



Bear Creek Environmental

**Stowe Mountain Resort
SMR 2000 Community Plan
Water Quality Management Plan**

2016 Monitoring Report

May 30, 2017

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Stowe Mountain Resort SMR 2000 Community Plan Water Quality Management Plan

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EXECUTIVE SUMMARY

- Bear Creek Environmental, LLC (BCE) was retained by Stowe Mountain Resort (SMR or the Resort) to conduct water quality monitoring and sediment assessments in the West Branch of the Little River watershed as part of the SMR Community 2000 Master Development Plan (MDP). The purpose of the water quality monitoring program is to provide information and guidance for water quality protection during construction and development at Spruce Peak.
- BCE monitored water quality at fifteen stream stations during the 2016 monitoring period (June 2016 through May 2017). The monitoring stations are within the vicinity of Spruce Peak and are located within the West Branch of the Little River watershed and Pinnacle Brook watershed. Fifteen years of water quality monitoring have taken place at Stowe Mountain Resort.
- SMR conducted monitoring at all the stations specified in the Settlement Agreement during 2016-2017 and at many supplemental water quality stations. Additionally, samples were collected during runoff events from the outlets of two sediment basins.
- For the 2016-2017 monitoring season, there were four event-based sampling rounds during storm or melt events that resulted in significant runoff. Event-based samples were analyzed for pH, turbidity, chloride, conductivity, and temperature. Samples collected from the four Big Spruce Brook stations were also analyzed for total iron.
- Turbidity values reported in 2016-2017 were generally low. The highest stream turbidities were measured on the Spruce side of the Resort.
- Baseflow water chemistry monitoring also occurred during 2016-2017. Little Spruce Brook at the mouth exhibited the highest alkalinity of all baseflow stations in 2016, which may be related to crushed limestone that was installed in the vicinity of the Adventure Center during construction to prevent iron seeps. Over the past few years, chloride concentrations at Little Spruce RM 0.1 have shown an increasing trend, though concentrations remain below the limits in the Vermont Water Quality Standards.
- Macroinvertebrate sampling to assess the biological integrity of streams within the vicinity of Stowe Mountain Resort took place at six monitoring stations during fall 2016. Five of the 2016 biomonitoring stations are on the West Branch, and the sixth station is located on Pinnacle Brook. Biological monitoring was discontinued on Big Spruce Brook

in 2016 due to extensive historic iron seeps that impact the biological community and are infeasible to remediate.

- The control station, located at the picnic area in Smuggler's Notch, upstream of the Resort on the West Branch, was found to have good biological integrity. This upper station is likely impacted by acid precipitation. Over the past several years, the macrobenthic community at this upstream control station has teetered on the edge of full support for class B2 biocriteria. This upper West Branch station has historically passed about half of the time.
- Kick net samples were collected at three biomonitoring stations on the West Branch within the Resort. West Branch station at river mile 8.0 is located immediately upstream of the Mansfield basin, and results indicate the biological integrity was good to fair. The West Branch station below the Mansfield parking lot exit (RM 7.5) had fair biological integrity. A station was added in 2016 just downstream of station 7.5 on the West Branch. This new station (RM 7.4) had good biological integrity in 2016.
- Biomonitoring also took place on the West Branch immediately upstream of the confluence of Pinnacle Brook. This station, which is located downstream of the Resort had good to very good biological integrity in 2016. Pinnacle Brook, the reference stream, had very good biological integrity.
- Macrobenthic results indicate that sedimentation may be an issue for some of the West Branch stations based on community composition. Sediment is likely entering the West Branch during the spring before sand cleanup occurs on the Resort parking lots. The Resort continues to modify its plowing and cleanup plan to target the reduction of this sediment source. Vermont Route 108, a State-maintained road, is also likely a source of sediment due to winter sanding practices.
- The West Branch of the Little River watershed is hydrologically "flashy" and receives higher precipitation amounts than most places in Vermont. For stations that are prone to scour, this may result in low densities of macroinvertebrates following large flow events.
- Historic event-based and baseflow water chemistry data suggest that the streams in the vicinity of Stowe Mountain Resort are acid stressed. Several stations have exhibited very low alkalinities, which results in a naturally low buffering capacity for these waterways. In particular, Long Trail Brook and Gondola Brook have historically had low pH's, which impacts the pH of the West Branch in the vicinity of the Resort where these brooks meet. This may have implications for the biological community of the West Branch stations within the Resort. Additionally, a large wetland complex on the West Branch just upstream of the Resort may impact the biological community and create a shift in functional feeding groups. Iron is another potential stressor to the macroinvertebrate community on the West Branch at stations within the Resort.



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Stowe Mountain Resort

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2016 Monitoring Report

1.0 INTRODUCTION

Bear Creek Environmental, LLC (BCE) was retained by Stowe Mountain Resort (SMR or the Resort) to conduct water quality monitoring and sediment assessments in the West Branch of the Little River watershed. This report summarizes the monitoring activities associated with the Water Quality Management Plan (WQMP) from summer 2016 through spring 2017 as part of the SMR Community 2000 Master Development Plan (MDP).

The purpose of the WQMP is to provide information and guidance for water quality protection during construction and development at Spruce Peak. SMR began the implementation of this plan in 1999. One primary objective of the WQMP is to document water quality conditions throughout the implementation of the MDP. Another objective is to show that the MDP will not result in any undue water pollution to the waters of Vermont according to Criterion 1 of Act 250. As part of the MDP, Spruce Peak construction started in 2003. The data collected in summer 2016 through spring 2017 represents the fourteenth year of monitoring during construction. Monitoring data has been collected annually from the Big Spruce Brook watershed and the West Branch Little River Watershed.

Big Spruce

Big Spruce Brook was placed on the Part C of the 2008 Vermont List of Priority Waters by the Agency of Natural Resources (ANR) as in need of further assessment to determine compliance with the Vermont Water Quality Standards (VWQS). In 2010, Big Spruce Brook was moved to Part B of the Vermont Priority Water List, based on monitoring data from the previous four years. Waters listed on Part B are considered impaired, but do not require the development of a Total Maximum Daily Load (TMDL). Rather, the development of a water quality remediation plan is required so that the VWQS are attained. The Agency of Natural Resources issued a 1272 order on May 6, 2010 to serve as a water quality remediation plan to address sources of iron and sediment identified in Big Spruce Brook (Refer to Appendix 2 of 2010 Monitoring Report; Nealon, 2011).

Following the issuance of the 1272 order, improvements were completed by SMR to remediate a local iron seep adjacent to the Club House and to improve stormwater management to reduce sediment impacts. Despite these remediation efforts, both Big Spruce monitoring stations have shown little improvement. In May 2015, extensive iron seeps were documented that are contributing to impairment of the macroinvertebrate community. These iron seeps do not appear to be related to construction activities at Spruce Peak, and have likely existed for many years. Bear Creek Environmental conducted a stream reconnaissance with Steve Fiske, Aquatic Biologist with the Vermont Department of Environmental Conservation (VDEC) during September 2015 and noted iron seeps are strong, extensive in length, and are in steep locations that are not accessible. Big Spruce Brook from river mile 0.2 to river mile 0.3 is listed as impaired on the 2016 Final Part B List of Priority Surface Waters due to sediment and iron. Big Spruce Brook was initially listed as impaired from river miles 0.3 to 0.8; however, this listing was removed as part of the final 2016 list due to the unknown cause of iron inputs and infeasibility for remediation within this section of the brook (State of Vermont, 2016).

Spruce Peak Realty is continuing to work with consultants and the VDEC for solutions to bring to bring Big Spruce Brook in compliance with VWQS; however, the remediation of these iron seeps does not appear to be feasible given the location and extent. The seeps are located at the

bottom of steep, heavily vegetated slopes where access is impractical. In 2015, The Mount Mansfield Company initiated an additional evaluation with VHB, Civil Engineering Associates and Bear Creek Environmental to explore options to reduce sedimentation in the Big Spruce watershed in the vicinity of the Sensation Lot, Spruce Peak Road, and from in-channel and bank erosion within the Ski Club drainage. The Ski Club drainage is located primarily on privately owned land. Although adjustments along the Ski Club drainage have been identified as a potential sediment source, no remediation work can occur on the brook without the consent, cooperation, and financial participation of the private landowner. In collaboration with the private landowner, Stowe Mountain Resort worked with a contractor during the 2016 construction season to replace a private driveway culvert over the Ski Club drainage that was causing channel and bank erosion.

West Branch of Little River

The West Branch from RM 7.5 to 8.0 was placed on the 2012 list of impaired waters by the ANR. Based on a meeting held between ANR and SMR on March 15, 2012, and written comments dated April 11, 2012, the West Branch was moved to Part B of the Vermont Priority Waters List, where it currently remains (State of Vermont, 2016). A 1272 order was issued by Pete LaFlamme of the ANR on May 3, 2012 to provide steps to be implemented to improve water quality of the West Branch (Refer to Appendix 2 of 2012 Monitoring Report; Nealon and Kinghorn, 2013). SMR developed and implemented measures during 2012 to reduce hydrologic and sediment impacts in the West Branch by improving stormwater management and infrastructure. Turbidity results from the past few years indicate the stormwater infrastructure is working to reduce sediment inputs; however, the macroinvertebrate metrics for the West Branch in the vicinity of the Resort are not consistently meeting Class B water quality standards. Further investigation is needed to determine the relationship between the flashy upland streams that feed into the West Branch within the Resort as well as the hydrologic characteristics of the West Branch watershed. Biologic and physical results indicate that the West Branch within the Resort has a tendency to settle out sands where the slope drops, yet is still susceptible to scour during large flow events. The proximity of Vermont Route 108 and the winter maintenance practices for this state managed road are likely factors contributing to

sedimentation of the West Branch. This state route is outside the control of Stowe Mountain Resort.

Minor construction activities within the Little Spruce watershed occurred during 2016 and early 2017 at Stowe Mountain Resort as part of the SMR 2000 Master Development Plan.

Construction work continued at the Spruce Adventure Center. This work mostly encompassed interior work, some trim/exterior, and final landscaping. Site work and construction of the Village Town Home project, which is also within the Little Spruce watershed, began in the late fall 2016 and will continue through May 2018. The Village Town Home project is located to the east of the Spruce Adventure Center.

A couple of construction projects that are within the West Branch watershed will likely be underway during the 2017 construction season. First, installation of the roadway and utilities to serve the Switchback subdivision is expected to begin during summer 2017. A tennis court in and adjacent to the Spruce Peak Center parking lot is also anticipated for the 2017 construction season. Ongoing single family construction that is outside the oversight of Spruce Peak Realty will be occurring in the Spruce single family neighborhood, above the Spruce Peak Base Area.

2.0 STUDY AREA AND METHODOLOGY

BCE monitored water quality at fifteen stream stations (see page I of Appendix I) during the 2016 monitoring period, as well as two stormwater basin outlets and two stations on a small drainage. In 2016, Stowe Mountain Resort worked with the State to refocus monitoring efforts on areas of concern. Event-based monitoring was reduced from quarterly to three times per year, and chloride was added as a parameter, as well as total iron on Big Spruce Brook only. Several monitoring stations on the Mansfield side of the Resort were removed from event-based monitoring and one was added on the Spruce side to target monitoring efforts there. Nine stations were sampled for baseflow water chemistry monitoring in 2016. In 2016, biological monitoring of benthic macroinvertebrates was discontinued on Big Spruce Brook.

The monitoring stations at Stowe Mountain Resort are located within the West Branch of the Little River watershed and Pinnacle Brook watershed. The drainage areas of the subwatersheds are included in Table I.

Table I. Drainage Areas of Subwatersheds in the Vicinity of SMR		
Subwatershed	Description	Drainage Area (Sq. miles)
West Branch	Above confluence with Pinnacle Brook	4.81
Pinnacle Brook	Tributary to West Branch	2.31
Big Spruce Brook	Tributary to West Branch	0.78
Little Spruce Brook	Tributary to Big Spruce Brook	0.12
Ski Club Drainage	Tributary to Big Spruce Brook	0.02
Gondola Brook	Tributary to Long Trail Tributary	0.90
Long Trail Tributary	Tributary to West Branch	1.44

The station numbering of the monitoring stations was revised in 2006 to provide a spatial reference to the stations and to be consistent with the methodology that the Vermont Department of Environmental Conservation (DEC) uses for numbering its stations. The first two letters of the station name are short for the surface water: West Branch of Little River (WB), Big Spruce Brook (BS), Little Spruce Brook (LS), Pinnacle Brook (PB), Ski Club drainage (SC), Gondola Brook (GB), and Long Trail Brook (LT). The number in the station name represents the river mile and is the distance from the mouth. The sediment basin outflow sampling locations are identified as outlets. A brief description of the stations and the rationale for sampling is provided below.

West Branch of Little River above Stowe Mountain Resort - WB8.8: Located behind the picnic area off Route 108 in Smugglers Notch, this upper monitoring station was added in 2011 to provide a local control station upstream of Stowe Mountain Resort.

West Branch of Little River at Barnes Camp - WB8.2: Located upstream of the Resort near Barnes Camp, this station offers a background turbidity monitoring station upstream of

the Mansfield Basin and development at the Mansfield Base area. This station was added in 2011 to better understand sources of turbidity to station WB8.0.

West Branch of Little River below Long Trail Tributary - WB8.0 (MS-16B): This station on the West Branch is located directly downstream of the intermountain connector lift and upstream of the discharge from the sedimentation basin that treats the stormwater from the Mt. Mansfield parking lot. It was added in 2006, per the recommendation of Steve Fiske, to bracket the Mt. Mansfield sedimentation basin.

West Branch of Little River above Big Spruce Brook - WB7.5 (MS-8): This station is located on the West Branch above the Big Spruce confluence. The station extends from the bridge at the exit of the Mansfield side of the Resort downstream to the first section of rock riprap. The purpose of sampling WB7.5 is to evaluate the water quality and biological community upstream of the Spruce Hamlet project and the golf course, yet downstream of the Mansfield Basin. Per the Settlement Agreement, sampling at WB7.5 is required annually until the year after completion of build out.

West Branch of Little River above Big Spruce Brook - WB7.4: This station is located downstream of the first section of rock riprap below the exit from the Mansfield side of the Resort and upstream of the large mass failure on the West Branch. It was sampled in fall 2016 to provide a station on the West Branch downstream of the Mansfield basins that appears to be less susceptible to scour.

West Branch of Little River above Pinnacle Brook Confluence - WB6.5 (MS-14): This station on the West Branch is located immediately above the confluence of Pinnacle Brook. The lower West Branch station is located below the Spruce Hamlet development and much of the drainage from the golf course. The Stowe Mountain Resort Settlement Agreement dated June 13, 2000 specifies that monitoring at WB6.5 be conducted every other year until the year after completion of build-out. SMR has gone beyond this agreement and has sampled WB6.5 annually.

Gondola Brook – GB0.1: The Gondola Brook station is located at the mouth of Gondola Brook, just downstream of the crossing that enters the Mansfield Basin Parking Lot. The station was added in 2012 to better track sources of turbidity.

Long Trail Brook – LT0.1: The Long Trail Brook station is located at the mouth of Long Trail Brook, just upstream of the crossing that enters the northernmost parking lot at the Resort. The station was added in 2012 to better track sources of turbidity.

Big Spruce Brook below Ski Trails – BS0.9 (MS-9): This station is located on Big Spruce Brook above the golf course limits. BS0.9 acts as the background water chemistry station for the golf course, and is located below the ski and lift construction and existing ski trails. Per the Stowe Mountain Resort Settlement Agreement dated June 13, 2000, no sampling is required at this station during the construction phase.

Big Spruce Brook above basin – BS0.7: Located on Big Spruce above the outlet of the Big Spruce Basin, this station was added voluntarily in 2009 by SMR to provide turbidity data upstream of the basin.

Big Spruce upstream of Club House – BS0.3 (MS-10A): This station on Big Spruce Brook is located immediately downstream of the new golf course bridge and upstream of the confluence with Little Spruce Brook. This station was added voluntarily by Stowe Mountain Resort following a site visit with Steve Fiske (DEC) in July 2006.

Big Spruce at Mouth – BS0.2 (MS-10): Located on Big Spruce Brook above the confluence of the West Branch, BS0.2 covers the area between the bridge crossing at the ski hostel and the bedrock outcrop, which is below the confluence of Little Spruce Brook. BS0.2 serves as the downstream monitoring station for the golf course. The Stowe Mountain Resort Settlement Agreement dated June 13, 2000 calls for annual monitoring at this station until the year after completion of build-out.

Little Spruce Brook – LS0.3: This station is located on Little Spruce Brook below the ski trails on Spruce Peak but above the construction at the Spruce Hamlet Development. Sampling at this station is not required by the Settlement Agreement. This station was added in 2016 at the request of Steve Fiske with the VDEC to track turbidity above the construction at Spruce Peak.

Little Spruce Brook – LS0.1 (MS-11): Located on Little Spruce Brook below the Spruce Hamlet Development, LS0.1 serves as a monitoring station downstream of the Spruce Hamlet Development. Sampling at this station during construction is not required by the Settlement Agreement. Stowe Mountain Resort (SMR) has conducted voluntary monitoring on Little Spruce throughout the construction phase.

Pinnacle Brook Lower– PB0.1 (MS-13): PB0.1 serves as the local/reference site. Below the upper monitoring station, a very small portion of the golf course (holes 7 and 8) drains toward Pinnacle Brook. The stump dump and the gravel pit also are located between the two Pinnacle Brook stations. The stump dump was covered and seeded in August 2006 and the gravel pit was closed off and seeded in August 2006 as well. Although no monitoring of Pinnacle Brook is required by the Stowe Mountain Resort Settlement Agreement dated June 13, 2000 during the construction phase, SMR has voluntarily sampled PB0.1 throughout the construction phase.

Ski Club Drainage – SC0.2: The upper Ski Club drainage monitoring station is located near the Ski Club, where a couple of small drainages come together. The station was added in 2010 to provide turbidity data above a steep section of the Spruce Peak Access Road, where road runoff has been a concern.

Ski Club Drainage – SC0.1: The lower Ski Club drainage monitoring station is located at the mouth of the Ski Club drainage, just upstream of the culvert that passes under the Spruce Peak Access Road to the Big Spruce Basin. The station was added in 2010 to provide turbidity data to better understand the sediment contribution to the basin.

Mt. Mansfield Basin Outlet (OUTLET 1): Outlet 1 drains from the Mansfield sedimentation basin into the West Branch between stations WB8.0 and WB7.5.

Big Spruce Basin (OUTLET 3): Outlet 3 drains into Big Spruce Brook immediately downstream of BS0.7.

Table 2 provides a list of monitoring parameters evaluated at the 2016-2017 monitoring stations. Table 3 shows the drainage and approximate elevation of the six biomonitoring stations.

Table 2. 2016-2017 Water Quality Monitoring Stations at Stowe Mountain Resort					
Station	Location	Monitoring Parameter			
		Baseflow	Turbidity	Sediment	Biomonitoring
WB8.8	West Branch at picnic area above SMR	+		+	+
WB8.2	West Branch above Barnes Camp		+		
WB8.0 (MS-16B)	West Branch below Barnes Camp	+	+	+	+
WB7.5 (MS-8)	West Branch below Mansfield exit	✓	✓	✓	✓
WB7.4	West Branch below riprap and above large mass failure			+	+
WB6.5 (MS-14)	West Branch above Pinnacle Brook confluence	✓		✓	✓
LT0.1	Long Trail Tributary at Mansfield Entrance		+		
GB0.1	Gondola Brook at Mansfield Entrance		+		
BS0.9 (MS-9)	Big Spruce Brook below ski trails	+	+	+	
BS0.7	Big Spruce above Big Spruce Basin		+		
BS0.3 (MS-10A)	Big Spruce upstream of Club House		+		
BS0.2 (MS-10)	Big Spruce Brook at mouth	✓	✓	✓	
LS0.3	Little Spruce Brook below ski trails	X	X		
LS0.1 (MS-11)	Little Spruce Brook at mouth	X	+		

Table 2. 2016-2017 Water Quality Monitoring Stations at Stowe Mountain Resort					
Station	Location	Monitoring Parameter			
		Baseflow	Turbidity	Sediment	Biomonitoring
PB0.1 (MS-13)	Lower Pinnacle Brook	+		+	+
SC0.2	Upper Ski Club Drainage		+		
SC0.1	Lower Ski Club Drainage		+		
Outlet 1	Mansfield Basin		+		
Outlet 3	Big Spruce Basin		+		
+ - additional voluntary monitoring by Stowe Mountain Resort not required in Settlement Agreement X - Station added per request of Steve Fiske !Basin outlet sampled only if there is a discharge to waters of the state.					

Table 3. Drainage and Elevation of Biomonitoring Stations			
Station	Location	Drainage Area (sq. mi.)	Elevation (feet)
WB8.8	West Branch at picnic area upstream of Resort	1.18	1605
WB8.0	West Branch upstream of Mansfield Basin	2.92	1480
WB7.5	West Branch downstream of Mansfield Basin	3.56	1410
WB 7.4	West Branch below riprap and above large mass failure	3.71	1409
WB 6.5	West Branch above confluence with Pinnacle Brook	4.81	1250
PB0.1	Pinnacle Brook at mouth	2.31	1255

3.0 WEATHER AND FLOW

Precipitation

The West Branch watershed lies exclusively within the Northern Green Mountains biophysical region. This region is characterized by Thompson and Sorenson (2005) as having high elevations and cool summers. The Green Mountains have a strong influence on the weather, resulting in an abundance of precipitation in the form of both rain and snow. Precipitation within the West Branch watershed averages 53 inches annually (USGS, Scott Olson, pers. comm., 2004). On the top of Mount Mansfield annual precipitation averages over 78 inches. For the 2016 calendar year, 64.62 inches of precipitation was reported at the Mount Mansfield weather station operated by the National Weather Service. Precipitation increases with elevation, at about an inch per 1000 feet of elevation (Wemple, 2002). Mount Mansfield receives more precipitation than most areas of the State. An orographic effect often occurs on Mount Mansfield.

Streamflow

Unitized annual peak stream flow values for the period of record from the West Branch and Ranch Brook are presented below in Table 4 and graphed in Figure 1. During 2016 the USGS West Branch gage was not operating between February 29, 2016 and August 31, 2016; therefore, the peak flow for the West Branch for Water Year 2016 is not available. The peak flow during the 2016 water year on Ranch Brook was 86.3 cfs/sq. mi, which is close to the median for 2001 through 2015.

