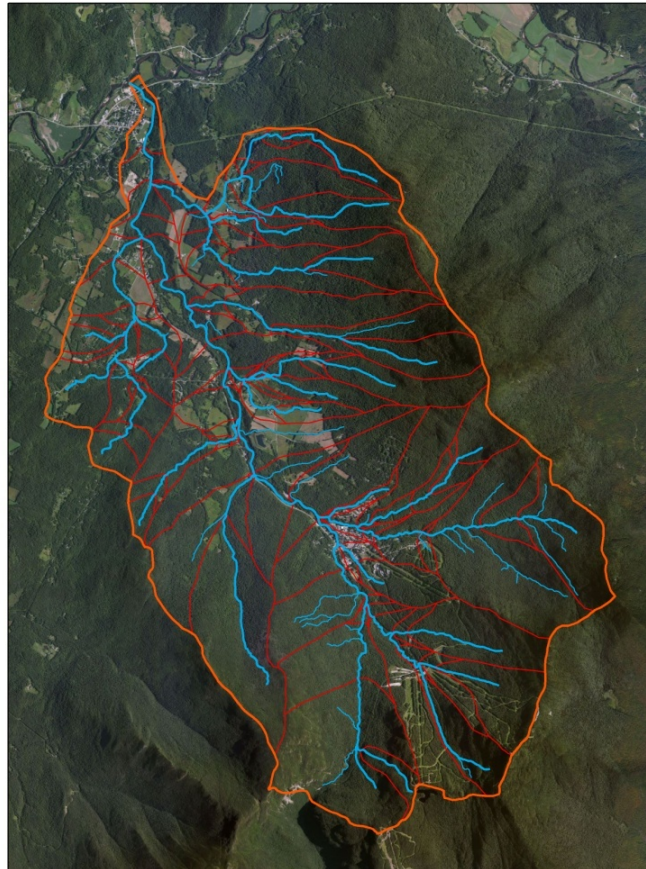


**Brewster River Phase 1 & 2
Stream Geomorphic Assessment Summary
March 15, 2013**



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Executive Summary

The Brewster River watershed is located in the Lamoille River Basin in northwestern Vermont. The watershed has a drainage area of 19.8 square miles and outlets to the Lamoille River immediately east of the VT Route 108 river crossing. The watershed is primarily located within the town of Cambridge, with small areas of the headwaters in the towns of Johnson, Morristown, and Stowe. The mainstem of Brewster River drains the northwestern face of Sterling Mountain and joins with a major tributary draining the north face of Mt Mansfield and the Smugglers Notch ski area.

Flooding and erosion hazards are a top concern for the citizens of Cambridge, and in particular the Village of Jeffersonville. In spring of 2011 (and again to a lesser degree during Tropical Storm Irene) severe flooding struck the Village at the confluence of the Brewster and Lamoille Rivers. This flooding caused extensive damage to homes and businesses within the Village. Prior to the flooding, erosion hazards along the eastern valley wall of the Brewster River in the Jeffersonville have plagued the Village. The native soils of the area, being of glacio-fluvial origin along the perimeter of the Brewster River valley, are prone to mass wasting during and following periods of heavy precipitation. Recent slope failures occurred in 1999 and 2006 and caused extensive sedimentation and property damage in the Village.

As a result of dealing with severe, repeat flood and erosion damage throughout Vermont over the last two decades, Vermont's river scientists and engineers now understand that hazard mitigation and river restoration projects are most successful when carried out within a context of how reach and watershed-scale stressors influence flood and erosion hazards. In an effort to understand the root causes of stream channel instability and flood/fluvial erosion hazards in the Brewster River watershed, the Lamoille County Planning Commission (LCPC) has sought to develop a database of Stream Geomorphic Assessment (SGA) data for reaches of significant size in the Brewster River watershed. This data allows for a much more comprehensive approach to flood and erosion hazard planning, in contrast to the conventional approach of multiple "spot fixes" with limited knowledge of the river system. Fitzgerald Environmental Associates, LLC (FEA) was hired by LCPC in fall of 2012 to assist with a Phase 1 SGA study, and complete a Phase 2 SGA study of the lower 4 reaches of the Brewster River. The objectives of the planning study are described below.

- 1) Develop baseline watershed and reach-scale data for the Brewster River.
- 2) Develop a basis for understanding the overall causes of channel instability, flood/erosion hazards, and habitat degradation along the river corridor in the watershed.
- 3) Characterize in greater detail the lowest four reaches of the Brewster River, and produce a list of preliminary river corridor restoration projects that can be further developed in the future to mitigate flood and erosion hazards in the Village of Jeffersonville.

Below is a summary of key findings from the Phase 1 and 2 SGA study:

- A total of 35 reaches along 14.5 river miles were delineated during the Phase 1 analysis. Full Phase 1 data and windshield survey data was collected by LCPC and FEA for the Brewster River mainstem and one impacted tributary reach (M01-M18 and T7.01) covering 8.4 miles and 18 reaches.
- The Phase 1 SGA approach resulted in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), providing a basis for understanding the natural and human-impacted conditions within the watershed. The Phase 1 data will also aid in future identification of specific stressors affecting the

physical conditions of the stream channels and structures (e.g., bridges and culverts, bank armoring, etc).

- Half of the assessed reaches (9) are found in a confined valley setting that would naturally support sediment transport channels with A or B-type geometry. The remaining nine (9) reaches are found in an unconfined valley setting with meandering, depositional C -type channel geometry.
- Approximately 88% of the watershed is forested, with agricultural land use representing approximately 7%. Developed lands (2%) are mainly associated with the Smugglers Notch Resort, the Village of Jeffersonville, and other residential developments along Route 108. Wetlands and other surface waters represent less than 1% of the watershed area, which is typical of an upland watershed in Vermont.
- Impact ratings were developed for each reach using the Phase 1 parameters representing four classes of watershed and reach-scale impacts: 1) Land Cover and Reach Hydrology; 2) Channel Modifications; 3) Floodplain Modifications and Planform Changes; 4) Bed and Bank Conditions. Out of a total possible impact score of 32, the average rating for all reaches was 7.9, with a maximum score of 24 and a minimum score of 0.
- Based on the Phase 1 impact ratings, a total of 9 high-priority reaches (in addition to the reaches assessed for Phase 2 data in this study) are recommended for Phase 2 assessment, including 7 mainstem reaches and 1 tributary reach. The selected reaches have a total channel length of 4.7 miles. In addition, 2 medium-priority reaches were selected for consideration due to their relatively high impact ratings.
- Four (4) reaches were identified for Phase 2 assessment during the 2012 field season (M01-M04: 1.4 miles). These reaches are found from the Brewster-Lamoille confluence up to a gorge east of Route 108. Detailed, reach-level data collected from the Phase 2 surveys were used for preliminary project identification.
- The geomorphic and habitat conditions were assessed as “fair” in each of the four segments surveyed for Phase 2 data. A stream type departure (C to B) was noted in the lowest segment (M01-A), indicating that this segment of the Brewster River (adjacent the Village) has incised and is only partially connected to its historical floodplain. Stream sensitivity ratings were developed for each Phase 2 segment to indicate the relative sensitivity of the river channel to undergo adjustments (e.g., bank erosion) in response to changes in the upslope watershed and/or river corridor. The lower two segments (M01-A and M01-B) had a rating of “very high”, while reaches M03 and M04 had ratings of “high.”
- Sediment management has been identified as a key concern in the Village of Jeffersonville due to ongoing conflicts at structures and road crossings, and flooding concerns. However, given the state of channel adjustments in the lower reaches of the Brewster, bank stabilization and/or channel reconfiguration is generally not advisable where the river is actively incising or redeveloping planform geometry. Numerous riverbank stabilization and channelization projects in Vermont and other states have failed due to a lack of understanding of channel adjustment processes and stage of channel evolution.

1.0 Project Background

The Lamoille County Planning Commission (LCPC) and the Vermont Department of Environmental Conservation (VTDEC) identified the Brewster River watershed in northwestern Vermont for assessment of fluvial geomorphic conditions. The study is part of a larger effort to characterize the physical and biological conditions of the Brewster River watershed and to aid in the identification of stressors on channel stability and aquatic biota communities. In addition, the study results will form the basis for future flood mitigation, stream corridor, and Fluvial Erosion Hazard (FEH) planning efforts in the watershed, particularly in the Village of Jeffersonville. Fitzgerald Environmental Associates, LLC. (FEA) was retained by LCPC in 2012 to assist with Phase 1 assessments and carry out Phase 2 assessments following the Stream Geomorphic Assessment (SGA) Protocols developed by the Vermont River Management Program (RMP).

Watershed restoration projects are most successful when carried out within a context for understanding how reach and watershed-scale stressors cause channel instability. The VTDEC SGA Protocols and River Corridor Planning Guide provides sound, scientifically-defensible methods for identifying stressors on channel stability and restoration projects that will address them appropriately (VTDEC, 2010). The overall goal of the VTDEC RMP is to “manage toward, protect, and restore the fluvial geomorphic equilibrium condition of Vermont rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner,” (VTDEC, 2010) achieved through:

- Fluvial erosion hazard mitigation;
- Sediment and nutrient load reduction; and
- Aquatic and riparian protection and restoration

The Phase 1 SGA approach results in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), providing a basis for understanding the natural and human-impacted conditions within the watershed. The SGA data also aids in the identification of specific stressors affecting the physical conditions of the stream channels and structures (e.g., bridges and culverts).

LCPC used the Stream Geomorphic Assessment Tool (SGAT) to develop the baseline GIS data for the watershed in late 2012. A total of 35 reaches along 14.5 river miles were delineated during the Phase 1 analysis. Full Phase 1 data, FIT, and windshield survey data was collected by LCPC and FEA for the mainstem and one impacted tributary reach (M01-M18 and T7.01) covering 8.4 miles.

Four (4) reaches were identified for Phase 2 assessment during the 2012 field season (M01-M04: 1.4 miles). Detailed, reach-level data collected from the Phase 2 surveys were used for preliminary project identification and development activities that meet the RMP goals stated above.

2.0 Watershed Background

2.1 Geographic Setting and Land Use History

The Brewster River watershed is located in the Lamoille River Basin in western Lamoille County, Vermont (Figure 1). The watershed has a drainage area of 19.8 square miles and outlets to the Lamoille River immediately east of the VT Route 108 river crossing. The watershed is primarily located within the town of Cambridge, with small areas of the headwaters in the towns of Johnson, Morristown, and Stowe (Figure 2). The mainstem of Brewster River drains the northwestern face of Sterling Mountain and joins with Tributary 7 from the north face of Mt Mansfield and the Smugglers Notch ski area. The mainstem flows north along VT108 to the Village of Jeffersonville and then to the Lamoille River.

Land cover data based on imagery from 2006 (NOAA, 2008a) are summarized in Table 1. The Brewster River is drained by a rural watershed, with forest representing the dominant cover type. Agricultural lands only cover 6.8% of the watershed, with a majority of larger farmlands found in the lower mainstem watershed along VT108 and Tributary 2. Some areas of suitably sloped lands, such as along Edwards Road (Tributary 4), continue to support extensive agricultural lands, including hayfields and pasture for cows, horses and sheep. There is limited developed in the watershed, with only 1.9% coverage. Concentrated areas of residential and commercial development are found in the village of Jeffersonville, along VT Rte. 108, and at the Smugglers Notch ski resort.

Table 1: Land cover data for Brewster River watershed and major sub-basins

Land Cover Type	Tributary 2 (Stebbins Rd)	Tributary 7 (Desjardin Rd)	Entire Watershed
Developed	2.8%	2.5%	1.9%
Agriculture	15.8%	0.4%	6.8%
Forest	77.4%	91.8%	88.2%
Scrub/Shrub	3.3%	5.1%	2.6%
Wetland	0.7%	0.1%	0.5%
Open Water	0.0%	0.0%	0.1%

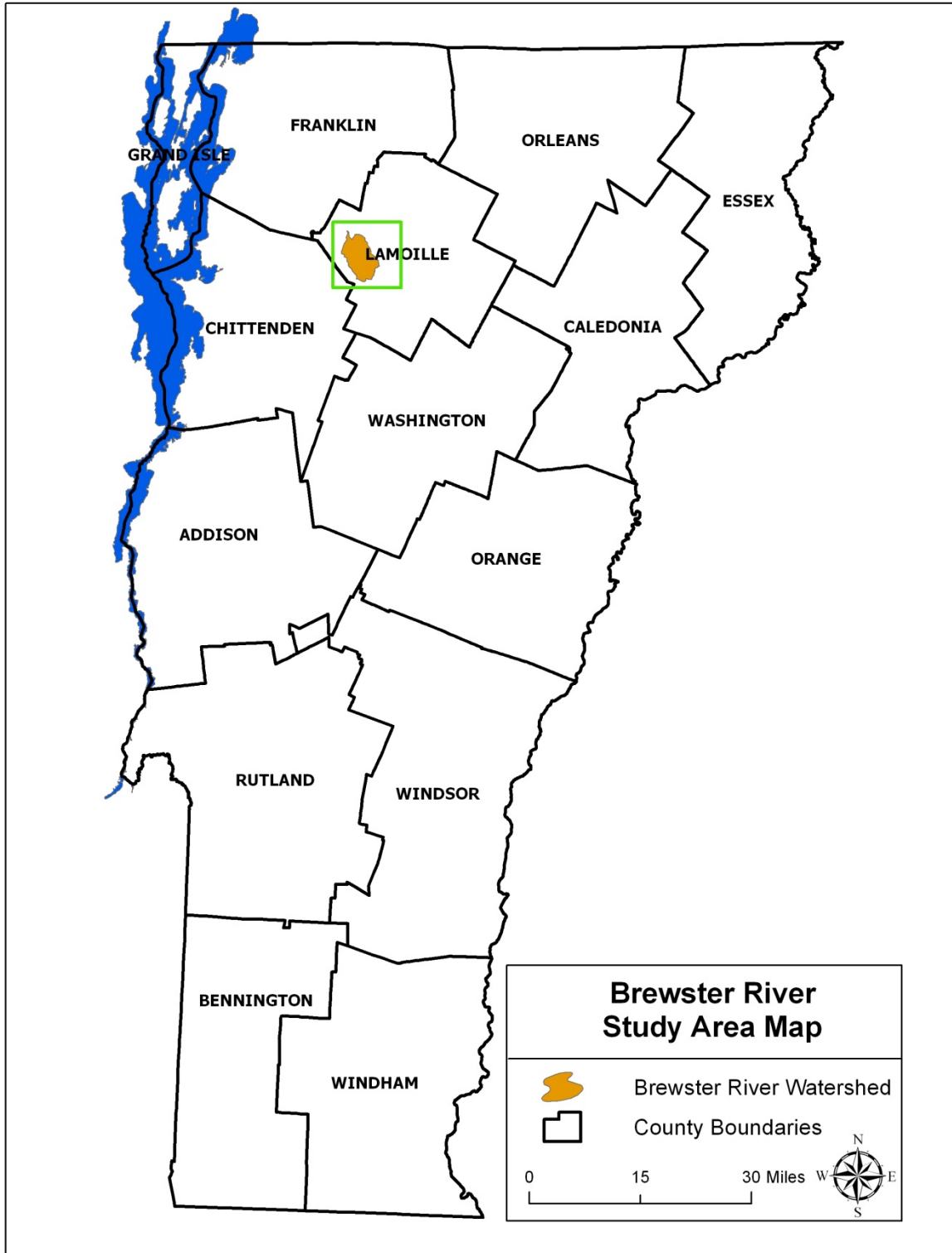


Figure 1: Watershed location map for the Brewster River watershed.

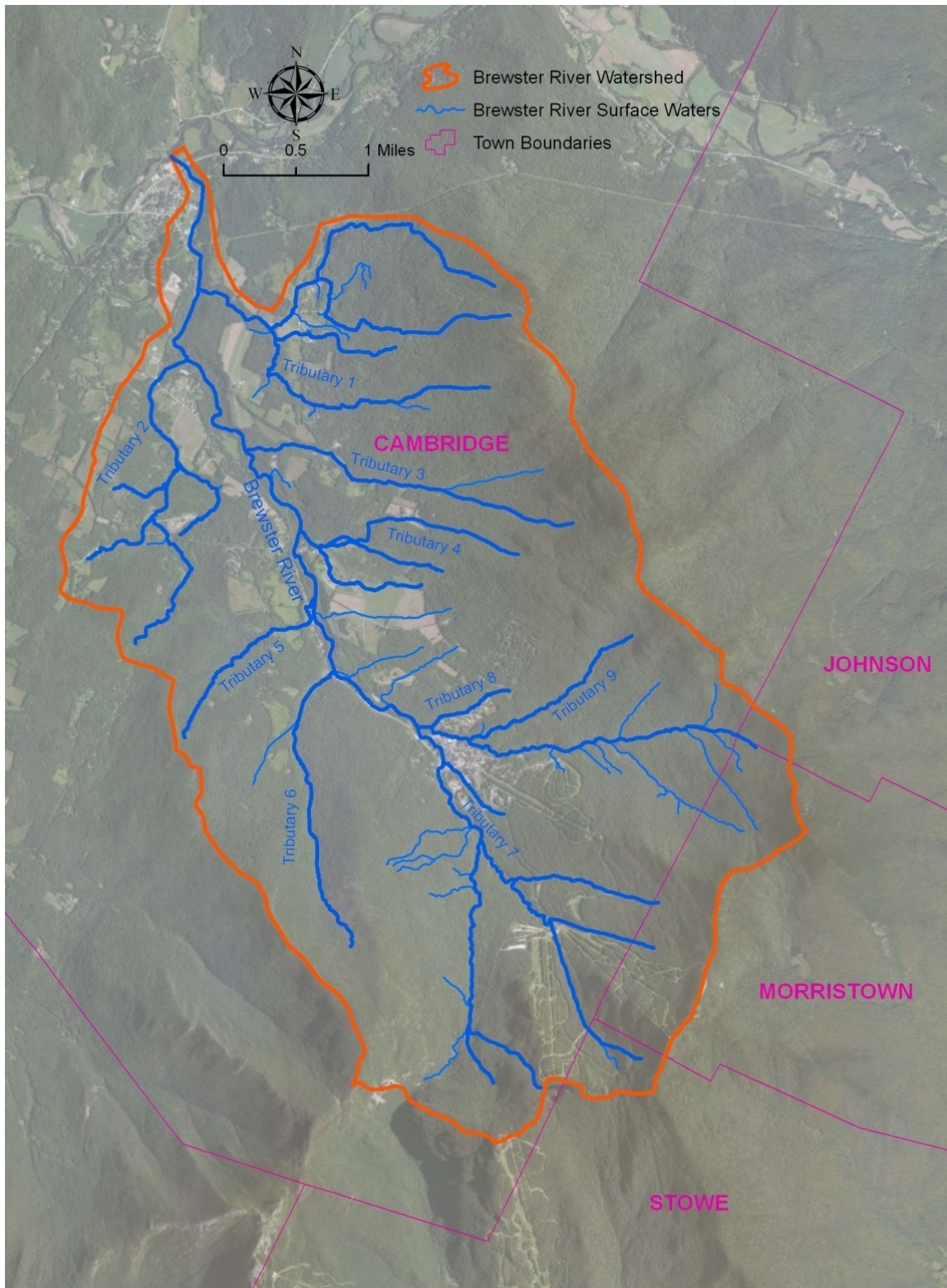


Figure 2: Brewster River watershed, surface waters, and town boundaries.

Historical Land Uses

Historically, the impacts of agricultural practices on the Vermont landscape left a lasting legacy on waterways like the Brewster River. Prior to the deforestation associated with human settlement, the watershed would have been a mixture of deciduous forest on the valley floors, coniferous forest along the mountain spines, and a mixture of both along the slopes. Deforestation and grazing, largely from sheep farms, likely left over 90 percent of the watershed devoid of trees at one time or another (Albers, 1998). This landscape change had a tremendous impact on waterways like the Brewster River. Exposed, highly-erodible soils (e.g. glacial tills) on steep slopes was carried to the valley floors where it aggraded on river bottoms; a legacy that still influences the way Vermont's rivers are managed today.

As Vermont's farmers began to move to the Midwest in search of more productive farmland in the mid to late 1800's, the deciduous forests along the mountain slopes began to recover (Albers, 1998). Throughout the early and mid 1900's, as more family farms on marginal lands were given up, the forests continued to recover. Today, approximately 90 percent of the Brewster River watershed is covered by forest. With the increasing tourism sector in the state, and the need for lumber for second-homes and construction, forestry has replaced agriculture in many of the rural hill slopes of Vermont.

2.2 Geologic and Geomorphic Setting

Geologic Setting

The underlying geology of the Brewster River watershed is comprised of a mixture of rock types from the Camel's Hump group of the Lower Cambrian era (Doll et al., 1961). The Underhill formation of quartz-sericite-albite-chlorite-biotite schist underlays most of the watershed. The Hazens Notch formation of carbonaceous and non-carbonaceous quartz-sericite-albite-chlorite schist is found in the headwaters draining Morse Mountain, and the subwatersheds for reaches M02-M05. The weathering of calcium carbonate rich (sea bottom) sediments in both of these formations results in basic, nutrient-rich soils that typically support diverse forest communities.

The presence of Glacial Lake Vermont also had a significant effect on the surficial geology of the lower watershed, perhaps as far upslope as reach M04. This lake formed approximately 14,000 years ago over the Lake Champlain basin during the retreat of the Laurentide ice sheet (Figure 3). The temporary lake was at an elevation of approximately 620' (current Lake Champlain elevation is approx. 100') and extended over a large portion of the current Lake Champlain basin (Wright, 2003). The great size of the lake, combined with the erosive forces of the glacier moving over bedrock surfaces caused large amounts of sediment deposition and

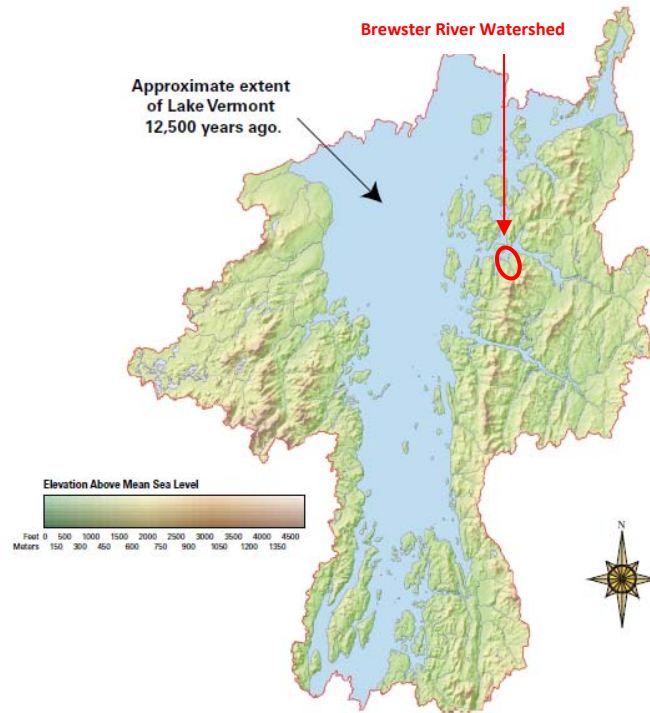


Figure 3: Extent of glacial Lake Vermont (LCBP, 2004).

allowed for the development of annual layering of fine sediments (e.g., varves) throughout the areas affected by glacial lakes (Ridge and Larson, 1990). Some of this fine sediment, in the form of glacio-lacustrine deposits throughout the Brewster River watershed, has a strong influence on both the stability of the valley side slopes and the channel and floodplain morphology. The native soils along Brewster River valley side slopes are prone to mass wasting during and following periods of heavy precipitation.

Geomorphic Setting

The Brewster River has a single main branch and 3 significant tributaries that were identified for full Phase 1 assessment. The mainstem of the Brewster River has an overall channel slope of 5.0%, with significant differences in the reference valley and channel morphology between the headwaters and lower reaches. The headwaters (Reaches M16-M18) have a channel slope of 16.4% and are found in narrowly confined valley settings typical of Vermont headwater channels. The lower reaches (Reaches M01-M14) have an average channel slope of 2.3% and are found in valley settings with variable width and confinement.

The first major tributary branching eastward from the mainstem is Tributary 1 (T1). T1 is found in a confined valley and has an overall channel slope of 8.5%. A small impoundment exists at the confluence of two other tributaries (T1.S1 and T1.S2) and causes ponding through reach T1.02. Tributary 2 (T2) has an overall channel slope of 3.6% has broad alluvial valleys in the lower reaches (T2.01-T2.03) with confinement increasing in the headwater reaches. Tributary 7 (T7) has an overall channel slope of 8.9% and is in a confined setting for all reaches except T7.01.

A summary of the average channel slopes for the mainstem and major tributaries is found in Table 2.

Table 2: Average channel slopes for mainstem and tributary channels

Channel (SGA Reaches)	Average Slope
Brewster River (M01 – M18)	5.0%
Upper Brewster River (M16 – M18)	16.4%
Lower Brewster River (M01 – M14)	2.3%
Tributary 1 (T7.01 – T1.06)	8.5 %
Tributary 2 (T2.01 – T2.09)	3.6%
Tributary 7 (T7.01-T7.06)	8.9%

2.3 Hydrology and Flood History

The United States Geological Survey (USGS) operates two real-time flow monitoring gages on the Lamoille River. A new gage (04292201) has been operating since September 2012 approximately 0.5 miles downstream of the mouth of the Brewster River. Gage 04292000, in Johnson, is approximately 12.5 miles upstream of the Brewster River and has flow records dating back to 1910. The Lamoille River flow data from 1912-1913 and 1929-2000 was included in a USGS study to summarize the flow-frequency characteristics of Vermont rivers and streams (Olsen, 2002). The magnitude and return frequency (e.g., 100-year flood) data produced from this study for the Lamoille River gage (04292000) are included below in Table 3.

Table 3: Frequency and magnitude of Lamoille River discharge (Johnson, VT)

Return Frequency	Discharge (cfs)
2 year	7,190
5 year	9,600
10 year	11,200
25 year	13,300
50 year	14,900
100 year	16,500
500 year	20,300

No stream gage records exist for the Brewster River; however major flood events for the Lamoille River can be expected to represent conditions in the Brewster River. The 25 year event has been exceeded three times over the period of record (1973, 1995, and 2011). A major flood occurred in the Village of Jeffersonville in April of 2011. The combination of high water levels in both the Lamoille and the Brewster Rivers caused the Brewster River to spill over its banks and follow Rte.15, flooding the village. Approximate minimum area of inundation is shown in Figure 4. Flood frequency and magnitude for the Brewster River were estimated using USGS StreamStats and are shown in Table 4.



Figure 4: Minimum area of estimated flood inundation in Jeffersonville VT, April 2011 (LCPC, 2012)

Table 4: Frequency and magnitude of Brewster River discharge (USGS StreamStats)

Return Frequency	Discharge (cfs)
2 year	636
5 year	934
10 year	1,150
25 year	1,470
50 year	1,730
100 year	2,010
500 year	2,710

2.4 Ecological Setting

With the exception of the western headwater reaches of Tributary 2, the Brewster River watershed is found within the Northern Green Mountain (NM) Biophysical Region (Thompson and Sorenson, 2000). The headwater reaches of Tributary 2 are found within the Champlain Valley (CV) Biophysical Region. This NM region is found along the northern section of the Appalachian Mountain systems which runs from Alabama to Quebec. The NM region is characterized by high elevation, milder summer temperatures, and primarily supports Northern Hardwood forests and the Spruce-Fir Northern Hardwood forests. The topography and elevation in the NM region play a significant role in reduced summer and winter temperatures and increased precipitation. The NM region was affected by glacial scour and deposition. Thick deposits of glacial till and glacial lake sediments cover much of the lowlands.

Elevations within the watershed range from 460 feet at the confluence with the Lamoille River up to approximately 3660 feet at Madonna Peak. With an average annual rainfall of approximately 60 inches (NOAA, 2013) and a temperate climate, the forest cover is comprised primarily of mixed hardwood, spruce, and fir tree species.

Very few natural lakes and wetlands exist in the NM region due to the steep topography. Most wetlands within the Brewster River watershed exist in the river corridors along Tributaries 1 and 2.

3.0 Data Collection

3.1 Data Collection Methods

The Vermont River Management Program (RMP) has invested many person-years of effort into developing a state-of-the-art system of Stream Geomorphic Assessment (SGA) protocols. The SGA protocols are intended to be used by resource managers, community watershed groups, municipalities and others to identify how changes to land use affect hydro-geomorphic processes at the landscape and reach scale, and how these changes alter the physical structure and biological habitat of streams in Vermont. The SGA protocols have become a key tool in the prioritization of restoration projects that will 1) reduce sediment and nutrient loading to downstream receiving waters such as Lake Champlain and the Connecticut River, 2) reduce the risk of property damage from flooding and erosion, and 3) enhance the quality of instream biological habitat. The protocols are based on defensible scientific principles and have been tested widely in many watersheds throughout the state. Data collected for the Brewster River watershed using the protocols will form the basis for preliminary project identification carried out during future River Corridor Planning efforts.

The SGA protocols include three phases (VTDEC, 2009):

- **Phase 1:** The Phase 1 SGA approach utilizes the Stream Geomorphic Assessment Tool (SGAT), a GIS extension developed by RMP for the collection of reach and watershed scale data. In addition to the GIS and remote sensing effort, a cursory field assessment (“windshield survey”) is included for the verification of stream and valley forms, significant channel features and the location of man-made infrastructure. The Phase 1 SGA approach results in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), which provides a basis for understanding the natural and human-impacted conditions within the watershed. The SGA data also aids in the identification of specific stressors affecting the physical conditions of the stream channels and structures (e.g., bridges and culverts). Table 5 summarizes the parameters collected in Phase 1 using the Feature Indexing Tool (FIT), which include those utilized to develop the final impact ratings.
- **Phase 2:** The Phase 2 approach builds upon Phase 1 data through the collection of reach-specific data about the current physical conditions. Characterization of reach conditions utilizes a suite of quantitative (e.g., channel geometry, pebble counts) and qualitative (e.g., pool-riffle habitat) measurements to calculate two indices: Rapid Geomorphic Assessment (RGA) Score; Rapid Habitat Assessment (RHA) score. Using the

RGA scores in conjunction with knowledge about the background or “reference” conditions, a sensitivity rating is developed to predict the degree to which the channel will adjust to human and natural impacts in the future. Table 5 summarizes the parameters collected and verified in Phase 2 using the Feature Indexing Tool (FIT).

Table 5: Parameters collected with FIT

Phase 1 Step	Phase 2 Step	Data Type	Impact	Sub-Impact
3.1	1.2	Point	Alluvial Fan	NA
3.2	1.6	Point	Grade Control	Dam Ledge Waterfall Weir
NA	3.3	Point	Mass Failure	NA
5.5	5.5	Point	Dredging	Dredging Gravel Mining Commercial Mining
NA	4.4	Point	Debris Jam	NA
NA	4.6	Point	Stormwater Input	NA
NA	4.9	Point	Beaver Dam	NA
NA	5.2	Point	Migration	Neck Cut Off Flood chute Avulsion Braiding
NA	5.3	Point	Steep Riffle or Head Cut	Head Cut Steep Riffle
NA	5.4	Point	Stream Crossing	Stream Ford Animal Crossing
NA	3.3	Point	Gully	NA
6.2	1.3	Line	Development	NA
6.1	1.3	Line	Encroachment	Berm Improved Path Road Railroad
5.3	3.1	Line	Bank Armoring or Revetment	Rip-Rap Hard Bank Other
7.2	3.1	Line	Erosion	NA
5.4	5.5	Line	Straightening	Straightening With Windrowing

- **Phase 3:** Phase 3 surveys involve the collection of detailed, reach-scale survey data to verify or build upon Phase 2 data. These surveys are typically carried out prior to project development for an “active” channel management approach (e.g., floodplain restoration), or for long-term monitoring purposes.

LCPC used SGAT to develop the baseline data layers for the watershed. The remaining Phase 1 data was collected remotely by LCPC for reaches along 14.5 river miles. All major human impacts and natural features were indexed in a GIS using the Feature Indexing Tool (FIT; VTDEC, 2009). A subset of 18 reaches over 8.4 miles was assessed for the full Phase 1 dataset, including windshield surveys and QA/QC by FEA.

3.2 Quality Assurance

The RMP Quality Assurance (QA) protocols outlined in the SGA protocols (VTDEC, 2009) were followed in order to ensure a complete and accurate dataset. LCPC, FEA and RMP shared responsibility for QA for the SGAT shapefiles and the finalized Phase 1 and 2 datasets. All metadata describing the data sources were entered in the Data Management System (DMS), with extraordinary sources noted in the comments section in Phase 1 Step 5, and Phase 2 Step 5 and Step 7. The DMS database for all assessed reaches in the watershed was finalized in March, 2013. The QA summary is included in Appendix C.

