Brewster River
River Corridor Plan

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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 and the Village of Jeffersonville, 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. 2011 flood damage was less severe in the middle and upper portions of the watershed. 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 and Phase 2 SGA study and to develop a River Corridor Plan for the Brewster River. The Phase 1 study and a portion of the Phase 2 study were completed in 2012-2013 and summarized in a report delivered in March of 2013. The remaining Phase 2 assessments were conducted in 2014 and are described in this report. The objectives of the Phase 2 SGA and River Corridor Plan are described below:

1) Develop a basis for understanding the overall causes of channel instability and habitat degradation along the river corridors in the watershed;
2) Collect the information needed to map river corridor zones in Cambridge;
3) Develop a list of preliminary corridor restoration projects that can be further developed in the future to mitigate flood and erosion hazards; and
4) Further develop project packets for three high priority projects to support future implementation.

This report covers the middle and upper reaches of the Brewster River from a gorge north of Highlander Drive (Reach M04) up to the Smugglers' Notch Resort (SNR) snowmaking pond (Reach M14), as well as several tributary reaches flowing through SNR. During our assessments, we noted a distinct transition point along the Brewster River corridor upstream of the (upper) Edwards Road crossing in Reach M11. Moving downstream from this point, the channel and valley slope, valley width, and sediment transport capacity transitions as the power of the river to carry sediment and debris lessens. The lower reaches

are generally characterized by wider valleys, lateral erosion and deposition processes, and planform adjustments. These reaches are dynamic and highly erosive during flood events due to ongoing adjustments to the channel bed and banks. Above this point, the upper reaches have greater potential for channel incision and erosion of the bed and banks. These headwaters reaches are generating large volumes of sediment and debris and transporting this material to downstream areas. The differences observed along these two zones of the river corridor have strong implications for the management approaches: passive restoration approaches (i.e., corridor protection) are emphasized in the lower reaches to avoid future conflicts with development along the river; whereas both active (i.e., reconnecting floodplains) and passive restoration approaches are recommended in the headwaters reaches to address sediment sources and storage zones, and areas of potential conflict due to channel instability.

Below is a summary of key findings from the Phase 2 SGA and River Corridor Plan:

Many of the reaches in the Brewster River watershed are dynamic and highly erosive during flood events due to ongoing adjustments to their dimensions, patterns, and profiles. These adjustments are in response to impacts from historical sedimentation in valleys from early European settlement and deforestation that caused hillslope erosion, as well as modern day impacts from channel straightening, dredging, berming, and corridor encroachment associated with adjacent roads and development. Recent large runoff events such as the spring 2011 floods and Tropical Storm Irene have also triggered channel incision, widening/deposition, mass wasting of valley side slopes, inputs of woody debris to the channel, and redevelopment of floodplain access in some areas. Ongoing vertical and lateral channel migration is likely in the future for many reaches within the watershed. Given these predictions for future channel adjustments, the following watershed-scale and site-specific management observations and approaches are summarized from the Phase 2 data and RCP.

- The spring 2011 floods triggered major channel adjustments in many of the Phase 2 reaches. The flooding unleashed a large volume of coarse sediment and woody debris into the channel as a result of stream bed and bank erosion and mass failure valley erosion. In some instances, the 2011 floods triggered severe channel adjustments even in reaches with limited corridor impacts. These reaches, such as M06, M12.A, and M13, tended to be on lower gradient reaches where large volumes of flood sediments were deposited.
- Grade control was very limited throughout the Phase 2 study reaches. Significant natural grade controls were found in segments M07.A (gorge), M14, T7.01, and the two mountain headwaters segments (T7S4.02.01 and T7S4.03). Man-made grade controls were indexed on M14 (large dam), T7.01 (failing timber crib dam), T7S1.01 (trout pond outlet), and small weirs on segments T7S1.02, T7S4.02.01, and T7S4.03.
- Lack of grade control, encroachment, and sediment transport alterations led to major incision along steeper segments, resulting in six (6) stream type departures due to incision. The subsequent massive deposition within the less steep and unconfined segments resulted in an additional two (2) stream type departures to D-type. Additional areas of deposition in the lower segments did not lead to a stream type departure, however large channel migration features were observed.
- 15 bridges and 5 culverts were assessed for geomorphic compatibility and aquatic organism passage (AOP) as part of the Phase 2 SGA work. Approximately one-third of the bridges had spans less than the reference bankfull channel width, indicating a high degree of structure vulnerability to flooding and erosion at these bridges. Only one of the five assessed culverts was not a major bankfull constriction. Four of the culverts do not allow for any aquatic organism passage (AOP).

- Site level approaches to restoration of dynamic equilibrium conditions were evaluated in detail at the reach scale. This effort resulted in the identification of 30 restoration project areas, including 10 projects that do not require significant further study (i.e., passive approaches such as buffer plantings and corridor protection), and 20 projects requiring further feasibility study or engineering design (i.e., active restoration approaches such as bridge replacements).

1.0 Project Background

1.1 Introduction

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 and river corridor planning efforts in the watershed. Fitzgerald Environmental Associates, LLC (FEA) was retained by LCPC to assist with Phase 1 assessments and carry out Phase 2 assessments following the Stream Geomorphic Assessment (SGA) Protocols developed by the Rivers Program in the Vermont Department of Environmental Conservation.

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 were collected by LCPC and FEA for the Brewster River main stem 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). The results of full Phase 1 assessment and the initial Phase 2 assessment are presented in the Brewster River Phase 1&2 Stream Geomorphic Summary Report, submitted to VTDEC in March of 2013 (FEA, 2013). An additional 14 reaches totaling 6.2 miles were selected for Phase 2 assessment in 2014. This report summarizes the SGA results and River Corridor Plan (RCP) for the reaches assessed in 2014.

1.2 Study Goals

Watershed restoration projects are most successful when carried out within a context for understanding how reach and watershed-scale stressors cause channel instability and increase flood hazards. 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,” (VTANR, 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). Ultimately, the Phase 1 results help guide planners in selecting reaches for more detailed Phase 2 data collection where this information can be valuable for flood vulnerability mapping, identification of river restoration projects, and long-term river corridor planning. The goal of the Phase 2 and RCP effort is to:

1) Develop a basis for understanding the overall causes of channel instability and habitat degradation along the river corridors in the watershed.

2) Collect the information needed to map river corridor zones in Cambridge.
3) Develop a list of preliminary corridor restoration projects that can be further developed in the future to mitigate flood and erosion hazards.
4) Further develop project packets for three high priority projects to support future implementation.

2.0 Methods

2.1 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 these protocols forms the basis for preliminary project identification carried out during Phase 2 SGA and 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 1 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.

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.

Table 1: 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

2.2 Quality Assurance

The VTDEC Quality Assurance (QA) protocols outlined in the SGA protocols (VTDEC, 2009) were followed in order to ensure a complete and accurate dataset. FEA and VTDEC shared responsibility for QA for the SGAT shapefiles and the finalized Phase 2 dataset. The DMS database for all Phase 2 assessed reaches in the watershed was finalized in February, 2015. The QA summaries for Phase 2 are included in Appendix A.

2.3 Bridge and Culvert Assessments

FEA conducted bridge and culvert surveys on all private and public bridges and culverts within the selected Phase 2 reaches. The Bridge and Culvert Assessment and Survey Protocols specified in

Appendix G of the Vermont Stream Geomorphic Assessment Handbook (VTDEC, 2009) were followed. Latitude and Longitude of each structure was recorded in the field with a GPS unit or digitized based on aerial imagery. The assessment included various photographs documenting the condition of each structure.

The Vermont Culvert Geomorphic Screening Tool (MMI, 2008a) and the Vermont Culvert Aquatic Organism Passage Screen Tool (MMI, 2008b) developed by Milone and MacBroom, Inc. for VTDEC were used to identify culverts within the study area that have a higher priority for replacement/retrofit due to geomorphic incompatibility and/or for being potential barriers to movement and migration of aquatic organisms.

2.4 Stressor and Departure Analysis

FEA followed the VTDEC methods for developing river corridor plans as outlined in the Vermont River Corridor Planning Guide (VTANR, 2010). This technical guide is directed towards river scientists, planners, and engineers engaged in finding economically and ecologically sustainable solutions to the conflicts between human investments and river dynamics. The guide provides explanations for the following:

- River science and societal benefits of managing streams in a sustainable manner toward equilibrium conditions
- Methods for assessing and mapping stream geomorphic conditions, and identifying and prioritizing river corridor protection and restoration projects
- Methods for examining project feasibility and negotiating management alternatives with stakeholders
- Information on current programs available to Vermont landowners, towns, and other interested parties to implement river corridor protection and restoration projects

Included in this approach is an extensive mapping exercise to lay the foundation for understanding stressors on stream channel stability at the watershed and reach scales. These maps are compiled as part of the stressor and departure analysis, and illustrate a gradient of human impacts and stream response across the watershed. The maps provide a basis for identifying projects through a step-wise procedure to screen potential projects for compatibility with long-term equilibrium conditions.

2.4.1 Stressor Analysis

The data collected through the Phase 1 and 2 SGA studies provides the basis for assessing the impacts to the hydrologic and sediment regimes, and the channel riparian and boundary conditions. This data, when combined with other watershed-scale data developed in this study, allows for the assessment of physical departure from reference conditions, and serves to validate watershed-scale patterns and stream conditions observed in the field.

Stressor, departure and sensitivity maps have been prepared to depict the effects of significant physical processes occurring within the Brewster River study area. These maps provide an indication of where channel adjustment processes have been altered, at both the watershed-scale and the reach-scale. The analysis of existing and historic departures from equilibrium conditions along a stream network allows for the prediction of future channel adjustments. This is helpful in developing and prioritizing potential river corridor protection and restoration projects.

2.4.2 Departure Analysis

Much research has shown that alluvial river channels in wide valleys will adjust their geometry and planform to accommodate changes in the discharge and sediment loading from the upslope watershed (Dunne and Leopold, 1978). This concept was summarized by Lane (1955) to show that stream power and sediment (size and distribution) will seek a dynamic equilibrium condition in the absence of anthropogenic disturbance or catastrophic natural storm events. Slight changes from one year to another, such as variation in rainfall amounts (and a resulting variation in discharge), may cause subtle changes in channel form. However, the cross-sectional shape and profile of a river is typically stable under reference watershed conditions, and predictable given knowledge about: 1) the geologic conditions of the watershed and river corridor, 2) the topography of the watershed and river corridor, and 3) the regional climate.

Analysis of a watershed's sediment regime is a useful approach for summarizing the reach and watershed-scale stressors affecting the equilibrium conditions of river channels. Sediment regime mapping provides a context for understanding the sediment transport and channel evolution processes (Schumm, 1977) which govern changes in geometry and planform for river channels in a state of disequilibrium. The VTANR River Corridor Planning Guide (VTANR, 2010) outlines a methodology for understanding the reference and altered sediment regimes of reaches according to data collected during the Phase 2 field assessments. The sediment regime types used in this analysis are summarized below in Table 2.

Table 2: Sediment regime types for corridor planning (VTANR, 2010).

Sediment Regime	Narrative Description
Transport	Steeper bedrock and boulder/cobble cascade and step-pool stream types; typically in more confined valleys, do not supply appreciable quantities of sediments to downstream reaches on an annual basis; little or no mass wasting; storage of fine sediment is negligible due to high transport capacity derived from both the high gradient and/natural entrenchment of the channel.
Confined Source and Transport	Cobble step pool and steep plane bed streams; confining valley walls, comprised of erodible tills, glacial lacustrine, glacial fluvial, or alluvial materials; mass wasting and landslides common and may be triggered by valley rejuvenation processes; storage of coarse or fine sediment is limited due to high transport capacity derived from both the gradient and entrenchment of the channel. Look for streams in narrow valleys where dams, culverts, encroachment (roads, houses, etc.), and subsequent channel management may trigger incision, rejuvenation, and mass wasting processes.
Unconfined Source and Transport	Sand, gravel, or cobble plane bed streams; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to entrenchment or incision and associated bed form changes; these streams are not a significant sediment supply due to boundary resistance such as bank armoring, but may begin to experience erosion and supply both coarse and fine sediment when bank failure lead to channel widening; storage of coarse or fine sediment is negligible due to high transport capacity derived from the deep incision and little or no floodplain access. Look for straightened, incised or entrenched streams in unconfined valleys, which may have been bermed and extensively armored and are in Stage II or early Stage III of channel evolution.
Fine Source and Transport & Coarse Deposition	Sand, gravel, or cobble streams with variable bed forms; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to vertical profile and associated bed form changes; these streams supply both coarse and fine sediments due to little or no boundary resistance; storage of fine sediment is lost or severely limited as a result of channel incision and little or no floodplain access; an increase in coarse sediment storage occurs due to a high coarse sediment load coupled with the lower transport capacity that results from a lower gradient and/or channel depth. Look for historically straightened, incised, or entrenched streams in unconfined valleys, having little or no boundary resistance, increased bank erosion, and large unvegetated bars. These streams are typically in late Stage III and Stage IV of channel evolution.

Table 2: Sediment regime types for corridor planning (VTANR, 2010).

Sediment Regime	Narrative Description
Coarse Equilibrium (in = out) & Fine Deposition	Sand, gravel, or cobble streams with equilibrium bedforms; at least one side of the channel is unconfined by valley walls; these streams transport and deposit coarse sediment in equilibrium (stream power—produce as a result of channel gradient and hydraulic radius—is balanced by the sediment load, sediment size, and channel boundary resistance); and store a relatively large volume of fine sediment due to the access of high frequency (annual) floods to the floodplain. Look for unconfined streams, which are not incised or entrenched, have boundary resistance (woody buffers), minimal bank erosion, and vegetated bars. These streams are Stage I, late IV, and Stage V.
Deposition	Silt, sand, gravel, or cobble streams with variable and braided bed forms; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to changes in slope and/or depth resulting in the predominance of transient depositional features; storage of fine and coarse sediment frequently exceeds transport**. Floodplains are accessed during high frequency (annual) floods. Look for unconfined streams, which are not incised or entrenched, have become significantly over-widened, and if high rates of bank erosion are present, it is offset by the vertical growth of unvegetated bars. These regimes may be located at zones of naturally high deposition (e.g., active alluvial fans, deltas, or upstream of bedrock controls), or may exist due to impoundment and other backwater conditions above weirs dams and other constrictions.

** Use of the "Deposition" regime characterization may be rare, but valuable as a planning tool, where the reach is storing far more than it is transporting during some defined planning period. The extreme example would be that of an impounded reach where all of the coarse and a great percentage of the fine sediments are being deposited, rather than transported downstream. This man-made condition may change, thereby changing the sediment regime, but is not likely over the period at which the corridor plan will be used.

Channel evolution models (CEM) also provide a basis for understanding the temporal scale of channel adjustments and departure in the context of SGA Phase 2 results. Both the "D" stage and "F" stage CEMs (VTDEC, 2009) are helpful for explaining the channel adjustment processes underway in the Brewster River watershed. The "F" stage CEM is used to understand the process that occurs when a stream degrades (incises) its bed. The more dominant adjustment process for the "D" stage channel evolution is aggradation, widening and planform change. D-stage CEM typically occurs where grade controls prevent severe channel incision and abandonment of the adjacent floodplain. The common stages of both CEMs are depicted in Figure 1 below.

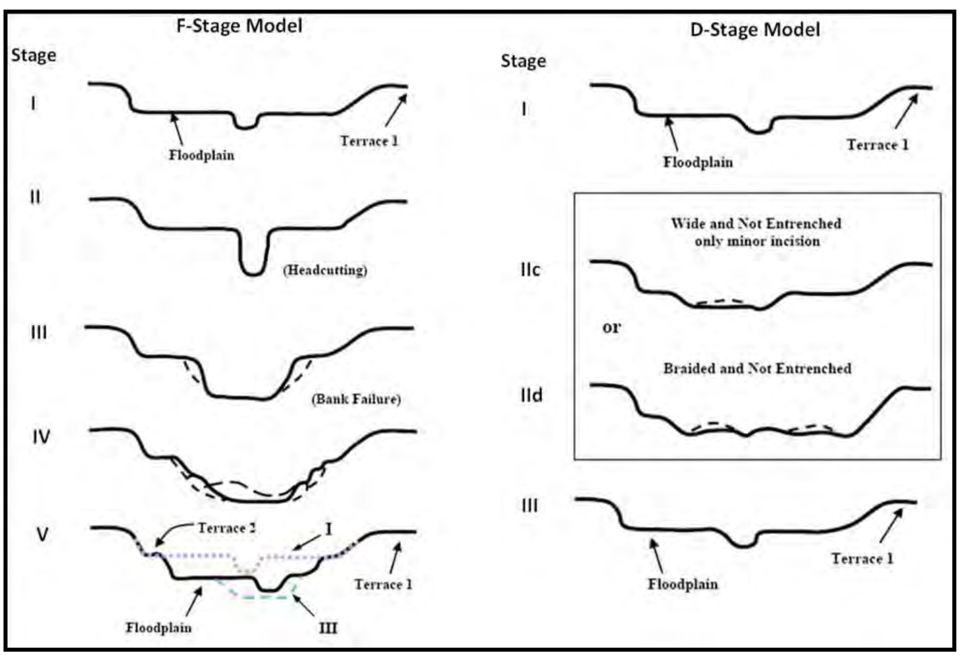


Figure 1: Typical channel evolution models for F-stage and D-stage (VTDEC, 2009).

2.4.3 Sensitivity Analysis

The following description of the sensitivity of various stream types to changes in sediment and flow regimes, boundary conditions and channel morphology, is included from the most recent version of the VTANR River Corridor Planning Guide (VTANR, 2010).

> Certain geomorphic stream types are inherently more sensitive than others, responding readily through lateral and/or vertical adjustments to high flow events and/or influxes of sediment. Other geomorphic stream types may undergo far less adjustment in response to the same watershed inputs. In general, streams receiving a large supply of sediment, having a limited capacity to transport that sediment, and flowing through finer-grained, non-cohesive materials are inherently more sensitive to adjustment and likely to experience channel evolution processes than streams with a lower sediment supply, higher transport capacity and flowing through cohesive or coarse-grained materials (Montgomery and Buffington, 1997). The geometry and roughness of the stream channel and floodplain (i.e., the width, depth, slope, sediment sizes, and floodplain relations) dictate the velocity of flow, how much erosive power is produced, and whether the stream has the competence to transport the sediment delivered from upstream (Leopold, 1994). If the energy produced by the depth and slope of the water is either too little or too great in relation to the sediment available for transport, the stream may be out of equilibrium and channel adjustments are likely to occur, especially during flood conditions (Lane, 1955).

Stream sensitivity maps have been prepared for the Brewster River study area. Sensitivity ratings were assigned using the VTDEC Protocols (VTDEC, 2009).

2.5 Project Identification

Site-specific projects were identified using methods outlined by VTANR in Chapter 6 Preliminary Project Identification and Prioritization (VTANR, 2010). This planning guide is intended to aid in the development of projects that protect and restore river equilibrium conditions. The projects identified for the study reaches can be classified under one of the following categories: Active Geomorphic Restoration, Passive Geomorphic Restoration, and Conservation.

Active Geomorphic Restoration implies the management of rivers to a state of geomorphic equilibrium through active, physical alteration of the channel and/or floodplain. Often this approach involves the removal of human constructed constraints or the construction of meanders, floodplains or stable banks. Riparian buffer re-vegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic Restoration allows rivers to return to a state of geomorphic equilibrium by removing factors adversely impacting the river and subsequently using the river's own energy and watershed inputs to re-establish its meanders, floodplains and equilibrium conditions. In many cases, passive restoration projects may require varying degrees of active measures to achieve ideal results. Riparian buffer re-vegetation and long-term protection of a river corridor (e.g., corridor easements) is essential to this alternative.

Conservation is an option to consider when stream conditions are generally "good" or "reference" and the channel is in a state of dynamic equilibrium. Typically, conservation is applied to minimally disturbed reaches where river structure and function and vegetation associations are relatively intact, and/or where high quality aquatic habitat is found.

3.0 Phase 2 Results and River Corridor Planning

The previous Phase 1 assessment of the Brewster River watershed prioritized reaches for further evaluation based on reference stream type, bedform, and impact scores. Phase 2 assessments were completed in 2013 on reaches M01 through M04 and are described in the 2013 Phase 1 and 2 Stream Geomorphic Assessment summary report (FEA, 2013). This section summarizes Phase 2 results for the remaining 10 reaches identified in the 2013 report and four additional sub-tributary reaches along Tributary 7.

3.1 Brewster River Watershed Background

A summary of background information for the Brewster River watershed is provided in a companion report, the Brewster River Phase 1 and 2 report (FEA, 2013). Please refer to this report for background information on the following topics:

- Geographic Setting and Land Use History
- Geologic and Geomorphic Setting
- Hydrology and Flood History
- Ecological Setting

3.2 Phase 2 Study Area Summary

Phase 2 assessments were conducted on 14 reaches from June through July of 2014. Two reaches were segmented in the field for a total of 16 Phase 2 reaches and segments covering 6.2 miles of stream channel (Figure 3). The following section includes a summary sheet for each assessed reach or segment and a summary of the watershed and reach-scale stressors on channel stability.

3.2.1 Brewster River Mainstem (Reaches/Segments M05-M14)

The 2014 Phase 2 assessed reaches on Brewster River started immediately upstream of Brewster River Gorge/Jefferson Falls and continued upstream to a large snowmaking impoundment on reach M14 in the Smugglers' Notch Ski Resort. The lower and middle reaches (M05 - M11) along the mainstem were predominantly lower slope depositional reaches located in an unconfined valley (Figure 2). Route 108 followed the left valley wall throughout this portion of the river corridor; however a forested buffer along most of the reaches reduced impacts from encroachment, armoring, straightening, and stormwater inputs. A short bedrock gorge was observed immediately downstream of the Brewster River Campground in segment M07-A. A larger bedrock gorge is located in reach M08, which was not included in this Phase 2 assessment. Bedrock grade control was otherwise very limited through these reaches.

Moderate to high incision was observed for most of the Brewster River study reaches. Some of this incision was related to widening and loss of lower floodplain benches during recent episodic flooding. Forested floodplain areas were observed along most of the reaches, however these floodplains were typically only accessible during larger events. Extreme incision was limited to reach M14, which has undergone significant degradation due to historic encroachment impacts and a major interruption to sediment transport due to the impoundment at the top of the reach.

3.2.2 Tributary 7 and Sub-Tributaries

Reaches T7.01 and T7S1.01 are located in highly developed areas in the Smugglers' Notch Village. Both reaches have significant encroachment and armoring impacts and as a result are extremely incised. Reach T7S1.02 flows through a forested valley, however it is impacted by historic armoring and encroachment from Route 108.

The two mountainous reaches (T7S4.03 and T7S4.02.01) have near continuous bedrock grade control. Some impacts from sediment and stormwater were observed, however both reaches appeared very stable.

Figure 2: Range of channel types and valley settings found within the Phase 2 study area, clockwise from top left: Widening and deposition in an unconfined valley (M06); recent incision with ongoing widening and deposition in a steeper yet unconfined valley (M12.B); recent widening with ongoing incision (T7.01); and steep boulder/bedrock channel in a narrowly confined valley (T7.S4.03).

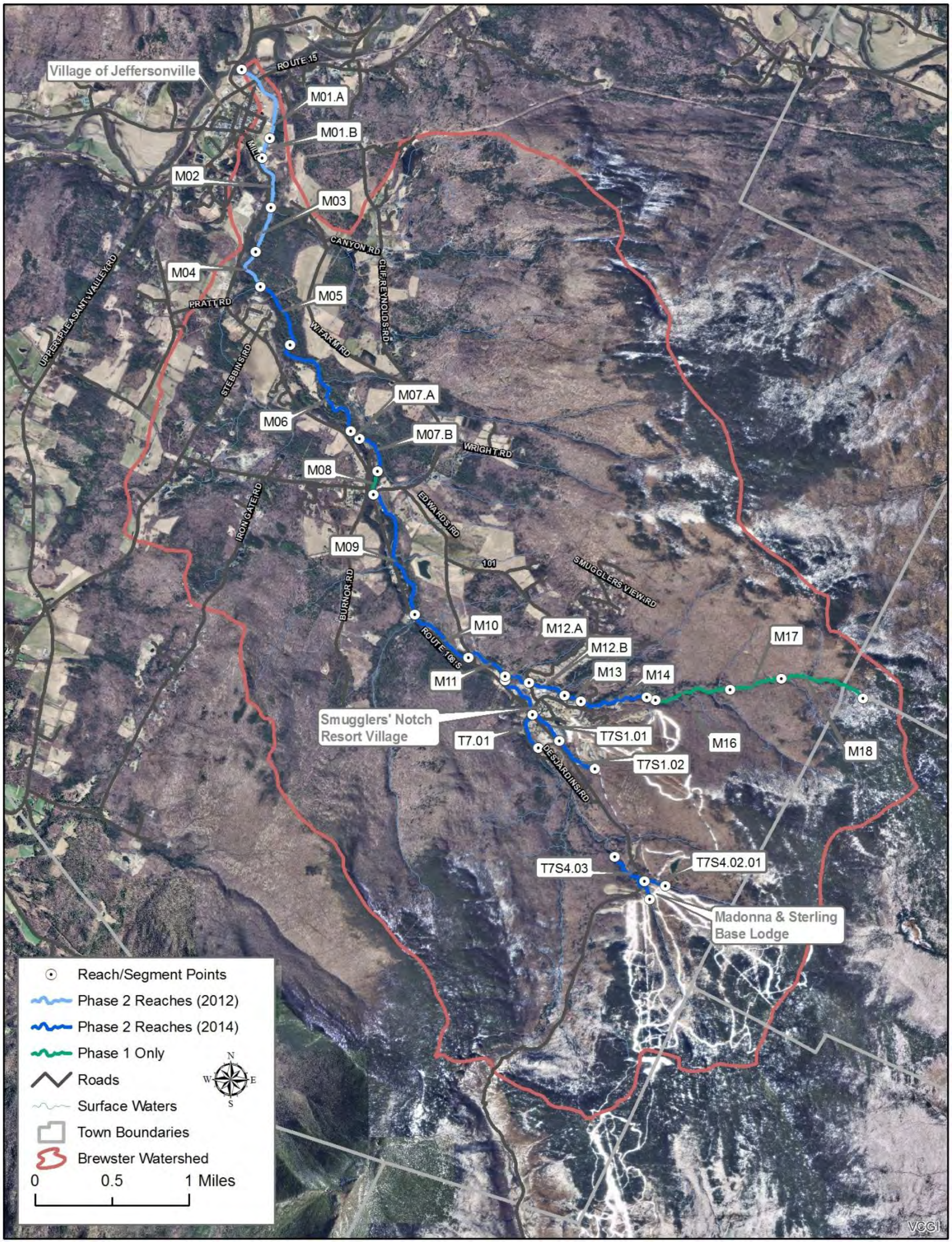


Figure 3: Brewster River SGA study area map.

3.3 Phase 2 Segment Summary Sheets

One page summaries for each Phase 2 segment/reach are presented in this section. The impact summary section assigns Not Significant, **Low**, or **High** levels of impact based on data collected during the Phase 2 assessments. Impact levels were assigned based on the longitudinal effect (<5% - Not Significant, 5-20% - Low, and >20% - High), and the overall impact of discrete features on the reach/segment (constrictions, stormwater inputs, steep riffles, etc.). Potential impacts for arches, bridges, and culverts were summarized with the following abbreviations:

- **AOP**: Aquatic organism passage
- **D**: Deposition upstream and/or downstream
- **E**: Bank erosion upstream and/or downstream
- **I**: Ice/Debris jamming
- **R/R**: Failing bank armor upstream and/or downstream
- **S**: Scour upstream and/or downstream

Habitat assessment rankings (i.e., size classes small to large) for large woody debris and pool counts are defined in Table 3.

Table 3: LWD and Pool Ranking for RHA.

Rank	LWD		Pool	
	Diameter (ft)	Length (relative to wbkf)	Depth (ft)	Length/Width (relative to wbkf)
1	0.5≤D<1.0	<0.5	1.0≤D<2.0	<0.5
2	0.5≤D<1.0	≥0.5	1.0≤D<2.0	≥0.5
3	1.0≤D<2.0	<0.5	2.0≤D<3.0	<0.5
4	1.0≤D<2.0	≥0.5	2.0≤D<3.0	≥0.5
5	D≥2.0	<0.5	D≥3.0	<0.5
6	D≥2.0	≥0.5	D≥3.0	≥0.5
7			D≥3.0	≥1.0

Stream: Brewster River **Reach:** M05 **Town:** Cambridge **Date Assessed**:07/17/14

Channel Length (ft): 2,553 **Channel Slope (%):** 1.18 **Sinuosity:** 1.05 **Watershed Area (mi^2):** 14.91

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	C	C

Ph2 Cross-Section Data

Curve Width (ft)	43.0
Bankfull Width (ft)	58
Max Depth (ft)	2.9
Width/Depth Ratio	29.9
Entrenchment Ratio	2.7
Incision Ratio	1.3

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
None in reach.			

\# of Other Constrictions: 0
\# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	2	4
2	2	12
3	2	1
4	7	5
5	0	0
6	2	1
7	-	0
#/mile	31	47

Number of Debris Jams: 1

Step 6/7 Summary

RHA Score/Condition	65/Good
Habitat Type Departure	None
RGA Score / Condition	70/Good
Dominant Adjustment	Widening
CEM Model Stage	F /III
Stream Type Departure	None
Stream Sensitivity	Moderate

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	**Deposition**
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- The only appropriate project in this reach would be corridor protection. No corridor protection projects have been identified as the entire river valley is conserved under the Brewster River Uplands Conservation Trust (through Vermont Land Trust).

Reach Highlights: This reach experienced the same widening and deposition during 2011 floods as we observed in M06. However, the damage was reduced in M05, likely due to sediment and floodwave attenuation in the upstream reach. Widening is the dominant process as the channel adjusts within the new geometry and as flood sediments work through the reach. Some planform adjustment is being initiated in the upstream end of the reach.

Moderate widening and some planform adjustment at the cross-section

Major LWD deposits along the entrance to a large forested floodplain on the left bank

Stream: Brewster River **Reach:** M06 **Town:** Cambridge **Date Assessed**:06/03/14

Channel Length (ft): 4,615 **Channel Slope (%):** 1.08 **Sinuosity:** 1.20 **Watershed Area (mi^2):** 14.77

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	C	C

Ph2 Cross-Section Data

Curve Width (ft)	42.8
Bankfull Width (ft)	59.6
Max Depth (ft)	2.6
Width/Depth Ratio	34.1
Entrenchment Ratio	2.9
Incision Ratio	1.7

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
Bedrock		58%	D

\# of Other Constrictions: 0
\# of Grade Controls: 1

Rapid Habitat Assessment

Rank	LWD	Pools
1	9	4
2	21	6
3	7	2
4	11	1
5	0	0
6	1	1
7	-	1
#/mile	56	17

Number of Debris Jams: 3

Step 6/7 Summary

RHA Score/Condition	69/Good
Habitat Type Departure	None
RGA Score / Condition	39/Fair
Dominant Adjustment	Planform
CEM Model Stage	F /IV
Stream Type Departure	None
Stream Sensitivity	Very High

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	**Steep Riffle**
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #1 - Buffer Planting - Mass failure on VLT owned hayfield has removed all existing woody vegetation, bank could continue to slide.
- #2 - Structure Removal - Remove an abandoned building located on the left bank in an active floodplain area.
- #3 - Conservation- reach is very active and has a nice riparian buffer throughout. Most of right floodplain is currently conserved in the Brewster Uplands Conservation Trust, Additional floodplain on the left bank is not conserved.

Reach Highlights: This reach dramatically widened and aggraded during the 2011 floods and is now re-establishing planform through the widened channel and deep cobble/gravel deposits. Major flood chutes, avulsions, and some braiding were observed. W/D ratio is decreasing as the channel reforms through the flood deposits.

Widened reach with significant deposition from recent flooding

Bank scour observed through most of reach indicating recent widening

Stream: Brewster River **Reach:** M07.B **Town:** Cambridge **Date Assessed**:06/03/14

Channel Length (ft): 1,517 **Channel Slope (%):** 1.25 **Sinuosity:** 1.08 **Watershed Area (mi^2):** 13.18

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Plane Bed	Plane Bed
Median Substrate	Cobble	Cobble
Stream Type	Bc	Bc

Ph2 Cross-Section Data

Curve Width (ft)	40.7
Bankfull Width (ft)	51
Max Depth (ft)	2.4
Width/Depth Ratio	32.2
Entrenchment Ratio	1.5
Incision Ratio	1.4

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
None in reach.			

# of Other Constrictions: 0
# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	4	1
2	0	1
3	0	0
4	0	0
5	0	0
6	0	1
7	-	1
#/mile	13	13

Number of Debris Jams: 0

Step 6/7 Summary

RHA Score/Condition	52/Fair
Habitat Type Departure	None
RGA Score / Condition	56/Fair
Dominant Adjustment	Widening
CEM Model Stage	F /III
Stream Type Departure	None
Stream Sensitivity	High

Impact Summary

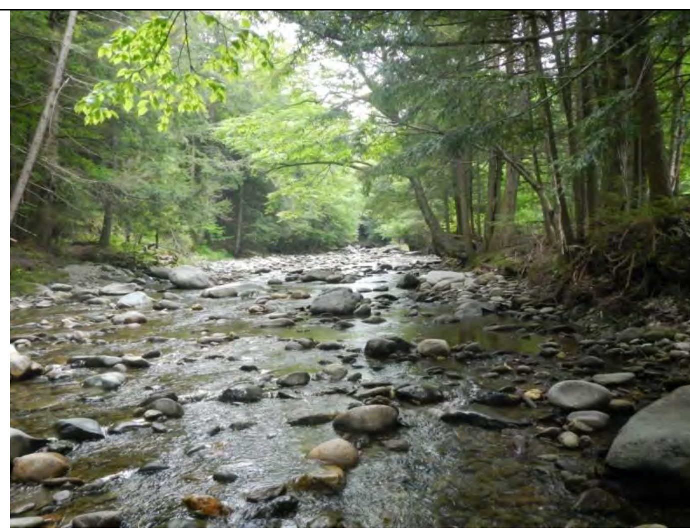
Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	Deposition
Encroachment	Migration
Development	**Steep Riffle**
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- No priority projects were identified within this segment, however flood resiliency planning efforts may benefit the campground. These may include maintenance and enhancement of the riparian buffer, flood proofing important buildings and infrastructure, and limiting further encroachment on the channel.

Reach Highlights: This segment incised and widened during 2011 flooding and scoured away lower benches. The current channel has access to a narrow floodplain bench. The campground is located on a historic terrace and is only accessible in the largest events. The entire segment has light development and floodplain clearing associated with the Brewster River Campground on the left bank. Recent widening reduced floodplain width and the channel is currently still widening, but may transition to stage IV with continuing aggradation.