Table 4. Annual Peak Flows West Branch and Ranch Brook USGS Gaging Stations				
Water Year	West Branch		Ranch Brook	
	Date	Unitized Peak Flow (cfs/sq. mi.)	Date	Unitized Peak Flow (cfs/sq. mi.)
2001	Aug. 31, 2001	81.0	Apr. 24, 2001	79.7
2002	May 17, 2002	85.8	Apr. 14, 2002	88.7
2003	Jun. 14, 2003	60.4	Mar. 29, 2003	52.1

Table 4. Annual Peak Flows West Branch and Ranch Brook USGS Gaging Stations				
Water Year	West Branch		Ranch Brook	
	Date	Unitized Peak Flow (cfs/sq. mi.)	Date	Unitized Peak Flow (cfs/sq. mi.)
2004	Nov. 20, 2003	91.0	Nov. 19, 2003	96.3
2005	Aug. 31, 2005	52.0	Aug. 31, 2005	55.8
2006	May 19, 2006	108.8	May 19, 2006	99.7
2007	Oct. 28, 2006	66.4	Oct. 28, 2006	93.2
2008	Jul. 24, 2008	87.4	Jul. 20, 2008	127.1
2009	May 10, 2009	127.4	May 10, 2009	83.9
2010	Aug. 04, 2010	372.6	Aug. 04, 2010	95.0
2010	Sep. 30, 2010	233.4	Sep. 30, 2010	297.4
2011	Apr. 27, 2011	306.2	Apr. 27, 2011	258.7
2011	Aug. 28, 2011	204.9	Aug. 28, 2011	121.3
2012	June 27, 2012	60.0	March 08, 2012	42.6
2013	May 23, 2013	135.1	July 4, 2013	205.3
2014	April 15, 2014	141.3*	April 15, 2014	135.3*
2015	June 9, 2015	122.3	June 9, 2015	111.8
2016	Not available ¹		April 1, 2016	86.3
Median ²		91.0		96.3
Mean ²		126.5		121.8
Maximum ²	Aug. 04, 2010	372.6	Sep. 30, 2010	297.4
Extreme Peak flow events (>250 cfs/square mi.) in bold font * Discharge is an estimate ¹ West Branch gage not in operation between February 29, 2016 and August 31, 2016 ² 2016 not included in summary statistics				

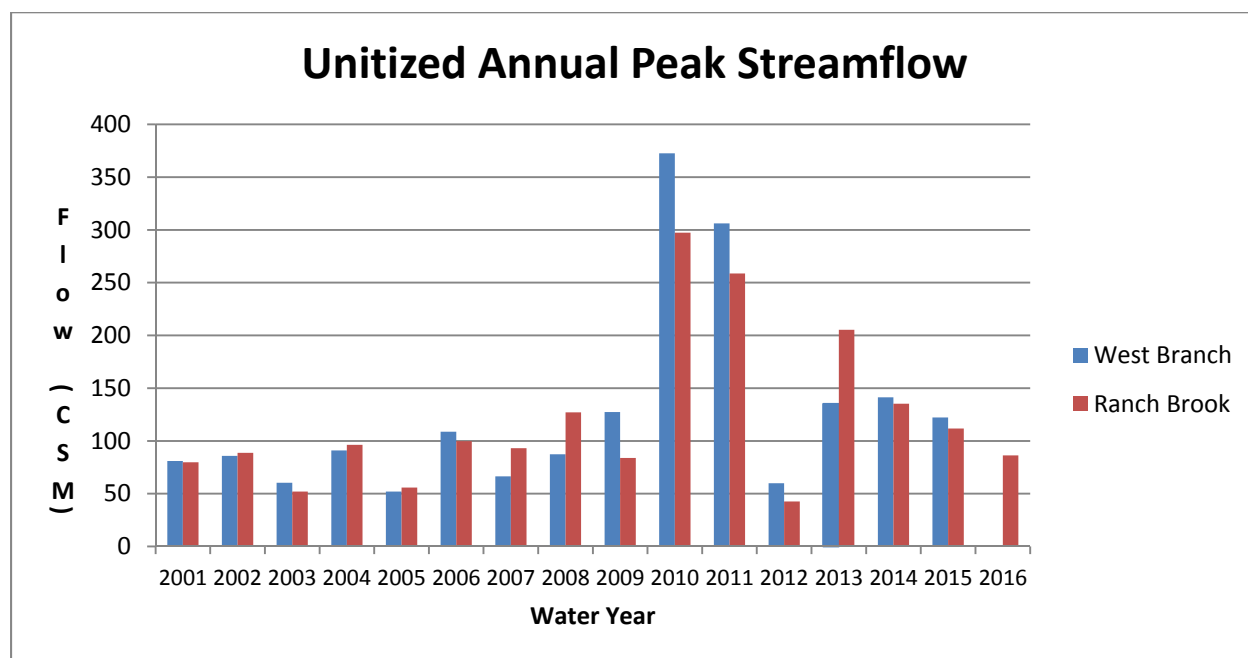


Figure 1. Annual unitized peak stream flow values for the West Branch and Ranch Brook.

4.0 WATER QUALITY STANDARDS

The Vermont Water Quality Standards (VWQS) (State of Vermont Water Resources Board, effective October 30, 2014) were in effect during 2016 and were used to evaluate water quality parameters for three the four event-based sampling rounds and the baseflow sampling that took place in July and September 2016. Table 5 shows the water quality standards used for comparison in this study. There are no established standards for conductivity or total suspended solids in surface water. Therefore, there are no comparisons against standards for these analytes in the tables and text. According to the 2014 VWQS, in general total phosphorus loads should be limited so as not to “contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses.”

Table 5. 2014 Vermont Water Quality Standards for Class B Waters	
Parameter	Standard
pH	6.5 to 8.5 s.u.
Chloride	230 mg/L average or 860 mg/L maximum
Iron	1.0 mg/L
Nitrate-nitrogen	5.0 mg/L
Total Phosphorus	0.012 mg/L ¹
Turbidity	10 NTU ²
Notes: 1. Standard for small, high gradient stream 2. Standard for cold water fish habitat	

The State of Vermont amended the Vermont Water Quality Standards in 2016. These new standards took effect on December 15, 2016, and thus were used to evaluate water chemistry monitoring for the one round of event-based sampling that was conducted after this date. The updated VWQS feature the same standards for pH, chloride, iron, nitrate, and total phosphorus as the 2014 standards. The standard for turbidity has changed and no longer applies to event-based monitoring. Applicable standards from the 2016 VWQS are featured below in Table 6.

Table 6. 2016 Vermont Water Quality Standards for Class B Waters	
Parameter	Standard
pH	6.5 to 8.5 s.u.
Chloride	230 mg/L average or 860 mg/L maximum
Iron	1.0 mg/L
Nitrate-nitrogen	5.0 mg/L
Total Phosphorus	0.012 mg/L ¹
Turbidity	25 NTU ²
Notes: 1. Standard for small, high gradient stream 2. Standard for annual average under dry weather baseflow conditions	

4.1 Baseflow Sampling Results

Baseflow chemistry monitoring was completed at the following stations during 2016: the West Branch at river miles 8.8, 8.0, 7.5, and 6.5, Big Spruce Brook at river miles 0.9 and 0.2, Little Spruce Brook at river miles 0.3 and 0.1, and Pinnacle Brook at river mile 0.1. Required

monitoring parameters include: Alkalinity, pH, and chloride for all the stations and total phosphorus for Big Spruce and Little Spruce only. Baseflow sampling occurred at two stations on Big Spruce Brook and one station on Little Spruce Brook on July 7, 2016. A second round of baseflow sampling occurred at all nine monitoring stations on September 21, 2016, two days before the annual biomonitoring. The results of baseflow water chemistry from 2000 through 2016 are found on pages 2 through 12 of Appendix I.

Alkalinity

Alkalinity indicates the buffering capacity of water. Aquatic life requires buffering capacity to minimize the impact of acid precipitation. Low alkalinity values, especially those below 4 mg/L as CaCO₃, suggest that a stream is critically acidified and the macroinvertebrate community would be likely impacted.

Figure 2 shows the mean alkalinity values of the West Branch biomonitoring stations for fall 2003 through fall 2016. In 2016, all West Branch stations had mean alkalinity values of less than 10 mg/L as CaCO₃, with the exception of the West Branch at RM 6.5. In previous monitoring years, the alkalinity of West Branch RM 6.5 has always been less than 20 mg/L. It is unclear whether the higher alkalinity recorded at RM 6.5 in 2016 is within the natural variation or is in response to higher alkalinities noted in streams within the past two years on the Spruce side of the Resort.

Alkalinity was high at Little Spruce station 0.1, measuring a reported 105 mg/L as CaCO₃ and 103 mg/L as CaCO₃ on July 7, 2016 and September 21, 2016, respectively. This contrasts with an alkalinity of 15 mg/L at Little Spruce station 0.3, which is located at the base of the ski trails. Alkalinity was reported at 145 mg/L as CaCO₃ for baseflow sampling in 2015 at LS 0.1, but was much lower for samples collected in 2013 and 2014 (6.8 mg/L and 6.7 mg/L, respectively). It is possible that limestone added to prevent iron seeps as part of the construction of the Adventure Center, contributed to increased alkalinity levels in 2015 and 2016.

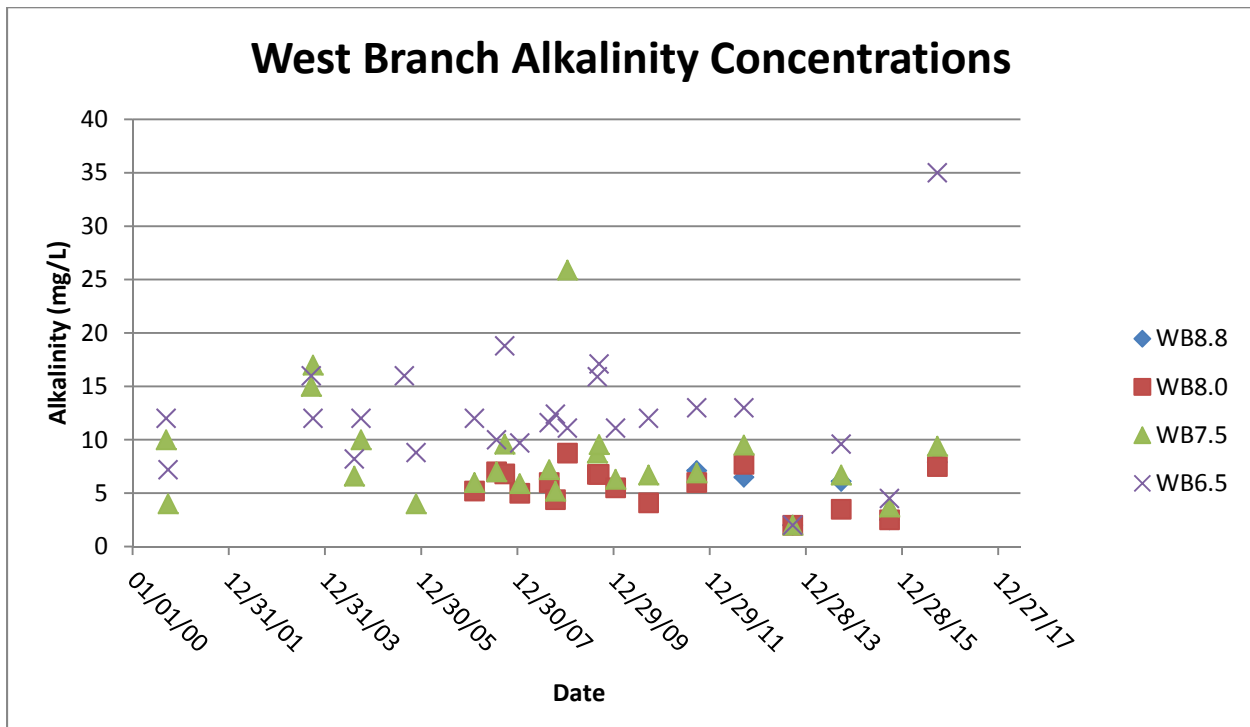


Figure 2. Alkalinity values from 2000 through 2016 for West Branch of Little River.

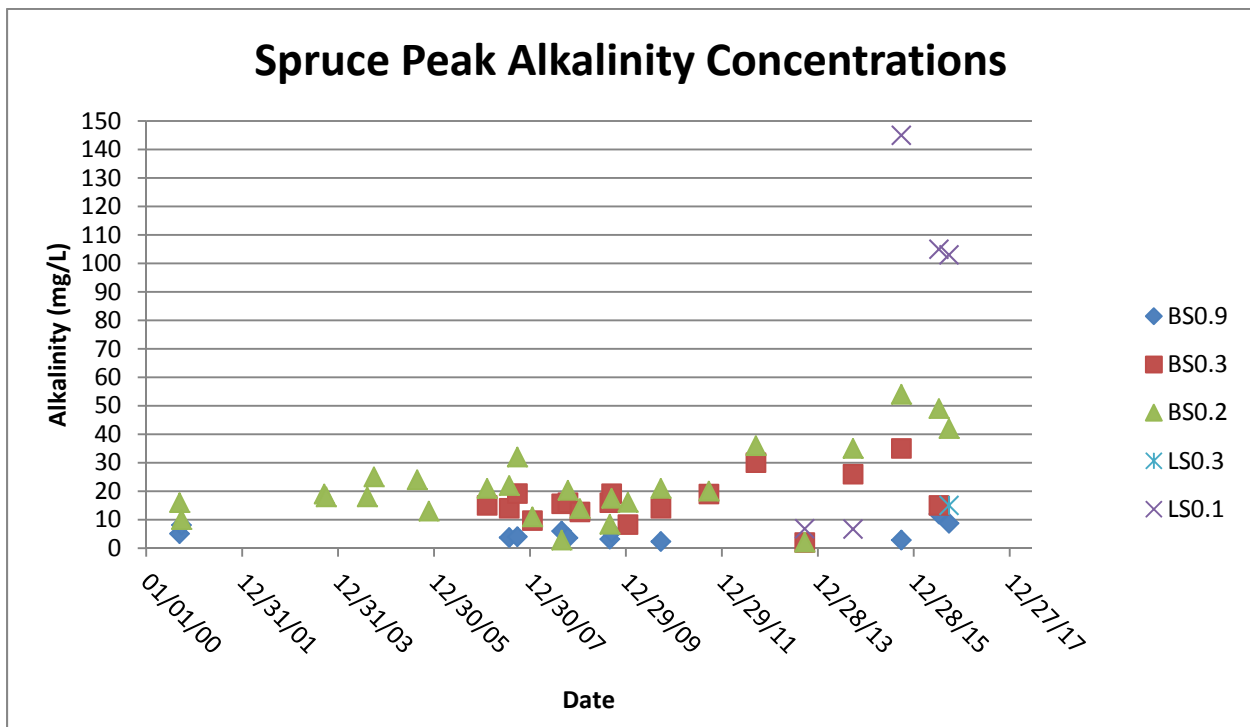


Figure 3. Alkalinity values from 2000 through 2016 for Spruce Peak.

The Big Spruce stations have had the highest alkalinity historically; while Pinnacle Brook and the upper West Branch stations have the lowest. For past years, alkalinity has shown an increasing trend from upstream to downstream on the West Branch. For the 2016 sampling round, Little Spruce Brook at RM 0.1 had the highest alkalinity, as mentioned above. Big Spruce Brook was next highest at RM 0.2 (49 mg/L CaCO_3 and 42 mg/L CaCO_3), followed by the West Branch at RM 6.5 (35 mg/L). The lowest alkalinity values were observed at Pinnacle Brook RM 0.1 (6.3 mg/L CaCO_3) and the West Branch RM 8.8 (7.9 mg/L CaCO_3). These low alkalinity values suggest that some of the streams at and surrounding Stowe Mountain Resort have a low buffering capacity and are susceptible to the impacts from acid precipitation.

pH

The pH values for all baseflow samples collected in 2016 were within the water quality standard limits of 6.5 to 8.5 s.u.

Chloride

Chloride concentrations for the West Branch watershed and the Big Spruce watershed over time are plotted below in Figures 4 and 5. As shown in Figure 4, the chloride concentrations at all the West Branch stations under baseflow conditions have been less than 25 mg/L. These concentrations are well below the chronic criteria for protection of aquatic life, which is listed as an average of 230,000 $\mu\text{g/L}$ (230 mg/L), as well as the acute criteria of 860,000 $\mu\text{g/L}$ (860 mg/L) maximum in the Vermont Water Quality Standards (State of Vermont, 2014 & 2016). As expected, the most downstream West Branch station sampled (WB6.5) had slightly higher chloride concentrations than the upstream stations. The average concentration for the 25 samples at WB6.5 is 12.4 mg/L. Chloride concentrations were lowest at the most upstream station, WB 8.8, and were less than the detection limit of 2.5 mg/L for the annual sampling that was conducted in September 2011 through 2016.

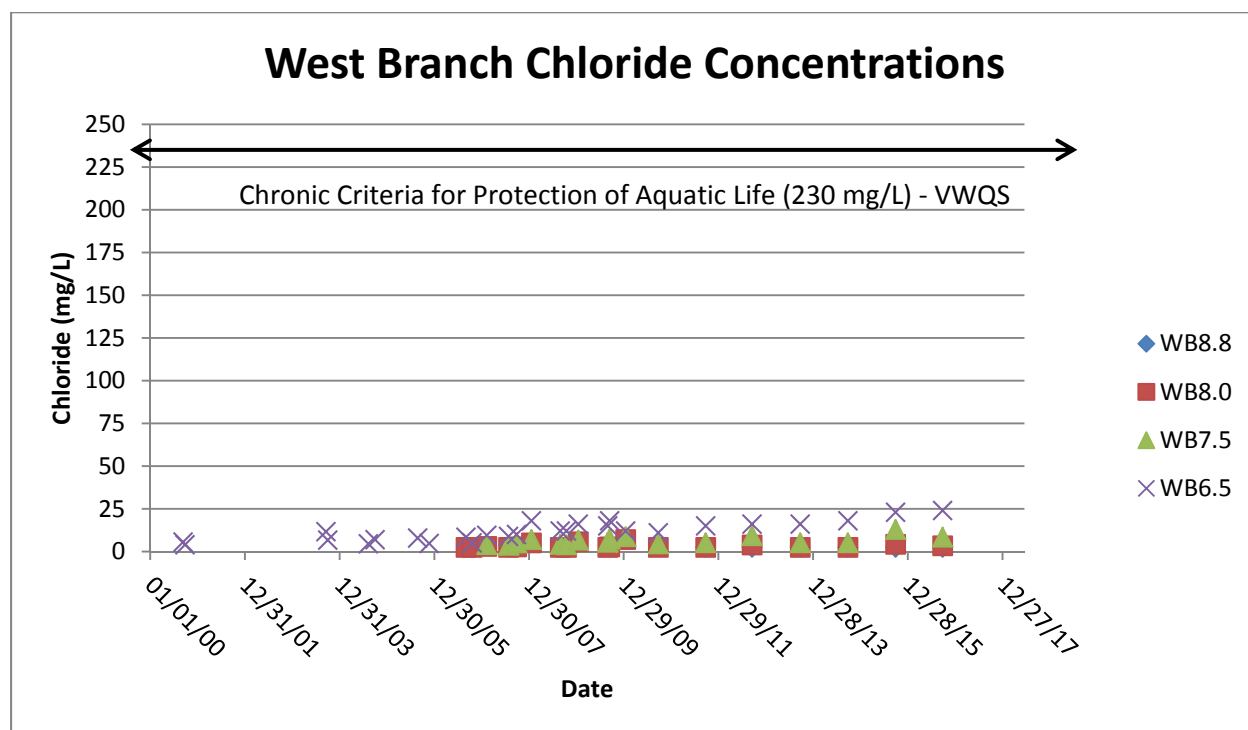


Figure 4. Chloride concentrations from 2000 through 2016 for West Branch of Little River.

Baseflow sampling in the Spruce Peak watershed has been conducted for different lengths of time at the monitoring stations. BS0.2, the most downstream station on Big Spruce Brook has the longest period of record (2000, 2003-2016). Chloride concentrations at this most downstream station suggest an upward trend over time. Baseflow sampling has been conducted at BS0.3 since 2006, but was discontinued in 2016. In general, chloride concentrations at BS0.3 have been slightly lower than BS0.2. The most upstream Big Spruce station (BS0.9) has been sampled 17 times over the years with chloride concentrations being recorded less than the detection limit of 2.5 mg/L each time, with the exception of July 2016 when it was reported to be 13 mg/L. The highest chloride concentrations recorded have been at the Little Spruce RM 0.1 station, near the mouth of the brook. Baseflow sampling has been conducted at LS0.1 annually during the past four years. LS at RM 0.3 was added in 2016, and the one chloride sample for the station was 24 mg/L. Chloride concentrations at LS0.1 have ranged from a low of 5.2 mg/L in 2014 to a high of 170 mg/L in 2015. Sampling at this station in 2016 yielded chloride concentrations of 120 mg/L and 130 mg/L on July 7 and September 21, respectively.

These most recent chloride values are elevated, but still below the chronic criteria for chloride listed in the VWQS.

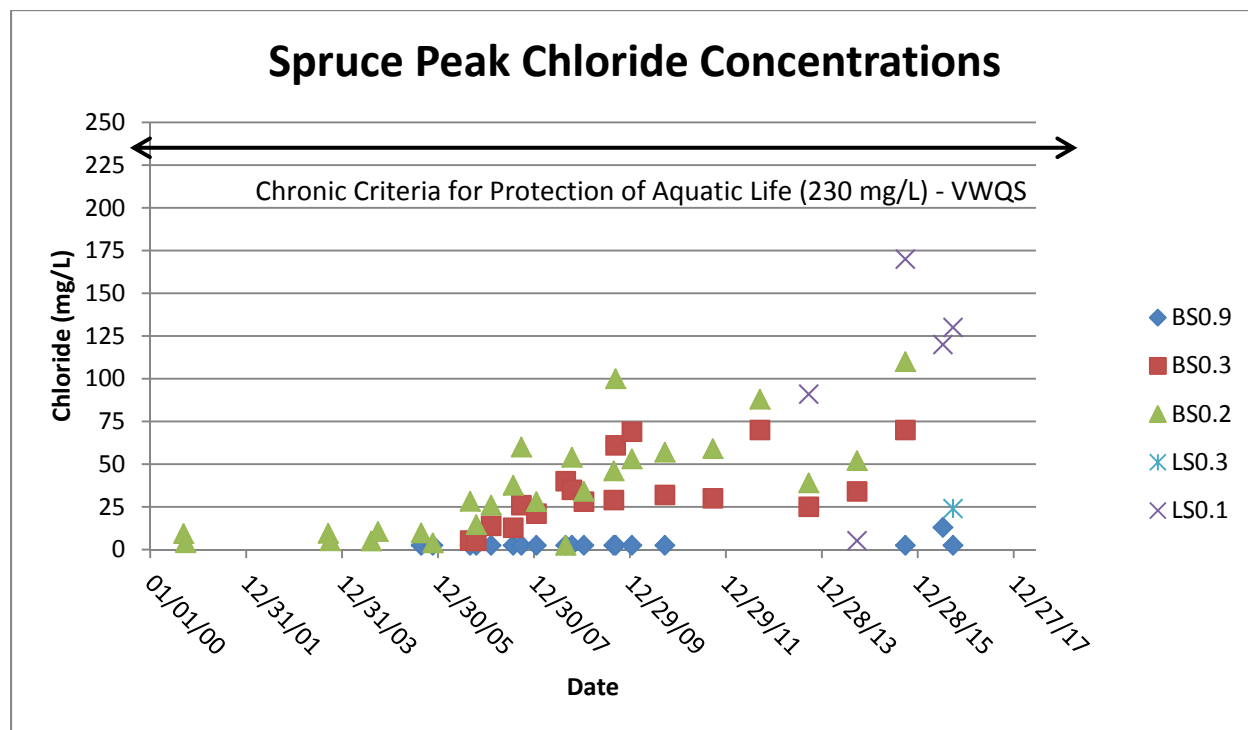


Figure 5. Chloride concentrations from 2000 through 2016 for Spruce Peak.

