
LOC14.4	9/7/2016	114.5	1.05	51.2	34.7	4.9		5.1
LOC20.3	9/7/2016	248.1	4.75	55.4	41.8	5.5		2.4
LOC21.5	9/7/2016	770.1	6.03	49.5	44.6	< 1		0.5
MDC1.2	9/7/2016	111.2	1.13	130	71.4	16.8		21.1
LOCNB0.2	9/7/2016	124.6	0.33	45.1	15.3	14.4		10.6

VT Water Quality Standards (effective October 2014):

- **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.

Middlebury River

Location	Date	Final E. Coli (mpn/100mL)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
MIR1.5	4/6/2016		12.8			2.2
MIR5.7	4/6/2016		6.7			1.2
MIR10.6	4/6/2016		9.1			0.64
MIR1.5	5/4/2016		14.8			3.3
MIR5.7	5/4/2016		7.3			0.77
MIR10.6	5/4/2016		8.2			0.51
MIR1.5	6/1/2016	172.3	20.4			9.6
MIR5.7	6/1/2016	6.3	5.8			4.2
MIR10.6	6/1/2016	2.0	9.1			0.47
MIR1.5	7/6/2016	461.1	21.3			4.3
MIR5.7	7/6/2016	5.2	8.2			0.56
MIR10.6	7/6/2016	12.2	14.4			0.28
MIR1.5	8/3/2016	209.8	20.4			3.9
MIR5.7	8/3/2016	3.1	5.8			< 0.2
MIR10.6	8/3/2016	4.1	11.3			0.47
MIR1.5	9/7/2016	866.4	21.9			4.9
MIR5.7	9/7/2016	3.0	7.6			0.27
MIR10.6	9/7/2016	2.0	12.9			< 0.2

VT Water Quality Standards (effective October 2014):

- **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	Final E. Coli (mpn/100mL)	TN (mg/L)	TP (ug/L)	DP (ug/L)	TSS (mg/L)		Turbidity (NTU)
NHR0.5	4/6/2016			11.1				2.9
NHR2	4/6/2016			10.9				3.14
NHR5	4/6/2016			8.28				1.66
NHR6	4/6/2016			6.54				0.66
NHR9	4/6/2016			6.92				0.66
NHR11.5	4/6/2016			6.77				0.69
NHR13	4/6/2016			6.27				0.45
NHR15	4/6/2016			7.29				1.02
NHM0.4	4/6/2016		0.59	29.4	15.7	5.9		9.4
NHM1.4	4/6/2016		0.55	23.3	18.5	4.4		7.9
NHM3.6	4/6/2016		0.53	17.6	11.7	4.4		6.2
NHM5.2	4/6/2016		0.5	20.2	12.4	4.6		6.9
NHWB0.2	4/6/2016		4.23	32.2	18.7	12.8		10.7
NHWB2.7	4/6/2016		0.33	11.1	6.3	3.7		1.24
NHR0.5	5/4/2016			11.9				2.83
NHR2	5/4/2016			12.4				2.94
NHR5	5/4/2016			7.99				1.74
NHR6	5/4/2016			< 5				0.91
NHR9	5/4/2016			5.56				0.54
NHR11.5	5/4/2016			6.53				1
NHR13	5/4/2016			6.23				1.31
NHR15	5/4/2016			5.39				0.3
NHM0.4	5/4/2016		0.48	36.4	20	8.8	JD	13.6
NHM1.4	5/4/2016		0.46	32.5	18	5.2	JD	10.8
NHM3.6	5/4/2016		0.47	28.9	18.1	6	JD	8.77
NHM5.2	5/4/2016		0.46	26.3	15.9	4.13	JD	6.3
NHWB0.2	5/4/2016		2.64	36	14.6	10.4	JD	9.4
NHWB2.7	5/4/2016		0.32	20.2	10.5	7.2	JD	3.58

VT Water Quality Standards (effective October 2014):

- **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	Final E. Coli (mpn/100mL)	TN (mg/L)	TP (ug/L)	DP (ug/L)	TSS (mg/L)		Turbidity (NTU)
NHR0.5	6/1/2016	50.39		12.9				8.55
NHR2	6/1/2016	79.36		12				4.38
NHR5	6/1/2016	44.34		< 5				0.65
NHR6	6/1/2016	17.31		5.03				0.44
NHR9	6/1/2016	12.11		< 5				0.5
NHR11.5	6/1/2016	**NA**		< 5				0.43
NHR13	6/1/2016	41.35		5.55				0.42
NHR15	6/1/2016	18.49		6.52				0.33
NHM0.4	6/1/2016	547.5	0.78	64	22.9	29.5		30
NHM1.4	6/1/2016	387.32	0.67	43.7	22.4	14.6		14.3
NHM3.6	6/1/2016	108.07	0.61	40	20.9	10.4		12.5
NHM5.2	6/1/2016	410.58	0.66	40.2	17.8	10.6		13.7
NHWB0.2	6/1/2016	770.1	3.49	17	12.9	2.2		1.46
NHWB2.7	6/1/2016	15.79	0.45	12.8	9.76	1.8		0.85
NHR0.5	7/6/2016	144.97		10.5				2.15
NHR2	7/6/2016	146.72		15.6				4.22
NHR5	7/6/2016	107.12		< 5				0.49
NHR6	7/6/2016	41.95		5.67				0.42
NHR9	7/6/2016	11		5.94				0.25
NHR11.5	7/6/2016	20.34		6.31				0.46
NHR13	7/6/2016	18.9		< 5				< 0.2
NHR15	7/6/2016	26.21		5.01				0.2
NHM0.4	7/6/2016	726.99	0.44	72.7	27.1	21.3	JD	27.3
NHM1.4	7/6/2016	1553.12	0.49	56.7	26.5	14.6	JD	15.7
NHM3.6	7/6/2016	235.93	0.58	57.3	26.6	12.9	JD	15.1
NHM5.2	7/6/2016	325.54	0.63	60.4	30.3	9.3	JD	13.1
NHWB0.2	7/6/2016	387.32	3.12	24.6	17.9	6.1		1.55
NHWB2.7	7/6/2016	44.12	0.54	17.1	8.24	1.7		1.56