Recent bank scour along the campground property



Relatively featureless channel bed

Stream: Brewster River **Reach:** M09 **Town:** Cambridge **Date Assessed**:06/03/14

Channel Length (ft): 4,841 **Channel Slope (%):** 1.84 **Sinuosity:** 1.09 **Watershed Area (mi^2):** 11.83

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Gravel	Gravel
Stream Type	C	C

Ph2 Cross-Section Data

Curve Width (ft)	38.8
Bankfull Width (ft)	48
Max Depth (ft)	2.9
Width/Depth Ratio	36.6
Entrenchment Ratio	3.0
Incision Ratio	1.7

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
Ledge		52	D
B	Edwards	232	None

# of Other Constrictions: 0
# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	7	4
2	9	5
3	0	2
4	3	1
5	0	1
6	0	0
7	-	0
#/mile	20	14

Number of Debris Jams: 2

Step 6/7 Summary

RHA Score/Condition	53/Fair
Habitat Type Departure	None
RGA Score / Condition	47/Fair
Dominant Adjustment	Planform
CEM Model Stage	F /IV
Stream Type Departure	None
Stream Sensitivity	Very High

Impact Summary

Bank Erosion	**Stormwater**
Armoring	Constrictions
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	**Steep Riffle**
Corridor LC	**Head Cut**
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #4 - Buffer planting - Mass failure in lower reach extends to hayfield on top of bank
- #5 - Conservation - Forested floodplain in lower reach provides valuable storage for flood flow and sediments. Much of this area is under management by the Brewster Uplands Conservation Trust.
- #6 - Bank stabilization - Severe erosion and channel migration is threatening a well-head on the Austin property
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas

Reach Highlights: This reach widened during the 2011 floods followed by major aggradation of flood related cobble and gravel. Planform adjustments are occurring as the river carves meanders through these sediments within the widened channel. A large channel avulsion occurred where the river dumped a huge volume of cobbles in the historic channel and is carving a new channel through the right bank with an active but small headcut that is a temporary feature as the bed adjusts slope through the new channel.

Channel avulsion with a minor headcut and major deposition through historic channel

Channel migration causing bank failure on the Austin property

Stream: Brewster River **Reach:** M10 **Town:** Cambridge **Date Assessed**:06/10/14

Channel Length (ft): 2,517 **Channel Slope (%):** 2.22 **Sinuosity:** 1.02 **Watershed Area (mi^2):** 10.51

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	Cb	B

Ph2 Cross-Section Data

Curve Width (ft)	36.9
Bankfull Width (ft)	39
Max Depth (ft)	2.8
Width/Depth Ratio	21.3
Entrenchment Ratio	1.5
Incision Ratio	1.8

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
None in reach.			

# of Other Constrictions: 0
# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	3	4
2	15	3
3	2	1
4	7	0
5	0	1
6	0	1
7	-	0
#/mile	56	20

Number of Debris Jams: 3

Step 6/7 Summary

RHA Score/Condition	59/Fair
Habitat Type Departure	None
RGA Score / Condition	40/Fair
Dominant Adjustment	Widening
CEM Model Stage	F /III
Stream Type Departure	C to B
Stream Sensitivity	High

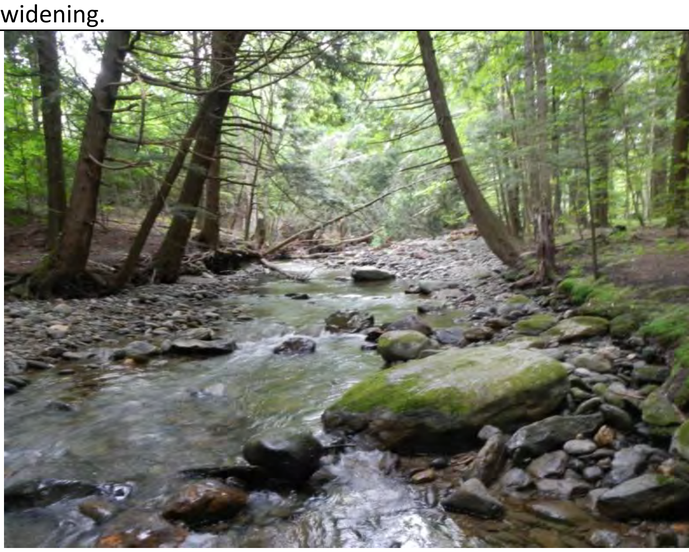
Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	Deposition
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #7 - Berm Removal - A historic berm on the right floodplain blocks access to a high floodplain during large events.
- #8 - Corridor Protection - A short stretch of accessible floodplain was observed on both banks along the avulsion/historic channel area. Some accessible right floodplain extends downstream from this area.
- #9 - Bank Stabilization - Recently abandoned channel downstream of Edwards Rd bridge could easily be re-accessed and armor along Route 108 is insufficient

Reach Highlights: Lack of grade control caused this reach to incise during 2011 flooding. Lower banks were also scoured leaving a deeply incised reach that has started to fill back in with coarse deposits working through the reach. Bank scour and erosion were observed throughout the reach. A large avulsion was observed at the top of the reach where the river reclaimed a historic abandoned channel. This stretch is approximately 450ft long and has less widening and retains access to narrow floodplain benches, however the primary floodplain is elevated. The remainder of the reach is encroached by Route 108 on the left floodplain and had increased incision and entrenchment. Degradation was classified as historic as the reach is now aggrading and widening.



Recently accessed historic channel in upper reach

Typical incised B-type geometry

Stream: Brewster River **Reach:** M11 **Town:** Cambridge **Date Assessed**:06/10/14

Channel Length (ft): 1,616 **Channel Slope (%):** 1.86 **Sinuosity:** 1.15 **Watershed Area (mi^2):** 8.55

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Very Broad	Very Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	C	Bc

Ph2 Cross-Section Data

Curve Width (ft)	33.7
Bankfull Width (ft)	45
Max Depth (ft)	2.1
Width/Depth Ratio	31.4
Entrenchment Ratio	1.4
Incision Ratio	1.8

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	Edwards Rd	89	D, E

\# of Other Constrictions: 0
\# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	3	1
2	2	3
3	0	2
4	0	0
5	0	1
6	0	1
7	-	1
#/mile	16	29

Number of Debris Jams: 0

Step 6/7 Summary

RHA Score/Condition	56/Fair
Habitat Type Departure	None
RGA Score / Condition	36/Fair
Dominant Adjustment	Widening
CEM Model Stage	F /III
Stream Type Departure	C to B
Stream Sensitivity	High

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	Deposition
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #10 - Bridge Replacement - Edwards Road bridge is undersized for the high sediment load moving through the reach

Reach Highlights: This reach scoured and incised during the May, 2011 flood and T.S. Irene flood (August, 2011). Near continuous heavy scour was observed along the lower banks and some erosion was indexed. The reach widened to over 100ft in several locations and has since filled back in with large cobble side bars. Some planform adjustments are ongoing but the reach appears to be widening and slowly rebuilding the bed as flood sediments work through. We assigned a departure to B type instead of F-type due to the overwidened bankfull, entrenchment would be less severe at curve width. Small benches were elevated but accessible through most of the reach, large floodplain areas were very high and not accessible.

Major deposition upstream of Edwards Rd bridge

Near continuous heavy bank scour throughout reach

Stream: Brewster River **Reach:** M12.A **Town:** Cambridge **Date Assessed:**07/17/14

Channel Length (ft): 962 **Channel Slope (%):** 1.5 **Sinuosity:** 1.10 **Watershed Area (mi^2):** 3.07

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Plane Bed
Median Substrate	Cobble	Cobble
Stream Type	C	D

Ph2 Cross-Section Data

Curve Width (ft)	21.5
Bankfull Width (ft)	59
Max Depth (ft)	2.0
Width/Depth Ratio	52.7
Entrenchment Ratio	1.7
Incision Ratio	1.3

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
None in reach.			

\# of Other Constrictions: 0
\# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	5	2
2	4	1
3	1	0
4	2	0
5	0	0
6	0	0
7	-	0
#/mile	65	16

Number of Debris Jams: 1

Step 6/7 Summary

RHA Score/Condition	58/Fair
Habitat Type Departure	Plane Bed
RGA Score / Condition	32/Poor
Dominant Adjustment	Aggradation
CEM Model Stage	D/IId
Stream Type Departure	C to D
Stream Sensitivity	Extreme

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	**Steep Riffle**
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #11 - Corridor Protection - Most of this segment is highly active and the entire corridor should be protected. A channel avulsion through the right floodplain is likely.

Reach Highlights: Huge volumes of flood sediments are working through this reach creating a temporary alluvial fan-like setting. This feature was not indexed on the maps in FIT because it does not appear to be permanent. Numerous flood chutes were observed throughout the reach on both floodplains. The upper reach was very wide and indicated major recent cobble deposition. The bed had built up and the stream was beginning to tip into the right floodplain downstream of the bridge. A large headcut was observed in one of the side channels and flow was observed in several channels through the floodplain. This reach underwent major widening and deposition during Irene and is adjusting planform around this large increase in sediment load. We selected stage IId from the D CEM model due to the high level of channel aggradation and widening. Entrenchment was below 2 however we assigned a departure from C to D due to major widening (2.5x HGC bkfw) and aggradation.

Braiding channel with major deposition

Multiple large flood chutes throughout reach

Stream: Brewster River **Reach:** M12.B **Town:** Cambridge **Date Assessed**:07/17/14

Channel Length (ft): 1,412 **Channel Slope (%):** 2.75 **Sinuosity:** 1.10 **Watershed Area (mi^2):** 3.07

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	B	F

Ph2 Cross-Section Data

Curve Width (ft)	21.5
Bankfull Width (ft)	32.3
Max Depth (ft)	2.0
Width/Depth Ratio	27.8
Entrenchment Ratio	1.4
Incision Ratio	2.1

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	N Hill Dr	260	D
B	Footbridge	68	D, E
B	Footbridge	149	D, E, S

# of Other Constrictions: 0
# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	2	1
2	1	1
3	1	1
4	0	0
5	0	0
6	0	0
7	-	0
#/mile	14	11

Number of Debris Jams: 0

Step 6/7 Summary

RHA Score/Condition	49/Fair
Habitat Type Departure	Plane Bed
RGA Score / Condition	40/Fair
Dominant Adjustment	Degradation
CEM Model Stage	F/II
Stream Type Departure	B to F
Stream Sensitivity	Extreme

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	Deposition
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #12 & 13 - Bridge Retrofit/Replacement -Project 12 bridge is in poor structural condition and is a debris jam hazard due to a center pier. Project 13 bridge is undersized and the abutments create a moderate constriction. Both bridges should be retrofitted or replaced with appropriately sized structures.
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This reach was selected as reference B type due to channel slope. The elevated floodplain in the upper portion of the segment was accessed in 2011, but it is unlikely that this is could be accessed in typical storm events. Numerous flood chutes do provide some attenuation throughout the segment. Recent scour removed floodplain benches, dropped the bed elevation, and smoothed the longitudinal profile. We assigned a departure to F-type based on entrenchment. Pools were largely absent and the reach showed some indication of transitioning to widening and stage III CEM.

Recent widening and deep incision throughout segment

Major constriction from bridge abutments at upper footbridge

Stream: Brewster River **Reach:** M13 **Town:** Cambridge **Date Assessed:**07/17/14

Channel Length (ft): 697 **Channel Slope (%):** 2.0 **Sinuosity:** 1.09 **Watershed Area (mi^2):** 2.18

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Plane Bed
Median Substrate	Cobble	Gravel
Stream Type	B	D

Ph2 Cross-Section Data

Curve Width (ft)	18.5
Bankfull Width (ft)	48
Max Depth (ft)	2.2
Width/Depth Ratio	42.5
Entrenchment Ratio	2.2
Incision Ratio	1.7

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
None in reach.			

\# of Other Constrictions: 0
\# of Grade Controls: 0

Rapid Habitat Assessment

Rank	LWD	Pools
1	0	0
2	4	1
3	1	0
4	2	0
5	0	0
6	0	0
7	-	0
#/mile	53	7

Number of Debris Jams: 0

Step 6/7 Summary

RHA Score/Condition	51/Fair
Habitat Type Departure	Plane Bed
RGA Score / Condition	40/Fair
Dominant Adjustment	Aggradation
CEM Model Stage	D/IId
Stream Type Departure	B to D
Stream Sensitivity	Extreme

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	**Dredging**

Potential Projects in Reach

- #14 - Corridor Protection - The entire reach is highly active and could provide valuable floodwater and sediment attenuation
- #15 - Berm Removal - A recently constructed berm on the left bank cuts off access to a nice forested floodplain and does not protect any significant infrastructure
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This short reach was located at a slight decrease in slope and increase in valley width. Coupled with the high sediment export from the upstream reach, this reach is highly active with recent major widening and current aggradation. Numerous flood chutes and an avulsion were observed. These multiple channels and large depositional features formed by huge volumes of sediment working through the reach have caused a departure from B to D. We assigned a reference B stream type because the current D type is likely not natural and is a response to upstream sediment sources and encroachment. A post-2011 flood windrowed cobble berm was observed that cut off access to a forested left flood plain and likely exacerbates a downstream mass failure.

Widening, aggradation, and mass failure

Cobble berm cutting off forested floodplain

Stream: Brewster River **Reach:** M14 **Town:** Cambridge **Date Assessed**:07/17/14

Channel Length (ft): 2,570 **Channel Slope (%):** 3.0 **Sinuosity:** 1.08 **Watershed Area (mi^2):** 2.15

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Step-Pool	Step-Pool
Median Substrate	Cobble	Cobble
Stream Type	B	F

Ph2 Cross-Section Data

Curve Width (ft)	18.4
Bankfull Width (ft)	30
Max Depth (ft)	1.9
Width/Depth Ratio	31.3
Entrenchment Ratio	1.3
Incision Ratio	2.4

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	Wood Run Dr	82	D
B	Abandoned	152	D, S

# of Other Constrictions: 0
# of Grade Controls: 5

Rapid Habitat Assessment

Rank	LWD	Pools
1	2	2
2	3	4
3	1	1
4	4	1
5	0	0
6	0	0
7	-	0
#/mile	50	16

Number of Debris Jams: 2

Step 6/7 Summary

RHA Score/Condition	43/Fair
Habitat Type Departure	None
RGA Score / Condition	34/Poor
Dominant Adjustment	Degradation
CEM Model Stage	F/II
Stream Type Departure	B to F
Stream Sensitivity	Extreme

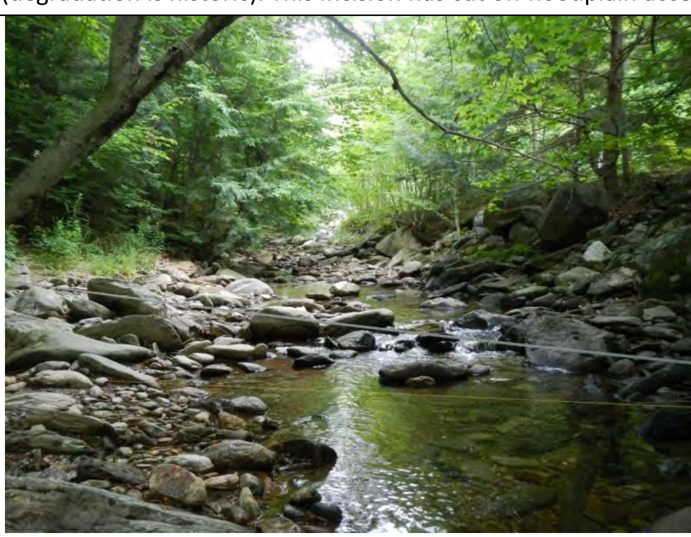
Impact Summary

Bank Erosion	**Stormwater**
Armoring	**Constrictions**
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	**Steep Riffle**
Corridor LC	**Head Cut**
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #16a - Bridge Retrofit/Replacement - Abutments under the Wood Run Dr. bridge constrict the channel to approximately 15'
- #16b- Install grade control structures to arrest a headcut caused by bridge constriction and protect a critical water line
- #17 - Berm Removal - A recently installed cobble berm cuts off access to a forested floodplain in the upper reach
- #18 - Dam Removal/Retrofit - The snowmaking pond at the top of the reach is a major interruption to sediment transport, fish passage, and is increasing scour and stream temperatures through the reach
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: A resort access road/path closely followed the left valley for most of the reach. This encroachment and interrupted sediment supply from the upstream impoundment caused this reach to recently incise and contributed a large volume of gravel and cobble to downstream reaches. Most of the reach has cut down to bedrock, so further incision is unlikely (degradation is historic). This incision has cut off floodplain access for all but the largest events leading to a departure to F-type.



Deep incision throughout reach

Large dam at the top of reach

Stream: 7th Tributary **Reach:** T7.01 **Town:** Cambridge **Date Assessed**:06/10/14

Channel Length (ft): 3,075 **Channel Slope (%):** 2.9 **Sinuosity:** 1.19 **Watershed Area (mi^2):** 4.88

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Riffle-Pool	Riffle-Pool
Median Substrate	Cobble	Cobble
Stream Type	B	F

Ph2 Cross-Section Data

Curve Width (ft)	26.3
Bankfull Width (ft)	38
Max Depth (ft)	1.8
Width/Depth Ratio	33.8
Entrenchment Ratio	1.1
Incision Ratio	2.7

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	108	266	
B	Covered Br	125	D, S

# of Other Constrictions: 2
# of Grade Controls: 5

Rapid Habitat Assessment

Rank	LWD	Pools
1	1	6
2	2	4
3	4	4
4	2	1
5	0	1
6	0	1
7	-	1
#/mile	15	30

Number of Debris Jams: 1

Step 6/7 Summary

RHA Score/Condition	50/Fair
Habitat Type Departure	None
RGA Score / Condition	38/Fair
Dominant Adjustment	Degradation
CEM Model Stage	F/II
Stream Type Departure	B to F
Stream Sensitivity	Extreme

Impact Summary

Bank Erosion	Stormwater
Armoring	**Constrictions**
Riparian Buffer	**Deposition**
Encroachment	**Migration**
Development	**Steep Riffle**
Corridor LC	Head Cut
Mass Failure	**Straightening**
Flow Regulation	Dredging

Potential Projects in Reach

- #19 - Bank Stabilization - Failing armor on left bank near condos
- #20 - Bank/Buffer Plantings - Several areas of reduced bank and buffer vegetation
- #21 - Bridge Retrofit - Concrete footings under covered bridge are scoured and at risk of failing
- #22 - Dam Removal - The breached timber crib dam in the upper reach is a minor grade control but is a fish passage barrier
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas

Reach Highlights: This reach widened and incised during the 2011 floods, scouring away lower banks resulting in a deeply incised and entrenched channel. Erosion was minimal within the reach, primarily due to bouldery and bedrock banks that were scoured back to clean rock/roots with no exposed soil. Armoring was observed throughout much of the reach to protect roads and properties encroaching the stream. Large cobble side bars have formed refilling much of the widened channel margins. The potential for future widening and planform adjustments is minimal given the bouldery soils, extensive armoring, and ledge found throughout the reach, indicating that this reach will be stuck in stage II of channel evolution.

Development and incision with failing bank armor

Failing timber crib dam, top of reach

Stream: First Tributary to T7 **Reach:** T7S1.01 **Town:** Cambridge **Date Assessed**:06/10/14

Channel Length (ft): 1,385 **Channel Slope (%):** 2.5 **Sinuosity:** 1.01 **Watershed Area (mi^2):** 0.31

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Very Broad	Very Broad
Bedform	Riffle-Pool	Plane Bed
Median Substrate	Gravel	Gravel
Stream Type	Cb	F

Ph2 Cross-Section Data

Curve Width (ft)	7.9
Bankfull Width (ft)	7.8
Max Depth (ft)	1.3
Width/Depth Ratio	7.4
Entrenchment Ratio	1.7
Incision Ratio	3.7

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
C	Mount View	76	S, AOP
B	Access Road	126	
B	Footpath	100	I, D

# of Other Constrictions: 0
# of Grade Controls: 1

Rapid Habitat Assessment

Rank	LWD	Pools
1	2	2
2	2	2
3	0	0
4	0	0
5	0	0
6	0	0
7	-	0
#/mile	15	15

Number of Debris Jams: 0

Step 6/7 Summary

RHA Score/Condition	31/Poor
Habitat Type Departure	Plane Bed
RGA Score / Condition	32/Poor
Dominant Adjustment	Degradation
CEM Model Stage	F/II
Stream Type Departure	C to F
Stream Sensitivity	Extreme

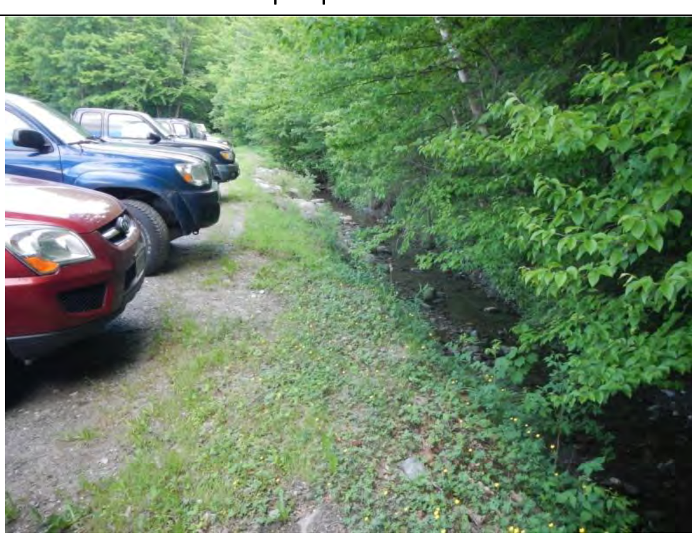
Impact Summary

Bank Erosion	**Stormwater**
Armoring	**Constrictions**
Riparian Buffer	**Deposition**
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	**Straightening**
Flow Regulation	**Dredging**

Potential Projects in Reach

- #23 - Bridge removal - A wooden footpath bridge immediately upstream of the tributary mouth is set below bankfull and is a debris jamming risk.
- #24 - Buffer Planting, Structure Replacement and Channel Restoration - Buffer plantings around the trout pond, replace Mountain View Dr culverts, and channel projects along the edge of a parking lot for the upper portion of the reach; wide range of possible projects.
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This heavily modified reach is departed to F-type and has very little opportunity to widen or adjust planform due to extensive encroachment and armoring. The majority of the reach is plane-bed likely due to bed scour and a combination of sedimentation and possible ditch maintenance dredging along the gravel parking area. Minimal erosion was indexed but the left bank was heavily scoured through most of the reach, and the right bank was near continuous rip-rap.



Channelized ditch along parking lot

Outlet of the trout pond

Stream: First Tributary to T7 **Reach:** T7S1.02 **Town:** Cambridge **Date Assessed**:07/02/14

Channel Length (ft): 1,645 **Channel Slope (%):** 3 **Sinuosity:** 1.01 **Watershed Area (mi^2):** 0.25

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	Broad	Broad
Bedform	Step-Pool	Riffle-Pool
Median Substrate	Cobble	Gravel
Stream Type	B	B

Ph2 Cross-Section Data

Curve Width (ft)	7.1
Bankfull Width (ft)	13
Max Depth (ft)	2.1
Width/Depth Ratio	9.2
Entrenchment Ratio	2.3
Incision Ratio	2.3

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
C	W Hill Dr	42	D, AOP

# of Other Constrictions: 0

# of Grade Controls: 1

Rapid Habitat Assessment

Rank	LWD	Pools
1	2	3
2	5	1
3	0	1
4	3	1
5	0	0
6	3	0
7	-	0
#/mile	16	19

Number of Debris Jams: 5

Step 6/7 Summary

RHA Score/Condition	54/Fair
Habitat Type Departure	Riffle-Pool
RGA Score / Condition	47/Fair
Dominant Adjustment	Widening
CEM Model Stage	F/III
Stream Type Departure	None
Stream Sensitivity	High

Impact Summary

Bank Erosion	**Stormwater**
Armoring	**Constrictions**
Riparian Buffer	**Deposition**
Encroachment	Migration
Development	**Steep Riffle**
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #25 - Road Management - Active access road through floodplain in lower reach is contributing sediment to channel
- #26 - Culvert Replacement - Major constriction and AOP barrier under West Hill Rd
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This short reach was incised and had minimal floodplain access, except during large events. The valley walls were very broad for the lower portion of the reach, gradually tightening to confined in the middle, and the back to very broad at the top. A very small culvert under West Hill Dr was causing upstream deposition and increased scour downstream. A lower historic road bed encroached the left bank for the entire portion below West Hill Dr. This has recently widened and could reconnect to the floodplain with future aggradation. A subtributary from the east drains into the bottom of the reach and is depositing a large amount of sediment on the shared floodplain. A lateral berm was observed that directs the subtributary to the reach.

Typical geometry

Increase gravel moving through reach

Stream: Second Trib to T7S4 **Reach:** T7S4.02.01 **Town:** Cambridge **Date Assessed:**07/02/14

Channel Length (ft): 756 **Channel Slope (%):** 10 **Sinuosity:** 1.01 **Watershed Area (mi^2):** 0.57

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	N Confined	N Confined
Bedform	Cascade	Cascade
Median Substrate	Boulder	Cobble
Stream Type	A	A

Ph2 Cross-Section Data

Curve Width (ft)	10.2
Bankfull Width (ft)	12
Max Depth (ft)	1.8
Width/Depth Ratio	12.3
Entrenchment Ratio	1.5
Incision Ratio	1.0

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	Ski Trail	97%	D, AOP
B	Ski Trail	245%	

# of Other Constrictions: 1
# of Grade Controls: 3

Rapid Habitat Assessment

Rank	LWD	Pools
1	1	0
2	16	4
3	3	1
4	9	4
5	0	2
6	8	1
7	-	0
#/mile	258	83

Number of Debris Jams: 3

Step 6/7 Summary

RHA Score/Condition	74/Good
Habitat Type Departure	None
RGA Score / Condition	77/Good
Dominant Adjustment	Stable
CEM Model Stage	F/I
Stream Type Departure	None
Stream Sensitivity	High

Impact Summary

Bank Erosion	**Stormwater**
Armoring	**Constrictions**
Riparian Buffer	Deposition
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This short and steep reach begins at the pump station where a concrete wall and a movable metal weir/gate are used to create a pond for snowmaking withdrawals. Above this the reach is steep and narrow with predominantly bedrock banks. Moderate to high increase in flow and sediment load is likely due to land clearing and conversion to a ski slope. Reach appeared stable and sediment accumulation was mostly limited to a large debris jam mid reach.

Ski trail bridge

Bedrock gorge with large boulders

Stream: Fourth Trib to T7 **Reach:** T7S4.03 **Town:** Cambridge **Date Assessed:**07/02/14

Channel Length (ft): 2,403 **Channel Slope (%):** 10 **Sinuosity:** 1.26 **Watershed Area (mi^2):** 0.96

Stream Type Summary

	P1 Reference	P2 Assessed
Confinement	S Confined	S Confined
Bedform	Cascade	Cascade
Median Substrate	Boulder	Cobble
Stream Type	A	A

Ph2 Cross-Section Data

Curve Width (ft)	12.8
Bankfull Width (ft)	22.5
Max Depth (ft)	2
Width/Depth Ratio	16.8
Entrenchment Ratio	1.4
Incision Ratio	1.0

Crossing/Constriction Summary

Type	Location	% wbkf	Impacts
B	Ski Trail	140	D
C	Route 108	94	D, AOP
C	Ski Trail	78	D, AOP

# of Other Constrictions: 2
# of Grade Controls: 9

Rapid Habitat Assessment

Rank	LWD	Pools
1	3	2
2	12	4
3	5	2
4	7	2
5	4	1
6	5	2
7	-	8
#/mile	79	46

Number of Debris Jams: 2

Step 6/7 Summary

RHA Score/Condition	76/Good
Habitat Type Departure	None
RGA Score / Condition	74/Good
Dominant Adjustment	Stable
CEM Model Stage	F/I
Stream Type Departure	None
Stream Sensitivity	High

Impact Summary

Bank Erosion	Stormwater
Armoring	Constrictions
Riparian Buffer	Deposition
Encroachment	Migration
Development	Steep Riffle
Corridor LC	Head Cut
Mass Failure	Straightening
Flow Regulation	Dredging

Potential Projects in Reach

- #27 - Gully Stabilization - A small gully has formed from a swale draining the base of the ski slope
- #28 - Stormwater Outfall - Assess options for reducing stormwater runoff and stabilizing outfall scour areas
- #29 - Stormwater Master Planning - Long-term planning for stormwater mitigation

Reach Highlights: This reach was steep and bedrock controlled throughout. The top portion was very steep and contained two large cascades. A snowmaking withdrawal dam with a removable weir/gate was located immediately upstream of the Route 108 culvert. The culvert under Route 108 was approximately 200ft long and very steep ending in a 10 ft free fall to a deep pool below. Below the culvert the channel alternated between a wider B-type geometry and bedrock waterfalls into in A-type cascade and step-pools. Some areas of deposition and increased gravel in the riffle sections indicate increased sediments loads from upstream areas. The reach was very stable and assessed as Type I.

Bedrock cascade and pool

Large culvert under 108

3.4 Phase 2 Results Summary

Rapid Habitat Assessment (RHA) and Rapid Geomorphic Assessment (RGA) scores for all Phase 2 reaches/segments are summarized in Table 4 and Figures 4 and 5. FEA divided the "Fair" category into "Low Fair" and "High Fair" to better indicate which reaches were closer to "Poor" or "Good" respectively. The "Fair" scores were split at the numerical mean for the categories (49%). Detailed summaries of geomorphic data for each segment are provided in Appendix B. Habitat assessment summary data is provided in Appendix C.

Table 4: Summary RHA and RGA data for all Phase 2 Reaches and Segments.

Reach/Segment	RHA Score	RHA Condition	RGA Score	RGA Condition
M05	65%	Good	70%	Good
M06	69%	Good	39%	Fair
M07.A	*	Fair	*	Good
M07.B	52%	Fair	56%	Fair
M09	53%	Fair	48%	Fair
M10	59%	Fair	40%	Fair
M11	56%	Fair	36%	Fair
M12.A	58%	Fair	33%	Poor
M12.B	49%	Fair	40%	Fair
M13	44%	Fair	40%	Fair
M14	43%	Fair	34%	Poor
T7.01	50%	Fair	38%	Fair
T7S1.01	31%	Poor	33%	Poor
T7S1.02	54%	Fair	48%	Fair
T7S4.02.01	74%	Good	78%	Good
T7S4.03	76%	Good	74%	Good

*RHA and RGA assigned based on administrative judgment, full assessments not conducted on M07.A

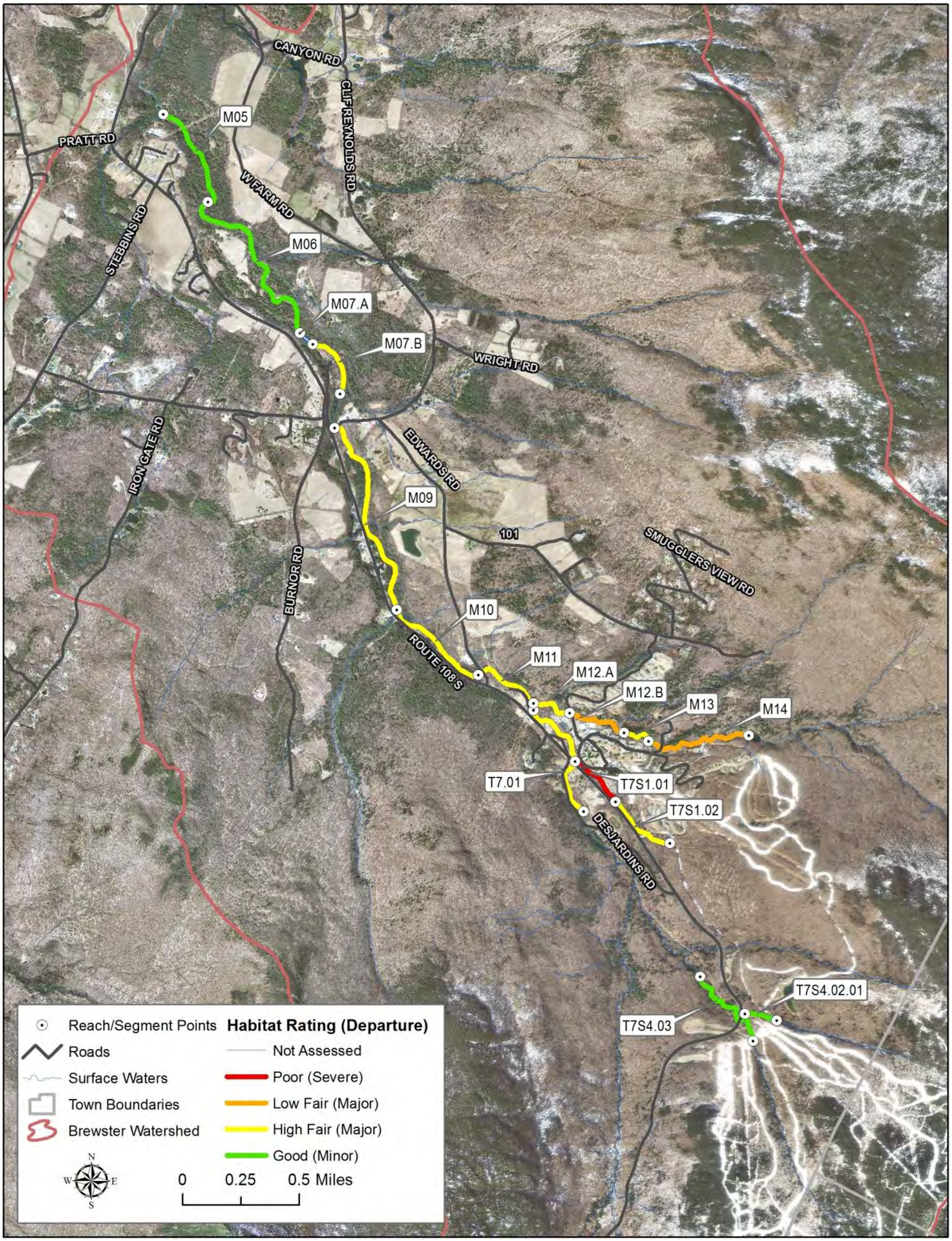


Figure 4: Rapid Habitat Assessment Ratings for the Brewster Watershed.

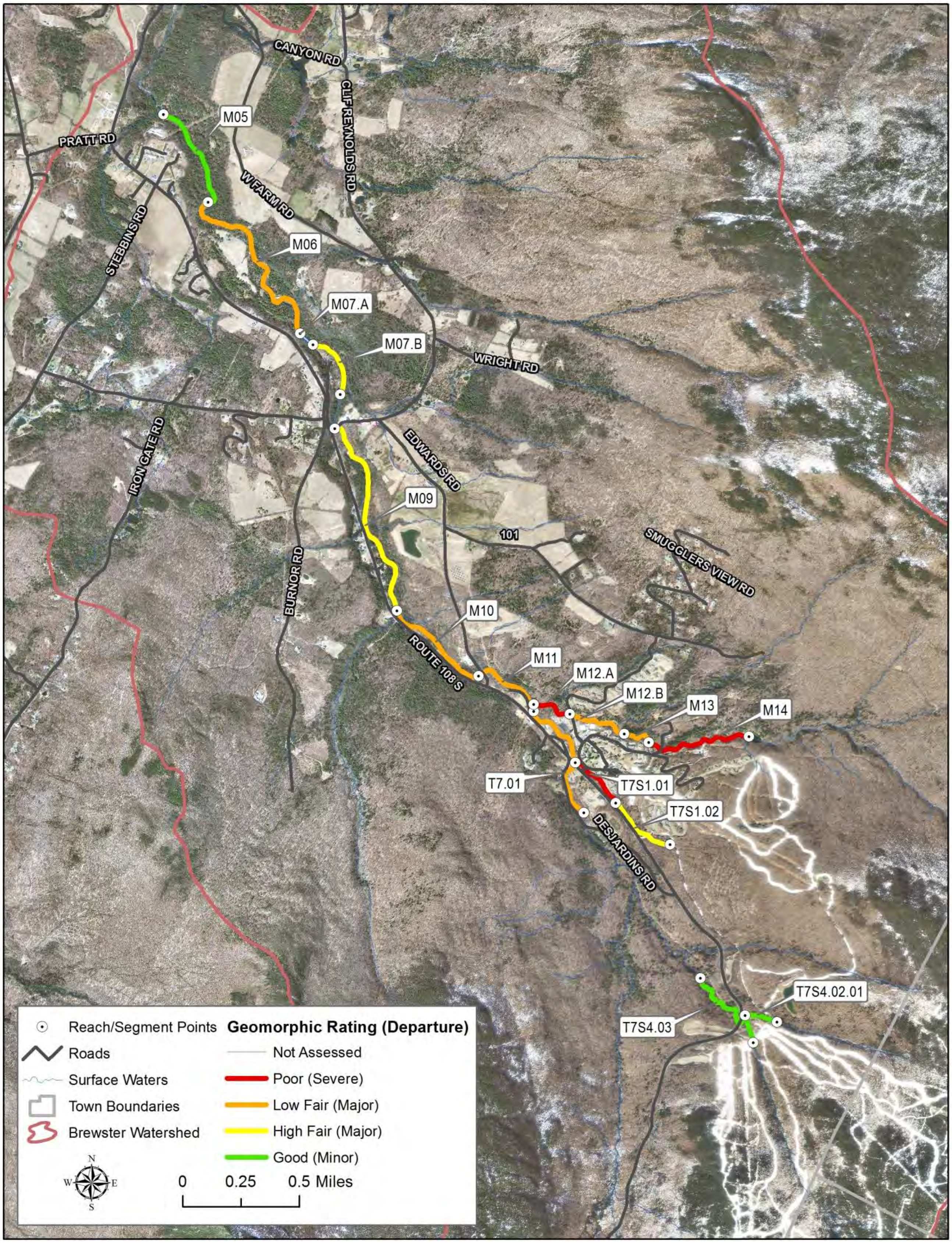


Figure 5: Rapid Geomorphic Assessment Ratings for the Brewster River Watershed.