Total Phosphorus

Two stations on Big Spruce Brook and two on Little Spruce Brook were monitored for total phosphorus in 2016. Total phosphorus concentrations in samples taken at Big Spruce RM 0.9 and 0.2 and at Little Spruce RM 0.3 were very low, all below 0.007 mg/L. Little Spruce Brook at RM 0.1 was sampled twice for total phosphorus. The results were 0.012 mg/L on July 7th and 0.006 mg/L on September 21st. Although the July total phosphorus measurement at this station was slightly elevated, it did not exceed the Vermont Water Quality Standard of 0.012 mg/L.

4.2 Event-based Sampling Results

For the 2016-2017 monitoring season, Bear Creek Environmental, LLC conducted four event-based monitoring rounds. Two of these sampling rounds involved sampling at a subset of stations rather than all of the monitoring stations (June 23, 2015 and March 10, 2016).

Event-based samples were collected during storm events that resulted in significant runoff (approximately greater than 0.5 inches of rain in 24 hours). In the case of the winter/spring events, sampling coincided with warm temperatures and/or rain that caused a significant snowmelt. Each event-based sample was analyzed for pH, turbidity, chloride, conductivity, and temperature. In addition, total iron was measured at the Big Spruce Brook stations for three of the four sampling rounds.

The first two of the four event-based sampling rounds for the 2016-2017 monitoring period were completed in mid to late summer of 2016. BCE also sampled during mid fall 2016, as well as late winter 2017. The results of event-based water chemistry sampling from 2000 through 2017 are found on pages 13 through 38 of Appendix I. Hourly precipitation data are available from the weather station at the turf care center for all of the events during the 2016-2017 monitoring period.

July 10, 2016

Bear Creek Environmental, LLC conducted the first round of event-based monitoring on July 10, 2016. Sampling on this date was spurred by two rain storms that resulted in high flows within the West Branch watershed. This was a partial sampling round, with samples collected at eight stations.

On July 9th, light rain fell on the Resort between the hours of about 4:00AM to 3:00PM. The rain tapered off overnight and began again around 8:00AM on the 10th. Moderate rainfall occurred between 8:00AM and 12:00PM. Event-based sampling occurred at the Resort between 11:55AM and 12:45PM. Figure 6 below shows the pattern of precipitation for the event-based sampling round on July 10, 2016. Approximately 0.79 inches of rain fell in a storm that occurred on July 9th, and one inch of rain fell during a separate storm that

occurred on July 10th at the time of sampling. USGS flow data are only available for the gaging station on Ranch Brook for the time period associated with sampling. The West Branch gage was not in operation at this time. Figure 7 shows the Ranch Brook hydrograph from July 9, 2016 to July 12, 2016. Ranch Brook peaked at 125 cfs (33 cfs/sq. mile) immediately preceding sampling around 11:00 AM on the 10th.

As shown in Figure 8, turbidity values were below the water quality standard of 10 NTU at all surface water stations on July 10, 2016. The highest turbidity result was on Big Spruce Brook at RM 0.2 (7.29 NTU). The stream station with the lowest turbidity value was upper Big Spruce Brook at RM 0.9 (1.38 NTU). The Big Spruce basin was the only basin outlet sampled, and it measured 9.16 NTU for turbidity. Overall, instream turbidity values were quite low, indicating that erosion and sediment control measures implemented and maintained by the Resort were working effectively. The range of turbidity values by station for this event is shown on the map (Figure 9).

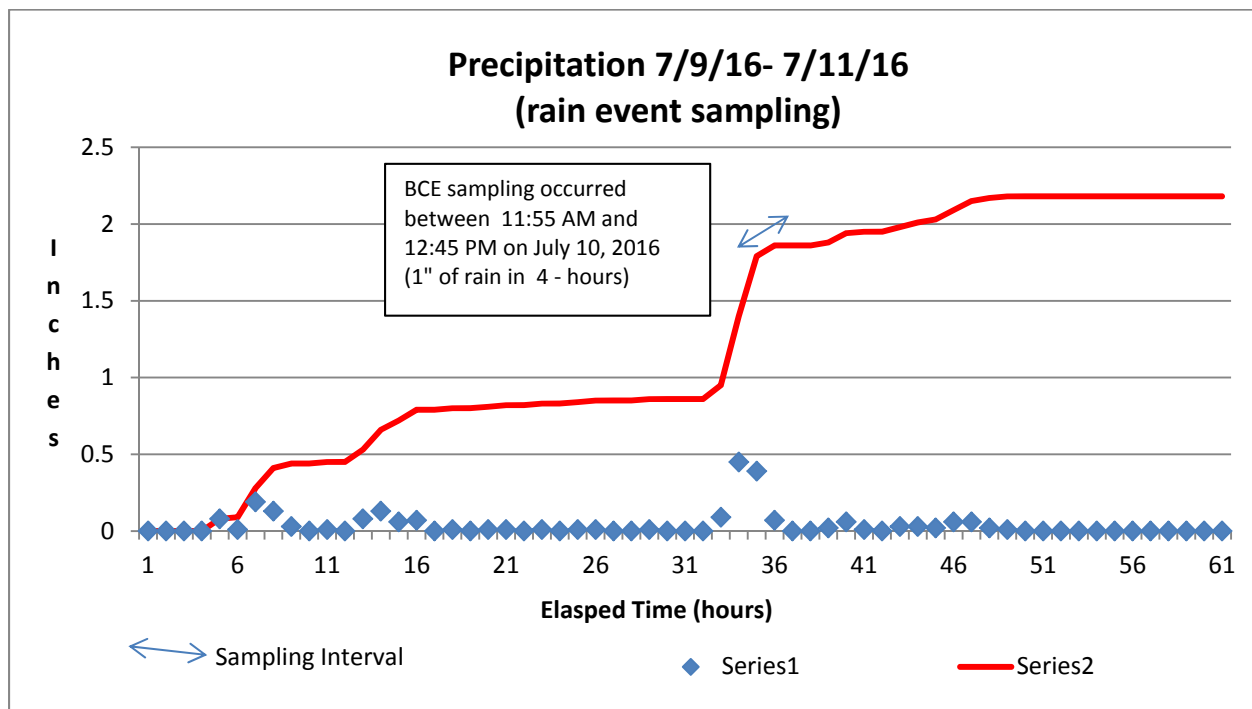


Figure 6. Precipitation for July 10, 2016 event.

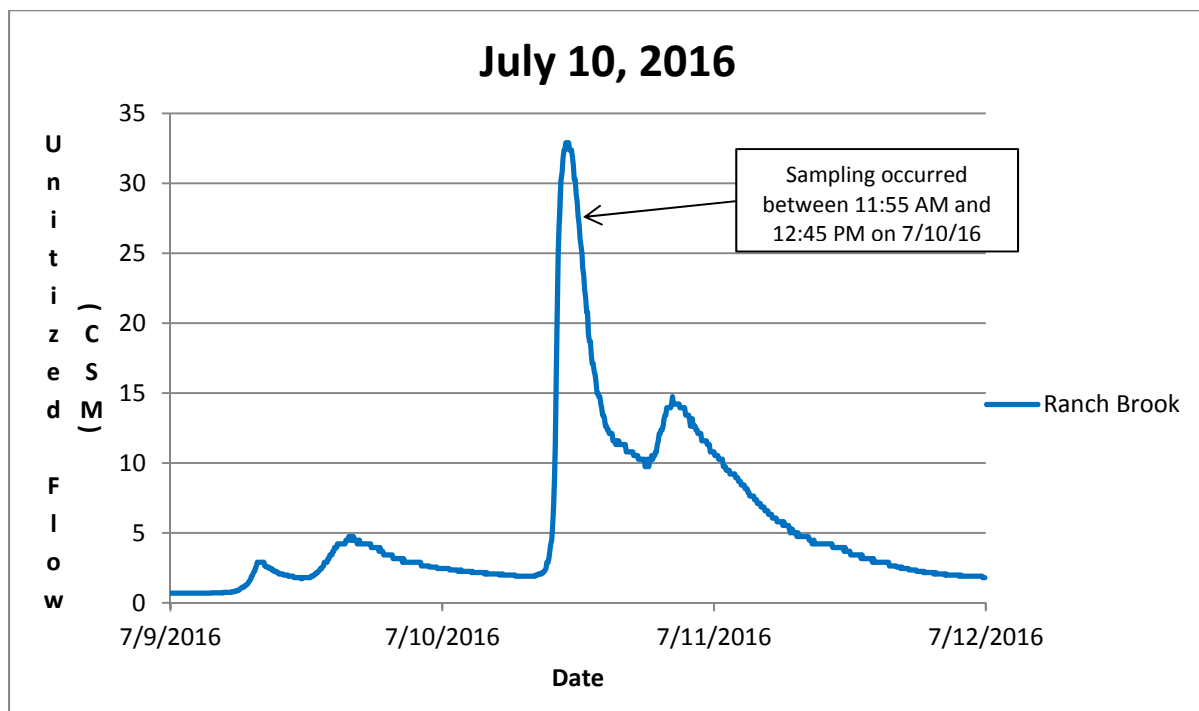


Figure 7. Ranch Brook hydrograph for July 10, 2016 sampling event.

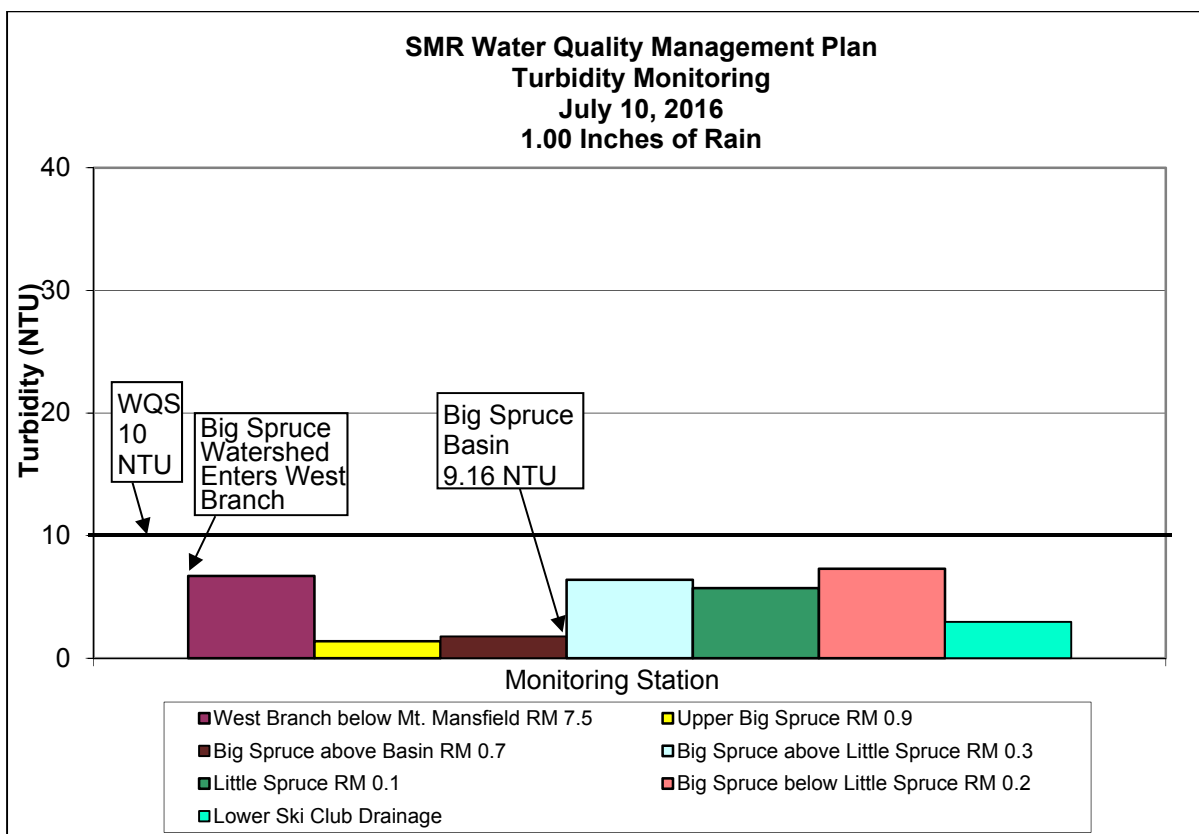


Figure 8. Turbidity results from July 10, 2016.

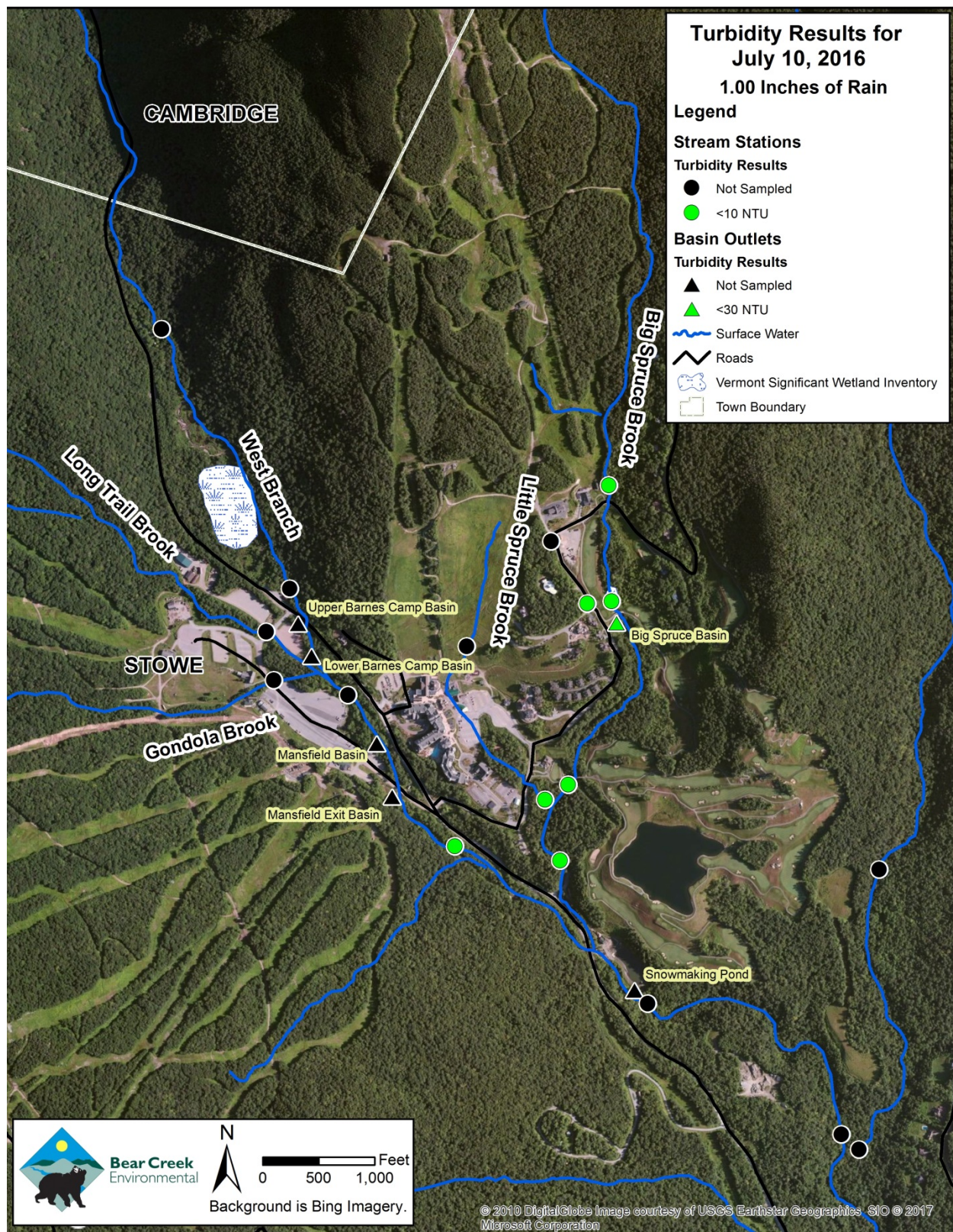


Figure 9. Turbidity Results for July 10, 2016.

August 17, 2016

The second round of event-based sampling took place on August 17th between 7:00 AM and 8:45 AM. The Resort received 2.12 inches of rain in the 22 hours preceding sampling, as shown in Figure 10. Provisional data from the USGS indicate that Ranch Brook peaked at 182 cfs (48 cfs/sq. mile) just before midnight on the 16th. Flows fell shortly thereafter, but additional rainfall caused flows to rise once more on the morning of the 17th. Sampling occurred on the 17th following the second peak of the hydrograph (Figure 11). Thirteen samples were collected and analyzed for turbidity.

As shown below in Figure 12, turbidity was below Vermont Water Quality Standards at all stations on August 17, 2016. Turbidities were very low overall, with the highest stream turbidity being 7.42 NTU on Long Trail Brook at RM 0.1. The only basin outlet sampled during this event was the Big Spruce basin, which had a turbidity of 7.02 NTU. Figure 13 displays turbidity values observed at each surface water and basin station on August 17th.

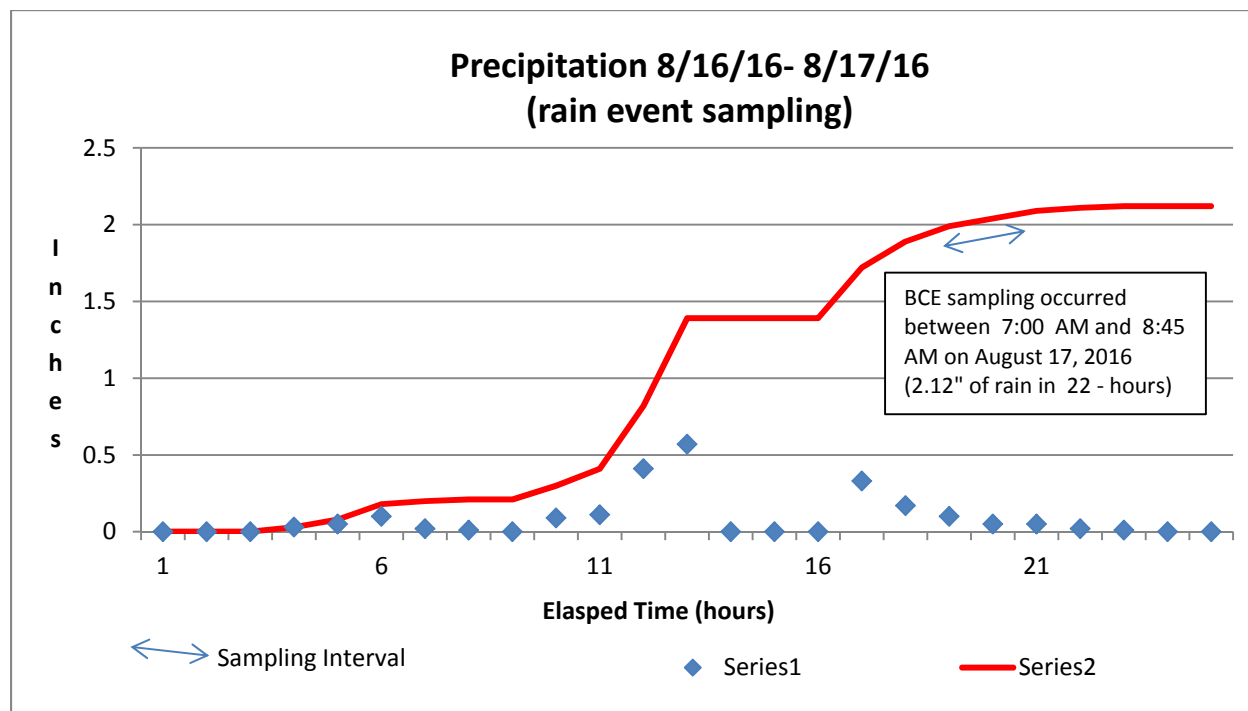


Figure 10. Precipitation at Stowe Mountain Resort on August 17, 2016.

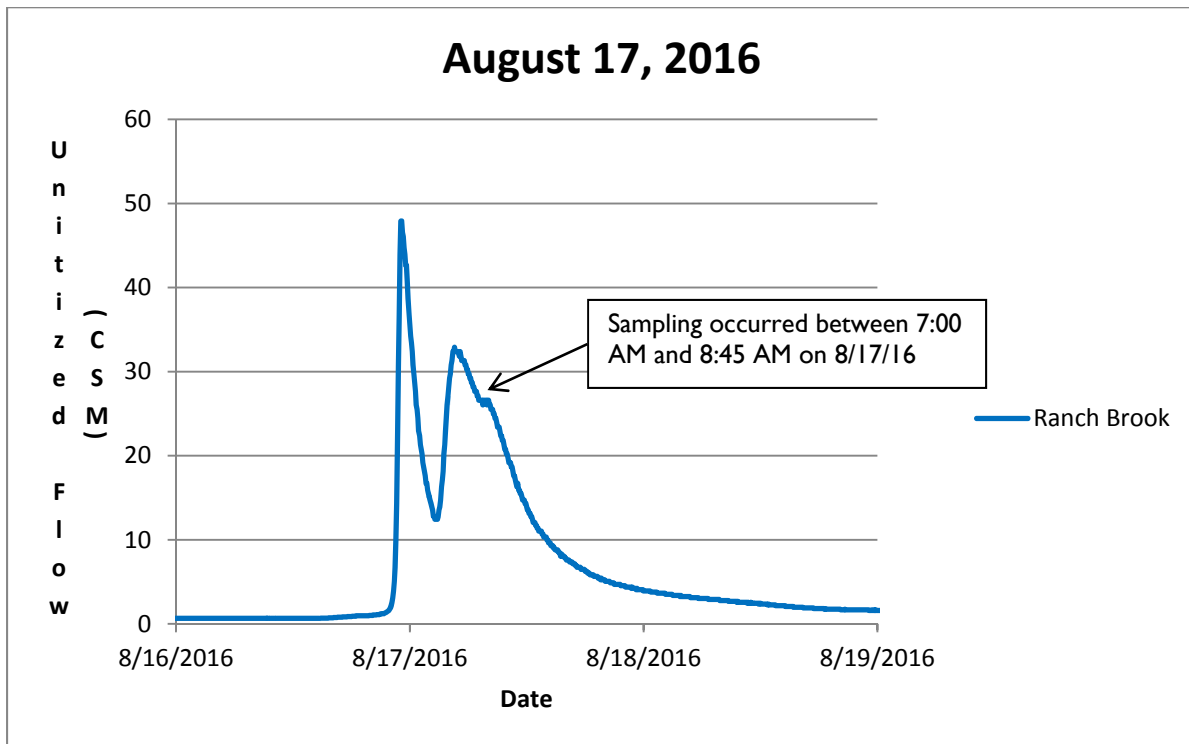


Figure 11. Ranch Brook hydrograph for August 17th sampling round.