VT Water Quality Standards (effective October 2014):

- **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	Final E. Coli (mpn/100mL)	TN (mg/L)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
NHR0.5	8/3/2016	81.26		11			3.17
NHR2	8/3/2016	101.44		19.5			4.79
NHR5	8/3/2016	81.62		5.16			0.72
NHR6	8/3/2016	34.98		< 5			0.4
NHR9	8/3/2016	13.23		5.81			< 0.2
NHR11.5	8/3/2016	3.04		5.95			< 0.2
NHR13	8/3/2016	11		5.24			0.23
NHR15	8/3/2016	104.6		6.08			0.26
NHM0.4	8/3/2016	165.02	0.4	62.4	28.1	20.6 JD	23
NHM1.4	8/3/2016	121.12	0.52	47.3	27	11 JD	12.8
NHM3.6	8/3/2016	325.54	0.51	44.4	25.5	9.8 JD	9.85
NHM5.2	8/3/2016	461.11	0.66	44.9	28.7	9 JD	10.5
NHWB0.2	8/3/2016	248.09	2.94	17.2	18.6	5 JD	0.9
NHWB2.7	8/3/2016	78	0.51	28.5	12.3	4.5 JD	3.78
NHR0.5	9/7/2016	325.54		11.9			2.68
NHR2	9/7/2016	123.56		18.1			5.58
NHR5	9/7/2016	74.39		6.11			0.99
NHR6	9/7/2016	21.09		7.01			0.43
NHR9	9/7/2016	3.06		< 5			< 0.2
NHR11.5	9/7/2016	6.32		< 5			0.27
NHR13	9/7/2016	6.32		< 5			0.26
NHR15	9/7/2016	12.11		8.12			0.26
NHM0.4	9/7/2016	290.93	0.5	72.9	22.5 JB	27.2	35.5
NHM1.4	9/7/2016	866.44	0.53	58.7	26.7 JB	15.4	18.7
NHM3.6	9/7/2016	161.62	0.6	50.6	18.6 JB	15.5	14.1
NHM5.2	9/7/2016	365.4	0.69	45	16.8 JB	8.8	12.1
NHWB0.2	9/7/2016	86.47	3.16	22.4	20.4 JB	< 1	0.68
NHWB2.7	9/7/2016	86.47	0.54	31.9	< 5 JB	12.97	11.8

VT Water Quality Standards (effective October 2014):

- **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.

Otter Creek (Lower)

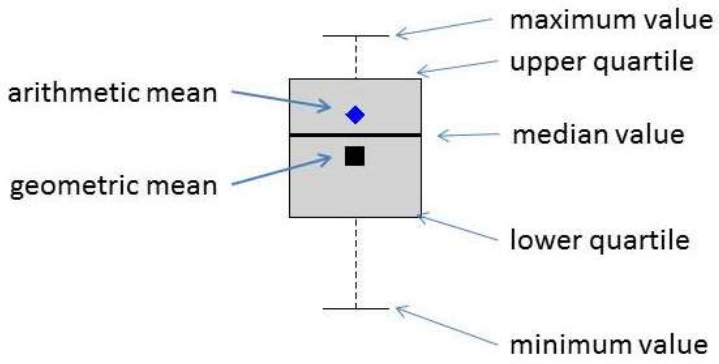
Location	Date	Final E. Coli (mpn/100mL)	TP (ug/L)	DP (ug/L)	TSS (mg/L)	Turbidity (NTU)
OTR7.3	4/6/2016		22.3			5.8
OTR18	4/6/2016		18.4			3.7
OTR7.3	5/4/2016		33.1			10.9
OTR18	5/4/2016		16.9			2.6
OTR7.3	6/1/2016	40.4	30.8			9.0
OTR18	6/1/2016	23.1	18.1			2.6
OTR7.3	7/6/2016	28.5	33.4			8.3
OTR18	7/6/2016	21.3	29.1			2.8
OTR7.3	8/3/2016	57.8	31.9			7.9
OTR18	8/3/2016	21.3	21.2			1.9
OTR7.3	9/7/2016	41.4	24.7			7.0
OTR18	9/7/2016	4.1	19.6			1.6

VT Water Quality Standards (effective October 2014):

- **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 – 2016 Water Quality Summary
2 Lewis Creek – 2016 Water Quality Summary
3 Little Otter Creek – 2016 Water Quality Summary
4 Middlebury River – 2016 Water Quality Summary
5 New Haven River – 2016 Water Quality Summary
6 Otter Creek (Lower) – 2016 Water Quality Summary