3.5 River Corridor Planning

The following sections summarize the stressor identification and departure maps. The mapping of physical stressors and natural or human constraints allowed for 1) a process-based approach to understanding stream conditions at different scales, and 2) an evaluation of the connectivity of stressors along the channel network. The maps were referenced during the project identification process summarized in Section 4.0.

3.5.1 Stressor Maps

Modifications to Riparian and Boundary Condition

The boundary conditions of a river encompass the bed and bank substrate, and the vegetation and root material found along the riverbank. Human alterations to the river boundary conditions are often made to increase the resistance of the banks and bed to reduce lateral and vertical adjustments. However, extensive removal of riparian vegetation in the absence of bank hardening can cause a decrease in boundary resistance, and lead to increased lateral migration. Other natural and human-installed features within the channel, such as bedrock ledges and dams, affect boundary resistance in an upstream and downstream direction by controlling vertical adjustment processes.

Alterations to the channel boundary conditions and riparian areas in the Brewster River study area have been mapped using the variables extracted from the Phase 2 field dataset (Figure 11). Bank armoring (e.g., rip-rap) highlights areas of increased resistance to lateral migration, whereas bank erosion highlights reaches where significant lateral adjustments are found. Additional data showing the location of natural and man-made channel features (e.g., ledges and dams) depict areas that have a resistance to channel change.

Areas influencing riparian zone and boundary conditions include:

Increased Boundary Resistance

- Areas of small grade controls on segments M14 and T7.01
- Large and near continuous grade controls on segments M07.A, T7S4.03, and T7S4.02.01 (Figure 6)
- On-stream dams located on segments M14 (Figure 7) and T7S1.01
- Weirs on segments M14, T7S1.02, T7S4.03, and T7S4.02.01
- Partially breached timber crib dam on segment T7.01
- Extensive bank armoring on segments M14, T7S1.01 (Figure 8), and T7.S1.02

Decreased Boundary Resistance

- High bank erosion in segment M12.B
- Large mass failures in segments: M06 (Figure 9), M13, and M14
- Dredging in segments M13 and T7S1.01
- High density of riparian buffer width impacts in segments T7.01 (Figure 10) and T7S1.01

Figure 6: Near continuous bedrock grade control on reach T7S4.03.

Figure 7: Weir and large dam on reach M14.

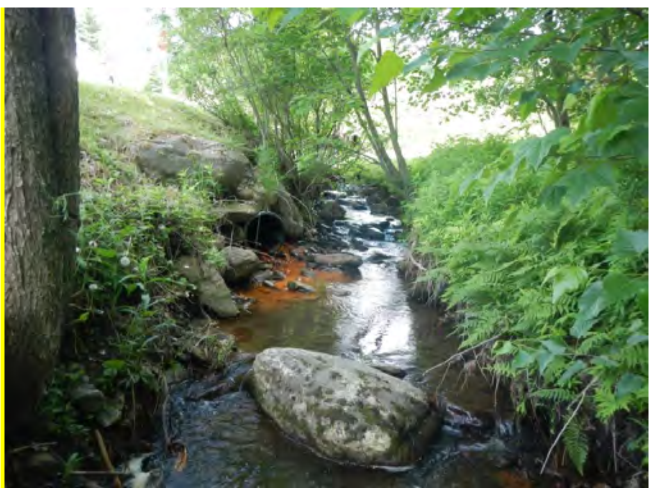


Figure 8: Bank armoring along road on reach T7S1.01

Figure 9: Large mass failure on reach M06.

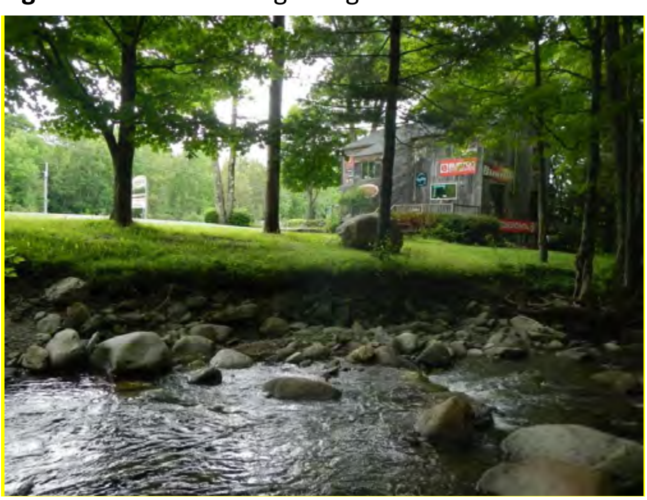


Figure 10: Buffer impacts along reach T7.01.

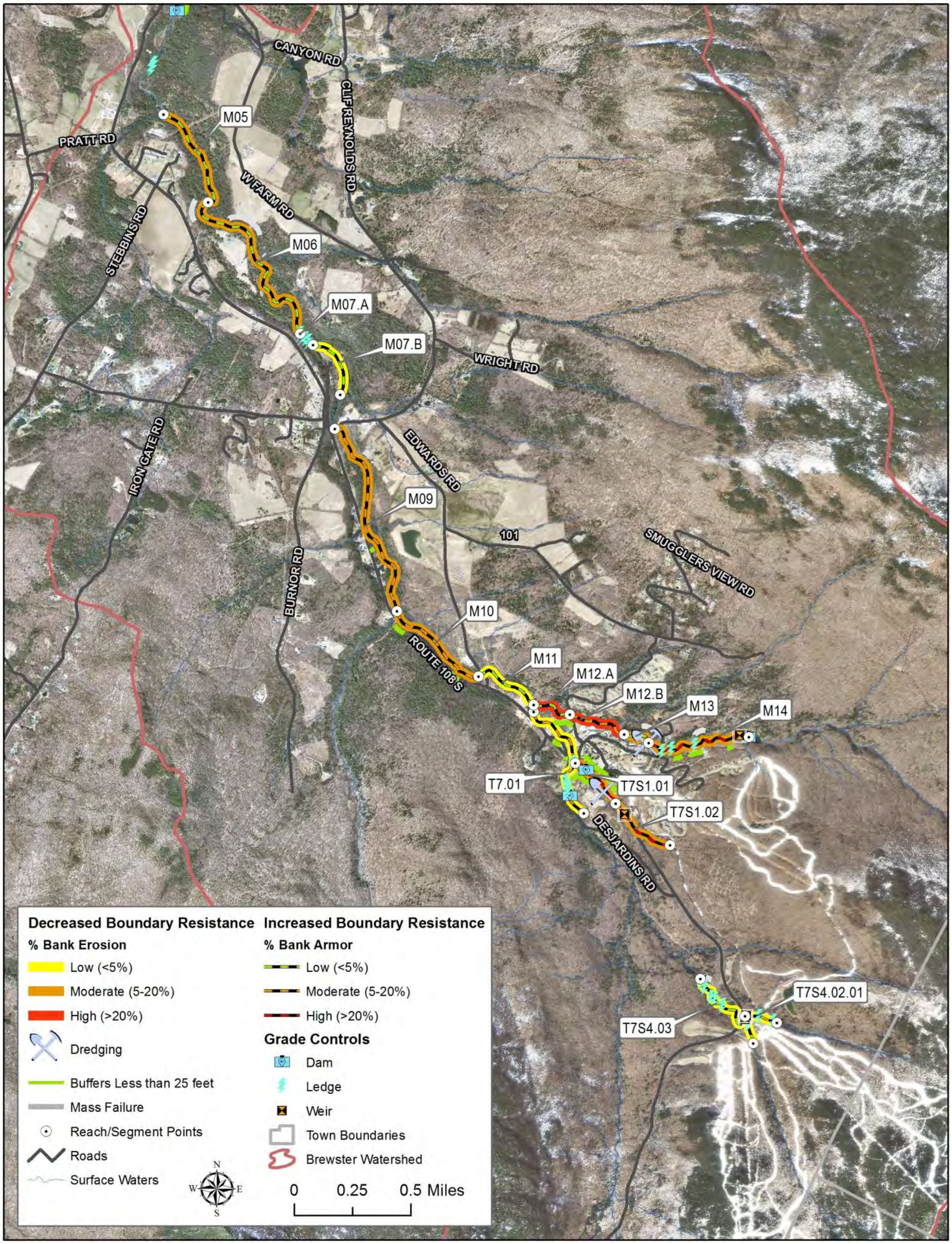


Figure 11: Riparian and boundary condition modifiers for the Brewster River watershed

Channel Slope and Depth Modifiers

Many of Vermont's rivers and streams have been historically manipulated and straightened to maintain an unnaturally steep slope, allowing for a short term sense of security from flooding and subsequent encroachment of infrastructure in the floodplain. Over time, many alluvial rivers will seek to redevelop a sinuous planform through the deposition of sediments in unconfined valleys. Following flood events when alluvial rivers become energized enough to transport large amounts of coarse sediment into depositional zones of the watershed, lateral channel migration intensifies and further channel straightening is required to protect infrastructure found in the floodplain. In larger alluvial rivers of Vermont, straightening and channelization typically ranges between 25 and 75 percent of the total river channel length in Vermont (VTANR, 2010).

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., encroachments) have resulted in an increase in channel depth (VTANR, 2010). Channel depths have typically been increased through the encroachment on the floodplain by roads 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).

Alterations to channel slope and depth in the Brewster River study area have been mapped using the variables extracted from the Phase 2 field dataset (Figure 17). Areas of channel straightening mapped during the Phase 1 and 2 assessments are included to depict areas of increased channel slope. Corridor encroachment data highlights where roads and development have reduced the floodplain area, typically resulting in increased stream power and channel deepening. Additional data showing the location of natural channel features (ledges) and man-made features including dams and weirs which depict areas that have a resistance to vertical channel change.

Areas impacted by increases in slope and depth or influenced by controls on slope and depth include:

Increases in Slope and Depth

- Extreme channel straightening in reach: T7S1.01 (Figure 12)
- Moderate straightening in reach: T7.01
- Extensive corridor encroachments from berms and adjacent roadways and embankments in segments: M10, M11, M12.B, M13, M14, T7.01, T7S1.01, and T7S1.02 (Figures 13 and 14)
- Dredging in segments: M13, T7S1.01

Controls on Slope and Depth

- Segments with numerous or large natural grade controls: M07.A, T7S4.03, and T7S4.02.01
- Segments with man-made grade controls:
  - Weirs: M14, T7S1.02, T7S4.03, and T7S4.02.01
  - Dam: M14, T7.01, and T7.S1.01 (Figures 15 and 16)

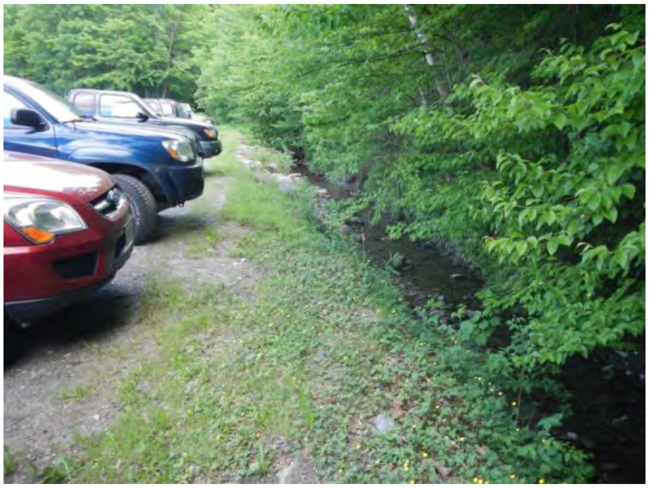


Figure 12: Extreme straightening along a road and water park parking area on reach T7S1.01

Figure 13: Recently constructed cobble berm blocking access to the left floodplain along reach M13.

Figure 14: Encroachment from Desjardins Rd on T7.01.

Figure 15: Partially breached timber crib dam on T7.01.

Figure 16: Three culverts at the outlet of the trout pond created by a small dam on reach T7S1.01.

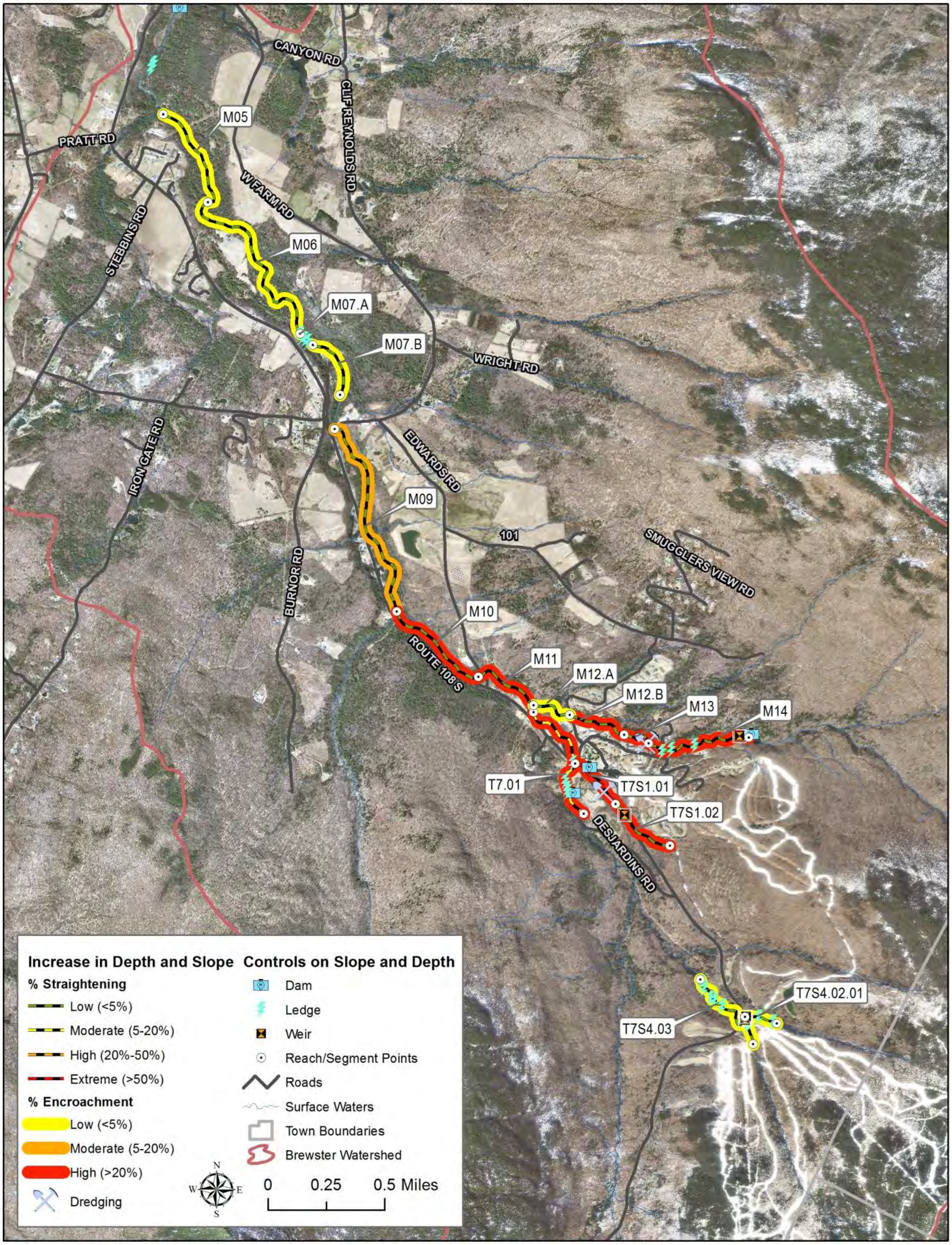


Figure 17: Controls on slope and depth for the Brewster River

Hydrologic Regime Stressors

The following description of the hydrologic regime of a river, and the general response to watershed-scale land use changes and stressors is included from the most recent version of the VTANR River Corridor Planning Guide (VTANR, 2010).

> The hydrologic regime may be defined as the timing, volume, and duration of flow events throughout the year and over time. The hydrologic regime may be influenced by climate, soils, geology, groundwater, watershed land cover, connectivity of the stream, riparian, and floodplain network, and valley and stream morphology. The hydrologic regime, as addressed in this section, is characterized by the input and manipulation of water at the watershed scale and should not be confused with channel and floodplain "hydraulics," which describes how the energy of flowing water affects reach-scale physical forms and is affected by reach-scale physical modifications (e.g., bridges modify channel and floodplain hydraulics).

When the hydrologic regime has been significantly altered, stream channels will respond by undergoing a series of channel adjustments. Where hydrologic modifications are persistent, the impacted stream will adjust morphologically (e.g., enlarging when stormwater peaks are consistently higher) and often result in significant changes in sediment loading and channel adjustments in downstream reaches. The current day stressors to the hydrologic regime have been mapped using the variables extracted from the Phase 2 field dataset (e.g., stormwater outfalls), houses and buildings present within each subwatershed, and density of the road network within each subwatershed. Wetlands are not prevalent within the Brewster River study area, therefore wetland loss is not a significant concern. Previous studies in Vermont have estimated that a road density of 4mi/mi^2 roughly corresponds to 5% watershed imperviousness. This level of imperviousness is associated with a decline in channel stability and biotic integrity (Fitzgerald, 2007). Due to the areas of concentrated development within the Smugglers' Notch Village, watershed imperviousness is likely much higher within the M11 and M14 subwatersheds. Stormwater outfall locations mapped during the Phase 2 assessments are included to depict areas of increased stormflows (Figure 20). The presence of a forested buffer between Route 108 and the mainstem through most of the lower and middle study area likely reduces the potential impact of stormwater runoff from the road.

Areas of impact to the hydrologic regime include:

- High road density in subwatersheds draining to reaches M05, M07, M11, M14, T7.01, T7S1.02, and T7S4.03 (Figure 18)
- Very high road density in subwatersheds draining to reaches M12, M13, and T7S1.01
- Stormwater inputs from developed areas and roads in M09, M12.B, M14, T7.01, T7S1.01, T7S1.02, T7S4.02.01, and T7S4.03 (Figure 19)

Figure 18: Roadside ditch conveying stormwater and sediment from West Hill Drive to reach T7S1.02.

Figure 19: Stormwater input from Desjardins Road to reach T7.01.

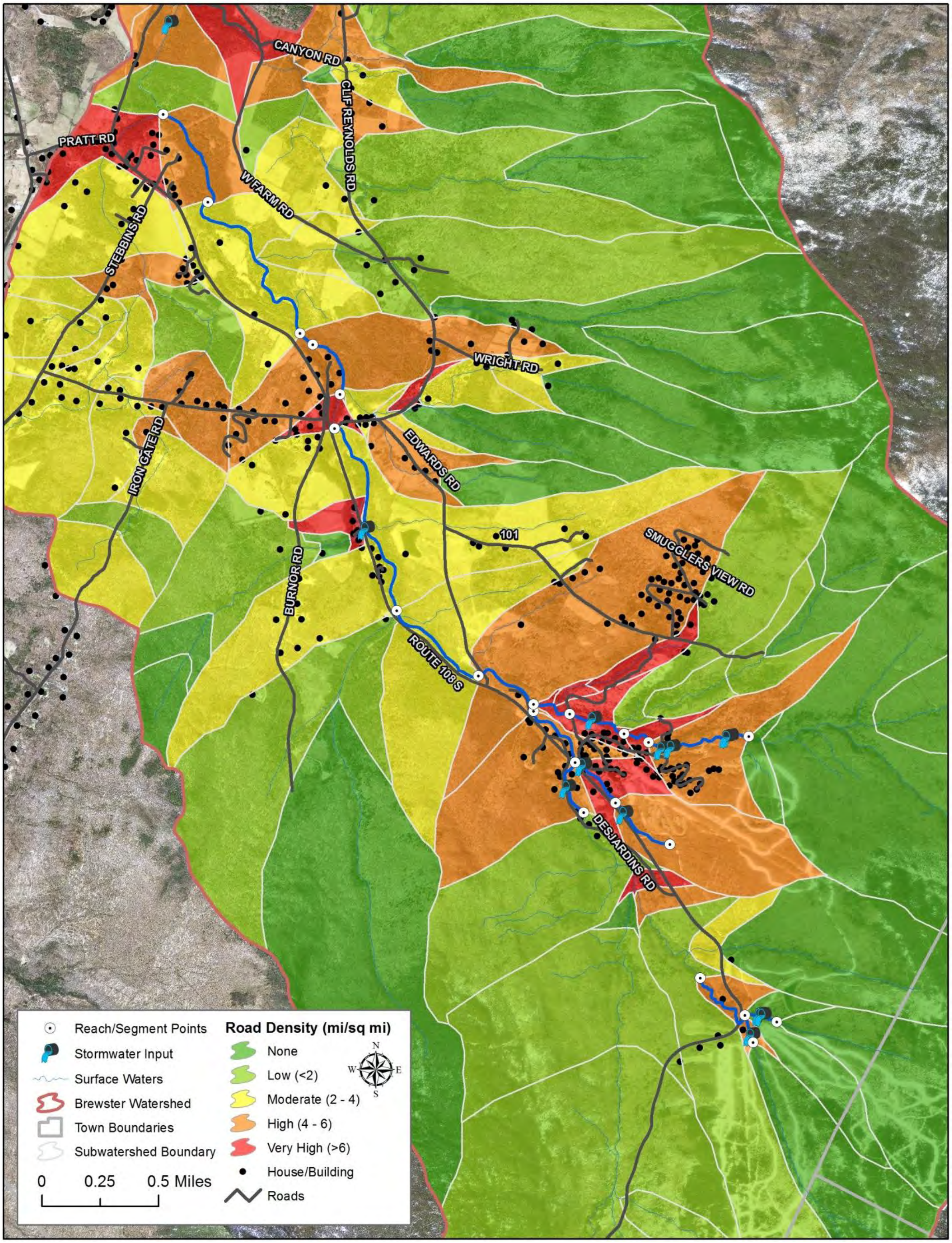


Figure 20: Hydrologic regime stressors for the Brewster River watershed.

3.5.2 Departure Analysis

The reference and existing sediment regime types have been mapped using data from the Phase 1 and 2 assessments (Figures 21 and 22). Several segments in the Brewster River watershed have undergone a departure in both sediment regime and stream type due to channel incision and/or widening as a result of: 1) historical land uses, 2) encroachments or development in the river corridor, or 3) extensive straightening and bank armoring. Many of the channel adjustments caused by these historic stressors were exacerbated by the extreme flood events of 2011, leading to further stream type departures. In some instances, the 2011 floods triggered severe channel adjustments even in reaches with limited corridor impacts. These reaches, such as M06, M09, M12.A, and M13, tended to be on moderate gradient channels lacking natural grade controls such as bedrock ledges. Three of the Phase 2 study reaches/segments were stable and did not contain a stream type or sediment regime departure (M07.A, T7S4.02.01, and T7S4.03).

Stream type departures (per Rosgen, 1994) are summarized below (Table 5) to better describe the reaches where physical changes in channel morphology have accompanied sediment regime changes.

Table 5: Summary of stream type departures from reference conditions.

Phase 2 Segment ID	Stream Type Departure	Dominant Adjustment Type
M10	C to B	Recent Incision and Active Aggradation/Widening
M11	C to B	Recent Widening and Bank Scour
M12.A	C to D	Major Aggradation and Widening
M12.B	B to F	Recent Incision/Scour and Active Widening
M13	B to D	Major Aggradation and Widening
M14	B to F	Active Incision
T7.01	B to F	Recent Incision/Widening and Encroachment/Armoring
T7S1.01	C to F	Major Encroachment and Straightening

In addition to the above-described stream type departures and the associated sediment regime departures, several reaches/segments of the Brewster River have undergone departures in sediment regimes in the absence of stream type departures. All reference and existing sediment regimes are summarized below in Table 6. An additional map summarizing dominant channel adjustment processes is included in Figure 23.

Table 6: Summary of Sediment Regime Departures.

Phase 2 Segment ID	Reference Sediment Regime	Existing Sediment Regime	Cause of Departure
M05	Coarse Equilibrium and Fine Deposition	Fine Source Transport and Coarse Deposition	Major recent deposition and active widening
M06	Coarse Equilibrium and Fine Deposition	Fine Source Transport and Coarse Deposition	Major recent deposition and active widening
M07.A	Transport	Transport	No Departure
M07.B	Coarse Equilibrium and Fine Deposition	Fine Source Transport and Coarse Deposition	Recent widening and active aggradation
M09	Coarse Equilibrium and Fine Deposition	Fine Source Transport and Coarse Deposition	Recent widening and active aggradation/planform
M10	Coarse Equilibrium and Fine Deposition	Fine Source Transport and Coarse Deposition	Recent incision and active widening/aggradation
M11	Coarse Equilibrium and Fine Deposition	Unconfined Source and Transport	Recent incision and active widening/aggradation
M12.A	Coarse Equilibrium and Fine Deposition	Deposition	Major recent deposition/widening and braided channel
M12.B	Coarse Equilibrium and Fine Deposition	Unconfined Source and Transport	Recent incision/scour and active widening
M13	Coarse Equilibrium and Fine Deposition	Deposition	Major recent deposition/widening and braided channel
M14	Transport	Unconfined Source and Transport	Major recent incision and upstream dam
T7.01	Coarse Equilibrium and Fine Deposition	Unconfined Source and Transport	Incision from armoring and encroachment
T7S1.01	Coarse Equilibrium and Fine Deposition	Unconfined Source and Transport	Incision from armoring and encroachment
T7S1.02	Transport	Fine Source Transport and Coarse Deposition	Recent widening and active aggradation
T7S4.02.01	Transport	Transport	No Departure
T7S4.03	Transport	Transport	No Departure

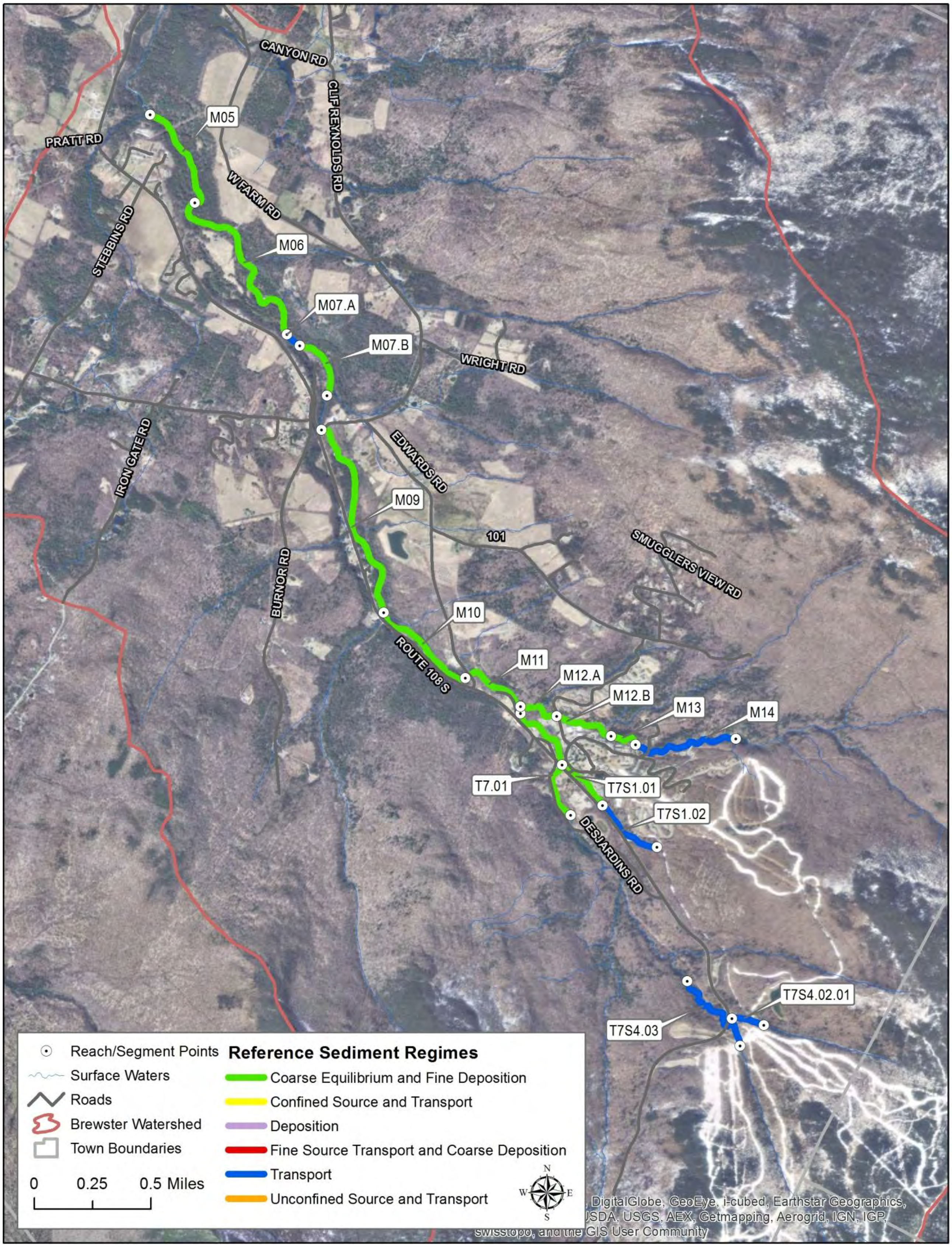


Figure 21: Reference Sediment Regime for Brewster River.

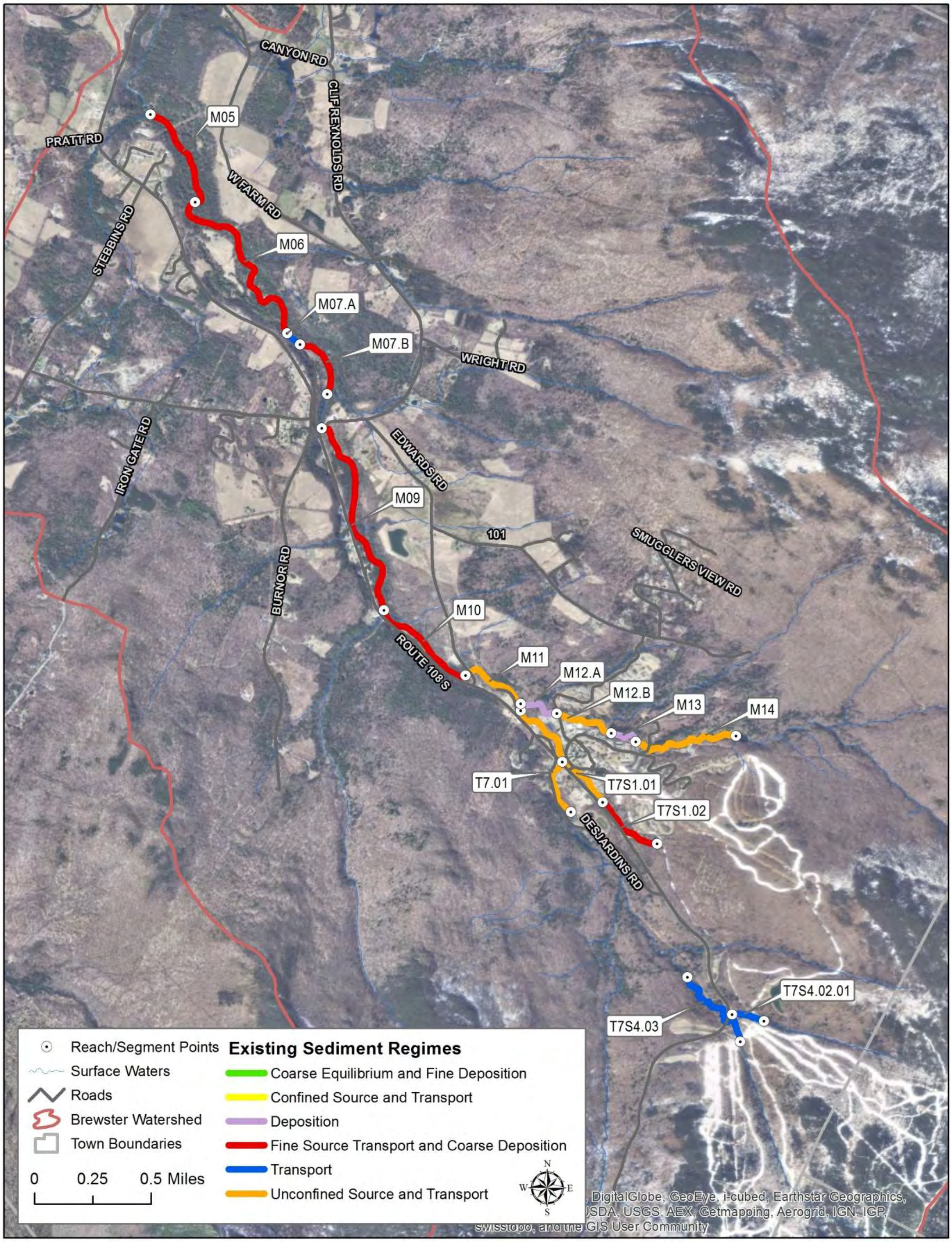


Figure 22: Existing Sediment Regime for Brewster River.