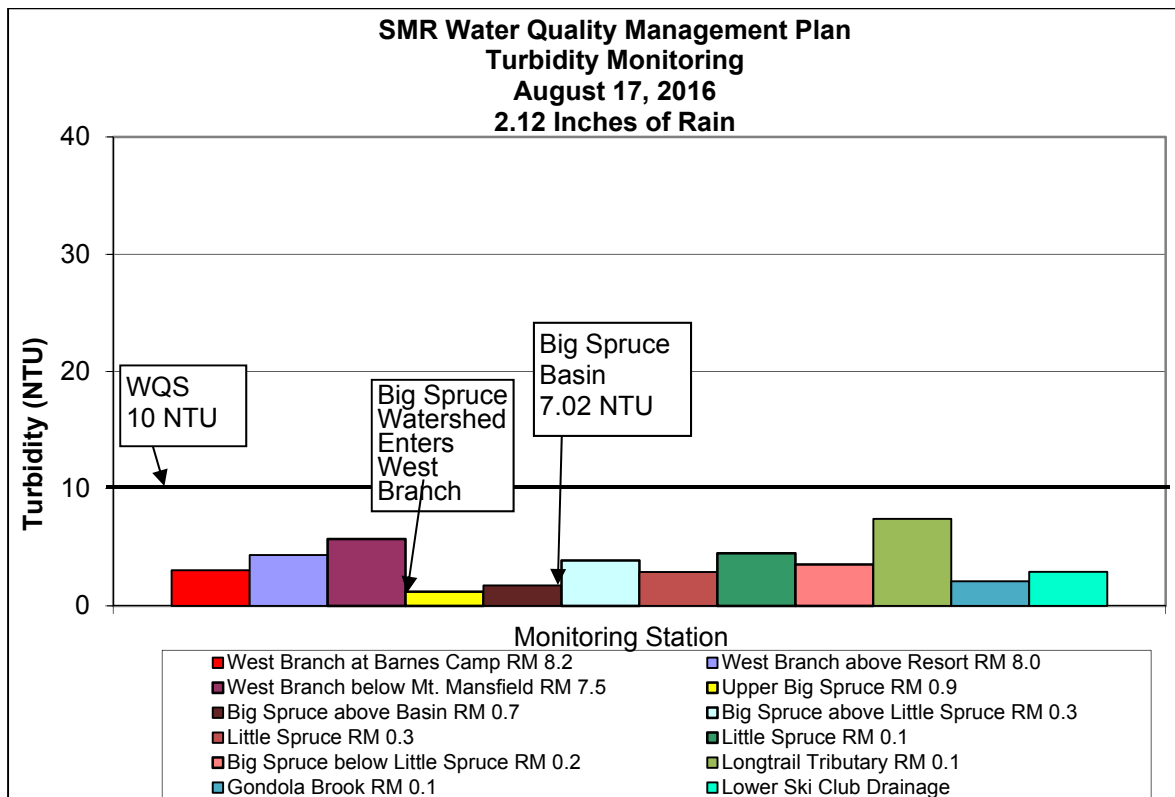


Figure 12. Turbidity results from August 17, 2016.

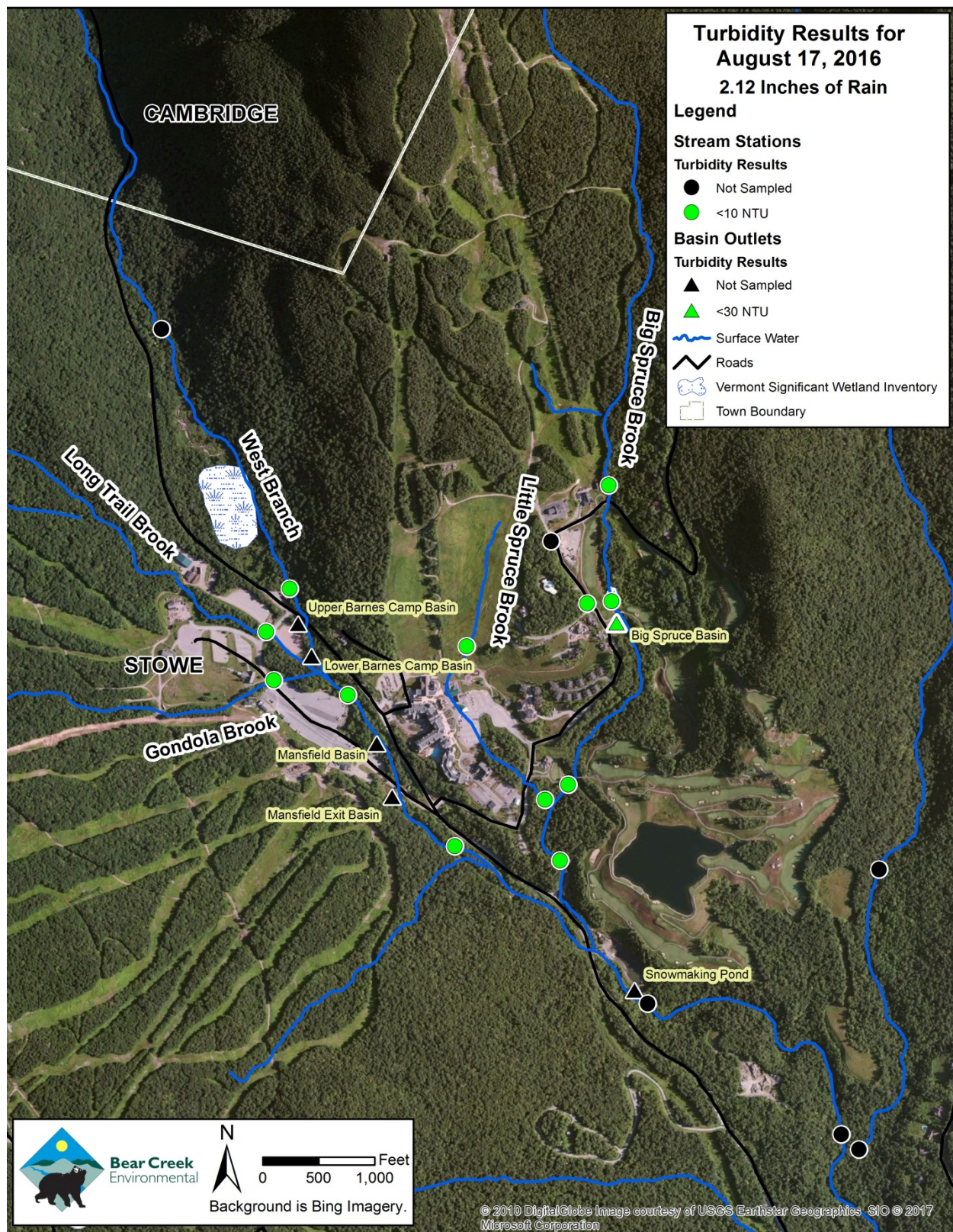


Figure 13. Turbidity results for August 17, 2016.

November 3, 2016

Light rain the morning of November 3, 2016 led to increased flows in the West Branch of the Little River watershed. A total of 0.55 inches of rain fell prior to sampling on this date, and it is possible that snowmelt from higher elevations on the mountain contributed to rising stream flows. Sampling occurred between 2:00 PM and 4:00 PM on the 3rd (Figure 14). According to provisional data from the USGS, the West Branch peaked at 122 cfs (26 cfs/sq. mile) at 4:05 PM on November 3rd, immediately after sampling concluded (Figure 15). The Ranch Brook gage peaked at 115 cfs (30 cfs/sq. mile) at 2:05 PM at the beginning of sampling. The results from the sampling conducted by Bear Creek Environmental are reported below.

The turbidity results for November 3, 2016 were good overall. Two stream stations exceeded the VWQS – Little Spruce at RM 0.1 (32.9 NTU) and Big Spruce at RM 0.2 (10.5 NTU). The remaining stream stations ranged from 1.15 NTU at Big Spruce RM 0.9 to 5.03 NTU at Big Spruce RM 0.3. The Ski Club drainage measured 6.03 NTU at the upper station and 13.1 at the lower station. The Mansfield Basin and Big Spruce Basin measured 6.05 NTU and 37.2 NTU, respectively. Figures 16 and 17 show the turbidity results for this rain event.

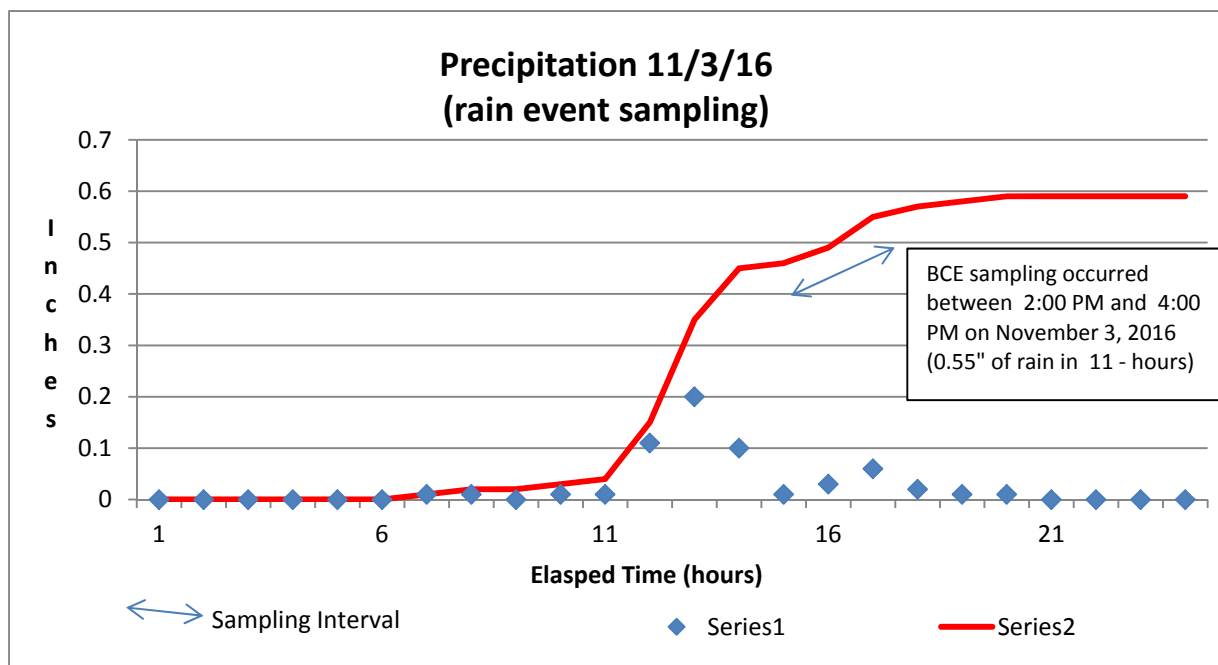


Figure 14. Precipitation data for November 3, 2016.

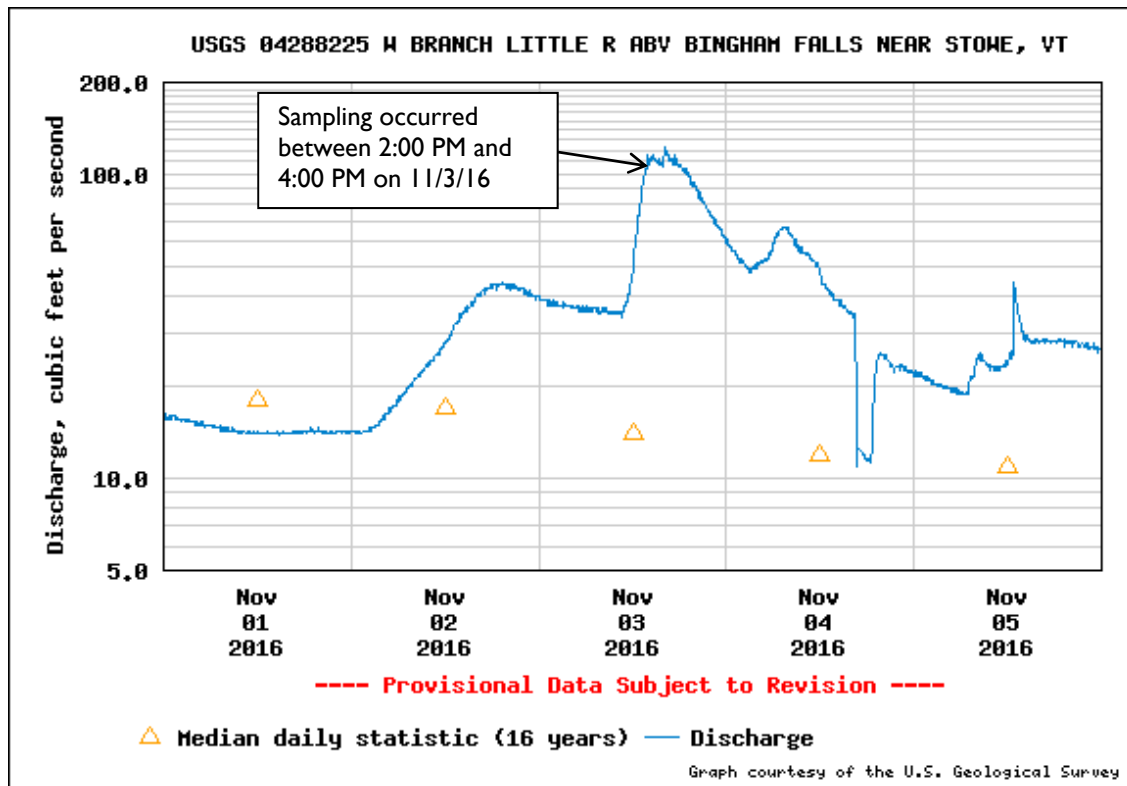


Figure 15. Hydrograph of the West Branch for November 3, 2016 event.

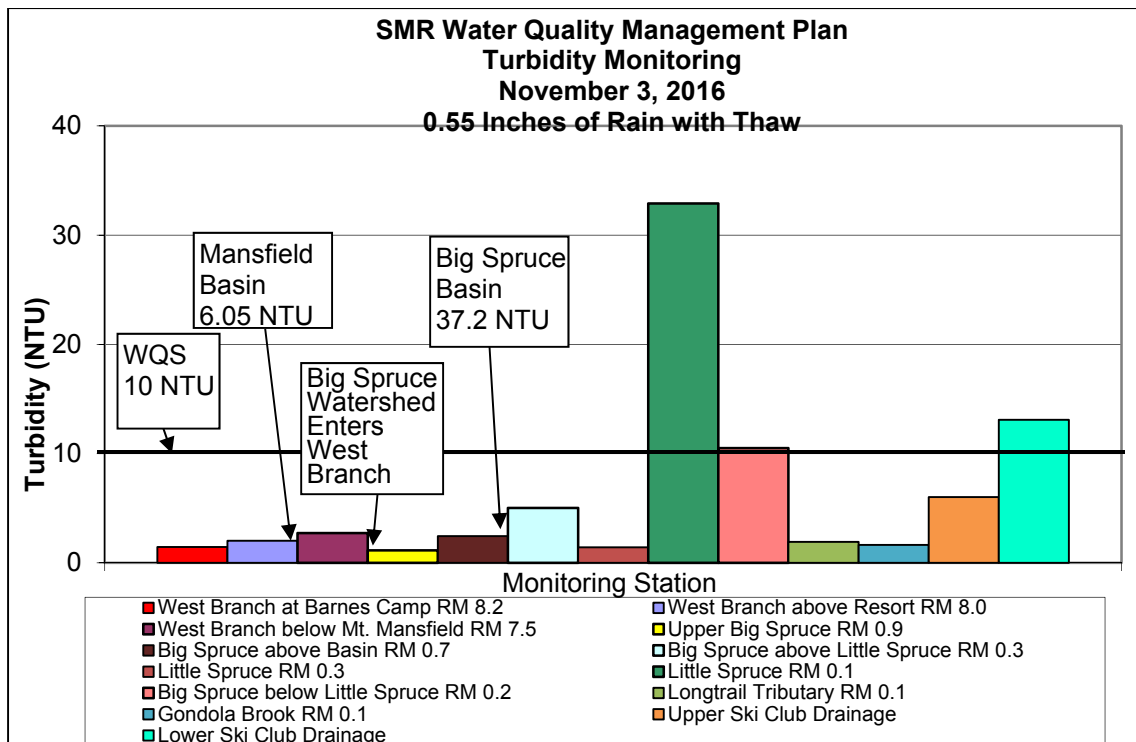


Figure 16. Turbidity results for sampling conducted on November 3, 2016.

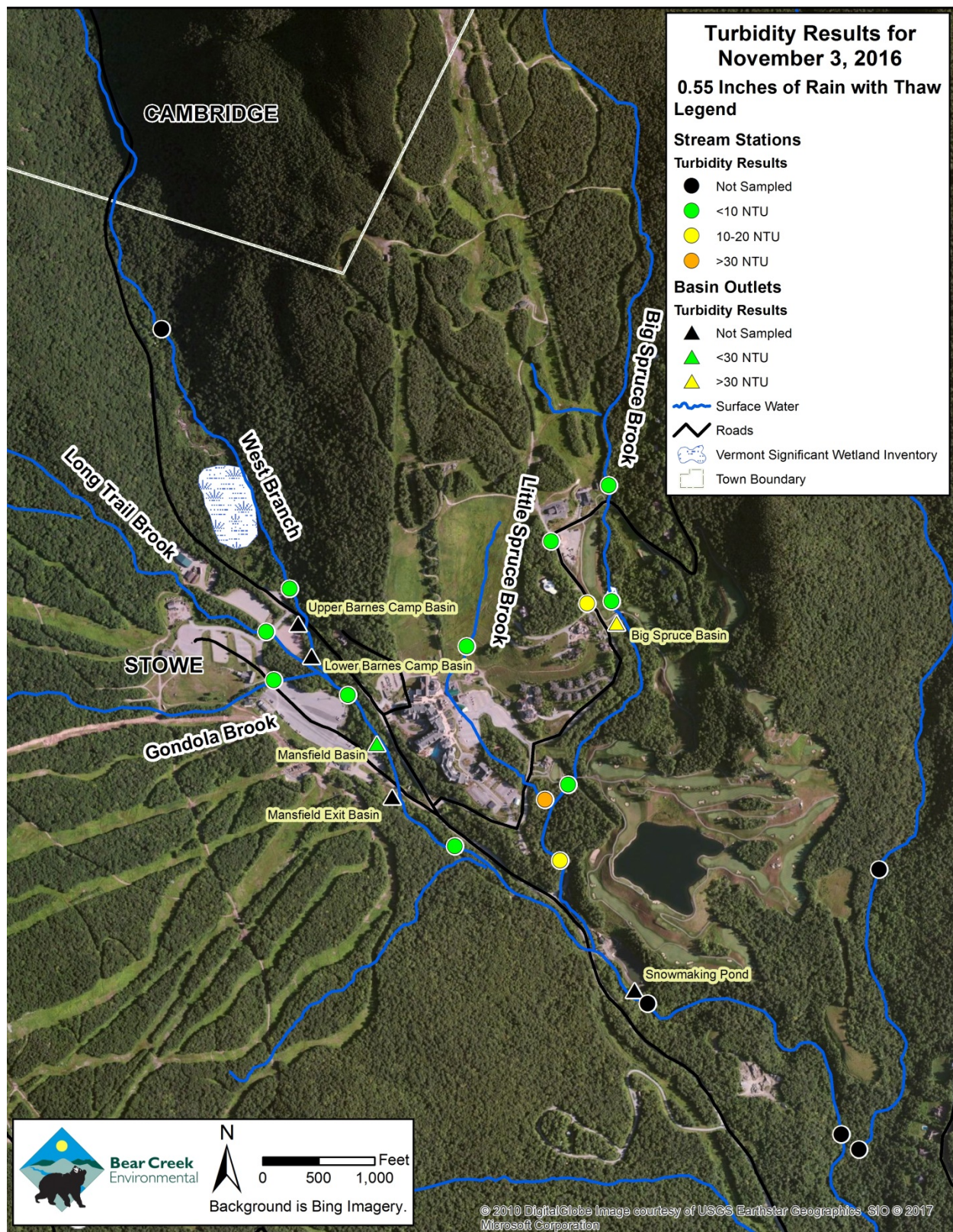


Figure 17. Map of turbidity results for sampling round on November 3, 2016.

February 25, 2017

Warm temperatures in the days leading up to February 25, 2017 led to substantial snowmelt at Stowe Mountain Resort and increased flows in the West Branch of the Little River watershed. Air temperatures peaked at 57.3 degrees Fahrenheit on the 25th, according to weather data from the Resort. Sampling began at 4:05 PM and ended at 5:55 PM, following sunset. Later that evening, a brief but intense storm brought 0.45 inches of rain on the Resort around 8:00 PM. The hydrograph of the West Branch, shown below in Figure 18, illustrates flows on the West Branch before during and after sampling. Flows increased throughout the day on the 25th due to warm temperatures and began to plateau around the time of sampling. The evening rain caused a sharp increase in flows after dark, with the West Branch peaking at 316 cfs (68 cfs/sq. mile) and Ranch Brook peaking at 232 cfs or 61 cfs/sq. mile.