4.0 Phase 1 Results

4.1 Reach Delineations

The 14.5 miles of surface waters within the Brewster River watershed were divided into 35 reaches during the SGAT analysis carried out by LCPC. Reach divisions were based on changes in valley geometry, channel slope, and the size and influence of tributaries entering the mainstem channel (VTDEC, 2009). Nine (9) major tributaries (e.g., drainage area exceeds 10% of mainstem drainage area at confluence) were identified during the SGAT analysis (see Figure 2). Reach M15 is an impounded snow-making pond for the Smuggler’s Notch ski resort and was not included in the Phase 1 analysis. Table 6 summarizes data for the mainstem and tributary watersheds. Detailed information about each reach location is found in the reach reports in Appendix A.

Table 6: Mainstem and tributary summary data

DMS ID	Name	Watershed Area (square miles)	Assessed River Length (mi)*	Number of Assessed Reaches*
M	Brewster Mainstem	19.8	7.8	17
T1	Tributary 1*	2.7	0.6	0
T2	Tributary 2*	1.7	2.6	0
T3	Tributary 3	1.3	0	0
T4	Tributary 4*	1.0	0	0
T5	Tributary 5	0.4	0	0
T6	Tributary 6	1.6	0	0
T7	Tributary 7*	4.9	3.5	8 [†]
T8	Tributary 8	0.1	0	0
T9	Tributary 9	0.8	0	0

* includes sub-tributary reaches (e.g., T1-S1.01, T4.S1.01)

† full Phase 1 data collection, including windshield surveys, was only completed for T7.01

4.2 Reference Stream Types

Windshield survey measurements and observations as well as remotely collected data of valley confinement, channel slope, and sinuosity were used to develop reference stream types for the assessed reaches according to the Rosgen (1994) and Montgomery and Buffington (1997) classification systems. Characterization of reference stream types is based on the channel forms and processes we would expect in a particular geologic and geomorphic setting without human influences. Detailed information about each reach reference stream type is found in the reach reports in Appendix A. Table 7 presents general valley and channel characteristics associated with reference stream types found in the Brewster River watershed.

Table 7: Reference stream type characteristics

Stream Type	Valley Confinement	Channel Slope	Sinuosity	Bedform	Number of Study Reaches*
A	Confined	> 4%	Low	Cascade or Step-pool	3 (17%)
B	Confined	2 – 4%	Low	Step-pool or Plane bed	6 (33%)
C	Unconfined	< 2%	Moderate	Riffle Pool	9 (50%)

* Number of reaches and percentage of total reaches represented by type.

Table 8: Reach and watershed characteristics

Surface Water	Reach ID	Watershed Area (Mi ²)	Channel Length (Mi)	Channel Width (ft)	Channel Slope [`]	Sinuosity	Valley Type*	Reference Stream Type ⁺	Bedform [‡]
Brewster River	M01	19.79	0.70	48.72	0.95	1.06	VB	C4	Riffle-Pool
	M02	19.65	0.36	48.56	2.91	1.02	SC	B1	Step-Pool
	M03	19.52	0.31	48.42	0.62	1.01	SC	B3	Riffle-Pool
	M04	16.71	0.30	45.23	1.5 [¥]	1.05	SC	B3	Riffle-Pool
	M05	14.91	0.48	43.01	1.18	1.05	BD	C4	Riffle-Pool
	M06	14.77	0.87	42.83	1.08	1.20	BD	C4	Riffle-Pool
	M07	13.18	0.36	40.73	2.88	1.08	BD	C3	Riffle-Pool
	M08	11.86	0.16	38.89	4.27	1.03	SC	B1	Cascade
	M09	11.83	0.92	38.84	1.84	1.09	BD	C3	Riffle-Pool
	M10	10.51	0.48	36.88	2.22	1.02	BD	C3	Riffle-Pool
	M11	8.55	0.31	33.68	1.86	1.15	VB	C3	Riffle-Pool
	M12	3.07	0.45	21.45	2.74	1.10	BD	C3	Riffle-Pool
	M13	2.18	0.13	18.46	2.87	1.02	BD	B3	Step-Pool
	M14	2.15	0.49	28.00	5.72	1.08	NW	B1	Step-Pool
	M16	1.90	0.53	17.39	5.72	1.07	SC	A1	Step-Pool
	M17	0.74	0.36	11.48	16.43	1.07	SC	A1	Cascade
	M18	0.57	0.61	10.22	25.63	1.06	NC	A1	Cascade
	Tributary 7	T7.01	4.88	0.58	26.32	2.93	1.19	VB	C3

* SC= Semi-confined; NW= Narrow; BD=Broad; VB=Very Broad, NC=No Confinement; † per Rosgen, 1994

‡ per Montgomery and Buffington, 1997

¥ Channel slope is based on dominant section of reach from the downstream reach break to the base of the waterfall

Figure 5 presents the location of the reference stream types developed for the Brewster River watershed. C-type and B-type reaches are most common in the watershed under reference conditions (50% and 33% respectively). C-type streams are typically characterized by a moderately sinuous channel found in a broad, unconfined valley setting with a balance between the upslope sediment supply and the transport capacity. B-type streams are typically characterized by a low to moderately sinuous channel in a confined valley that is dominated by sediment transport processes. Three reaches were characterized as A-type. These reaches are typically found in the steep headwater areas. Data from the reaches covered in the full phase 1 analysis are shown in Table 8.

Most of the reaches found along the mainstem of the Lower Brewster River are C-type streams under reference conditions, with the exception of Reaches M02, M03, M04, M08, M13 and M14. M02-M04 are found in a confined valley setting with gorges and numerous grade controls where the Brewster River descends through an area with shallow underlying bedrock (Hazens Notch schist formation). Moving upslope, the reaches of the Upper Brewster River begin to enter confined valley settings at Reach M16. The upper Brewster River is dominated by sediment transport streams of A and B types. The tributary reaches generally follow the similar pattern of unconfined C-type reaches in the lower reaches transitioning to confined A and B-type in the headwaters.

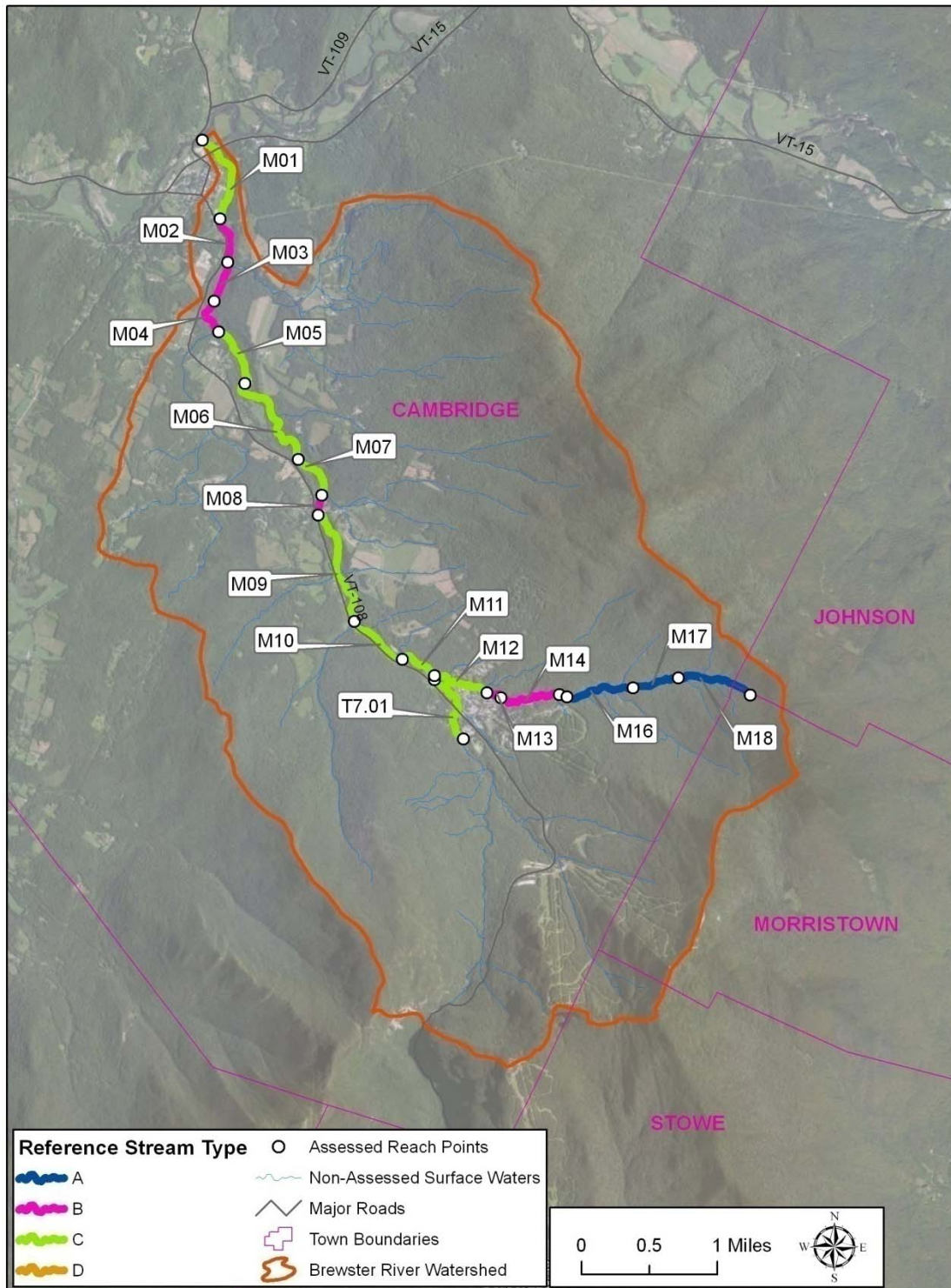


Figure 5: Reference stream types per Rosgen (1994) for the Brewster River watershed.

4.3 Watershed Geology and Soils

The NRCS soils data (NRCS, 2008) was utilized to review the parent material of the watershed. Figure 7 depicts the main classes of parent materials distributed across the watershed. Grade controls observed in the field during the windshield surveys are also displayed in Figure 6, but do not represent exhaustive mapping of these features outside of the Phase 2 assessment area (M01-M04). The presence of numerous other grade controls in the headwaters reaches are likely where bedrock outcroppings are present. Detailed geologic information about each reach is found in the reach reports found in Appendix B.

Dredging and berming were observed during windshield surveys in reaches M12 and M14 (Figure 6). The channel dredging and berming along the left (south) bank were likely in response to recent flood events and were likely an attempt to restrict channel migration towards a hiking trail and condominiums in the left (south) corridor.

Ten natural grade controls exist along Reaches M02-M04. In each of these reaches, these bedrock areas act as controls on vertical stability and have caused the historic deposition of alluvium along the channel and valley bottom in the areas upslope of the controls. A long bedrock gorge runs through Reach M02 and contains 7 channel spanning bedrock grade controls as well as remnants of several old mill dams (Figure 8). A large waterfall (Brewster River Gorge/Jefferson Falls) is found in Reach M04 (Figure 9). Additionally, one human-enhanced grade control is found in Reach M03 and is associated with a popular swimming area.



Figure 6: Berming along the left bank in Reach M12

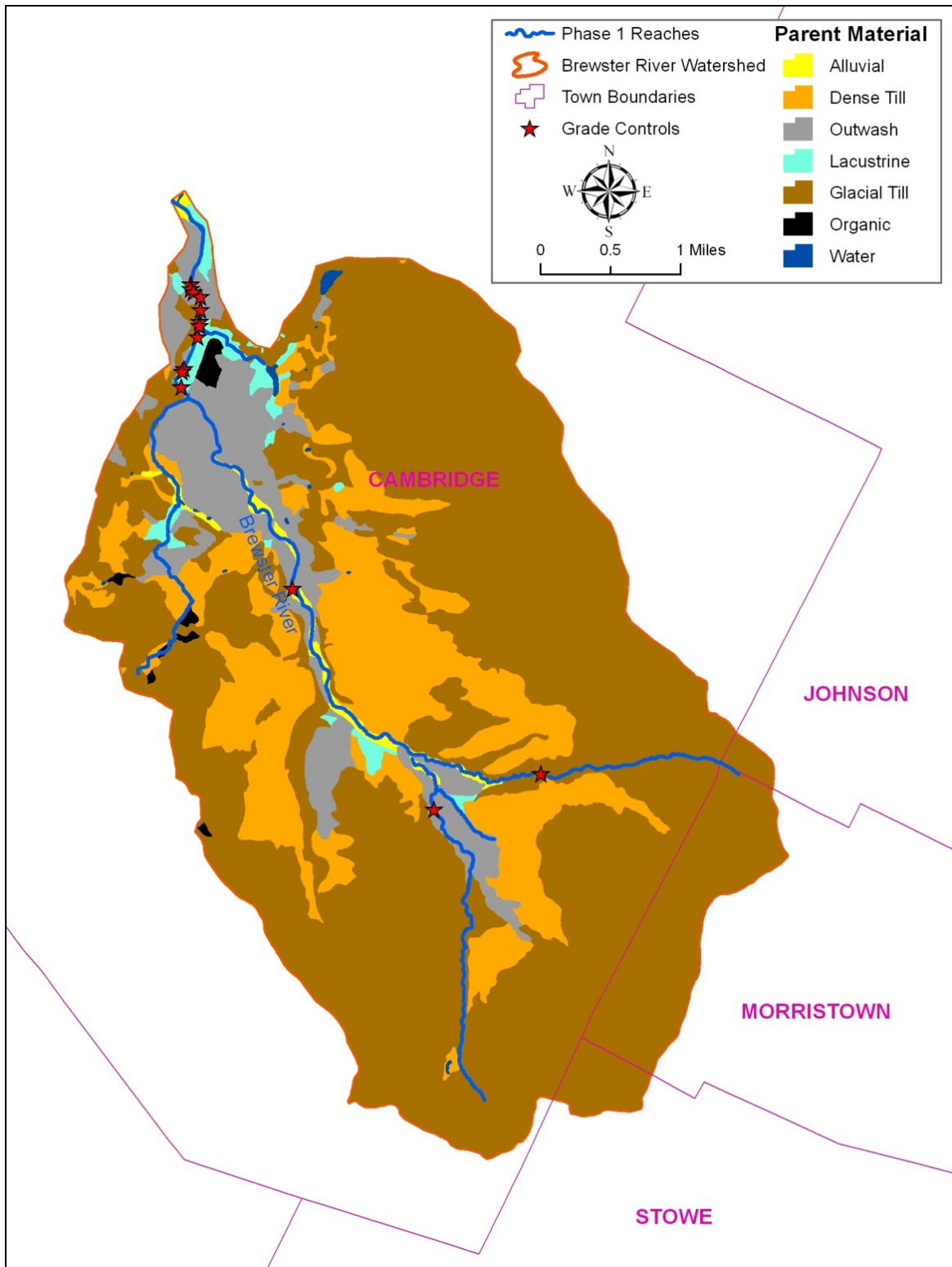


Figure 7: Parent Materials and Grade Controls within the Brewster River watershed.



Figure 8: Grade control in M02



Figure 9: Brewster River Gorge in M04

4.4 Land Cover and Reach Hydrology

Step 4 of the Phase 1 protocols evaluates the impacts of watershed land use, riparian vegetative cover, and other reach-scale controls on hydrologic processes. Conversion of natural forest cover to urban and agricultural land uses in a watershed, even at low levels (e.g., 10% of watershed area), has been shown to have measurable deleterious effects on channel stability and aquatic biota (Paul and Meyer, 2001; CWP, 2003). Loss of forest cover reduces the infiltration capacity of soils, and typically results in increased runoff during infrequent storm events and reduced baseflow during the dry periods of the year. In addition, direct impacts to riparian cover along the river bank and within the corridor are also known to have negative impacts on channel stability (e.g., loss of boundary resistance) and available habitat for biota (e.g., canopy shading, large woody debris, etc.). Other local-scale influences on reach hydrology include adjacent wetlands, small tributaries, and other sources of groundwater inputs (abundant in reaches M03, M06, and M12). These areas provide important inputs of cooler waters that are critical for microhabitats, especially during the late summer and fall months when water temperatures can become elevated to levels that are harmful to native cold water fish.

Land cover in the Brewster River watershed was summarized with the SGAT tool using data derived from 1992 satellite imagery (VCGI, 2003). This dataset was clipped to the local watershed (e.g., area draining directly to reach) and stream corridor to understand the impacts to each reach at each scale. Impact ratings were automatically generated upon upload of the data to the DMS based on the rankings provided in Table 9. In addition to the DMS summarized data, more recent land cover data (NOAA, 2008) was summarized at the subwatershed scale, as previously reviewed in Table 1 in Section 2.1 and as shown in Figure 10.

Table 9: SGA land use impact ratings

Impact Rating	Land Cover Value
High	10% or more of reach watershed is crop and/or urban
Low	Between 2 - 10% of reach watershed is crop and/or urban
Not Significant	Less than 2% of reach watershed is crop and/or urban

Historic land cover data for the reach watershed and corridor scales was reviewed using a series of orthophotos from the study area from 1970's.

Riparian buffer widths were estimated remotely and verified in the field where possible during the windshield surveys. Areas where the buffer widths were less than 25 feet were mapped remotely and indexed using the FIT. Areas that received high impact scores for the lack of a healthy riparian buffer were due to roadway encroachment or were alluvial valleys where adjacent lands have been intensively used for agricultural or residential uses for many years. Reaches in this condition included: M01, M02, M03, M10, M11, M12, and T7.01.

Groundwater and small tributary inputs were reviewed for each reach using the National Wetlands Inventory (NWI, 2003) and the Vermont Hydrography Dataset. Additional detailed information about each Step 4 parameter for all reaches is found in the reach reports found in Appendix A.

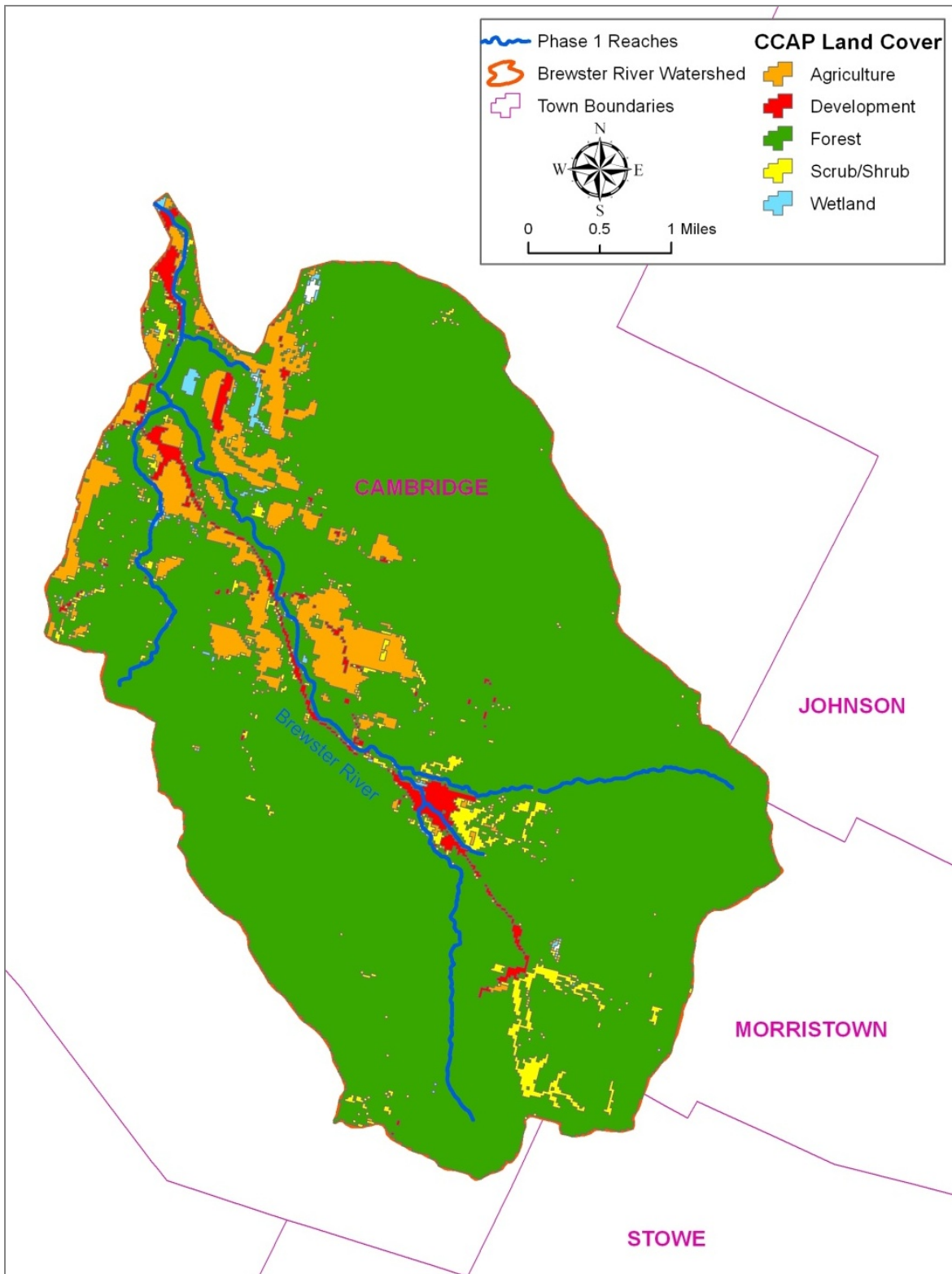


Figure 10: CCAP land cover data for the Brewster River Watershed

4.5 Instream Channel Modifications

Data collected as part of SGA Step 5 aids in the understanding of how direct impacts to the channel boundaries have altered the sediment supply and transport regimes at the reach scale. Flow-regulating structures that span the channel impact the natural flow variability in downstream reaches, and interrupt the sediment supply along the channel network. These features often result in reduced instream habitat as well as channel incision in downstream areas where the sediment transport capacity exceeds the limited supply from upslope. Bridges and culverts that are inadequately sized to accommodate channel forming flows have similar impacts to habitat and sediment transport as flow-regulating structures. In addition, culverts that have severely “perched” outlets create a discontinuity in habitat along the channel by preventing fish passage. Bank armoring, channel straightening, and dredging are human impacts that increase the sediment transport capacity of the channel through the increase of 1) resistance to lateral migration, and 2) channel slope. Further discussion of the impacts of instream channel modifications is provided in the SGA Phase 1 Handbook (VTDEC, 2009). Reaches with significant impacts from these features are summarized below. Additional detailed information about each Step 5 parameter for all reaches is found in the reach reports found in Appendix A.

Impoundments and Flow Regulations

Flow regulations were reviewed and mapped using the VTANR Dam Inventory (VTANR, 2005), as well as further field observations and discussions with VTDEC staff. These features are summarized below for the mainstem and tributary reaches. Each of the flow regulations indexed with the FIT is considered a run-of-the-river feature (e.g., no current water withdrawals).

Mainstem: There is one impoundment on the mainstem that is considered a large (e.g., upstream impoundment is wider than channel width) run-of-the-river impoundment that is actively managed to change discharges or volumes. A 200’ long by 30’ high earthen dam is located at the top of reach M14 and creates a 1.5 acre pond used for snowmaking withdraws at the Smuggler’s Notch ski resort (Figure 11). This flow regulation is listed as a “high” impact.



Figure 11: Smuggler’s Notch snowmaking pond above Reach M14

Tributaries: One flow regulation was noted on the tributary reach T7.01. A small unmaintained run-of-the-river impoundment is listed as a “low” impact.

Bridges and Culverts

The locations and lengths of bridge and culvert crossings were mapped remotely and were verified in the field where possible. A total of 13 structures were noted on the 35 assessed reaches. The bridges and culverts located in Reaches M02, M03, and T7.02 were considered insignificant as they represented less than 5% of the reach channel length. Bridges and culverts located in Reaches M01, M11, M12, M14, and T7.01 were considered to have a “Low” impact.

Bank Armoring

Bank armoring and revetments were noted in detail for reaches M01-M04 during Phase 2 assessments, and as observed during the windshield survey for the remainder of the mainstem and reach T7.01. Mainstem areas where bank armoring was noted were primarily in the vicinity of bridges and buildings near the stream channel. Extensive armoring was present in Reach M01 along two commercial properties on the left bank, under three bridges, and on the toe of the slope along the mass failures (Figure 12). More than one-third (37.2%) of the channel length in this reach was armored, resulting in a “High” impact rating. Additionally, some armoring was noted primarily along road embankments in Reaches M02, M09, M12, M14, and T7.01.



Figure 12: Bank armoring in Reach M01

Channel Straightening and Dredging

An area of channel straightening was inferred in Reach M01 along the mass failures and upstream to the schoolbus parking lot. Extensive stream channel and bank modification was undertaken in response to the mass failures and the stream channel was likely straightened and armored during this process. Two areas of dredging and berming were noted during the windshield survey in reaches M12 and M14. Both areas appeared to have aggraded large cobble bars during recent episodic flood events. Heavy machinery was used to dredge and windrow these cobbles primarily on the left bank to stop channel migration towards a hiking path and condominiums (Figure 6).

4.6 Floodplain Modifications and Planform Changes

Due to the historical development of road networks and settlement patterns in the lowland areas of Vermont, many alluvial rivers in the state have been encroached upon by roads and development over the years. As discussed in the previous section, many of these areas have also been historically manipulated and straightened to maintain an unnaturally steep slope in a state of sediment transport, allowing for a short term sense of security from flooding and subsequent encroachment of infrastructure in the floodplain. In addition to historic alterations to channel slope in Vermont's alluvial rivers, the lowering of stream beds (e.g., dredging) and the raising of floodplains (e.g., berming) has resulted in an increase in channel depth (VTANR, 2007a). Channel depths have typically been increased through the encroachment on the floodplain by roads, development and railroads and subsequent filling and armoring required to construct and maintain this infrastructure. Increases in impervious cover have also led to the deepening and eventual widening of channels throughout urbanized areas of Vermont (Fitzgerald, 2007). These human impacts tend to induce a series of channel adjustments that begin with channel incision and leads to widening and eventually a redevelopment of a sinuous planform in alluvial reaches. Reaches with significant impacts associated with the above-described human impacts are summarized below according to the SGA impact ratings listed in Table 10. Reaches affected by an increase in depositional or migrational features are also summarized below. Additional detailed information about each Step 6 parameter for all reaches is found in the reach reports found in Appendix A.

Table 10: Impact ratings for corridor encroachments and development

Impact Rating	Impact Criteria
High	Greater than 20% of reach length affected.
Low	Between 5 - 20% of reach length affected.
Not Significant	Less than 5% of reach length affected.

Encroachments

Following the Phase 1 protocol, any berms, roads, driveways, railroads and/or improved paths found within the stream corridor were indexed using the FIT. These areas were identified using 2011 Bing aerial imagery, and were confirmed and/or refined during the field observations. Figure 13 depicts the reaches where encroachment has significantly impacted the stream corridor, with ratings based on the percentage of the reach length that was impacted as indicated in Table 10. Impacts classified as "High" from corridor encroachment were found in reaches M01, M07, M10-M14 and T7.01. Impacts classified as "Low" were found in reaches M03 and M09.

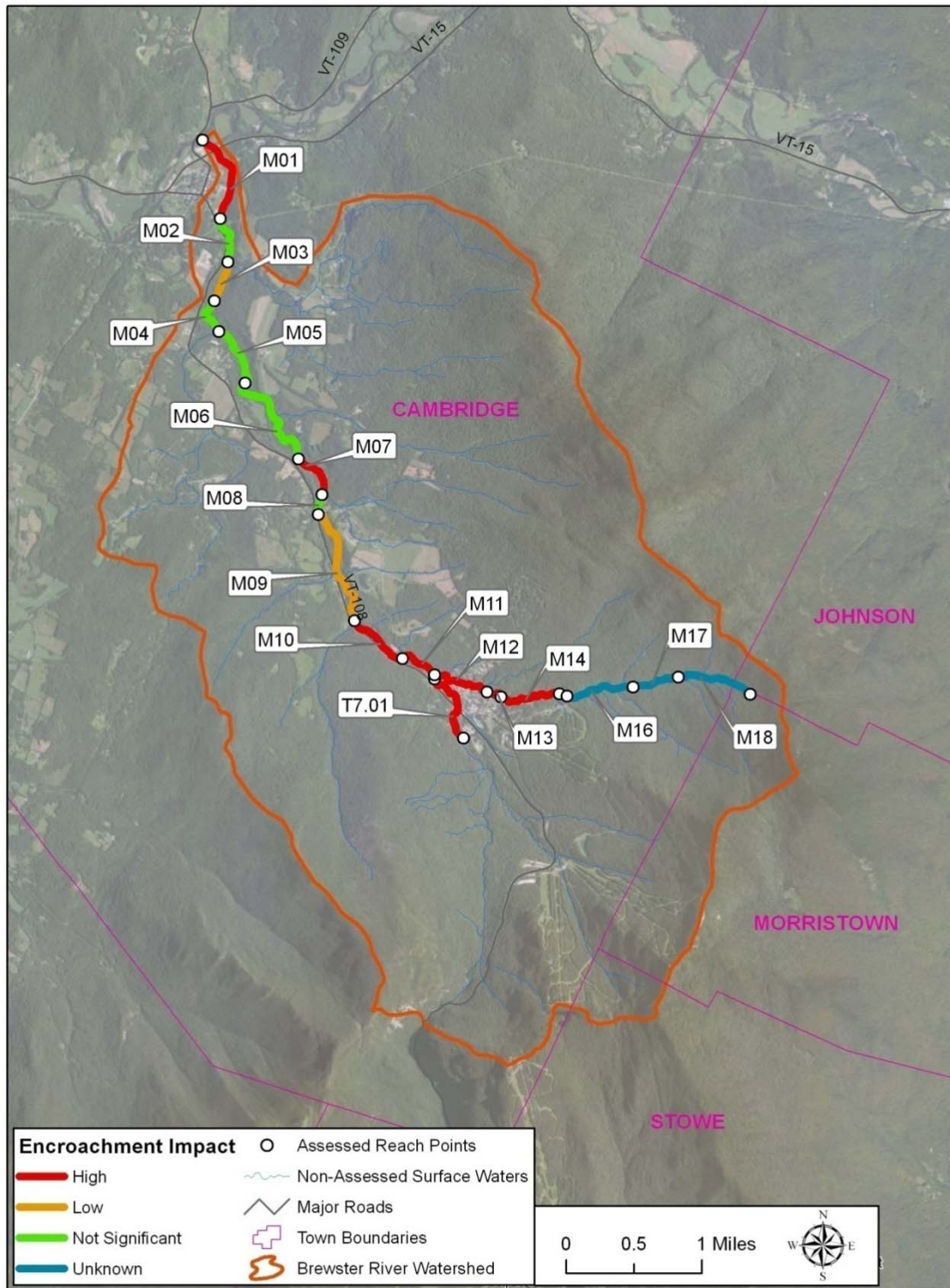


Figure 13: Impacts from corridor encroachments in the Brewster River watershed

Development

The impact of development within the stream corridor was evaluated using 2011 Bing aerial imagery, and were confirmed and/or refined during the field observations. The presence of development was indexed using the FIT, and impact ratings for each reach were developed based on SGA criteria presented in Table 10. Impacts classified as “High” from corridor development were found in reaches M01, M07, and T7.01. Impacts classified as “Low” were found in reaches M09 and M12.

Depositional Features

Sediment depositional features (e.g., point bars, mid channel bars, etc.) were evaluated using the 2011 Bing aerial imagery, and were confirmed and/or refined during the field observations. Reaches with multiple types of depositional features indicated where upslope sediment supply exceeded the transport capacity. These areas represent conditions that are favorable for increased lateral channel migration that could endanger adjacent infrastructure and properties. Depositional areas in the undeveloped reaches along VT Route 108 may play an important role in sediment storage. Reaches M06, M09, and M11 appear to be storing large amounts of coarse sediment within the river corridor, resulting in reduced downstream sediment loading in Jeffersonville Village. In general, reaches with high impacts from depositional features were found at large channel slope changes or the confluence of tributaries and subtributaries that are carrying high sediment loads. Five mainstem reaches were identified with these conditions, including M01 (Figure 14), M04 (Figure 15), M06, M09, and M11. Additional detailed data about the types of depositional features and their relative impacts for all reaches are found in the reach reports found in Appendix A.



Figure 14: Large mid channel bar in Reach M01



Figure 15: Mid channel bar below waterfall in Reach M04

Meander Migration

Recent and historic aerial photographs and imagery were reviewed to identify areas of channel migration, bifurcation, and avulsions on the Brewster River mainstem and its tributaries. Orthophotos (1:5K) from the 1970's and 1990's were compared to 2011 imagery from Bing maps. Previous channel locations were compared with two recent sources of imagery: 1) the Vermont Hydrography Dataset stream centerlines developed from the aerial photographs during the 1990's for the watershed; 2) the 2011 Bing aerial imagery. Four reaches were characterized as having "high" migration impact and two reaches have a "low" impact (Table 11).

For reaches characterized within unconfined valley settings (C-type channels), meander geometry was reviewed following the Phase 1 protocols. Four of the 18 reaches had meandering profiles suitable for assessment of meander width and wavelength. Shapefiles were developed to indicate the areas where meander width and wavelength was measured (Figure 16). Where the meander wavelengths and widths fell outside of the range of expected values relative to the predicted channel width, impact ratings of high or low were assigned according to the degree of departure (VTDEC, 2009). Four of the assessed reaches had impacts for meander width and/or meander wavelength (Table 11).