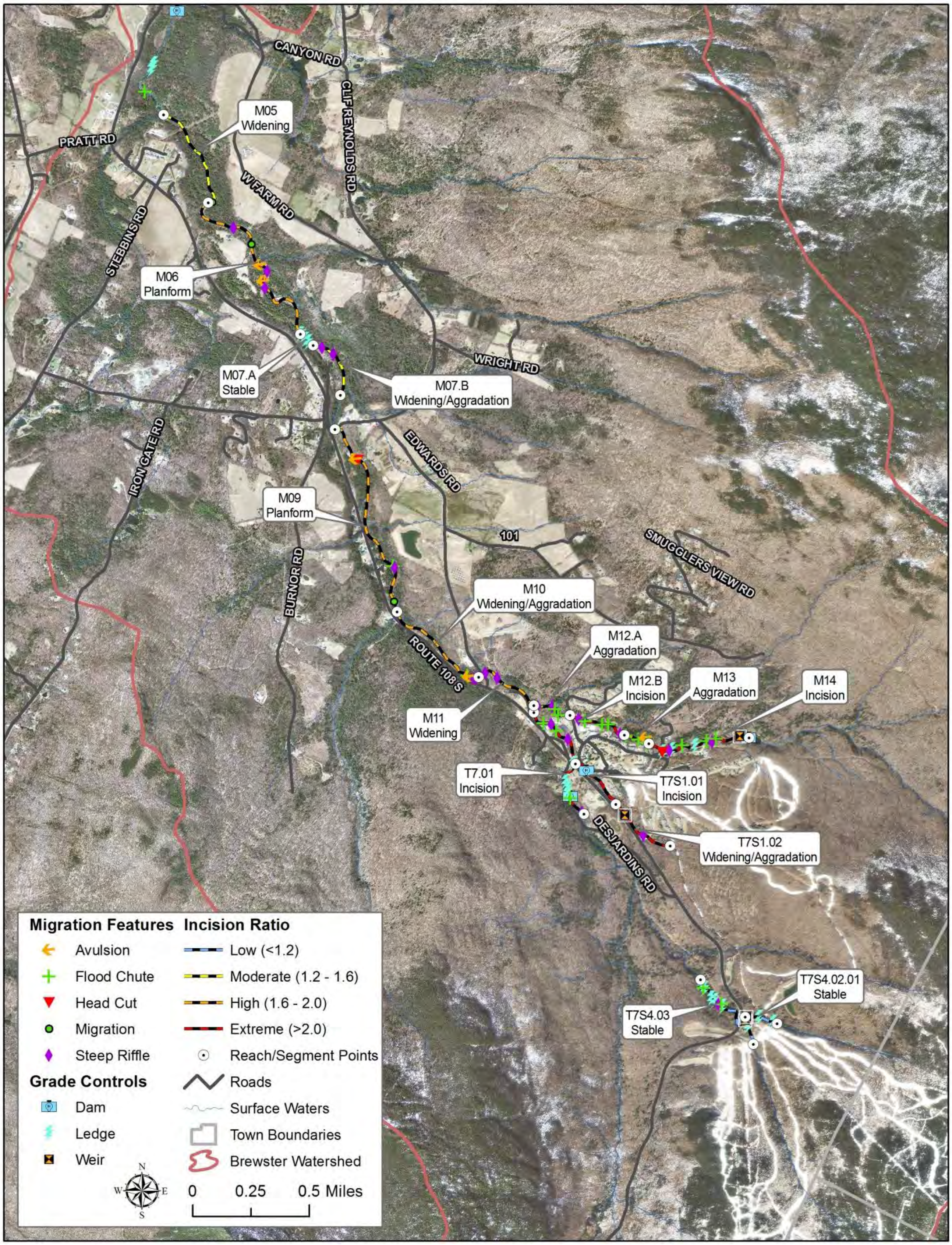


Figure 23: Channel Adjustment Process Map for Brewster River.

3.5.3 Sensitivity Analysis

The methods outlined in the VTANR Corridor Planning Guide have been used to describe the stream sensitivities of the segments in the Brewster River study area. Using the stream geometry and substrate data in conjunction with overall geomorphic stability (RGA score) as determined during the Phase 2 surveys, stream sensitivity ratings have been assigned to each segment (Figure 25). Six (6) segments have heightened sensitivities of "Extreme" and one (1) segment has heightened sensitivities of "Very High" due to human impacts. The increased stream sensitivity ratings are most often because of stream type departures (STD) (Table 7).

Four (4) of the extreme sensitivity segments were due to channel incision resulting from encroachment, armoring, or straightening. The remaining two (2) extreme sensitivity segments were due to major aggradation and widening in locations where flood sediments were deposited during and following the 2011 events (Figure 24).

Figure 24: Major deposition in segment M12.A causing a departure from C to D type and an extreme sensitivity rating.

Table 7: Very High and Extreme sensitivity segments and descriptions of the specific impacts and adjustments.

Phase 2 Segment ID	Stream Sensitivity	Description of Impacts
M09	Very High	Widening, Aggradation
M12.A	Extreme	STD, Aggradation, Widening
M12.B	Extreme	STD, Incision, Widening
M13	Extreme	STD, Aggradation, Widening
M14	Extreme	STD, Incision
T7.01	Extreme	STD, Incision
T7S1.01	Extreme	STD, Incision

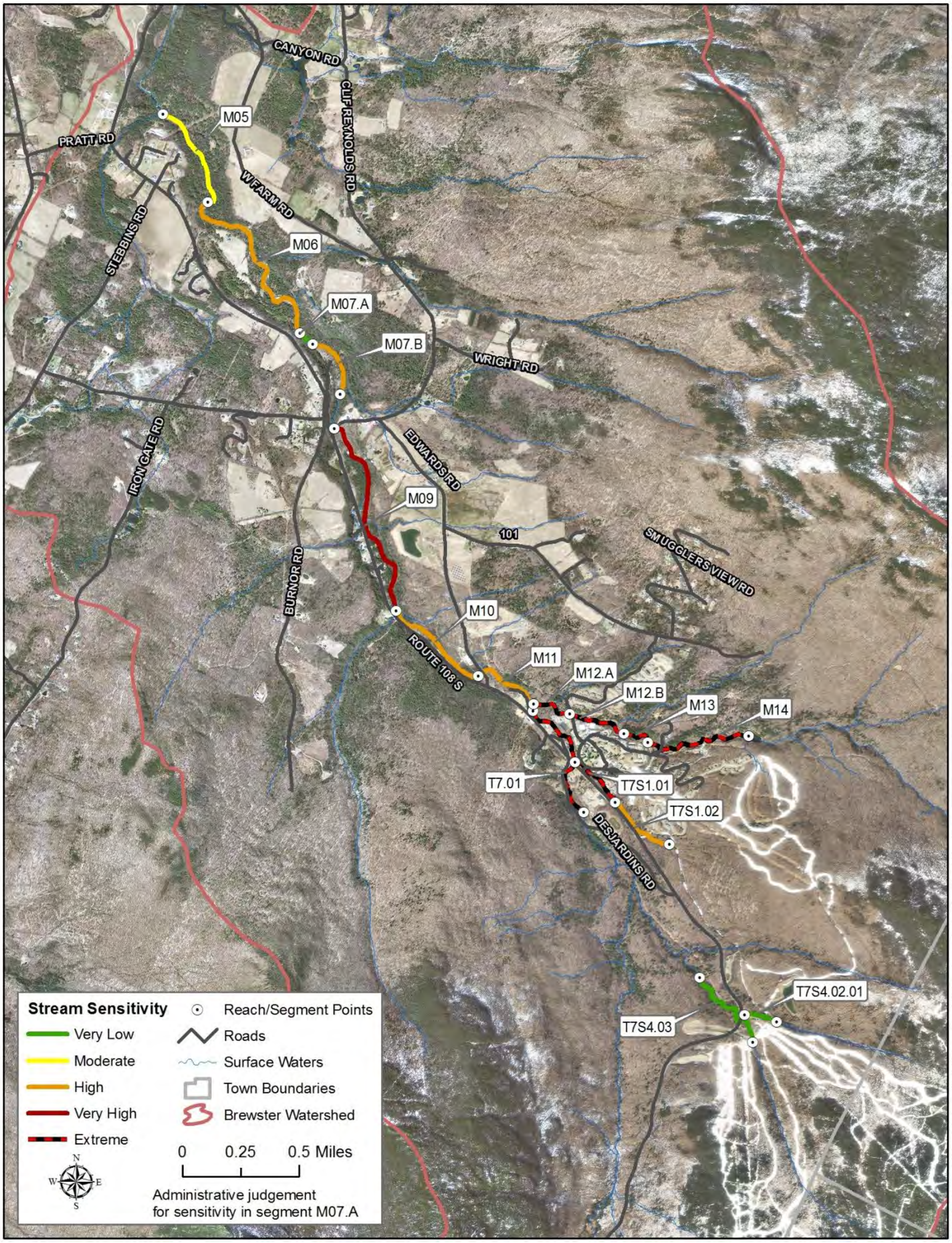


Figure 25: Stream Sensitivity Ratings for Brewster River.

4.0 Preliminary Project Identification

4.1 Watershed Level Opportunities

4.1.1 Stormwater Runoff

Increased stormwater runoff, even in rural areas of Vermont, can increase peak flood flows and the erosive power of the streams. Stormwater runoff originating from gravel roads and exposed soil during development, or over farm fields can add significant sediment inputs to streams. Increasing development results in more driveways and roads, which funnels sediment and runoff directly into streams. Sediment from roads and driveways can be addressed with improved drainage ditch networks, limiting future driveway lengths in sensitive areas, and other approaches. The Vermont Better Back Roads program provides assistance for towns seeking ways to reduce rural stormwater problems. Smugglers' Notch Village represents a dense commercial and residential development area with large areas of impervious surfaces (rooftops, parking lots, and roads). However, stormwater treatment ponds and other retention systems were installed during construction to reduce runoff volume and pollutant load from much of this area.

Smugglers' Notch Resort is keenly aware of stormwater issues and is making efforts to address runoff from the densely developed Village area. Representatives from Smuggs' have expressed concerns about stormwater in several areas (See Project 29). The existing stormwater ponds for the development along Mountain View Extension and Aspens Drive are out-dated and under-performing. Runoff from this area flows to Reach M14 and to a sub-tributary that enters T7S1.01 at the trout pond. The sub-tributary has caused repeat flooding issues near the water park. The Resort is interested in adding additional stormwater treatment features, but it will be challenging to address these issues within the limited available area and to maintain the aesthetic of the Resort.

Outside of the Resort Village, the Brewster River watershed generally has limited stormwater impacts due to the largely forested watershed and low road densities. A forested buffer exists along both sides of the Brewster River for most of the study area, limiting the number of stormwater outfalls and allowing for some treatment of runoff within the floodplain before reaching the river. In the future, if development pressures heighten concerns about impacts from stormwater runoff, Cambridge could consider enacting local standards and guidelines for stormwater treatment or mitigation. Local planning efforts are important to control and monitor stormwater and development impacts on natural resources. By planning proactively, towns can reduce long-term costs and risks associated with stormwater runoff. Options that the towns could consider at the local level include:

- Requiring stormwater controls for development projects which are not large enough in size to fall under state regulatory permits (less than 1 acre impervious cover), but likely have a measurable impact on the conditions of adjacent waterbodies (e.g., habitat, water quality).
- Incorporating more rigorous requirements for stormwater control of new development in headwaters areas. Research in Vermont has shown that physical and biotic conditions in small watersheds (< 5 square miles in area) are impacted by very low levels of impervious cover (as low as 5 percent; Fitzgerald, 2007).
- Encouraging Low Impact Development (LID) and green stormwater infrastructure by offering development density incentives for those projects which result in reduced footprints of impervious cover.

4.1.2 River Corridor Zones

Many Vermont communities found along rivers large and small have faced significant property losses and risks to public safety during past flood events. While inundation-related flood loss is a significant component of flood disasters, the predominant mode of damage during floods in Vermont is fluvial erosion. Fluvial erosion hazards have been increased and exacerbated by historical channel management practices in Vermont such as channel straightening, berming, and floodplain encroachment.

Towns can reduce flood recovery and infrastructure maintenance costs and increase public safety by limiting development in areas adjacent to rivers with a high potential for vertical and lateral adjustment. The River Corridor zone can be thought of as the corridor a river or stream requires to redevelop or maintain equilibrium conditions over the long term. River Corridor zones also indicate which reaches that have a higher propensity for severe migration during flood events. These reaches, which are given elevated ratings of “very high” or “extreme”, are high priority reaches for protection, especially when there is little existing protection afforded by wetlands or conservation easements.

4.1.3 Stream Crossings

Throughout Vermont, undersized and poorly aligned river crossings interrupt floodflows, sediment and woody debris movement downstream, and fish and wildlife migration. These conditions result in 1) channel instability and/or damage to infrastructure and personal property, 2) increased flooding, and 3) decreased fish and wildlife population health. Some culverts and bridges in the Brewster River study area are currently undersized and causing various problems such as upstream deposition, excessive erosion, and downstream bed degradation (Tables 8 and 9). As such structures come up for replacement, resizing them to accommodate expected discharge and sediment loads and placing them in proper alignment with stream channels is highly recommended. Locations of all culverts and bridges are shown in Appendix D (see Map ID#) and Appendix E for the Canyon Road structures.

Table 8: Summary of culvert data in the Brewster River watershed.

Reach	Map ID #	Location	% Bankfull Width	Geomorphic Compatibility	Aquatic Organism Passage* (AOP)	AOP Retrofit Potential**
T7S1.01	1	Mountain View Drive	25	Partially Compatible	Red	LLL
T7S1.02	2	West Hill Drive	42	Mostly Compatible	Gray	MLL
T7S4.03	3	Route 108	94	Mostly Compatible	Red	LLL
T7S4.03	4	Smuggs' Access Road	39	Partially Compatible	Red	LLL
T1.01	N/A	Canyon Road	39	Mostly Incompatible	Red	LLL

*Notes on AOP
Green: Full AOP for all aquatic organisms
Gray: Reduced AOP for all aquatic organisms
Orange: No AOP for all aquatic organisms except adult salmonids
Red: No AOP for all aquatic organisms including adult salmonids

** Notes on AOP Retrofit Potential:
H: High probability the existing culvert can be retrofitted
M: Medium probability the existing culvert can be retrofitted
L: Low probability the existing culvert can be retrofitted
Position 1 (left): For strong swimmers
Position 2 (Center): For moderate swimmers
Position 3 (right): For weak swimmers

Table 9: Summary of Bridge and Arch Data in the Brewster River watershed.

Map ID #	SGA Reach/ Segment	SGA ID	Road	Material	Curve Channel Width (ft)	Road Width (ft)	Structure Height (ft)	Structure Span (ft)	% Bankfull Width
1	M09	100000000008021	Edwards Rd	Concrete	38.8	25	50	90	232
2	M11	100000000108021	Edwards Rd	Concrete	33.7	24	7	30	89
3	M12	100000000408021	N Hill Drive	Timber	21.5	28	10.5	56	260
4	M12	700000003708023	Private foot path	Timber	21.5	10	7	32	149
5	M12	700000003808023	Private foot path	Timber	21.5	10	6	15	68
6	M14	100000000308021	Wood Run Dr	Steel	18.4	17	11	15	82
7	M14	700000003608023	Abandoned Trail	Steel	18.4	14	6	28	152
8	T7.01	200000000008022	Route 108	Steel	26.3	36	12.5	70	269
9	T7.01	700000003408023	Private covered br.	Timber	26.3	12	10.5	33	125
10	T7S1.01	700000003508023	Access road	Timber	7.9	10	3.5	10	127
11	T7S4.02.01	700000004108023	Access road	Concrete	10.2	9	15	9.9	97
12	T7S4.02.01	700000004208023	Ski trail	Steel	10.2	25	33	50	490
13	T7S4.03	700000003908023	Access road	Concrete	12.8	20	12	18	141
N/A	T1.01	100031000208021	Canyon Rd	Concrete	20.3	21	9.3	33	103
N/A	T1.01	100033000008021	West Farm Rd	Concrete	20.3	18	7.0	24	89

4.2 Site-Level Project Opportunities

The site-level projects developed for the Brewster River watershed are provided below in Table 10. The project strategy, technical feasibility, and priority for each project are listed by project number and reach/segment. A total of 30 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, priorities for hazard mitigation and ecological benefit, relative costs, and potential partners.

Table 10 includes a ranking of project priority, using our best professional judgment (and input from VTDEC and LCPC), of hazard mitigation and ecological benefits. Many river corridor restoration projects help mitigate flood and erosion hazards **and** improve the ecological conditions of the reach and watershed as a whole (e.g., improved habitat, protection of water quality, etc.). However, some project types provide a greater benefit to one over the other. While it is difficult to place a specific value on each project, rankings of “low,” “medium,” and “high” are intended to provide a means to compare the types of benefits each project provides relative to the others. A summary of what is meant by these two priority types is provided below.

> *Hazard Mitigation Priority:* refers to the potential for the project to mitigate flood and erosion hazards for the river corridor in the reach and in downstream areas. For example, replacing an undersized culvert with an appropriately sized structure could reduce flood/erosion hazards around the structure and downstream.
>
> *Ecological Benefits Priority:* refers to the potential for the project to improve aquatic habitat conditions and water quality in the reach and watershed. For example, a riparian buffer planting will improve habitat by increasing shading along the river and reducing long-term bank erosion.

The project locations for the study area are included on the maps provided in Appendix D. The 30 projects are further broken down by category as follows: Twenty (20) active geomorphic restoration projects and ten (10) passive geomorphic restoration projects, including two conservation projects.

The corridor planning partners reviewed and commented on the list of preliminary projects via email in October and November of 2014. Three project “bundles” from the initial list of 29 total projects were chosen for further development. Project summaries are included in Appendix E for three high priority project bundles:

1. Project 6: Reach M09 - bank stabilization along the Austin Property;
2. Project 10: Reach M11 – channel surveying and characterization around the Edwards Road bridge;
3. Project 28: Reach T1.01 - Canyon Road slope stabilization, bank armoring, buffer planting, ditch maintenance.

Fifteen projects are located within the Smugglers' Notch Resort (SNR) and were discussed at a meeting on March 6, 2015 with representatives from the Resort, LCPC, LCCD, and VTDEC. The SNR representatives provided additional detail and background for these projects and expressed a strong interest for increasing flood resiliency and mitigating stormwater runoff throughout the Resort.

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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 **VLT Property** Reach M06 44.62223 N 72.81913 W	**Passive Restoration** Buffer Planting	A large mass failure on the right bank extends up to the edge of a hayfield on the VLT Brewster Uplands Conservation Trust property. A row of pines at the edge of the field recently fell down the slope, leaving no woody vegetation. The toe of the slope is currently protected by a debris jam.	The top of the slope will continue to fail until a stable slope is achieved. Planting a woody buffer will slow soil loss and hopefully arrest the upper portion of the mass failure. Woody plantings at least 50' into the hayfield will help stabilize the upper slope over time. Plantings should be set back from the top of the slope at least 25ft to avoid loss from active erosion.	Low	Moderate	Stabilize a large failing bank to reduce major sediment inputs to the channel.	Low	Vermont Land Trust; LCNRCD Trees for Streams
#2 **Floodplain** Reach M06 44.61903 N 72.81831 W	**Active Restoration** House/Debris Removal	An abandoned structure is located on the left bank in an active floodplain area	Work with private landowner to remove structure.	Low	Low	Prevent debris from entering the channel in future flood events	Moderate	Private Landowner
#3 **Floodplain** Reach M06 44.61806 N 72.81774 W	**Passive Restoration** Conservation	The majority of the accessibly floodplain within the reach is part of the Brewster Uplands Conservation Trust, however the channel is highly active and additional floodplain on the left bank throughout the reach and the right bank in the upper reach could also be conserved.	Work with private land owners to prevent stream corridor from future development.	Low	Moderate	Downstream benefits through the maintenance of water and sediment attenuation in this riparian area.	Low to Moderate	VLT; Private Landowner

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#4 **VLT Property/Private Farm** Reach M09 44.6078 N 72.80908 W	**Passive Restoration** Buffer Planting	A mass failure on the right bank extends to the edge of hayfield. Failure could extend and threaten a barn to the south. The failing bank is on VLT property, the hayfield is privately owned. Similar to Project #1 the toe is fairly stable but the upper bank will continue to erode.	Plant woody vegetation at least 50' into the field to stabilize the soil and hopefully arrest the upper part of the mass failure. Plantings should be set back from the top of the slope at least 25ft to avoid loss from active erosion.	Low	Low	Stabilize a failing bank to reduce sediment inputs to the channel, long term protection of nearby barn.	Low	Vermont Land Trust; Private Landowner; LCNRCD Trees for Streams
#5 **Floodplain** Reach M09 44.60342 N 72.80851 W	**Passive Restoration** Conservation	The majority of the accessible floodplain within the reach is part of the Brewster Uplands Conservation Trust, however additional accessible floodplain was observed on both banks in the upper portion of the reach.	Work with private land owners to prevent stream corridor from future development. Extend conserved land upstream along the right bank.	Low	Low	Downstream benefits through the maintenance of water and sediment attenuation in this riparian area.	Low	VLT; Private Landowners
#6 **Austin Property** Reach M09 44.59993 N 72.80684 W	**Active Restoration** Bank Stabilization	The channel is migrating into the left bank and is undercutting large hemlock and pine trees along the Austin Property. The channel migrated rapidly during the 2011 floods and is threatening the well head for the property.	Alternatives analysis to provide a range of bank stabilization and planting options. Some rock armoring will likely be required, boulder vanes may be effective for pushing the thalweg away from the well-head. **Note: a project packet has been developed for this site and is included in Appendix E.**	Moderate	Low	Protect well head and reduce bank erosion.	Moderate	Private Landowner; LCNRCD Trees for Streams

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#7 **Floodplain Berm** Reach M10 44.59502 N 72.80088 W	**Active Restoration** Berm Removal	An approximately 300ft long and 3-4 ft high historic berm was observed along the right floodplain. This berm cuts off access to a forested floodplain during large flood events. The floodplain elevation increases downstream along the berm. Access is relatively easy from the north.	Remove portions of the berm along the upstream end to restore access to the floodplain during large events.	Low	Low	Increase sediment and floodwater attenuation in the reach.	Low	Private Landowner; Town of Cambridge; VTANR
#8 **Floodplain near Edwards Rd** Reach M10 44.59466 N 72.79983 W	**Passive Restoration** Corridor Protection	Highly active channel setting was observed for approximately 700ft downstream of the Edwards Rd bridge. The channel relocated to a historic channel during the 2011 floods and currently has access to some forested floodplain on both banks.	Protect corridor from future development. It is unlikely that development would occur in this area given the flood and erosion risks; however it is important to identify this area given the channel migration.	Moderate	Moderate	Protect active corridor from future development, protect floodplain area.	Low	Private Landowner; VTANR ERP; Town of Cambridge
#9 **Route 108** Reach M10 44.59421 N 72.79982 W	**Active Restoration** Bank Stabilization	The channel that was abandoned during 2011 floods could easily be re-accessed and armoring along Route 108 is insufficient. Channel is currently dry.	Monitor the instability along Route 108 and ensure sufficient protection of Route 108 during future flood events.	Moderate	Low	Reduce risk of road washout during future floods.	Moderate	VTRANS
#10 **Edwards Rd Bridge** Reach M11 44.59446 N 72.79876 W	**Active Restoration** Bridge Replacement	1928 bridge is only a minor bankfull constriction (89%) based on curve width; however a larger structure would better accommodate the large sediment load through this reach.	Replace with a larger structure that will improve sediment transport through the reach. **Note: a project packet has been developed for this site and is included in Appendix E.**	Moderate	Low	Reduced risk of debris or sediment accumulation at bridge during a storm event, improve sediment transport through reach.	High	VTRANS

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#11 **Floodplain downstream of N Hill Dr** Segment M12.A 44.59231 N 72.79203 W	**Passive Restoration** Corridor Protection	M12.A is a highly active segment with major deposition and numerous flood chutes through both floodplains. The channel may fully avulse into the right floodplain in the upper segment. Full avulsion may lead to mass failure along the right valley wall and could threaten North Hill Dr.	Given historical land use development patterns in this area along Brewster River, this active river area should not be developed or encroached. Protect corridor from future development and assess future erosion risk if channel avulses.	**High**	Moderate	Major sediment and floodwater attenuation area. Channel may fully avulse to the right floodplain which is currently undeveloped.	Low	Smugglers' Notch Resort
#12 **Bridge at Tennis Courts** Segment M12.B 44.59155 N 72.78952 W	**Active Restoration** Bridge Replacement	Wooden footbridge is causing some upstream sediment deposition but is not a bankfull constriction (150%). Scour around the footing and the pier are a major concern for the structural integrity of the bridge.	Replace bridge with more secure abutments and without a pier to reduce the risk of debris snagging, scour, and undermining. ***While the priority indicated is moderate, this project may be a higher priority for Smugglers Notch Resort.**	Moderate*	Low	Replace with a stronger structure and reduce the risk of ice/debris jamming on a pier.	Moderate	Smugglers' Notch Resort
#13 **Bridge** Segment M12.B 44.59085 N 72.78685 W	**Active Restoration** Bridge Replacement/ Retrofit	Wooden footbridge is causing some upstream and downstream sediment deposition and the abutments create a bankfull constriction (68%).	Replace abutments with poured concrete or stacked stone to increase bankfull width to a minimum of 21 feet.	Low	Low	Improve sediment transport through reach and reduce the risk of ice/debris jamming.	Moderate	Smugglers' Notch Resort
#14 **Floodplain along Mountain View Drive** Reach M13 44.59054 N 72.78464 W	**Passive Restoration** Corridor Protection	The forested left floodplain is accessible along most of the reach and could provide valuable sediment and floodwater attenuation following berm removal (#15) with no increased risk to nearby condominiums.	Protect corridor from future development. Some form of long-term protection could likely be established through SNR's land use planning (i.e., formal conservation easement may not be necessary).	Low	Low	Provide valuable floodplain attenuation in an area with very high sediment load.	Low	Smugglers' Notch Resort

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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
#15 **Floodplain along Mountain View Drive** Reach M13 44.59048 N 72.78452 W	**Active Restoration** Berm Removal	A newly constructed cobble berm is cutting off access to a large forested left floodplain and likely exacerbating a downstream mass failure. Reach has a very high sediment load.	Remove cobble berm to restore access to left floodplain.	**High**	Moderate	Provide sediment and stormflow attenuation during storms.	Low	Smugglers' Notch Resort
#16a **Wood Run Dr Bridge** Reach M14 44.58973 N 72.78323 W	**Active Restoration** Bridge Replacement/ Retrofit	Steel and concrete bridge has a span of 22ft, however armoring along the abutments creates a confinement to 15ft (80% of bankfull width) and is causing some upstream sediment deposition.	Retrofit bridge to increase bankfull width through the abutments. ***While the priority indicated is moderate, this project may be a higher priority for Smugglers Notch Resort.**	Moderate*	Low	Improve sediment transport through reach and reduce the risk of ice/debris jamming. Reduced risk of channel be erosion upstream at water line crossing.	High	Smugglers' Notch Resort
#16b **Wood Run Dr Bridge** Reach M14 44.58973N 72.78323	**Active Restoration** Grade Control Construction	A critical water line crosses the stream immediately upstream of the Wood Run Dr bridge. The channel is actively downcutting and is eroding below the water line.	Install multiple boulder weir structures to control grade and arrest the headcut. This project should be completed in conjunction with increasing the width of the bridge. ***While the priority indicated is moderate, this project may be a higher priority for Smugglers Notch Resort.**	Moderate*	Low	Arrest headcut and protect critical water line.	High	Smugglers' Notch Resort
#17 **Floodplain along Resort Access Road** Reach M14 44.59046 N 72.77777 W	**Active Restoration** Berm Removal	A newly constructed cobble berm is cutting off access to a forested left floodplain and likely exacerbating a downstream scour. Reach has a very high sediment load.	Remove cobble berm to restore access to left floodplain. Need to ensure that the access road and the two critical water lines running under the road are adequately protected.	Moderate	Moderate	Provide sediment and stormflow attenuation during storms.	Low	Smugglers' Notch Resort

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#18 Snowmaking Pond Dam Reach M14 44.59062 N 72.77565 W	**Active Restoration** Dam Retrofit or Removal	The snowmaking pond interrupts sediment transport and is likely causing increased bed scour in the downstream reach. The pond is likely impacting temperature and dissolved oxygen (DO). Pond is typically dredged on a 5-year schedule (last completed in 2010).	Consider alternatives for short term and long-term channel restoration, including: plantings to increase shading; more frequent dredging to remove organics and increase downstream DO; Retrofit dam/sluiceway to allow AOP; Remove dam and restore channel in long-term.	Low	**High**	Restore natural sediment transport through reach, decrease stream temperature, increase dissolved oxygen, remove AOP barrier.	Very High	Smugglers' Notch Resort
#19 Old 108 Loop Condominiums Reach T7.01 44.59058 N 72.79198 W	**Active Restoration** Bank Stabilization and Buffer Plantings	Existing large rip-rap is undermined and falling into the river. Single row of small trees behind armor is at risk, minimal risk to improved structures.	Remove existing armor and install a bulk toe to arrest scour along the bank. Replace rip-rap and add additional woody plantings along top of bank.	Low	Low	Stabilize bank and protect condominiums.	Moderate	Private Landowners
#20 Upstream and Downstream of Route 108 bridge Reach T7.01 Multiple Sites	**Passive Restoration** Buffer Planting	Areas of reduced or missing bank and buffer vegetation were observed near the Route 108 bridge.	Plant woody vegetation along the top of bank and into the floodplain.	Low	Low	Increase shading and woody debris inputs to stream and stabilize banks.	Low costs for materials and labor for buffer plantings.	LCNRCD Trees for Streams
# 21 Private Covered Bridge Reach T7.01 44.58842 N 72.79134 W	**Active Restoration** Bridge Retrofit	Both of the abutments for the covered bridge are undermined and are in need of replacement	Replace or repair both abutments and include a bulk toe to prevent future scour	Moderate	Low	Protect the bridge from washing out due to abutment failure.	Moderate	Private Landowner

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#22 **Timber Crib Dam** Reach T7.01 44.58722 N 72.79123 W	**Active Restoration** Dam Removal	Historic timber crib is partially breached but still represents a significant AOP barrier and debris/ice jam risk. Not enough water and sediment is stored behind dam to present a significant flooding concern if the dam failed.	Partially or fully remove dam.	Moderate	Moderate	Remove AOP barrier and reduce downstream flooding risk from ice/debris jamming.	Moderate	LCNRCD; USFWS; VTANR
#23 **Under Route 108 Bridge** Reach T7S1.01 44.58894 N 72.79063 W	**Active Restoration** Bridge Removal	Non-maintained footpath bridge is a major channel constriction. The bridge is very low and is likely backwatered or submerged during flood events.	Remove the bridge and replace with stepping stones or similar structures that will have less impact on high flows.	Moderate	Low	Reduce risk of ice/debris jamming	Low	Smugglers' Notch Resort
#24 **Mountain View Dr** Reach T7S1.01 Multiple Sites	**Active and Passive Restoration** Buffer Planting, Channel Restoration, BMP Implementation, Structure Replacement	The majority of this reach is highly modified. The recently constructed trout pond has minimal overhanging vegetation. The reach upstream of the pond is fully straightened and receives large volumes of sand and gravel from the road and parking area. Smuggs' is aware that the triple culverts under Mountain View Dr may need replacement soon.	Alternatives analysis for a range of projects: buffer planting along trout pond, channel restoration to improve floodwater attenuation, parking lot practices to reduce sediment inputs. Replace Mountain View Dr culverts with a bridge or single large culvert (squash or box), potentially remove trout pond and incorporate additional parking and stormwater treatment.	Moderate	**High**	Increase shading and woody debris inputs to stream, reduce sediment inputs, improve floodplain attenuation. Reduce risk of flood damage to parking lot, nearby structures, and Mountain View Dr crossing.	Low to High	Smugglers' Notch Resort; VTANR ERP

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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
#25 **Upstream of Water Park** Reach T7S1.02 44.58636 N 72.78669 W	**Active Restoration** Sub-tributary stabilization and road management	A small sub-tributary enters the reach near the downstream boundary and is depositing large volumes of fine sediment in the channel and along the floodplain. A lateral berm was recently installed to redirect flow away from the parking lot.	Upslope stormwater analysis to determine source of sediment and options for reducing impacts on tributary and T7. Stabilize dirt access road and reduce surface erosion.	Low	Moderate	Reduce sediment inputs to channel.		Smugglers' Notch Resort
#26 **West Hill Dr Culvert** Reach T7S1.02 44.58442 N 72.7843 W	**Active Restoration** Culvert Replacement/ Retrofit	Culvert is undersized causing upstream sediment deposition. Culvert is preventing AOP; however longitudinal AOP is compromised by downstream structure at trout pond.	Replace with a larger structure.	Moderate	Moderate	Improve sediment transport through reach, reduce risk of culvert being overtopped and damaging road, remove AOP barrier.	Moderate	Smugglers' Notch Resort
#27 **Ski Instructor Building** Reach T7S4.03 44.5717 N 72.77507 W	**Passive Restoration** Buffer Planting and Stabilization	Concentrated flow from an interception trench at the base of the ski slope is flowing under the ski instructor building and causing some gullying before reaching the stream.	Stabilize the flow area with check-dams and plantings. Divert flow around building.	Moderate	Low	Protect building footers from erosion, reduce sediment inputs to the channel.	Low	Smugglers' Notch Resort
#28 **Stormwater Outfalls** Reaches: M09, M12.B, M14, T7.01, T7S1.02, T7S4.02.01, T7.S4.03	**Active Restoration** Stormwater Treatment	Numerous small storm water pipes draining roadways and developed areas which directly discharge into the Brewster River. Several outfalls are located high on the bank leading to scour along the toe of the slope.	Assess opportunities for reducing stormwater runoff through swales, wetlands, or other BMP treatments. Stabilize banks below elevated outfalls to reduce scour.	Low	Moderate	Reduce sediment and pollutant loading	Low to High depending on required treatment	LCPC; VTDEC; Smugglers' Notch Resort

Table 10: Site-Level Project Identification for the Brewster River Watershed.

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
#29 Smugglers' Notch Resort Reaches: M12.B, M13, M14, T7S1.01, T7.S1.02, T7S4.02.01, T7.S4.03	**Passive Restoration** Stormwater Master Planning	Smugglers' Notch Resort has expressed interest in developing a stormwater master plan to address ongoing stormwater concerns within the developed areas of the resort. Very limited space exists for stormwater treatment practices.	Work with Smugglers' Notch Resort and project partners to identify stormwater issues and assess the capacity and performance of current treatment systems and identify opportunities for retrofit or new green stormwater infrastructure.	Low	Moderate	Reduce stormwater runoff, flooding issues, sediment and pollutant loading	Low to High	VTDEC; LCPC; Smugglers' Notch Resort
#30 Canyon Road Reach T1.01 44.6359 N 72.82286 W	**Active Restoration** Slope Stabilization, Stormwater Management	Lower Canyon Road follows a small tributary (T1.01) to the Brewster River for approx. ½ mile. There are several areas of unstable road embankments along the stream. Rilling of the road surface and erosion along the ditches is a large source of fine sediment to the channel.	Rebuild unstable road embankments with placed rip-rap walls to limit encroachment on the channel. Improve ditch maintenance and BMPs (i.e., small sedimentation basins) to reduce sedimentation. Consider elevating and regarding the road surface away from the stream channel in some areas to improve public safety and water quality.	**High**	Moderate	Reduced risk of catastrophic road failure during future floods. Reduce frequency of ditch maintenance following installation of BMPs. Improved water quality and habitat.	Moderate to High	Town of Cambridge; Better Backroads Grant; VTANR; VTrans; LCPC

5.0 Conclusions & Recommendations

Many reaches of the Brewster River are still adjusting their width, depth, and planform to the following historical and ongoing impacts: 1) aggradation of sediment in the valleys due to European settlement and deforestation that occurred during the 1700's and 1800's; 2) channel straightening, dredging, and corridor encroachment associated with adjacent roads, agriculture, and other land uses; 3) significant floods in recent years such as those in Spring of 2011 and Tropical Storm Irene in August of 2011.