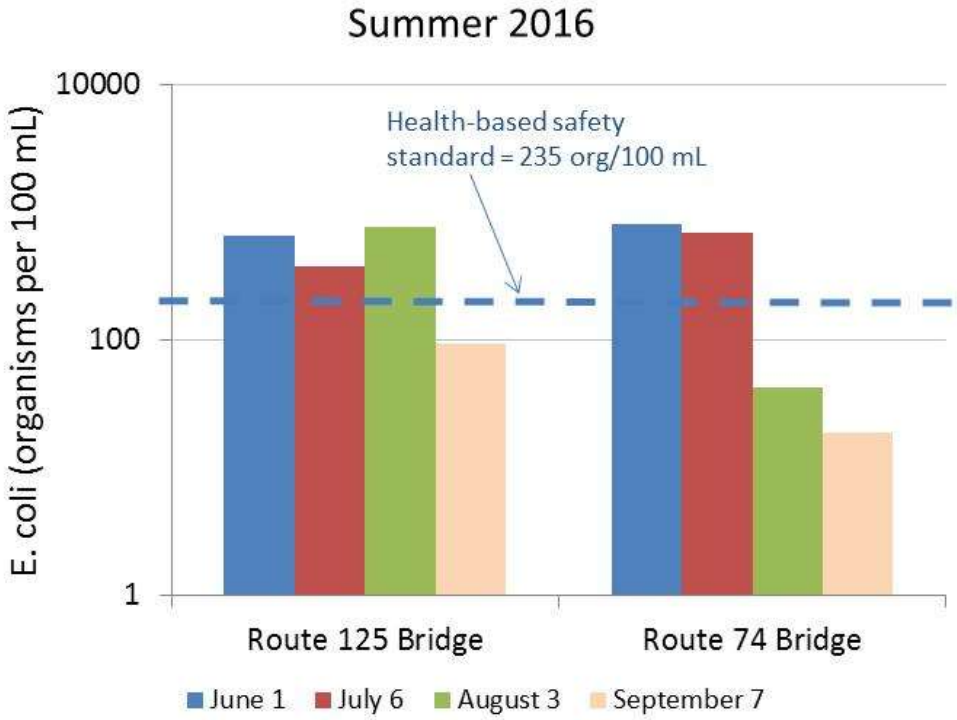
Lemon Fair River - 2016 Water Quality Summary
Addison County River Watch Collaborative

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 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records for similar, nearby rivers (Otter Creek and Little Otter Creek). Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

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 18.9 to 816 organisms/100 mL. Vermont Water Quality Criteria (October 2014) 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 on June 1 and July 6, and the standard was again exceeded on August 3 at the Route 125 Bridge site. The geometric mean of summer sampling results was 365 org/100mL at LFR6.7 and 146 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 21.7 to 485 NTUs, with a mean of 182 NTUs. Highest concentrations were detected during low-flow conditions on August 3. The Vermont state standard of 25 NTUs (for Class B warm-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to all six sample dates. Detected concentrations were above the standard at both sites on all six sample dates, with the exception of LFR12 on May 4.

Phosphorus was detected at moderate levels during the six spring and summer sampling dates of 2016. Concentrations ranged from 56 to 357 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 very low levels on the July, August, and September sample dates. Based on gaging records for nearby rivers of similar character (Little Otter Creek and Otter Creek), flows in Lemon Fair were likely at or below the low median monthly flow on these dates. The mean of the results available for these three summer sampling dates exceeded the instream phosphorus criterion at each sentinel station: 310 and 247 µg/L at LFR12 and LFR6.7, respectively. It is possible that 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 was also tested at each site; DP as a percentage of Total Phosphorus ranged from 4.6 to 48% during these six sample dates which occurred during dry-weather, low-flow conditions.

2017: The Addison County River Watch Collaborative will continue to monitor for *E.coli*, phosphorus (total and dissolved), total suspended sediments, and turbidity at these two sentinel sites in 2017. An increased number of parameters and additional monitoring sites will be evaluated when a more intensive monitoring focus rotates back to the Lemon Fair for a two-year period beginning in the year 2018.

For more information, contact the Lemon Fair sampling coordinator:
Barb Otsuka, 388-6829, botsuka@sover.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

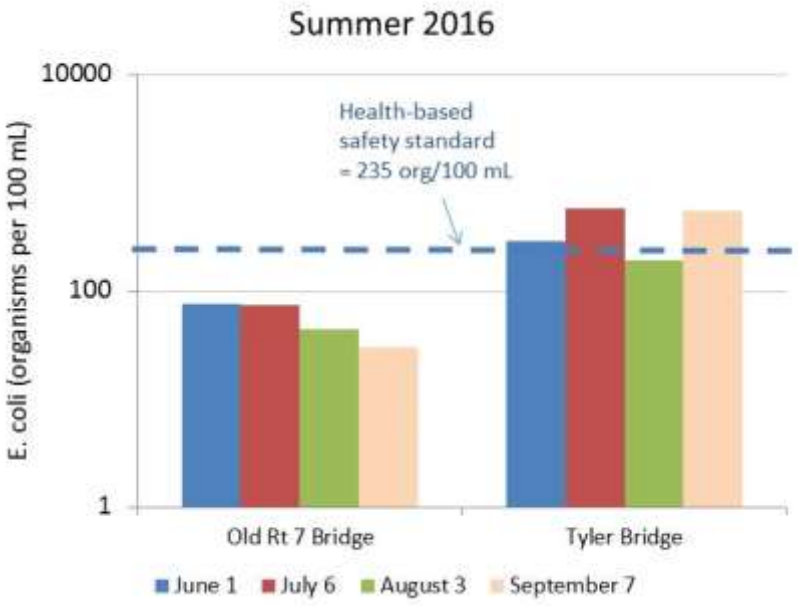
Lewis Creek - 2016 Water Quality Summary
Addison County River Watch Collaborative

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.

During 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records from the USGS streamflow gage located at the Route 7 crossing. Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

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



E.coli counts in the Lewis Creek at the two sentinel stations ranged from 29.8 to 579 organisms/100 mL. Vermont Water Quality Criteria (October 2014) 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 three of the four summer sample dates at the Tyler Bridge station (LCR14). The geometric mean of summer sampling results was 366 org/100mL at LCR14 and 52

org/100mL at LCR3.7; the value for station LCR14 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. This station is also located downstream of the confluence with Hollow Brook which flows through wetlands populated by beavers.

Turbidity levels in the Lewis Creek at the sampled stations ranged from 1.8 to 8.7 NTUs, with a mean level of 4.1 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 all six sample dates. The turbidity standard was not exceeded at either sentinel station on the six sample dates in 2016. 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 moderate concentrations during the six Spring and Summer sampling dates, ranging from 11 to 28 µg/L, with an average of 17.7 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 were below the low median monthly flow on the July, August, and September sample dates, based on records from the USGS streamflow gage located at the Route 7 crossing. The mean of the phosphorus results available for these three summer sampling dates did not exceed the instream nutrient standard of 27 µg/L. 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.