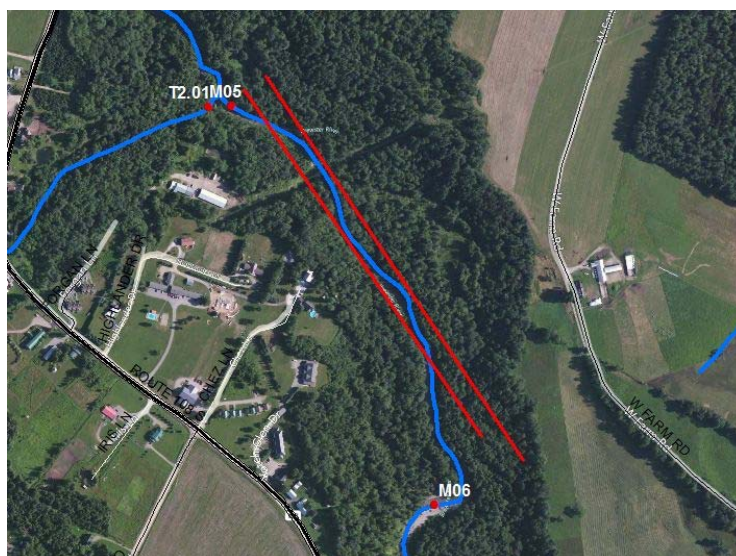


Figure 16: Meander geometry assessment on Reach M05

Table 11: Impact ratings for meander migration and geometry

Reach	Meander Migration		Meander Width Impact	Meander Wavelength Impact
	Type	Impact		
M01	Migration	High	High	High
M05	Migration	Low	High	Low
M06	Multiple	High	N.S	High
M09	Migration	High	High	High
M11	Multiple	High	N/E	N/E
M12	Multiple	Low	N/E	N/E

4.7 Bed and Bank Windshield Surveys

Windshield surveys were completed following the initial classification of stream type and substrate based on remotely sensed data alone. Surveys were completed in late November on all reaches accessible by public roads. Twelve (12) of the 18 reaches in the study area were at least partially

accessible by roads and were viewed. The Phase 1 parameters verified and/or evaluated during the field surveys included:

- General stream and valley geometry, including valley width and confinement, bed substrate, and bedform features (Step 2).
- Grade controls and areas of known or potential alluvial fans (Step 3).
- Impacts on the buffer and stream corridor, including areas of reduced buffer vegetation, road encroachments, and the presence of development within the stream corridor (Steps 4 and 6).
- Types of stream crossing structures (e.g., bridges and culverts), and their potential for causing ice and debris jams (Steps 5 and 7).
- Areas of bank erosion and armoring (Steps 5 and 7).
- Areas of increased sediment deposition and meander migration (Step 6).

Particular attention was paid to recording bank erosion and ice/debris jam potential at the stream crossings. Due to limited direct accessibility on most reaches, bank erosion along the entire channel length was not practical; rather, bank erosion plainly visible along roads or at stream crossings was indexed using the FIT. Therefore the relative length of the reach impacted by bank erosion was likely underestimated compared to typical Phase 2 field observations. Debris and ice jam potential at points of channel constrictions associated with stream crossings and sharp channel bends were recorded in the field. Qualitative ratings of the impact of these areas on sediment and debris continuity were developed and entered into the DMS. Table 12 summarizes those reaches where impacts from bank erosion or ice and debris jam potential were noted.

Table 12: Reaches with observed bank erosion or ice and debris jam potential

Reach	Bank Erosion		Ice and Debris Jams	
	% of Reach	Height (ft)	Types	Impact
M01*	22.5%	5.8	Bridge	High
M03	3.2%	4.7	None	None
M05	0.0%	0.0	Bend	Low
M06	0.0%	0.0	Multiple	High
M09	0.0%	0.0	Multiple	Low
M11	1.0%	7.0	Multiple	High
M12	0.0%	0.0	Multiple	Low
T7.01	0.0%	0.0	Bridge	Low

*M01 was the only reach with a high impact rating for bank erosion

5.0 Phase 1 Data Analysis

5.1 Final Impact Ratings and Geomorphic Condition

Based on the Phase 1 impact scores, the DMS also develops predictions for channel adjustment processes (VTDEC, 2009). These predictions are based on the dominant impacts recorded for each reach, and are categorized based on the impacts typically associated with the following four channel

adjustment processes: 1) Degradation (e.g., channel incision); 2) Aggradation (e.g., increased sediment deposition); 3) Channel widening (e.g., increased bank erosion); 4) Planform Changes (e.g., irregular meander patterns) (Table 13 and Figure 17). Using the channel adjustment process ratings, a provisional geomorphic rating is developed for each reach based on the methods outlined in the SGA Phase 1 protocols (VTDEC, 2009). Table 14 outlines the four possible geomorphic ratings based on the SGA methods, and Figure 18 presents the provisional geomorphic condition for all study reaches.

Table 13: Final Impact Score Parameters for Phase 1 Dataset

Phase 1 Step	Phase 1 Parameter	Impact Category
4.1	Local Watershed Land Cover/Land Use	Land Use
4.2	Corridor Watershed Land Cover/Land Use	
4.3	Riparian Buffer Width	
5.1	Flow Regulations	Channel Modifications
5.2	Bridges and Culverts	
5.3	Bank Armoring	
5.4	Channel Straightening	
5.5	Dredging and Gravel Mining	
6.1	River Corridor Encroachments	Floodplain Modifications and Planform Changes
6.2	River Corridor Development	
6.3	Depositional Features	
6.4	Meander Migration	
6.5	Meander Belt Width Departure	
6.6	Meander Wavelength Departure	
7.2	Bank Erosion	Bed and Bank Conditions
7.3	Debris and Ice Jam Potential	

Table 14: SGA Reach Condition Ratings

SGA Rating	Predicted Conditions and Processes
Reference	In Equilibrium – no apparent or significant channel, floodplain, or land cover modifications; channel geometry is likely to be in balance with the flow and sediment produced in its watershed.
Good	In Equilibrium but may be in transition into or out of the range of natural variability – minor erosion or lateral adjustment but adequate floodplain function; any adjustment from historic modifications nearly complete.
Fair	In Adjustment – moderate loss of floodplain function; or moderate to major planform adjustments that could lead to channel avulsions.
Poor	In Adjustment and Stream Type Departure - may have changed to a new stream type or central tendency of fluvial processes – significant channel and floodplain modifications may have altered the channel geometry such that the stream is not in balance with the flow and sediment produced in its watershed.

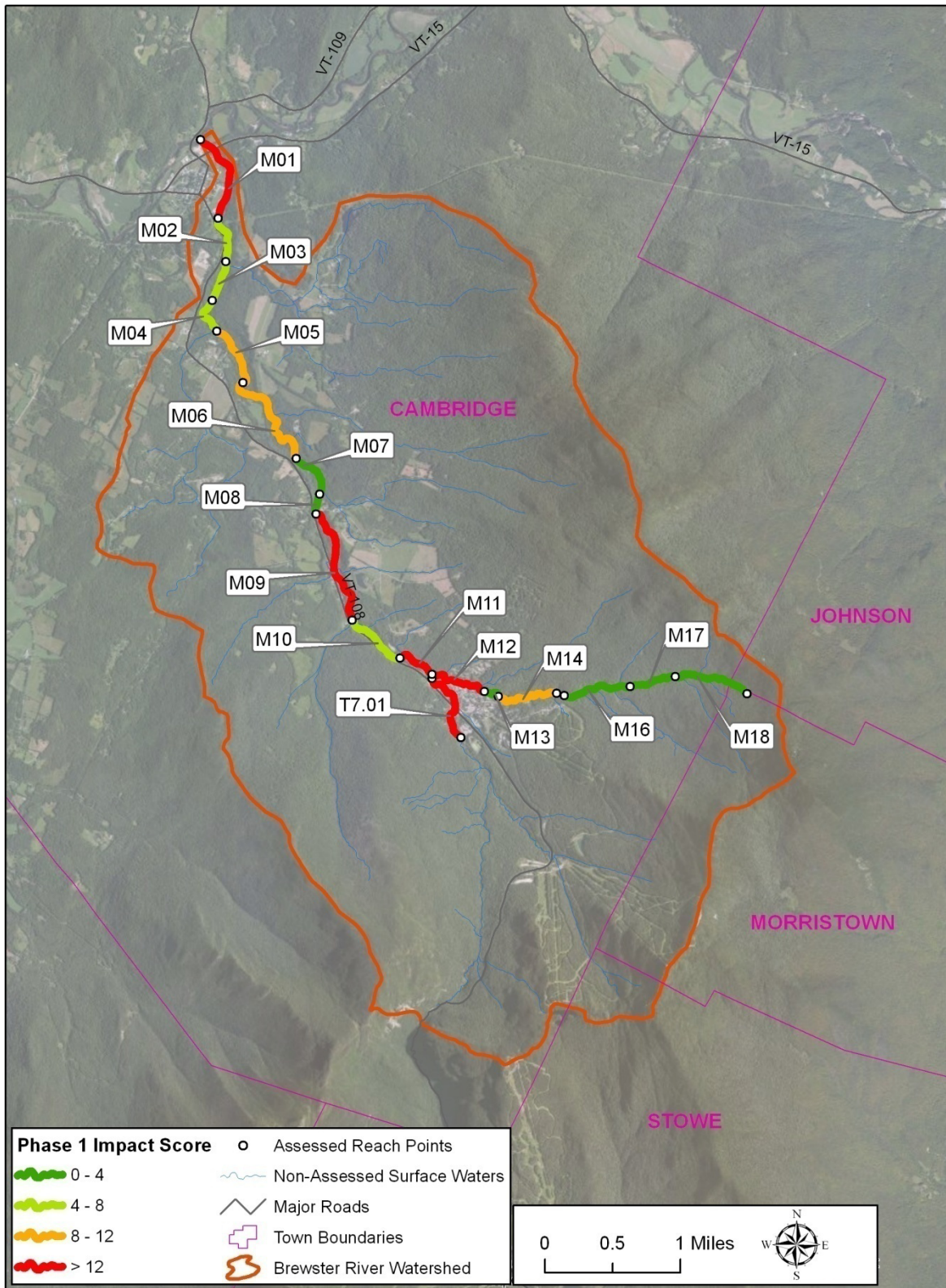


Figure 17. Phase 1 impact scores in the Brewster River watershed

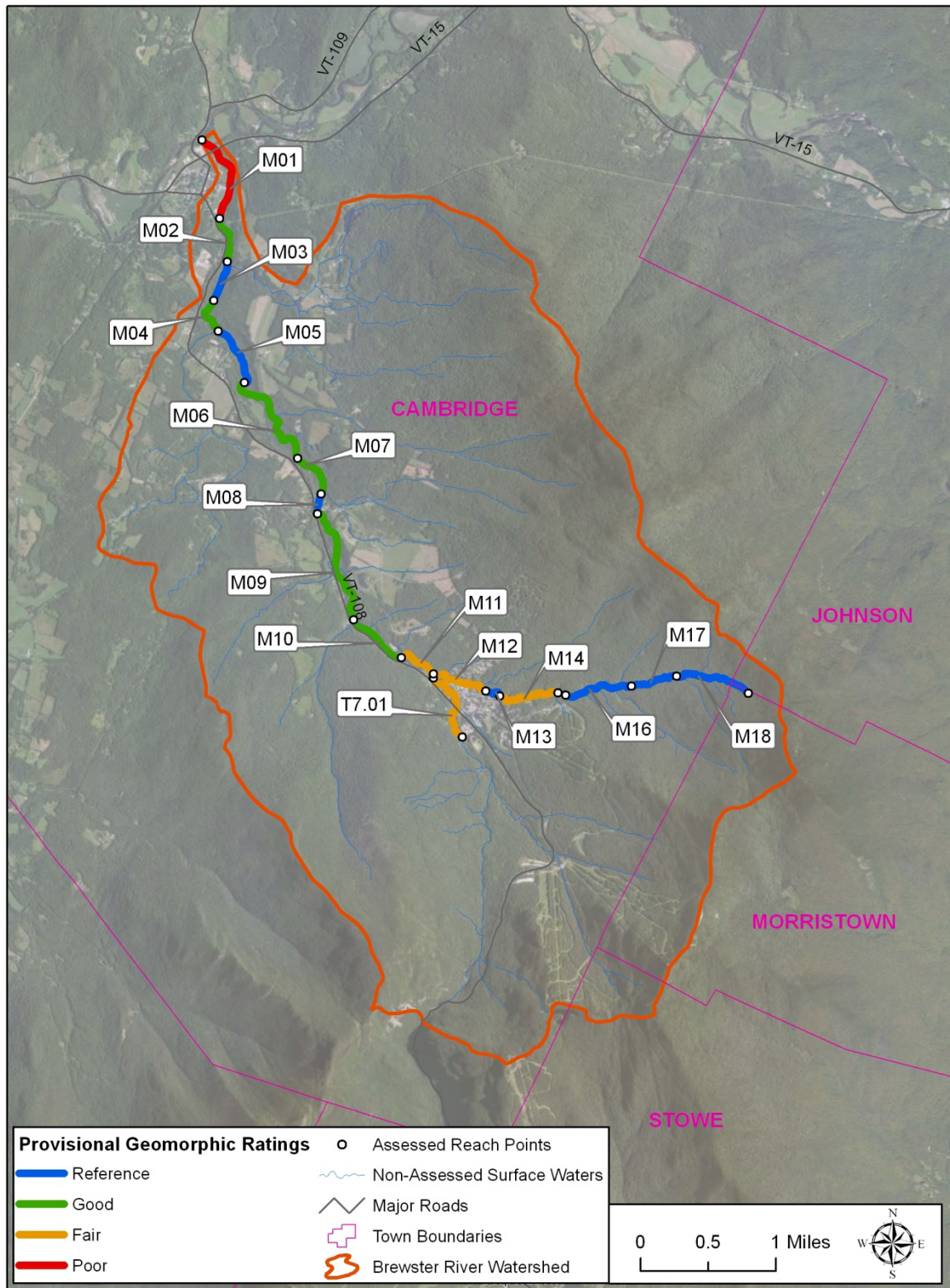


Figure 18: Provisional geomorphic ratings for phase 1 reaches in the Brewster River watershed

5.2 Phase 2 Reach Recommendations

Using the Phase 1 Impact Ratings as the primary basis for reach selection, a list of high priority reaches was compiled for further Phase 2 surveys. Table 15 summarizes the selected reaches based on watershed location, channel length, and preliminary reference stream type.

Table 15: Phase 1 Impact Ratings and Phase 2 Priority Recommendations

Surface Water	Reach ID	Channel Length (Mi)	Reference Stream Type ⁺	Bedform [‡]	Impact Score (Geo Condition)	Phase 2 Priority
Brewster River	M01	0.70	C4	Riffle-Pool	24 (Poor)	Completed
	M02	0.36	B1	Step-Pool	6 (Good)	Completed
	M03	0.31	B3	Riffle-Pool	5 (Reference)	Completed
	M04	0.30	B3	Riffle-Pool	5 (Good)	Completed
	M05	0.48	C4	Riffle-Pool	9 (Reference)	High
	M06	0.87	C4	Riffle-Pool	11 (Good)	High
	M07	0.36	C3	Riffle-Pool	4 (Good)	Moderate
	M08	0.16	B1	Cascade	1 (Reference)	Low
	M09	0.92	C3	Riffle-Pool	14 (Good)	High
	M10	0.48	C3	Riffle-Pool	8 (Good)	High
	M11	0.31	C3	Riffle-Pool	14 (Fair)	High
	M12	0.45	C3	Riffle-Pool	13 (Fair)	High
	M13	0.13	B3	Step-Pool	4 (Reference)	High
	M14	0.49	B1	Step-Pool	9 (Fair)	High
	M16	0.53	A1	Step-Pool	0 (Reference)	Low
	M17	0.36	A1	Cascade	0 (Reference)	Low
	M18	0.61	A1	Cascade	0 (Reference)	Low
	Tributary 7	T7.01	0.58	C3	Riffle-Pool	16 (Fair)

* SC= Semi-confined; NW= Narrow; BD=Broad; VB=Very Broad, NC=No Confinement; † per Rosgen, 1994

‡ per Montgomery and Buffington, 1997

6.0 Phase 2 Survey Results

Based on input from the Town of Cambridge and Village of Jeffersonville, a list of four (4) priority reaches (M01-M04) were selected for further Phase 2 surveys as part of this project (Figure 17). Table 8 (in Section 4.2) provides reach and watershed characteristics for the selected reaches. Surveys were completed during early December, 2012.

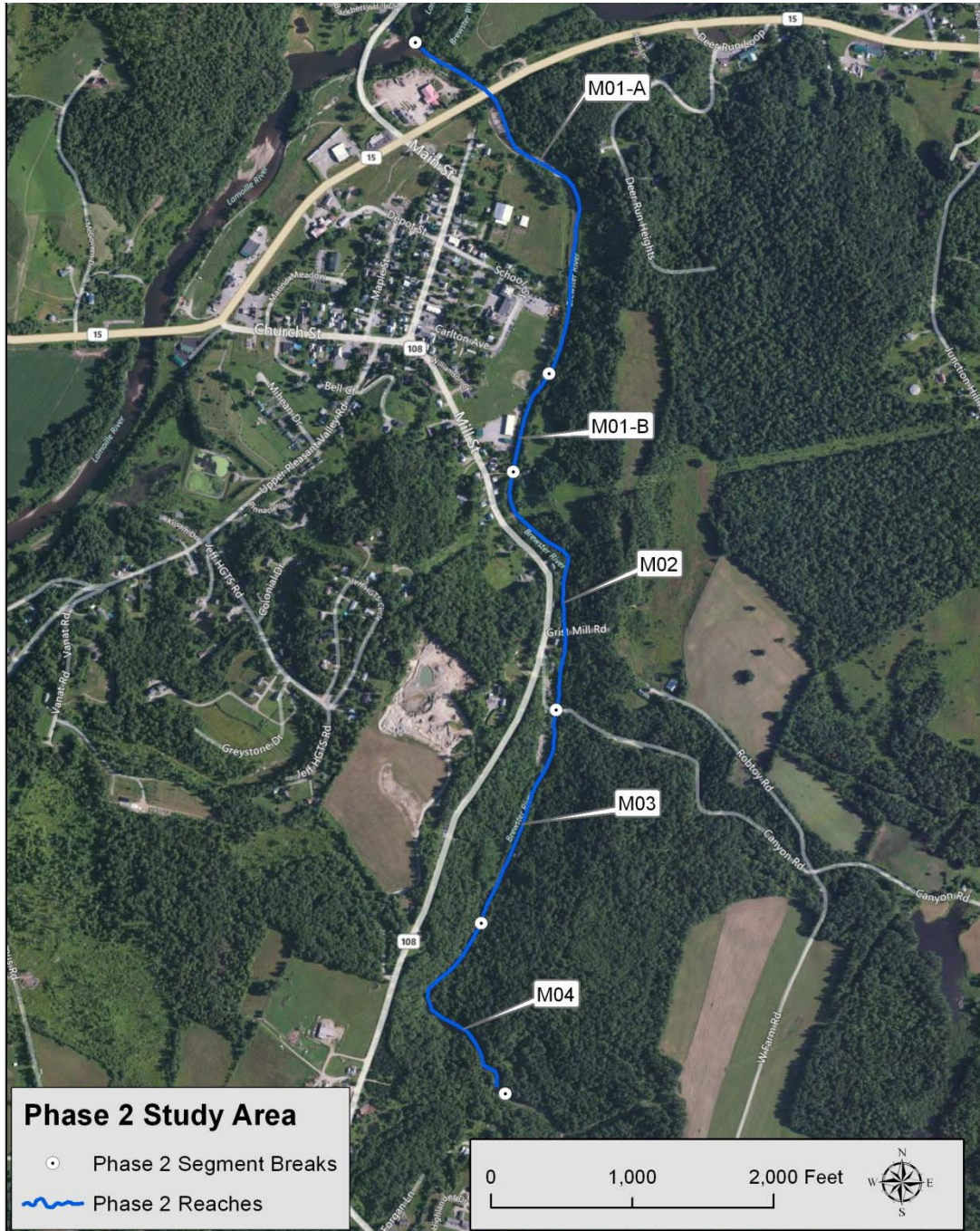


Figure 19: Map of Phase 2 Study Area

6.1 Phase 2 Reach Narratives

M01-A

Reach M01 was segmented due to a change in channel dimensions, slope, and stream type approximately ½ mile up from the confluence with the Lamoille River. Segment A extends 2680 feet upstream from the Lamoille River. This segment is in a very broad valley and has a channel slope of approximately 0.6%. Armoring and buffer impacts are present along the VT Rte. 15 corridor. Two bridges are located in the lower portion of the segment (VAST trail bridge and VT15). A major rain event in the Spring of 2011 caused the Brewster River to spill over and follow VT Rte. 15 southward with major flooding in the village of Jeffersonville. The channel immediately upstream of VT Rte. 15 underwent significant channel migration and aggradation during this event (see Figures 18 and 19).



Figure 20: Large coarse gravel bar immediately upstream of VT Rte. 15, approximately 12,000ft² and 2-4 feet above water.



Figure 21: 400 feet of bank erosion upstream of VT Rte. 15

Three large mass failures are present along the right bank in M01-A. The downstream failure occurred in 2006. The two larger mass failures initiated three different times in April-July 1999. These mass failures have been well studied and it is estimated that 30,000m³ of sediment were deposited in the 1999 events. Additional mass failures were recorded along the reach in 1911, 1919, 1942, and 1954 (Becker et al., 2009). An extensive restoration effort was undertaken to clean up and stabilize the area following the 1999 slides. Bank armoring along these features is currently stable but future erosion of the valley toe could trigger additional slumping (Figure 20).



Figure 22: A 180' by 70' Mass failure on the right bank. The largest mass failure (350' by 150') is in the background approximately 100' from the channel

The left floodplain downstream of VT15 is developed and the bank is armored. The left floodplain upstream of VT15 is mowed meadow and shrub/saplings. The right floodplain is primarily shrub/sapling throughout the reach. This segment has C-type channel morphology and riffle pool bedform by reference. The cross-section was taken near the top of the segment immediately upstream of the mass failures. The substrate was predominately cobble (35%) and coarse gravel (32%), with a median substrate size of 40mm. The width-to-depth and entrenchment ratios are 23.7 and 1.8 respectively. The segment is highly incised (IR = 1.7) with minimal floodplain access throughout. This high entrenchment and incision ratios lead to a stream type departure from C (riffle pool) to B_c channel morphology, plane bed bedform, and a "Very High" stream sensitivity rating. The dominant adjustment process observed was aggradation.

Floodplain access and entrenchment ratio varies considerably throughout Reach M01, and in particular M01-A (Figure 21). However, actual flood hydraulics are affected by the backwater from the Lamoille. The SGA protocol for determining floodprone width based on bankfull dimensions was followed, but this approach does not account for backwater effects in large events for tributaries approaching the confluence of a larger river. On average, the entrenchment ratio is in the B-type range for this reach, which as noted above, is a departure from the C-type by reference.

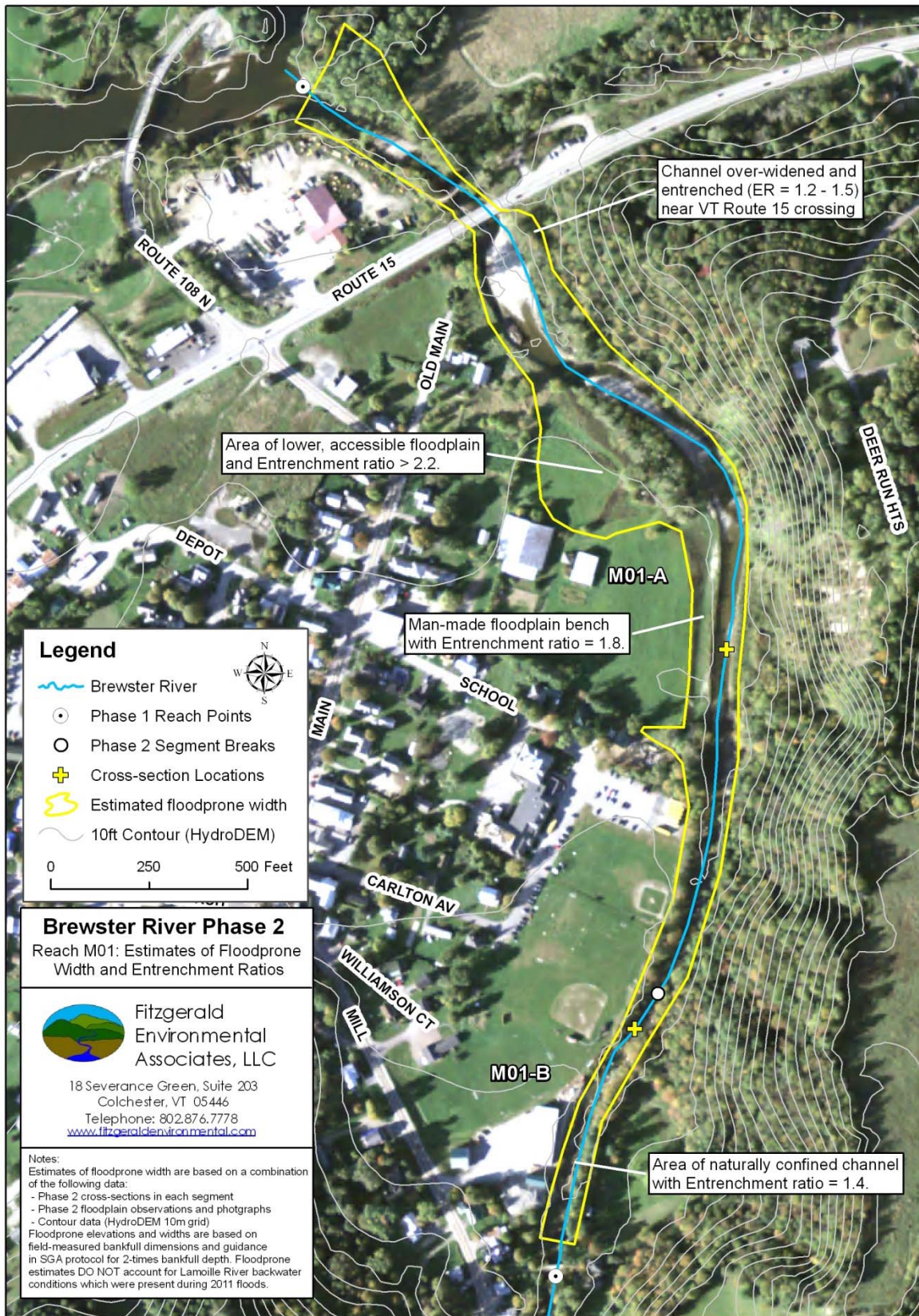


Figure 23: Variation in floodprone width in Reach M01.

Stage III of the F channel evolution model was selected to characterize current channel morphology, as widening is seen as the dominant process. Overall the channel was unstable and entrenched with a RGA score of "Fair". Habitat was rated as fair due to moderate woody debris and pool habitat features as well as good connectivity and hydrologic characteristics.

M01-B

This short segment is 781' in length and begins approximately 800' upstream of the mass



Figure 24: B_c channel morphology in segment M01-B

failures where the channel increases in slope and is classified as having B_c channel morphology and plane bed bedform (departed from riffle-pool by reference). The segment has a slope of approximately 1.3% (Figure 22). The right corridor is well buffered with the exception of a private residence accessed by a private bridge at the top of the reach. The right valley wall is typically continuous to the

channel. The left corridor has a narrow (30') vegetated buffer for most of the reach and then extends over a large floodplain occupied by athletic fields. A commercial property with extensive bank armoring is present in the left corridor at the top of the reach (Figure 23). This segment is different from M01-A in that it is found in a transitional setting from steeper sloped,



Figure 25: Left bank armoring and development

higher energy channel down to a lower gradient setting in the Lamoille River valley. The valley is naturally semi-confined; it did not appear that any floodplain benches of this B-type stream

were significantly filled on the west (left) bank that would change the floodplain geometry or entrenchment ratios.

The cross-section was taken at a representative riffle in the lower reach and substrate was similar to M01-A: cobble (31%), coarse gravel (29%) and a median particle size of 60mm. The width-to-depth and entrenchment ratios are 23.8 and 1.3 respectively. Minor/moderate incision was observed (IR=1.3) on this segment. Channel evolution stage III of the F channel evolution model was selected to characterize the dominant adjustment process of short-term enlargement of channel geometry from widening caused by episodic flood events. The segment has a "Fair" rating for geomorphic and habitat assessments and a stream sensitivity of "Very High".

M02

Reach M02 is 1890' long and runs from a private bridge to the Canyon Rd covered bridge. This reach is predominantly a bedrock gorge and was not fully assessed (Figure 24).

Channel spanning bedrock grade controls start approximately 150' up from the reach break and continue throughout the reach. This reach is classified as a type B with step-pool bedform. A gully was observed running approximately 400' under the right-of-way for utility lines in the right corridor near the top of the reach.

Several old walls from historic mills were present along the reach but are no longer causing any major channel constriction. Several houses were present in the immediate left corridor; however impact is minimal due to the stable bedrock banks and steep valley walls.



Figure 26: Bedrock gorge typical of Reach M02

M03

Reach M03 is 1605' long and runs from the Canyon Rd covered bridge to the reach break at a valley wall constriction and bedrock grade control. A gravel parking area is present in the lower left corridor and is used to access a swimming area and trails to the upstream waterfall. A grade control is present at the swimming area that appears to be a bedrock outcrop and boulders spanning the channel with concrete poured over to form a dam (Figure 25). This was likely constructed to create a swimming area on the upstream side, which has since fully filled in with gravel and cobbles.



Figure 27: Combined natural and man-made grade control at swimming area in M03

An abandoned dirt road follows the stream in the left corridor and leads to a clearing that may be a historic dump. The right corridor is steep and fully buffered with primarily coniferous forest. Minimal floodplain access is present in the left corridor leading to a semi-confined setting. The reach has an approximate slope of 1% and is classified as type B_c with plane-bed bedform (Figure 26). A small mass failure is present on the right bank at the top of the reach. This may be due to a seep or runoff being concentrated by a water bar on the hiking trail following the river. The cross-section was taken at a representative riffle in the middle of the reach. The substrate was predominately cobble (40%) and coarse gravel (23%) with a median particle size of 85mm. The width-to-depth and entrenchment ratio are 27.1 and 1.2 respectively. The entrenchment ratio is low due to recent channel enlargement during episodic flooding events. These events caused flood benches on both sides to be scoured back creating an over-widened channel; these benches will likely reform with sedimentation in the future and the channel will continue have B-type dimensions. A channel evolution stage of III was selected for this reach using the F channel evolution model. Overall the dominant channel process is widening due to episodic flooding events. This reach has a “Fair” rating for geomorphic and habitat assessments and a stream sensitivity of “High”.

There is very little floodplain storage in this reach due to the naturally confined valley setting, and therefore there is limited potential to increase floodwater or sediment storage in the channel or floodplain. This reach, and upstream reach M04, may naturally adjust between B-type and F-type geometry depending on the deposition and bench formation along the channel margins in between flood events, and the resulting entrenchment ratios.



Figure 28: Reach M03 looking upstream from the cross-section

M04

Reach M04 is 1607' long and runs from the reach break at a valley wall constriction (Figure 27) to the reach break above the large waterfall. A channel spanning bedrock grade control is present at the bottom of the reach. A large depositional area is located immediately downstream of the waterfall with numerous bars found throughout the reach (Figure 15). A large flood chute runs along the right valley wall cutting through the elevated floodplain forest below the waterfall. The entrance to this flood chute is approximately 5-6' above current bankfull elevation, however it appears to have been accessed during recent flooding events. Overall channel slope is approximately 5.6% and channel slope below the waterfall is approximately 1%. The reach is classified as type B_a with plane-bed bedform. The cross-section was taken at a representative riffle in the middle of the reach. The substrate was predominately cobble (43%) and coarse gravel (30%) with a median particle size of 70mm. The width-to-depth and entrenchment ratio are 29.9 and 1.1 respectively. The entrenchment is

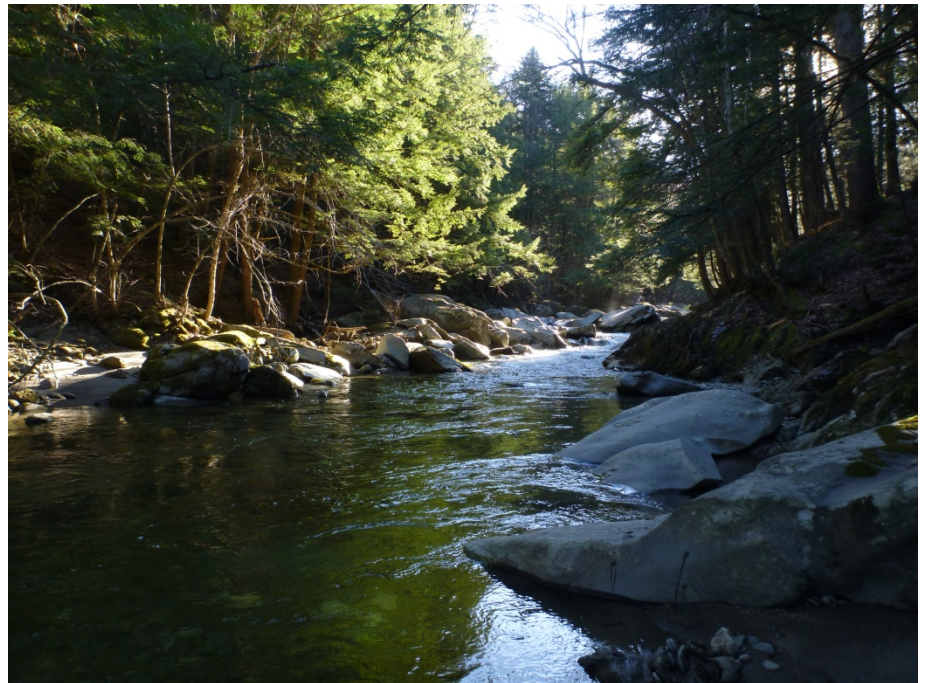


Figure 29: Valley wall constriction at the reach break between M03 and M04

very low due to recent channel enlargement during episodic flooding events. The dominant process in this reach is widening with increased deposition. Bedrock and boulder substrate underpinning the stream has limited vertical migration. A channel evolution stage of III was selected for the reach using the F channel evolution model. This reach has a “Fair” rating for geomorphic and habitat assessments and a stream sensitivity of “High”.