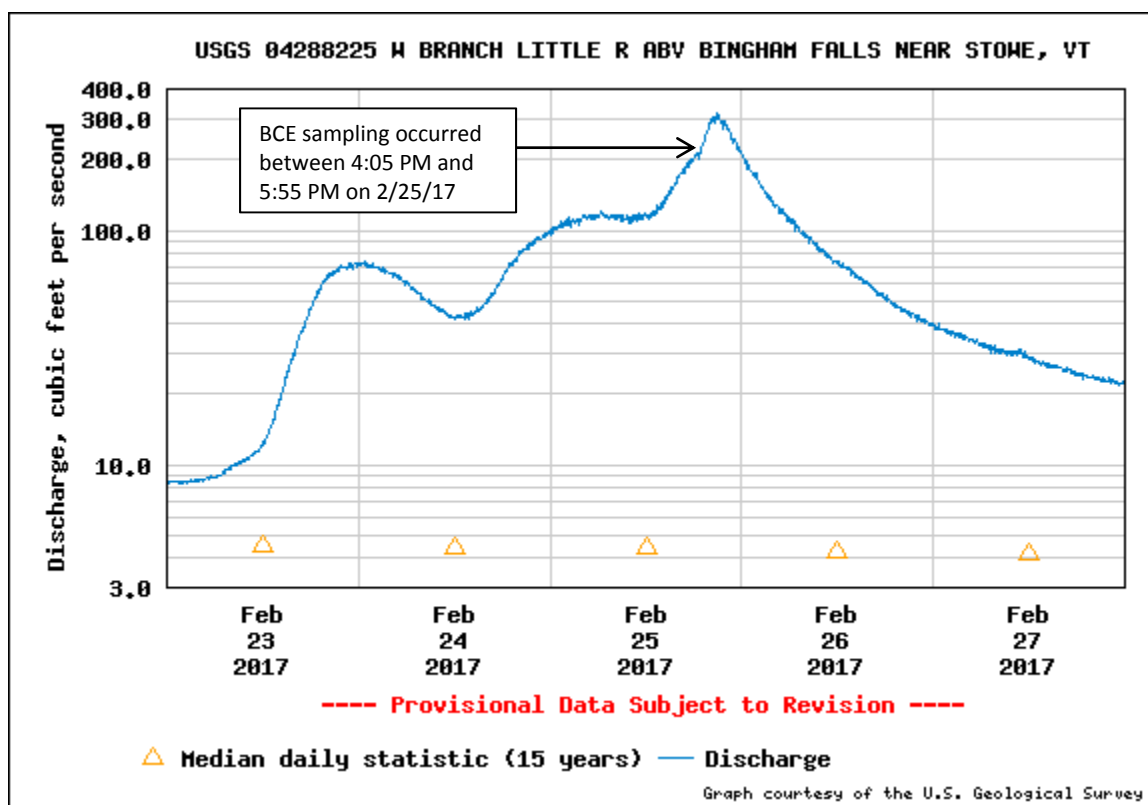


Figure 18. Hydrograph of the West Branch for the February 25, 2017 event.

Turbidity results were low overall for the stream stations sampled during the February 25, 2017 melt event. The highest turbidities were observed at the lower and upper Ski Club drainage stations, at 45.1 NTU and 22.2 NTU, respectively. Little Spruce Brook at RM 0.3 had a turbidity of 17.5 NTU at the time of sampling, while lower Little Spruce Brook had a turbidity of 13.8 (RM 0.1). The highest turbidity on Big Spruce Brook was recorded at RM 0.3 at 16.6 NTU. Turbidities on the Mansfield side of the Resort were all low, below 9 NTU. Samples were not collected from any sediment basins due to lack of safe access for sampling. Turbidity results for this event are shown below in Figures 19 and 20.

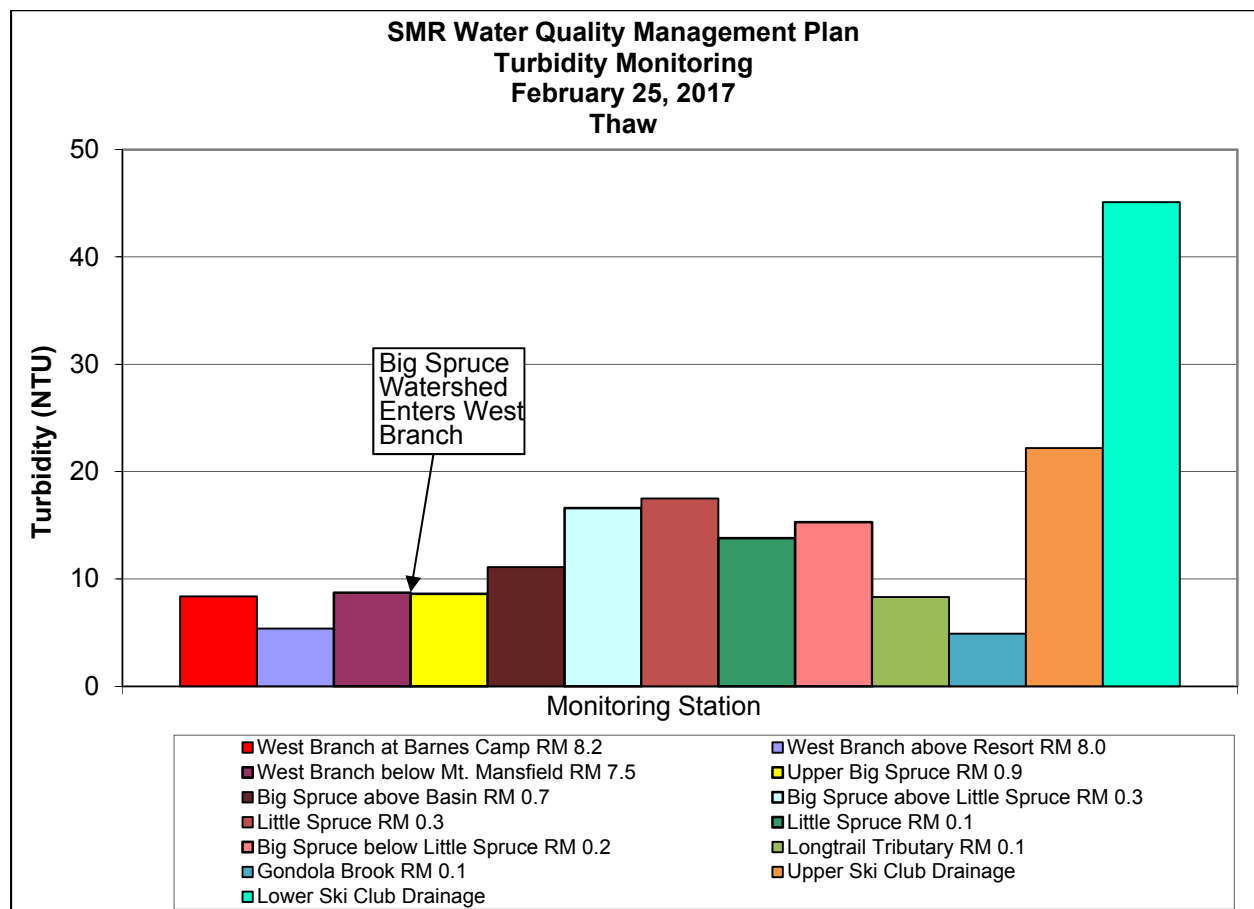


Figure 19. Turbidity results for sampling conducted on February 25, 2017.

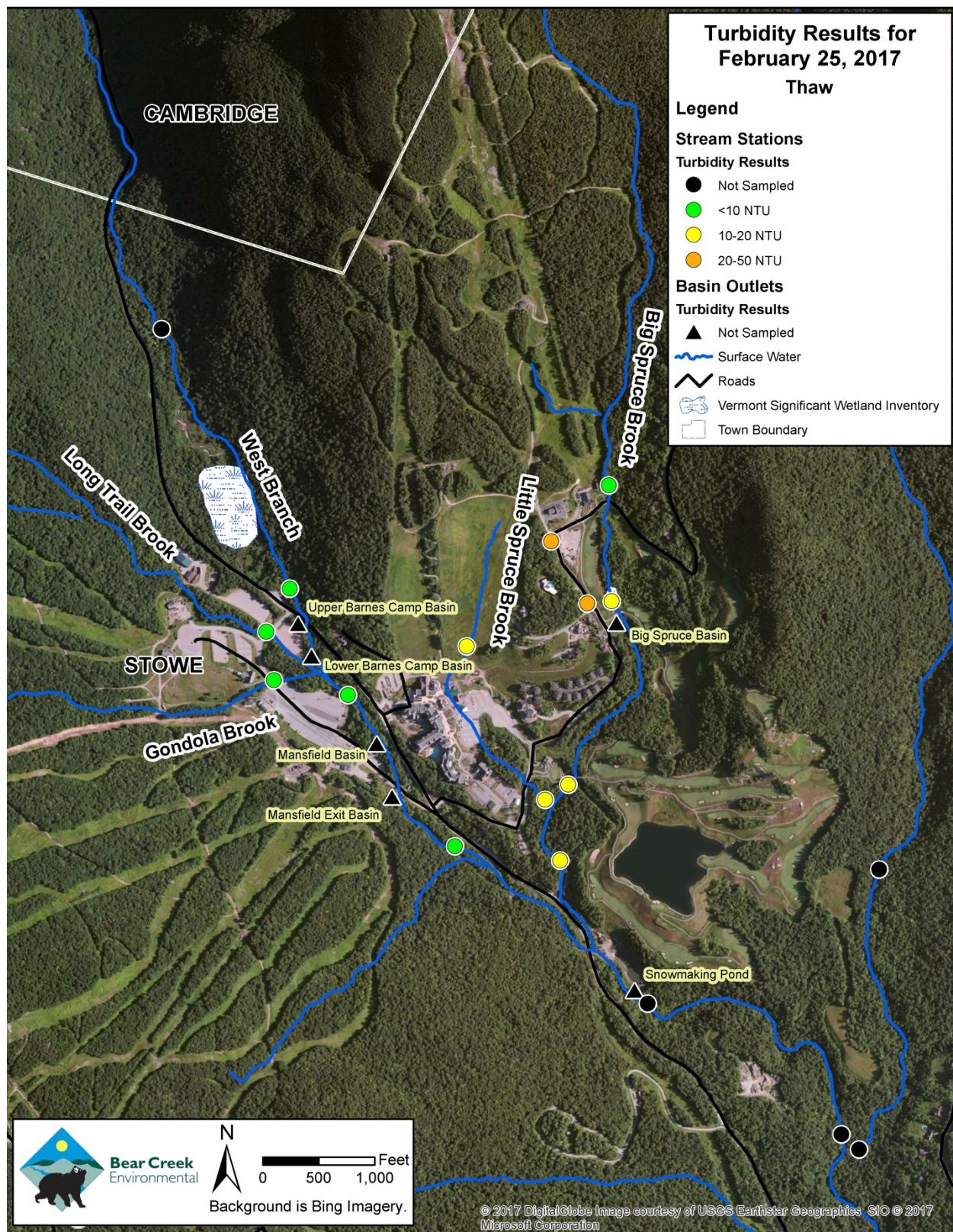


Figure 20. Map showing the turbidity results from the February 25, 2017 sampling event.

The event-based chemistry results for 2000 to 2016 are summarized in Appendix I. A mean value, maximum value, and the sample size are presented for the construction monitoring that has occurred between fall 2003 and spring 2017.

pH

Event-based sampling reveals that streams in the vicinity of Stowe Mountain Resort are critically acidified. In particular, the high elevation streams and undeveloped watersheds appeared to be severely acid stressed. The West Branch below Barnes Camp, Long Trail Brook and Gondola Brook have mean pH values of less than 6.0 s.u., as shown below in Figure 21. The West Branch above the Resort has a low buffering capacity, as indicated by several years of baseflow chemistry results. Below Barnes Camp, Gondola Brook and Long Trail Brook flow into the West Branch. These small upland streams have low pHs and appear to lower the pH of the West Branch as they flow together. This has implications for the biological community at station WB 8.0 and below.

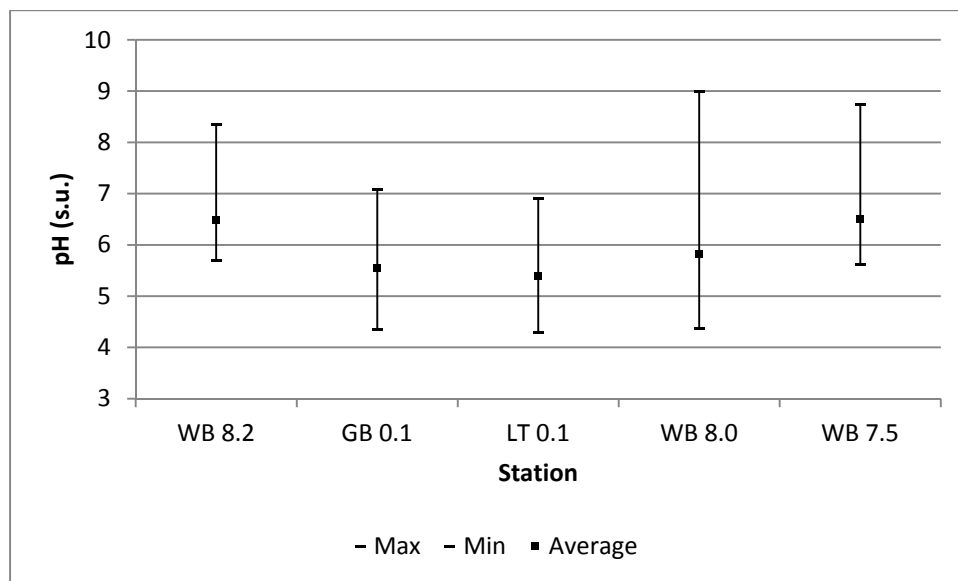


Figure 21. Range and average pH Values for the West Branch.

On the Spruce side of the Resort, stream acidification has also historically been an issue. Upper Big Spruce Brook in the vicinity of RM 0.9 has exhibited low pH values for event-based monitoring over its 14-year monitoring history. The mean pH for BS 0.9 for event-based monitoring is 5.09 s.u. and the minimum is 3.38 s.u., as shown below in Figure 22. Stream pH generally increases downstream of BS 0.9 according to these historic data.

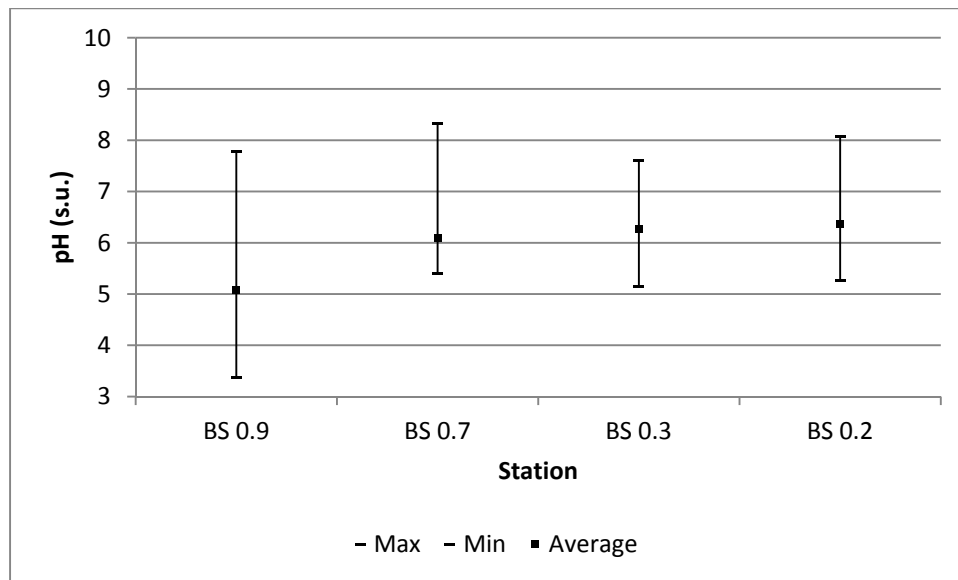


Figure 22. Range and average pH values for Big Spruce Brook.

Conductivity

In general, conductivity levels were highest on Little Spruce Brook and lowest on the upper West Branch, Long Trail Brook, and Gondola Brook. The mean conductivity for the period of fall 2003 through spring 2015 for each of the monitoring stations is provided below in Figure 23.

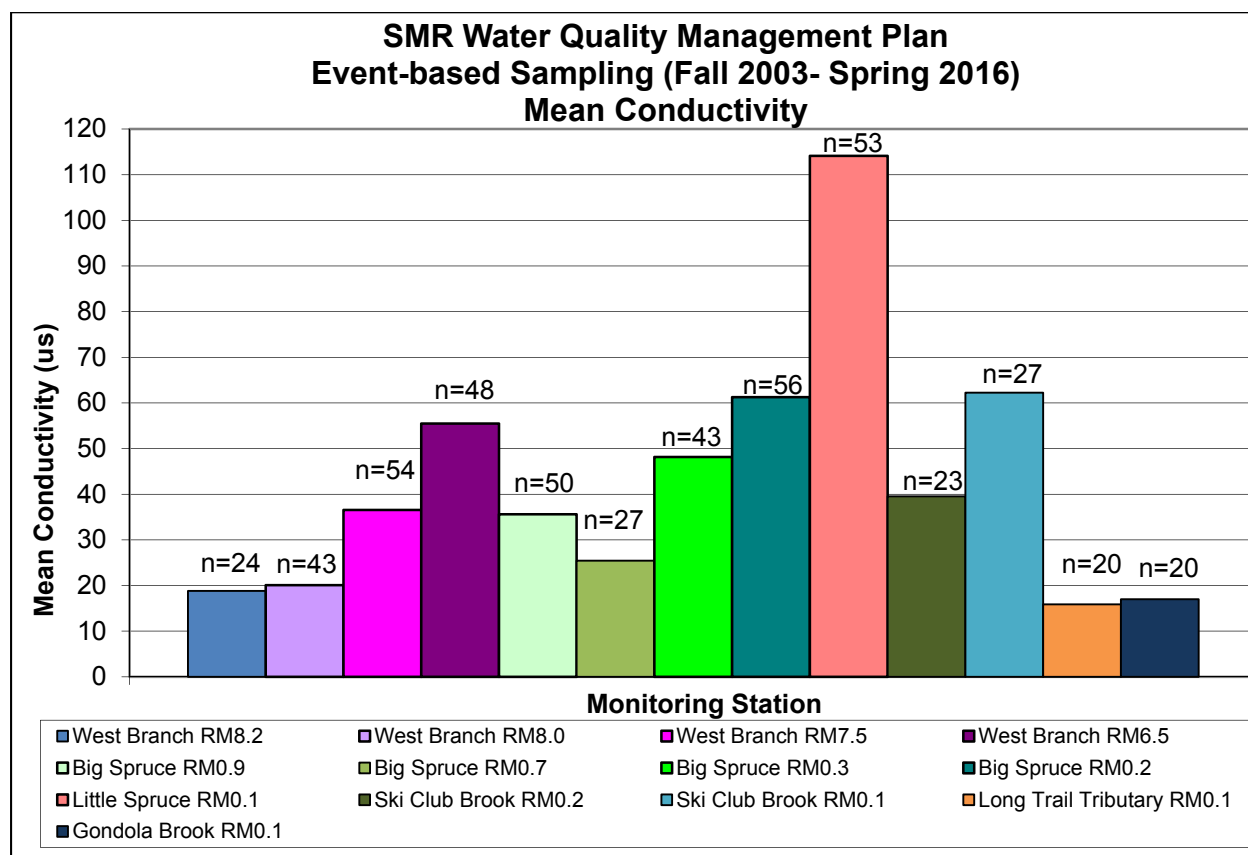


Figure 23. Mean conductivity reported for event-based sampling for fall 2003 through spring 2016.

5.0 EPSC PROGRAM AND MONITORING

Event-based monitoring is used by the Resort to sample turbidity and target areas for improvement. As discussed in Section 5.2, four precipitation/snow melt events were sampled during the spring 2016 to spring 2017 monitoring period. BCE sampled on July 10, August 17, and November 3, 2016, and February 25, 2017.

Table 7 below summarizes the turbidity results for each event sampled during the 2016-2017 monitoring period. The final column of Table 7 shows the station's average turbidity for the monitoring period. In general, turbidity levels were low during the July 10, 2016 and August 17, 2016 events. Turbidity levels were low on the Mansfield side of the Resort during all four events, but slightly elevated on the Spruce side of the Resort on November 3, 2016 and February 25, 2017.

West Branch Subwatershed

West Branch

For most of the events that were sampled during the 2016-2017 monitoring year, turbidity results for the West Branch were low. At the time of sampling, no turbidities on the West Branch, Gondola Brook or Long Trail Brook exceeded the Vermont Water Quality Standard of 10 NTU.

Big Spruce Subwatershed

Big Spruce Brook

The turbidity values at the Big Spruce upper stations (RM 0.9 and RM 0.7) were typically low. For the four events, turbidity ranged from 3.53 NTU to 15.3 NTU at the lowest Big Spruce Station.

Little Spruce Brook

The turbidity of the lower Little Spruce Brook station ranged from 4.49 NTU to 32.9 NTU for the four event-based sampling events during the 2016-2017 monitoring period. The highest reported turbidity at that station during the monitoring period occurred during an early November rain event. This slightly elevated turbidity value may be linked to construction activities at Spruce Peak; however, the source of the sediment could not be identified.

Ski Club Drainage

This drainage located upstream of the Big Spruce basin is intermittent and is typically dry during the summer. While not required by ANR, two stations were sampled on this drainage to get a better understanding of potential sediment sources to Big Spruce Brook. Elevated turbidity was observed on Ski Club drainage on February 25, 2017 during a winter melt event. The turbidity at the downstream Ski Club drainage stations was 45.1 NTU on this date. The source of this turbidity is likely attributable to channel and bank erosion within the drainage. Stormwater improvements made at the Sensation Lot have helped reduce sediment reaching the Big Spruce Basin.

Table 7. Event-Based Sampling Turbidity Results Spring 2016-Spring 2017 Stowe Mountain Resort					
Station	July 10, 2016	August 17, 2016	Nov. 3, 2016	February 25, 2017	Average
WB8.2 (above SMR)		3.05	1.45	8.38	4.29
WB8.0		4.34	2.03	5.36	3.91
WB7.5	6.70	5.70	2.73	8.72	5.96
LT0.1		7.42	1.93	8.32	5.89
GB0.1		2.10	1.64	4.91	2.88
BS0.9	1.38	1.22	1.15	8.62	3.09
BS0.7	1.77	1.75	2.45	11.1	4.27
BS0.3	6.39	3.88	5.03	16.6	7.98
BS0.2	7.29	3.53	10.5	15.3	9.16
LS0.3		2.89	1.43	17.5	7.27
LS0.1	5.72	4.49	32.9	13.8	14.2
SC0.2			6.03	22.2	14.1
SC0.1	2.96	2.91	13.1	45.1	16.0
Outlet 1 (Mansfield Basin)			6.05		6.05
Outlet 3 (Big Spruce Basin)	9.16	7.02	37.2		17.8
Precipitation	1.0"	2.12"	0.55" with melt	melt	
Streamflow (cfs) at time of sampling – West Branch	Not available ¹	Not available ¹	106 to 115	169 to 203	
<p>Stream station turbidity exceeds 10 NTU Sediment basin outflow with elevated turbidity (> 100 NTU)</p> <p>1. Flow data unavailable for the West Branch. Gauge was out of operation from March 1, 2016 until September 1, 2016. On July 10, 2016, flows on Ranch Brook were between 79 and 109 cfs when sampling occurred. On August 17, 2016, flows were between 93 and 103 cfs on Ranch Brook during sampling.</p>					

Stowe Mountain Resort expanded its program during the 2007 construction season to promote erosion prevention and sediment control across the Resort. This program has been continued over the past several years. A report prepared by Stowe Mountain Resort describing the erosion prevention/sediment control (EPSC) improvement projects is provided in Appendix 2. During spring 2016 and 2017, as part of routine maintenance at the Resort, accumulated sand from the winter was removed from parking lots, roads, culvert inlets, swales, water bars, stone check dams and sediment basins to prevent sediment reaching surface waters. Stormwater improvements made to the Resort in 2012 in response to the 1272 order issued on May 3, 2012 are summarized in Nealon and Kinghorn (2013). EPSC activities on the Spruce side of the Resort are reported in the 2016 EPSC Annual Monitoring report, which is included in Appendix 2 of this report.