There is a distinct transition point along the Brewster River corridor upstream of the (upper) Edwards Road crossing in Reach M11. Moving downstream from this point, the channel and valley slope, valley width, and sediment transport capacity transition as the power of the river to carry sediment and debris lessens. The lower reaches are generally characterized by wider valleys, lateral erosion and deposition processes, and planform adjustments. These reaches are dynamic and highly erosive during flood events due to ongoing adjustments to the channel bed and banks. Above this point, the upper reaches have greater potential for channel incision and erosion of the bed and banks. These headwaters reaches are generating large volumes of sediment and debris and transporting this material to downstream areas. The differences observed along these two zones of the river corridor have strong implications for the management approaches: passive restoration approaches (i.e., corridor protection) are emphasized in the lower reaches to avoid future conflicts with development along the river; whereas both active (i.e., reconnecting floodplains) and passive restoration approaches are recommended in the headwaters reaches to address sediment sources and storage zones, and areas of potential conflict due to channel instability.

Given the predictions for future river channel adjustments summarized in this report, the Town of Cambridge and Village of Jeffersonville (in cooperation with LCPC, VTDEC, and Smugglers' Notch Resort) are wise to take a long-term corridor planning approach to better understand, plan for, and mitigate flooding and fluvial erosion hazards. The watershed-scale and site-specific projects summarized in this plan provide opportunities to reduce flood vulnerabilities along rivers by proactively pursuing mitigation and restoration projects that will pay dividends in the long-term. For example, bridge and culvert replacements can be prioritized at the municipal and resort level based on the data provided in this report. Other longer term projects affecting multiple landowners, such as high-priority corridor protection areas, will require engaging many stakeholders in the community to improve each town's flood resiliency.

It is recommended that the following flood resiliency strategies and projects be pursued in the Brewster River watershed:

- Severely undersized structures (i.e., width less than 50% bankfull channel width) are extremely vulnerable to failure in future floods due to the volume of coarse sediment and woody debris currently stored in the channel that will be mobilized. These structure replacements and retrofits are described in Section 4.1.3 of the report.
- With the exception of the area around Jeffersonville Village, the Brewster River does not have detailed flood hazard mapping from the FEMA Flood Insurance Studies. As such, inundation-based flood risks are either unknown or underestimated in many cases, particularly in areas where the streams are smaller (i.e., less than 50 feet wide) but still transport large volumes of sediment and debris. River Corridor zones should be considered by the Town of Cambridge to

better map flood and erosion risks for both the safety and protection of their citizens, and the infrastructure controlled by the municipality.

- High priority river corridor protection projects, such as those included in Table 10, provide opportunities for comprehensive planning at the river corridor scale to mitigate flood and erosion hazards. Although these projects may take years of planning and community interaction to implement, they are equally important as the "active" projects.
- Smugglers' Notch Resort (SNR) has cooperated in the development of this plan through the review of potential restoration projects, and has offered support for following through with some of the high-priority projects located on or along SNR property. During these discussions, it was noted that portions of the SNR Village around Mountain View Extension and Aspens Drive could benefit from better stormwater management. The development of a stormwater master plan for this area to address out-dated stormwater treatment infrastructure is recommenced to improve channel stability, aquatic habitat, and water quality in downstream river reaches.

6.0 References

Dunne, T. and Leopold, L. B., 1978, Water in Environmental Planning, WH Freeman and Co., San Francisco, CA.

FEA (Fitzgerald Environmental Associates, LLC.), 2013, Brewster River Phase 1 & 2 Stream Geomorphic Assessment Summary, March 15, 2013.

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.

Lane, E. W. 1955, The Importance of Fluvial Morphology in Hydraulic Engineering. In: Proceedings of American Society of Civil Engineers. p. 1-17

MMI (Milone & MacBroom, Inc.) 2008a, The Vermont Culvert Geomorphic Capability Screening Tool. South Burlington, Vermont.

MMI (Milone & MacBroom, Inc.) 2008b, The Vermont Culvert Aquatic Organism Passage Screening Tool, South Burlington, Vermont.

Montgomery, D. R., & Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins, *Geological Society of America Bulletin*, 109(5), 596-611.

Rosgen, D. L., 1994, A classification of natural rivers, Catena, 22(3), 169 - 199.

Schumm, S. A., 1977, The Fluvial System, John Wiley and Sons, New York.

VTANR (Vermont Agency of Natural Resources), 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).

7.0 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 ft^2 (4,046.87 m^2). 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 make 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 -- oil 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 exceedance -- 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 2 Data QA/QC Summary

QA Notes For: **Brewster River**
Ph2 Assessment by Fitzgerald Environmental
Data checked by Staci Pomeroy
FEA Response - 2/2/15
Staci – 2/12/15
January 9, 2015

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.

General Notes:

Thank you for the good notes and narratives in steps 5 & 7, and for providing segmentation information in the Phase 1 comments. These help support and enhance the data.

Reach Notes:

M05: - No notes on data.

A general thought after walking the reach…. Seemed like a good potential for flow to get into the floodplain at the ~ reach break /sharp bend at upstream end of reach. If for some reason at the area where the flow gets shunted into the floodplain were to get jammed with sediment and/or debris and more flow were to end up on the floodplain; how would that reach change if is potential for the floodplain channel(s) to be captured again in the future….??? Just thinking of how we might anticipate future channel changes. If the bend at the upstream end were to jam with debris/sediment and the channel avulsed river left along the valley wall, that would be consistent with planform adjustments we'd expect moving from stage III to IV CEM. Given the low slope through the reach I think this is possible and probably wouldn't result in much vertical instability and it might improve floodplain access further. Thanks. Helpful to have context for the importance of those areas and how it may influence future channel adjustments.

M06: - No notes on data

M07 – Phase 1, step 6.3 channel bars notes as "none". There are multiple in P2. Please update. Updated Ok

M07A: Please fill in step 3 buffer/corridor using remote information. Updated Ok

M07B:

- Step 2 stream type sub-slope noted as "c". Phase 1 indicates >2% for both valley and channel. Is only area of gorge in reach creating slope values >2%? Did you do field slope measures for this segment? Yes it was 1.25% in the field, added step 2 comment. Ok – thanks for adding a comment

M09:

- Step 7 CEM = IV. Do you think the 2011 event pushed it out of an earlier stage of CEM? Yes, major flood deposits in 2011 likely pushed this reach out of stage III. I see the incision ratio is high, 1.7, and that in the narrative it notes the reach widened and then followed up by major aggradation. Step 7 aggradation is noted as "historic" Unchecked historic since there is still a lot of mobile sediment upstream. Ok If given time for the new bars/floodplain to become vegetated/stable, do you think we'd move to stage V? It is certainly possible if planform adjustment and aggradation continue. There is enough wood along the banks to help raise the bed. Ok or Because I see a head cut noted, is this reach likely to move back to stage III or II if an event happens? Head cut is limited to a recent avulsion, aggradation is the primary process

- Does the head cut need to be addressed? Is it something that would cause loss of floodplain and/or other issues if not addressed? Headcut is located at an avulsion/neck cutoff where the elevation is adjusting to the shortened path length. It won't go much further upstream but the channel will definitely widen at that location during the next storm. Huge cobble deposits fill the old channel, it would take a really big event to re-access that channel. Ok – that is helpful for context on this type of potential adjustment and how it influence the reach

M10:

- This reaches is notes as a "Cb" ref. stream type in Phase 1 and as a STD from C to B in P2 step 7. The slope and valley types are on the cusp of B/C stream types. I see in the narrative "river reclaimed historic abandoned channel. This stretch is ~ 450 ft. long and has near reference B-type geometry with accessible floodplain benches on both banks..." Do you think that only this small portion of channel would have had "B" features and the rest would have been "C" naturally; is there a difference in the setting, etc? That was poorly worded, the reach should be Cb by reference and has departed to B due to incision. The abandoned channel was also incised but retained access to lower floodplain benches, larger floodplain was elevated. Updated the step 7 narrative Ok
  - I am thinking about management needs. Would we expect this reach to move toward a C stream type or are conditions such that this will continue to be a "B", given available floodplain, etc? Berm removal and bed aggradation could restore floodplain access and move the reach back towards C. Ok – good to know and helps show value of possible project and/or impact of berm, and how aggradation in this reach is a part of helping move the stream toward more stable condition.

M11:

- Phase 1 step 6.5/6.6 – are notes as NA. If this is a "C" stream type this should be applicable. Please review and update. No true meanders were present, but we also did not observe straightening or armor. Updated with the geometry for the long skinny meander shape, high impacts for both. Ok
- Step 1 notes '"yes' for human caused change in valley width, and the width is ~ 100' difference between P1 and P2. Are you considering the P1 valley (pink) accurate? Is rte. 108 really cutting off floodplain on the other side? We have a different Ph1 VW file which I will send to you. True VW is along the far edge of 108. Ok
- The P2 valley wall (yellow) pinches at the upstream end a at the drive way edge. Is there bedrock or some other valley wall defining feature there that would shift the vw from rte. 108? The end of the driveway is built up to meet the elevation of 108 (which is built up several feet). Ok

- At the bridge, I'd not count this as a valley wall as you've drawn it unless the bridge is on ledge at that location, such that the valley is naturally defined with this pinch point. While the bridge may pinch the valley (captured in our constrictions), it is not necessarily a fixed feature that could not be changed to provide a wider opening.
  - This is important, because if we use the pinched valley wall you provided, it would change our River Corridor width in this area to a very narrow corridor. We do not want to reduce our River Corridor

width to a very narrow valley at the bridges unless it is truly a change in valley type. Is this area ledge? If not, I will move the vw back to 108. Understood and updated Ok

M12A:

- Step 7.2 notes this as a STD from C to D. Step 5 notes that most of the reach is an alluvial fan. Would we expect this segment to naturally be an alluvial fan? Continue to be an alluvial fan? The reach does not represent a large enough change in slope or confinement to expect a natural alluvial fan setting - removed the AF from FIT. The large volume of cobbles deposited in the reach leading to a departure to D are also likely a temporary feature, keeping reference as C type. Updated step 7 comment. Ok
- Step 2.15 for "sub-reach" has "C4" noted. This is the same as the reaches references stream type, so not a sub-reach for the overall reach. Unless you think this should be a sub-reach with a "D4" reference stream type; you would not fill in step 2.15. Sub-reach is for slope, Cb for Ph1, and just C for sub-reach. Ok
- If this is a STD from C to D, for management strategies, should we be managing this as a "D," with likely multiple channels (as noted multiple flood chutes), or consider that it could be managed toward a single thread "C"?
  - This will also be important as we look at the width of the river corridor needed in this area. As we may need to increase the multiplier from 3 to 4 times channel width, and/or look to make sure to include additional areas that may be captured by an alluvial fan process. I think it should be managed for D since this segment will be very active for the foreseeable future. Ok – this should be flagged in our report so folks understand, while it may not be an alluvial fan area naturally, current conditions may continue for the foreseeable future and management strategies should account for that.
- Step 7 narrative notes head cut was observed in one of the side channels. Anything to consider for addressing? The channel is mostly likely going to jump into the series of flood chutes on the right bank, the main channel is completely filled with cobble flood deposits. Ok – I'll look to see if we are able to map the extent of those channels/flood chutes to make sure are captured in the corridor.

M12B:

- Step 7 notes that the reach could be C or B ref., and you selected "C" based on sinuosity and a large flat floodplain instead of multiple low benches. Sinuosity is noted as "low" and "1.1". This does not seem a good indicator for a C. Slope is noted as ~2.7-3% for channel and valley. Would we get a higher sinuosity in this type of valley setting? Changed reference to B, the slope, substrate, and sinuosity are all a stretch for C. M12A will remain a C4 sub-reach by reference. Ok
  - Is the large flat floodplain noted throughout the reach? The incision ratio is 2.13! Is that a really historic floodplain or do you think something we lost access to because of current development/etc.? The large floodplain is located on the left bank in the upper portion of the segment. This area was accessed in 2011 and could still be accessed in smaller events for some attenuation via a large flood chute. It does appear that the bed and lower benches were recently scoured away, but it is unlikely that the bed has dropped enough recently to have disconnected from the larger floodplain, therefore it could be considered historic. Ok – good to know there is access possible.
  - Would we have enough room for enough floodplain area for a C to set up if channel were to go through CEM? - Probably not, changed to reference B Ok
    - Again, I'm thinking of management strategies. How would we look to manage this reach long term? If currently an F, would we try to help move back toward a "C", or would we have a better chance of managing toward a "B"?
- Step 7.1 "historic" noted as "no" for degradation. Are we likely to have additional incision? The narrative notes "reach shows some indication of transitions to widening and CEM III. What do you

think is limiting it from moving to CEM III, it appears to have widened and aggrading some from 2011 flooding? Updated to yes Ok

- Valley wall is narrowed at the bridge. Is this a change in the valley area, or simply related to the bridge abutments? Similar considerations as noted for bridge/valley wall in M11. VW narrows due to elevated approaches to the bridge. Very unlikely that floodwaters would get out of the channel and go over the road here. I'm not looking to see if the floodwaters would go over the road, I'm looking to see if the bridge approach was removed, would I have a wider valley. Is there bedrock or some other natural features that are causing the pinch at this bridge, or is it simply the approach fill material? Adjusted VW

M13:

- Step 7 indicates STD from B to D. Step 5 notes "numerous flood chutes and …..in this high slope D-type alluvial fan reach." Narrative notes, reach located at slight change in valley slope and width. With high bed load deposition being cause of shift from B to D.
    - Would you expect an alluvial fan to set up naturally here? Is this really more of a "D" by reference. We think the increased sediment load that is causing the braiding the D type geometry is a temporary response to the upstream scour caused by recent flooding and the dam interrupting sediment transport. The reach does not represent a large enough change in slope of confinement to expect a natural alluvial fan setting - removed the AF from FIT and updated step 5 and 7 comments. Ok
    - If not a D by reference; considering management needs, would we try to manage this reach back to a B (single thread step-pool), or expect that for the foreseeable future, this will be an alluvial fan area with multiple thread channels? We are recommending corridor protection/conservation and removal of a berm to increase floodplain access and sediment storage. Ok – good to flag in the report
- Step 2 incision ratio noted as 1.7, and not "historic". Is this reach still at risk of incision, given the level of aggradation noted. CEM is noted as III, so still anticipating widening? Is the amount of aggradation not quite enough to create a new floodplain (CEM IV) or bring the channel back up to connect to the historic floodplain? This short reach is highly variable, the upper portion is closer to B by reference and has reduced floodplain access, therefore some incision and/or widening is possible. The remainder of the reach has access to floodplain and has widened to accommodate the large volume of sediment. Berm removal is recommended to further improve floodplain access and attenuate coarse sediment within the

reach. Incision was changed to historic to represent the majority of the reach and we believe that the reach is in Stage III but is close to Stage IV, especially following berm removal. Ok – good to know

M14:

- Phase 1 note indicates "dredging noted in step 5 associated with berm observed during windshield survey". Was the dredge/berming confirmed in Phase 2 to update this note? This was FIT'd in the wrong spot, moved down to M13, updated Ph1 comment and deleted M14 point. Ok
- Step 2.8 incision ratio– Excel workbook shows the "human elevated" incision ratio (2.89), not incision ratio shown in step 2.8 (2.35). Please workbook update for reach incision ratio. Updated and uploaded Ok
    - From the XS it looks like this was taken in the area of the berm. Is that accurate? The berm is not marked as such in the XS notes, so wanted to confirm if that was a berm or not in the XS. If yes, please mark in the XS notes. Yes, added notes to XS Ok
    - The XS looks like the road side is the lower floodplain side for this reach, or is there floodplain potentially available opposite the road? Thinking of management and long term needs if aiming to move back to a "B" stream type, do we have the space w/o road area for floodplain or not. The right floodplain is typically higher than the road, occasionally at the same elevation; it would be very difficult to restore floodplain access. The upstream berm is recommended for removal and would restore access to a small forested floodplain. Ok
    - Do you think the berm was created to prevent flooding of the road; or just a poor flood recovery effort? If it were to be removed would there be benefits? I think the berm is mostly just extra material from grading the road, does not look like an intentional flood protection feature. Minimal benefits if removed and would increase potential damage to road.
- Step 3.1 revetment types noted as "multiple and other". Please note what the types are in notes. Helpful for tracking types and understand level of bank protection. Other is the concrete spillway at top of reach, added comment to step 5. Ok
- Step 4.6 "up/down flow reg." noted as "none", but also as "run of river dam". Please review and update. Updated Ok

T7.01:

- Phase 1 note – "breached dam represents a high risk of ice jamming within reach". Is there hazard for failure of the dam? Consequences of dam failure? Trying to determine if we should encourage the town to include this in their Hazard Mitigation Plan for possible planning needs, flood concerns, etc. Dam has mostly failed, it is holding enough sediment to warrant some concern. Only real risk would be if a bunch of ice or debris hung up and then let loose. Ok – Lets note this in report, and we can flag with LCPC/Cambridge/Smuggs may be something to look at removal and/or at least to consider in Hazard Mitigation Plans to be aware of.

- Step 7 narrative notes " ….future widening and planform adjustments is minimal given the extensive armoring indicating this reach will be stuck in CEM II" There is only about 500 ft/side out of ~ 3,000ft noted as armored. This does not seem like it would prevent widening/planform change in all areas of the reach. Is there really limited area for adjustments in areas not armored? Is it the likelihood of continued armoring due to the level of encroachment that is going to prevent further channel adjustments? Added additional description of ledge and bouldery soils to reduce future widening. Ok

- Considerations for management strategies. If you feel this reach is stuck in stage II, do we need to manage this as an "F" instead of trying to move back to a "B"? The only potential floodplain within the reach has buildings right on the bank, so it might require managing for F. Ok – good to flag in report
- Valley wall (yellow) is pulled away from Rte. 108 to the edge of the drive way. Is this truly a change in valley wall feature, or encroachment? Unless a strong valley wall feature, will pull the valley wall back to rte. 108. Updated VW Ok

T7S1.01:

- Step 4.8 channel constrictions – What is the bridge in picture DSCN0144 (looks like at the start of reach at downstream end, but is not listed in step 4.8. Should it be? Added as a constriction Ok
  - Instream culvert is noted as having no problems. Looking at the picture of the triple culverts (picture DSCN0149), looked like scour below Added scour below Ok
- Step 5.5 dredging – noted as "none". Step 7 narrative notes "possible ditch maintenance dredging along gravel parking lot….". Is the dredging noted in step 7 something that should be marked for step 5? Added dredging in FIT Ok
- Step 7.1 degradation historical is noted as "no". Do you think this is likely to continue? The incision ratio of 3.69 is fairly extreme for this little stream. Widening and planform opportunities are minimal, I think degradation will likely continue. Ok – yikes, that is important to flag in report. Could helps support way important to do project and/or be way we keep an eye on this reach to see if adjustments continue and impacts from that adjustments.
- Step 7.3 widening historical is noted as "yes". The width of 7.8 is almost the same as Phase 1 -7.9ft. Has the stream widened? No and changed to no. Ok
- Step 7 narrative " heavily modified reach departed to F…..little opportunity to widen or adjust planform due to extensive encroachment and armoring…." Thinking of management strategies…. Should we be aiming to move back to a "C" stream type , or something other than "F"… would there be room for a "B"? We are recommending a channel restoration project along the parking area and the road, could add in some bench features to get B geometry, but most likely the reach should be managed as an F. Ok – good to flag in report

T7.S1.02:

- Step 1.2 Alluvial fan noted as "yes". I do not recall any strong evidence of an alluvial fan at the bottom of this reach. What are you looking at for flagging this reach has having an area of alluvial fan? This will be important for corridor width and management strategies.
  - Were you looking at the flow paths we saw in the woods? Pictures DSCN0535-526 show the flow we saw in the woods ,but we did not trace this back up to where it started or if connected to channel as part of a fan system. Do you think they were? Removed AF from FIT, added description of the subtributary to step 7 comments. Ok
- Step 7 narrative "reach was incised and had minimal floodplain…….. this reach is likely stuck in stage II." The reach was able to maintain its reference stream type of "B" and has an entrenchment ratio of 2.3, so fairly big for a "B". Is the floodplain not available for any level of channel adjustments?
  - Channel width is 13 ft. compared to Phase 1 estimate of 7.1 ft. Do you think the channel width will narrow up or is the Phase 1 estimate not accurate and reference width would be wider? Has the stream already widened? Changed it to stage III given the Ph2 bankfull width. Lots of sediment coming from upstream, could aggrade and reconnect to floodplain. Ok
- Step 7.1 degradation historic noted as "no". Thinking management strategies, if likely stuck in stage II, but able to currently maintain a "B", will the reach be able to maintain a "B" or is it sensitive enough that could further incise and have a STD? Changed to III, if sediment transport was improved through

structure replacement it's possible that the bed could aggrade and re-establish floodplain access. Ok – good to note in report

T7S4.03:

- Phase 1 step 7.3 ice/debris jams noted as "none'. There is 1 in Phase 2. Please update. Updated Ok
- Step 2 channel width is 22.5 ft. Phase 1 notes ref. width of 12.8. Do you think the reach has widened from 12.8 to 22.5; or is 22.5 a correct width for the reach and Phase 1 should be updated? This will influence our corridor width, so want to make sure using correct width. I have a comment in step 5 that mentions how the cross-section was collected at the only riffle in the reach and isn't particularly representative. I added a note that the actual width was 10 - 15'. Ok

T7S4.02.01:

- Phase 1 step 7.3 ice/debris jams noted as "none'. There are 2 in Phase 2. Please update. Updated Ok
- Step 4.8 channel constrictions only notes one bridge. Phase 1 indicates 2 bridges on reach. I realize the one bridge is fairly high off the reach, but the fill at the bottom of the abutments can/does influence the reach, please note in 4.8 for tracking purposes. Updated Ok

APPENDIX B

Phase 2 Stream Geomorphic Assessment Data

Phase 2 Segment Summary Report **Brewster River**

Stream:	**Brewster RIver**	SGAT Version:	**4.56**
Reach:	**M05-0**	Organization:	**Fitzgerald Environmental**
Segment Length(ft):	**2,553**	Observers:	**EPF, SEP**
Rain:	**Yes**	Completion Date:	**7/17/2014**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Begins just upstream of large waterfall; ends 2,500 feet upstream, just upstream of sharp bend in channel.**

Step 5 - Notes: **Channel became overwidened in many locations with cobbles deposited during recent episodic flooding (2011). Some bank erosion noted. Good floodplain access in upper reach on left overbank downstream of large depositional feature at reach break.**

Step 7 - Narrative: **This reach experienced the same widening and deposition during 2011 floods as we observed in M06. However, the damage was reduced in M05, likely due to sediment and floodwave attenuation in the upstream reach. Widening is the dominant process as the channel adjusts within the new geometry and as flood sediments work through the reach. Some planform adjustment is being initiated in the upstream end of the reach.**

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:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	**Very Steep**	**Hilly**
Continuous w/ Bank:	**Sometimes**	**Sometimes**
Within 1 Bankfull W:	**Sometimes**	**Sometimes**
Texture:	**N.E.**	**Gravel**

1.5 Valley Features	
Valley Width (ft):	**350**
Width Determination:	**Measured**
Confinement Type:	**BD**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Stream: **Brewster RIver**   Reach: **M05-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**57.50**	2.11 Riffle/Step Spacing:	**160 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.90**	2.12 Substrate Composition		Bed:	**300 mm**
2.3 Mean Depth (tf):	**1.92**	Bedrock:	**0.0 %**	Bar:	**120 mm**
2.4 Floodprone Width (ft.):	**158.00**	Boulder:	**9.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.80**	Cobble:	**42.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**33.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**29.95**	Fine Gravel:	**8.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**2.75**	Sand:	**8.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.31**	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:	**4.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**15**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**340.9**	**326.1**	Dominant:	**Coniferous**	**Coniferous**
Material Type:	**Gravel**	**Gravel**	Erosion Height (ft.):	**5.3**	**6.1**	Sub-dominant:	**Shrubs/Sapling**	**Herbaceous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**None**	**None**	Bank Canopy		
Lower			Revetment Length:	**0.0**	**0.0**	Canopy %:	**76-100**	**76-100**
Material Type:	**Gravel**	**Gravel**				Mid-Channel Canopy:	**Open**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Coniferous**
Sub-Dominant	**Mixed Trees**	**Mixed Trees**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M05-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs	**None**
4.2 Adjacent Wetlands:	**Abundant**	Flow Reg. Use:		Field Ditch:	Road Ditch:
4.3 Flow Status:	**Moderate**	Impoundments:	**None**	Other:	Tile Drain:
4.4 # of Debris Jams:	**1**	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: **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:	**2**	Delta:	**0**	Flood chutes:	**0**	Avulsion:	**0**	5.5 Straightening:	**None**
Point:	**5**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**5**	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 Gradiant Type	Left	Right
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	**13**	**None**	**No**	Geomorphic Rating	**0.70**
7.2 Channel Aggradation	**13**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**13**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**17**	**None**	**No**	Geomorphic Condition	**Good**
Total Score	**56**			Stream Sensitivity	**Moderate**

Phase 2 Segment Summary Report Brewster River

Stream:	Brewster RIver	SGAT Version:	4.56
Reach:	M06-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	4,615	Observers:	JHB, MPL
Rain:	No	Completion Date:	6/3/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - Location: **Begins 2,500 feet upstream of second tributary, just upstream of sharp bend in channel; ends where Brewster comes close to Rt 108, about .3 mile north of Campground Rd.**

Step 5 - Notes: **Gorge in segment M07-A starts approximately 200' downstream of the M06/M07 reach break but was not segmented out of M06. DMS data reflects non-gorge influenced reach geometry.**

Step 7 - Narrative: **This reach dramatically widened and aggraded during the 2011 floods and is now re-establishing planform through the widened channel and deep cobble/gravel deposits. Major flood chutes, avulsions, and some braiding were observed. W/D ratio is decreasing as the channel reforms through the flood deposits.**

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:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Steep
Continuous w/ Bank:	Never	Sometimes
Within 1 Bankfull W:	Never	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features	
Valley Width (ft):	380
Width Determination:	Measured
Confinement Type:	BD
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?
Ledge	Mid-segment	8.0	4.0	Yes	

Stream: **Brewster RIver** Reach: **M06-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**59.60**	2.11 Riffle/Step Spacing:	**200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.60**	2.12 Substrate Composition		Bed:	**450 mm**
2.3 Mean Depth (tf):	**1.75**	Bedrock:	**0.0 %**	Bar:	**140 mm**
2.4 Floodprone Width (ft.):	**170.00**	Boulder:	**11.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.40**	Cobble:	**40.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**36.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**34.06**	Fine Gravel:	**9.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**2.85**	Sand:	**4.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.69**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**4.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**49**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**585.4**	**54.7**
Erosion Height (ft.):	**5.3**	**4.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Coniferous**	**Coniferous**
Bank Canopy		
Canopy %:	**51-75**	**76-100**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**36.0**
Gullies	**One**	**60.0**

	Left	Right
Mass Failures	**237.0231**	**583.3429**
Height	**40.0**	**44.8**
Gullies Number	**1**	
Gullies Length	**4**	

Stream: **Brewster RIver** Reach: **M06-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**

4.2 Adjacent Wetlands: **Abundant**

4.3 Flow Status: **Low**

4.4 # of Debris Jams: **3**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**

Field Ditch: Road Ditch:

Other: Tile Drain:

Overland Flow: Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	25	Yes	Yes	Yes	Yes	Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **6** Delta: **0**

Point: **7** Island: **0**

Side: **15** Braiding: **1**

Diagonal: **4**

5.2 Other Features

Flood chutes: **0**

Neck Cutoff: **1**

Avulsion: **2**

5.3 Steep Riffles and Head Cuts

Head Cuts: **0**

Steep Riffles: **3**

Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score: **0**

Habitat Rating: **0.00**

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type	Left	Right
6.8 Bank Stability:		
6.9 Bank Vegetation Protection		
6.10 Riparian Veg. Zone Width:		

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**10**	**None**	**Yes**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**8**	**None**	**No**
7.4 Change in Planforml	**5**	**None**	**No**
Total Score	**31**		

Geomorphic Rating	**0.39**
Channel Evolution Model	**F**
Channel Evolution Stage	**IV**
Geomorphic Condition	**Fair**
Stream Sensitivity	**High**

Phase 2 Segment Summary Report **Brewster River**

Stream: **Brewster RIver**
Reach: **M07-A**
Segment Length(ft): **390**
Rain: **No**

SGAT Version: **4.56**
Organization: **Fitzgerald Environmental**
Observers: **JHB, MPL**
Completion Date: **6/3/2014**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **Begins where Brewster comes close to Rt 108, about .3 mile north of Campground Rd., ends at the top of the bedrock gorge 550ft downstream of campground rd.**

Step 5 - Notes:

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation:

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

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

1.4 Adjacent Side — Left — Right

Hillside Slope:

Continuous w/ Bank:

Within 1 Bankfull W:

Texture:

1.5 Valley Features

Valley Width (ft): **90**
Width Determination: **Measured**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

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

Stream: **Brewster RIver** Reach: **M07-A**

Step 2. Stream Channel

2.1Bankfull 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 (tf):		Bedrock:	%	Bar:		
2.4 Floodprone Width (ft.):		Boulder:	%	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):		Cobble:	%	Stream Type:	**A**	
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:	**Cascade**	
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	%	Field Measured Slope:	**4**	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type		
2.9 Sinuosity:		Detritus:	**0.0 %**	Reference Stream Type:		**A**
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:		**Bedrock**
				Reference Subclass Slope:		
				Reference Bedform:		**Step-Pool**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**0.0**	**0.0**	Dominant:	**Deciduous**	**Coniferous**
Material Type:	**Mix**	**Mix**	Erosion Height (ft.):	**0.0**	**0.0**	Sub-dominant:	**Coniferous**	**Deciduous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**None**	**None**	Bank Canopy		
Lower			Revetment Length:	**0.0**	**0.0**	Canopy %:	**76-100**	**76-100**
Material Type:	**Bedrock**	**Bedrock**				Mid-Channel Canopy:	**Closed**	
Consistency:	**Cohesive**	**Cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant		
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant		
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M07-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:

4.2 Adjacent Wetlands:

4.3 Flow Status:

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**

Field Ditch:

Road Ditch:

Other:

Tile Drain:

Overland Flow:

Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid:

Point:

Side:

Diagonal:

Delta:

Island:

Braiding: **0**

5.2 Other Features

Flood chutes: **0**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **0**

Neck Cutoff: **0**

Avulsion: **0**

Head Cuts: **0**

Trib Rejuv.:

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score:

Habitat Rating:

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type	Left	Right
6.8 Bank Stability:		
6.9 Bank Vegetation Protection		
6.10 Riparian Veg. Zone Width:		

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Score	STD	Historic
7.1 Channel Degradation			
7.2 Channel Aggradation			
7.3 Widening Channel			
7.4 Change in Planforml			
Total Score			

Geomorphic Rating

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Good**

Stream Sensitivity

Phase 2 Segment Summary Report Brewster River

Stream:	Brewster RIver	SGAT Version:	4.56
Reach:	M07-B	Organization:	Fitzgerald Environmental
Segment Length(ft):	1,517	Observers:	JHB, MPL
Rain:	No	Completion Date:	6/3/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - Location: **Begins at the top of the bedrock gorge 550ft downstream of campground rd., ends 150 feet upstream of fourth tributary.**

Step 5 - Notes: **Two large bars (point and side) filled much of the widened channel leading to concentrated flow and two steep riffles. Heavy scour along the left bank (without erosion indexed) indicates that lower benches were likely scoured away when the channel widened during recent flooding.**

Step 7 - Narrative: **This segment incised and widened during 2011 flooding and scoured away lower benches. The current channel has access to a narrow floodplain bench. The campground is located on a historic terrace and is only accessible in the largest events. The entire segment has light development and floodplain clearing associated with the Brewster River Campground on the left bank. Recent widening reduced floodplain width and the channel is currently still widening, but may transition to stage IV with continuing aggradation.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	565		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Steep
Continuous w/ Bank:	Never	Never
Within 1 Bankfull W:	Never	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft):	400
Width Determination:	Measured
Confinement Type:	BD
In Rock Gorge:	No
Human Caused Change in Valley Width?:	No

1.6 Grade Controls: **None**

Stream: **Brewster RIver**   Reach: **M07-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**51.25**	2.11 Riffle/Step Spacing:	**300 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.40**	2.12 Substrate Composition		Bed:	**570 mm**
2.3 Mean Depth (tf):	**1.59**	Bedrock:	**0.0 %**	Bar:	**220 mm**
2.4 Floodprone Width (ft.):	**76.00**	Boulder:	**17.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.25**	Cobble:	**45.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**20.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**32.23**	Fine Gravel:	**16.0 %**	Subclass Slope:	**c**
2.7 Entrenchment Ratio:	**1.48**	Sand:	**2.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.35**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	**1.25**
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**4**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**0.0**
Erosion Height (ft.):	**0.0**	**0.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Coniferous**	**Coniferous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**26-50**	**>100**
Sub-Dominant	**>100**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Coniferous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**Residential**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M07-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs	**None**
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	Road Ditch:
4.3 Flow Status:	**Low**	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: **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:	**1**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**1**	Braiding:	**0**	Steep Riffles:	**2**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:		6.4 Sediment Deposition:		Stream Gradiant Type	Left	Right
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	**12**	**None**	**No**	Geomorphic Rating	**0.56**
7.2 Channel Aggradation	**10**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**11**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**12**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**45**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report **Brewster River**

Stream:	**Brewster RIver**	SGAT Version:	**4.56**
Reach:	**M09-0**	Organization:	**Fitzgerald Environmental**
Segment Length(ft):	**4,841**	Observers:	**JHB, MPL**
Rain:	**No**	Completion Date:	**6/3/2014**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Begins at Edwards Rd bridge; ends just downstream of sixth tributary, about .5 mile north of Rt 108/Edwards Rd intersection.**

Step 5 - Notes: **Huge cobble bars were observed along several outside bends. The channel avulsed through a historic flood chute in the lower reach. New meanders are carving through flood sediments in the mid and upper reach.**

Step 7 - Narrative: **This reach widened during the 2011 floods followed by major aggradation of flood related cobble and gravel. Planform adjustments are occurring as the river carves meanders through these sediments within the widened channel. A large channel avulsion occurred where the river dumped a huge volume of cobbles in the historic channel and is carving a new channel through the right bank with an active but small headcut.**

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:	419	6	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	459		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	**Steep**	**Hilly**
Continuous w/ Bank:	**Never**	**Never**
Within 1 Bankfull W:	**Never**	**Never**
Texture:	**Mixed**	**Mixed**

1.5 Valley Features

Valley Width (ft):	**340**
Width Determination:	**Measured**
Confinement Type:	**BD**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**Yes**

1.6 Grade Controls: **None**

Stream: **Brewster RIver** Reach: **M09-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**48.00**	2.11 Riffle/Step Spacing:	**200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.85**	2.12 Substrate Composition		Bed:	**550 mm**
2.3 Mean Depth (tf):	**1.31**	Bedrock:	**0.0 %**	Bar:	**220 mm**
2.4 Floodprone Width (ft.):	**146.00**	Boulder:	**15.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.85**	Cobble:	**31.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**36.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**36.64**	Fine Gravel:	**15.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**3.04**	Sand:	**3.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.70**	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:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**19**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**409.5**	**98.8**
Erosion Height (ft.):	**5.1**	**6.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**641.8**	**79.5**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**

Mid-Channel Canopy: **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**0-25**	**None**
W less than 25	**116**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**Commercial**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**80.0**
Gullies	**None**	