As in Reach M03, there is very little floodplain storage in this reach due to the naturally confined valley setting, and therefore there is limited potential to increase floodwater or sediment storage in the channel or floodplain. This reach may naturally adjust between B-type and F-type geometry depending on the deposition and bench formation along the channel margins in between flood events, and the resulting entrenchment ratios.

6.2 Phase 2 SGA Results

A complete summary of the individual Rapid Habitat Assessment (RHA) and Rapid Geomorphic Assessment (RGA) scores are shown below (Table 16). Additional, segment-specific data summaries are provided in Appendix B for each reach assessed for Phase 2 data.

Phase 2 Segment ID	RHA Condition	RHA Score	RGA Score	RGA Condition	Stream Sensitivity
M01-A	Fair	0.47	0.36	Fair	Very High
M01-B	Fair	0.59	0.61	Fair	Very High
M03	Fair	0.59	0.54	Fair	High
M04	Fair	0.59	0.7	Fair	High
Note: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment					

6.3 Site-Level Project Opportunities

The site-level projects developed for the Brewster River watershed are provided below in Table 17. The project strategy, technical feasibility, and priority for each project are listed by project number and reach/segment. A total of 6 projects were identified to promote the restoration or protection of channel stability and aquatic habitat. The table summarizes key information for each project, including the site stressors and constraints, project strategy, priority (for both hazard mitigation and ecological benefit), relative costs, and potential partners. The project locations for the study area are included on the Figures 26 and 27. I'd like to see the inclusion of a few more projects, perhaps ones Staci mentions in the preceding pages.

Table 17: Site-specific Opportunities for River Restoration and Protection								
Project #, Location, Reach, Lat/Long	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Potential Partners & Funding
#1 VT15 Segment M01-A 44.64841 N 72.82737 W	Active Restoration Bank Stabilization	Major bank erosion on the left bank immediately upstream of VT15 threatening utilities and the roadway. VTrans could only arrest erosion within the VT 15 right-of-way.	Bank armoring to stop bank erosion upstream of VT15. Plant left (south) bank. Use a setback of 15ft with larger tree stock to avoid loss from channel migration; Plant smaller, more vigorous stock along near bank.	High	Low	Reduced possibility of road and utilities damage	Moderate to high costs for design and installation of rock armor; Relatively low costs for native plant materials and labor.	VTrans; Village of Jeffersonville; Town of Cambridge; Landowner
#2 Old Main St. Floodplain Segment M01-A 44.64738 N 72.82664 W	Active Restoration Floodplain Restoration	Meadow along left bank upstream of VT15. Stream is actively migrating downstream. Floodplain bench created following 1999 landslide does not appear to be accessed by river annually.	Increase floodplain access along left (west) bank by regarding floodplain into field at a lower elevation.	High	Low	Important sediment and floodwater attenuation reach to take pressure off erosion and flood pinch point at downstream bridge.	Potentially moderate to high costs for easements due to private ownership, design costs, and restoration work.	LCPC; Village of Jeffersonville; Town of Cambridge; VTDEC
#3 Schoolbus parking lot Segment M01-A 44.64449 N 72.82513 W	Active Restoration Stormwater Treatment	A small storm water pipe draining the schoolbus parking area directly discharges into the Brewster River upstream of the mass failures.	Construct a small treatment swale, wetland, or other BMP on north side of parking lot and re-direct runoff.	Low	Moderate	Reduced sediment and pollutant loading	Moderate to high costs for design and installation of BMP.	LCPC; Village of Jeffersonville; Town of Cambridge; VTDEC
#4 Town Garage Segment M01-B 44.64182 N 72.82647 W	Active Restoration Stormwater Treatment	Stormwater pipe draining the town garage property and parking lot along the left bank discharges into the Brewster River.	Re-direct runoff to the north to a treatment area before discharging to the River. Construct a small treatment swale, wetland, or other BMP.	Low	Moderate	Reduced sediment and pollutant loading	Moderate to high costs for design and installation of BMP.	Village of Jeffersonville; Town of Cambridge; LCPC; VTDEC

Table 17: Site-specific Opportunities for River Restoration and Protection								
Project #, Location, Reach, Lat/Long	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Hazard Mitigation Priority	Ecological Benefits Priority	Project Benefits	Costs	Potential Partners & Funding
#5 Power line clearing gully Reach M02 44.63760 N 72.82514 W	Active Restoration Stormwater Treatment	Eroding gully formed along a natural flow path through brush/tree clearing under power lines.	Stabilize banks and plant with erosion control seed mix and/or native woody vegetation to reduce sediment runoff and further erosion	Low	Moderate	Reduced sediment and pollutant loading	Low to moderate costs for design and installation of BMPs.	Landowner; LCPC; VTDEC; VYCC
#6 Brewster Gorge parking area Reach M03 44.63649 N 72.82540 W	Active Restoration Stormwater Treatment	Eroded drainage ditch draining the gravel parking area upstream of Canyon Rd.	Construct a vegetated swale to reduce sediment runoff from parking area	Low	Moderate	Reduced sediment and pollutant loading	Moderate to high costs for design and installation of BMP.	LCPC; Village of Jeffersonville; Town of Cambridge; VTDEC
#7 Swimming area dam Reach M03 44.63556 N 72.82558 W	Active Restoration Dam Removal	A channel spanning ~6' tall dam that was constructed for a swimming hole is causing sediment deposition upstream and interrupting sediment transport. Biologically the dam is a barrier to aquatic organism passage and may increase water temperature.	Remove dam and restore historic Brewster River channel. Needs further investigation with local officials as to history and use of structure, and impact on downstream sediment transport.	Moderate	High	Improve habitat connectivity. Potential restoration of natural hydrologic and sediment regimes.	Potentially high costs for study and implementation of dam removal projects.	LCPC; Village of Jeffersonville; Town of Cambridge; VTDEC; VTFWD
#8 Brewster Gorge hiking trail erosion Reach M03 44.63283 N 72.82721 W	Active Restoration Stormwater Treatment	Bank erosion and potential for small mass failure due to concentrated runoff from waterbars on hiking trail.	Stabilize upper bank near runoff source; Add stone armor and/or weirs to slope along runoff pathway to reduce erosion.	Low	Moderate	Reduced sediment and pollutant loading	Low to moderate costs for design and installation of BMPs.	LCPC; Village of Jeffersonville; Town of Cambridge; VTDEC; VYCC

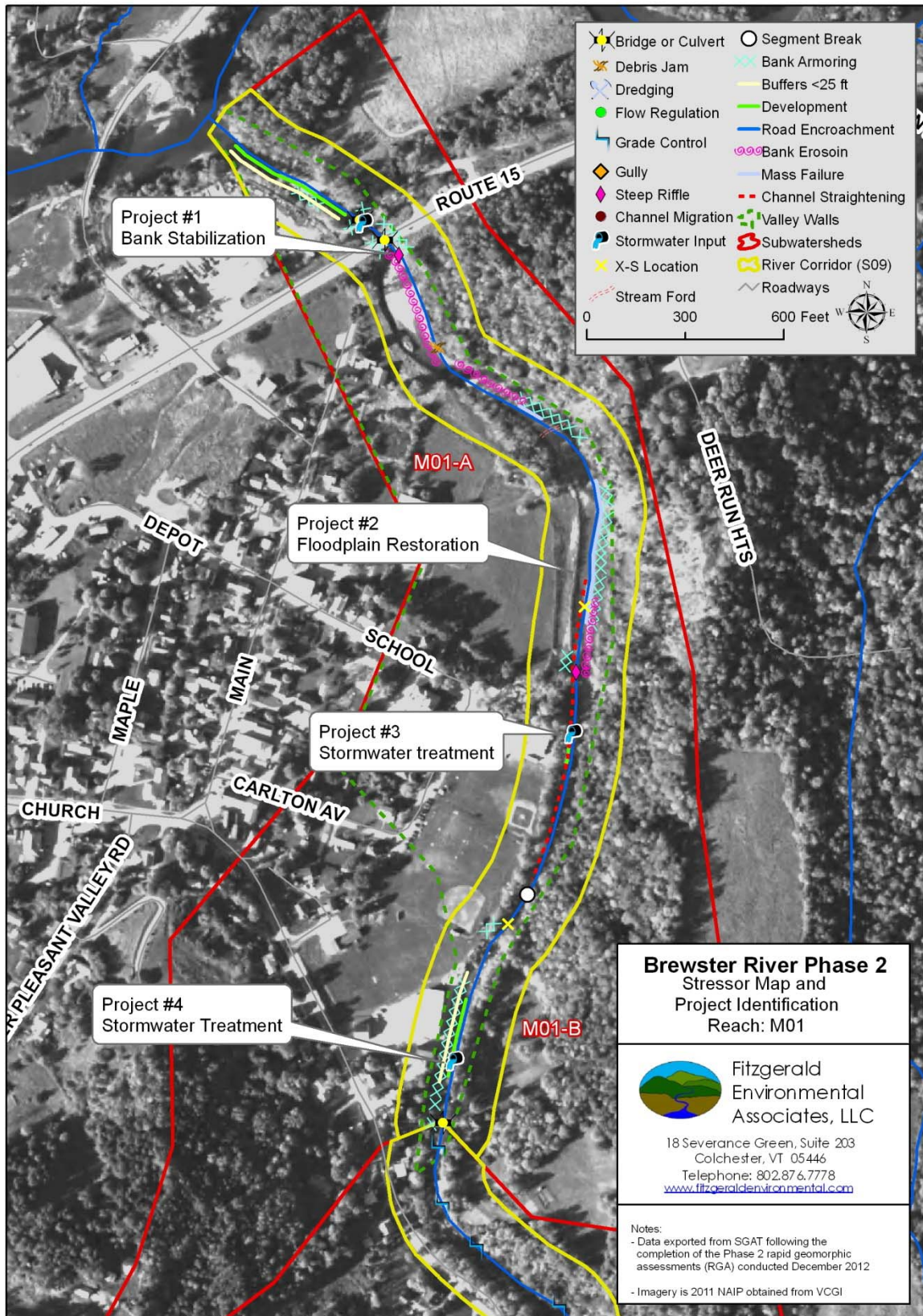


Figure 30: Reach M01 stressor map and project identification

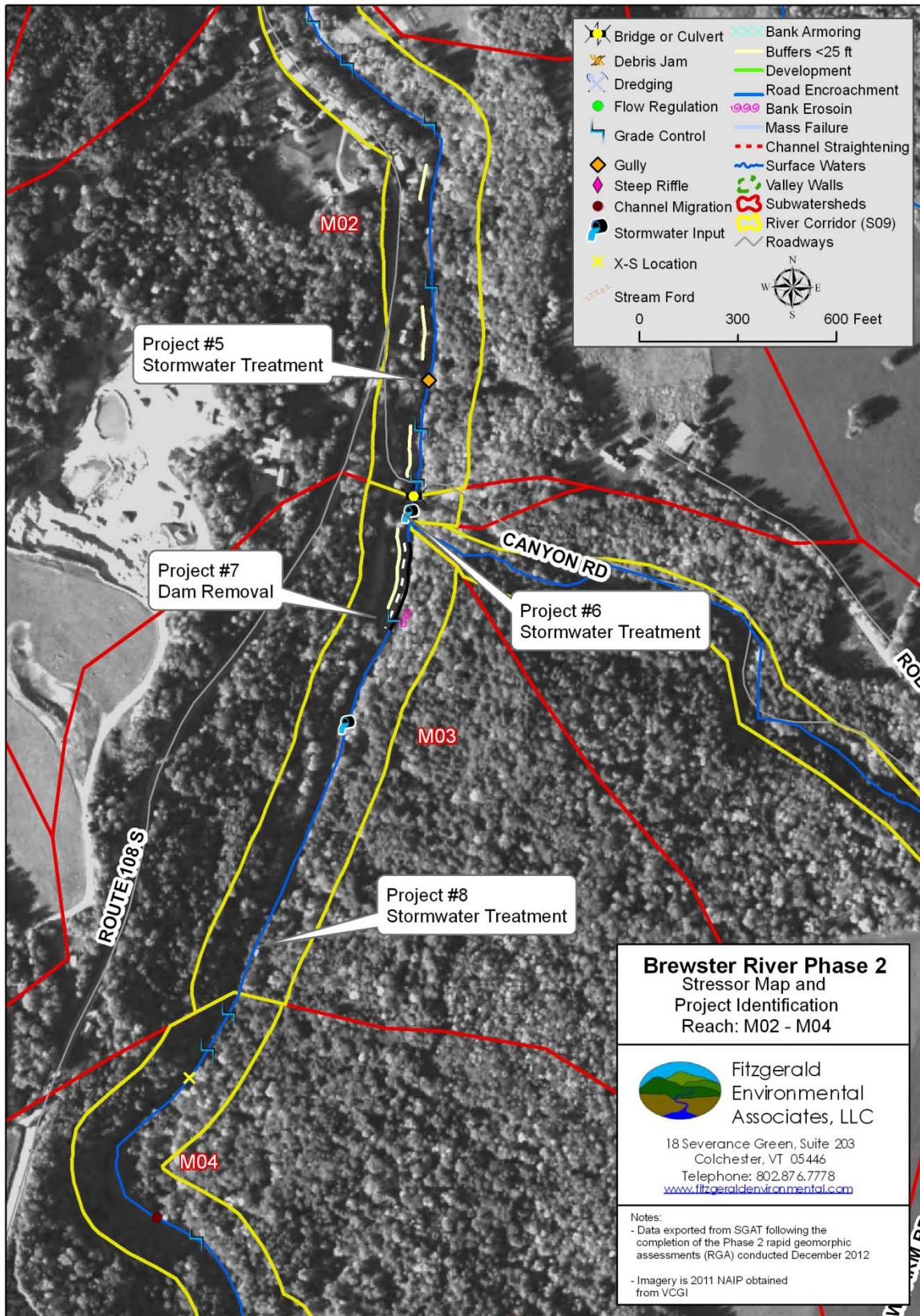


Figure 31: Reaches M02-M04 stressor map and project identification

7.0 Conclusions and Recommendations

The reaches of the Brewster River are still adjusting their dimensions, patterns, and profiles to impacts from historical sedimentation in the valleys from early European settlement and deforestation that caused hillslope erosion, as well as modern day impacts from channel straightening, dredging and corridor encroachment associated with adjacent roads, upslope development, and other land uses. Recent flood events over the last 20 years likely triggered channel incision and redevelopment of floodplain access in some reaches. Ongoing vertical and lateral channel migration is likely in the future for many reaches in the watershed.

Given these predictions for future channel adjustments, the municipalities in the watershed (in cooperation with LCPC and VTDEC) are wise to take a long-term corridor planning approach to better understand, plan for, and mitigate flooding and fluvial erosion hazards in the watershed. The following watershed-scale and site-specific management approaches are recommended in the Brewster River watershed:

- Further develop a Phase 2 SGA dataset for the nine (9) high-priority reaches identified in Section 5. This data will aid in the understanding of sediment and floodwater storage upstream of the Village of Jeffersonville, and support comprehensive planning along the entire river corridor.
- Consider in the future the adoption of a Fluvial Erosion Hazard (FEH) zone ordinance to prevent additional conflicts in river corridors resulting from new development. Also consider appropriate stream setbacks in areas where the FEH may not be mapped (e.g., smaller, headwaters tributaries draining to the Brewster River).
- Sediment management has been identified as a key concern in the Village of Jeffersonville due to ongoing conflicts at structures and road crossings, and flooding concerns. However, given the state of channel adjustments in the lower reaches of the Brewster, bank stabilization and/or channel reconfiguration is generally not advisable where the river is actively incising or redeveloping planform geometry. Numerous riverbank stabilization and channelization projects in Vermont and other states have failed due to a lack of understanding of channel adjustment processes and stage of channel evolution.

8.0 References

- Albers, J., 2000, *Hands on the Land: A History of the Vermont Landscape*, MIT Press, Cambridge, MA.
- Becker, L., Springston, G., and Kanat, L., 2009. Progress Report for Geotechnical Study of the Jeffersonville Landslide, Northwestern Vermont, 2009. Available at: <http://www.anr.state.vt.us/dec/geo/pdfdocs/ProgressJeff.pdf>. Accessed December, 2012
- CWP (Center for Watershed Protection), 2003, *Impacts of Impervious Cover on Aquatic Systems*. Watershed Protection Research Monograph: 39-49.
- Doll, C.G., Cady, W.M., Thompson, J.B., and M.P. Billings, 1961, *Centennial Geologic Map of Vermont: Vermont Geologic Survey*, Available at: www.anr.state.vt.us/dec/geo/centmap.htm. Accessed October, 2007
- Fitzgerald, E. P., 2007, *Linking urbanization to stream geomorphology and biotic integrity in the Lake Champlain Basin, Vermont* [M.S. Thesis]: Burlington, Vermont, University of Vermont, 121 p.
- LCBP (Lake Champlain Basin Program), 2004, *Nature of the Basin: Lake Champlain Basin Atlas, Geology of the Basin*. Accessed, January 2013, Available at: http://www.lcbp.org/Atlas/HTML/nat_geology.htm
- LCPC (Lamoille County Planning Commission), 2012, *GIS-based estimation of flood inundation areas during 2011 flooding along Lamoille River*, GIS layers developed by LCPC.
- Montgomery, D. R., & Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins, *Geological Society of America Bulletin*, 109(5), 596-611.
- NOAA (National Oceanic and Atmospheric Administration), 2008, *Land Cover Analysis Data for New England – Coastal Change Analysis Program*. Accessed May, 2008 and available at: <http://www.csc.noaa.gov/crs/lca/ccap.html>
- NOAA (National Oceanic and Atmospheric Administration), 2013, *National Climatic Data Center – Annual Climatological Summary*. Accessed January 2013 and available at: <http://www.ncdc.noaa.gov/cdo-web/>
- NRCS (Natural Resources Conservation Service), 2008, *Soil Survey Data for Lamoille County*.
- NWI (National Wetlands Inventory), 2003, *US Fish and Wildlife Service Digital Publication of the National Wetlands Inventory Data from 1983*. Available at: www.vcgi.org. Accessed April, 2007

- Olsen, S.A., 2002, Flow-frequency Characteristics of Vermont Streams, USGS Water-Resources Investigations Report 02-4238
- Paul, M. J., and J. L. Meyer, 2001, Streams in the urban landscape. *Annual Review of Ecology and Systematics* 32:333-365.
- Ridge, J.C. and Larsen, F.D., 1990, Re-evaluation of Antevs' New England varve chronology and new radiocarbon dates of sediments from Glacial Lake Hitchcock: *Geological Society of America*, v. 102, p. 889-899
- Rosgen, D. L., 1994, A classification of natural rivers, *Catena*, 22(3), 169 - 199.
- Thompson, E.H., and E.R. Sorenson, 2000, *Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont*, Vermont Department of Fish and Wildlife and The Nature Conservancy.
- USGS (United States Geological Survey), 2008, Real-time Flow Monitoring Data for Vermont Rivers, available at: <http://waterdata.usgs.gov/nwis>
- VCGI (Vermont Center for Geographic Information), 2003, Land Cover/Land Use Spatial Data for Vermont, Imagery dates: 1991 through 1993, Available at: www.vcgi.org
- VTANR (Vermont Agency of Natural Resources), 2005, Vermont Dam Inventory, Accessed June, 2008 at: www.vcgi.org
- VTANR, 2010, Vermont Agency of Natural Resources River Corridor Planning Guide. April, 2010. Accessed in April, 2010 at: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_restoration.htm
- VTDEC (Vermont Department of Environmental Conservation), 2009, Stream Geomorphic Assessment Handbook - Phase 1 & 2 Protocols. Vermont Agency of Natural Resources Publication. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm.
- VTDEC (Vermont Department of Environmental Conservation), 2008, Draft List of Priority Surface Waters Outside the Scope of Clean Water Act Section 303(d).
- Wright, S. F., 2003, *Glacial Geology of the Burlington/Colchester Quadrangles, Northern Vermont*. Department of Geology, University of Vermont, Accessed January 2013. Available at: <http://www.anr.state.vt.us/dec/geo/pdfdocs/GlacGeoBurlwright.pdf>

9.0 Glossary of Terms

Adapted from:

Restoration Terms, by Craig Fischenich, February, 2000, USAE Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Rd., Vicksburg, MS 39180

And

Vermont Stream Geomorphic Assessment Handbook, 2007, Vermont Agency of Natural Resources, Waterbury, VT http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Acre -- A measure of area equal to 43,560 ft² (4,046.87 m²). One square mile equals 640 acres.

Adjustment process -- or type of change, that is underway due to natural causes or human activity that has or will result in a change to the valley, floodplain, and/or channel condition (e.g., vertical, lateral, or channel plan form adjustment processes)

Aggradation -- A progressive buildup or raising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that stream discharge and/or bed-load characteristics are changing. Opposite of degradation.

Algae -- Microscopic plants that grow in sunlit water containing phosphates, nitrates, and other nutrients. Algae, like all aquatic plants, add oxygen to the water and are important in the fish food chain.

Alluvial -- Deposited by running water.

Alluvium -- A general term for detrital deposits made by streams on riverbeds, floodplains, and alluvial fans; esp. a deposit of silt or silty clay laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas or lakes.

Anadromous -- Pertaining to fish that spend a part of their life cycle in the sea and return to freshwater streams to spawn.

Aquatic ecosystem -- Any body of water, such as a stream, lake, or estuary, and all organisms and nonliving components within it, functioning as a natural system.

Armoring -- A natural process where an erosion-resistant layer of relatively large particles is established on the surface of the streambed through removal of finer particles by stream flow. A properly armored streambed generally resists movement of bed material at discharges up to approximately 3/4 bank-full depth. Augmentation (of stream flow) -- Increasing flow under normal conditions, by releasing storage water from reservoirs.

Avulsion -- A change in channel course that occurs when a stream suddenly breaks through its banks, typically bisecting an overextended meander arc.

Backwater -- (1) A small, generally shallow body of water attached to the main channel, with little or no current of its own, or (2) A condition in subcritical flow where the water surface elevation is raised by downstream flow impediments.

Backwater pool -- A pool that formed as a result of an obstruction like a large tree, weir, dam, or boulder.

Bank stability -- The ability of a streambank to counteract erosion or gravity forces.

Bankfull channel depth -- The maximum depth of a channel within a riffle segment when flowing at a bank-full discharge.

Bankfull channel width -- The top surface width of a stream channel when flowing at a bank-full discharge.

Bankfull discharge -- The stream discharge corresponding to the water stage that overtops the natural banks. This flow occurs, on average, about once every 1 to 2 years and given its frequency and magnitude is responsible for the shaping of most stream or river channels.

Bankfull width -- The width of a river or stream channel between the highest banks on either side of a stream.

Bar -- An accumulation of alluvium (usually gravel or sand) caused by a decrease in sediment transport capacity on the inside of meander bends or in the center of an overwide channel.

Barrier -- A physical block or impediment to the movement or migration of fish, such as a waterfall (natural barrier) or a dam (man-made barrier).

Base flow -- The sustained portion of stream discharge that is drawn from natural storage sources, and not affected by human activity or regulation.

Bed load -- Sediment moving on or near the streambed and transported by jumping, rolling, or sliding on the bed layer of a stream. See also suspended load.

Bed material -- The sediment mixture that a streambed is composed of.

Bed material load -- That portion of the total sediment load with sediments of a size found in the streambed.

Bed roughness -- A measure of the irregularity of the streambed as it contributes to flow resistance. Commonly expressed as a Manning "n" value.

- Bed slope** -- The inclination of the channel bottom, measured as the elevation drop per unit length of channel.
- Bedform** -- Individual patterns which streams follow that characterize the condition of the stream bed into several categories. (See: braided, dune-ripple, plane bed, riffle-pool, step-pool, and cascade)
- Benthic invertebrates** -- Aquatic animals without backbones that dwell on or in the bottom sediments of fresh or salt water. Examples: clams, crayfish, and a wide variety of worms.
- Berms** -- mounds of dirt, earth, gravel, or other fill built parallel to the stream banks designed to keep flood flows from entering the adjacent floodplain.
- Biota** -- All living organisms of a region, as in a stream or other body of water.
- Boulder** -- A large substrate particle that is larger than cobble, between 10 and 160 inches in diameter.
- Boundary resistance** -- The ability a stream bank has to withstand the erosional forces of the flowing water at varying intensities. Under natural conditions boundary resistance is increased due to stream bank vegetation (roots), cohesive clays, large boulder substrate, etc.
- Braided** -- A stream channel characterized by flow within several channels, which successively meet and divide. Braiding often occurs when sediment loading is too large to be carried by a single channel.
- Braiding (of river channels)** -- Successive division and rejoining of riverflow with accompanying islands.
- Buffer strip** -- A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.
- Canopy** -- A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leaves, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.
- Cascade** -- A short, steep drop in streambed elevation often marked by boulders and agitated white water.
- Catchment** -- (1) The catching or collecting of water, especially rainfall. (2) A reservoir or other basin for catching water. (3) The water thus caught. (4) A watershed.
- Channel** -- An area that contains continuously or periodically flowing water that is confined by banks and a streambed.
- Channelization** -- The process of changing (usually straightening) the natural path of a waterway.
- Channel evolution model (CEM)** -- A series of stages used to describe the erosional or depositional processes that occur within a stream or river in order to regain a dynamic equilibrium following a disturbance.
- Clay** -- Substrate particles that are smaller than silt and generally less than 0.0001 inches in diameter.
- Coarse gravel** -- Substrate that is smaller than cobble, but larger than fine gravel. The diameter of this stream-bottom particulate is between 0.63 and 2.5 inches.
- Cobble** -- Substrate particles that are smaller than boulders and larger than gravels, and are generally between 2.5 and 10 inches in diameter.
- Confinement** -- see Valley confinement
- Confluence** -- (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.
- Conifer** -- A tree belonging to the order Gymnospermae, comprising a wide range of trees that are mostly evergreens. Conifers bear cones (hence, coniferous) and have needle-shaped or scalelike leaves.
- Conservation** -- The process or means of achieving recovery of viable populations.
- Contiguous habitat** -- Habitat suitable to support the life needs of a species that is distributed continuously or nearly continuously across the landscape.
- Cover** -- "cover" is the general term used to describe any structure that provides refuge for fish, reptiles or amphibians. These animals seek cover to hide from predators, to avoid warm water temperatures, and to rest, by avoiding higher velocity water. These animals come in all sizes, so even cobbles on the stream bottom that are not sedimented in with fine sands and silt can serve as cover for small fish and salamanders. Larger fish and reptiles often use large boulders, undercut banks, submerged logs, and snags for cover.
- Critical shear stress** -- The minimum amount of shear stress exerted by stream currents required to initiate soil particle motion. Because gravity also contributes to streambank particle movement but not on streambeds, critical shear stress along streambanks is less than for streambeds.]
- Cross-section** -- A series of measurements, relative to bankfull, that are taken across a stream channel that are representative of the geomorphic condition and stream type of the reach.
- Crown** -- The upper part of a tree or other woody plant that carries the main system of branches and the foliage.
- Crown cover** -- The degree to which the crowns of trees are nearing general contact with one another.
- Cubic feet per second (cfs)** -- A unit used to measure water flow. One cubic foot per second is equal to 449 gallons per minute.
- Culvert** -- A buried pipe that allows flows to pass under a road.

Debris flow -- A rapidly moving mass of rock fragments, soil, and mud, with more than half of the particles being larger than sand size.

Deciduous -- Trees and plants that shed their leaves at the end of the growing season.

Degradation -- (1) A progressive lowering of the channel bed due to scour. Degradation is an indicator that the stream's discharge and/or sediment load is changing. The opposite of aggradation. (2) A decrease in value for a designated use.

Detritus -- is organic material, such as leaves, twigs, and other dead plant matter, that collects on the stream bottom. It may occur in clumps, such as leaf packs at the bottom of a pool, or as single pieces, such as a fallen tree branch.

Dike -- (1) (Engineering) An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (2) A low wall that can act as a barrier to prevent a spill from spreading. (3) (Geology) A tabular body of igneous (formed by volcanic action) rock that cuts across the structure of adjacent rocks or cuts massive rocks.

Dissolved oxygen (DO) -- The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation.

Ditch -- A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.

Drainage area -- The total surface area upstream of a point on a stream that drains toward that point. Not to be confused with watershed. The drainage area may include one or more watersheds.

Drainage basin -- The total area of land from which water drains into a specific river.

Dredging -- Removing material (usually sediments) from wetlands or waterways, usually to make them deeper or wider.

Dune-ripple -- A bedform associated with low-gradient, sand-bed channels; the low gradient nature of the channel causes the sand to form a sequence of dunes and small ripples; significant sediment transport typically occurs at most stream stages.

Ecology -- The study of the interrelationships of living organisms to one another and to their surroundings.

Ecosystem -- Recognizable, relatively homogeneous units, including the organisms they contain, their environment, and all the interactions among them.

Embankment -- An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, support roads or railways, or for other similar purposes.

Embeddedness -- is a measure of the amount of surface area of cobbles, boulders, snags and other stream bottom structures that is covered with sand and silt. An embedded streambed may be packed hard with sand and silt such that rocks in the stream bottom are difficult or impossible to pick up. The spaces between the rocks are filled with fine sediments, leaving little room for fish, amphibians, and bugs to use the structures for cover, resting, spawning, and feeding. A streambed that is not embedded has loose rocks that are easily removed from the stream bottom, and may even "roll" on one another when you walk on them.

Entrenchment ratio --The width of the flood-prone area divided by the bankfull width.

Epifaunal -- "epi" means surface, and "fauna" means animals. Thus, "epifaunal substrate" is structures in the stream (on the stream bed) that provide surfaces on which animals can live. In this case, the animals are aquatic invertebrates (such as aquatic insects and other "bugs"). These bugs live on or under cobbles, boulders, logs, and snags, and the many cracks and crevices found in these structures. In general, older decaying logs are better suited for bugs to live on/in than newly fallen "green" logs and trees.

Ephemeral streams -- Streams that flow only in direct response to precipitation and whose channel is at all times above the water table.

Equilibrium Condition -- The state of a river reach in which the upstream input of energy (flow of water) and materials (sediment and debris) is equal to its output to downstream reaches. Natural river reaches without human impacts tend towards a "stable" state where predictable channel forms are maintained over the long term under varying flow conditions.

Erosion -- Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Eutrophic -- Usually refers to a nutrient-enriched, highly productive body of water.

Eutrophication -- The process of enrichment of water bodies by nutrients.

Fine gravel -- Is substrate which is larger than sand, but smaller than coarse gravel. It is between 0.08 and 0.63 inches in diameter.

Flash flood -- A sudden flood of great volume, usually caused by a heavy rain. Also, a flood that crests in a short length of time and is often characterized by high velocity flows.

Floodplain -- Land built of fine particulate organic matter and small substrate that is regularly covered with water as a result of the flooding of a nearby stream.

Floodplain (100-year) -- The area adjacent to a stream that is on average inundated once a century.

Floodplain Function – Flood water access of floodplain which effects the velocity, depth, and slope (stream power) of the flood flow thereby influencing the sediment transport characteristics of the flood (i.e., loss of floodplain access and function may lead to higher stream power and erosion during flood).

Flow -- The amount of water passing a particular point in a stream or river, usually expressed in cubic feet per second (cfs).

Fluvial -- Migrating between main rivers and tributaries. Of or pertaining to streams or rivers.

Fluvial Geomorphology—The study of how rivers and their landforms interact over time through different climatic conditions.

Ford -- A shallow place in a body of water, such as a river, where one can cross by walking or riding on an animal or in a vehicle.

Fry -- A recently hatched fish.

Gabion -- A wire basket or cage that is filled with gravel or cobble and generally used to stabilize streambanks.

Gaging station -- A particular site in a stream, lake, reservoir, etc., where hydrologic data are obtained.