Highlights for the EPSC are provided below. All disturbed areas were seeded and mulched.

- Waterbar and sediment basin maintenance on the Snowplant road
- Mansfield to Spruce Cat road rebuilt with new waterbars
- Mansfield Bus Lot maintenance including basin cleaning
- Mansfield Exit Basin conveyances re-armored and basin capacity restored
- Ditching, grading, and/or waterbar repair on Cliff Trail workroad, Gondola workroad, Sterling workroad, Spruce Catwalk, Sepp's workroad, Houghton's workroad, Liftline workroad, Midway workroad, and High road
- Armoring and cleaning of ditches at the Midway lots; permeable swale pipe flushed and restored
- Sediment basins cleaned, swales repaired, check dams re-established, large basin enlarged at Big Spruce Road and Sensation Lot

6.0 SEDIMENT ASSESSMENT

BCE conducted pebble counts at specified sediment monitoring stations to evaluate channel materials. A substrate summary table of the pebble counts is included in Appendix 3 on pages 1 and 2. The results of each pebble count are shown on pages 3 through 18 of Appendix 3.

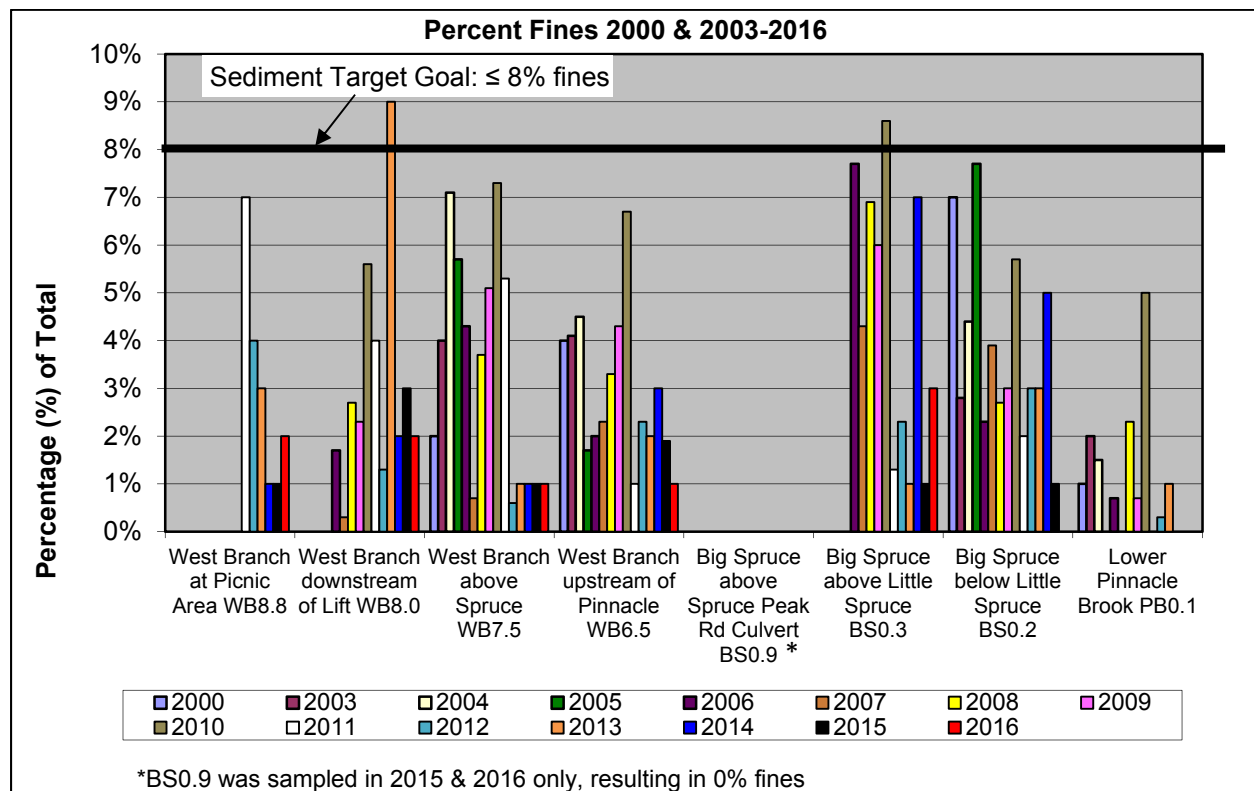
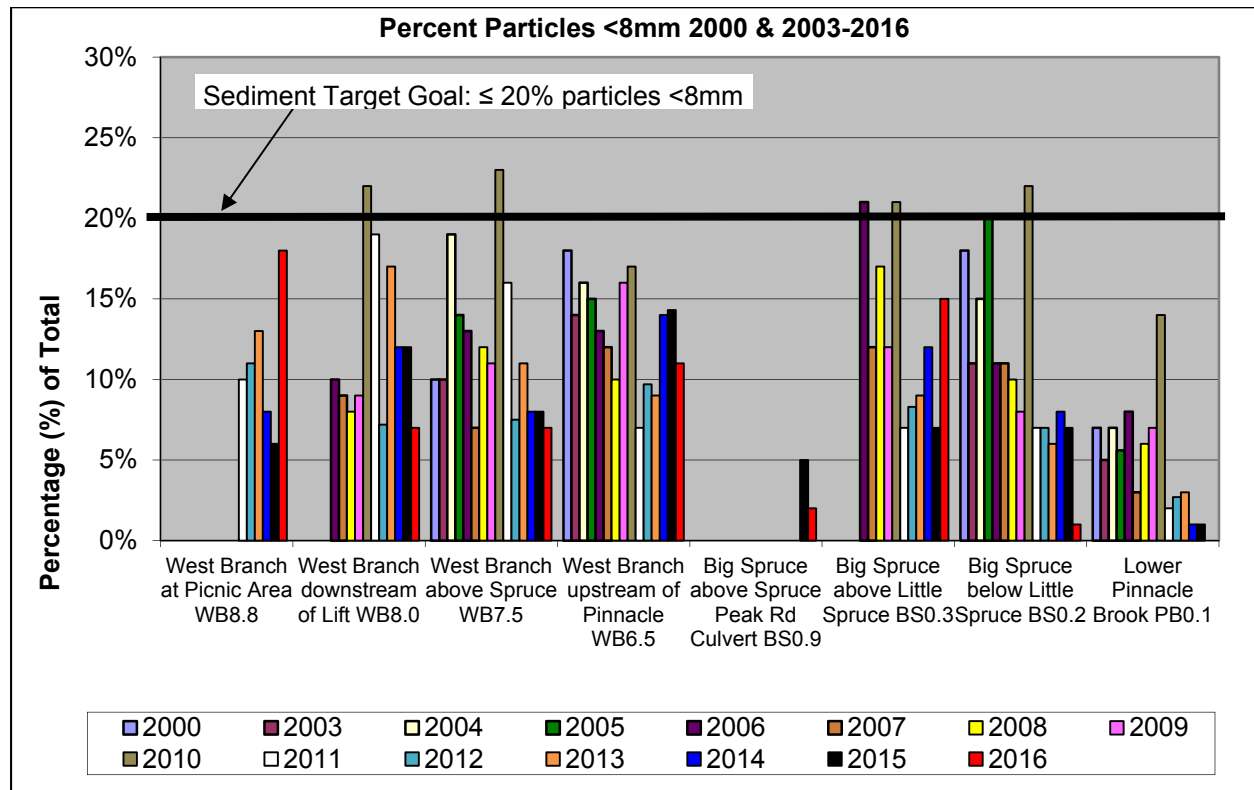
Embeddedness:

Embeddedness was assessed at the five biomonitoring stations, as well as two additional stations on Big Spruce Brook. All of the stations sampled had embeddedness estimates of 0-25% (very good) in 2016 and met the target goals. The West Branch station 8.0 was on the high end of the range, with an average embeddedness of 25%.

Channel Materials:

The pebble count data serve as an important tool for understanding improvement in habitat from remediation efforts as well as impacts from catastrophic flood events. As shown below in Figure 24, the percentage of particles less than 8 mm met the target threshold of less than or equal to 20 percent of the substrate composition at all monitoring stations in 2016. Both the graph of the percentage of particles less than 8 mm and the percent fines (Figure 25), indicate there was a shift toward smaller particle sizes in 2010. A high flow event in August 2010 was the primary cause and the percentage of fines has generally decreased since 2010 as the sediment works its way through the study area. This shift can be seen for each station on the graphs in Appendix 3.

All the monitoring stations in 2016 also met the target for percent fines. Each station met all three target goals for sediment in 2016. Streams in the vicinity of SMR will continue to be monitored for changes in channel substrate condition as the MDP continues to be implemented.



Figures 24 and 25. Substrate Assessment.

7.0 BIOMONITORING AND HABITAT ASSESSMENT

Macroinvertebrate kick net sampling and habitat assessments were conducted by Catherine Szal on September 23, 2016. Biomonitoring and habitat assessments were completed by Ms. Szal on five West Branch stations and one Pinnacle Brook station. Catherine collected a kick net sample at river mile 7.4, which has not been previously monitored by the Resort, on the West Branch for the purpose of comparing the results to the WB 7.5 station.

The sampling took place primarily under low flow conditions; however, flows increased slightly throughout the course of the day due to rain. Two replicate kick net samples were collected at each station with the exception of the West Branch station WB 7.4. Figure 26 shows the flow conditions in the West Branch for the past several monitoring years. During the 2010 field season, a large flood event occurred in early August, causing major damage at the Resort and changes to the channel morphology and extreme scouring of the streambed. A second flood event took place about a week after the kick net samples were collected on September 26, 2010. During 2011, the daily mean stream flow exceeded 250 cfs as a result of Tropical Storm Irene. The 2012, 2013, 2014, and 2015 monitoring seasons are characterized as having low to moderate flows during the monitoring period. In 2016, the United States Geological Survey discontinued its flow gage on the West Branch from February 29, 2016 to September 1, 2016 due to a lack of funding. Gaging resumed on September 1, 2016, showing that flows were low for the rest of the fall. On the September 23, 2016 sampling date, the day began with low flows of 3.17 cfs at midnight. Light rain in the early morning led to a slight increase in flows – a peak of 12.3 cfs about an hour before sampling began, 6.44 cfs when sampling began later in the morning, to 6.91 cfs when sampling ended in the afternoon. Flows rose once more in the afternoon to a peak of 13.5 cfs approximately an hour and a half after sampling ended.

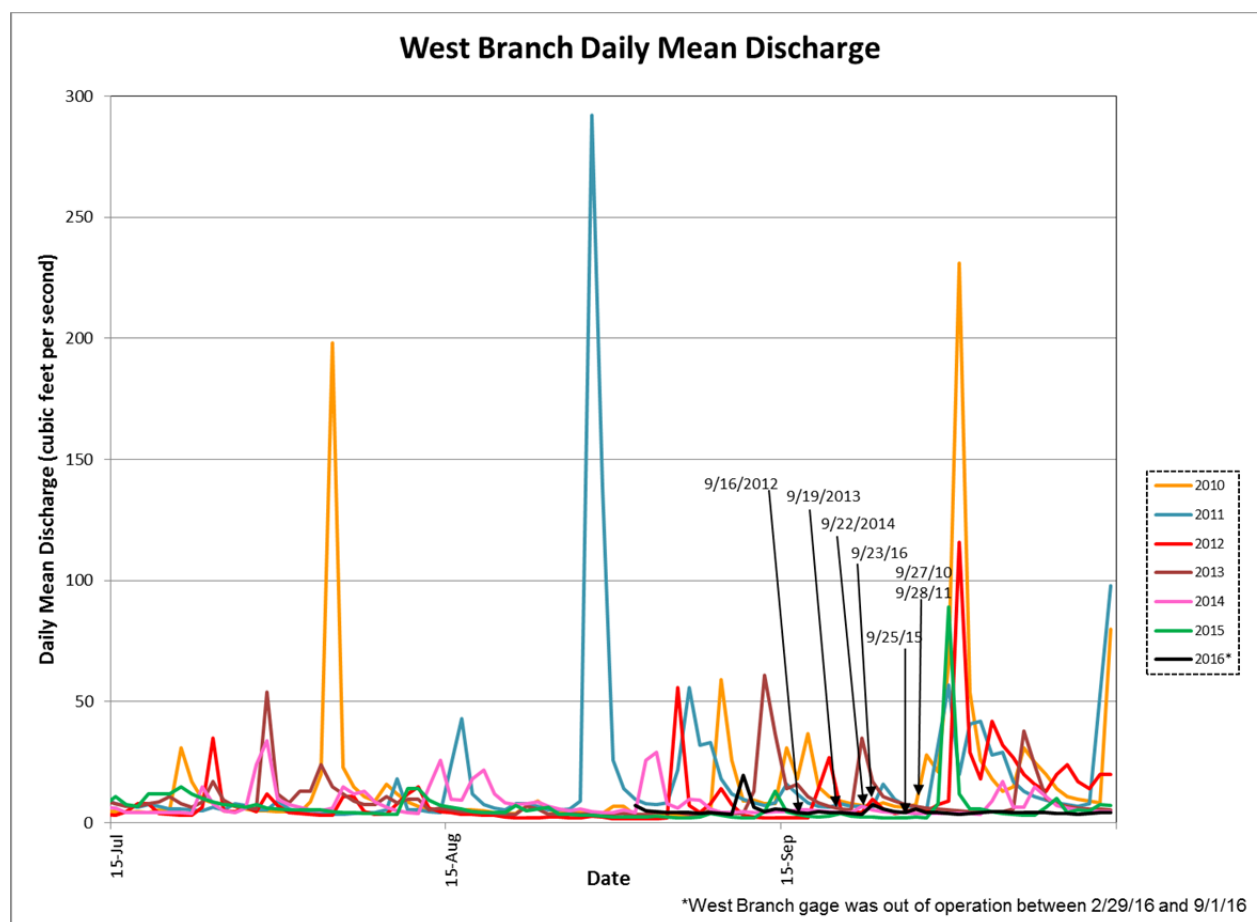


Figure 26. Daily mean discharge on West Branch between mid-July and mid-October for monitoring years 2010 through 2016.

7.1 Habitat Assessment

Qualitative habitat assessments were made at the six biomonitoring stations on September 23, 2016. Field sheets and observations from these habitat assessments conducted by BCE are provided on pages I through I2 of Appendix 4. Silt ratings and substrate embeddedness ratings for each station are provided below in Table 8. The silt is rated from 0 to 5 by the biologist. A rating of 0 indicates silt is absent, while a rating of 5 reflects considerable silt as evidenced by a chocolate brown color. Silt can impair aquatic insects by clogging gills. Both Embeddedness ratings were estimated to the nearest quartile by the biologist collecting the kick net samples. Bear Creek scientists also calculated the percent embeddedness by measuring the percentage of substrate covered by fine sediment for

twenty random cobbles. Embeddedness is an important habitat parameter as it provides a qualitative measure of the interstitial spaces available for colonization by aquatic insects.

Table 8. Substrate Embeddedness and Silt Ratings				
Stream	RM	Silt Rating (0-5)	Pebble Count Embeddedness (Percentage)	Biomonitoring Embeddedness (Percentage)
West Branch	8.8	2-3	6	5-25
	8.0	3	23	5-25
	7.5	3	13	5-25
	7.4	3	22	5-25
	6.5	2	11	5-25
Pinnacle Brook	0.1	2	4	0-5
Silt rating (0 – none; 5- chocolate)				

West Branch of Little River – RM 8.8:

West Branch RM 8.8 has a surrounding land use of forest and is located off the Notch Road about a half mile upstream of Barnes Camp. Riffle embeddedness was estimated to be within the range of 5-25% and the silt rating was “2-3”. Fine particulate organic material (FPOM) was noted to be present at this station and influenced the silt rating. Diatom coverage on the gravel dominated substrate was estimated to be 50 percent. Stream bank stability was very good (60-80% stable), as shown below in Figure 27.

West Branch of Little River – RM 8.0:

West Branch RM 8.0 is located downstream of the transfer lift crossing. Small iron seeps were present along the stream margins. Embeddedness was in the range of 5-25% in the riffle habitat. Bank stability was good (40-60% stable). Canopy cover was estimated to be partly open, creating a cover of about 70 percent (Figure 28). The diatom cover was 90 percent.

West Branch of Little River RM 7.5:

West Branch RM 7.5 is located downstream of the exit to the Mansfield parking lot, below the outlets of both the Mansfield Basin and the Mansfield Exit Basin. Diatoms were the dominant periphytic cover. Embeddedness was estimated to be 5-25%, and light iron staining was noted. The leaves were mainly on providing a canopy cover of 80 percent, as shown in Figure 29.

West Branch of Little River RM 7.4

West Branch 7.4 was added in 2016 to provide a station downstream of the Mansfield parking lot and basin that is less prone to scouring than RM 7.5. The station is located just downstream of station 7.5, immediately below the riprap along Route 108 but above the mass failure on the south bank of the brook. Embeddedness at this station was between 5-25%, canopy cover was 40%, and the station was lower gradient than 7.5 (Figure 30).

West Branch of Little River (RM 6.5):

The lowest station on the West Branch is at RM 6.5, and is located immediately upstream of the confluence with Pinnacle Brook. Bank stability in 2016 was rated as very good at WB 6.5, and substrate embeddedness was rated as 5-25 percent. The diatom coverage was approximately 90 percent. Canopy cover was partly open and was estimated to be 60 percent, as shown in Figure 31.

Pinnacle Brook – RM0.1:

The reference/control station for biomonitoring is located at the mouth of Pinnacle Brook. In 2016, bank stability was rated as excellent (80-100% stable). Based on habitat observations, the silt rating was 2-3 and embeddedness minimal (0 to 5 percent). Canopy cover was approximately 70 percent and leaves were still on the trees. There was 80% diatom cover and a 10% cover of blue-green algae. Figure 32 shows the Pinnacle Brook monitoring station.



Figure 27. West Branch RM 8.8 (9/23/16).



Figure 28. West Branch RM 8.0 (9/23/16).



Figure 29. West Branch RM7.5 (9/23/2016).



Figure 30. West Branch RM7.4 (9/23/2016).



Figure 31. West Branch RM 6.5 above the confluence with Pinnacle Brook (9/23/16).

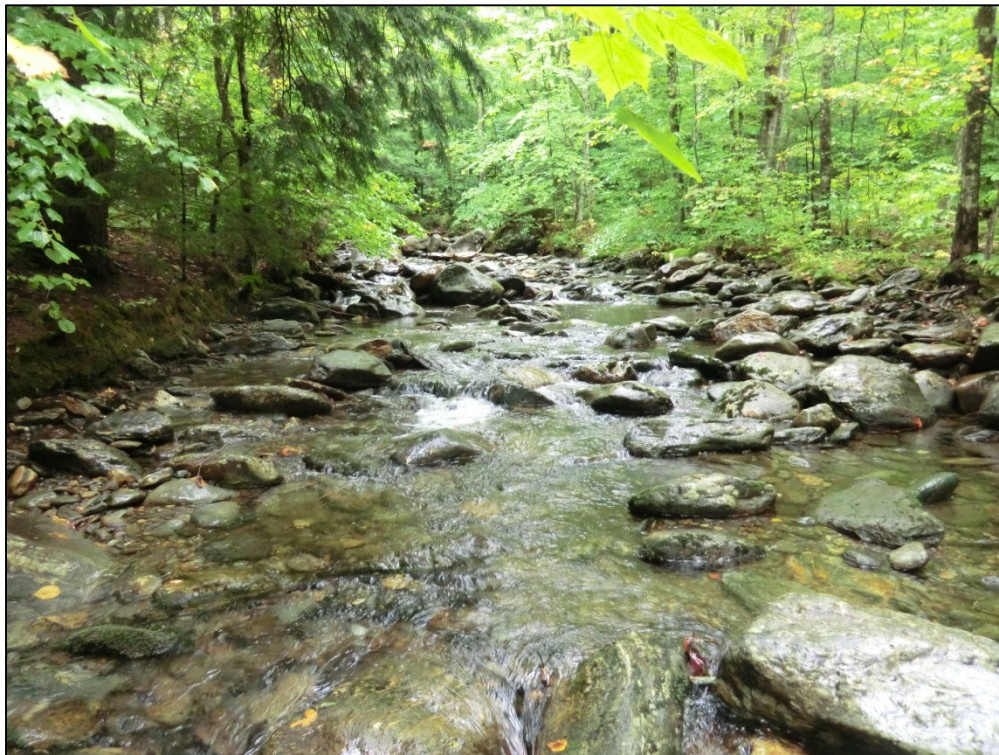


Figure 32. Pinnacle Brook monitoring station (9/23/16).

Large Woody Debris Study

In the fall of 2016, Bear Creek Environmental conducted a field reconnaissance aimed at identifying possibilities for reducing streambed scour for macroinvertebrate habitat in the vicinity of the Resort. The reconnaissance focused on large woody debris (LWD), an integral component to stream systems that helps to dissipate in-channel energy and provides habitat and energy for aquatic organisms. BCE aimed to collect baseline data pertaining to the amount and location of large woody debris on the West Branch within the Resort. A section of the West Branch, roughly from Barnes Camp upstream down to the arch under Route 108 was walked to record data surrounding LWD and streambed features. In addition, BCE scientists conducted a field reconnaissance of a local reference stream, Ranch Brook, to compare the West Branch to a stream with a less developed, more forested watershed. Field notes and maps from the LWD study are provided on pages 13 through 21 of Appendix 4.

The results of the reconnaissance suggest that there is a higher concentration of both individual pieces of large woody debris and debris jams (multiple pieces of LWD that pile up and create a jam) in the study reach of the West Branch of the Little River than in the study reach on the reference stream, Ranch Brook. These findings were contrary to what BCE expected to find, though neither stream had abundant LWD. The West Branch was found to have approximately three times more LWD (individual pieces) than Ranch Brook. This LWD increases habitat complexity on the West Branch. Streambank instability is likely a contributor to the accrual of LWD on the West Branch.