	Left	Right
Mass Failures		**81.667 21**
Height		**80.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M09-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**

4.2 Adjacent Wetlands: **Abundant**

4.3 Flow Status: **Low**

4.4 # of Debris Jams: **2**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs

Field Ditch: **0** Road Ditch: **1**

Other: **0** Tile Drain: **0**

Overland Flow: **0** Urb Strm Wtr Pipe: **0**

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	20	No	No	Yes	Yes	Deposition Above,Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **1** Point: **7** Side: **9**

Diagonal: **0** Delta: **0** Island: **1** Braiding: **0**

5.2 Other Features

Flood chutes: **1**

Neck Cutoff: **0** Avulsion: **1**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **2** Head Cuts: **1** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score: **0**

Habitat Rating: **0.00**

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type	Left	Right
6.8 Bank Stability:		
6.9 Bank Vegetation Protection		
6.10 Riparian Veg. Zone Width:		

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	12	None	Yes
7.2 Channel Aggradation	11	None	Yes
7.3 Widening Channel	8	None	No
7.4 Change in Planforml	7	None	No
Total Score	38		

Geomorphic Rating	**0.47**
Channel Evolution Model	**F**
Channel Evolution Stage	**IV**
Geomorphic Condition	**Fair**
Stream Sensitivity	**Very High**

Phase 2 Segment Summary Report **Brewster River**

Stream:	Brewster RIver	SGAT Version:	4.56
Reach:	M10-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	2,517	Observers:	JHB, MPL
Rain:	Yes	Completion Date:	6/10/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - 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.**

Step 5 - Notes: **The channel fully avulsed downstream of the Edwards Rd bridge in to what appears to be a historic channel. This avulsed channel is very stable and has good floodplain access. The abandoned channel could easily be reaccessed and is currently indexed as a flood chute. A huge point bar is located upstream of the bridge.**

Step 7 - Narrative: **Lack of grade control caused this reach to incise during 2011 flooding. Lower banks were also scoured leaving a deeply incised reach that has started to fill back in with coarse deposits working through the reach. Bank scour and erosion were observed throughout the reach. A large avulsion was observed at the top of the reach where the River reclaimed a historic abandoned channel. This stretch is approximately 450ft long and has less widening and retains access to narrow floodplain benches, however the primary floodplain is elevated. The remainder of the reach is encroached by Rt 108 on the left floodplain and had increased incision and entrenchment. Degradation was classified as historic as the reach is now aggrading and widening.**

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:	295	3	0	
Road:	2,445	0	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Hilly
Continuous w/ Bank:	Always	Never
Within 1 Bankfull W:	Always	Never
Texture:	Mixed	Mixed

1.5 Valley Features	
Valley Width (ft):	290
Width Determination:	Measured
Confinement Type:	BD
In Rock Gorge:	No
Human Caused Change in Valley Width?:	No

1.6 Grade Controls: **None**

Stream:	**Brewster RIver**	Reach:	**M10-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**39.40**	2.11 Riffle/Step Spacing:	**160 ft.**	2.13 Average Largest Particle on		
2.2 Max Depth (ft.):	**2.80**	2.12 Substrate Composition		Bed:	**600**	**mm**
2.3 Mean Depth (tf):	**1.85**	Bedrock:	**0.0 %**	Bar:	**140**	**mm**
2.4 Floodprone Width (ft.):	**60.00**	Boulder:	**20.0 %**	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):	**4.95**	Cobble:	**36.0 %**	Stream Type:	**B**	
Human Elev FloodPln (ft.):		Coarse Gravel:	**34.0 %**	Bed Material:	**Cobble**	
2.6 Width/Depth Ratio:	**21.30**	Fine Gravel:	**7.0 %**	Subclass Slope:	**None**	
2.7 Entrenchment Ratio:	**1.52**	Sand:	**3.0 %**	Bed Form:	**Riffle-Pool**	
2.8 Incision Ratio:	**1.77**	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:	**3.0 %**	Reference Stream Type:		
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**27**	Reference Bed Material:		
				Reference Subclass Slope:		
				Reference Bedform:		

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**297.7**	**181.3**	Dominant:	**Deciduous**	**Deciduous**
Material Type:	**Mix**	**Mix**	Erosion Height (ft.):	**6.7**	**7.1**	Sub-dominant:	**Herbaceous**	**Herbaceous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**Rip-Rap**	**None**	Bank Canopy		
Lower			Revetment Length:	**352.0**	**0.0**	Canopy %:	**76-100**	**76-100**
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**				Mid-Channel Canopy:	**Open**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**26-50**	**>100**
Sub-Dominant	**0-25**	**None**
W less than 25	**316**	**0**
Buffer Vegitation Type		
Dominant	**Deciduous**	**Mixed Trees**
Sub-Dominant	**Mixed Trees**	**Coniferous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Commercial**	**Forest**
Sub-dominant	**Shrubs/Sapling**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M10-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **4**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments:
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**
Field Ditch: Road Ditch:
Other: Tile Drain:
Overland Flow: Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **2** Diagonal: **2**
Point: **4** Delta: **0**
Side: **8** Island: **0**
Braiding: **0**

5.2 Other Features
Flood chutes: **1**
Neck Cutoff: **0**
Avulsion: **1**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **2**
Head Cuts: **0**
Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type <u>Left</u> <u>Right</u>
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined**	Score	STD	Historic		
7.1 Channel Degradation		**7**	**C to B**	**Yes**	Geomorphic Rating	**0.40**
7.2 Channel Aggradation		**11**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel		**5**	**None**	**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml		**9**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score		**32**			Stream Sensitivity	**High**

Phase 2 Segment Summary Report Brewster River

Stream:	Brewster RIver	SGAT Version:	4.56
Reach:	M11-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	1,616	Observers:	JHB, MPL
Rain:	Yes	Completion Date:	6/10/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - Location: **Begins 100 feet downstream of Edwards Rd bridge; ends just upstream of seventh tributary entering at Notch View Rd.**

Step 5 - Notes: **A huge cobble bar (7ft tall) was observed immediately upstream of the Edwards Rd Bridge. Additional large cobble side bars were present throughout the reach filling in the overwidened channel.**

Step 7 - Narrative: **This reach scoured and incised during May, 2011 flood and T.S. Irene flood. Near continuous heavy scour was observed along the lower banks and some erosion was indexed. The reach widened to over 100ft in several locations and has since filled back in with large cobble side bars. Some planform adjustments are ongoing but the reach appears to be widening and slowly rebuilding the bed as flood sediments work through. We assigned a departure to B type instead of F-type due to the overwidened bankfull, entrenchment would be less severe at curve width. Small benches were elevated but accessible through most of the reach, large floodplain areas were very high and not accessible.**

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:	697	0	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	54		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Very Steep
Continuous w/ Bank:	Never	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features	
Valley Width (ft):	350
Width Determination:	Measured
Confinement Type:	VB
In Rock Gorge:	No
Human Caused Change in Valley Width?:	Yes

1.6 Grade Controls: **None**

Stream: **Brewster RIver** Reach: **M11-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**44.91**	2.11 Riffle/Step Spacing:	**180 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.10**	2.12 Substrate Composition		Bed:	**550 mm**
2.3 Mean Depth (tf):	**1.43**	Bedrock:	**0.0 %**	Bar:	**150 mm**
2.4 Floodprone Width (ft.):	**61.00**	Boulder:	**18.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.85**	Cobble:	**46.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**23.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**31.41**	Fine Gravel:	**11.0 %**	Subclass Slope:	**c**
2.7 Entrenchment Ratio:	**1.36**	Sand:	**2.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.83**	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:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**5**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**67.9**	**94.7**
Erosion Height (ft.):	**6.0**	**6.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**49.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Coniferous**	**Coniferous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**26-50**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**Residential**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M11-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**

4.2 Adjacent Wetlands: **Minimal**

4.3 Flow Status: **Low**

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs **None**

Field Ditch: Road Ditch:

Other: Tile Drain:

Overland Flow: Urb Strm Wtr Pipe:

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	30	Yes	Yes	Yes	Yes	Deposition Above,Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **0** Point: **2** Side: **4**

Diagonal: **1** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features

Flood chutes: **0**

Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0** Trib Rejuv.: **No**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **2**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **None**

Straightening Length (ft.): **0**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score: **0**

Habitat Rating: **0.00**

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type	Left	Right
6.8 Bank Stability:		
6.9 Bank Vegetation Protection		
6.10 Riparian Veg. Zone Width:		

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	5	C to B	Yes
7.2 Channel Aggradation	8	None	No
7.3 Widening Channel	5	None	No
7.4 Change in Planforml	11	None	No
Total Score	29		

Geomorphic Rating	**0.36**
Channel Evolution Model	**F**
Channel Evolution Stage	**III**
Geomorphic Condition	**Fair**
Stream Sensitivity	**High**

Phase 2 Segment Summary Report   Brewster River

Stream:	Seventh tributary to Brewster River	SGAT Version:	4.56
Reach:	T7.01-0	Organization:	Fitzgerald Environmental
Segment Length(ft):	3,075	Observers:	JHB, MPL
Rain:	Yes	Completion Date:	6/10/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - 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.**

Step 5 - Notes: **Large side bars were observed through most of the reach as the channel fills in areas where lower banks were scoured during recent flooding. Steep riffles were observed in locations where the flow was pinched due to the formation of large bars along the margins.**

Step 7 - Narrative: **This reach widened and incised during the 2011 floods, scouring away lower banks resulting in a deeply incised and entrenched reach. Erosion was minimal within the reach, primarily due to bouldery and bedrock banks that were scoured back to clean rock/roots with no exposed soil. Armoring was observed throughout much of the reach to protect roads and properties encroaching the stream. Large cobble side bars have formed refilling much of the widened channel margins. The potential for future widening and planform adjustments is minimal given the bouldery soils, extensive armoring, and ledge found throughout the reach, indicating that this reach will be stuck in stage II.**

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:	303	3	0	
Road:	2,319	2	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	606		600	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Steep	Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features	
Valley Width (ft):	180
Width Determination:	Measured
Confinement Type:	BD
In Rock Gorge:	No
Human Caused Change in Valley Width?:	Yes

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Mid-segment	4.0	2.5	Yes	
Ledge	Mid-segment	0.0	0.0	Yes	
Ledge	Mid-segment	4.0	2.0	No	
Ledge	Mid-segment	4.0	2.0	No	
Ledge	Mid-segment	5.0	2.0	No	

Stream: **Seventh tributary to Brewster River** Reach: **T7.01-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**37.50**	2.11 Riffle/Step Spacing:	**200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.80**	2.12 Substrate Composition		Bed:	**450 mm**
2.3 Mean Depth (tf):	**1.11**	Bedrock:	**0.0 %**	Bar:	**180 mm**
2.4 Floodprone Width (ft.):	**41.00**	Boulder:	**20.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.80**	Cobble:	**47.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**17.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**33.78**	Fine Gravel:	**14.0 %**	Subclass Slope:	
2.7 Entrenchment Ratio:	**1.09**	Sand:	**2.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.67**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	**2**
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**9**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**44.1**	**0.0**
Erosion Height (ft.):	**9.0**	**0.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**517.3**	**439.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**0-25**	**26-50**
W less than 25	**467**	**100**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Deciduous**
Sub-Dominant	**Herbaceous**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Commercial**	**Forest**
Sub-dominant	**Forest**	**Commercial**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**20.0**
Gullies	**None**	

	Left	Right
Mass Failures		**46.545**
Height		**20.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Seventh tributary to Brewster River** Reach: **T7.01-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**

4.2 Adjacent Wetlands: **Minimal**

4.3 Flow Status: **Low**

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **Small Run of River**

Flow Reg. Use: **Other**

Impoundments:

Impoundment Loc.:

4.6 Up/Down Strm flow reg.: **None**

(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs

Field Ditch: **0** Road Ditch: **1**

Other: **0** Tile Drain: **0**

Overland Flow: **0** Urb Strm Wtr Pipe: **0**

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Old Abutment	34	Yes	Yes	Yes	Yes	Deposition Above,Alignment
Bridge	70	Yes	Yes	Yes	Yes	None
Bridge	33	Yes	Yes	Yes	Yes	Deposition Above,Scour Below
Old Abutment	25	Yes	Yes	Yes	Yes	Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types Diagonal: **2**

Mid: **2** Delta: **0**

Point: **4** Island: **0**

Side: **10** Braiding: **0**

5.2 Other Features

Flood chutes: **3**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **3**

Neck Cutoff: **0**

Avulsion: **0**

Head Cuts: **0**

Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **Straightening**

Straightening Length (ft.): **466**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:

6.2 Pool Substrate:

6.3 Pool Variability:

Total Score: **0**

Habitat Rating: **0.00**

Habitat Stream Condition:

6.4 Sediment Deposition:

6.5 Channel Flow Status:

6.6 Channel Alteration:

6.7 Channel Sinuosity:

Stream Gradiant Type Left Right

6.8 Bank Stability:

6.9 Bank Vegetation Protection

6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**5**	**B to F**	**No**
7.2 Channel Aggradation	**10**	**None**	**No**
7.3 Widening Channel	**7**	**None**	**Yes**
7.4 Change in Planforml	**8**	**None**	**Yes**
Total Score	**30**		

Geomorphic Rating **0.38**

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Fair**

Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report **Brewster River**

Stream: **Fourth tributary to T7**
Reach: **T7S4.03-0**
Segment Length(ft): **2,403**
Rain: **No**

SGAT Version: **4.56**
Organization: **Fitzgerald Environmental**
Observers: **JHB, MPL**
Completion Date: **7/2/2014**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **This reach begins at the reach break 0.35 miles downstream of the Smugglers Notch lodge and continues upstream to the reach break just South of the Smugglers Notch lodge**

Step 5 - Notes: **Most of the reach was bedrock cascades and pools, deposition was limited to slower water areas above large grade controls. A few flood chutes were observed in the lower portion of the reach. The cross section and pebble count were conducted at the only true riffle in the reach. The reach was predominantly bedrock and boulder cascade and much narrower, typically around 10 to 15' wide. Step 2 substrate data reflects the substrate at the riffle, and the reach is classified as A2.**

Step 7 - Narrative: **This reach was steep and bedrock controlled throughout. The top portion was very steep and contained two large cascades. A snowmaking withdrawal dam with a removable weir/gate was located immediately upstream of the Route 108 culvert. The culvert under Route 108 was approximately 200ft long and very steep ending in a 10 ft free fall to a deep pool below. Below the culvert the channel alternated between a wider B-type geometry and bedrock waterfalls into in A-type cascade and step-pools. Some areas of deposition and increased gravel in the riffle sections indicate increased sediments loads from upstream areas. The reach was very stable and assessed as Type I.**

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:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Sometimes	Always
Within 1 Bankfull W:	Always	Always
Texture:	Bedrock	Bedrock

1.5 Valley Features
Valley Width (ft): **50**
Width Determination: **Measured**
Confinement Type: **SC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Mid-segment	12.0	8.0	Yes	
Ledge	Mid-segment	13.0	12.0	No	
Waterfall	Mid-segment	16.0	14.0	Yes	
Ledge	Mid-segment	13.0	9.0	No	
Ledge	Mid-segment	8.0	4.0	No	
Waterfall	Mid-segment	19.0	15.0	Yes	
Ledge	Mid-segment	13.0	8.0	No	
Ledge	Mid-segment	7.5	2.0	No	
Weir	Mid-segment	5.5	5.0	Yes	

Stream: **Fourth tributary to T7** Reach: **T7S4.03-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**22.50**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.00**	2.12 Substrate Composition		Bed:	**750 mm**
2.3 Mean Depth (tf):	**1.34**	Bedrock:	**9.0 %**	Bar:	**160 mm**
2.4 Floodprone Width (ft.):	**31.00**	Boulder:	**13.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**2.00**	Cobble:	**37.0 %**	Stream Type:	**A**
Human Elev FloodPln (ft.):		Coarse Gravel:	**24.0 %**	Bed Material:	**Boulder**
2.6 Width/Depth Ratio:	**16.79**	Fine Gravel:	**12.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.38**	Sand:	**5.0 %**	Bed Form:	**Cascade**
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:	**Moderate**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**36**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**
Lower		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**7.6**
Erosion Height (ft.):	**0.0**	**4.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**85.7**

Near Bank Vegetation Type	Left	Right
Dominant:	**Coniferous**	**Coniferous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Coniferous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**15.0**
Gullies	**None**	

	Left	Right
Mass Failures		**21.287 5**
Height		**15.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Fourth tributary to T7** Reach: **T7S4.03-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **1**

4.5 Flow Regulation Type **Small Withdrawal**
Flow Reg. Use: **Recreation**
Impoundments:
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **0**
Other: **0** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **1**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	18	Yes	No	No	Yes	Deposition Above,Deposition Below
Bedrock Outcrops	20	Yes	No	No	Yes	None
Instream Culvert	12	Yes	No	Yes	Yes	Deposition Above,Deposition Below
Other	4	Yes	No	Yes	Yes	Deposition Above
Instream Culvert	10	Yes	No	Yes	Yes	Deposition Above,Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Diagonal: **0**
Mid: **3** Delta: **0**
Point: **1** Island: **0**
Side: **6** Braiding: **0**

5.2 Other Features
Flood chutes: **2**
Neck Cutoff: **0**
Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **1**
Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type Left Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	17	None	No
7.2 Channel Aggradation	13	None	No
7.3 Widening Channel	13	None	No
7.4 Change in Planforml	16	None	No
Total Score	59		

Geomorphic Rating **0.74**
Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Good**
Stream Sensitivity **Very Low**

Phase 2 Segment Summary Report **Brewster River**

Stream: **Second tributary to T7S4**
Reach: **T7S4.02.01-0**
Segment Length(ft): **756**
Rain: **No**

SGAT Version: **4.56**
Organization: **Fitzgerald Environmental**
Observers: **JHB, MPL**
Completion Date: **7/2/2014**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **This reach begins at the reach break upstream of the Rt-108 crossing on T7S4.03 and continues upstream to the next reach break Northwest of the Smugglers Notch ski lodge.**

Step 5 - Notes: **The cross section and pebble count were conducted at the only true riffle in the reach. The reach was predominantly bedrock and boulder cascade. Step 2 substrate data reflects the substrate at the riffle, and the reach was classified as A2.**

Step 7 - Narrative: **This short and steep reach begins at the pump station where a concrete wall and a movable metal weir/gate are used to create a pond for snowmaking withdrawals. Above this the reach is steep and narrow with predominantly bedrock banks. Moderate to high increase in flow and sediment load is likely due to land clearing and conversion to a ski slope. Reach appeared stable and sediment accumulation was mostly limited to a large debris jam mid reach.**

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:	0		0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Always	Always
Within 1 Bankfull W:	Always	Always
Texture:	Bedrock	Bedrock

1.5 Valley Features

Valley Width (ft): **18**
Width Determination: **Measured**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Weir	Mid-segment	5.5	5.0	Yes	

Stream: **Second tributary to T7S4** Reach: **T7S4.02.01-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**12.30**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.80**	2.12 Substrate Composition		Bed:	**750 mm**
2.3 Mean Depth (tf):	**1.00**	Bedrock:	**20.0 %**	Bar:	**N/A mm**
2.4 Floodprone Width (ft.):	**18.00**	Boulder:	**21.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**1.80**	Cobble:	**30.0 %**	Stream Type:	**A**
Human Elev FloodPln (ft.):		Coarse Gravel:	**23.0 %**	Bed Material:	**Boulder**
2.6 Width/Depth Ratio:	**12.30**	Fine Gravel:	**1.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.46**	Sand:	**5.0 %**	Bed Form:	**Cascade**
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:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**37**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**
Lower		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**30.8**
Erosion Height (ft.):	**0.0**	**8.0**
Revetment Type:	**Rip-Rap**	**None**
Revetment Length:	**55.3**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Coniferous**	**Coniferous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**None**	**51-100**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Coniferous**	**Coniferous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**20.0**
Gullies	**None**	

	Left	Right
Mass Failures		**22.6714**
Height		**20.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Second tributary to T7S4** Reach: **T7S4.02.01-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **2**

4.5 Flow Regulation Type **Small Withdrawal**
Flow Reg. Use: **Recreation**
Impoundments:
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **2**
Other: **0** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	25	Yes	No	No	No	None
Other	4	Yes	No	Yes	Yes	Deposition Above
Bridge	9.9	Yes	No	Yes	Yes	Deposition Above

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **0** Point: **0** Side: **1**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **0**
Neck Cutoff: **0** Avulsion: **0**

5.3 Steep Riffles and Head Cuts
Steep Riffles: **0** Head Cuts: **0** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type Left Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	16	None	No
7.2 Channel Aggradation	15	None	No
7.3 Widening Channel	14	None	No
7.4 Change in Planforml	17	None	No
Total Score	62		

Geomorphic Rating	**0.77**
Channel Evolution Model	**F**
Channel Evolution Stage	**I**
Geomorphic Condition	**Good**
Stream Sensitivity	**Very Low**

Phase 2 Segment Summary Report **Brewster River**

Stream: **First tributary to T7**
Reach: **T7S1.01-0**
Segment Length(ft): **1,385**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **Fitzgerald Environmental**
Observers: **JHB, MPL**
Completion Date: **6/10/2014**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Begins at T7.01, just downstream of the Rt 108 crossing; crosses the entrance road into Smuggler's Notch Village, follows Gateway Rd then ends 250 feet downstream of parking lot.**

Step 5 - Notes: **Man-made trout pond in the middle of the reach impounds approximately 150ft of channel and was not segmented out. Cross-section was collected in upper portion of reach but is representative of the lower reach.**

Step 7 - Narrative: **This heavily modified reach is departed to F-type and has very little opportunity to widen or adjust planform due to extensive encroachment and armoring. The majority of the reach is plane-bed likely due to bed scour and a combination of sedimentation and possible ditch maintenance dredging along the gravel parking area. Minimal erosion was indexed but the left bank was heavily scoured through most of the reach, right bank was near continuous rip-rap.**

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:	64	2	0	
Road:	1,146	0	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	1,157		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Very Steep	Hilly
Continuous w/ Bank:	Sometimes	Never
Within 1 Bankfull W:	Sometimes	Never
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft): **90**
Width Determination: **Measured**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Mid-segment	3.0	3.0	Yes	

Stream: **First tributary to T7** Reach: **T7S1.01-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**7.80**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**1.30**	2.12 Substrate Composition		Bed:	**250 mm**
2.3 Mean Depth (tf):	**1.06**	Bedrock:	**0.0 %**	Bar:	**50 mm**
2.4 Floodprone Width (ft.):	**13.00**	Boulder:	**5.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.80**	Cobble:	**27.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**50.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**7.36**	Fine Gravel:	**17.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.67**	Sand:	**1.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**3.69**	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:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Eroded**	# Large Woody Debris:	**4**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Mix**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**109.3**	**0.0**
Erosion Height (ft.):	**1.5**	**0.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**88.8**	**786.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Bare**
Sub-dominant:	**Shrubs/Sapling**	**Herbaceous**
Bank Canopy		
Canopy %:	**76-100**	**1-25**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**26-50**	**0-25**
Sub-Dominant	**>100**	**26-50**
W less than 25	**266**	**1,087**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**None**
Sub-Dominant	**Herbaceous**	**Herbaceous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Shrubs/Sapling**	**Commercial**
Sub-dominant	**Residential**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **First tributary to T7** Reach: **T7S1.01-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	4.5 Flow Regulation Type	**Small Run of River**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**Minimal**	Flow Reg. Use:	**Recreation**	Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Low**	Impoundments:		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.:		Affected Length (ft):			**0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**10**	**Yes**	**Yes**	**Yes**	**Yes**	**None**
Instream Culvert	**6**	**No**	**No**	**Yes**	**Yes**	**Scour Below**
Bridge	**8**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above**

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:	**With Windrowing**
Point:	**3**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**825**
Side:	**4**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**Dredging**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:		6.4 Sediment Deposition:		Stream Gradiant Type	Left	Right
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	**4**	**C to F**	**No**	Geomorphic Rating	**0.32**
7.2 Channel Aggradation	**7**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**8**	**None**	**No**	Channel Evolution Stage	**II**
7.4 Change in Planforml	**7**	**None**	**No**	Geomorphic Condition	**Poor**
Total Score	**26**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report **Brewster River**

Stream:	**First tributary to T7**	SGAT Version:	**4.56**
Reach:	**T7S1.02-0**	Organization:	**Fitzgerald Environmental**
Segment Length(ft):	**1,645**	Observers:	**JHB, MPL**
Rain:	**No**	Completion Date:	**7/2/2014**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Begins 250 feet south of large parking lot to the right of the entrance road into Smuggler's Notch Village; runs alongside of Rt 108 and ends 250 feet upstream from a side road crossing.**

Step 5 - Notes: **Ph1 slope is 11.6%, there was one steep stretch observed in the field but average slope was below 4% for a large majority of the reach. Steep riffle was observed below a large mid channel bar where the stream was cutting down through flood sediments.**

Step 7 - Narrative: **This short reach was incised and had minimal floodplain access, except during large events. The valley walls were very broad for the lower portion of the reach, gradually tightening to confined in the middle, and the back to very broad at the top. A very small culvert under West Hill Dr was causing upstream deposition and increased scour downstream. A lower historic road bed encroached the left bank for the entire portion below West Hill Dr. This has recently widened and could reconnect to the floodplain with future aggradation. A subtributary from the east drains into the bottom of the reach and is depositing a large amount of sediment on the shared floodplain. A lateral berm was observed that directs the subtributary to the reach.**

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:	867	0	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Very Steep	Steep
Continuous w/ Bank:	Sometimes	Never
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft):	**70**
Width Determination:	**Measured**
Confinement Type:	**BD**
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?
Weir	Mid-segment	2.0	1.5	Yes	

Stream: **First tributary to T7** Reach: **T7S1.02-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**13.00**	2.11 Riffle/Step Spacing:	**150 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.05**	2.12 Substrate Composition		Bed:	**350 mm**
2.3 Mean Depth (tf):	**1.41**	Bedrock:	**2.0 %**	Bar:	**100 mm**
2.4 Floodprone Width (ft.):	**30.00**	Boulder:	**9.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.65**	Cobble:	**33.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**21.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**9.22**	Fine Gravel:	**20.0 %**	Subclass Slope:	
2.7 Entrenchment Ratio:	**2.31**	Sand:	**15.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.27**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	**3**
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**4.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**13**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**83.5**	**225.5**
Erosion Height (ft.):	**3.1**	**2.6**
Revetment Type:	**Rip-Rap**	**None**
Revetment Length:	**754.6**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Shrubs/Sapling**
Sub-dominant:	**Shrubs/Sapling**	**Deciduous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**>100**	**26-50**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Shrubs/Sapling**	**Mixed Trees**
Sub-Dominant	**Mixed Trees**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**Commercial**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**8.0**
Gullies	**None**	

	Left	Right
Mass Failures		**38.12363**
Height		**7.9**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **First tributary to T7** Reach: **T7S1.02-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **4**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments:
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **1**
Other: **0** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Instream Culvert	3	Yes	No	Yes	Yes	Deposition Above,Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Point: **0** Side: **6**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **0**
Neck Cutoff: **0** Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **1** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type Left Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined** Score	STD	Historic
7.1 Channel Degradation	**5**	**None**	**Yes**
7.2 Channel Aggradation	**11**	**None**	**No**
7.3 Widening Channel	**10**	**None**	**No**
7.4 Change in Planforml	**12**	**None**	**No**
Total Score	**38**		

Geomorphic Rating	**0.47**
Channel Evolution Model	**F**
Channel Evolution Stage	**III**
Geomorphic Condition	**Fair**
Stream Sensitivity	**High**

Phase 2 Segment Summary Report Brewster River

Stream:	Brewster RIver	SGAT Version:	4.56
Reach:	M12-A	Organization:	Fitzgerald Environmental
Segment Length(ft):	962	Observers:	JHB, MPL
Rain:	Yes	Completion Date:	7/17/2014
		Qualtiy Control Status - Consultant:	Provisional
		Qualtiy Control Status - Staff:	Provisional

Step 0 - Location: **This reach begins at the reach break northeast of Notch View Rd and continues upstream to the segmentation point just downstream of the North Hill Dr bridge**

Step 5 - Notes: **Most of this reach contains huge cobble/gravel deposits and numerous large flood chutes. The channel may fully avulse in the upper segment and follow the right valley wall. Steep riffles were found where the channel was carving through deep deposits of flood sediments, usually at constrictions or debris.**

Step 7 - Narrative: **Huge volumes of flood sediments are working through this reach creating a temporary alluvial fan like setting. This feature was not included in FIT because it does not appear to be permanent. Numerous flood chutes were observed throughout the reach on both floodplains. The upper reach was very wide and indicated major recent cobble deposition. The bed had built up and the stream was beginning to tip into the right floodplain downstream of the bridge. A large headcut was observed in one of the side channels and flow was observed in several channels through the floodplain. This reach underwent major widening and deposition during Irene and is currently adjusting planform around this large increase in sediment load. We selected stage IId from the D CEM model due to the high level of channel aggradation and widening. Entrenchment was below 2 however we assigned a departure from C to D due to major widening (2.5x HGC bkfw) and aggradation.**

Step 1. Valley and Floodplain

1.1 Segmentation: Channel Dimensions

1.2 Alluvial Fan: None

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0	5	0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	28	0	0	0
Dev.:	202		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Steep
Continuous w/ Bank:	Never	Never
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features	
Valley Width (ft):	250
Width Determination:	Measured
Confinement Type:	BD
In Rock Gorge:	No
Human Caused Change in Valley Width?:	Yes

1.6 Grade Controls: None

Stream:	Brewster RIver	Reach:	M12-A

Step 2. Stream Channel

2.1Bankfull Width (ft.):	59.00	2.11 Riffle/Step Spacing:	150 ft.	2.13 Average Largest Particle on			
2.2 Max Depth (ft.):	2.00	2.12 Substrate Composition		Bed:	400	mm	
2.3 Mean Depth (tf):	1.12	Bedrock:	0.0 %	Bar:	110	mm	
2.4 Floodprone Width (ft.):	103.00	Boulder:	14.0 %	2.14 Stream Type			
2.5 Aband. Floodpn (ft.):	2.50	Cobble:	47.0 %	Stream Type:	D		
Human Elev FloodPln (ft.):		Coarse Gravel:	18.0 %	Bed Material:	Cobble		
2.6 Width/Depth Ratio:	52.68	Fine Gravel:	18.0 %	Subclass Slope:	None		
2.7 Entrenchment Ratio:	1.75	Sand:	3.0 %	Bed Form:	Plane Bed		
2.8 Incision Ratio:	1.25	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:	2.0 %	Reference Stream Type:	C		
2.10 Riffles Type:	Sedimented	# Large Woody Debris:	12	Reference Bed Material:	Cobble		
				Reference Subclass Slope:			
				Reference Bedform:	Riffle-Pool		

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	299.8	105.9	Dominant:	Deciduous	Deciduous
Material Type:	Mix	Mix	Erosion Height (ft.):	3.6	4.0	Sub-dominant:	Shrubs/Sapling	Shrubs/Sapling
Consistency:	Non-cohesive	Non-cohesive	Revetment Type:	Rip-Rap	None	Bank Canopy		
Lower			Revetment Length:	4.3	0.0	Canopy %:	76-100	76-100
Material Type:	Mix	Boulder/Cobble				Mid-Channel Canopy:	Closed	
Consistency:	Non-cohesive	Non-cohesive						

3.2 Riparian Buffer

3.3 Riparian Corridor

Buffer Width	Left	Right	Corridor Land	Left	Right		Left	Right
Dominant	51-100	>100	Dominant	Residential	Forest	Mass Failures		
Sub-Dominant	26-50	26-50	Sub-dominant	Commercial	Shrubs/Sapling	Height		
W less than 25	190	0	(Legacy)	Amount	Mean Hieght	Gullies Number	0	
Buffer Vegitation Type			Failures	None		Gullies Length	0	
Dominant	Shrubs/Sapling	Mixed Trees	Gullies	None				
Sub-Dominant	Mixed Trees	Shrubs/Sapling						

Stream: **Brewster RIver** Reach: **M12-A**

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:	**1**	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: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**1**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**4**	Delta:	**0**	Flood chutes:	**3**	Avulsion:	**0**	5.5 Straightening:	**None**
Point:	**2**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**4**	Braiding:	**0**	Steep Riffles:	**3**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:		6.4 Sediment Deposition:	Stream Gradiant Type	Left	Right
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		**9**	**None**	**No**	Geomorphic Rating	**0.32**
7.2 Channel Aggradation		**4**	**C to D**	**No**	Channel Evolution Model	**D**
7.3 Widening Channel		**5**	**None**	**No**	Channel Evolution Stage	**IId**
7.4 Change in Planforml		**8**	**None**	**No**	Geomorphic Condition	**Poor**
Total Score		**26**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report **Brewster River**

Stream:	**Brewster RIver**	SGAT Version:	**4.56**
Reach:	**M12-B**	Organization:	**Fitzgerald Environmental**
Segment Length(ft):	**1,412**	Observers:	**JHB, MPL**
Rain:	**Yes**	Completion Date:	**7/17/2014**
		Qualtiy Control Status - Consultant:	**Provisional**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **This reach begins at the segmentation point just downstream of the North Hill Dr bridge and continues about 1,000ft upstream to the next reach break.**

Step 5 - Notes: **Large side bars filled in the lower bank areas that were scoured out by recent flooding. Steep riffles, and numerous flood chutes indicate that this reach is very active and that large volumes of flood sediments are working through the reach.**

Step 7 - Narrative: **This reach was selected as reference B type due to channel slope. The elevated floodplain in the upper portion of the segment was accessed in 2011, but it is unlikely that this is could be accessed in typical storm events. Numerous flood chutes do provide some attenuation throughout the segment. Recent scour removed floodplain benches, dropped the bed elevation, and smoothed the longitudinal profile. We assigned a departure to F-type based on entrenchment. Pools were largely absent and the reach showed some indication of transitioning to widening and stage III CEM.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	231	5	0	5
Road:	0		0	
Railroad:	0		0	
Imp. Path:	450	0	957	0
Dev.:	442		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Very Steep
Continuous w/ Bank:	Never	Never
Within 1 Bankfull W:	Never	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft):	**170**
Width Determination:	**Measured**
Confinement Type:	**BD**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**No**

1.6 Grade Controls: **None**

Phase 2 Segment Summary Report — Brewster River

Stream: **Brewster RIver** Reach: **M12-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**32.29**	2.11 Riffle/Step Spacing:	**130 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.00**	2.12 Substrate Composition		Bed:	**500 mm**
2.3 Mean Depth (tf):	**1.16**	Bedrock:	**0.0 %**	Bar:	**180 mm**
2.4 Floodprone Width (ft.):	**46.00**	Boulder:	**6.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**4.25**	Cobble:	**48.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**31.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**27.84**	Fine Gravel:	**11.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.42**	Sand:	**4.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.13**	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:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**4**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**67.7**	**376.8**
Erosion Height (ft.):	**4.0**	**4.3**
Revetment Type:	**Multiple**	**Rip-Rap**
Revetment Length:	**210.6**	**30.3**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**26-50**	**26-50**
W less than 25	**141**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Herbaceous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Residential**	**Forest**
Sub-dominant	**Forest**	**Shrubs/Sapling**
(Legacy)	Amount	Mean Hieght
Failures	**None**	
Gullies	**None**	

	Left	Right
Mass Failures		
Height		
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M12-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **None**
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.:

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **0**
Other: **0** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **1**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	15	Yes	No	Yes	Yes	Deposition Above,Deposition Below
Bridge	32	Yes	No	Yes	Yes	Deposition Above,Scour Above,Scour Below,Alignment
Bridge	56	No	No	Yes	Yes	Deposition Above,Deposition Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Point: **2** Side: **7**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **3**
Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **2** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type	Left	Right
6.8 Bank Stability:		
6.9 Bank Vegetation Protection		
6.10 Riparian Veg. Zone Width:		

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Unconfined	Score	STD	Historic
7.1 Channel Degradation		5	C to F	Yes
7.2 Channel Aggradation		7	None	No
7.3 Widening Channel		10	None	No
7.4 Change in Planforml		10	None	No
Total Score		32		

Geomorphic Rating	**0.40**
Channel Evolution Model	**F**
Channel Evolution Stage	**II**
Geomorphic Condition	**Fair**
Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report Brewster River

Stream: **Brewster RIver**
Reach: **M13-0**
Segment Length(ft): **697**
Rain: **Yes**

SGAT Version: **4.56**
Organization: **Fitzgerald Environmental**
Observers: **JHB, MPL**
Completion Date: **7/17/2014**
Qualtiy Control Status - Consultant: **Provisional**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - 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.**

Step 5 - Notes: **Numerous flood chutes and an avulsion create multiple channels in this high slope D-type alluvial reach.**

Step 7 - Narrative: **This short reach was located at a slight decrease in slope and increase in valley width. Coupled with the high sediment export from the upstream reach, this reach is highly active with recent major widening and current aggradation. Numerous flood chutes and an avulsion were observed. These multiple channels and large depositional features formed by huge volumes of sediment working through the reach have caused a departure from B to D. We assigned a reference B stream type because the current D type is likely not natural and is a response to upstream sediment sources and encroachment. A post-2011 flood windrowed cobble berm was observed that cut off access to a forested left flood plain and likely exacerbates a downstream mass failure.**

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:	158	5	0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	693	0	0	
Dev.:	0		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Extr.Steep
Continuous w/ Bank:	Never	Sometimes
Within 1 Bankfull W:	Never	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft): **175**
Width Determination: **Estimated**
Confinement Type: **BD**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Brewster RIver** Reach: **M13-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**48.00**	2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**2.15**	2.12 Substrate Composition		Bed:	**400 mm**
2.3 Mean Depth (tf):	**1.13**	Bedrock:	**0.0 %**	Bar:	**160 mm**
2.4 Floodprone Width (ft.):	**105.00**	Boulder:	**8.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**3.75**	Cobble:	**38.0 %**	Stream Type:	**D**
Human Elev FloodPln (ft.):		Coarse Gravel:	**25.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**42.48**	Fine Gravel:	**22.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**2.19**	Sand:	**7.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.74**	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:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**7**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

Bank Texture	Left	Right
Upper		
Material Type:	**Mix**	**Mix**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**50.0**	**0.0**
Erosion Height (ft.):	**3.0**	**0.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Deciduous**	**Deciduous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**76-100**	**76-100**
Mid-Channel Canopy:	**Closed**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**>100**	**None**
W less than 25	**0**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Residential**	**Forest**
Sub-dominant	**Forest**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**18.0**
Gullies	**None**	

	Left	Right
Mass Failures		**71.83807**
Height		**18.0**
Gullies Number	**0**	
Gullies Length	**0**	

Stream: **Brewster RIver** Reach: **M13-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Abundant**	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:	**Low**	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: **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:	**2**	Delta:	**0**	Flood chutes:	**3**	Avulsion:	**1**	5.5 Straightening:	**None**
Point:	**1**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**0**
Side:	**6**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**Dredging**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:		6.4 Sediment Deposition:		Stream Gradiant Type	Left	Right
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	**10**	**None**	**Yes**	Geomorphic Rating	**0.40**
7.2 Channel Aggradation	**9**	**B to D**	**No**	Channel Evolution Model	**D**
7.3 Widening Channel	**4**	**None**	**No**	Channel Evolution Stage	**IId**
7.4 Change in Planforml	**9**	**None**	**No**	Geomorphic Condition	**Fair**
Total Score	**32**			Stream Sensitivity	**Extreme**

Phase 2 Segment Summary Report Brewster River

Stream: Brewster RIver
Reach: M14-0
Segment Length(ft): 2,570
Rain: Yes

SGAT Version: 4.56
Organization: Fitzgerald Environmental
Observers: JHB, MPL
Completion Date: 7/17/2014
Qualtiy Control Status - Consultant: Provisional
Qualtiy Control Status - Staff: Provisional

Step 0 - Location: **Begins 240 feet from Mountain View Dr., directly north of Nordland Dr.; ends at dam.**

Step 5 - Notes: **This reach scoured down to bedrock in many locations and had heavily scoured or eroded banks throughout. Some sediment was stored in bars within the reach but it appears that most of the sediment has been transported downstream. Steep riffles were observed in two locations where large volumes of flood cobbles were stacked up above a grade control. Concrete spillway at the top of the reach is listed as an "other" revetment, remaining left bank armoring is rip-rap.**

Step 7 - Narrative: **A resort access road/path closely followed the left valley for most of the reach. This encroachment and interrupted sediment supply from the upstream impoundment caused this reach to recently incise and contributed a large volume of gravel and cobble to downstream reaches. Most of the reach has cut down to bedrock, so further incision is unlikely (degradation is historic). This incision has cut off floodplain access for all but the largest events leading to a departure to F-type.**

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:	701	4	0	
Road:	0		0	
Railroad:	0		0	
Imp. Path:	2,507	0	0	
Dev.:	116		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Steep	Very Steep
Continuous w/ Bank:	Never	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Mixed	Mixed

1.5 Valley Features

Valley Width (ft): **115**
Width Determination: **Measured**
Confinement Type: **BD**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **Yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Mid-segment	35.0	5.0	Yes	
Ledge	Mid-segment	4.0	3.0	No	
Ledge	Mid-segment	3.0	2.0	No	
Ledge	Mid-segment	0.0	0.0	No	
Weir	Mid-segment	3.0	1.0	Yes	

Stream: **Brewster RIver**   Reach: **M14-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**30.00**	2.11 Riffle/Step Spacing:	**120 ft.**	2.13 Average Largest Particle on		
2.2 Max Depth (ft.):	**1.85**	2.12 Substrate Composition		Bed:	**650**	**mm**
2.3 Mean Depth (tf):	**0.96**	Bedrock:	**0.0 %**	Bar:	**180**	**mm**
2.4 Floodprone Width (ft.):	**38.00**	Boulder:	**27.0 %**	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):	**4.35**	Cobble:	**33.0 %**	Stream Type:	**F**	
Human Elev FloodPln (ft.):	**5.35**	Coarse Gravel:	**15.0 %**	Bed Material:	**Cobble**	
2.6 Width/Depth Ratio:	**31.25**	Fine Gravel:	**20.0 %**	Subclass Slope:	**None**	
2.7 Entrenchment Ratio:	**1.27**	Sand:	**5.0 %**	Bed Form:	**Step-Pool**	
2.8 Incision Ratio:	**2.35**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	**3**	
Human Elevated Inc. Rat.:	**2.89**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type		
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	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	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**130.2**	**322.1**	Dominant:	**Coniferous**	**Coniferous**
Material Type:	**Mix**	**Mix**	Erosion Height (ft.):	**4.0**	**3.2**	Sub-dominant:	**Deciduous**	**Deciduous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**Multiple**	**Other**	Bank Canopy		
Lower			Revetment Length:	**846.3**	**141.3**	Canopy %:	**76-100**	**76-100**
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**				Mid-Channel Canopy:	**Closed**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**>100**
Sub-Dominant	**0-25**	**None**
W less than 25	**426**	**0**
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right		Left	Right
Dominant	**Forest**	**Forest**	Mass Failures		**44.28188**
Sub-dominant	**Commercial**	**None**	Height		**12.0**
(Legacy)	Amount	Mean Hieght	Gullies Number	**0**	
Failures	**One**	**12.0**	Gullies Length	**0**	
Gullies	**None**				

Stream: **Brewster RIver** Reach: **M14-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Low**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **Large Withdrawal**
Flow Reg. Use: **Recreation**
Impoundments:
Impoundment Loc.:
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.: **Run-of-river Dam**

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **4**
Other: **0** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	15	Yes	No	Yes	Yes	Deposition Above,Deposition Below
Bridge	28	Yes	No	Yes	Yes	Deposition Above,Scour Above,Scour Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **3** Point: **4** Side: **6**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **3**
Neck Cutoff: **0**
Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **2**
Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score: **0**
Habitat Rating: **0.00**
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type — Left — Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type: **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	4	B to F	Yes
7.2 Channel Aggradation	9	None	No
7.3 Widening Channel	6	None	No
7.4 Change in Planforml	8	None	No
Total Score	27		

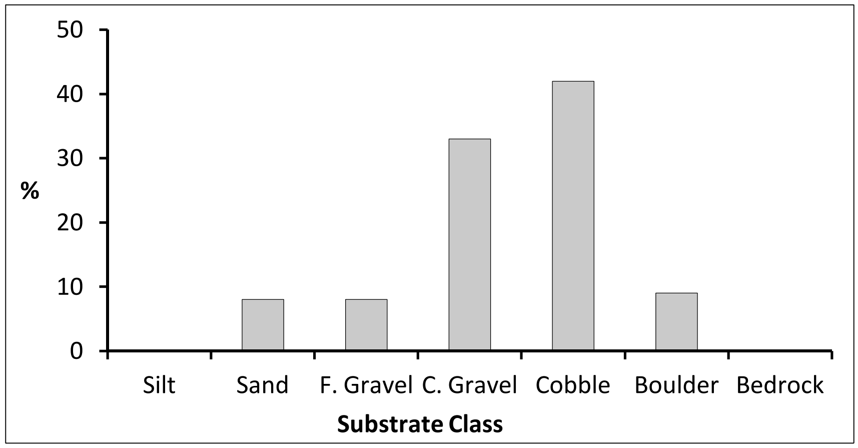
Geomorphic Rating	**0.34**
Channel Evolution Model	**F**
Channel Evolution Stage	**II**
Geomorphic Condition	**Poor**
Stream Sensitivity	**Extreme**

APPENDIX C

Reach Habitat Data Summary Sheets

Reach/Segment Information

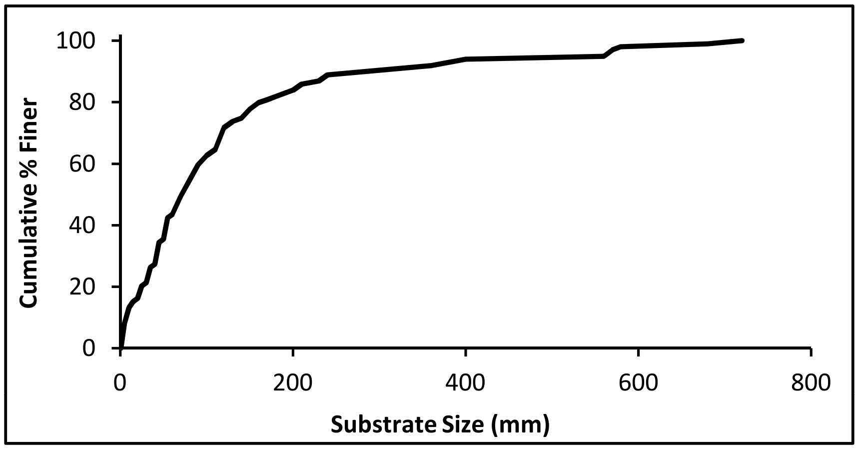
SGA ID:	M05
Length (ft):	2,553
Reference Bedform Type:	Riffle-Pool
Total RHA Score:	104
RHA Percentage:	65%
Overall Habitat Condition:	Good



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	8
F. Gravel	2 - 16	8
C. Gravel	16 - 64	33
Cobble	64 - 256	42
Boulder	256 - 4096	9
Bedrock	> 4096	0

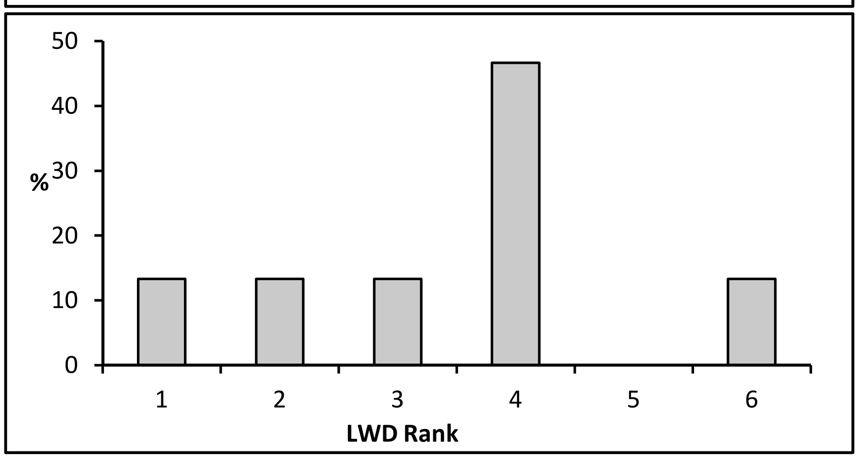
Median Substrate Size:	70	mm
Avg. Largest Particle (Bar):	120	mm
Riffle Stability Index (RSI):	72	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	2
2	0.5 ≤ D < 1.0	≥ 0.5	2
3	1.0 ≤ D < 2.0	< 0.5	2
4	1.0 ≤ D < 2.0	≥ 0.5	7
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	2

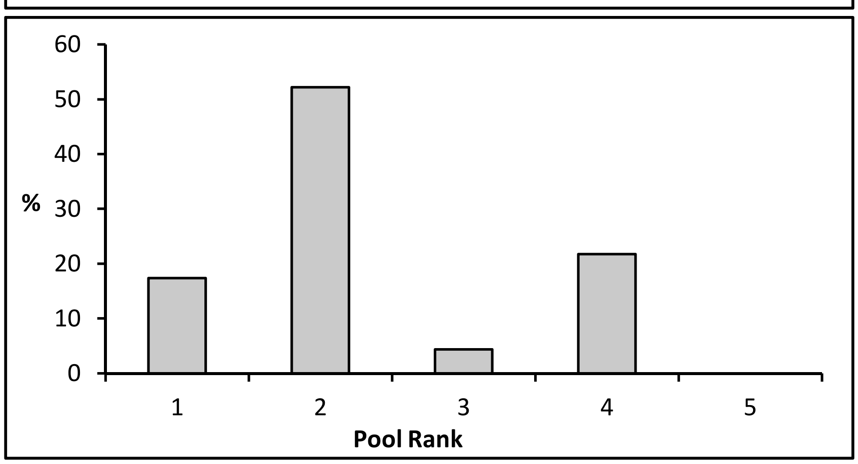
 # LWDs/mile: 31



Pools

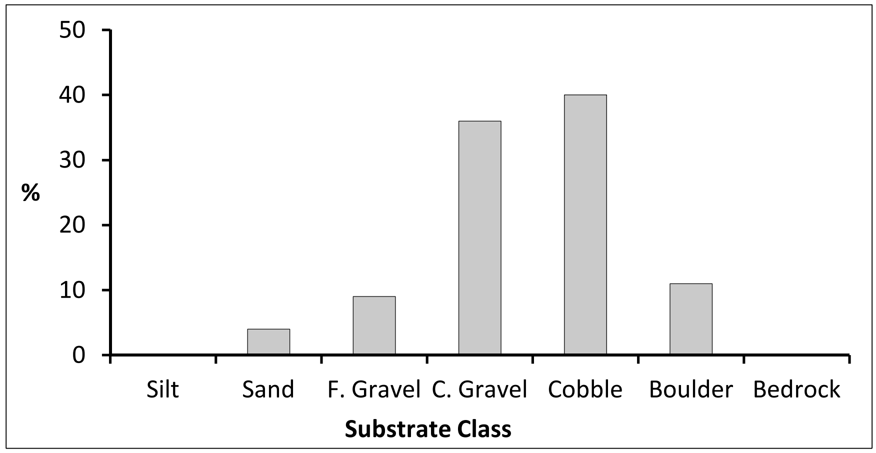
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	4
2	1.0 ≤ D < 2.0	≥ 0.5	12
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	5
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 48



Reach/Segment Information

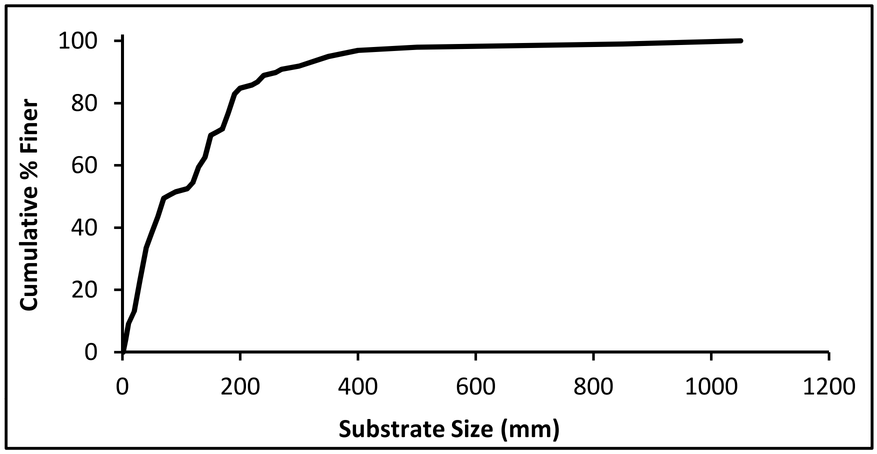
SGA ID:	M06
Length (ft):	4,615
Reference Bedform Type:	Riffle-pool
Total RHA Score:	110
RHA Percentage:	69%
Overall Habitat Condition:	Good



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	4
F. Gravel	2 - 16	9
C. Gravel	16 - 64	36
Cobble	64 - 256	40
Boulder	256 - 4096	11
Bedrock	> 4096	0

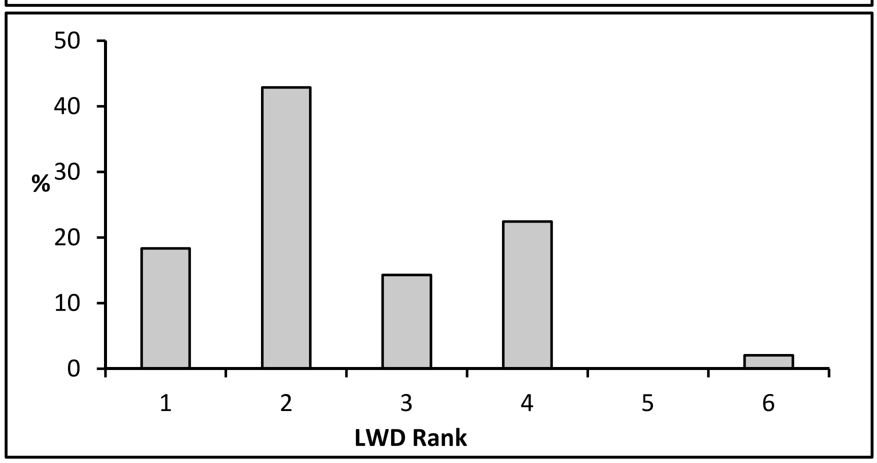
Median Substrate Size:	75	mm
Avg. Largest Particle (Bar):	140	mm
Riffle Stability Index (RSI):	63	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	9
2	0.5 ≤ D < 1.0	≥ 0.5	21
3	1.0 ≤ D < 2.0	< 0.5	7
4	1.0 ≤ D < 2.0	≥ 0.5	11
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	1

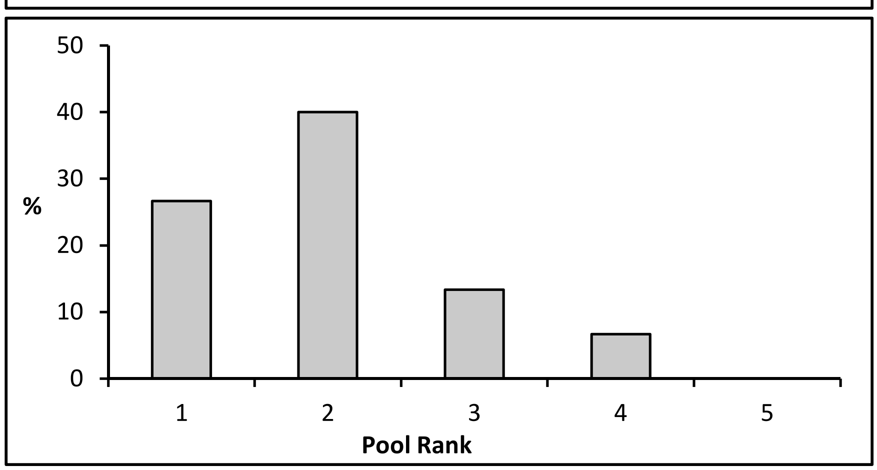
 # LWDs/mile: 56



Pools

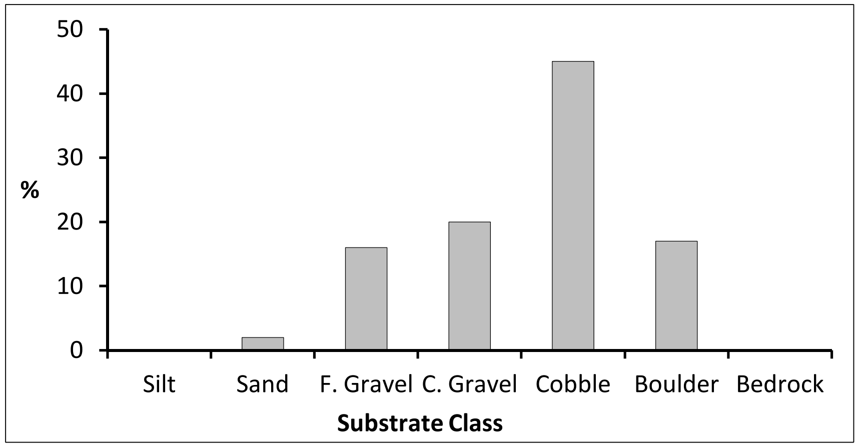
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	4
2	1.0 ≤ D < 2.0	≥ 0.5	6
3	2.0 ≤ D < 3.0	< 0.5	2
4	2.0 ≤ D < 3.0	≥ 0.5	1
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	1

 # Pools/mile: 17



Reach/Segment Information

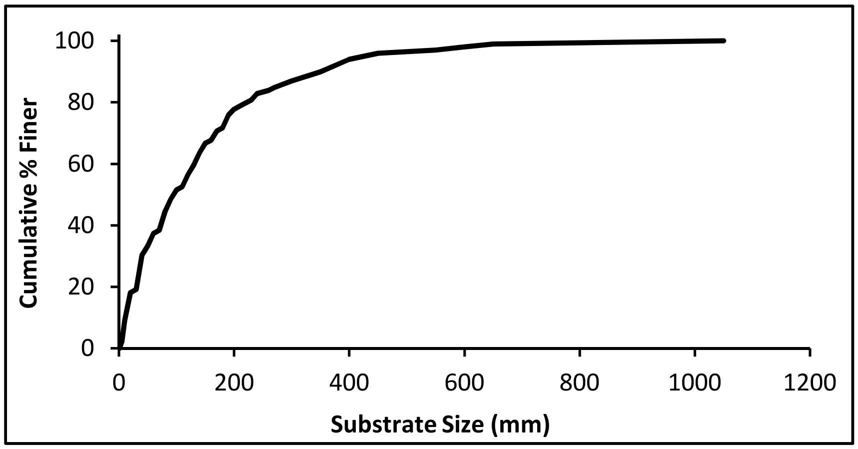
SGA ID:	M07.B
Length (ft):	1,517
Reference Bedform Type:	Plane-Bed
Total RHA Score:	83
RHA Percentage:	52%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	2
F. Gravel	2 - 16	16
C. Gravel	16 - 64	20
Cobble	64 - 256	45
Boulder	256 - 4096	17
Bedrock	> 4096	0

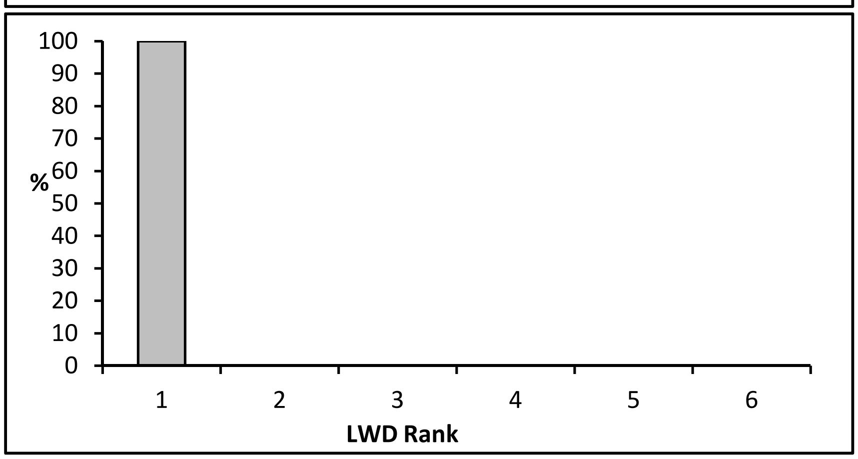
Median Substrate Size:	90	mm
Avg. Largest Particle (Bar):	220	mm
Riffle Stability Index (RSI):	80	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	4
2	0.5 ≤ D < 1.0	≥ 0.5	0
3	1.0 ≤ D < 2.0	< 0.5	0
4	1.0 ≤ D < 2.0	≥ 0.5	0
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

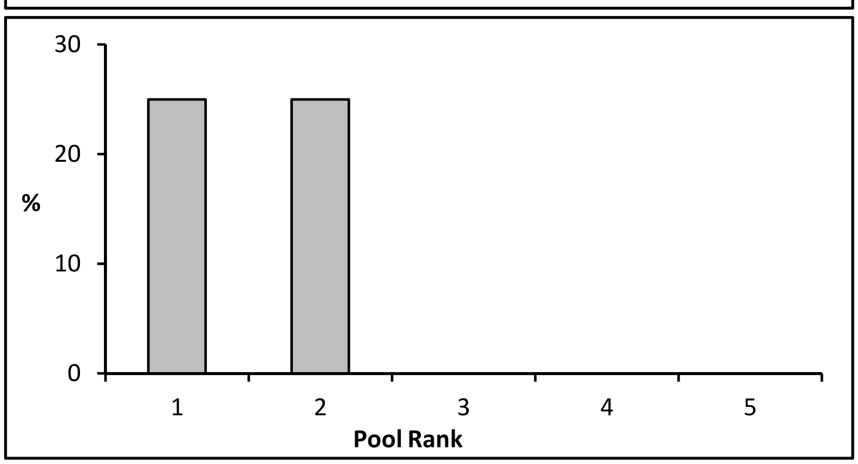
 # LWDs/mile: 14



Pools

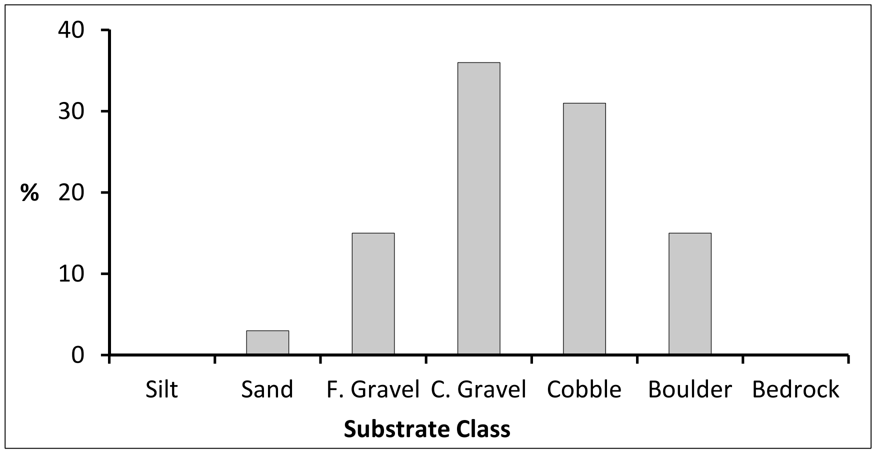
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	1
2	1.0 ≤ D < 2.0	≥ 0.5	1
3	2.0 ≤ D < 3.0	< 0.5	0
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	1

 # Pools/mile: 14



Reach/Segment Information

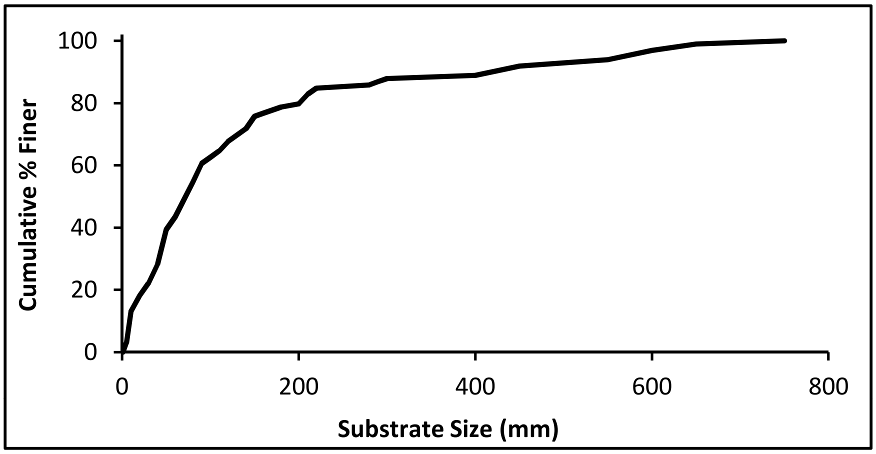
SGA ID:	M09
Length (ft):	4,841
Reference Bedform Type:	Riffle-pool
Total RHA Score:	84
RHA Percentage:	53%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	3
F. Gravel	2 - 16	15
C. Gravel	16 - 64	36
Cobble	64 - 256	31
Boulder	256 - 4096	15
Bedrock	> 4096	0

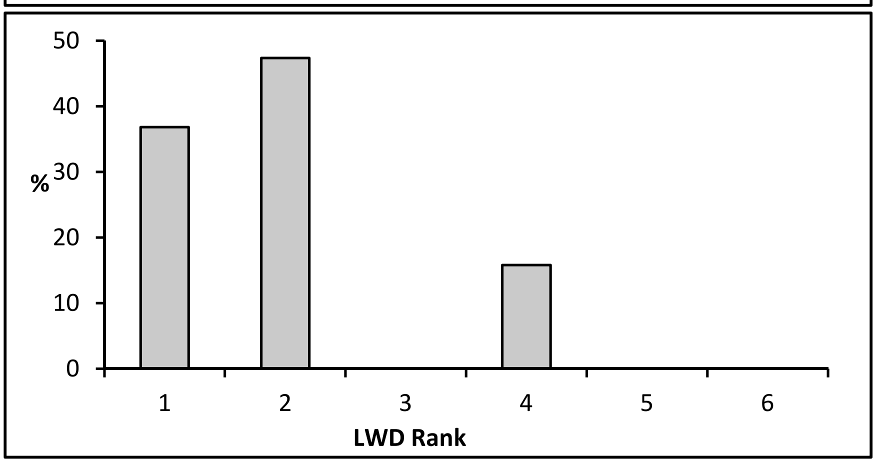
Median Substrate Size:	60	mm
Avg. Largest Particle (Bar):	220	mm
Riffle Stability Index (RSI):	85	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	7
2	0.5 ≤ D < 1.0	≥ 0.5	9
3	1.0 ≤ D < 2.0	< 0.5	0
4	1.0 ≤ D < 2.0	≥ 0.5	3
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

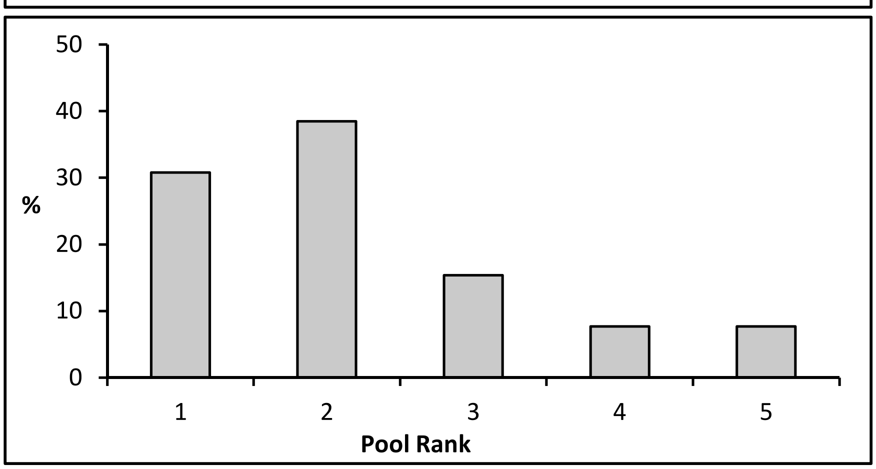
 # LWDs/mile: 21



Pools

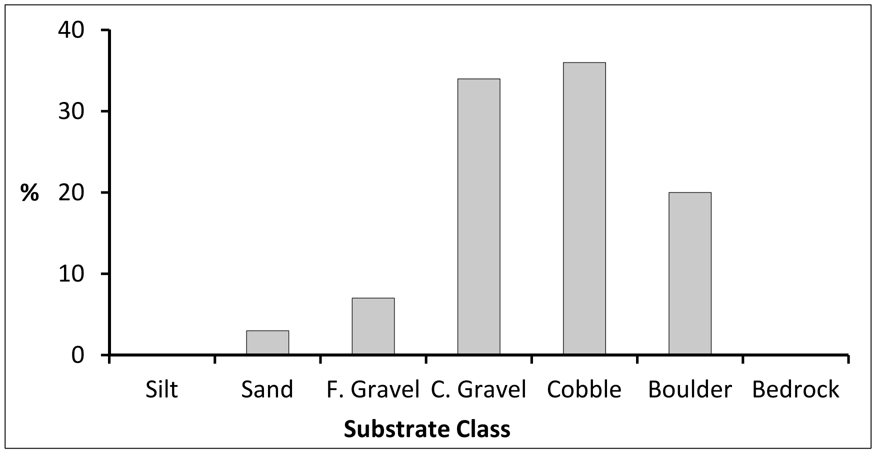
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	4
2	1.0 ≤ D < 2.0	≥ 0.5	5
3	2.0 ≤ D < 3.0	< 0.5	2
4	2.0 ≤ D < 3.0	≥ 0.5	1
5	D ≥ 3.0	< 0.5	1
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 14



Reach/Segment Information

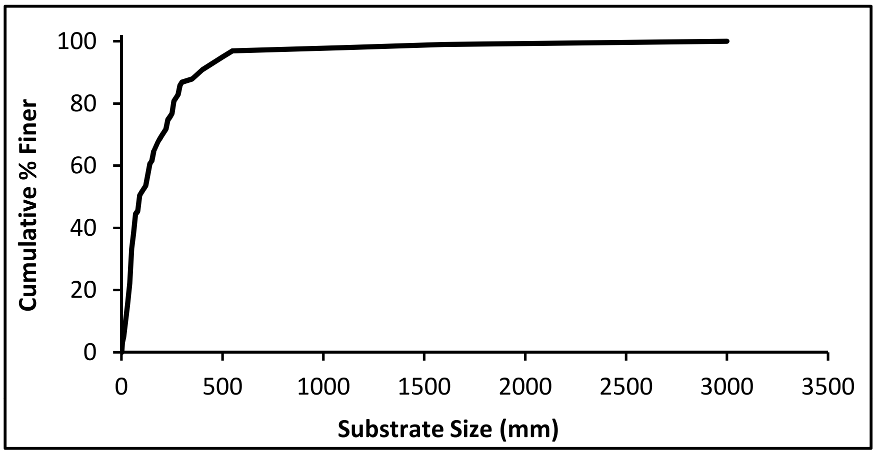
SGA ID:	M10
Length (ft):	2,518
Reference Bedform Type:	Riffle-pool
Total RHA Score:	95
RHA Percentage:	59%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	3
F. Gravel	2 - 16	7
C. Gravel	16 - 64	34
Cobble	64 - 256	36
Boulder	256 - 4096	20
Bedrock	> 4096	0