Gallons per minute (gpm) -- A unit used to measure water flow.

Geographic information system (GIS) -- A computer system capable of storing and manipulating spatial data.

Geomorphology -- A branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place due to erosion of the primary elements and the buildup of erosional debris.

Glide -- A section of stream that has little or no turbulence.

Grade control -- A fixed feature on the streambed that controls the bed elevation at that point, effectively fixing the bed elevation from potential incision; typically bedrock, dams, or culverts.

Gradient -- Vertical drop per unit of horizontal distance.

Grass/forb -- Herbaceous vegetation.

Gravel -- An unconsolidated natural accumulation of rounded rock fragments, mostly of particles larger than sand (diameter greater than 2 mm), such as boulders, cobbles, pebbles, granules, or any combination of these.

Groundwater -- Subsurface water and underground streams that can be collected with wells, or that flow naturally to the earth's surface through springs.

Groundwater basin -- A groundwater reservoir, defined by an overlying land surface and the underlying aquifers that contain water stored in the reservoir. In some cases, the boundaries of successively deeper aquifers may differ and make it difficult to define the limits of the basin.

Groundwater recharge -- Increases in groundwater storage by natural conditions or by human activity. See also artificial recharge.

Groundwater Table -- The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

Habitat -- The local environment in which organisms normally live and grow.

Habitat diversity -- The number of different types of habitat within a given area.

Habitat fragmentation -- The breaking up of habitat into discrete islands through modification or conversion of habitat by management activities.

Headcut -- A sharp change in slope, almost vertical, where the streambed is being eroded from downstream to upstream.

Headwater -- Referring to the source of a stream or river.

High gradient streams -- typically appear as steep cascading streams, step/pool streams, or streams that exhibit riffle/pool sequences. Most of the streams in Vermont are high gradient streams.

Hydraulic gradient -- The slope of the water surface. See also streambed gradient.

Hydraulic radius -- The cross-sectional area of a stream divided by the wetted perimeter.

Hydric -- soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper horizon.

Hydrograph -- A curve showing stream discharge over time.

Hydrologic balance -- An accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time. Hydrologic region -- A study area, consisting of one or more planning subareas, that has a common hydrologic character.

Hydrologic unit Code (HUC) -- A distinct watershed or river basin defined by an 8-digit code.

Hydrology -- The scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship to living things.

Hyporheic zone -- The area under the stream channel and floodplain where groundwater and the surface waters of the stream are exchanged freely.

Impoundment -- An area where the natural flow of the river has been disrupted by the presence of human-made or natural structure (e.g. weir or beaver dam). The impoundment backwater extends upstream causing sediment to be deposited on the stream bottom.

Improved paths -- Paths that are maintained and typically involve paved, gravel or macadam surfaces.

Incised river -- A river that erodes its channel by the process of degradation to a lower base level than existed previously or is consistent with the current hydrology.

Incision ratio -- The low bank height divided by the bankfull maximum depth.

Infiltration (soil) -- The movement of water through the soil surface into the soil.

Inflow -- Water that flows into a stream, lake,

Instream cover -- The layers of vegetation, like trees, shrubs, and overhanging vegetation, that are in the stream or immediately adjacent to the wetted channel.

Instream flows -- (1) Portion of a flood flow that is contained by the channel. (2) A minimum flow requirement to maintain ecological health in a stream.

Instream use -- Use of water that does not require diversion from its natural watercourse. For example, the use of water for navigation, recreation, fish and wildlife, aesthetics, and scenic enjoyment.

Intermittent stream -- Any nonpermanent flowing drainage feature having a definable channel and evidence of scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet these two criteria.

Irrigation diversion -- Generally, a ditch or channel that deflects water from a stream channel for irrigation purposes.

Islands -- mid-channel bars that are above the average water level and have established woody vegetation.

Kame -- a deposit of stratified glacial drift in isolated mounds or steep-sided hills.

Lake -- An inland body of standing water deeper than a pond, an expanded part of a river, a reservoir behind a dam

Landslide -- A movement of earth mass down a steep slope.

Large woody debris (LWD) -- Pieces of wood at least 6 ft. long and 1 ft. in diameter (at the large end) contained, at least partially, within the bankfull area of a channel.

Levee -- An embankment constructed to prevent a river from overflowing (flooding).

Limiting factor -- A requirement such as food, cover, or another physical, chemical, or biological factor that is in shortest supply with respect to all resources necessary to sustain life and thus "limits" the size or retards production of a population.

Low gradient -- streams typically appear slow moving and winding, and have poorly defined riffles and pools.

Macroinvertebrate -- Invertebrates visible to the naked eye, such as insect larvae and crayfish.

Macrophytes -- Aquatic plants that are large enough to be seen with the naked eye.

Main Stem -- The principal channel of a drainage system into which other smaller streams or rivers flow.

Mass movement -- The downslope movement of earth caused by gravity. Includes but is not limited to landslides, rock falls, debris avalanches, and creep. It does not however, include surface erosion by running water. It may be caused by natural erosional processes, or by natural disturbances (e.g., earthquakes or fire events) or human disturbances (e.g., mining or road construction).

Mean annual discharge -- Daily mean discharge averaged over a period of years. Mean annual discharge generally fills a channel to about one-third of its bank-full depth.

Mean velocity -- The average cross-sectional velocity of water in a stream channel. Surface values typically are much higher than bottom velocities. May be approximated in the field by multiplying the surface velocity, as determined with a float, times 0.8.

Meander -- The winding of a stream channel, usually in an erodible alluvial valley. A series of sine-generated curves characterized by curved flow and alternating banks and shoals.

Meander amplitude -- The distance between points of maximum curvature of successive meanders of opposite phase in a direction normal to the general course of the meander belt, measured between center lines of channels.

Meander belt width -- the distance between lines drawn tangential to the extreme limits of fully developed meanders. Not to be confused with meander amplitude.

Meander length -- The lineal distance down valley between two corresponding points of successive meanders of the same phase.

Mid-channel Bars -- bars located in the channel away from the banks, generally found in areas where the channel runs straight. Mid-channel bars caused by recent channel instability are unvegetated.

Milligrams per liter (mg/l) -- The weight in milligrams of any substance dissolved in 1 liter of liquid; nearly the same as parts per million by weight.

Moraine -- a mass of till either carried by an active glacier or deposited on the land after a glacier recedes.

Natural flow -- The flow past a specified point on a natural stream that is unaffected by stream diversion, storage, import, export, return flow, or change in use caused by modifications in land use.

Neck cutoff -- A channel migration feature where the land that separates a meander bend is cut off by the lateral migration of the channel. This process may be part of the equilibrium regime or associated with channel instability.

Outfall -- The mouth or outlet of a river, stream, lake, drain or sewer.

Outwash -- water-transported material carried away from the ablation zone of a melting glacier.

Oxbow -- An abandoned meander in a river or stream, caused by cutoff. Used to describe the U-shaped bend in the river or the land within such a bend of a river.

Peat -- Partially decomposed plants and other organic material that build up in poorly drained wetland habitats.

Perched groundwater -- Groundwater supported by a zone of material of low permeability located above an underlying main body of groundwater with which it is not hydrostatically connected.

Perennial streams -- Streams that flow continuously.

Permeability -- The capability of soil or other geologic formations to transmit water.

pH -- The negative logarithm of the molar concentration of the hydrogen ion, or, more simply acidity.

Planform -- The channel shape as if observed from the air. Changes in planform often involve shifts in large amount of sediment, bank erosion, or the migration of the channel. A channel straightened for agricultural purposes has a highly impacted planform.

Point bar -- The convex side of a meander bend that is built up due to sediment deposition.

Pond -- A body of water smaller than a lake, often artificially formed.

Pool -- A reach of stream that is characterized by deep, low-velocity water and a smooth surface.

Potential plant height -- the height to which a plant, shrub or tree would grow if undisturbed.

Probability of exceedence -- The probability that a random flood will exceed a specified magnitude in a given period of time.

Railroads -- Used or unused railroad infrastructure.

Rapids -- A reach of stream that is characterized by small falls and turbulent, high-velocity water.

Reach -- A section of stream having relatively uniform physical attributes, such as valley confinement, valley slope, sinuosity, dominant bed material, and bed form, as determined in the Phase 1 assessment.

Rearing habitat -- Areas in rivers or streams where juvenile fish find food and shelter to live and grow.

Reference stream type -- Uses preliminary observations to determine the natural channel form and process that would be present in the absence of anthropogenic impacts to the channel and the surrounding watershed.

Refuge area -- An area within a stream that provides protection to aquatic species during very low and/or high flows.

Regime theory -- A theory of channel formation that applies to streams that make a part of their boundaries from their transported sediment load and a portion of their transported sediment load from their boundaries. Channels are considered in regime or equilibrium when bank erosion and bank formation are equal.

Restoration -- The return of an ecosystem to a close approximation of its condition prior to disturbance.

Riffle -- A reach of stream that is characterized by shallow, fast-moving water broken by the presence of rocks and boulders.

Riffle-pool ratio -- The ratio of surface area or length of pools to the surface area or length of riffles in a given stream reach; frequently expressed as the relative percentage of each category. Used to describe fish habitat rearing quality.

Riffle-step ratio -- ratio of the distance between riffles to the stream width.

Riparian area -- An area of land and vegetation adjacent to a stream that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains. Riparian buffer is the width of naturally vegetated land adjacent to the stream between the top of the bank (or top of slope, depending on site characteristics) and the edge of other land uses. A buffer is largely undisturbed and consists of the trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface. The buffer serves to protect the water body from the impacts of adjacent land uses. Riparian corridor includes lands defined by the lateral extent of a stream's meanders necessary to maintain a stable stream dimension, pattern, profile, and sediment regime. For instance, in stable pool-riffle streams, riparian corridors may be as wide as 10-12 times the channel's bankfull width. In addition the riparian corridor typically corresponds to the land area surrounding and including the stream that supports (or could support if unimpacted) a distinct ecosystem, generally with abundant and diverse plant and animal communities (as compared with upland communities).

Riparian habitat -- The aquatic and terrestrial habitat adjacent to streams, lakes, estuaries, or other waterways.

Riparian -- Located on the banks of a stream or other body of water.

Riparian vegetation -- The plants that grow adjacent to a wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, meadow, etc., and that rely upon the hydrology of the associated water body.

Ripple -- (1) A specific undulated bed form found in sand bed streams. (2) Undulations or waves on the surface of flowing water.

Riprap -- Rock or other material with a specific mixture of sizes referred to as a "gradation," used to stabilize streambanks or riverbanks from erosion or to create habitat features in a stream.

River channels -- Large natural or artificial open streams that continuously or periodically contain moving water, or which form a connection between two bodies of water.

River miles -- Generally, miles from the mouth of a river to a specific destination or, for upstream tributaries, from the confluence with the main river to a specific destination.

River reach -- Any defined length of a river.

River stage -- The elevation of the water surface at a specified station above some arbitrary zero datum (level).

Riverine -- Relating to, formed by, or resembling a river including tributaries, streams, brooks, etc.

Riverine habitat -- The aquatic habitat within streams and rivers.

Roads -- Transportation infrastructure. Includes private, town, state roads, and roads that are dirt, gravel, or paved.

Rock -- A naturally formed mass of minerals.

Rootwad -- The mass of roots associated with a tree adjacent to or in a stream that provides refuge for fish and other aquatic life.

Run (in stream or river) -- A reach of stream characterized by fast-flowing, low-turbulence water.

Runoff -- Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.

Sand -- Small substrate particles, generally from 0.002 to 0.08 in diameter. Sand is larger than silt and smaller than gravel.

Scour -- The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material and can be classed as general, contraction, or local scour.

Sediment -- Soil or mineral material transported by water or wind and deposited in streams or other bodies of water.

Sedimentation -- (1) The combined processes of soil erosion, entrainment, transport, deposition, and consolidation. (2) Deposition of sediment.

Seepage -- The gradual movement of a fluid into, through, or from a porous medium. **Segment**: A relatively homogenous section of stream contained within a reach that has the same reference stream characteristics but is distinct from other segments in the reach in one or more of the following parameters: degree of floodplain encroachment, presence/absence of grade controls, bankfull channel dimensions (W/D ratio, entrenchment), channel sinuosity and slope, riparian buffer and corridor conditions, abundance of springs/seeps/adjacent wetlands/stormwater inputs, and degree of channel alterations.

Sensitivity -- of the valley, floodplain, and/or channel condition to change due to natural causes and/or anticipated human activity.

Shoals -- unvegetated deposits of gravels and cobbles adjacent to the banks that have a height less than the average water level. In channels that are over-widened, the stream does not have the power to transport these larger sediments, and thus they are deposited throughout the channel as shoals.

Silt -- Substrate particles smaller than sand and larger than clay; between 0.0001 and 0.002 inches in diameter.

Siltation -- The deposition or accumulation of fine soil particles.

Sinuosity -- The ratio of channel length to direct down-valley distance. Also may be expressed as the ratio of down-valley slope to channel slope.

Slope -- The ratio of the change in elevation over distance.

Slope stability -- The resistance of a natural or artificial slope or other inclined surface to failure by mass movement.

Snag -- Any standing dead, partially dead, or defective (cull) tree at least 10 in. in diameter at breast height and at least 6 ft tall. Snags are important riparian habitat features.

Spawning -- The depositing and fertilizing of eggs (or roe) by fish and other aquatic life.

Spillway -- A channel for reservoir overflow.

Stable channel -- A stream channel with the right balance of slope, planform, and cross section to transport both the water and sediment load without net long-term bed or bank sediment deposition or erosion throughout the stream segment.

Stone -- Rock or rock fragments used for construction.

Straightening -- the removal of meander bends, often done in towns and along roadways, railroads, and agricultural fields.

Stream -- A general term for a body of water flowing by gravity; natural watercourse containing water at least part of the year. In hydrology, the term is generally applied to the water flowing in a natural narrow channel as distinct from a canal. Stream banks are features that define the channel sides and contain stream flow within the channel; this is the portion of the channel bank that is between the toe of the bank slope and the bankfull elevation. The banks are distinct from the streambed, which is normally wetted and provides a substrate that supports aquatic organisms. The top of bank is the point where an abrupt change in slope is evident, and where the stream is generally able to overflow the banks and enter the adjacent floodplain during flows at or exceeding the average annual high water.

Stream channel -- A long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.

Stream condition -- Given the land use, channel and floodplain modifications documented at the assessment sites, the current degree of change in the channel and floodplain from the reference condition for parameters such as dimension, pattern, profile, sediment regime, and vegetation.

Stream gradient -- A general slope or rate of change in vertical elevation per unit of horizontal distance of the bed, water surface, or energy grade of a stream.

Stream morphology -- The form and structure of streams.

Stream order -- A hydrologic system of stream classification. Each small unbranched tributary is a first-order stream. Two first-order streams join to make a second-order stream. A third-order stream has only first-and second-order tributaries, and so forth.

Stream reach -- An individual segment of stream that has beginning and ending points defined by identifiable features such as where a tributary confluence changes the channel character or order.

Stream type -- Gives the overall physical characteristics of the channel and helps predict the reference or stable condition of the reach.

Stream type departure -- When the current stream type differs from the reference stream type as a response to anthropogenic or severe natural disturbances. These departures are often characterized by large-scale incision, deposition, or changes in planform.

Streambank armoring -- The installation of concrete walls, gabions, stone riprap, and other large erosion resistant material along stream banks.

Streambank erosion -- The removal of soil from streambanks by flowing water.

Streambank stabilization -- The lining of streambanks with riprap, matting, etc., or other measures intended to control erosion.

Streambed -- (1) The unvegetated portion of a channel boundary below the baseflow level. (2) The channel through which a natural stream of water runs or used to run, as a dry streambed.

Streamflow -- The rate at which water passes a given point in a stream or river, usually expressed in cubic feet per second (cfs).

Step (in a river system) --A step is a steep, step-like feature in a high gradient stream (> 2%). Steps are composed of large boulders lines across the stream. Steps are important for providing grade-control, and for dissipating energy. As fast-shallow water flows over the steps it takes various flow paths thus dissipating energy during high flow events.

Substrate -- (1) The composition of a streambed, including either mineral or organic materials. (2) Material that forms an attachment medium for organisms.

Surface erosion -- The detachment and transport of soil particles by wind, water, or gravity. Or a group of processes whereby soil materials are removed by running water, waves and currents, moving ice, or wind.

Surface water -- All waters whose surface is naturally exposed to the atmosphere, for example, rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc., and all springs, wells, or other collectors directly influenced by surface water.

Suspended sediment -- Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.

Suspended sediment load -- That portion of a stream's total sediment load that is transported within the body of water and has very little contact with the streambed.

Tailwater -- (1) The area immediately downstream of a spillway. (2) Applied irrigation water that runs off the end of a field.

Thalweg -- (1) The lowest thread along the axial part of a valley or stream channel. (2) A subsurface, groundwater stream percolating beneath and in the general direction of a surface stream course or valley. (3) The middle, chief, or deepest part of a navigable channel or waterway.

Tractive Force --The drag on a streambed or bank caused by passing water, which tends to pull soil particles along with the streamflow.

Transpiration -- An essential physiological process in which plant tissues give off water vapor to the atmosphere.

Tributary -- A stream that flows into another stream, river, or lake.

Turbidity -- A measure of the content of suspended matter that interferes with the passage of light through the water or in which visual depth is restricted. Suspended sediments are only one component of turbidity.

Urban runoff -- Storm water from city streets and gutters that usually carries a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.

Valley confinement -- Referring to the ratio of valley width to channel width. Unconfined channels (confinement of 4 or greater) flow through broader valleys and typically have higher sinuosity and area for floodplain. Confined channels (confinement of less than 4) typically flow through narrower valleys.

Valley wall -- The side slope of a valley, which begins where the topography transitions from the gentle-sloped valley floor. The distance between valley walls is used to calculate the valley confinement.

Variable-stage stream -- Stream flows perennially but water level rises and falls significantly with storm and runoff events.

Velocity -- In this concept, the speed of water flowing in a watercourse, such as a river.

Washout -- (1) Erosion of a relatively soft surface, such as a roadbed, by a sudden gush of water, as from a downpour or floods. (2) A channel produced by such erosion.

Water quality -- A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

Waterfall -- A sudden, nearly vertical drop in a stream, as it flows over rock.

Watershed -- An area of land whose total surface drainage flows to a single point in a stream.

Watershed management -- The analysis, protection, development, operation, or maintenance of the land, vegetation, and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents.

Watershed project -- A comprehensive program of structural and nonstructural measures to preserve or restore a watershed to good hydrologic condition. These measures may include detention reservoirs, dikes, channels, contour trenches, terraces, furrows, gully plugs, revegetation, and possibly other practices to reduce flood peaks and sediment production.

Watershed restoration -- Improving current conditions of watersheds to restore degraded habitat and provide long-term protection to aquatic and riparian resources.

Weir -- A structure to control water levels in a stream. Depending upon the configuration, weirs can provide a specific "rating" for discharge as a function of the upstream water level.

Wetland -- Areas adjacent to, or within the stream, with sufficient surface/groundwater influence to have present hydric soils and aquatic vegetation (e.g. cattails, sedges, rushes, willows or alders).

Width/depth ratio -- The ratio of channel bankfull width to the average bankfull depth. An indicator of channel widening or aggradation, and used for stream type classification.

APPENDIX A

Phase 1 Reach Summary Reports

Brewster River

Phase 1 - Reach Summary Report

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **JEFFERSONVILLE**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Reach ID: **M01**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins at confluence with Lamoille River and ends at bridge crossing private drive just upstream of Town Garage.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6496187863**
 1.3 Downstream Longitude: **-72.829253072**

Step 2. Stream Type

2.1 Elevation Upstream: **495**
 2.1 Elevation Downstream: **460**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **3,480.5 ft.** **0.66** Miles
 2.3 Valley Slope: **1.0**
 2.4 Channel Length: **3,688.7 ft.** **0.70** Miles
 2.5 Channel Slope: **0.95 %**
 2.6 Sinuosity: **1.06**
 2.7 Watershed Area: **19.8** Square Miles
 2.8 Channel Width: **48.7** feet
 2.9 Valley Width: **513.5** feet
 2.10 Confinement Ratio: **10.5**
 2.10 Confinement Type: **Very Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Gravel**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Ice-Contact** **51.8 %**
 3.3 Sub-dom. Geological Mat.: **Glacial Lake**
 3.4 Valley Slope Left: **Flat**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **A** **51.8 %**
 Flooding: **None/Rare** **79.7 %**
 Water Table Deep: **6.0** **97.3 %**
 Water Table Shallow: **6.0** **97.3 %**
 Erodibility: **Moderate** **29.3 %**

7.4 Comments:
Reach was segmented during Phase 2: M01A = 2,860 ft, C to B STD ; M01B - 786 ft -SubReach - Ref. stream type Bc-riffle pool, no STD, but departure in bedform from riffle-pool to plane bed.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Urban**
 Current Dominant Land Cover: **Forest** **77.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Field**
 Current Dominant Land Cover: **Crop** **20.0 %**
 Current Sub-Dominant Land Cover: **Forest**
 4.3 Riparian Buffer **Left Bank** **Right Bank**
 Dominant: **26-50** **>100**
 Sub-dominant: **0-25** **None**
 Length w / less than 25 ft.: **726.0 ft.** **0.0 ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **2** **10.0 %**
 5.3 Bank Armoring: **1,371.9** **37.2 %**
 Left: **588.2 ft.** Right: **783.7 ft.**
 5.4 Channel Straightening: **936.1** **25.4 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft.** **0.0**
One Side **Both Sides**
 Road: **0.0 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **747.9 ft.** **0.0 ft.**
 6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Migration**
 6.5 Meander Width: **48 ft.** Ratio: **1.0**
 6.6 Wavelength: **48 ft.** Ratio: **1.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **831.36** **ft**
 7.2 Bank Height: **5** **ft**
 7.3 Ice/Debris Jam Potential: **Bridge**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
2	2	1	0	1	2	2	0	0	2	2	2	2	2	2	2	24
High	High	Low	N.S.	Low	High	High	N.S.	Unk.	High	High	High	High	High	High	High	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **JEFFERSONVILLE**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M02**
 SGAT Version: **4.56**
 Date Last Edited: **February, 28 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins at bridge crossing private drive just upstream of Town Garage and ends 90 feet upstream of bridge on Canyon Rd, at confluence with first tributary entering from east.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6412721286**
 1.3 Downstream Longitude: **-72.8265419369**

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Urban**
 Current Dominant Land Cover: **Forest 77.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 36.0 %**
 Current Sub-Dominant Land Cover: **Urban**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **26-50** **>100**
 Sub-dominant: **0-25** **None**
 Length w / less than 25 ft.: **413.0 ft.** **0.0 ft.**

Step 2. Stream Type

2.1 Elevation Upstream: **550**
 2.1 Elevation Downstream: **495**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **1,853.5 ft.** **0.35** Miles
 2.3 Valley Slope: **3.0**
 2.4 Channel Length: **1,891.9 ft.** **0.36** Miles
 2.5 Channel Slope: **2.91 %**
 2.6 Sinuosity: **1.02**
 2.7 Watershed Area: **19.6** Square Miles
 2.8 Channel Width: **48.6** feet
 2.9 Valley Width: **135.5** feet
 2.10 Confinement Ratio: **2.8**
 2.10 Confinement Type: **Semi-confined**
 2.11 Reference Stream Type: **B**
 Bedform: **Step-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Bedrock**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **1** **0.6 %**
 5.3 Bank Armoring: **31.8** **1.7 %**
 Left: **31.8 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **Ledge**
 3.3 Dominant Geological Mat.: **Ice-Contact 65.9 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Ext. Steep**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **B 37.6 %**
 Flooding: **None/Rare 100.0 %**
 Water Table Deep: **6.0 63.1 %**
 Water Table Shallow: **6.0 63.1 %**
 Erodibility: **Severe 55.5 %**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft.** **0.0**
One Side Both Sides
 Road: **0.0 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **0.0 ft.** **0.0 ft.**
 6.3 Channel Bars: **None**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

This reach is predominantly a bedrock gorge and was not fully assessed in Phase 2, but limited field observations were made.

Step 7. Windshield Survey

7.1 Bank Erosion: **0** **ft**
 7.2 Bank Height: **No Data** **ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6
High	High	High	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	N.S.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **JEFFERSONVILLE**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M03**
 SGAT Version: **4.56**
 Date Last Edited: **March, 08 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 90 feet upstream of bridge on Canyon Rd, at confluence with first tributary entering from east; ends 1,500 feet upstream.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6366397213**
 1.3 Downstream Longitude: **-72.8253435831**

Step 2. Stream Type

2.1 Elevation Upstream: **560**
 2.1 Elevation Downstream: **550**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **1,605.5 ft.** **0.30** Miles
 2.3 Valley Slope: **0.6**
 2.4 Channel Length: **1,624.6 ft.** **0.31** Miles
 2.5 Channel Slope: **0.62 %**
 2.6 Sinuosity: **1.01**
 2.7 Watershed Area: **19.5** Square Miles
 2.8 Channel Width: **48.4** feet
 2.9 Valley Width: **180.0** feet
 2.10 Confinement Ratio: **3.7**
 2.10 Confinement Type: **Semi-confined**
 2.11 Reference Stream Type: **B**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **c**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **Dam**
 3.3 Dominant Geological Mat.: **Glacial Lake** **57.3 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **B** **60.0 %**
 Flooding: **None/Rare** **100.0 %**
 Water Table Deep: **6.0** **100.0 %**
 Water Table Shallow: **6.0** **89.7 %**
 Erodibility: **Very Severe** **100.0 %**

7.4 Comments:

Dam at the swimming hole parking area appears to be a combination of ledge and boulders with concrete poured over to form a dam. The dam causes backwater for approximately 300" and has completely filled in with sand and gravel.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **79.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **44.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100** **>100**
 Sub-dominant: **0-25** **None**
 Length w / less than 25 ft.: **258.0 ft.** **0.0 ft.**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **1** **1.4 %**
 5.3 Bank Armoring: **0.0** **0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **281.4 ft.** **17.3**
 One Side Both Sides
 Road: **281.4 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **0.0 ft.** **0.0 ft.**

6.3 Channel Bars: **Side**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **51.87** **ft**
 7.2 Bank Height: **4** **ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	5
Low	High	Low	N.S.	N.S.	N.S.	N.S.	N.S.	Low	N.S.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **JEFFERSONVILLE**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M04**
 SGAT Version: **4.56**
 Date Last Edited: **March, 12 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 1,500 feet upstream of confluence with first tributary; ends just upstream of second tributary.**

1.1 Reach Description:

1.2 Towns: **Cambridge**

1.3 Downstream Latitude: **44.6324822502**
 1.3 Downstream Longitude: **-72.8273652719**

Step 2. Stream Type

2.1 Elevation Upstream: **585**
 2.1 Elevation Downstream: **560**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **1,530.5 ft.** **0.29** Miles
 2.3 Valley Slope: **1.6**
 2.4 Channel Length: **1,606.6 ft.** **0.30** Miles
 2.5 Channel Slope: **1.56 %**
 2.6 Sinuosity: **1.05**
 2.7 Watershed Area: **16.7** Square Miles
 2.8 Channel Width: **45.2** feet
 2.9 Valley Width: **100.0** feet

2.10 Confinement Ratio: **2.2**
 2.10 Confinement Type: **Semi-confined**
 2.11 Reference Stream Type: **B**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **c**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **Multiple**
 3.3 Dominant Geological Mat.: **Glacial Lake** **64.5 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Ext. Steep**
 3.4 Valley Slope Right: **Very Steep**
 3.5 Soils
 Hydrologic Group: **B** **87.8 %**
 Flooding: **None/Rare** **100.0 %**
 Water Table Deep: **6.0** **100.0 %**
 Water Table Shallow: **6.0** **76.7 %**
 Erodibility: **Very Severe** **100.0 %**

7.4 Comments:

The stream section from the downstream reach break to the base of the waterfall is 1015ft long with a slope of approximately 1.5%. This is the dominant condition for the reach and was used to classify the reach in Step 2 as Bc, Riffle-Pool by reference. The waterfall is 350ft of channel length and has an approximate slope of 25%. The short section upstream of the waterfall is 165ft long and has an approximate slope of 1.5%. The overall slope of the entire reach including the waterfall is 5.6%.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **79.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **42.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100** **>100**
 Sub-dominant: **None** **None**
 Length w / less than 25 ft.: **0.0 ft.** **0.0 ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0** **0.0 %**
 5.3 Bank Armoring: **0.0** **0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft.** **0.0**
One Side Both Sides
 Road: **0.0 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **0.0 ft.** **0.0 ft.**

6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Flood Chute**
 6.5 Meander Width: **N/A** Ratio: **0.0**
 6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0** **ft**
 7.2 Bank Height: **No Data** **ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
2	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	5
High	Low	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	N.S.	High	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **JEFFERSONVILLE, MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M05**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins just upstream of second tributary; ends 2,500 feet upstream, just upstream of sharp bend in channel.**

1.1 Reach Description:

1.2 Towns: **Cambridge**

1.3 Downstream Latitude: **44.6291633144**

1.3 Downstream Longitude: **-72.8266875295**

Step 2. Stream Type

2.1 Elevation Upstream: **680**

2.1 Elevation Downstream: **650**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **2,420.5 ft. 0.46 Miles**

2.3 Valley Slope: **1.2**

2.4 Channel Length: **2,553.1 ft. 0.48 Miles**

2.5 Channel Slope: **1.18 %**

2.6 Sinuosity: **1.05**

2.7 Watershed Area: **14.9 Square Miles**

2.8 Channel Width: **43.0 feet**

2.9 Valley Width: **342.0 feet**

2.10 Confinement Ratio: **8.0**

2.10 Confinement Type: **Broad**

2.11 Reference Stream Type: **C**

Bedform: **Riffle-Pool**

Sub-Class Slope: **None**

Bed Material: **Gravel**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**

3.2 Grade Control: **None**

3.3 Dominant Geological Mat.: **Ice-Contact 100.0 %**

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Very Steep**

3.4 Valley Slope Right: **Hilly**

3.5 Soils

Hydrologic Group: **A 100.0 %**

Flooding: **None/Rare 100.0 %**

Water Table Deep: **6.0 100.0 %**

Water Table Shallow: **6.0 100.0 %**

Erodibility: **Very Severe 100.0 %**

7.4 Comments:

Ice/Debris Jam potential indicated by aerial imagery.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 81.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.2 Corridor

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 41.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer

Left Bank Right Bank

Dominant: **>100 >100**

Sub-dominant: **None None**

Length w / less than 25 ft.: **0.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):

Type: **None**

Use:

5.2 Bridges and Culverts: **0 0.0 %**

5.3 Bank Armoring: **0.0 0.0 %**

Left: **0.0 ft.** Right: **0.0 ft.**

5.4 Channel Straightening: **0.0 0.0 %**

5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**

One Side Both Sides

Road: **0.0 ft. 0.0 ft.**

Railroad: **0.0 ft. 0.0 ft.**

Berm: **0.0 ft. 0.0 ft.**

Improved Path: **0.0 ft. 0.0 ft.**

6.2 Development: **0.0 ft. 0.0 ft.**

6.3 Channel Bars: **Point**

6.4 Meander Migration: **Migration**

6.5 Meander Width: **120 ft. Ratio: 2.8**

6.6 Wavelength: **665 ft. Ratio: 15.5**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**

7.2 Bank Height: **No Data ft**

7.3 Ice/Debris Jam Potential: **Bend**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	0	0	0	0	0	0	0	0	1	1	2	1	0	1	9
Low	High	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	N.S.	Low	Low	High	Low	N.S.	Low	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M06**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 2,500 feet upstream of second tributary, just upstream of sharp bend in channel; ends where Brewster comes close to Rt 10, about .3 mile north of Campground Rd.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6237046091**
 1.3 Downstream Longitude: **-72.8227636321**

Step 2. Stream Type

2.1 Elevation Upstream: **730**
 2.1 Elevation Downstream: **680**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **3,859.5 ft. 0.73 Miles**
 2.3 Valley Slope: **1.3**
 2.4 Channel Length: **4,614.7 ft. 0.87 Miles**
 2.5 Channel Slope: **1.08 %**
 2.6 Sinuosity: **1.20**
 2.7 Watershed Area: **14.8 Square Miles**
 2.8 Channel Width: **42.8 feet**
 2.9 Valley Width: **427.5 feet**
 2.10 Confinement Ratio: **10.0**
 2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**

Bedform: **Riffle-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Gravel**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Ice-Contact 51.9 %**
 3.3 Sub-dom. Geological Mat.: **Alluvial**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Steep**
 3.5 Soils
 Hydrologic Group: **A 51.9 %**
 Flooding: **None/Rare 51.9 %**
 Water Table Deep: **6.0 51.9 %**
 Water Table Shallow: **6.0 51.9 %**
 Erodibility: **Severe 51.9 %**

7.4 Comments:

Ice/Debris Jam potential indicated by aerial imagery.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 81.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 20.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100 >100**
 Sub-dominant: **None None**
 Length w / less than 25 ft.: **0.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0 0.0 %**
 5.3 Bank Armoring: **0.0 0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0 0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**
One Side Both Sides
 Road: **0.0 ft. 0.0 ft.**
 Railroad: **0.0 ft. 0.0 ft.**
 Berm: **0.0 ft. 0.0 ft.**
 Improved Path: **0.0 ft. 0.0 ft.**
 6.2 Development: **0.0 ft. 0.0 ft.**