7.2 Macrobenthic Results

The macroinvertebrate kick net samples collected in 2016 were processed and identified by Catherine Szal. Bear Creek Environmental, LLC calculated the biometrics for the samples, which underwent a quality control review by DEC aquatic biologist, Steve Fiske. A brief description of the biometrics is provided below.

Density – the abundance of animals in a sample.

Richness – the number of taxa or species in a sample.

EPT Index – the number of species in a sample from the water quality sensitive orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).

Percent Modal Affinity – The measure of similarity of orders to a reference community.

Biotic Index – BI (0-10) – Each taxon is assigned a tolerance value based on the organism's response to nutrient/organic enrichment. Tolerance values range from 0 to 10 (0=very intolerant, 10=tolerant). The calculation takes into account the taxon's Relative Abundance in the community and pollution tolerance.

Oligochaeta – The percentage of the animals from the order Oligochaeta. A high percentage of aquatic worms is indicative of sedimentation and embeddedness in a stream.

EPT/EPT & Chironomidae – This ratio measures the abundance of water quality sensitive species from the EPT orders to more tolerant species from the family Chironomidae (midges).

Pinkham-Pearson Coefficient of Similarity (PPCS-F) – The measure of the similarity of functional feeding group percentages in a sample to a reference

All biomonitoring stations sampled during 2016 in the vicinity of SMR are located below 2,500 feet in elevation. All six sampling stations fall into the stream type “small-size high gradient” (SHG). For this reason, the Class B2 scoring guidelines for SHG were applied. The outcomes of the scoring guidelines are summarized in Tables 9 through 15 below. The Class B2 threshold values are provided at the bottom of each table. A biological integrity of good or better indicates the sample met Class B biocriteria.

West Branch of Little River – RM 8.8: Station RM8.8 is located at the picnic area in Smugglers Notch off of Route 108. This is the sixth year the West Branch upstream of Stowe Mountain Resort has been sampled by Stowe Mountain Resort. Steve Fiske of the Vermont DEC also sampled the West Branch above the Resort in the vicinity of RM8.8 in early September 2007 and 2011. The biometrics for September 2016 indicate the West Branch station RM8.8 has good biological integrity, although the percentage of oligochaeta (worms) in the 2016 sample was notably higher than previous monitoring years.

The West Branch station at RM 8.8 did not pass Class B2 biocriteria during four of the eight sampling events (Tables 9 and 10) during the period of 2007 through 2016 due to low EPT Richness and/or Richness. In three of the four years when the station passed Class B2 biocriteria, at least one of the metrics was close to the threshold value. This suggests the macrobenthic community upstream of the Resort is teetering on meeting Class B2 biocriteria. The low EPT Richness values may be attributed to impacts from acid precipitation. Alkalinity over the past five years of baseflow sampling has averaged only 5.4 mg/L, indicating a poor buffering capacity.

Table 9. Historic results for application of biocriteria (2007 through 2016)

Station	Percentage of sampling rounds passing	N
West Branch RM 8.8	50%	8
West Branch RM 8.0	14%	14
West Branch RM 7.5	28%	18
West Branch RM 7.4	N/A	1
West Branch RM 6.5	60%	20
Pinnacle Brook RM 0.1	100%	15

**Table 10. Macroinvertebrate Results
West Branch of Little River RM 8.8
Picnic Area off of Route 108 in the Notch**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/7/2007 DEC	1124.5	30	14	77.4	2.37	0.3	0.75	0.63	Class B2 Not Supported: Fair
9/9/2011 ¹ DEC	379.2	36	19	63.8	2.18	1.6	0.77	0.38	Class B2 Supported: Good
9/28/2011 ¹ BCE	275.5	23.5	15.5	54	1.12	0.0	0.91	0.35	Class B2 Not Supported: Fair
9/16/12 BCE	427.2	24.5	15.5	61.3	1.19	0.2	0.88	0.46	Class B2 Not Supported: Fair to Good
9/19/13 BCE	369.4	27.0	15.5	63.5	1.98	0.0	0.88	0.43	Indeterminate (+) for Class B2: Good to Fair
9/22/14 BCE	501.8	27.5	17.5	66.0	1.90	0.50	0.79	0.47	Class B2 Supported: Good

Table 10. Macroinvertebrate Results West Branch of Little River RM 8.8 Picnic Area off of Route 108 in the Notch									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/25/15 BCE	410.6	29.0	17.0	49.7	1.23	0.5	0.85	0.44	Class B2 Supported: Good
9/23/16 BCE	356.6	32.5	16.0	50.1	1.40	6.8	0.81	0.42	Class B2 Supported: Good
Annual Mean 2007-2016	502.5	28.7	16.2	61.0	1.67	1.3	0.83	0.46	
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	
¹ Large flood event in August 2011 Note: DEC and BCE station locations are not exact, but are within the same reach									

West Branch of Little River – RM 8.0: The upper West Branch station was added in 2006 to provide a control station on the West Branch that is located above the discharge from the Mount Mansfield sedimentation basin. Density in the kick net samples was suppressed in 2016 (Table 11), resulting in an outcome of fair to good biological integrity. The percentage of worms in 2016 was slightly elevated, but was less than the Class B2 threshold. The PPCS-F metric was influenced by the dominance of a stonefly (Sweltsa sp. – order Chloroperlidae) that is a predator, resulting in value just below the threshold. This metric is not of concern; given this stonefly is a water quality sensitive species.

The iron seeps, embedded substrate, and lack of CPOM at this station are possible reasons for the low densities in the kick net samples. Water quality sensitive EPT organisms depend upon clean spaces between gravel and cobbles to colonize. The Resort is diligent about erosion prevention and sediment control, but does not have full control over sedimentation, as the VT Route 108 is maintained by the State of Vermont.

Both the lack of CPOM and the low densities suggest scour may occur during high flow events. A review of the historic biomonitoring data indicates the percentage of *Baetis tricaudatus* was elevated (>20% of the sample) in 6 of the past 11 years of biomonitoring. This species of mayfly tends to colonize immediately following freshet events. WB8.0 is located immediately below the location where the West Branch, Gondola Brook and Long Trail Brook converge. These brooks are high gradient and flashy and the timing of the peak runoff as these brook meet, may contribute to elevated flows and velocities at WB8.0. The amount of CPOM at WB8.0 has been noted to be in low abundance. It is speculated that CPOM is scoured from the substrate when velocities are high.

Another stressor at WB8.0 is the low buffering capacity. The alkalinity at West Branch RM 8.0 for baseflow samples has averaged only 5.6 mg/L as CaCO₃, suggesting the station is acid stressed. Water chemistry data samples collected within the past five years have shown pH values in the 4 to 6 s.u. range on multiple occasions, indicating this West Branch in this location is affected by acidic pulses. The tributaries (Gondola Brook and Long Trail Brook) that merge just upstream of WB8.0 have very low alkalinities, in the range of 2.0 to 2.6 mg/L CaCO₃. The low buffering capacity of these tributaries likely impacts the macroinvertebrate carrying capacity, thereby reducing the drift upstream of WB8.0.

**Table 11. Macroinvertebrate Results
West Branch of Little River RM 8.0 (MS-16b)
Above Discharge from Mount Mansfield Parking Area**

Year	Density	Richness	EPT	PMA -O	BI	% Oligo.	EPT/ EPT+C	PPCS -FG	Outcome
10/10/2006 BCE	199.5	26	13.5	65	2.19	10.0	0.89	0.61	Class B2 Not Supported: Fair
9/7/2007 BCE	682	26	15.0	60	3.01	13.0	0.93	0.42	Indeterminate for Class B2: Fair
9/7/2007 ANR	1204	33	14.0	63	3.50	8.0	0.87	0.36	Class B2 Not Supported: Fair
9/12/2008 BCE	184.5	24.0	13.5	65	3.38	9.3	0.93	0.34	Class B2Not Supported: Fair
9/10/2009 BCE	567	23.5	14.5	69	3.29	1.5	0.94	0.55	Class B2 Not Supported: Fair

**Table 11. Macroinvertebrate Results
West Branch of Little River RM 8.0 (MS-16b)
Above Discharge from Mount Mansfield Parking Area**

Year	Density	Richness	EPT	PMA -O	BI	% Oligo.	EPT/ EPT+C	PPCS -FG	Outcome
9/27/2010 ¹ BCE	77	15.5	9.0	59.5	2.13	0.8	0.90	0.35	Class B2 Not Supported: Poor
9/28/2011 ¹ BCE	89.5	20.0	13.5	67	2.13	6.1	0.91	0.52	Class B2 Not Supported: Poor
9/16/2012 BCE	399.5	29.5	17.5	78.3	2.49	2.7	0.89	0.46	Class B2 Supported: Good
10/24/12 ² DEC	837.0	30.0	17.0	68.1	2.58	8.2	0.69	0.34	Class B2 Not Supported: Fair to Good
9/19/2013 BCE	160.5	24.5	14.0	67.2	2.98	3.8	0.87	0.32	Class B2 Not Supported: Fair
9/22/14 DEC ³	434.7	35.0	16.0	56.9	3.78	17.5	0.93	0.40	Class B2 Not Supported: Fair
9/22/14 BCE	469.7	30.0	19.0	60.3	3.71	11.2	0.95	0.45	Class B2 Supported: Good
9/25/15 BCE	223.5	31.0	19.0	65.1	1.99	6.8	0.84	0.48	Class B2 Not Supported: Fair to Good
9/23/16 BCE	250.0	29.0	17.0	75.5	1.70	5.5	0.92	0.37	Class B2 Not Supported: Good to fair
Annual Mean (2006-2016)	322.3	25.9	14.9	66.6	2.66	6.5	0.90	0.44	
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	
¹ Large flood events in August 2010 and August 2011									
² Sampled five days following a freshet event.									
³ One replicate only									

West Branch of Little River RM 7.5: The West Branch station at RM 7.5 is located below the discharge from the Mt. Mansfield sedimentation basins and downstream of the exit from the Mansfield parking lot. Similar to the previous couple of years, density was less than the threshold of greater than 300 organisms needed to meet Class B2 biocriteria (Table 12). The

percentage of Oligochaeta (worms) was slightly under the threshold of less than 12 percent.

Worms colonize in the sediment. This station appears to be stressed by sediment and/or scour.

Table 12. Macroinvertebrate Results West Branch of Little River RM7.5 (MS-8) Below Lower Exit to Mount Mansfield (Above Big Spruce Brook Confluence)									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	118	24.5	13	55	2.08	1.9	0.76	0.40	Class B2 Not Supported: Fair
Sept. 2000 VANR	605	22	12	55	3.13	0.0	0.70	0.39	Class B2 Not Supported: Fair
Sept. 2001 VANR	130	25.5	15	72	2.68	0.40	0.80	0.47	Class B2 Not Supported: Fair
Oct. 2003 PEA ¹	123.5	18.5	8.5	49	3.56	44.0	0.57	0.41	Class B2 Not Supported: Poor
Nov. 2004 PEA	165.5	25	14	58	1.45	14.1	0.90	0.54	Class B2 Not Supported: Fair
Sept. 2005 BCE	179	34	15	73	2.19	23	0.80	0.47	Class B2 Not Supported: Fair
10/10/2006 BCE	185.5	26	17	64	1.76	5.9	0.91	0.60	Class B2 Not Supported: Fair
9/7/2007 BCE	629	28.5	17.5	65	2.28	3.3	0.93	0.44	Class B2 Supported: Good
9/12/2008 BCE	213.5	26.5	16.0	67	2.89	2.5	0.91	0.48	Class B2 Not Supported: Fair
9/10/2009 BCE	477.5	28	16.5	71	2.45	1.8	0.86	0.44	Class B2 Supported: Good
9/26/2009 BCE	350.0	28.5	19.0	70	1.95	1.7	0.90	0.50	Class B2 Supported: Good
9/27/2010 ² BCE	88	23	14.5	65	2.63	7.3	0.92	0.49	Class B2 Not Supported: Poor
9/28/2011 ² BCE	99.5	19.5	13	68	2.23	1.5	0.88	0.51	Class B2 Not Supported: Poor
9/16/12 BCE	417.3	30.0	18.0	69.4	2.83	0.6	0.91	0.43	Class B2 Supported: Good
9/19/2013 BCE	260.5	33.0	19.0	66.8	2.39	12.5	0.88	0.41	Indeterminate for Class B2 (Fair to Good)
9/22/14 BCE	344.2	29.5	18.5	68.0	2.19	8.4	0.91	0.36	Class B2 Supported: Good

Table 12. Macroinvertebrate Results West Branch of Little River RM7.5 (MS-8) Below Lower Exit to Mount Mansfield (Above Big Spruce Brook Confluence)									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/25/15 BCE	237.5	32.5	21.0	68.5	2.09	7.1	0.83	0.49	Class B2 Not Supported: Fair to Good
9/23/16 BCE	247.0	29.5	17.0	72.2	1.60	11.0	0.91	0.55	Class B2 Not Supported: Fair
Annual Mean (2006-2016)	285.1	27.8	17.2	67.7	2.28	5.6	0.90	0.48	
Annual Mean (2000-2016)	256.0	27.0	15.9	65.7	2.35	9.0	0.85	0.47	
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	
¹ Petroleum spill in 2003 ² Large flood event in August 2010									

West Branch of Little River RM 7.4: 2016 is the first year that macroinvertebrate biomonitoring was conducted at RM7.4 on the West Branch. This station was sampled to provide additional information about the biological community below Stowe Mountain Resort. RM 7.4 is located below the discharge from the Mount Mansfield Sediment basins, and is downstream of the riprapped section, but upstream of the large mass failure. The station is located in a section of stream that appears to be less prone to scour. The biological integrity at RM 7.4 reflects an improvement from RM 7.5, especially in terms of richness, EPT Richness and density (Table 13). All the metrics are full support for Class B2 biocriteria. The percent Oligochaeta metric is slightly elevated, indicating sediment may be a stressor within this reach.

Table 13. Macroinvertebrate Results West Branch of Little River RM7.4 Below riprap and above large mass failure (Above Big Spruce Brook Confluence)									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/23/2016 BCE ¹	370.8	39	21.0	81.7	1.77	8.4	0.89	0.49	Class B2 Supported: Good
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	
¹ One replicate									

West Branch of Little River (RM 6.5): This is the fifth consecutive year, since the extreme high flow events in 2010 and 2011 that the metrics for RM6.5 passed the biocriteria (Table 14). All eight metrics exceeded the threshold values, and the macroinvertebrate community was found to be of good to very good biological integrity.

Table 14. Macroinvertebrate Results West Branch of Little River RM 6.5 (MS-14) Above Pinnacle Brook									
Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	420	38	21	70	3.35	0.4	0.69	0.44	Class B1 Supported: V.Good
Oct. 2003 ¹ PEA	135	24.5	14	58	3.62	19.5	0.64	0.56	Class B2 Not Supported: Fair
Nov. 2004 PEA	364	38	23.5	65	3.01	14.1	0.90	0.65	Indeterminate
Sept. 2005 BCE & DEC	352	43	24	80	1.91	9.2	0.83	0.52	Class B2 Supported: Good
10/10/2006 BCE	212	30.5	20.5	70	1.86	1.8	0.90	0.67	Class B2-3 Not Supported: Fair
9/7/2007 BCE	626	27	16.0	81	2.06	1.8	0.91	0.59	Class B2 Supported: Good
9/12/2008 BCE	272	25	15.0	64	3.40	2.7	0.95	0.52	Class B2 Not Supported: Fair

**Table 14. Macroinvertebrate Results
West Branch of Little River RM 6.5 (MS-14)
Above Pinnacle Brook**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/12/2008 DEC	302	35	20	73.7	2.90	1.7	0.91	0.60	Class B2 Supported: Good
9/10/2009 BCE	593	30	18.5	74.7	2.47	0	0.90	0.52	Class B2 Supported: VG to Good
9/11/2009 DEC	694.5	44	26	76.7	2.86	1.7	0.87	0.59	Class B1 Supported: VG to Exc.
9/27/2010 ² BCE	158.5	31.5	21.5	64	2.67	2.0	0.95	0.53	Class B2 Not Supported: Fair
9/9/2011 ² DEC	266	43	23	69.7	3.45	1.9	0.92	0.62	Class B2 Not Supported: Fair
9/28/2011 ² BCE	207.5	25.5	18	53	3.98	0.6	0.96	0.41	Class B2 Not Supported: Fair
8/30/2012 DEC	936.0	39.7	23.7	71.5	2.67	1.0	0.84	0.49	Class B1 Supported: V.Good
9/16/2012 BCE	340.9	34.5	22.0	73.0	2.47	1.2	0.83	0.45	Class B2 Supported: Good
10/24/12 ³ DEC	589.5	42.0	29.0	60.5	1.64	3.6	0.93	0.29	Class B2 Not Supported: Fair to good
9/19/13 ⁴ BCE	350.2	35.0	22.5	69.5	2.67	3.1	0.89	0.39	Class B2 Supported: Good
9/22/14 BCE	354.3	33.0	21.5	65.1	3.17	2.4	0.93	0.49	Class B2 Supported: Good
9/25/15 BCE	374.8	41.5	24.5	65.5	2.46	1.5	0.69	0.47	Class B2 Supported: Good
9/23/16 BCE	368.1	36.5	24.0	80.1	1.92	2.3	0.92	0.60	Class B2 Supported: Good to VG
Annual Mean (2006-2016)	386.4	33.9	21.2	70.3	2.63	1.8	0.89	0.53	
Annual Mean (2000-2016)	368.1	34.5	21.1	69.8	2.72	4.2	0.86	0.53	
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	

**Table 14. Macroinvertebrate Results
West Branch of Little River RM 6.5 (MS-14)
Above Pinnacle Brook**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	

¹ Petroleum spill in 2003
² Large flood event in August 2010 and 2011
³ Sampled five days after a freshet event
⁴ PPCS slightly under threshold value of 0.40 with very good EPT and Richness numbers.

Pinnacle Brook – RM0.1: Pinnacle Brook acts as a local control/reference station for the other biomonitoring stations at Stowe Mountain Resort. The 2016 macroinvertebrate results from the lower Pinnacle Brook station indicate the biological integrity was very good as summarized in Table 15.

**Table 15. Macroinvertebrate Results
Pinnacle Brook MS-13 At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
Sept. 2000 PEA	714	35.5	21.5	72	2.05	0.0	0.68	0.56	Class A1 Supported: Exc.
Oct. 2003 PEA	1098	28	16.5	65	1.20	0.4	0.91	0.40	Class B2 Supported: Good
Nov. 2004 PEA	499	32.5	17.5	58	2.17	3.1	0.76	0.53	Class B2 Supported: Good
Sept. 2005 BCE	601	53	22	67	2.43	14.0 ¹	0.64	0.47	Class B2 Supported: Very Good to good
10/10/2006 BCE	499	30	18	70	1.61	0	0.90	0.65	Class B2 Supported: Good
9/7/2007 BCE	791.5	28	18	79	2.00	0	0.79	0.58	Class B2 Supported: Good
9/12/2008 BCE	411.5	33.5	17.5	61	2.58	1.5	0.64	0.39 ²	Class B2: Good
9/10/2009 BCE	649.5	30	18	74	3.17	0.2	0.68	0.68	Class B2 Supported: Good to very good

**Table 15. Macroinvertebrate Results
Pinnacle Brook MS-13 At Mouth**

Year	Density	Richness	EPT	PMA-O	BI	% Oligo.	EPT/EPT+C	PPCS-FG	Outcome
9/27/2010 BCE	439	30.5	19	80	1.94	0.6	0.75	0.56	Class B2 Supported: Good to very good
9/28/2011 ³ BCE	320.5	28.5	17.5	69	2.01	0.4	0.83	0.45	Class B2-3 Supported: Good
9/16/2012 BCE	607.7	37.5	21.5	77.1	1.97	0	0.74	0.54	Class A1 Supported: Exc.
9/19/13 BCE	412.0	40.5	24.5	77.6	2.56	0.3	0.79	0.45	Class B1 Supported: Very Good
9/22/14 BCE	426.3	35.5	21.0	64.9	2.15	1.0	0.70	0.48	Class B1 Supported: Very Good
9/25/15 BCE	462.5	38.0	23.5	67.4	1.85	0.0	0.74	0.57	Class B1 Supported: Very Good
9/23/16 BCE	393.4	37.0	23.0	68.9	1.16	0.6	0.88	0.46	Class B2 Supported: Very Good
Annual Mean (2006-2016)	492.1	33.5	20.1	71.7	2.09	0.4	0.77	0.53	
Annual Mean (2000- 2016)	555.0	34.5	19.9	70.1	2.06	1.5	0.76	0.52	
Full Support Class B2	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45	
Meets Threshold	≥300	≥27	≥16	≥45	≤4.50	≤12	≥0.45	≥0.40	
Near Threshold	≥250	≥26	≥15	≥40	≤4.65	≤14.5	≥0.43	≥0.35	
Non-Support	<250	<26	<15	<40	>4.65	>14.5	<0.43	<0.35	

¹high percentage of Oligochaeta in 2005 not associated with deposition (Naididae)

²Functional feeding group metric is dissimilar to the reference Class B2-3 community because it is critically acidified.
Overall biological integrity is good.

³Flood event in late. August 2011 (Tropical Storm)

General Trends

A map showing the results of the 2016 monitoring is provided below in Figure 33. WB 8.8, located upstream of the Resort passed Class B2 biocriteria. Both WB 8.0 and WB 7.5 within

the Resort did not pass Class B2 biocriteria due to low density. WB 7.4, located slightly downstream of WB 7.5, met the thresholds for all eight metrics and passed Class B2 biocriteria. Both WB 6.5, located just upstream of the confluence of Pinnacle Brook, and PB 0.1, situated at the mouth of Pinnacle Brook, met Class B2.