2017: The Addison County River Watch Collaborative will continue to monitor for *E.coli*, total phosphorus, and turbidity at these two sentinel sites in 2017. Additionally, the Collaborative has received technical and financial support from the Vermont Department of Environmental Conservation to conduct bracket monitoring in 2017 during both dry-weather and wet-weather conditions at additional sites in the vicinity of the Hollow Brook confluence to gain a better understanding of water quality patterns and potential sources of elevated pathogens, nutrients and sediments in this region.

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. 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:
Louis DuPont, 453-5538, ldupont@gmavt.net
Lewis Creek Association Executive Director:
Marty Illick, 425-2002, marty.illick@gmail.com
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

Little Otter Creek - 2016 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 is the subject of a more intensive monitoring focus, where rotational as well as sentinel stations are monitored and additional parameters are being 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 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records from the USGS streamflow gage located at the Route 7 crossing of Little Otter Creek. Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

Samples were tested for *E.coli*, phosphorus (total and dissolved), total 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 14.5 to 1414 organisms/100 mL. Vermont Water Quality Criteria (October 2014) 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 four 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: LOC7.8 (Middlebrook Rd), LOC20.3 (Sawyer Road), LOC21.5

(Kilbourn), and MDC1.2 (Mud Creek tributary at Middlebrook Rd) (Figure 1). The geometric mean value at these four sites exceeded the state's water quality standard of 126 org/ 100 mL (Figure 2). Detected *E.coli* counts at sentinel stations LOC7.8 and MDC1.2 were largely consistent with historic monitoring results which have included chronic exceedances of the standard.

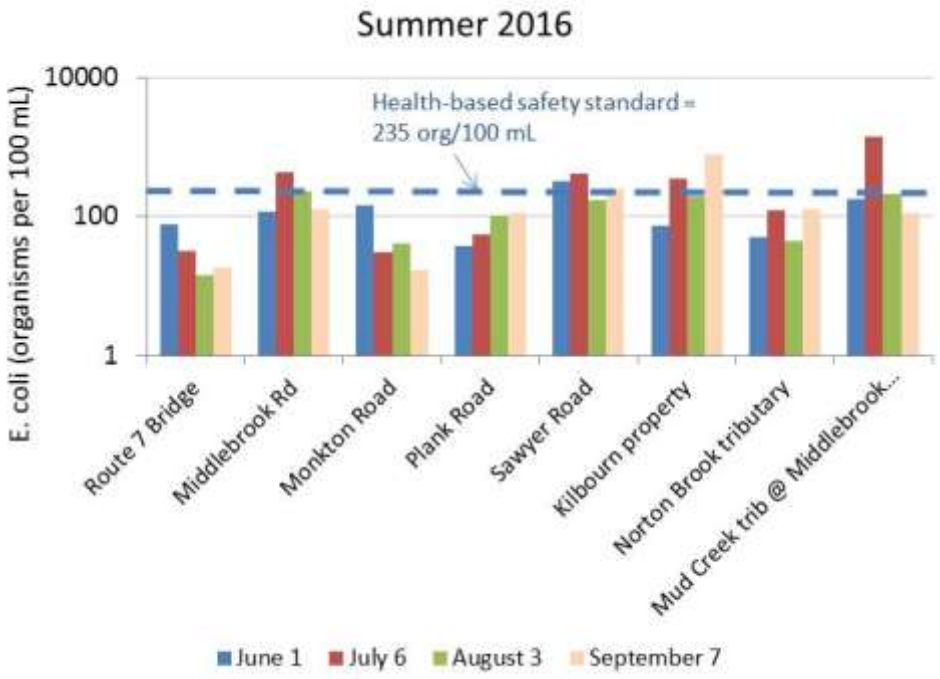


Figure 1. *E.coli* measured at Little Otter Creek stations on four dry-weather, low-flow dates in 2016.

Figure 2. *E.coli* monitoring results for Little Otter Creek, on four summer sampling dates exhibiting dry-weather, low-flow conditions, 2016. Subwatersheds draining to stations with geometric mean values greater than 126 org/100 mL are depicted in red.

Turbidity levels reported for the Little Otter Creek stations ranged from 0.5 to 156 NTUs, with a mean level of 29 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 all six sample dates. Except for stations LOC20.3 and LOC21.5, Turbidity values exceeded this standard on three or more sampling dates. The distribution of Turbidity results is displayed in the box-and-whisker plot below (Fig 3). The whiskers extend to the maximum and minimum values detected over six sampling events, while the gray-shaded box represents the interquartile range 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 baseflow conditions, with the corresponding number of samples (n) indicated in blue along the top of the chart. Based on past years' sampling results, Turbidity values tend to increase with distance downstream along the main stem. Turbidity can also become elevated at times of increased flow – during a Summer thunderstorm, or during Spring runoff conditions.