6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Multiple**
 6.5 Meander Width: **300 ft. Ratio: 7.0**
 6.6 Wavelength: **883 ft. Ratio: 20.6**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**
 7.2 Bank Height: **No Data ft**
 7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	0	0	0	0	0	0	0	0	2	2	0	2	0	2	11
Low	High	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	N.S.	High	High	N.S.	High	N.S.	High	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M07**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins where Brewster comes close to Rt 10, about .3 mile north of Campground Rd., ends 150 feet upstream of fourth tributary.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6155806211**
 1.3 Downstream Longitude: **-72.814711547**

Step 2. Stream Type

2.1 Elevation Upstream: **785**
 2.1 Elevation Downstream: **730**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **1,767.5 ft.** **0.33** Miles
 2.3 Valley Slope: **3.1**
 2.4 Channel Length: **1,907.3 ft.** **0.36** Miles
 2.5 Channel Slope: **2.88 %**
 2.6 Sinuosity: **1.08**
 2.7 Watershed Area: **13.2** Square Miles
 2.8 Channel Width: **40.7** feet
 2.9 Valley Width: **321.5** feet
 2.10 Confinement Ratio: **7.9**

2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **b**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial** **60.2 %**
 3.3 Sub-dom. Geological Mat.: **Ice-Contact**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Steep**
 3.5 Soils
 Hydrologic Group: **A** **39.8 %**
 Flooding: **None/Rare** **39.8 %**
 Water Table Deep: **6.0** **75.3 %**
 Water Table Shallow: **6.0** **75.3 %**
 Erodibility: **Moderate** **39.8 %**

7.4 Comments:
Ice/Debris Jam potential indicated by aerial imagery.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **82.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **51.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100** **>100**
 Sub-dominant: **None** **None**
 Length w / less than 25 ft.: **0.0 ft.** **0.0 ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0** **0.0 %**
 5.3 Bank Armoring: **0.0** **0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft.** **0.0**
One Side Both Sides
 Road: **0.0 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **565.3 ft.** **0.0 ft.**

6.3 Channel Bars: **None**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0** **ft**
 7.2 Bank Height: **No Data** **ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
Low	Low	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	High	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M08**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 150 feet upstream of fourth tributary; ends at Edwards Rd bridge.**

1.1 Reach Description:

1.2 Towns: **Cambridge**

1.3 Downstream Latitude: **44.6118046733**

1.3 Downstream Longitude: **-72.8111964187**

Step 2. Stream Type

2.1 Elevation Upstream: **820**

2.1 Elevation Downstream: **785**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **793.5 ft. 0.15 Miles**

2.3 Valley Slope: **4.4**

2.4 Channel Length: **820.3 ft. 0.16 Miles**

2.5 Channel Slope: **4.27 %**

2.6 Sinuosity: **1.03**

2.7 Watershed Area: **11.9 Square Miles**

2.8 Channel Width: **38.9 feet**

2.9 Valley Width: **103.0 feet**

2.10 Confinement Ratio: **2.6**

2.10 Confinement Type: **Semi-confined**

2.11 Reference Stream Type: **B**

Bedform: **Cascade**

Sub-Class Slope: **a**

Bed Material: **Bedrock**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**

3.2 Grade Control: **Waterfall**

3.3 Dominant Geological Mat.: **Ice-Contact 82.4 %**

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Hilly**

3.4 Valley Slope Right: **Steep**

3.5 Soils

Hydrologic Group: **A 82.4 %**

Flooding: **None/Rare 82.4 %**

Water Table Deep: **6.0 91.0 %**

Water Table Shallow: **6.0 91.0 %**

Erodibility: **Very Severe 82.4 %**

7.4 Comments:

Ice/Debris Jam potential indicated by aerial imagery. Rte. 108 is just outside the corridor along the entire reach.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Field**

Current Dominant Land Cover: **Forest 83.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.2 Corridor

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 54.0 %**

Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer Left Bank Right Bank

Dominant: **>100 >100**

Sub-dominant: **26-50 51-100**

Length w / less than 25 ft.: **0.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):

Type: **None**

Use:

5.2 Bridges and Culverts: **1 3.0 %**

5.3 Bank Armoring: **0.0 0.0 %**

Left: **0.0 ft.** Right: **0.0 ft.**

5.4 Channel Straightening: **0.0 0.0 %**

5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**

One Side Both Sides

Road: **0.0 ft. 0.0 ft.**

Railroad: **0.0 ft. 0.0 ft.**

Berm: **0.0 ft. 0.0 ft.**

Improved Path: **0.0 ft. 0.0 ft.**

6.2 Development: **0.0 ft. 0.0 ft.**

6.3 Channel Bars: **None**

6.4 Meander Migration: **None**

6.5 Meander Width: **N/A Ratio: 0.0**

6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**

7.2 Bank Height: **No Data ft**

7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Low	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	N.S.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M09**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins at Edwards Rd bridge; ends just downstream of sixth tributary, about .5 mile north of Rt 108/Edwards Rd intersection.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.6096565169**
 1.3 Downstream Longitude: **-72.8116780226**

Step 2. Stream Type

2.1 Elevation Upstream: **909**
 2.1 Elevation Downstream: **820**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **4,458.5 ft. 0.84 Miles**
 2.3 Valley Slope: **2.0**
 2.4 Channel Length: **4,841.4 ft. 0.92 Miles**
 2.5 Channel Slope: **1.84 %**
 2.6 Sinuosity: **1.09**
 2.7 Watershed Area: **11.8 Square Miles**
 2.8 Channel Width: **38.8 feet**
 2.9 Valley Width: **347.0 feet**
 2.10 Confinement Ratio: **8.9**
 2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial 68.6 %**
 3.3 Sub-dom. Geological Mat.: **Ice-Contact**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Hilly**
 3.5 Soils
 Hydrologic Group: **Not Rated 68.6 %**
 Flooding: **Frequent 68.6 %**
 Water Table Deep: **6.0 31.4 %**
 Water Table Shallow: **6.0 29.1 %**
 Erodibility: **slight 5.1 %**

7.4 Comments:

NULL

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 83.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 36.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100 >100**
 Sub-dominant: **26-50 None**
 Length w / less than 25 ft.: **0.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0 0.0 %**
 5.3 Bank Armoring: **0.0 0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0 0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **418.6 ft. 8.6**
One Side Both Sides
 Road: **418.6 ft. 0.0 ft.**
 Railroad: **0.0 ft. 0.0 ft.**
 Berm: **0.0 ft. 0.0 ft.**
 Improved Path: **0.0 ft. 0.0 ft.**
 6.2 Development: **459.0 ft. 0.0 ft.**

6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Migration**
 6.5 Meander Width: **38 ft. Ratio: 1.0**
 6.6 Wavelength: **38 ft. Ratio: 1.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**
 7.2 Bank Height: **No Data ft**
 7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	0	0	0	0	0	0	1	1	2	2	2	2	0	1	14
Low	High	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Low	Low	High	High	High	High	N.S.	Low	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M10**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins just downstream of sixth tributary, about .5 mile north of Rt 108/Edwards Rd intersection; ends 100 feet downstream of Edwards Rd bridge.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.5983506445**
 1.3 Downstream Longitude: **-72.8062136888**

Step 2. Stream Type

2.1 Elevation Upstream: **965**
 2.1 Elevation Downstream: **909**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **2,476.5 ft.** **0.47 Miles**
 2.3 Valley Slope: **2.3**
 2.4 Channel Length: **2,517.5 ft.** **0.48 Miles**
 2.5 Channel Slope: **2.22 %**
 2.6 Sinuosity: **1.02**
 2.7 Watershed Area: **10.5 Square Miles**
 2.8 Channel Width: **36.9 feet**
 2.9 Valley Width: **277.0 feet**
 2.10 Confinement Ratio: **7.5**

2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **b**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial 87.7 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Ext. Steep**
 3.4 Valley Slope Right: **Steep**
 3.5 Soils
 Hydrologic Group: **Not Rated 87.7 %**
 Flooding: **Frequent 87.7 %**
 Water Table Deep: **2.5 10.4 %**
 Water Table Shallow: **1.5 10.4 %**
 Erodibility: **slight 11.3 %**

7.4 Comments:
Ice/Debris Jam potential indicated by aerial imagery.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 86.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 36.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer **Left Bank Right Bank**
 Dominant: **51-100 >100**
 Sub-dominant: **26-50 None**
 Length w / less than 25 ft.: **738.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0 0.0 %**
 5.3 Bank Armoring: **0.0 0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0 0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **2,445.3 ft. 97.1**
One Side Both Sides
 Road: **2,445.3 ft. 0.0 ft.**
 Railroad: **0.0 ft. 0.0 ft.**
 Berm: **0.0 ft. 0.0 ft.**
 Improved Path: **0.0 ft. 0.0 ft.**
 6.2 Development: **0.0 ft. 0.0 ft.**

6.3 Channel Bars: **Side**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**
 7.2 Bank Height: **No Data ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	2	0	0	0	0	0	2	0	1	0	0	0	0	0	8
Low	High	High	N.S.	N.S.	N.S.	N.S.	N.S.	High	N.S.	Low	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M11**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 100 feet downstream of Edwards Rd bridge; ends just upstream of seventh tributary entering at Noth View Rd.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.5943153104**
 1.3 Downstream Longitude: **-72.7990912774**

Step 2. Stream Type

2.1 Elevation Upstream: **995**
 2.1 Elevation Downstream: **965**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **1,409.5 ft.** **0.27** Miles
 2.3 Valley Slope: **2.1**
 2.4 Channel Length: **1,616.6 ft.** **0.31** Miles
 2.5 Channel Slope: **1.86 %**
 2.6 Sinuosity: **1.15**
 2.7 Watershed Area: **8.5** Square Miles
 2.8 Channel Width: **33.7** feet
 2.9 Valley Width: **436.0** feet
 2.10 Confinement Ratio: **12.9**
 2.10 Confinement Type: **Very Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial** **62.3 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Flat**
 3.4 Valley Slope Right: **Steep**
 3.5 Soils
 Hydrologic Group: **Not Rated** **62.3 %**
 Flooding: **Frequent** **62.3 %**
 Water Table Deep: **6.0** **19.3 %**
 Water Table Shallow: **6.0** **19.3 %**
 Erodibility: **Moderate** **37.7 %**

7.4 Comments:
Ice/Debris Jam potential indicated by aerial imagery.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **85.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest** **27.0 %**
 Current Sub-Dominant Land Cover: **Urban**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100** **>100**
 Sub-dominant: **26-50** **None**
 Length w / less than 25 ft.: **99.0 ft.** **0.0 ft.**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **1** **18.6 %**
 5.3 Bank Armoring: **0.0** **0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **893.7 ft.** **55.3**
One Side Both Sides
 Road: **893.7 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **53.7 ft.** **0.0 ft.**

6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Multiple**
 6.5 Meander Width: **N/A** Ratio: **0.0**
 6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **159.58** **ft**
 7.2 Bank Height: **7** **ft**
 7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	1	0	1	0	0	0	2	0	2	2	0	0	1	2	14
Low	High	Low	N.S.	Low	N.S.	N.S.	N.S.	High	N.S.	High	High	N/A	N/A	Low	High	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M12**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins just upstream of seventh tributary entering at Notch View Rd; ends 300 feet upstream of the ninth tributary, 230 feet northwest of parking area on Hakone Dr.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.5925752272**
 1.3 Downstream Longitude: **-72.7942653232**

Step 2. Stream Type

2.1 Elevation Upstream: **1,060**
 2.1 Elevation Downstream: **995**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **2,162.5 ft. 0.41 Miles**
 2.3 Valley Slope: **3.0**
 2.4 Channel Length: **2,374.2 ft. 0.45 Miles**
 2.5 Channel Slope: **2.74 %**
 2.6 Sinuosity: **1.10**
 2.7 Watershed Area: **3.1 Square Miles**
 2.8 Channel Width: **21.5 feet**
 2.9 Valley Width: **200.0 feet**
 2.10 Confinement Ratio: **9.3**
 2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **b**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial 68.7 %**
 3.3 Sub-dom. Geological Mat.: **Ice-Contact**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **Not Rated 68.7 %**
 Flooding: **Frequent 68.7 %**
 Water Table Deep: **6.0 31.3 %**
 Water Table Shallow: **6.0 30.6 %**
 Erodibility: **Moderate 31.3 %**

7.4 Comments: **Dredging noted in Step 5 is associated with the berm observed during the windshield survey.**

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 88.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 46.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer **Left Bank Right Bank**
 Dominant: **26-50 26-50**
 Sub-dominant: **51-100 >100**
 Length w / less than 25 ft.: **155.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **3 6.7 %**
 5.3 Bank Armoring: **93.3 3.9 %**
 Left: **93.3 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0 0.0 %**
 5.5 Dredging History: **Dredging**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **1,552.2 ft. 65.4**
One Side Both Sides
 Road: **0.0 ft. 0.0 ft.**
 Railroad: **0.0 ft. 0.0 ft.**
 Berm: **117.1 ft. 0.0 ft.**
 Improved Path: **478.0 ft. 957.0 ft.**
 6.2 Development: **643.9 ft. 0.0 ft.**

6.3 Channel Bars: **None**
 6.4 Meander Migration: **Multiple**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**
 7.2 Bank Height: **No Data ft**
 7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	1	0	1	0	0	2	2	2	0	1	0	0	0	1	13
Low	High	Low	N.S.	Low	N.S.	N.S.	High	High	High	N.S.	Low	N/A	N/A	N.S.	Low	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M13**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 300 feet upstream of the ninth tributary, 230 feet northwest of parking area on Hakone Dr.; ends 240 feet from Mountain View Dr., directly north of Nordland Dr.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.590755888**
 1.3 Downstream Longitude: **-72.7863911777**

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 88.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 60.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **51-100** **>100**
 Sub-dominant: **26-50** **None**
 Length w / less than 25 ft.: **0.0 ft.** **0.0 ft.**

Step 2. Stream Type

2.1 Elevation Upstream: **1,080**
 2.1 Elevation Downstream: **1,060**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **686.5 ft.** **0.13** Miles
 2.3 Valley Slope: **2.9**
 2.4 Channel Length: **697.5 ft.** **0.13** Miles
 2.5 Channel Slope: **2.87 %**
 2.6 Sinuosity: **1.02**
 2.7 Watershed Area: **2.2** Square Miles
 2.8 Channel Width: **18.5** feet
 2.9 Valley Width: **150.0** feet
 2.10 Confinement Ratio: **8.1**
 2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **B**
 Bedform: **Step-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Cobble**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **None**
 Use:
 5.2 Bridges and Culverts: **0** **0.0 %**
 5.3 Bank Armoring: **0.0** **0.0 %**
 Left: **0.0 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geological Mat.: **Alluvial 67.8 %**
 3.3 Sub-dom. Geological Mat.: **Till**
 3.4 Valley Slope Left: **Hilly**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **Not Rated 67.8 %**
 Flooding: **Frequent 67.8 %**
 Water Table Deep: **6.0 32.2 %**
 Water Table Shallow: **2.0 32.2 %**
 Erodibility: **Moderate 32.2 %**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **692.8 ft.** **99.3**
One Side Both Sides
 Road: **0.0 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **0.0 ft.** **0.0 ft.**
 Improved Path: **692.8 ft.** **0.0 ft.**
 6.2 Development: **0.0 ft.** **0.0 ft.**
 6.3 Channel Bars: **None**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

7.4 Comments:

NULL

Step 7. Windshield Survey

7.1 Bank Erosion: **0** **ft**
 7.2 Bank Height: **No Data** **ft**
 7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4
Low	Low	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	High	N.S.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M14**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins 240 feet from Mountain View Dr., directly north of Nordland Dr.; ends at dam.**

1.1 Reach Description:

1.2 Towns: **Cambridge**

1.3 Downstream Latitude: **44.5902268301**

1.3 Downstream Longitude: **-72.7842814618**

Step 2. Stream Type

2.1 Elevation Upstream: **1,227**

2.1 Elevation Downstream: **1,080**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **2,370.5 ft. 0.45 Miles**

2.3 Valley Slope: **6.2**

2.4 Channel Length: **2,570.0 ft. 0.49 Miles**

2.5 Channel Slope: **5.72 %**

2.6 Sinuosity: **1.08**

2.7 Watershed Area: **2.2 Square Miles**

2.8 Channel Width: **28.0 feet**

2.9 Valley Width: **140.0 feet**

2.10 Confinement Ratio: **5.0**

2.10 Confinement Type: **Narrow**

2.11 Reference Stream Type: **B**

Bedform: **Step-Pool**

Sub-Class Slope: **a**

Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**

3.2 Grade Control: **Dam**

3.3 Dominant Geological Mat.: **Till 75.3 %**

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Ext. Steep**

3.4 Valley Slope Right: **Ext. Steep**

3.5 Soils

Hydrologic Group: **B 75.3 %**

Flooding: **None/Rare 75.3 %**

Water Table Deep: **6.0 75.3 %**

Water Table Shallow: **2.0 75.3 %**

Erodibility: **Very Severe 75.3 %**

7.4 Comments:

Flow regulation noted in Step 5 is the water withdrawal impoundment and pond used for snow-making. Dredging noted in Step 5 is associated with the berm observed during the windshield survey.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 89.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.2 Corridor

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 51.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer Left Bank Right Bank

Dominant: **26-50 >100**

Sub-dominant: **51-100 >100**

Length w / less than 25 ft.: **0.0 ft. 0.0 ft.**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):

Type: **Large Withdrawal**

Use: **Recreation**

5.2 Bridges and Culverts: **2 5.8 %**

5.3 Bank Armoring: **0.0 0.0 %**

Left: **0.0 ft.** Right: **0.0 ft.**

5.4 Channel Straightening: **0.0 0.0 %**

5.5 Dredging History: **Dredging**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **2,714.2 ft. 105.6**

One Side Both Sides

Road: **0.0 ft. 0.0 ft.**

Railroad: **0.0 ft. 0.0 ft.**

Berm: **207.3 ft. 0.0 ft.**

Improved Path: **2,506.9 ft. 0.0 ft.**

6.2 Development: **116.2 ft. 0.0 ft.**

6.3 Channel Bars: **None**

6.4 Meander Migration: **None**

6.5 Meander Width: **N/A Ratio: 0.0**

6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**

7.2 Bank Height: **No Data ft**

7.3 Ice/Debris Jam Potential: **None**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	1	0	2	1	0	0	2	2	0	0	0	0	0	0	0	9
Low	Low	N.S.	High	Low	N.S.	N.S.	High	High	N.S.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M16**
 SGAT Version: **4.56**
 Date Last Edited: **February, 28 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins at reservoir inlet just west of Mt Mansfield State Forest boundary, ends .53 miles upstream.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.590343926**
 1.3 Downstream Longitude: **-72.7744181349**

Step 2. Stream Type
 2.1 Elevation Upstream: **1,400**
 2.1 Elevation Downstream: **1,240**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **2,603.5 ft. 0.49 Miles**
 2.3 Valley Slope: **6.1**
 2.4 Channel Length: **2,797.8 ft. 0.53 Miles**
 2.5 Channel Slope: **5.72 %**
 2.6 Sinuosity: **1.07**
 2.7 Watershed Area: **1.9 Square Miles**
 2.8 Channel Width: **17.4 feet**
 2.9 Valley Width: **50.0 feet**
 2.10 Confinement Ratio: **2.9**
 2.10 Confinement Type: **Semi-confined**
 2.11 Reference Stream Type: **A**
 Bedform: **Step-Pool**
 Sub-Class Slope: **None**
 Bed Material: **Boulder**

Step 3. Basin Characteristics
 3.1 Alluvial Fan:
 3.2 Grade Control:
 3.3 Dominant Geological Mat.: **Till 100.0 %**
 3.3 Sub-dom. Geological Mat.: **Alluvial**
 3.4 Valley Slope Left: **Ext. Steep**
 3.4 Valley Slope Right: **Ext. Steep**
 3.5 Soils
 Hydrologic Group: **B 85.9 %**
 Flooding: **None/Rare 100.0 %**
 Water Table Deep: **6.0 100.0 %**
 Water Table Shallow: **2.0 85.9 %**
 Erodibility: **Very Severe 100.0 %**

7.4 Comments:

NULL

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 91.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 68.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **>100 >100**
 Sub-dominant: **None None**
 Length w / less than 25 ft.: **ft. ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
 Type:
 Use:
 5.2 Bridges and Culverts: **0 0.0 %**
 5.3 Bank Armoring: **0.0 0.0 %**
 Left: **ft. Right: ft.**
 5.4 Channel Straightening: **0.0 %**
 5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**
One Side Both Sides
 Road: **ft. ft.**
 Railroad: **ft. ft.**
 Berm: **ft. ft.**
 Improved Path: **ft. ft.**
 6.2 Development: **ft. ft.**

6.3 Channel Bars: **None**
 6.4 Meander Migration: **None**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**
 7.2 Bank Height: **0 ft**
 7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.S.	N.S.	N.D.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	Unk.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	0

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M17**
 SGAT Version: **4.56**
 Date Last Edited: **February, 28 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins .53 miles upstream of reservoir; ends .36 miles upstream.**

1.1 Reach Description:

1.2 Towns: **Cambridge**

1.3 Downstream Latitude: **44.5913600851**

1.3 Downstream Longitude: **-72.7645700088**

Step 2. Stream Type

2.1 Elevation Upstream: **1,715**

2.1 Elevation Downstream: **1,400**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **1,796.5 ft. 0.34 Miles**

2.3 Valley Slope: **17.5**

2.4 Channel Length: **1,916.8 ft. 0.36 Miles**

2.5 Channel Slope: **16.43 %**

2.6 Sinuosity: **1.07**

2.7 Watershed Area: **0.7 Square Miles**

2.8 Channel Width: **11.5 feet**

2.9 Valley Width: **25.0 feet**

2.10 Confinement Ratio: **2.2**

2.10 Confinement Type: **Semi-confined**

2.11 Reference Stream Type: **A**

Bedform: **Cascade**

Sub-Class Slope: **None**

Bed Material: **Bedrock**

Step 3. Basin Characteristics

3.1 Alluvial Fan:

3.2 Grade Control:

3.3 Dominant Geological Mat.: **Till 100.0 %**

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Ext. Steep**

3.4 Valley Slope Right: **Ext. Steep**

3.5 Soils

Hydrologic Group: **C 73.6 %**

Flooding: **None/Rare 100.0 %**

Water Table Deep: **6.0 100.0 %**

Water Table Shallow: **6.0 73.6 %**

Erodibility: **Very Severe 100.0 %**

7.4 Comments:

NULL

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 92.0 %**

Current Sub-Dominant Land Cover: **Field**

4.2 Corridor

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 67.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer Left Bank Right Bank

Dominant: **>100 >100**

Sub-dominant: **None None**

Length w / less than 25 ft.: **ft. ft.**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**

Type:

Use:

5.2 Bridges and Culverts: **0 0.0 %**

5.3 Bank Armoring: **0.0 0.0 %**

Left: **ft. Right: ft.**

5.4 Channel Straightening: **0.0 %**

5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**

One Side Both Sides

Road: **ft. ft.**

Railroad: **ft. ft.**

Berm: **ft. ft.**

Improved Path: **ft. ft.**

6.2 Development: **ft. ft.**

6.3 Channel Bars: **None**

6.4 Meander Migration: **None**

6.5 Meander Width: **N/A Ratio: 0.0**

6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**

7.2 Bank Height: **0 ft**

7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.S.	N.S.	N.D.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	Unk.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Brewster River**
 Topo Maps: **MOUNT MANSFIELD, WHITEFACE MOUNTAIN**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **M18**
 SGAT Version: **4.56**
 Date Last Edited: **February, 28 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins .9 miles upstream form reservoir; ends .6 miles upstream.**

1.1 Reach Description:

1.2 Towns: **Cambridge, Morristown**

1.3 Downstream Latitude: **44.5924345411**

1.3 Downstream Longitude: **-72.7578665593**

Step 2. Stream Type

2.1 Elevation Upstream: **2,540**

2.1 Elevation Downstream: **1,715**

2.1 Is Gradient Gentle?: **No**

2.2 Valley Length: **3,035.5 ft. 0.57 Miles**

2.3 Valley Slope: **27.2**

2.4 Channel Length: **3,219.5 ft. 0.61 Miles**

2.5 Channel Slope: **25.63 %**

2.6 Sinuosity: **1.06**

2.7 Watershed Area: **0.6 Square Miles**

2.8 Channel Width: **10.2 feet**

2.9 Valley Width: **20.0 feet**

2.10 Confinement Ratio: **2.0**

2.10 Confinement Type: **Narrowly Confined**

2.11 Reference Stream Type: **A**

Bedform: **Cascade**

Sub-Class Slope: **None**

Bed Material: **Bedrock**

Step 3. Basin Characteristics

3.1 Alluvial Fan:

3.2 Grade Control:

3.3 Dominant Geological Mat.: **Till 100.0 %**

3.3 Sub-dom. Geological Mat.: **Alluvial**

3.4 Valley Slope Left: **Ext. Steep**

3.4 Valley Slope Right: **Ext. Steep**

3.5 Soils

Hydrologic Group: **C 56.6 %**

Flooding: **None/Rare 100.0 %**

Water Table Deep: **6.0 100.0 %**

Water Table Shallow: **6.0 89.5 %**

Erodibility: **Very Severe 100.0 %**

7.4 Comments:

NULL

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 91.0 %**

Current Sub-Dominant Land Cover: **Field**

4.2 Corridor

Historic Land Cover: **Forest**

Current Dominant Land Cover: **Forest 68.0 %**

Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer Left Bank Right Bank

Dominant: **>100 >100**

Sub-dominant: **None None**

Length w / less than 25 ft.: **ft. ft.**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**

Type:

Use:

5.2 Bridges and Culverts: **0 0.0 %**

5.3 Bank Armoring: **0.0 0.0 %**

Left: **ft. Right: ft.**

5.4 Channel Straightening: **0.0 %**

5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **0.0 ft. 0.0**

One Side Both Sides

Road: **ft. ft.**

Railroad: **ft. ft.**

Berm: **ft. ft.**

Improved Path: **ft. ft.**

6.2 Development: **ft. ft.**

6.3 Channel Bars: **None**

6.4 Meander Migration: **None**

6.5 Meander Width: **N/A Ratio: 0.0**

6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0 ft**

7.2 Bank Height: **0 ft**

7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.S.	N.S.	N.D.	N.S.	N.S.	N.S.	N.S.	N.S.	Unk.	Unk.	N.S.	N.S.	N/A	N/A	N.S.	N.S.	

Brewster River

Basin: **Lamoille**
 Stream Name: **Seventh tributary to Brewster River**
 Topo Maps: **MOUNT MANSFIELD**
 Watershed: **Lamoille River**
 Sub-watershed: **Lamoille River -- Gihon River to mouth**

Phase 1 - Reach Summary Report

Reach ID: **T7.01**
 SGAT Version: **4.56**
 Date Last Edited: **March, 07 2013**
 QA Status: **No checks are complete**
 Is Reach An Impoundment?: **No**

Step 1. Reach Location **Begins at M12 by Notch View Rd; runs parallel to Rt 108 and Old 108 Loop. then crosses Rt 108 and runs parallel to Desjardins Rd; ends 90 feet downstream of Desjardins Rd bridge.**

1.1 Reach Description:
 1.2 Towns: **Cambridge**
 1.3 Downstream Latitude: **44.5921513724**
 1.3 Downstream Longitude: **-72.7942826434**

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Forest 82.0 %**
 Current Sub-Dominant Land Cover: **Crop**
 4.2 Corridor
 Historic Land Cover: **Forest**
 Current Dominant Land Cover: **Crop 24.0 %**
 Current Sub-Dominant Land Cover: **Urban**
 4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **0-25** **51-100**
 Sub-dominant: **51-100** **0-25**
 Length w / less than 25 ft.: **826.0 ft.** **0.0 ft.**

Step 2. Stream Type

2.1 Elevation Upstream: **1,090**
 2.1 Elevation Downstream: **1,000**
 2.1 Is Gradient Gentle?: **No**
 2.2 Valley Length: **2,585.5 ft.** **0.49** Miles
 2.3 Valley Slope: **3.5**
 2.4 Channel Length: **3,074.8 ft.** **0.58** Miles
 2.5 Channel Slope: **2.93 %**
 2.6 Sinuosity: **1.19**
 2.7 Watershed Area: **4.9** Square Miles
 2.8 Channel Width: **26.3** feet
 2.9 Valley Width: **290.0** feet

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):
 Type: **Small Run of River**
 Use: **Other**
 5.2 Bridges and Culverts: **2** **6.5 %**
 5.3 Bank Armoring: **259.3** **8.4 %**
 Left: **259.3 ft.** Right: **0.0 ft.**
 5.4 Channel Straightening: **0.0** **0.0 %**
 5.5 Dredging History: **None**

2.10 Confinement Ratio: **11.0**
 2.10 Confinement Type: **Very Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-Class Slope: **b**
 Bed Material: **Cobble**

Step 3. Basin Characteristics

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **Dam**
 3.3 Dominant Geological Mat.: **Ice-Contact 57.7 %**
 3.3 Sub-dom. Geological Mat.: **Alluvial**
 3.4 Valley Slope Left: **Steep**
 3.4 Valley Slope Right: **Hilly**
 3.5 Soils
 Hydrologic Group: **A 55.3 %**
 Flooding: **None/Rare 57.7 %**
 Water Table Deep: **6.0 57.7 %**
 Water Table Shallow: **6.0 57.7 %**
 Erodibility: **Severe 57.7 %**

Step 6. Floodplain Modifications

6.1 Berms & Roads - old: **2,701.6 ft.** **87.9**
One Side Both Sides
 Road: **2,319.4 ft.** **0.0 ft.**
 Railroad: **0.0 ft.** **0.0 ft.**
 Berm: **382.3 ft.** **0.0 ft.**
 Improved Path: **0.0 ft.** **0.0 ft.**
 6.2 Development: **605.8 ft.** **599.6 ft.**

Dam noted in step 5 is Morse's Mill. No information obtained about this mill.