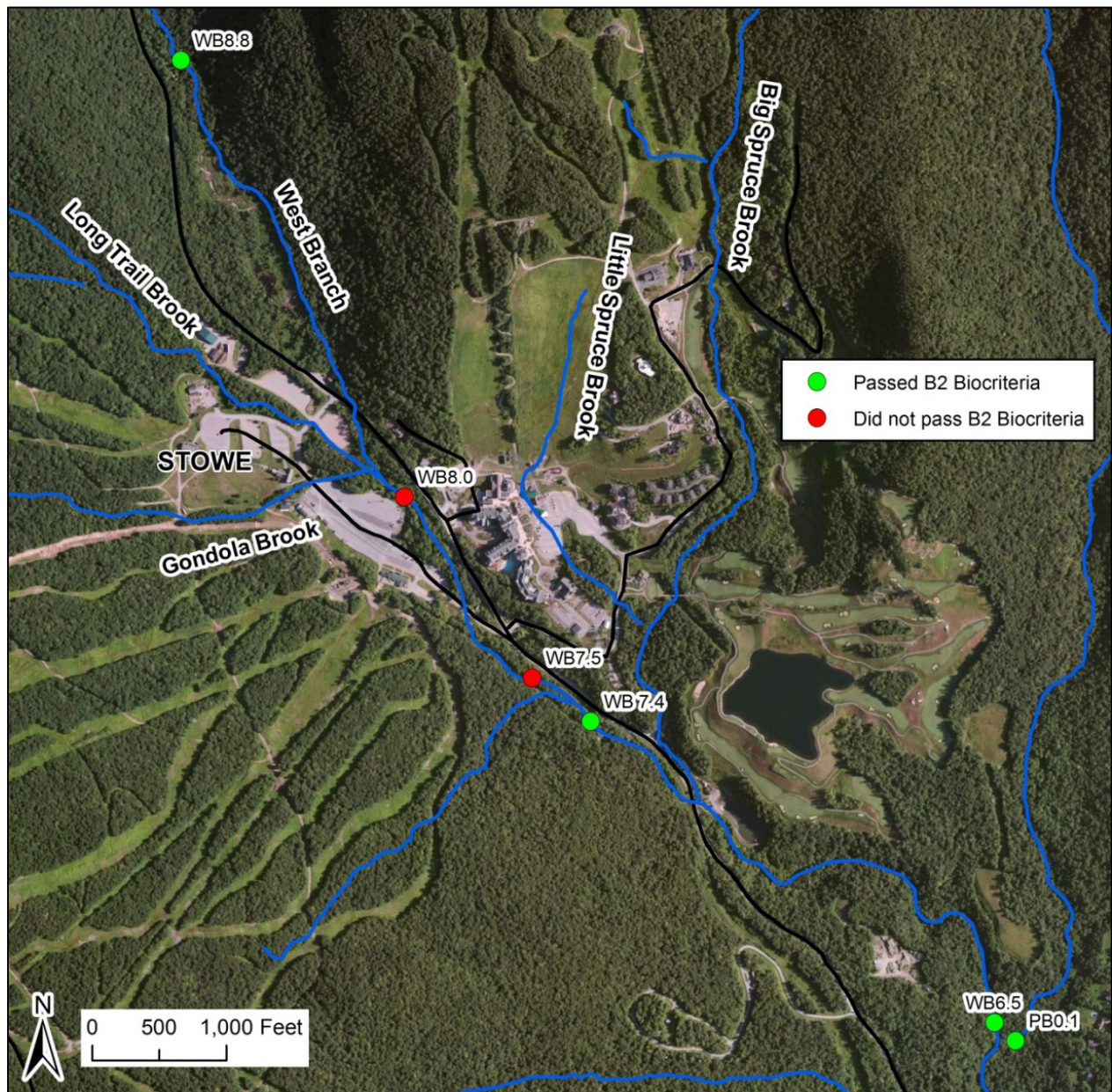


Figure 33. Results of 2016 biological monitoring.

Graphs of some of the key biometrics were created to better understand trends of the macroinvertebrate community of the West Branch. Biomonitoring data for the past five years collected by Bear Creek Environmental for Stowe Mountain Resort was utilized. The graph of density (Figure 34) shows the number of bugs at RM 8.8 above the Resort is low, but is above the threshold of 300 organisms. The average density in the kick net samples at RM 8.0 and 7.5 (within the Resort) has been less than the threshold of 300 organisms in about half of the years. A recovery in density occurs at RM 6.5 below the Resort.

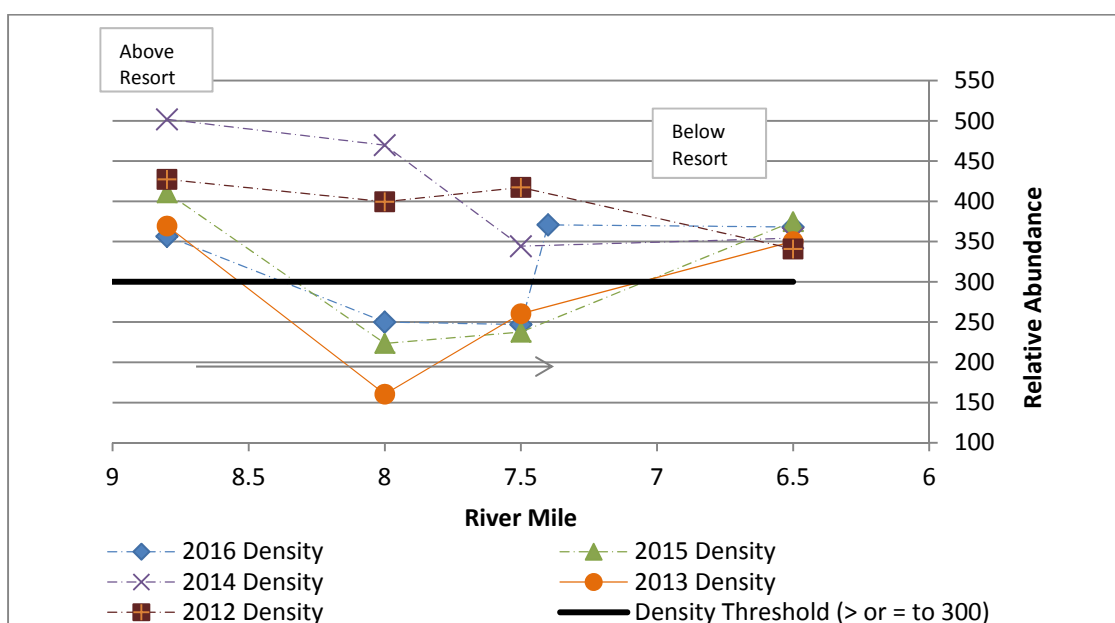


Figure 34. Density in kick net samples for past five years on West Branch.

A second graph (Figure 35) shows the number of water quality sensitive organisms from the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). Upstream of the Resort at RM 8.8 the number of EPT taxa hover around the threshold value of 16. In other words, in some years the metric is lower than the threshold value and the station does not meet Class B2. In other years, the number of EPT taxa is just above the threshold value. The low EPT Richness and Total Richness are likely attributed to very low alkalinity. Based on water chemistry data collected at RM 8.0, this station also has a low alkalinity and low EPT and Richness, although there was only one sampling event within the past five years that resulted in EPT Richness and Richness values less than the thresholds.

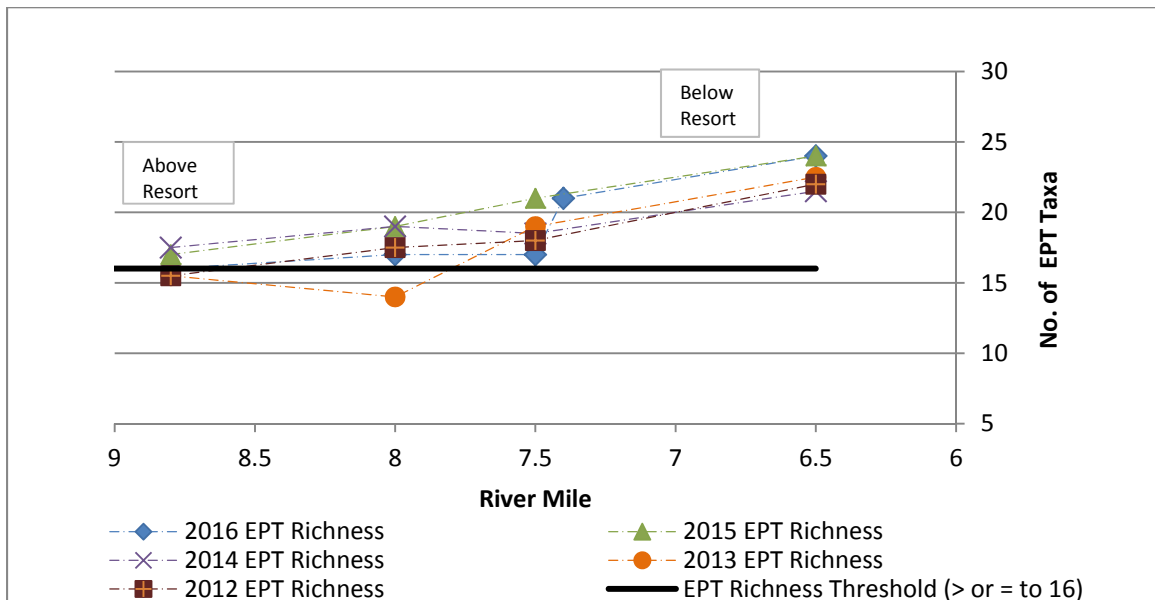


Figure 35. Number of EPT Taxa in kick net samples for past five years on West Branch.

Biomonitoring results from WB8.0 and WB 7.5, within the Resort, indicate sedimentation is an issue. The percentage of Oligochaeta at WB 8.0 and WB 7.5 is high compared to stations above and below the Resort, as shown below in Figure 36. Four years ago, Stowe Mountain Resort implemented significant stormwater improvements associated with the parking lots at Mount Mansfield. The Resort continues to look for opportunities to improve stormwater management.

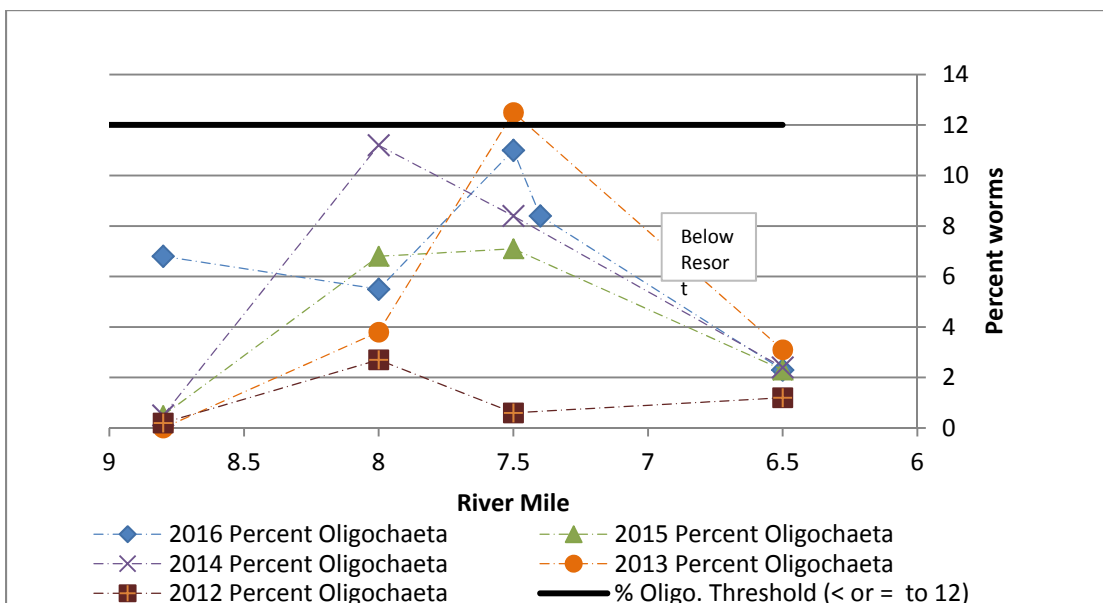


Figure 36. Percentage of Oligochaeta in kick net samples for past five years on West Branch.

7.3 Fish Population Monitoring

The Vermont Department of Fish and Wildlife (VDFW) has been monitoring wild brook trout populations annually since 1994 at three stations on the West Branch in the vicinity of Stowe Mountain Resort and two stations on Ranch Brook (Figure 37). Monitoring stations are summarized in the Table 16. Trout densities per mile have been provided courtesy of Rich Kirn, Fisheries Biologist with the VDFW, and are included in Appendix 4 on pages 22 and 23.

The mean number of young-of-the-year brook trout per mile from 1997 through 2016 is highest on West Branch 10 (1527) and West Branch 20 (1266). In 2016, young-of-the-year densities at West Branch 10 were 600 fish per mile. This density is lower than the other stations and is low compared with the historical average. The other three stations (Ranch 10, Ranch 20 and West Branch 23) have similar average densities of young-of-the-year trout in the range of 860 to 1000 fish per mile. Mean densities of yearling and older trout for 1997 through 2016 are in the range of 700 to 1100 trout per mile. Graphs showing the number of young-of-the-year and yearling and older wild brook trout are provided below in Figures 38 and 39, respectively. The results indicate there is a healthy wild brook trout population in the West Branch in the vicinity of Stowe Mountain Resort.

**Table 16. Vermont Fish and Wildlife Department
Annual Brook Trout Monitoring Stations**

Station	Elevation (feet)	Location
West Branch 10	1550	Near Barnes Camp
West Branch 20	1440	Mansfield Parking Lot Exit
West Branch 23	1410	At Stowe Mountain Resort pump house
Ranch Brook 10	1200	Near Ranch Camp
Ranch Brook 20	960	Above confluence with West Branch

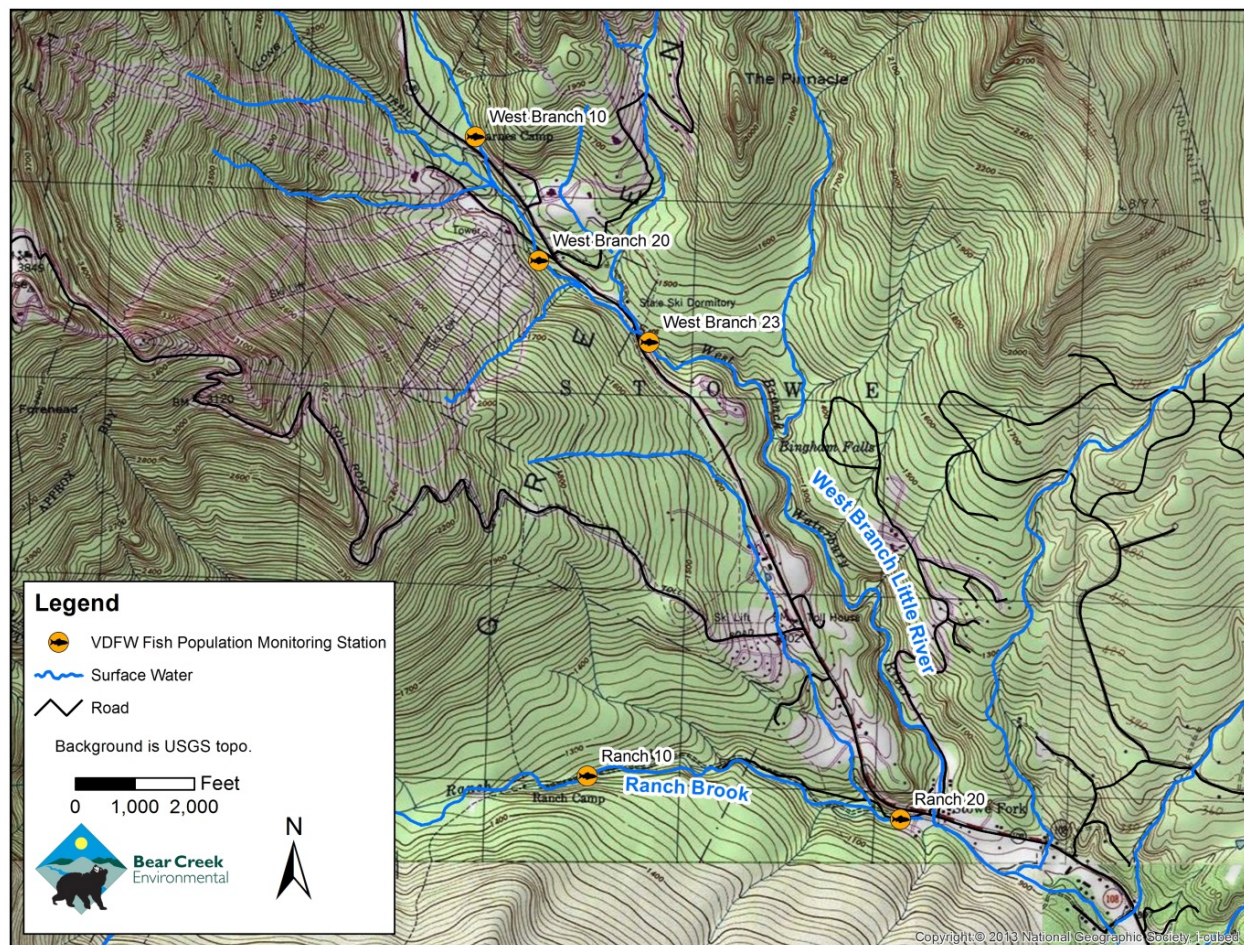


Figure 37. Vermont Fish and Wildlife Department Brook Trout Monitoring Stations.

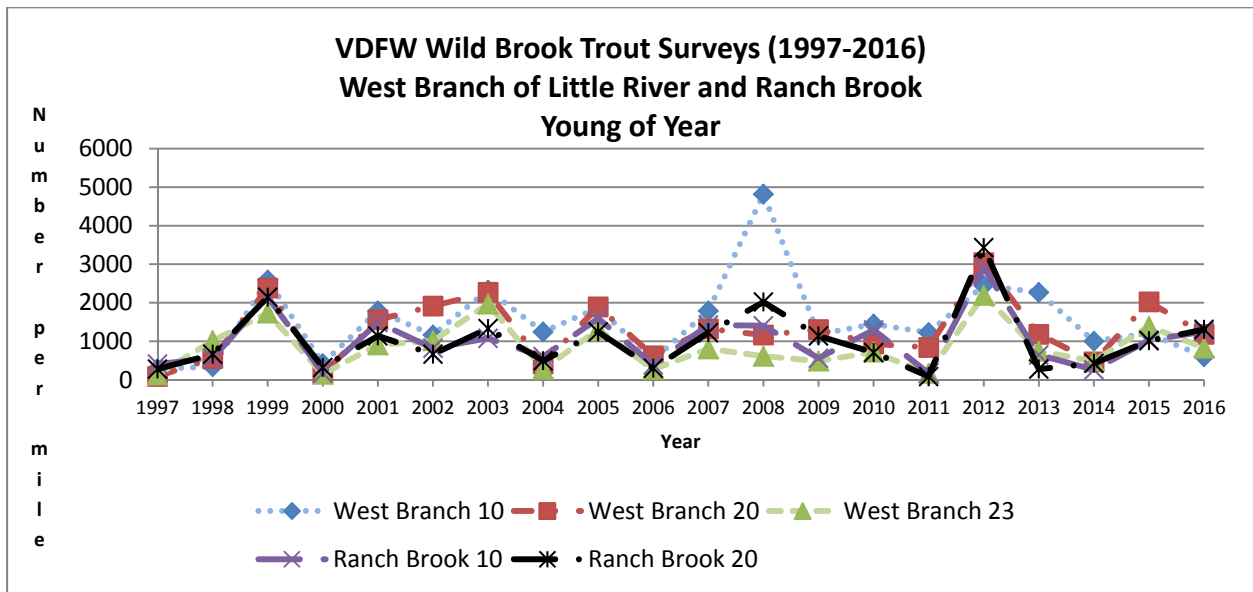


Figure 38. Vermont Fish and Wildlife Department brook trout young-of-year data.

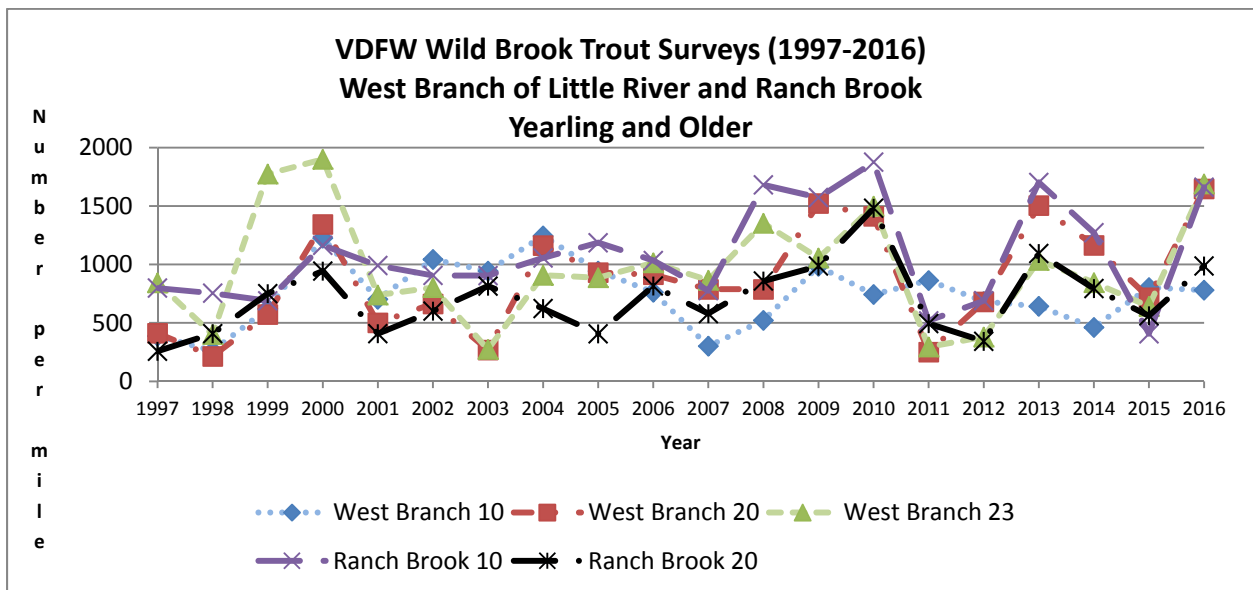


Figure 39. Vermont Fish and Wildlife Department brook trout yearling and older data.

8.0 PROPOSED 2017-2018 MONITORING

The monitoring program for the 2017-2018 monitoring year will remain the same as the 2016-2017 monitoring with the exception of event-based water quality monitoring being added back in at the Mansfield Exit Basin outlet. A table of showing the expected tasks, products and schedule for the 2017-2018 monitoring is provided below.

Table 17. Schedule of Tasks and Products		
Task	Stations	Date
Event-based Water Quality Three times annually	West Branch at RM 8.2, 8.0, 7.5 Long Trail Brook RM 0.1 Gondola Brook RM 0.1 Big Spruce Brook at RM 0.9, 0.7, 0.3, 0.2 Little Spruce Brook at RM 0.3, 0.1 Ski Club Drainage Upper and Lower Mansfield Basin Outlet Mansfield Exit Basin Outlet Big Spruce Basin Outlet	Spring 2017 – Spring 2018
Macroinvertebrate kick net sampling Once annually	West Branch at RM 8.8, 8.0, 7.5, 7.4, 6.5 and Pinnacle Brook RM 0.1	September 1 – October 15, 2017
Baseflow Water Chemistry Once annually at time of kick net sampling	West Branch at RM 8.8, 8.0, 7.5, 6.5 Pinnacle Brook RM 0.1 Big Spruce Brook at RM 0.9, 0.2 Little Spruce Brook at RM 0.3, 0.1	September 1 – October 15, 2017
Water Quality Monitoring and Biomonitoring Report	(Refer to stations above)	Spring 2018

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