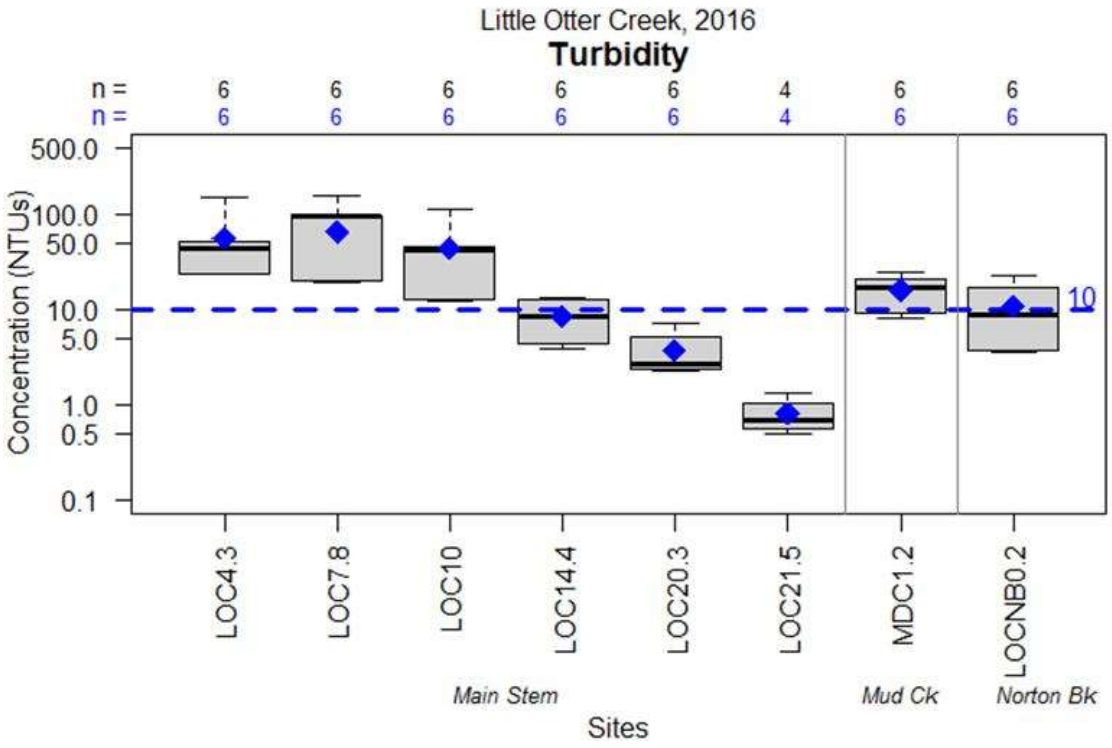


Figure 3. Summary of Turbidity Results for Little Otter Creek, 2016.

Nitrogen levels were detected at relatively low concentrations at most stations during the spring and summer sampling dates. Concentrations ranged from 0.2 to 6 mg/L, with an average of 1.6 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 will be scheduled for these stations in 2017 to detect nitrite and nitrate forms of nitrogen.

Phosphorus levels were detected at low to moderate concentrations during the six spring and summer sampling dates, ranging from 16 to 185 µg/L, with an average of 79 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 Little Otter Creek were below the low median monthly flow on the July, August, and September sample dates, based on records from the USGS streamflow gage located at the Route 7 crossing. 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 4). 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. Dissolved phosphorus was also tested at each site; as a percentage of Total Phosphorus, DP ranged from 19 to 100% during these six sample dates which occurred during dry-weather, low-flow conditions.

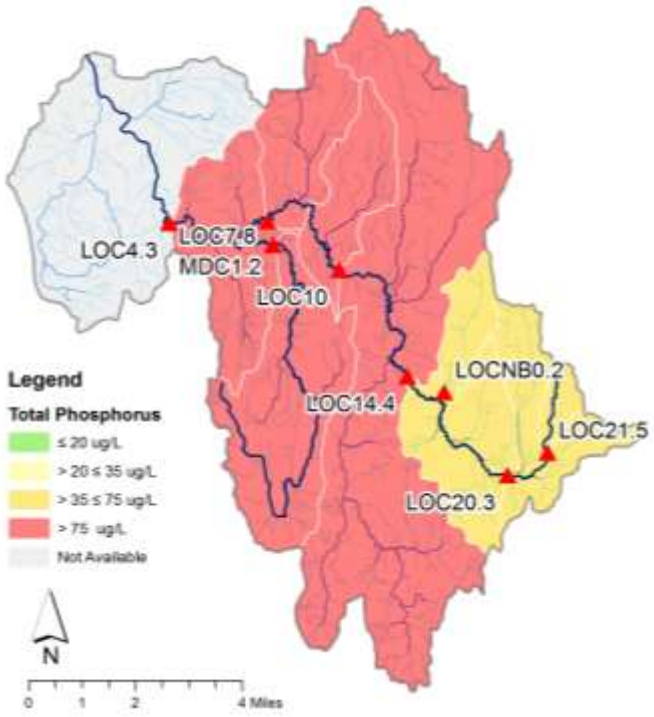


Figure 4. Mean value of Total Phosphorus detected on July, August and September sample dates during low flow conditions at or below the Low-Median-Monthly Flow, Little Otter Creek, 2016.

2017: The Little Otter Creek will continue to be a focus watershed in 2017, with the same sentinel and rotational sites monitored for *E.coli*, total and dissolved phosphorus, total nitrogen, and turbidity. Given the elevated TN concentrations at upper main stem sites, an additional lab analysis has been scheduled to detect nitrite and nitrate forms of nitrogen. Beginning in year 2018 and continuing through 2021, the number of sampling locations in this watershed will be reduced to two sentinel stations, LOC4.3 and MDC1.2, as the focus of more intensive sampling rotates to another Collaborative watershed.