6.3 Channel Bars: **Mid-channel**
 6.4 Meander Migration: **Flood Chute**
 6.5 Meander Width: **N/A Ratio: 0.0**
 6.6 Wavelength: **N/A Ratio: 0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0** **ft**
 7.2 Bank Height: **No Data** **ft**
 7.3 Ice/Debris Jam Potential: **Bridge**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.3	Total
1	2	2	1	1	1	0	0	2	2	1	1	0	0	1	1	16
Low	High	High	Low	Low	Low	N.S.	N.S.	High	High	Low	Low	N/A	N/A	Low	Low	

APPENDIX B

Phase 2 Segment Summary Reports



Phase 2 Segment Summary Report Brewster River

Stream:	Brewster River	SGAT Version:	4.56
Reach:	M01-A	Organization:	Fitzgerald Environmental
Segment Length(ft):	2,860	Observers:	JHB, SPP; FEA
Rain:	Yes	Completion Date:	12/6/2012
		Quality Control Status - Consultant:	Provisional
		Quality Control Status - Staff:	Provisional

- Step 0 - Location: **From confluence with Lamoille River to increase in confinement ~400' upstream of schoolbus parking area and 800' upstream of largest mass failure**
- Step 5 - Notes: **Large depositional feature upstream of Rt15 crossing w/ sizable aggradation of coarse pebbles and cobbles. Erosion on upstream LB that is a threat to power line and underground utilities. Source of excess sediment is likely the MF on the upstream right valley wall at bend. The large MF feature W>300' H~150' has undergone several restorations. A floodplain bench on LB across from MF site likely attenuates some flood flow, but did not expand the floodprone width substantially to restore attenuation potential to likely reference geometry of C-type.**
- Step 7 - Narrative: **Stream type departure from C to B. Entrenchment ratio is greater than 1.4 due to remediation effort to reshape banks at cross-section location. However, portions of the segment, particularly downstream near Rt. 15, are more entrenched with F-type geometry (entrenchment ratios <1.2).**

Step 1. Valley and Floodplain

1.1 Segmentation: Channel Dimensions	1.4 Adjacent Side	<u>Left</u>	<u>Right</u>	1.5 Valley Features
1.2 Alluvial Fan: None	Hillside Slope:	Flat	Extr.Steep	Valley Width (ft): 520
1.3 Corridor Encroachments:	Continuous w/ Bank:	Never	Sometimes	Width Determination: Estimated
<u>Length (ft)</u> <u>One</u> <u>Height</u> <u>Both</u> <u>Height</u>	Within 1 Bankfull W:	Never	Sometimes	Confinement Type: VB
Berm: 0 0	Texture:	Sand	Sand	In Rock Gorge: No
Road: 0 0				Human Caused Change in Valley Width?: No
Railroad: 0 0				
Imp. Path: 0 0				
Dev.: 507 0				

1.6 Grade Controls:



Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River** Reach: **M01-A**

Step 2. Stream Channel

2.1 Bankfull Width (ft.):	62.40	2.11 Riffle/Step Spacing:	350 ft.	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	3.55	2.12 Substrate Composition		Bed:	180 mm
2.3 Mean Depth (ft):	2.63	Bedrock:	0.0 %	Bar:	120 mm
2.4 Floodprone Width (ft.):	110.00	Boulder:	1.0 %	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	6.15	Cobble:	35.0 %	Stream Type:	B
Human Elev FloodPln (ft.):		Coarse Gravel:	32.0 %	Bed Material:	Gravel
2.6 Width/Depth Ratio:	23.73	Fine Gravel:	19.0 %	Subclass Slope:	c
2.7 Entrenchment Ratio:	1.76	Sand:	12.0 %	Bed Form:	Plane Bed
2.8 Incision Ratio:	1.73	Silt and Smaller:	1.0 %	Field Measured Slope:	
Human Elevated Inc. Rat.:	0.00	Silt/Clay Present:	No	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	Low	Detritus:	5.0 %	Reference Stream Type:	
2.10 Riffles Type:	Sedimented	# Large Woody Debris:	12	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks			Typical Bank Slope:	Steep				
Bank Texture			Bank Erosion	<u>Left</u>	<u>Right</u>	Near Bank Vegetation Type	<u>Left</u>	<u>Right</u>
Upper	<u>Left</u>	<u>Right</u>	Erosion Length (ft.):	366.8	464.6	Dominant:	Shrubs/Sapling	Herbaceous
Material Type:	Sand	Sand	Erosion Height (ft.):	6.4	5.3	Sub-dominant:	Herbaceous	Deciduous
Consistency:	Non-cohesive	Non-cohesive	Revetment Type:	Rip-Rap	Rip-Rap	Bank Canopy		
Lower			Revetment Length:	165.6	783.7	Canopy %:	1-25	26-50
Material Type:	Gravel	Gravel				Mid-Channel Canopy:	Open	
Consistency:	Non-cohesive	Non-cohesive						

3.2 Riparian Buffer

Buffer Width	<u>Left</u>	<u>Right</u>
Dominant	26-50	>100
Sub-Dominant	0-25	0-25
W less than 25	385	0
Buffer Vegetation Type		
Dominant	Herbaceous	Deciduous
Sub-Dominant	Shrubs/Sapling	Shrubs/Sapling

3.3 Riparian Corridor

Corridor Land	<u>Left</u>	<u>Right</u>	Mass Failures	<u>Left</u>	<u>Right</u>
Dominant	Commercial	Forest	Height		512.82
Sub-dominant	Residential	Pasture	Gullies Number	0	121.4
(Legacy)	<u>Amount</u>	<u>Mean Hieght</u>	Gullies Length	0	
Failures	Multiple	95.0			
Gullies	None				



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M01-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: Minimal	4.5 Flow Regulation Type None	4.7 Stormwater Inputs
4.2 Adjacent Wetlands: Minimal	Flow Reg. Use:	Field Ditch: 0 Road Ditch: 0
4.3 Flow Status: Moderate	Impoundments:	Other: 0 Tile Drain: 0
4.4 # of Debris Jams: 1	Impoundment Loc.:	Overland Flow: 0 Urb Strm Wtr Pipe: 2
	4.6 Up/Down Strm flow reg.: None	4.9 # of Beaver Dams: 0
	(old) Upstrm Flow Reg.: None	Affected Length (ft): 0

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	48	Yes	Yes	Yes	Yes	Deposition Above, Scour Above, Scour Below
Bridge	110	Yes	Yes	No	Yes	Deposition Above, Deposition Below, Alignment

Step 5. Channel Bed and Planform Changes

5.1 Bar Types Diagonal: 0	5.2 Other Features Neck Cutoff: 0	5.4 Stream Ford or Animal Crossing: Yes
Mid: 2 Delta: 0	Flood chutes: 0	Avulsion: 0
Point: 3 Island: 0	5.3 Steep Riffles and Head Cuts Head Cuts: 0	Straightening: Straightening
Side: 0 Braiding: 0	Steep Riffles: 2	Trib Rejuv.: No
		Straightening Length (ft.): 936
		5.5 Dredging: None

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	6.4 Sediment Deposition:	Stream Gradient Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	6.5 Channel Flow Status:	6.8 Bank Stability:		
6.3 Pool Variability:	6.6 Channel Alteration:	6.9 Bank Vegetation Protection		
Total Score: 0	6.7 Channel Sinuosity:	6.10 Riparian Veg. Zone Width:		
Habitat Rating: 0.00				
Habitat Stream Condition:				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Unconfined	Score	STD	Historic		
7.1 Channel Degradation		8	C to B	Yes	Geomorphic Rating	0.36
7.2 Channel Aggradation		8	None	No	Channel Evolution Model	F
7.3 Widening Channel		6	None	No	Channel Evolution Stage	III
7.4 Change in Planform		7	None	No	Geomorphic Condition	Fair
Total Score		29			Stream Sensitivity	Very High



Phase 2 Segment Summary Report Brewster River

Stream:	Brewster River	SGAT Version:	4.56
Reach:	M01-B	Organization:	Fitzgerald Environmental
Segment Length(ft):	781	Observers:	JHB, SPP; FEA
Rain:	Yes	Completion Date:	12/6/2012
		Quality Control Status - Consultant:	Provisional
		Quality Control Status - Staff:	Provisional

Step 0 - Location: **From segment break at upstream baseball field to reach break 20' upstream of private bridge to house behind green mountain troutfitters**

Step 5 - Notes: **This reach is situated in a naturally entrenched valley and transitional zone, and therefore is considered a Bc sub-reach. It did not appear to us that any floodplain benches of this B-type stream were significantly filled on the west (left) bank that would change the entrenchment ratio (ER). Our cross-section is representative of the reach. Based on field notes, the ER varies between 1.3 and 1.5 in this transitional area and doesn't appear to be severely manipulated. A true floodplain was not observed, and incision ratio was based on a shallow-sloped bench just above bankfull on the right bank in the cross-section.**

Step 7 - Narrative: **Episodic flood events have caused minor channel widening. The entrenchment ratio is lower than is would be naturally due to the widening of bankfull channel.**

Step 1. Valley and Floodplain

1.1 Segmentation:	Channel Dimensions	1.4 Adjacent Side	<u>Left</u>	<u>Right</u>	1.5 Valley Features
1.2 Alluvial Fan:	None	Hillside Slope:	Flat	Extr.Steep	Valley Width (ft): 120
1.3 Corridor Encroachments:		Continuous w/ Bank:	Sometimes	Sometimes	Width Determination: Measured
<u>Length (ft)</u>	<u>One</u>	<u>Height</u>	<u>Both</u>	<u>Height</u>	Within 1 Bankfull W: Sometimes
Berm:	0		0		Texture: Sand
Road:	0		0		Sand
Railroad:	0		0		In Rock Gorge: No
Imp. Path:	0		0		Human Caused Change in Valley Width?: No
Dev.:	241		0		

1.6 Grade Controls:



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River** Reach: **M01-B**

Step 2. Stream Channel

2.1 Bankfull Width (ft.):	58.10	2.11 Riffle/Step Spacing:	110 ft.	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	3.60	2.12 Substrate Composition		Bed:	300 mm
2.3 Mean Depth (ft.):	2.44	Bedrock:	0.0 %	Bar:	N/A mm
2.4 Floodprone Width (ft.):	78.00	Boulder:	16.0 %	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	4.60	Cobble:	31.0 %	Stream Type:	B
Human Elev FloodPln (ft.):		Coarse Gravel:	29.0 %	Bed Material:	Gravel
2.6 Width/Depth Ratio:	23.81	Fine Gravel:	17.0 %	Subclass Slope:	c
2.7 Entrenchment Ratio:	1.34	Sand:	6.0 %	Bed Form:	Plane Bed
2.8 Incision Ratio:	1.28	Silt and Smaller:	1.0 %	Field Measured Slope:	
Human Elevated Inc. Rat.:	0.00	Silt/Clay Present:	No	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	Low	Detritus:	5.0 %	Reference Stream Type:	B
2.10 Riffles Type:	Sedimented	# Large Woody Debris:	19	Reference Bed Material:	Gravel
				Reference Subclass Slope:	c
				Reference Bedform:	Riffle-Pool

Step 3. Riparian Features

3.1 Stream Banks			Typical Bank Slope:	Moderate				
Bank Texture			Bank Erosion	<u>Left</u>	<u>Right</u>	Near Bank Vegetation Type	<u>Left</u>	<u>Right</u>
Upper	<u>Left</u>	<u>Right</u>	Erosion Length (ft.):	0.0	0.0	Dominant:	Herbaceous	Herbaceous
Material Type:	Gravel	Gravel	Erosion Height (ft.):	0.0	0.0	Sub-dominant:	Deciduous	Coniferous
Consistency:	Non-cohesive	Non-cohesive	Revetment Type:	Rip-Rap	None	Bank Canopy		
Lower			Revetment Length:	422.6	0.0	Canopy %:	51-75	76-100
Material Type:	Boulder/Cobbles	Boulder/Cobbles				Mid-Channel Canopy:	Closed	
Consistency:	Non-cohesive	Non-cohesive						

3.2 Riparian Buffer

Buffer Width	<u>Left</u>	<u>Right</u>	Corridor Land
Dominant	0-25	26-50	Dominant
Sub-Dominant	26-50	>100	Sub-dominant
W less than 25	340	0	(Legacy)
Buffer Vegetation Type			Failures
Dominant	Invasives	Coniferous	Gullies
Sub-Dominant	Shrubs/Sapling	Herbaceous	

3.3 Riparian Corridor

	<u>Left</u>	<u>Right</u>		<u>Left</u>	<u>Right</u>
Dominant	Commercial	Pasture	Mass Failures		
Sub-Dominant	None	Forest	Height		
W less than 25	<u>Amount</u>	<u>Mean Hieght</u>	Gullies Number	0	
Buffer Vegetation Type			Gullies Length	0	
Dominant	None				
Sub-Dominant	None				



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M01-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: Minimal	4.5 Flow Regulation Type None	4.7 Stormwater Inputs
4.2 Adjacent Wetlands: None	Flow Reg. Use:	Field Ditch: 0 Road Ditch: 0
4.3 Flow Status: Moderate	Impoundments: None	Other: 0 Tile Drain: 0
4.4 # of Debris Jams: 0	Impoundment Loc.:	Overland Flow: 0 Urb Strm Wtr Pipe: 1
	4.6 Up/Down Strm flow reg.: None	4.9 # of Beaver Dams: 0
	(old) Upstrm Flow Reg.: None	Affected Length (ft): 0
4.8 Channel Constrictions: None		

Step 5. Channel Bed and Planform Changes

5.1 Bar Types	Diagonal: 0	5.2 Other Features	Neck Cutoff: 0	5.4 Stream Ford or Animal Crossing: No
Mid: 1	Delta: 0	Flood chutes: 0	Avulsion: 0	5.5 Straightening: None
Point: 0	Island: 0	5.3 Steep Riffles and Head Cuts	Head Cuts: 0	Straightening Length (ft.): 0
Side: 2	Braiding: 0	Steep Riffles: 0	Trib Rejuv.: No	5.5 Dredging: None

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	6.4 Sediment Deposition:	Stream Gradient Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	6.5 Channel Flow Status:	6.8 Bank Stability:		
6.3 Pool Variability:	6.6 Channel Alteration:	6.9 Bank Vegetation Protection		
Total Score: 0	6.7 Channel Sinuosity:	6.10 Riparian Veg. Zone Width:		
Habitat Rating: 0.00				
Habitat Stream Condition:				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	<u>Confined</u>	<u>Score</u>	<u>STD</u>	<u>Historic</u>		
7.1 Channel Degradation		11	None	Yes	Geomorphic Rating	0.61
7.2 Channel Aggradation		13	None	No	Channel Evolution Model	F
7.3 Widening Channel		11	None	No	Channel Evolution Stage	III
7.4 Change in Planform		14	None	No	Geomorphic Condition	Fair
Total Score		49			Stream Sensitivity	Very High



Phase 2 Segment Summary Report **Brewster River**

Stream:	Brewster River	SGAT Version:	4.56
Reach:	M02-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	1,892	Observers:	JHB, SPP; FEA
Rain:	Yes	Completion Date:	12/6/2012
		Quality Control Status - Consultant:	Provisional
		Quality Control Status - Staff:	Provisional
		Why Not Assessed:	bedrock gorge

Step 0 - Location: **From reach break upstream of private bridge, to reach break immediately upstream of Canyon Rd covered bridge**

Step 5 - Notes: **Reach was not fully assessed due to: 1) bedrock controlled channel throughout (80% of reach), and 2) landowner permission was not granted in middle of reach.**

Step 7 - Narrative: **No significant adjustments noted due to bedrock controls.**

Step 1. Valley and Floodplain

1.1 Segmentation:	1.4 Adjacent Side	<u>Left</u>	<u>Right</u>	1.5 Valley Features
1.2 Alluvial Fan: None	Hillside Slope:	Extr.Steep	Extr.Steep	Valley Width (ft): 136
1.3 Corridor Encroachments:	Continuous w/ Bank:	Always	Always	Width Determination: Estimated
<u>Length (ft)</u> <u>One</u> <u>Height</u> <u>Both</u> <u>Height</u>	Within 1 Bankfull W:	Always	Always	Confinement Type: SC
Berm: 0 0	Texture:	Bedrock	Bedrock	In Rock Gorge: Yes
Road: 0 0				Human Caused Change in Valley Width?: No
Railroad: 0 0				
Imp. Path: 0 0				
Dev.: 0 0				

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Mid-segment	9.0	7.0	Yes	
Ledge	Mid-segment	10.0	6.0	Yes	
Ledge	Mid-segment	3.0	2.0	Yes	
Ledge	Mid-segment	7.0	4.0	Yes	
Ledge	Mid-segment	0.0	0.0	Yes	
Ledge	Mid-segment	4.0	1.0	Yes	
Ledge	Mid-segment	5.0	2.0	Yes	



Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M02-0**

Step 2. Stream Channel

2.1 Bankfull Width (ft.):	2.11 Riffle/Step Spacing:	2.13 Average Largest Particle on
2.2 Max Depth (ft.):	2.12 Substrate Composition	Bed:
2.3 Mean Depth (ft):	Bedrock: %	Bar:
2.4 Floodprone Width (ft.):	Boulder: %	2.14 Stream Type
2.5 Aband. Floodpn (ft.):	Cobble: %	Stream Type: B
Human Elev FloodPln (ft.):	Coarse Gravel: %	Bed Material: Bedrock
2.6 Width/Depth Ratio: 0.00	Fine Gravel: %	Subclass Slope:
2.7 Entrenchment Ratio: 0.00	Sand: %	Bed Form: Step-Pool
2.8 Incision Ratio: 0.00	Silt and Smaller: %	Field Measured Slope:
Human Elevated Inc. Rat.: 0.00	Silt/Clay Present:	2.15 Sub-reach Stream Type
2.9 Sinuosity:	Detritus: 0.0 %	Reference Stream Type:
2.10 Riffles Type:	# Large Woody Debris: 7	Reference Bed Material:
		Reference Subclass Slope:
		Reference Bedform:

Step 3. Riparian Features

3.1 Stream Banks			Typical Bank Slope: Steep					
Bank Texture			Bank Erosion	<u>Left</u>	<u>Right</u>	Near Bank Vegetation Type <u>Left</u>	<u>Right</u>	
Upper	<u>Left</u>	<u>Right</u>	Erosion Length (ft.):	0.0	0.0	Dominant: Deciduous	Coniferous	
Material Type:	Sand	Sand	Erosion Height (ft.):	0.0	0.0	Sub-dominant: Coniferous	Deciduous	
Consistency:	Non-cohesive	Non-cohesive	Revetment Type:	Rip-Rap	None	Bank Canopy		
Lower			Revetment Length:	31.8	0.0	Canopy %:	51-75	76-100
Material Type:	Bedrock	Bedrock			Mid-Channel Canopy:		Open	
Consistency:	Cohesive	Cohesive						

3.2 Riparian Buffer

Buffer Width	<u>Left</u>	<u>Right</u>
Dominant	26-50	>100
Sub-Dominant	0-25	None
W less than 25	413	0
Buffer Vegetation Type		
Dominant	Deciduous	Coniferous
Sub-Dominant	Herbaceous	Shrubs/Sapling

3.3 Riparian Corridor

Corridor Land	<u>Left</u>	<u>Right</u>	<u>Left</u>	<u>Right</u>
Dominant	Residential	Forest	Mass Failures	
Sub-dominant	Forest	None	Height	
(Legacy)	<u>Amount</u>	<u>Mean Hieght</u>	Gullies Number	1
Failures	None		Gullies Length	400
Gullies	One	4.0		



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M02-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: Minimal	4.5 Flow Regulation Type None	4.7 Stormwater Inputs None
4.2 Adjacent Wetlands: Minimal	Flow Reg. Use:	Field Ditch: Road Ditch:
4.3 Flow Status: Moderate	Impoundments:	Other: Tile Drain:
4.4 # of Debris Jams: 0	Impoundment Loc.:	Overland Flow: Urb Strm Wtr Pipe:
	4.6 Up/Down Strm flow reg.: None	4.9 # of Beaver Dams: 0
	(old) Upstrm Flow Reg.:	Affected Length (ft): 0

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	45	Yes	No	Yes	Yes	None
Bedrock Outcrops	60	No	No	No	Yes	None
Bridge	57	Yes	Yes	No	Yes	Deposition Below, Scour Above

Step 5. Channel Bed and Planform Changes

5.1 Bar Types Diagonal:	5.2 Other Features Neck Cutoff: 0	5.4 Stream Ford or Animal Crossing: No
Mid: Delta:	Flood chutes: 0	5.5 Straightening: None
Point: Island:	5.3 Steep Riffles and Head Cuts Head Cuts: 0	Straightening Length (ft.): 0
Side: Braiding: 0	Steep Riffles: 0	Trib Rejuv.: No
		5.5 Dredging: None

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	6.4 Sediment Deposition:	Stream Gradient Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	6.5 Channel Flow Status:	6.8 Bank Stability:		
6.3 Pool Variability:	6.6 Channel Alteration:	6.9 Bank Vegetation Protection		
Total Score:	6.7 Channel Sinuosity:	6.10 Riparian Veg. Zone Width:		
Habitat Rating:				
Habitat Stream Condition:				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Score	STD	Historic	Geomorphic Rating
7.1 Channel Degradation				Geomorphic Rating
7.2 Channel Aggradation				Channel Evolution Model
7.3 Widening Channel				Channel Evolution Stage
7.4 Change in Planform				Geomorphic Condition
Total Score				Stream Sensitivity

Good



Phase 2 Segment Summary Report Brewster River

Stream: Brewster River
Reach: M03-0
Segment Length(ft): 1,625
Rain: Yes

SGAT Version: 4.56
Organization: Fitzgerald Environmental
Observers: JHB, SPP; FEA
Completion Date: 12/6/2012
Quality Control Status - Consultant: Provisional
Quality Control Status - Staff: Provisional

Step 0 - Location: Reach break upstream of Canyon Rd covered bridge to reach break at valley wall constriction

Step 5 - Notes: Bankfull and floodplain dimensions do not vary significantly in the reach. The channel appears to have experienced widening in the bankfull channel due to the 2011 flood events. Lower flood benches may have been blown out during flooding, leaving a wider channel than the predicted width of 48 feet. Given the floodprone width of 80ft, the pre-flood entrenchment ratio was likely 1.4-1.6. The cross-section indicates a terrace above the right bank. We do not think this is an abandoned floodplain, but rather a glacial-era terrace. These are common in this setting with lacustrine deposits found all along the right valley. 30% "channel enlargement" for this setting may be partially attributable to a wider than HGC average, which is typical in a confined setting with below average slope. This reach, and upstream reach M04, may naturally adjust between B-type and F-type geometry depending on the deposition and bench formation along the channel margins in between flood events, and the resulting entrenchment ratios.

Step 7 - Narrative: Widening is the dominant process based on recent flooding. No stream type departure because entrenchment ratio is within +/- 0.2 of B type, and no significant human-caused departures in channel/floodplain geometry were evident. See step 5 for further comments regarding natural stream type and adjustment processes.

Step 1. Valley and Floodplain

1.1 Segmentation: None

1.2 Alluvial Fan: None

1.3 Corridor Encroachments:

	Length (ft)	One	Height	Both	Height
Berm:	0			0	
Road:	281	2		0	
Railroad:	0			0	
Imp. Path:	0			0	
Dev.:	0			0	

1.4 Adjacent Side

Hillside Slope:

Continuous w/ Bank:

Within 1 Bankfull W:

Texture:

Left

Right

Hilly

Extr.Steep

Sometimes

Always

Sometimes

Always

Sand

Gravel

1.5 Valley Features

Valley Width (ft): 180

Width Determination: Measured

Confinement Type: SC

In Rock Gorge: No

Human Caused Change in Valley Width?: No

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Mid-segment	8.0	5.0	Yes	



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River** Reach: **M03-0**

Step 2. Stream Channel

2.1 Bankfull Width (ft.):	62.00	2.11 Riffle/Step Spacing:	100 ft.	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	3.45	2.12 Substrate Composition		Bed:	300 mm
2.3 Mean Depth (ft.):	2.29	Bedrock:	0.0 %	Bar:	N/A mm
2.4 Floodprone Width (ft.):	73.00	Boulder:	16.0 %	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	4.10	Cobble:	40.0 %	Stream Type:	B
Human Elev FloodPln (ft.):		Coarse Gravel:	23.0 %	Bed Material:	Cobble
2.6 Width/Depth Ratio:	27.07	Fine Gravel:	12.0 %	Subclass Slope:	c
2.7 Entrenchment Ratio:	1.18	Sand:	9.0 %	Bed Form:	Plane Bed
2.8 Incision Ratio:	1.19	Silt and Smaller:	0.0 %	Field Measured Slope:	
Human Elevated Inc. Rat.:	0.00	Silt/Clay Present:	No	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	Low	Detritus:	5.0 %	Reference Stream Type:	
2.10 Riffles Type:	Sedimented	# Large Woody Debris:	10	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks				Typical Bank Slope:	Steep	
Bank Texture			Bank Erosion	<u>Left</u>	<u>Right</u>	
Upper	<u>Left</u>	<u>Right</u>	Erosion Length (ft.):	0.0	51.9	
Material Type:	Sand	Sand	Erosion Height (ft.):	0.0	4.7	
Consistency:	Non-cohesive	Non-cohesive	Revetment Type:	None	None	
Lower			Revetment Length:	0.0	0.0	
Material Type:	Boulder/Cobbl	Boulder/Cobbl				
Consistency:	Non-cohesive	Non-cohesive				
				Near Bank Vegetation Type	<u>Left</u>	<u>Right</u>
				Dominant:	Shrubs/Sapling	Coniferous
				Sub-dominant:	Deciduous	Herbaceous
				Bank Canopy		
				Canopy %:	76-100	76-100
				Mid-Channel Canopy:	Closed	

3.2 Riparian Buffer

Buffer Width	<u>Left</u>	<u>Right</u>	Corridor Land
Dominant	>100	>100	Dominant
Sub-Dominant	0-25	None	Sub-dominant
W less than 25	258	0	(Legacy)
Buffer Vegetation Type			Failures
Dominant	Shrubs/Sapling	Coniferous	Gullies
Sub-Dominant	Deciduous	Shrubs/Sapling	

3.3 Riparian Corridor

	<u>Left</u>	<u>Right</u>	<u>Left</u>	<u>Right</u>
Dominant	Shrubs/Sapling	Forest	Mass Failures	13.89
Sub-Dominant	Forest	None	Height	20.0
W less than 25	<u>Amount</u>	<u>Mean Hieght</u>	Gullies Number	0
Failures	One	20.0	Gullies Length	0
Gullies	None			



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M03-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: Abundant	4.5 Flow Regulation Type: None	4.7 Stormwater Inputs
4.2 Adjacent Wetlands: None	Flow Reg. Use:	Field Ditch: 0 Road Ditch: 1
4.3 Flow Status: Moderate	Impoundments: None	Other: 0 Tile Drain: 0
4.4 # of Debris Jams: 0	Impoundment Loc.:	Overland Flow: 0 Urb Strm Wtr Pipe: 1
	4.6 Up/Down Strm flow reg.: None	4.9 # of Beaver Dams: 0
	(old) Upstrm Flow Reg.: None	Affected Length (ft): 0

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	50	Yes	No	Yes	Yes	Deposition Below, Scour Below
Bridge	60	Yes	Yes	Yes	No	Deposition Above, Deposition Below, Scour Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types	Diagonal: 0	5.2 Other Features	Neck Cutoff: 0	5.4 Stream Ford or Animal Crossing: No
Mid: 0	Delta: 0	Flood chutes: 0	Avulsion: 0	5.5 Straightening: None
Point: 0	Island: 0	5.3 Steep Riffles and Head Cuts	Head Cuts: 0	Straightening Length (ft.): 0
Side: 2	Braiding: 0	Steep Riffles: 0	Trib Rejuv.: No	5.5 Dredging: None

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	6.4 Sediment Deposition:	Stream Gradient Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	6.5 Channel Flow Status:	6.8 Bank Stability:		
6.3 Pool Variability:	6.6 Channel Alteration:	6.9 Bank Vegetation Protection:		
Total Score: 0	6.7 Channel Sinuosity:	6.10 Riparian Veg. Zone Width:		
Habitat Rating: 0.00				
Habitat Stream Condition:				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Confined	Score	STD	Historic		
7.1 Channel Degradation		10	None	No	Geomorphic Rating	0.51
7.2 Channel Aggradation		11	None	No	Channel Evolution Model	F
7.3 Widening Channel		8	None	No	Channel Evolution Stage	III
7.4 Change in Planform		12	None	No	Geomorphic Condition	Fair
Total Score		41			Stream Sensitivity	High



Phase 2 Segment Summary Report **Brewster River**

Stream:	Brewster River	SGAT Version:	4.56
Reach:	M04-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	1,607	Observers:	JHB, SPP; FEA
Rain:	Yes	Completion Date:	12/6/2012
		Quality Control Status - Consultant:	Provisional
		Quality Control Status - Staff:	Provisional

Step 0 - Location: **From reach break at valley wall constriction to base of large waterfall**

Step 5 - Notes: **Large deposit of cobble/pebble downstream of waterfall w/ evidence of widening (MCB's). No vertical migration due to coarse boulder and bedrock underneath. The channel appears to have experienced widening in the bankfull channel due to the 2011 flood events. Lower flood benches were likely blown out during flooding, leaving a wider channel than the predicted width of 45 feet.**

The waterfall has an elevation change of 65 feet. The natural slope of the channel below the waterfall is ~1.0%.

Entrenchment ratio (1.1) is unnaturally low due to widening of lower banks from flood event. 30% "channel enlargement" for this setting may be partially attributable to a wider than HGC average, which is typical in a confined setting with below average slope. This reach, and downstream reach M03, may naturally adjust between B-type and F-type geometry depending on the deposition and bench formation along the channel margins in between flood events, and the resulting entrenchment ratios.

Step 7 - Narrative: **Widening and aggradation following an episodic flooding event. Significant amount of bedload washed down through waterfall. Sediments unstable underfoot and minor to moderate widening along lower banks following event. Widening is the dominant process based on recent flooding. No stream type departure was noted because no significant human-caused departures in channel/floodplain geometry were evident. No severe lateral or vertical instability noted. See step 5 for further narrative regarding natural stream type and adjustment processes.**

Step 1. Valley and Floodplain

1.1 Segmentation: None	1.4 Adjacent Side	<u>Left</u>	<u>Right</u>	1.5 Valley Features
1.2 Alluvial Fan: None	Hillside Slope:	Extr.Steep	Very Steep	Valley Width (ft): 100
1.3 Corridor Encroachments:	Continuous w/ Bank:	Always	Sometimes	Width Determination: Measured
<u>Length (ft)</u> <u>One</u> <u>Height</u> <u>Both</u> <u>Height</u>	Within 1 Bankfull W:	Always	Sometimes	Confinement Type: SC
Berm: 0 0	Texture:	Bedrock	Bedrock	In Rock Gorge: No
Road: 0 0				Human Caused Change in Valley Width?: No
Railroad: 0 0				
Imp. Path: 0 0				
Dev.: 0 0				

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Mid-segment	10.0	6.0	Yes	
Waterfall	Mid-segment	65.0	60.0	Yes	
Ledge	Mid-segment	3.0	1.0	No	



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River** Reach: **M04-0**

Step 2. Stream Channel

2.1 Bankfull Width (ft.):	58.00	2.11 Riffle/Step Spacing:	200 ft.	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	2.80	2.12 Substrate Composition		Bed:	270 mm
2.3 Mean Depth (ft.):	1.94	Bedrock:	3.0 %	Bar:	N/A mm
2.4 Floodprone Width (ft.):	64.00	Boulder:	9.0 %	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	2.80	Cobble:	43.0 %	Stream Type:	B
Human Elev FloodPln (ft.):		Coarse Gravel:	30.0 %	Bed Material:	Cobble
2.6 Width/Depth Ratio:	29.90	Fine Gravel:	11.0 %	Subclass Slope:	c
2.7 Entrenchment Ratio:	1.10	Sand:	4.0 %	Bed Form:	Plane Bed
2.8 Incision Ratio:	1.00	Silt and Smaller:	0.0 %	Field Measured Slope:	
Human Elevated Inc. Rat.:	0.00	Silt/Clay Present:	No	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	Low	Detritus:	10.0 %	Reference Stream Type:	
2.10 Riffles Type:	Sedimented	# Large Woody Debris:	10	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks			Typical Bank Slope:	Steep				
Bank Texture			Bank Erosion	<u>Left</u>	<u>Right</u>	Near Bank Vegetation Type	<u>Left</u>	<u>Right</u>
Upper	<u>Left</u>	<u>Right</u>	Erosion Length (ft.):	0.0	0.0	Dominant:	Herbaceous	Herbaceous
Material Type:	Bedrock	Sand	Erosion Height (ft.):	0.0	0.0	Sub-dominant:	Coniferous	Deciduous
Consistency:	Cohesive	Non-cohesive	Revetment Type:	None	None	Bank Canopy		
Lower			Revetment Length:	0.0	0.0	Canopy %:	76-100	76-100
Material Type:	Bedrock	Boulder/Cobble				Mid-Channel Canopy:	Closed	
Consistency:	Cohesive	Non-cohesive						

3.2 Riparian Buffer

Buffer Width	<u>Left</u>	<u>Right</u>	Corridor Land
Dominant	>100	>100	Dominant
Sub-Dominant	None	None	Sub-dominant
W less than 25	0	0	(Legacy)
Buffer Vegetation Type			Failures
Dominant	Deciduous	Coniferous	Gullies
Sub-Dominant	Herbaceous	Herbaceous	

3.3 Riparian Corridor

	<u>Left</u>	<u>Right</u>	<u>Left</u>	<u>Right</u>
Dominant	Forest	Forest	Mass Failures	
Sub-Dominant	None	None	Height	
W less than 25	<u>Amount</u>	<u>Mean Hieght</u>	Gullies Number	0
Buffer Vegetation Type			Gullies Length	
Dominant	None			
Sub-Dominant	None			



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Phase 2 Segment Summary Report

Brewster River

Stream: **Brewster River**

Reach: **M04-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: Minimal	4.5 Flow Regulation Type None	4.7 Stormwater Inputs None
4.2 Adjacent Wetlands: Minimal	Flow Reg. Use:	Field Ditch: Road Ditch:
4.3 Flow Status: Moderate	Impoundments: None	Other: Tile Drain:
4.4 # of Debris Jams: 0	Impoundment Loc.:	Overland Flow: Urb Strm Wtr Pipe:
	4.6 Up/Down Strm flow reg.: None	4.9 # of Beaver Dams: 0
	(old) Upstrm Flow Reg.:	Affected Length (ft): 0
4.8 Channel Constrictions:		

Step 5. Channel Bed and Planform Changes

5.1 Bar Types Diagonal: 0	5.2 Other Features Neck Cutoff: 0	5.4 Stream Ford or Animal Crossing: No
Mid: 2 Delta: 0	Flood chutes: 1 Avulsion: 0	5.5 Straightening: None
Point: 1 Island: 0	5.3 Steep Riffles and Head Cuts Head Cuts: 0	Straightening Length (ft.): 0
Side: 3 Braiding: 0	Steep Riffles: 0 Trib Rejuv.: No	5.5 Dredging: None

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	6.4 Sediment Deposition:	Stream Gradient Type	<u>Left</u>	<u>Right</u>
6.2 Pool Substrate:	6.5 Channel Flow Status:	6.8 Bank Stability:		
6.3 Pool Variability:	6.6 Channel Alteration:	6.9 Bank Vegetation Protection		
Total Score: 0	6.7 Channel Sinuosity:	6.10 Riparian Veg. Zone Width:		
Habitat Rating: 0.00				
Habitat Stream Condition:				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	<u>Confined</u>	<u>Score</u>	<u>STD</u>	<u>Historic</u>		
7.1 Channel Degradation		13	None	No	Geomorphic Rating	0.64
7.2 Channel Aggradation		11	None	No	Channel Evolution Model	F
7.3 Widening Channel		12	None	No	Channel Evolution Stage	III
7.4 Change in Planform		15	None	No	Geomorphic Condition	Fair
Total Score		51			Stream Sensitivity	High

APPENDIX C

Phase 1 & 2 QA Summaries

QA Notes For: **Brewster River**
Ph2 Assessment by Fitzgerald Environmental
Data checked by Staci Pomeroy
February 11, 2013

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the comments below, please update this document (preferably in a second color) with what steps were (or were not) taken to address the comments/questions.