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

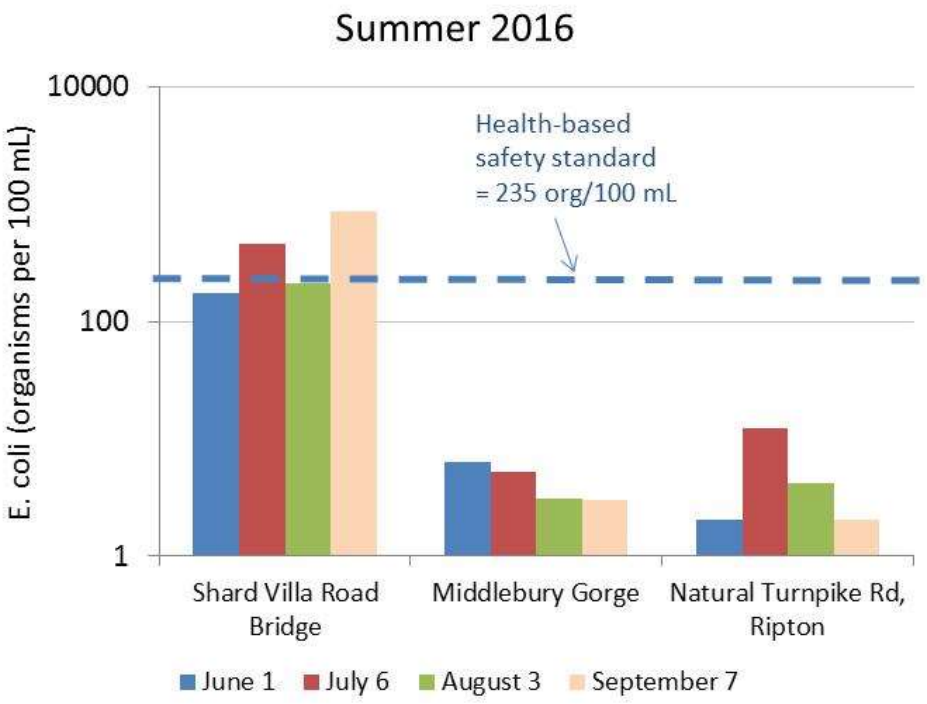
Middlebury River – 2016 Water Quality Summary
Addison County River Watch Collaborative

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 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records from the nearby USGS streamflow gage on the New Haven River. Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

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 2.0 to 866 organisms/ 100 mL. Vermont Water Quality Criteria (October 2014) 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 on two dates in 2016. 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 far 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 2016 were relatively low, ranging from <0.2 to 9.6 NTUs, with an average level of 2.3 NTUs for all samples collected. The Vermont state standard of 10 NTUs (for Class B cold-water fisheries) is applicable during dry-weather, baseflow conditions which were relevant to all six sample dates. Detected concentrations were below the standard at all three sentinel sites on all 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 – 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 low levels during the six spring and summer sampling dates of 2016. Concentrations ranged from 5.8 to 21.9 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 below the low median monthly flow on the July, August, and September sample dates. The mean of the results available for these three summer sampling dates was calculated as 21.2, 7.2 and 12.9 ug/L at MIR1.5, MIR5.7 and MIR10.6, respectively, each below the instream phosphorus criterion. Past years' sampling results, which include additional sites, show an increasing trend in phosphorus concentrations with distance downstream from the Middlebury Gorge.

2017: 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 2017. 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:
Heidi Willis, 352-4327, redsprings@myfairpoint.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

Focus watershed:
2016 and 2017

New Haven River - 2016 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 is the subject of a more intensive monitoring focus, where rotational as well as sentinel stations are monitored and additional parameters are being 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 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records from the USGS streamflow gage on the New Haven River at Brooksville. Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

Samples were tested for *E.coli*, phosphorus (total and dissolved), total 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 3.0 to 1,553 organisms/100 mL. Vermont Water Quality Criteria (October 2014) 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. The box-and-whisker chart in Figure 1 summarizes *E. coli* concentrations detected at all stations on summer sampling dates. The whiskers extend to the maximum and minimum values, while the gray-shaded box represents the interquartile range 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 number of samples (n) represented by each box-and-whisker is displayed across the top of the chart. The horizontal, gray dashed lines in Figure 1 represent the health-based and geomean standards for *E.coli*.

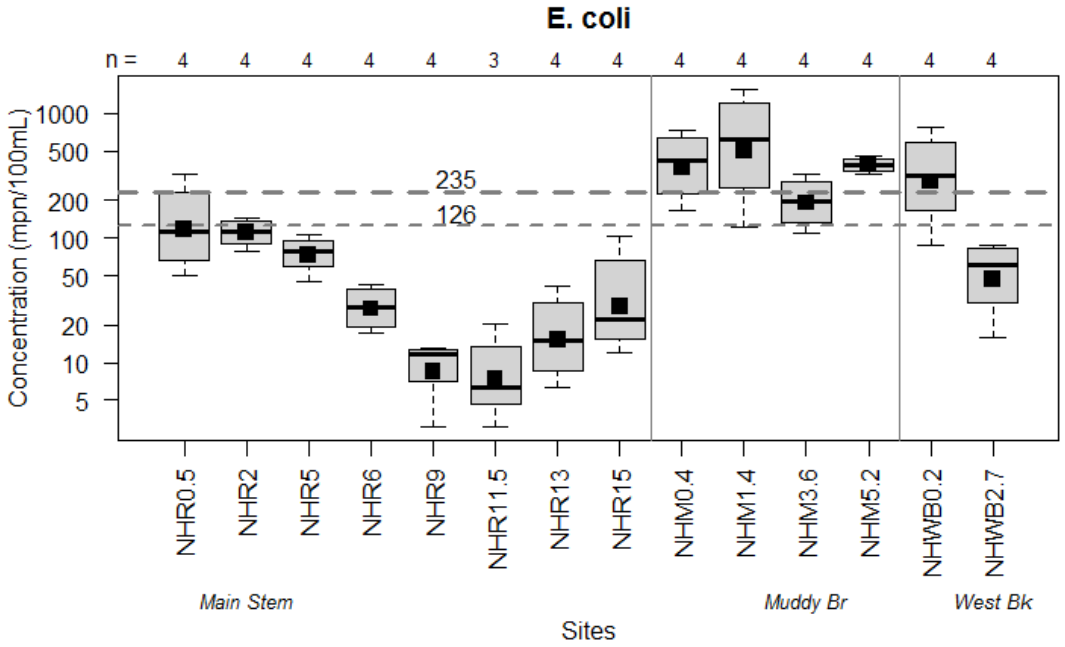


Figure 1. *E.coli* measured at New Haven River watershed stations on four dry-weather, low-flow dates in 2016.