Responses by Joe/Evan, 3/8/13

General Notes:

- Phase 1 and Phase 2 QA note will be for reaches M01-M04. Remainder of Phase 1 QA notes (M05-M18, trib T7) will done separately.
- Phase 2 -Step 2.12 Detritus – noted as “0%” on all reaches. Was this due to conditions at time of visit, or is there really no detritus?
We have now entered detritus data based on field notes and photographs.
- Stream types, based on the cross-sections for the reaches M01A/B, M03, and M04; do not generally fit in the expected range for the classification system based on the entrenchment ratio found at the cross-sections. In each instance an adjustment factor of +/- 0.2 (or greater) was used to adjust the stream type to another stream type within that adjustment range (B or F stream types). This has been highlighted here because there is a significant interest in flooding issues on the Brewster River.

Please see notes below for each reach/segment addressing stream geometry and typing.

Streams are divided into categories or typed based in part on their degree of entrenchment. Highly entrenched streams ($ER < 1.4$) do not spill out onto a floodplain during high flows, such that flows are contained within the stream channel itself. During floods, moderately entrenched streams ($ER = 1.4 - 2.2$) spill out into the floodprone area while streams exhibiting little or no entrenchment ($ER > 2.2$) access their floodplain at bankfull flows.

The use of the adjustment factor can be appropriate, however, it can often lead to confusion in later use of the data if someone is to look just at the “stream type” or just the “xs numbers” with no knowledge of the setting and/or explanation as to why the adjustment factor was used. It can also imply different things about what the flooding potential and stream condition is based on the parameter the person is looking at; they say potentially two different things: B streams are less entrenched and have some floodplain access; the entrenchment values under 1.4 indicate a stream that is highly entrenched and does not have any floodplain.

Due to the significant interest around flooding concerns on the Brewster, and the interest to use this SGA data toward flood studies; I am looking for stronger explanations around the stream types chosen for reaches. Additional cross-sections in the reaches would help provide further support and this will be a recommendation for additional work needed. Where ever possible, I would request additional information around any measurements taken along the reach is noted and if possible spatial location of that information provided. Documentation of this information will support the stream types assigned, and further discussions of options for possible flood mitigation strategies and emergency planning. Specific questions/comments for each reach are noted below.

Stream Type	(1) Entrenchment Ratio (+/- 0.2 units)	(2) Width/depth (+/- 2 units)	(3) Sinuosity (+/- 0.2 units)	Slope % (See Note)
F – Single Thread	<1.4 - Entrenched	>12 – Mod. to High	>1.2 – Low to Mod.	<2
B – Single Thread	1.4 -2.2 – Moderately Entrenched	>12 – Moderate	>1.2 – Low to Mod.	2-4

Reach	Width/depth	Entrenchment	incision	Stream type
M01A	23.73	1.76	1.73	Fc3
M01B	23.81	1.34	1.28	Bc3
M03	27.07	1.18	1.19	Bc4
M04	29.90	1.10	1.00	Ba4 (? “a” subslope, notes indicate ~1% = Bc4)

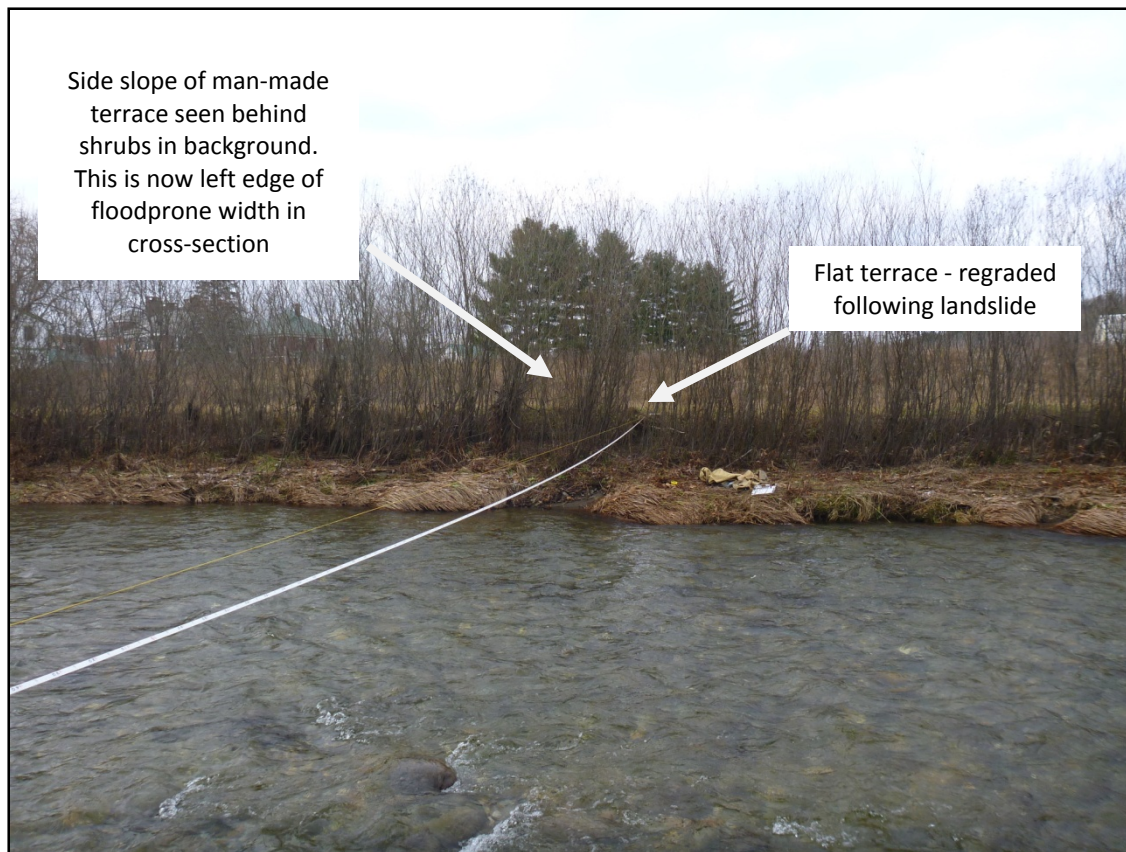
Reach Notes:

M01 –

- Phase 1 – Please note in the Phase 1 comments that the reach has been segmented and provide brief segment info. (ie: M01A = 2,860 ft, C to B STD ; M01B – 786 ft -SubReach – Ref. stream type Bc-riffle pool ; etc.) This will help document overall condition of reach if someone just looking at Phase 1 information. **We have entered these notes in Phase 1, Step 7.**
- Phase 1 – Step 5.2 – bridge/culvert noted as 2; in Phase 2 there are 3 listed – 2 in M01A, 1 in M01B – Please confirm if there are 2 or 3 structures and update FIT if additional structure
The private bridge at the M01/M02 reach break is in M02 for Ph1, moved structure info to M02 for Ph2.

M01A –

- Step 1.2 – Alluvial Fan- Given the setting, steep/confined/high bed load upstream coming into wide flat valley, would you expect this area to be an alluvial fan naturally? Just looking at the reaches upstream and how this area seems to be where have sharp change in slope and confinement didn’t know if perhaps part of story as to why so much sediment settling out in this area.
There is a sharp change in slope in the channel network at this point, but the parent material here is outwash not alluvium. There is alluvium throughout the Lamoille floodplain near the Route 15 bridge, but not south of that point. Topography and parent material suggest this was a glacial outwash plain, but not currently an active alluvial fan.
- Step 1.3 – Berm - In cross-section there is a berm noted as the left valley wall. There is none in the FIT. Should there be? Confirm if berm should be noted and/or provide more explanation in XS as to what berm is referencing. This would also update Phase 1 step 6.1.
We have removed this note re: “berm” from the XS excel sheet, and replaced it with “side slope of a man-made terrace”. See photograph below indicating different features shown on cross-section.



- Step 2.5/2.8 – Human Elevated Floodplain – If the berm is counted, review to determine if the HRAF also needs to be updated – is there floodplain behind the berm? **See above note re: absence of berm.**
- Step 2.14 – Stream type – Narrative indicates “entrenchment ratio is greater than 1.4 due to remediation effort to reshape the banks at cross-section location. However, most of the reach has F-type geometry with entrenchment ratios <1.2.”
 - If you have other notes as to measurements, please provide those measures in the narrative to show what the range entrenchment was along the reach. “Less than 1.2” is very entrenched, and this is a bit out of the usual +/- 0.2 adjustment; having more information as to measurements taken would further support the stream type chosen.

We have taken a second look at this segment in more detail, including the channel geometry throughout the whole segment. We agree with you that we should consider this segment a B-type (departure from C) based on the entrenchment ratio. Portions of the lower segment around Rt 15 are widened and incised enough that, in the absence of backwater from the Lamoille (which is not a realistic scenario), the entrenchment ratio would be lower than 1.4 due to the depth available relative to a likely maximum bankfull depth of 3.5. See photograph below with stadia rod. The left banks were between 7-8ft tall at this bend where the bar has formed, therefore the 2-times max depth would result in an entrenchment ratio of close to 1 as the channel is like a rectangular weir.

As you know, trying to type tributary streams at confluences is challenging due to tailwater effects, etc. We have noted in report with a map those areas with more F-type geometry and those with departed B-type geometry.



- If you have notes as to other measurements, would you be able to document where those measures were taken? **See above comments.**
- Are there locations of “B” stream type as well as “F”? Any “C”? If yes, are any areas worth highlighting as to either their floodplain access and/or lack of it. This is valuable to know to understand what type of flood plain access (if any) may be available along this reach. Can they be shown on the map? **See above comments. We have made a map to include in the report that depicts this variation.**
- How is the floodplain access near the Rte. 15 bridge (upstream) perhaps different than the upper portions of this segment? There has been significant discussion in the community that the stream has aggraded such that there are now floods accessing the area more frequently.
 - Is this really more a function of the Lamoille backing up? **Looking at aerial photographs from the Spring 2011 flooding certainly suggests that backwater from the Lamoille caused the ponding back up Brewster even on the east side of Rt 15.**
 - Is the gravel bar upstream of the bridge causing changes in the flooding? **I don't think so. Recall Rob Evan's analogy of brick in bathtub - if the drain is constricted (Lamoille backwater) the attenuation re: volume of tub is not significantly affected by material in tub.**
- There are several advocates in the community that want to dig the channel deeper to hold more floodwaters; how would this change the entrenchment, what would it mean for the channel condition and sensitivity. Is the channel already holding more floodwaters than might be expected and is that part of the channels dynamic nature? **The channel is already incised, and digging deeper will risk further destabilizing the toe of slope at mass failures - especially the 1962 failure downstream of larger one where the toe is right at the meander bend. Given the pre-mass failure mitigation state of channel - which was likely at least moderately incised I believe - I would guess the channel is probably holding equal or more floodwater in cross-section than it would naturally for this setting (C-type).**
- If the reach is significantly entrenched, and in stage 3 of CEM, it will potentially need to develop significant floodplain at a lower elevation in order for the stream to reach some form of equilibrium.
 - What does this mean to the community?

Some widening and aggradation will likely occurred, but I don't see the bed raising on its own significantly because there is still enough power with the lower than expected entrenchment ratio to push material downstream.

- Will the significant aggradation in the area allow for a reconnection of the higher floodplain without going through CEM? See above.
- Would a more significant active floodplain restoration project allow for enough floodplain to get entrenchment >1.4 ($? >2$)?

This is a possibility, but I still think the major constraint to flood mitigation is not the volume available in Brewster channel+floodplain cross-section, but rather the backwater from Lamoille.

- Should the reach be a modified reference for management strategies...maybe you'd never be able to come back to a "C", but could you obtain a "B" (like at the cross-section) with some level of active restoration and what would that buy you?

I think the only way these questions can be answers is by looking at the hydraulics in this area.

This level of alternatives analysis is well beyond our SOW and I hesitate to speculate.

*Extra side note from Staci - You may not necessarily answer the notes from the last few bullets in this document (though certainly provide notes as able), but are thoughts/questions to consider in reporting information for this reach. It is **very important** that the stream characterization be as fully described on this reach as much as possible, as it is the primary area that the community is focusing on for possible flood mitigation strategies, and information from this study will be used to further engineering studies that will investigate what those possible strategies might be. Knowing what type of floodplain connection and possible conditions of the stream that will contribute to that access will provide ideas of what may be feasible or not for flood mitigation.*

Step 2 – review of the cross-section – Was noted that it was done at the restoration site where a floodplain cut was done. There appears to be a bench on the left side.

- Did this appear to be a natural bench or one created during the restoration after the mass failure? The note in the step 5 notes indicates that the "floodplain cut on LB" across from MF site likely attenuates some flow but not enough. Discussion with the Stream Alt. Engineer (Barry Cahoon), seem to indicate they'd provided a bench at bankfull or slightly higher. Do you think there has been significant incision since the project? I could not tell what might have been the created bench versus the natural floodplain on the cross-section.

See photograph and additional comments above. I think this bench is substantially higher than bankfull today - this is reflected in the reported $IR = 1.76$. When we were reviewing field data, we ran manning's on this section and compared to Stream stats Q2 value of approx. 650 cfs. If you raise bankfull to the bench, you get $Q = 2,500$ cfs, whereas it is approx. 1,000cfs at bankfull depth shown in current section. Likewise, the current bankfull width is 62ft, but if you raise to bench you get 69ft, which is well over HGR-predicted width of 48ft.

- Why was the back of the bench/base of the berm decided as the RAF? The LTOB would seem to be a better RAF. This is being accessed by before the back of the bench and is lower.
- Was there rip-rap on the right bank at the cross-section. The note in the cross-section sheet mentions it. If yes, please indicate in the "notes" of the cross-section measurements when rip-rap was encountered and where it ended in the course of the cross-section.

Agree. This has been revised and the resulting incision ratio is 1.59.
Added notes in excel XS.

- Step 3.2 – right riparian buffer – sub-dominant – "0-25". I do not see any reduction of buffer width in this area other than at the mass failure with less veg. but is not a managed veg. Why 0-25 as subdominant? Sub-dom was 26-50, changed to none. Originally classified as 26-50 due to the parking area at Rte. 15, but this is small percentage of total reach.
- Step 4.4 – Debris Jam – Was this channel spanning? If yes, is it causing local issues/impacts such as sediment build up/flow diversion that would impact flooding? Folks are pretty sensitive in this area about debris jams, so just looking to get an idea of if this is something to monitor for possible flood issues. The debris jam was not channel spanning, it was a large tree with root wad along the left bank reaching the middle of the channel at an angle. See below photo.



- Step 7.1 – Row 4 – In “Fair” “human change in valley confinement.....” None is noted in step 1 for either change in confinement type. Should this be in “good”..some change in channel confinement (? bridge.... As no encroachments)
 Agree. We have changed this to “good” and considered change in degradation score.
- Step 7.2 – Row 2 in “fair” – “substrate may be >70% fine/feel soft underfoot”. The substrate appears to be mostly coarse gravel and cobbles; was it that the sediment felt soft underfoot?
 Agree that this score is too harsh. Have revised to good. There was a lot of aggradation of gravel upstream of bridge, some of which was loose and mobile, but not necessarily soft underfoot.
- Step 7.3 – Row 3 – in “fair” incision between 1.4 and 2, entrenchment >2” This should be “poor” as entrenchment is <2 (especially if an F and < 1.2 as indicated in narrative)
 Revised here and in 7.1 row 2.
- Step 7 – Stream Sensitivity – “Very High”; due to STD would be “Extreme”
 Looking back at past QA notes on other projects, there seems to be some inconsistency among DEC river scientists on this issue. Based on the sensitivity table in SGA protocol, do you need a RGA score of poor **and** STD for extreme? Others have said so in past, which is why we kept at “very high”. With a STD from C to B, would we type as extreme no matter geo condition rating of poor or fair?

M01B –

- Step 0 – “from reach break at up....” Think this would be “segment” break. **Corrected in DMS**
- Step 2.7 – Entrenchment – looking at the cross-section what is the left “terrace/LVW”? The valley width is noted as 500 ft; but between the left/right valley wall noted on the XS is <100 ft. Is this fill? When I look at the picture of the area, looks like it is a high bank with the rip-rap behind the town garage; was this considered a valley wall? Almost the entire left bank appeared to be rip-rapped, is that causing change in channel confinement? Is this area naturally entrenched?
 This area is naturally entrenched, which is why we called it a Bc sub-reach. It did not appear to us that any floodplain benches of this B-type stream were significantly filled on the west (left) bank that would change the ER. Our cross-section is representative of the reach. Based on field notes and further review of photos, the ER varies between 1.3 and 1.5 in this transitional area and doesn’t appear to be severely manipulated so we’ll stick with B with no departure. However, we need to revise the Phase 2 field verified VWs to reflect this, and have updated Step 1.5.

- Step 2.8 – incision ratio. There was not much to see of either the bankfull or RAF on the cross-section. Is there more of a RAF feature in other areas of the reach?

There isn't much natural floodplain in this reach to begin with b/c of the setting. See photo below taken from XS looking downstream.



- Step 2.15 – noted as a sub-reach of “B”. Was there other measurements that help support an entrenchment > 1.4 (though within the ± 0.2 adjustment), could still be potentially viewed as an F unless there seems to be some level of floodplain access in the reach.

We don't think there is enough change in floodprone width from development, etc to call this a STD.

- As noted above, please provide notes as to other measurements taken that help support the classification. If able to map the location of the measures that would also be helpful.
- What level of floodplain is available along the segment? It does not appear to be significantly incised; are there areas for floodwater storage or limited?
- This segment is described as a “sub-reach” with different reference stream type. Is this naturally a transition zone?

Yes.

- Step 4.8 channel constrictions – noted as “bridge”. This does not appear to be in the FIT. Please review and update. Moved bridge to M02, updated DMS
- Step 7 – A “Confined” RGA form was used. The valley type noted in step 1 is VB. Please review and determine if the valley type is correct or needs to be updated. If the natural valley type is not updated, review the RGA and use “unconfined”.

This was a mistake that should have been picked up after we changed from unconfined to confined field sheets. Revised in DMS for Step 1.5.

M02 - Thank you for review and completing steps that were possible for the un-assessed reach. The administrative judgment of “B” stream type will be used for corridor planning.

- Phase 1 – Please add a comment in the notes as to that this is a gorge so not fully assessed in Phase 2, but limited field observations done. This will help in later use of the data.

Notes added in Step 5 of DMS.

- Step 7 geomorphic condition – noted as “Fair”. Please provide an explanation in the notes as to why “fair” condition was assigned. With a bedrock gorge it is not easy to pick up why it is in fair condition simply from the few parameters filled in. Any information that will help explain this condition will help in using the data and considerations of corridor/channel management strategies.
After review of the notes and fact that channel is mostly bedrock controlled, we have changed this to “good.”

M03

- Phase 1 – Please provide a note as to what the dam is. As this was the dam created at the swimming hole, will help with review of the data to know it is not a typical dam. Added note in step 7
- Step 2.7 – Entrenchment 1.18 – The note in step 7 indicates that no “STD because entrenchment ratio is +/- 0.2 of a B”.
 - If possible, please provide notes as to the other measurements taken that show the range of entrenchment values along the reach.
Bankfull and floodplain dimensions do not vary significantly in the reach. The channel appears to have experienced widening in the bankfull channel due to the 2011 flood events. Lower flood benches were likely blown out during flooding, leaving a wider channel than the predicted width of 48 feet. Given the floodprone width of 80ft, the pre-flood entrenchment ratio was likely 1.4-1.6.
 - Looking at the cross-section it looks like there is an old floodplain (long flat bench on the right bank and is included in the valley width). There is just barely flood access of 1.2 and within what looks to be the channel. What is the feature on the right?
We think this is a glacial-era terrace. These are common in this setting with lacustrine deposits found all along the right valley.
 - A small change in the bankfull elevation to 5.1 -5.3+ (similar to the RAF – though not easy to see what the feature was) would make this feature appear to be accessed. Are there other areas that have more floodplain access than what is shown in the cross-section?
Please see notes above for M01-A regarding the manning’s calculations in relation to stream stats, etc. We took this into account on reaches M03 and M04 - the calculations are included in the spreadsheet. I am not comfortable raising the bankfull depth as the resulting Q from manning’s is too high for the reach, drainage area, etc.
 - Could this have been a B that has departed to an F if all flows are really now being contained in the channel as the cross-section would seem to indicate? Even if you allowed for the +/- 0.2; is it good to indicate it is a B if all flows now in the channel?
We think these benches will likely reform with sedimentation in the future and the channel will continue have B-type dimensions.
- Step 4.8 – Channel constrictions – one of these is noted as “other”. I see in the FIT a bridge noted. And I see a bridge in Phase 1 step 5.2. Please indicate what “other” is in the notes. If not a bridge, please provide a note in the FIT description field.
It is a bridge and we have updated the DMS.
- Step 7.1 Row 2; Step 7.3 Row 3- in Fair (incision $>1.4 < 2$, entrenchment >1.4) ; This would be poor as your entrenchment is <1.4 (1.18).
Revised in DMS.
- Step 7.1 Row 3 – in Fair (eroded steps). – Noted as “sedimented”. It could be in “good” mostly complete
Revised in DMS.
- Step 7.2 – Row 2 Fair; Step 7.3 Row 4; Step 7.4 Row 2 – Multiple unvegetated mid-channel side or diagonal bars present. Sediment buildup at constrictions leading to steep riffles and/or flood chutes . Could this be in “good,” there are only 2 side bars noted in the reach, no steep riffles, no flood chutes, no diagonal bars. Is there some other bars and/or issues that are not easily shown but would push this to fair?
Both M04 and M03 showed signs of sedimentation from 2011 floods - it appeared that significant sediment was flushed through the gorge downstream, especially in M04. Scores for sedimentation were a bit harsh for M03 and we have revised them.
- Step 7.3 Row 5 – What was considered a “major channel and/or flow alteration increase in flow and/or sediment load?
See above notes. Revised to “good”.

M04

- Phase 1, a good note as to the waterfall and how that is affecting the slope of the reach. How long is the section of waterfall in the segment? Should it have been segmented as a sub-reach to reduce the influence on the rest of the reach? It is noted that the slope below the waterfall would be ~ 1%; this would seem to indicate that the subslope for most of the reach would be “c”. Is this a semi-confined low slope valley, expect for the waterfall?
- Phase 1 step 7.2 – No data for bank height. Please update.
- Step 2.7 – Entrenchment – 1.10 –Note in step 5, says “unnaturally low due to widening from flood events.”
 - This could indicate a stream type departure. It will take the channel getting at least back to a width of 45 ft (approx. width from HGC) to give an entrenchment of 1.4. Was there other areas not as over widened that have a higher entrenchment or more floodplain area? Such that the entrenchment ratio would be higher.
See notes above regarding M03 and episodic changes in channel from flooding. We feel the same about this reach - there is just not enough evidence to call this a highly unstable channel with significant departure from “reference.” Notes added to DMS. We think that benches will likely reform with sedimentation in the future and the channel will continue have B-type dimensions. Benches forming 5ft on either bank seems realistic.
 - If the stream has been over widened during the flood such that it is changing entrenchment, perhaps this is important to catch as a departure, to show.....what does it mean for the sensitivity of the stream, what does it mean for possible management strategies or needs?
See notes above.
 - This reach was noted as in “good” condition. In the DMS the Step 2 Flood questions note that the channel enlargement of ~ 60%. Is this a stable channel?
Enlargement is only 30%. This has been corrected in DMS.
 - If possible, please provide notes as to other measurements taken that support the stream type chosen.
Additional notes added in DMS.
- Step 3.1 – Bank texture – left bank – upper material sand – noted as “cohesive”. This would be “non”.
Fixed in DMS.
- Step 7.1 Row 2 and Step 7.3 Row 3 – noted in reference; should be poor as entrenchment <1.4.
 - $2.0 \leq \text{Incision Ratio or } [(\text{Channel Slope} < 4\% \text{ and Entrenchment Ratio} < 1.4) \text{ or } (\text{Channel Slope} \geq 4\% \text{ and Entrenchment Ratio} < 1.2)]$ (it is the “Or” that is easily over looked as the rest of the categories say “and”)
Fixed in DMS. Overall score for degradation reduced.
- Step 7.2 Row 1 – nothing is checked ; expect was just over looked
Fixed.
- Step 7.2 Row 4 – in Reference (w/d <=20), should be “good” (w/d >20 <=30) currently w/d =29.9
Fixed.

QA Notes For: **Brewster River**
Ph1 Assessment by LCPC & Fitzgerald Environmental
Data checked by Staci Pomeroy
February 19, 2013

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the comments below, please update this document (preferably in a second color) with what steps were (or were not) taken to address the comments/questions.

Responses by Melinda Scott (LCPC)

General Notes:

- Phase 1 QA notes for reaches : M05-M18, and trib T7. Phase 1 and Phase 2 QA notes were done separately for reaches M01-M04.
- For all reaches - Step 4.3 riparian buffer - Sub-dominant condition blank. Please look to provide a sub-dominant buffer condition; if the same as the dominant condition enter "none" to indicate no difference from dominant condition. **Sub-dominant condition entered for all reaches.**

Reach Notes:

- M07 –
 - Step 2.11 – stream type : noted as "Cb", slope of 2.88% valley type broad. This may be a "B" and will likely take field verification to determine how much flood plain is available. What this will mean is that for now there will be a wider river corridor created if an "FEH" is generated. **This is where the campground is, the owner says it often floods. I did not change the stream type.**
 - Step 6.2 Development – There is a bit more at the upper left side of the corridor near the upstream reach break. Please review and update as needed. **The development is not within the corridor, so none added.**
- M08
 - Step 2.11 stream bed material and bedform – noted as bedrock and step pool. Did you make the observations in the windshield survey? Generally do not see step pools in a bedrock dominated streams; these are often more of a cascade; and boulder/cobbles are often more observed with step-pools. Confirm if bedrock and/or step-pool still makes sense given what you know about the stream. **Changed to "bedrock/cascade" as we observed a gorge/waterfall at the access point along the reach.**
 - Please add a note in the "comments" that "rte. 108 is just outside the corridor along the entire reach". Just looking to capture that the road is not in the corridor, but it is just on the edge of the corridor and may be an issue at a later date if the river moves in that direction. **Comment added in Step 7.**
- M10
 - Step 6.4 meander migration – currently blank. Please update with information or enter "none" if no migration observed. **Entered "None" and impact of "not significant". Also changed the depositional features to "side" with an impact of "low."**
- M12
 - Step 5.2 bridge/culvert - The FIT point for the downstream bridge (goes up to the condos) is not on the bridge, is slightly downstream. Look to place FIT point on the bridge. **FIT point moved to bridge.**
 - There may be a culvert at the upstream end. It looks like a path crosses the stream up near the upstream reach break. Look to see if you see it too. If we can't determine if there is something there, lets add a note in the comments that "there may be an additional structure near the upstream reach break along the path – field verification needed" **There is definitely a path, so either a bridge or culvert is there. Added point and delineated it as "unknown" either bridge or culvert.**
 - Step 5.5 – dredging noted. Please add a note in the comment as to what type of dredging was noted (ie: was it observed during windshield survey, was it associated with the berm; or information from another

source). This will help with understanding the possible extent of dredging and what it might have been associated with. **Comment added in Step 7: “Dredging noted in Step 5 is associated with the berm observed during the windshield survey.” Already noted in FIT.**

- Step 7.3 – ice/debris jam – noted as multiple. Most of the notes for ice/debris jams indicate from aerial imagery. No note as made for this reach. Were there anything specific that made you think this reach had multiple areas that might cause ice/debris jams? **I noted areas of actual debris jams observed from Google Earth imagery. Multiple areas were observed.**

- M14
 - Step 2.11 stream bed material and bedform – noted as bedrock and step pool. Did you make the observations in the windshield survey? Generally do not see step pools in a bedrock dominated streams; these are often more of a cascade; and boulder/cobbles are often more observed with step-pools. Confirm if bedrock and/or step-pool still makes sense given what you know about the stream. **Bed material changed from bedrock to cobble; we walked this entire reach.**
 - Step 5.1 – flow reg. Please add a note in the comments as to what the dam was for (snow making). This will help give context to what the dam is used for. **Note added: “Flow regulation noted in Step 5 is the water withdrawal impoundment and pond used for snow-making.” Already noted in FIT.**
 - Step 5.5 – dredging noted. Please add a note in the comment as to what type of dredging was noted (ie: was it observed during windshield survey, was it associated with the berm; or information from another source). This will help with understanding the possible extent of dredging and what it might have been associated with. **Note added: “Dredging noted in Step 5 is associated with the berm observed during the windshield survey.” Already noted in FIT.**

- M16
 - Step 2.11 stream bed material and bedform – noted as bedrock and step pool. Did you make the observations in the windshield survey? Generally do not see step pools in a bedrock dominated streams; these are often more of a cascade; and boulder/cobbles are often more observed with step-pools. Confirm if bedrock and/or step-pool still makes sense given what you know about the stream. **Bed material changed from bedrock to boulder. Slope not steep enough for cascade, so changing the bed material made more sense.**

- M16, M17, M18
 - Step 5 – blank. Please enter “none” (or “no data/not evaluate”). **Entered “none” for these reaches.**

- T7.01
 - Step 5.1 flow reg. – Please add a note in the comments that the dam is “Morses Mill” dam. I could not find any other information as to what the dam is for; but if you have any information please add to notes. Helps provide context for the dam and what it may be used for and/or how it may impact the stream. **Note added. I also could not find any information about the dam.**
 - Step 5.5 bridge/culvert. The FIT point for the upstream bridge (covered bridge) looks to be just upstream of the bridge. Please look to make sure the point is on the bridge. **Point moved to bridge.**

- T7.02
 - Step 6.1 road - There are road/driveway along the right (looking downstream) that can be captured. Please review and update FIT. **This looks to be a power line on closer inspection. Impact added and note made in comments that it is a power line.**

- T7.03
 - Step 2.11 stream type. – noted as Ba. With a 10+% slope this is likely an “A”. Valley type is difficult to tell in these areas, but slope is high enough that limited flood plain likely. Please update to an “A”. **Updated to “A.”**
 - Step 5 – blank. Please enter “none” (or “no data/not evaluate”). **Entered “none.”**

- T7.04
 - Step 2.10 – confinement type – currently blank. Please look to indicate confinement type. If not able to determine a possible confinement type, please provide a note in the comments that confinement type not able to be determined from remote sensing information. **Entered “semi-confined.”**

- T7.05

- Step 2.10 confinement type – currently blank. Please look to indicate confinement type. If not able to determine a possible confinement type, please provide a note in the comments that confinement type not able to be determined from remote sensing information. Entered “narrowly-confined.”
- Step 2.11 stream bed material and bedform – noted as bedrock and step pool. Did you make the observations in the windshield survey? Generally do not see step pools in a bedrock dominated streams; these are often more of a cascade; and boulder/cobbles are often more observed with step-pools. Confirm if bedrock and/or step-pool still makes sense given what you know about the stream. Bed material changed to “boulder.”
- Step 6.1 – improved path - is noted in two locations. The path is not easy to observe on the NAIP photo. I see in the FIT description that this is a ski/walk path. Was there other information that showed the path along these couple stretches of river? Please note this in the comments to help indicate what the path is and how it was identified. The path was noted from the E911 Local Trails layer. Note added in FIT, and also for T7.04.
- T7.06
 - Step 2.10 confinement type – currently blank. Please look to indicate confinement type. If not able to determine a possible confinement type, please provide a note in the comments that confinement type not able to be determined from remote sensing information. Entered “narrowly-confined.”
 - Step 5 – blank. Please enter “none” (or “no data/not evaluate”). Entered “none.”
- T7S1.01
 - Step 2.11 stream type – noted as “D”. This does not appear to be a braided system. This is more likely a Cb or B, as the slope is almost 4%. Update to “Cb”. Updated to Cb.
 - Step 5.2 bridge/culvert - There is a structure at the lower end of the reach. It looks to be a bridge. Please FIT. If not able to determine if bridge/culvert, make a note in the comments that structure type uncertain at this time, field verification needed. Point added and note made.
 - Step 6.1/6.2 – Development/encroachments – along the right side (looking downstream), both road and development are within the corridor. Please review and update. Added road and development.
- T7S1.02
 - Step 2.10 confinement type – currently blank. Please look to indicate confinement type. If not able to determine a possible confinement type, please provide a note in the comments that confinement type not able to be determined from remote sensing information. Entered “narrowly-confined.”
 - Step 2.11 stream type. – noted as Ba. With a 11+% slope this is likely an “A”. Valley type is difficult to tell in these areas, but slope is high enough that limited flood plain likely. Please update to an “A”. Updated to “A.”
 - Step 5.2 bridge/culvert – There is a structure at the upper end of the reach. It looks to be a bridge. Please FIT. If not able to determine if bridge/culvert, make a note in the comments that structure type uncertain at this time, field verification needed. Point added and note made.