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.

E. coli counts at popular recreational sites (e.g., Bartlett's Falls [NHR11.5], Sycamore Park [NHR6], and New Haven Mills [NHR5]) were below the health-based standard of 235 org/100 mL on all summer dates except for the September 3 sample from Nash Bridge in New Haven (NHR2).

Turbidity levels at the New Haven River watershed sites ranged from <0.2 to 35.5 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 all six sample dates.

The box-and-whisker plot in Figure 2 below shows the full distribution of Turbidity results for samples collected during six spring and summer events in 2016. The blue diamond 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. Detected concentrations were below the standard at all main stem sites on all six sample dates, 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 on multiple sample dates for all four of the Muddy Branch stations.

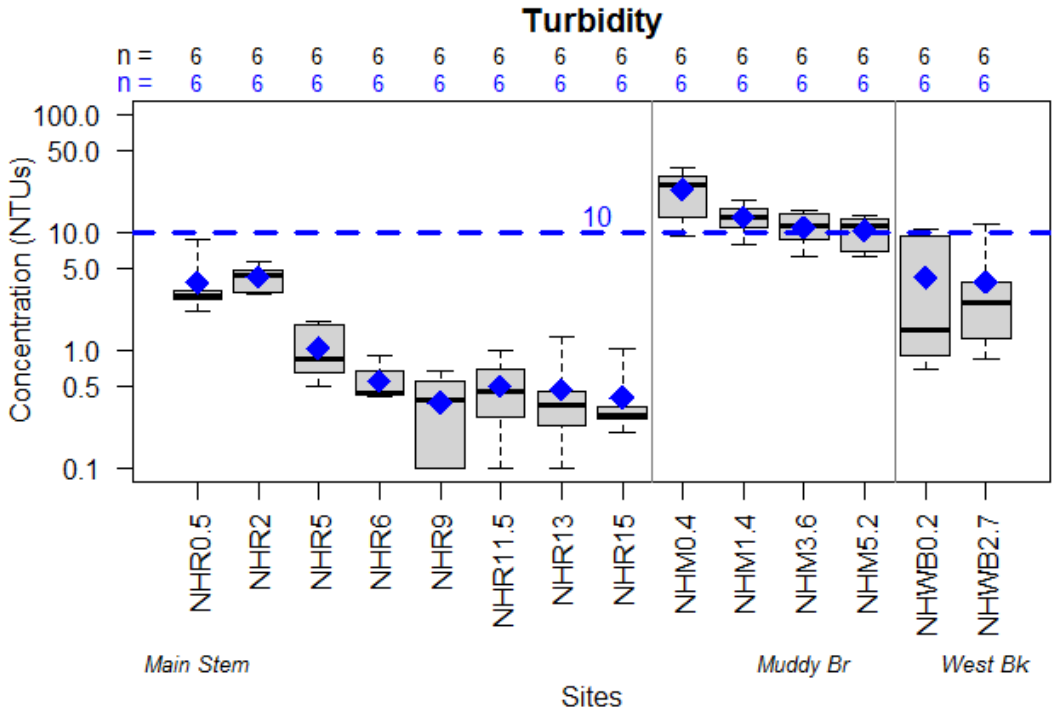


Figure 2. Summary of Turbidity results for New Haven River, 2016.

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.

Nitrogen was tested in samples collected only from the new stations established in West Brook and Muddy Branch, and was detected at relatively low concentrations at most stations during the six spring and summer sampling dates, ranging from 0.3 to 4.2 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) is not to 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 will be scheduled for these stations in 2017 to detect nitrite and nitrate forms of nitrogen.

Phosphorus was detected at low to moderate concentrations on the New Haven River during the spring and summer sampling dates. Concentrations ranged from 5.0 to 73 µg/L, with an average of 22.5 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 New Haven River at Brooksville, flows were below the low median monthly flow on the July, August, and September sample dates. The mean of the results available for these three summer sampling dates exceeded the standard at all four stations on the Muddy Branch (Figure 3). 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. Dissolved phosphorus was also tested at each of the six new sites in 2016. As a percentage of Total Phosphorus, DP ranged from 31 to 100% during these six sample dates which occurred during dry-weather, low-flow conditions.

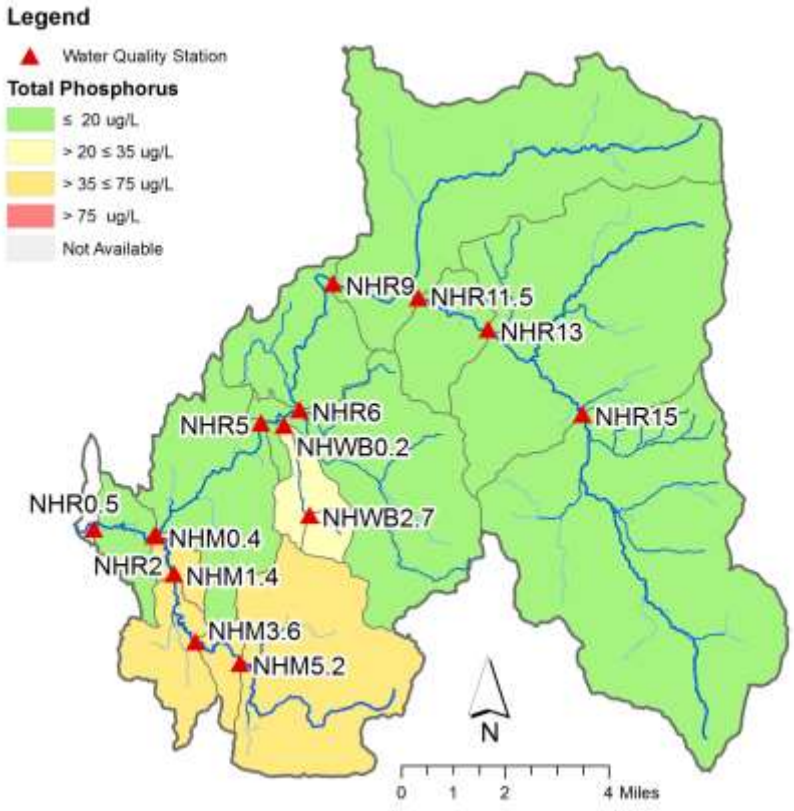


Figure 3. Mean value of Total Phosphorus detected on July, August and September sample dates during low flow conditions at or below the Low-Median-Monthly Flow, New Haven River, 2016

2017: The New Haven River will continue to be a focus watershed in 2017, with the same sentinel and rotational sites monitored for *E.coli*, total and dissolved phosphorus, total nitrogen, and turbidity. Given the elevated nitrogen concentrations in tributary sites, an additional lab analysis has been scheduled to detect nitrite and nitrate forms of nitrogen. Beginning in year 2018 and continuing through 2021, the number of sampling locations in this watershed will be reduced to two sentinel stations, NHR2 and NHR9, and two swimming hole sites, NHR11.5 and NHR6, as the focus of more intensive sampling rotates to another Collaborative watershed.

For more information, contact the New Haven River sampling coordinator:
Richard Butz, 453-6052, butzra@yahoo.com
Addison County River Watch Collaborative managing director:
Matt Witten, 434-3236, mwitten@gmavt.net
or visit our web page at: www.acrpc.org/acrwc

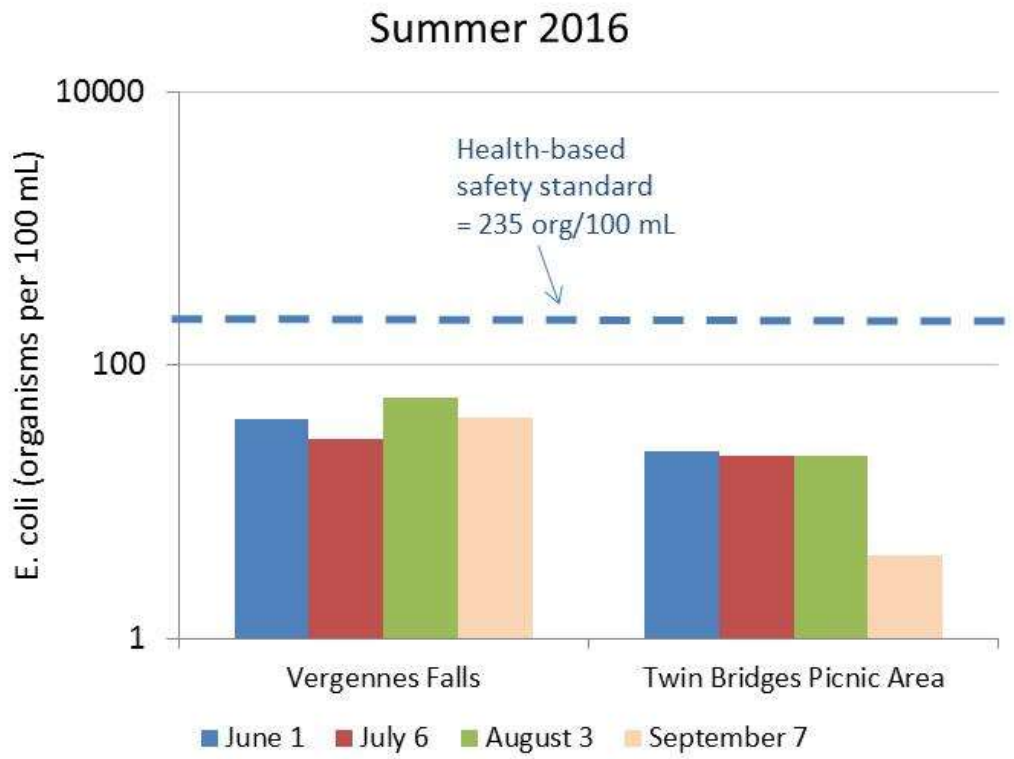
Otter Creek – 2016 Water Quality Summary
Addison County River Watch Collaborative

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 2016, sampling occurred on two spring dates (April 6 and May 4) and four summer dates (June 1, July 6, August 3, and September 7). Following a February thaw and final ice-out and snowmelt in early March, the April and May sampling events took place during relatively low flows, characterized as baseflow conditions on the river, based on streamflow gaging records from the Otter Creek station at Middlebury. Given below-normal rainfall, the June, July, August and September events occurred during low to very-low flows also representative of baseflow conditions (i.e., relatively stable flow stage, not significantly rising or falling in response to a rainfall or snowmelt event). On an average annual basis, flows in 2016 were below normal in the six Addison County watersheds monitored by the Collaborative.

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 4.1 to 57.8 organisms/100 mL. Vermont Water Quality Criteria (October 2014) 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. Neither standard was exceeded on the four summer sampling dates. 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.

Turbidity levels at the Otter Creek stations ranged from 1.6 to 10.9 NTUs, with a mean value of 5.3 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 relevant to all six sample dates. Detected concentrations were below the standard at both sentinel sites on all 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 16.9 to 33.4 µg/L, with a mean of 25 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 below the low median monthly flow on the July, August, and September sample dates. The mean of the results available for these three summer sampling dates was calculated as 23.3 and 30 µg/L at OTR18 and OTR7.3, respectively . The result for station OTR7.3 slightly exceeds the instream phosphorus criterion for WWMG waters. These reaches of the Otter Creek might instead be classified as a Slow Winder stream ecotype, but criteria have not yet been developed for this stream classification.

2017: 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 2017. 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:
Heidi Willis, 352-4327, redsprings@ myfairpoint.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