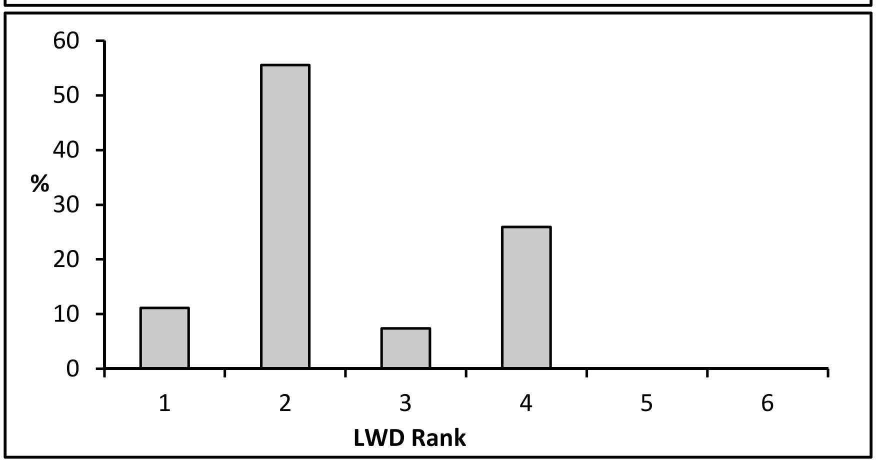
Median Substrate Size:	85	mm
Avg. Largest Particle (Bar):	140	mm
Riffle Stability Index (RSI):	61	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	3
2	0.5 ≤ D < 1.0	≥ 0.5	15
3	1.0 ≤ D < 2.0	< 0.5	2
4	1.0 ≤ D < 2.0	≥ 0.5	7
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

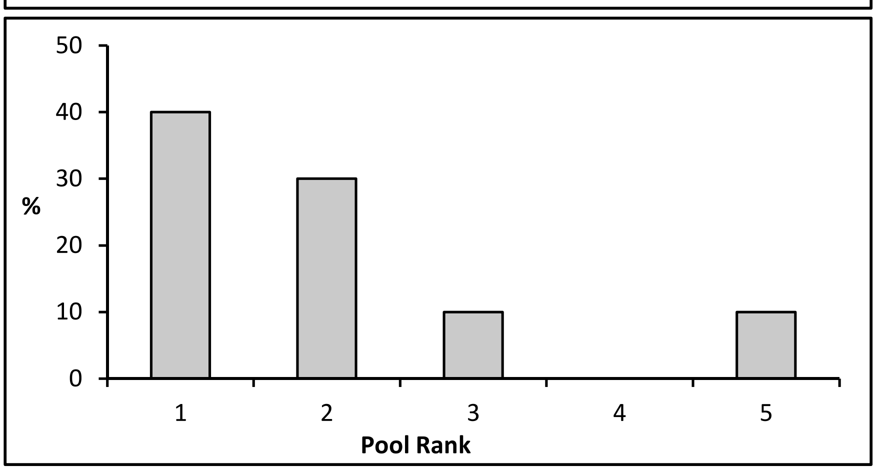
 # LWDs/mile: 57



Pools

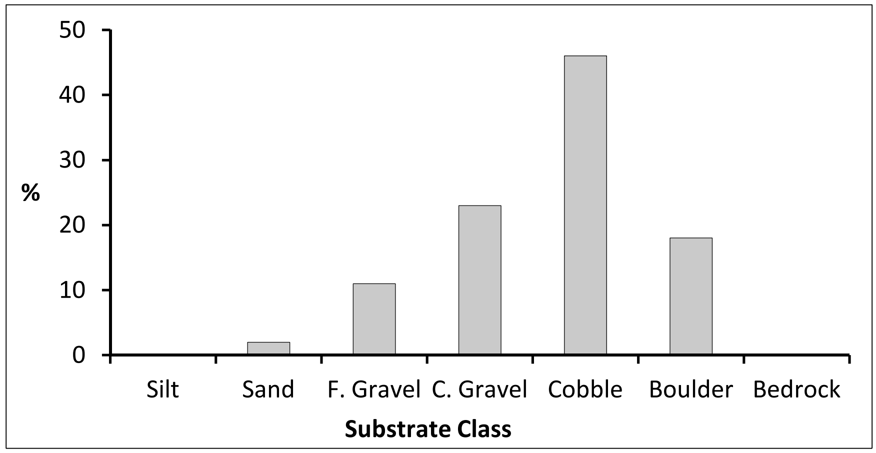
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	4
2	1.0 ≤ D < 2.0	≥ 0.5	3
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	1
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 21



Reach/Segment Information

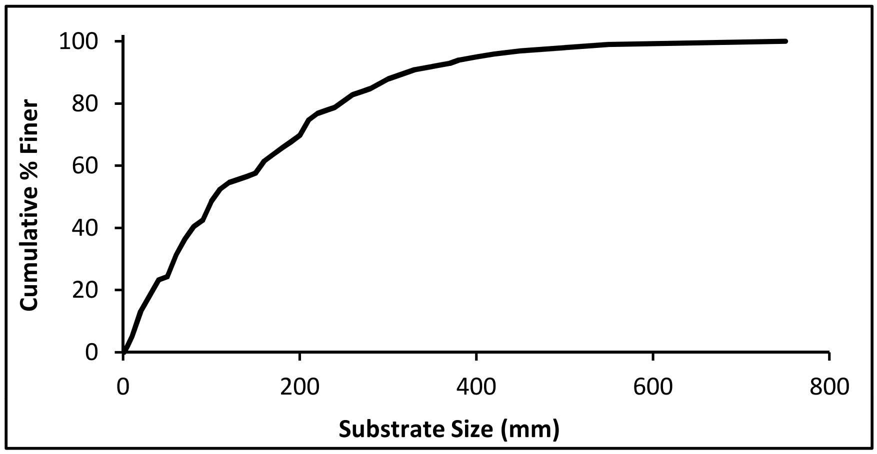
SGA ID:	M11
Length (ft):	1,617
Reference Bedform Type:	Riffle-pool
Total RHA Score:	92
RHA Percentage:	58%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	2
F. Gravel	2 - 16	11
C. Gravel	16 - 64	23
Cobble	64 - 256	46
Boulder	256 - 4096	18
Bedrock	> 4096	0

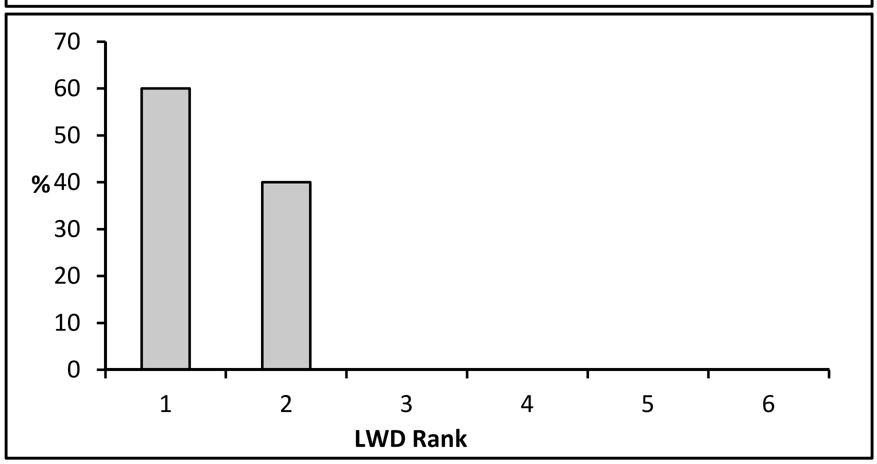
Median Substrate Size:	100	mm
Avg. Largest Particle (Bar):	150	mm
Riffle Stability Index (RSI):	58	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	3
2	0.5 ≤ D < 1.0	≥ 0.5	2
3	1.0 ≤ D < 2.0	< 0.5	0
4	1.0 ≤ D < 2.0	≥ 0.5	0
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

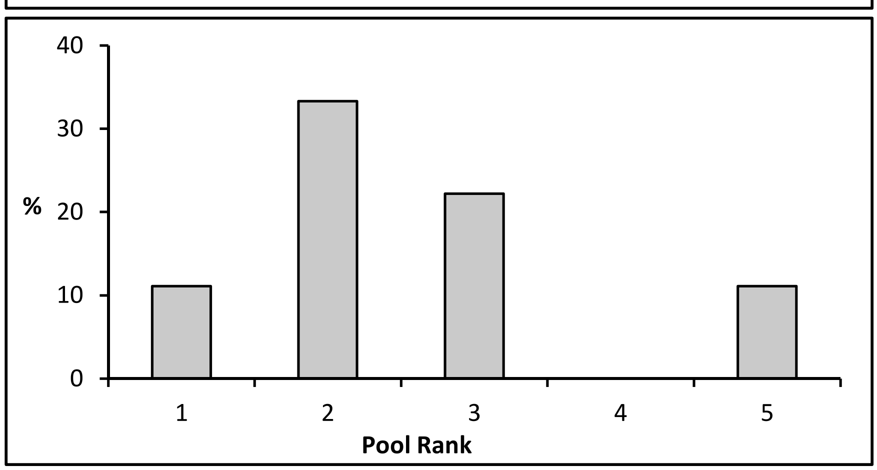
 # LWDs/mile: 16



Pools

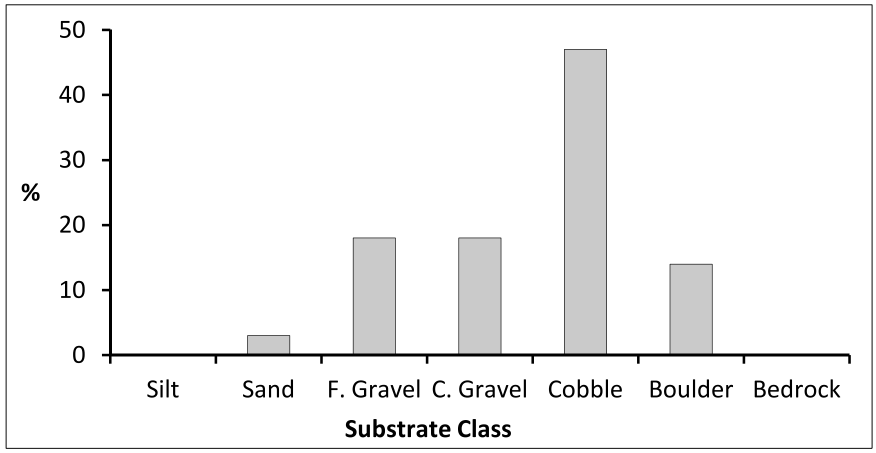
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	1
2	1.0 ≤ D < 2.0	≥ 0.5	3
3	2.0 ≤ D < 3.0	< 0.5	2
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	1
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	1

 # Pools/mile: 29



Reach/Segment Information

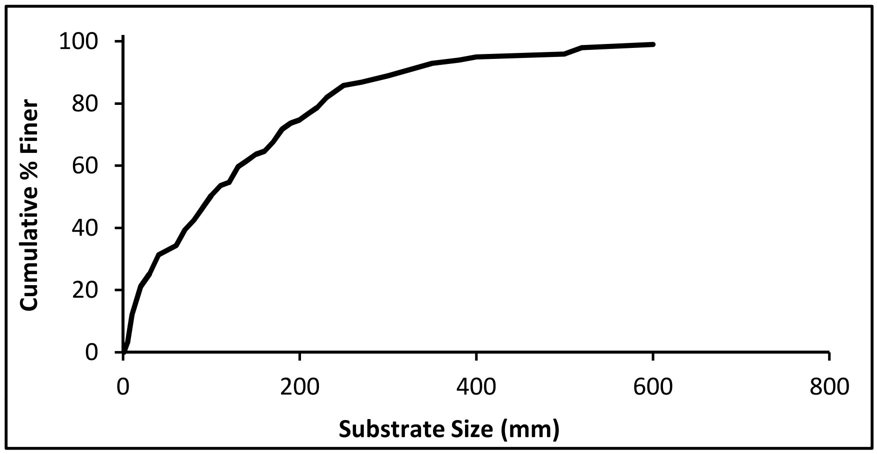
SGA ID:	M12.A
Length (ft):	962
Reference Bedform Type:	Riffle-pool
Total RHA Score:	92
RHA Percentage:	58%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	3
F. Gravel	2 - 16	18
C. Gravel	16 - 64	18
Cobble	64 - 256	47
Boulder	256 - 4096	14
Bedrock	> 4096	0

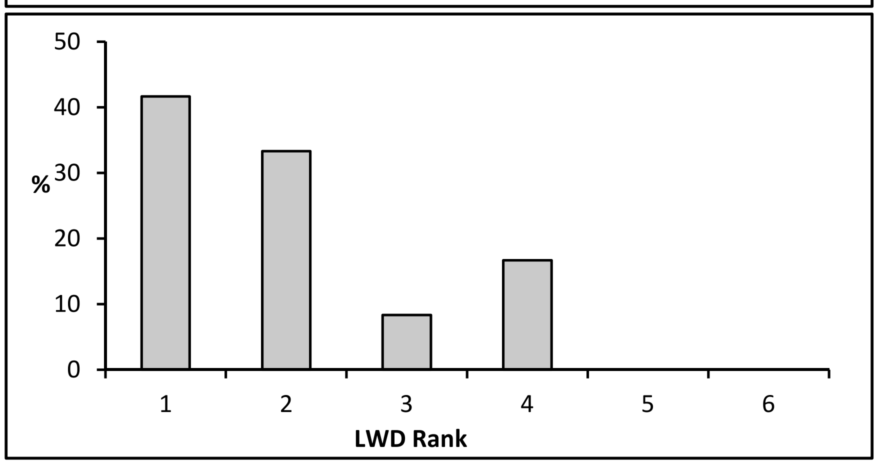
Median Substrate Size:	95	mm
Avg. Largest Particle (Bar):	110	mm
Riffle Stability Index (RSI):	54	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	5
2	0.5 ≤ D < 1.0	≥ 0.5	4
3	1.0 ≤ D < 2.0	< 0.5	1
4	1.0 ≤ D < 2.0	≥ 0.5	2
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

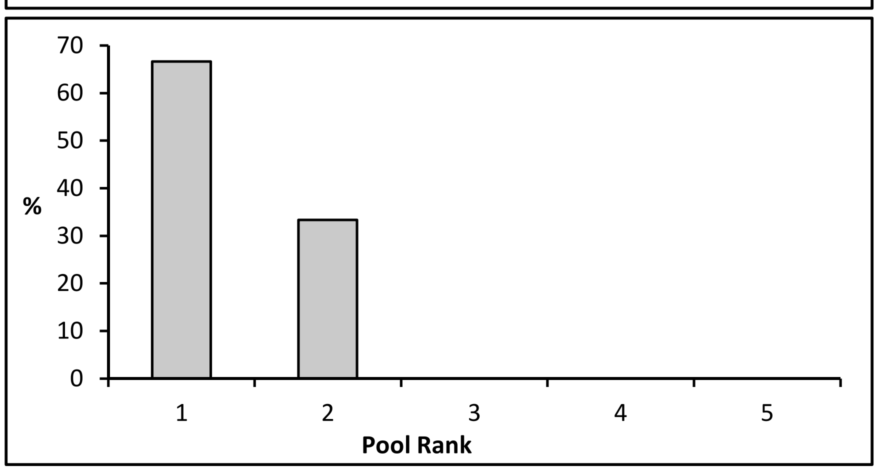
 # LWDs/mile: 66



Pools

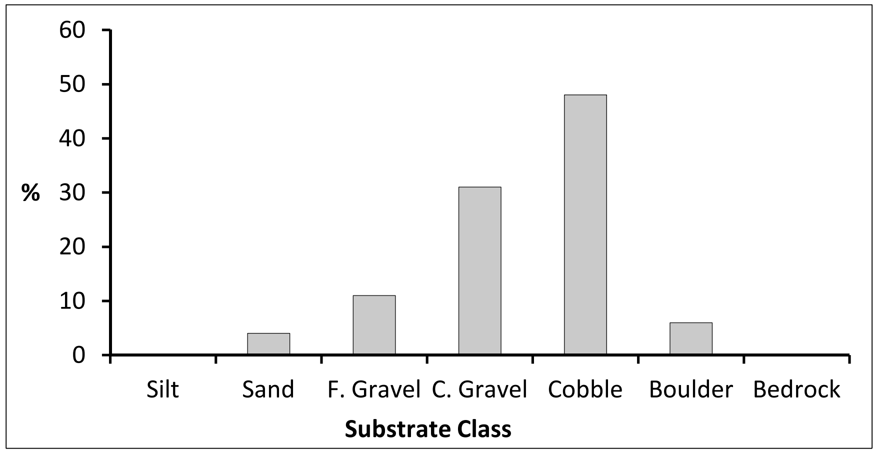
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	2
2	1.0 ≤ D < 2.0	≥ 0.5	1
3	2.0 ≤ D < 3.0	< 0.5	0
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 16



Reach/Segment Information

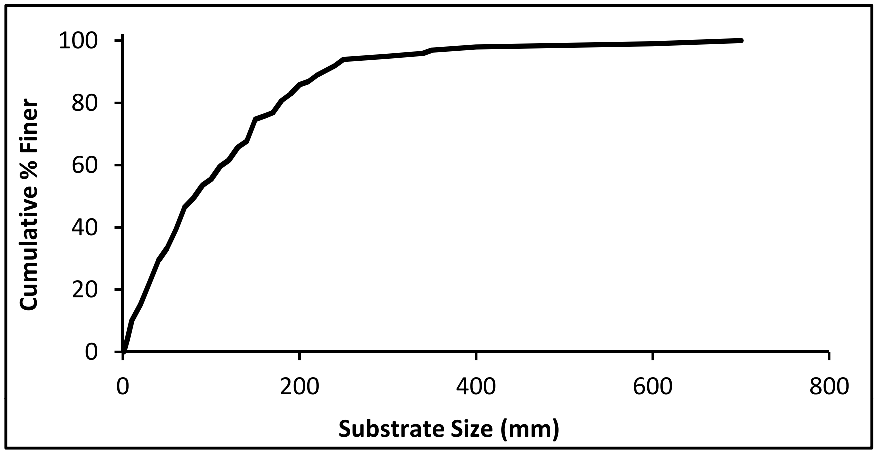
SGA ID:	M12.B
Length (ft):	1,412
Reference Bedform Type:	Riffle-pool
Total RHA Score:	79
RHA Percentage:	49%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	4
F. Gravel	2 - 16	11
C. Gravel	16 - 64	31
Cobble	64 - 256	48
Boulder	256 - 4096	6
Bedrock	> 4096	0

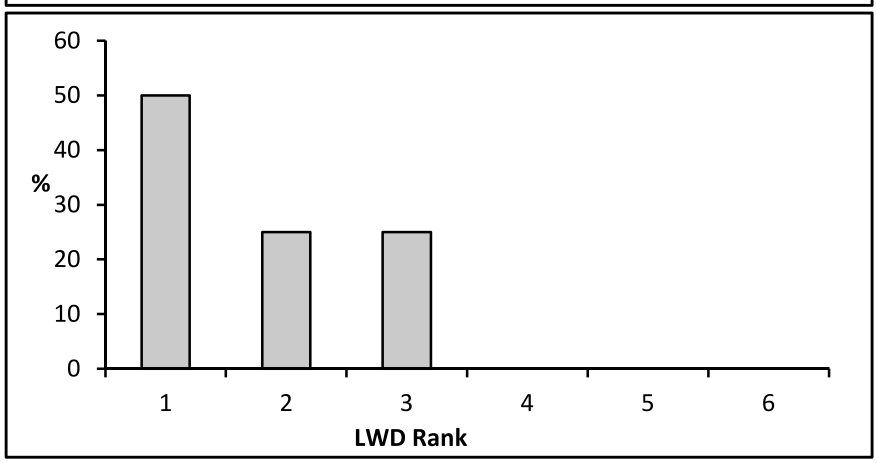
Median Substrate Size:	80	mm
Avg. Largest Particle (Bar):	180	mm
Riffle Stability Index (RSI):	81	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	2
2	0.5 ≤ D < 1.0	≥ 0.5	1
3	1.0 ≤ D < 2.0	< 0.5	1
4	1.0 ≤ D < 2.0	≥ 0.5	0
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

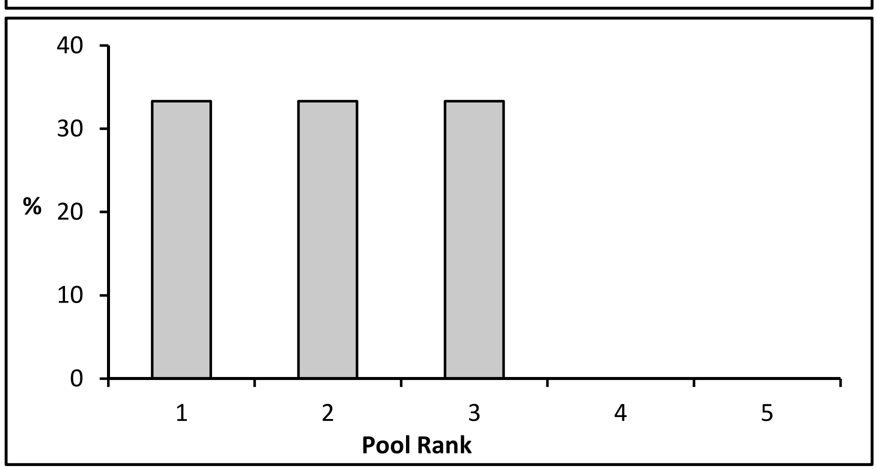
 # LWDs/mile: 15



Pools

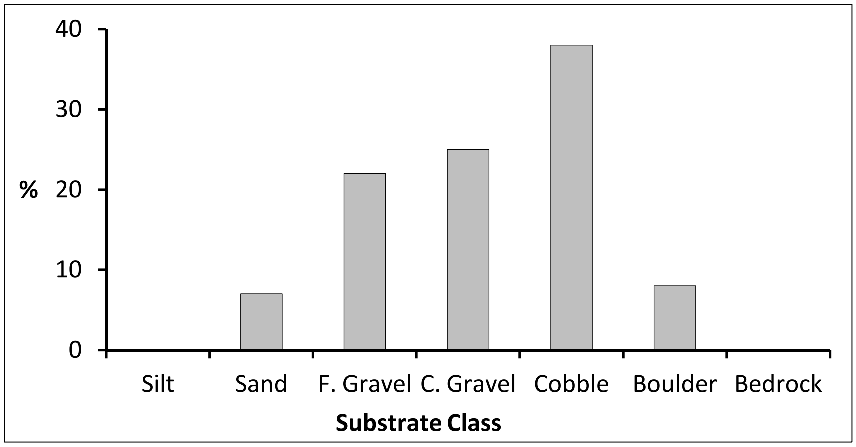
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	1
2	1.0 ≤ D < 2.0	≥ 0.5	1
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 11



Reach/Segment Information

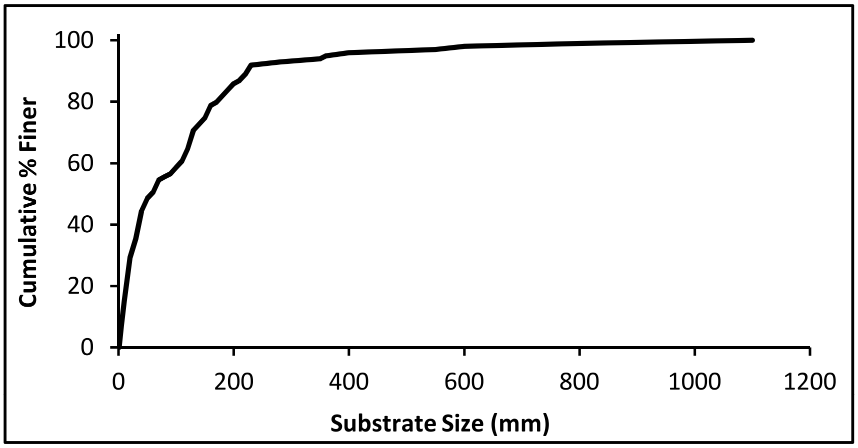
SGA ID:	M13
Length (ft):	697
Reference Bedform Type:	Riffle-pool
Total RHA Score:	82
RHA Percentage:	51%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	7
F. Gravel	2 - 16	22
C. Gravel	16 - 64	25
Cobble	64 - 256	38
Boulder	256 - 4096	8
Bedrock	> 4096	0

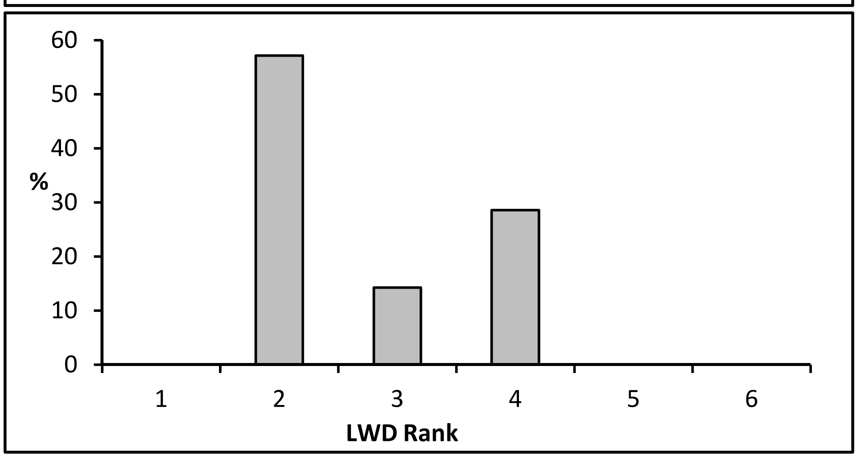
Median Substrate Size:	55	mm
Avg. Largest Particle (Bar):	160	mm
Riffle Stability Index (RSI):	79	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	0
2	0.5 ≤ D < 1.0	≥ 0.5	4
3	1.0 ≤ D < 2.0	< 0.5	1
4	1.0 ≤ D < 2.0	≥ 0.5	2
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

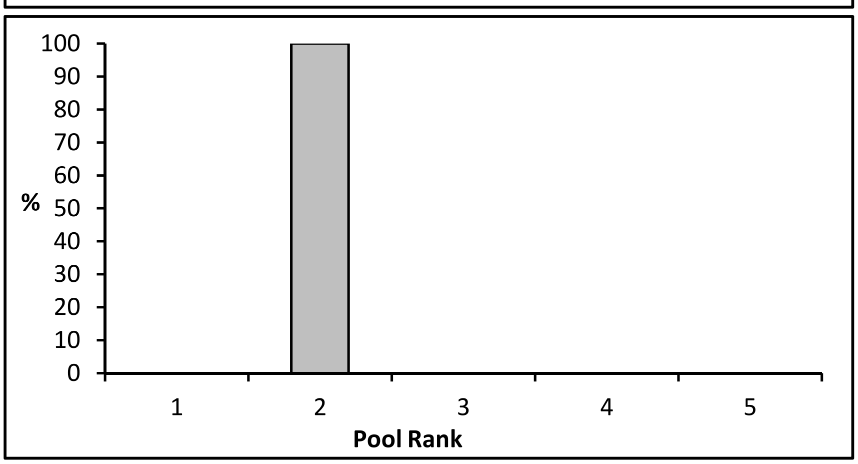
 # LWDs/mile: 53



Pools

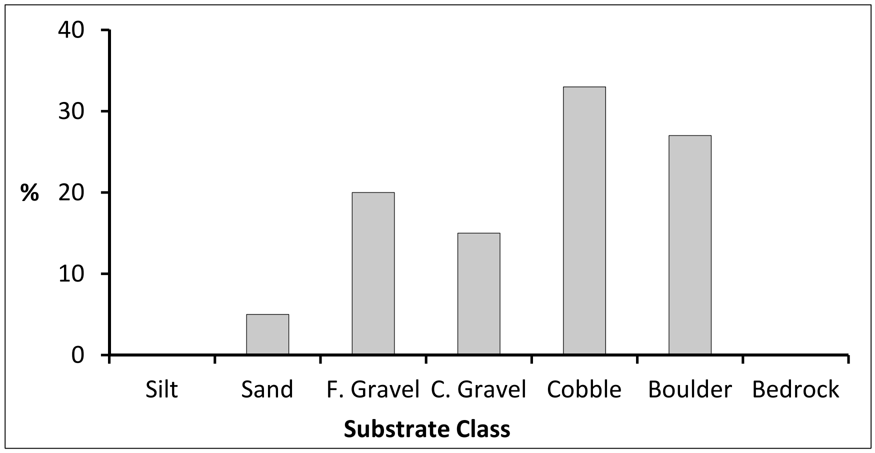
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	0
2	1.0 ≤ D < 2.0	≥ 0.5	1
3	2.0 ≤ D < 3.0	< 0.5	0
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 8



Reach/Segment Information

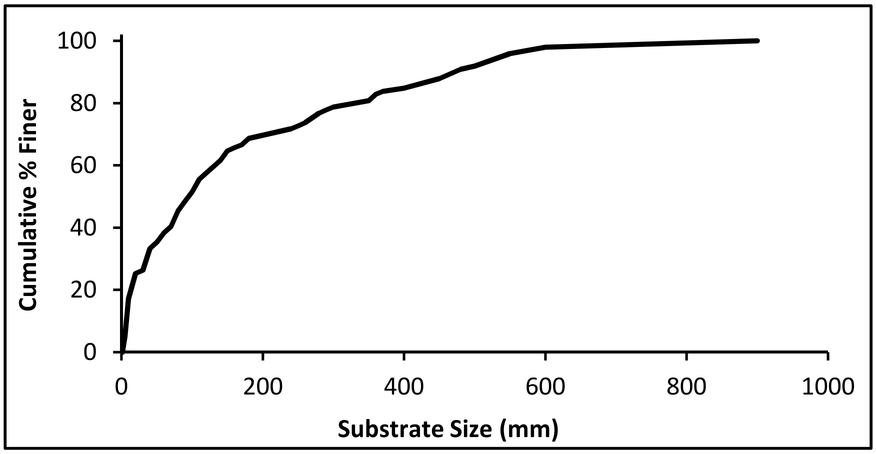
SGA ID:	M14
Length (ft):	2,570
Reference Bedform Type:	Step-pool
Total RHA Score:	68
RHA Percentage:	43%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	5
F. Gravel	2 - 16	20
C. Gravel	16 - 64	15
Cobble	64 - 256	33
Boulder	256 - 4096	27
Bedrock	> 4096	0

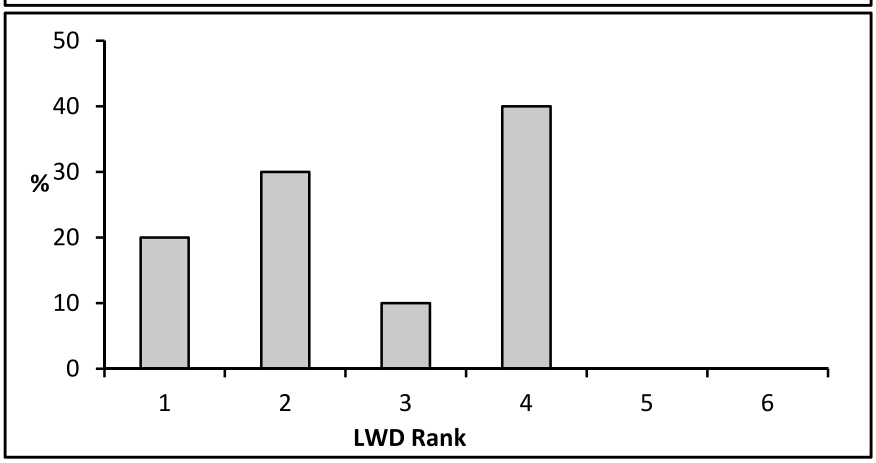
Median Substrate Size:	90	mm
Avg. Largest Particle (Bar):	180	mm
Riffle Stability Index (RSI):	69	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	2
2	0.5 ≤ D < 1.0	≥ 0.5	3
3	1.0 ≤ D < 2.0	< 0.5	1
4	1.0 ≤ D < 2.0	≥ 0.5	4
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

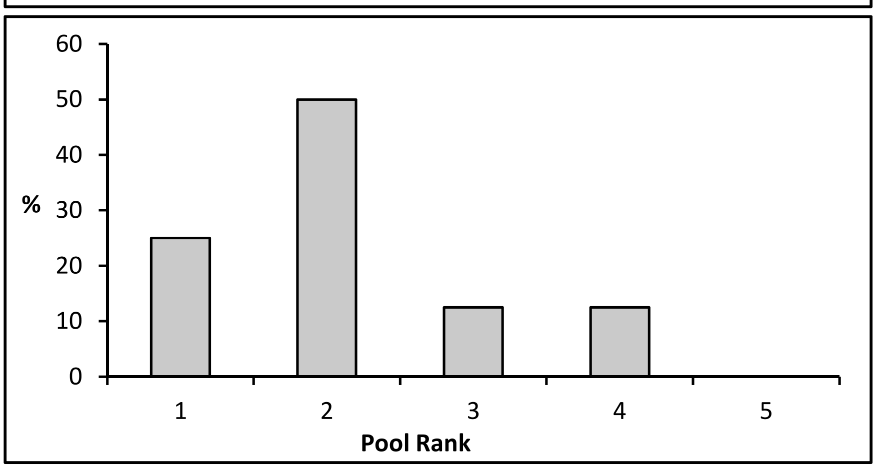
 # LWDs/mile: 21



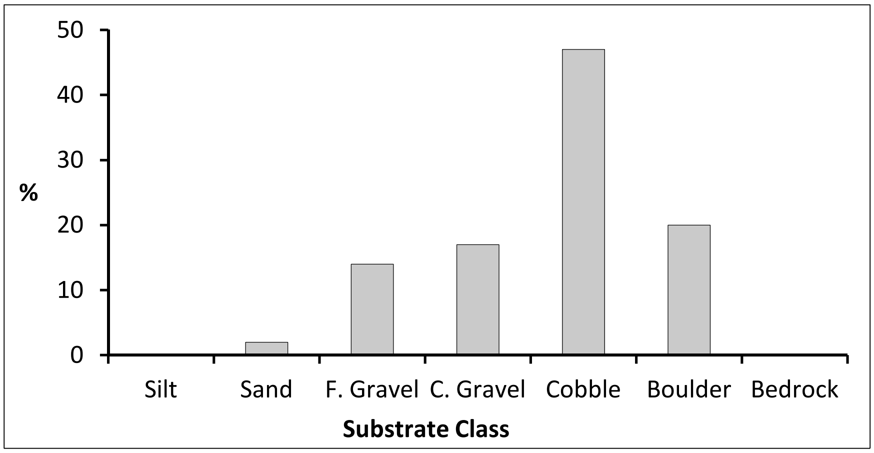
Pools

Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	2
2	1.0 ≤ D < 2.0	≥ 0.5	4
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	1
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 16



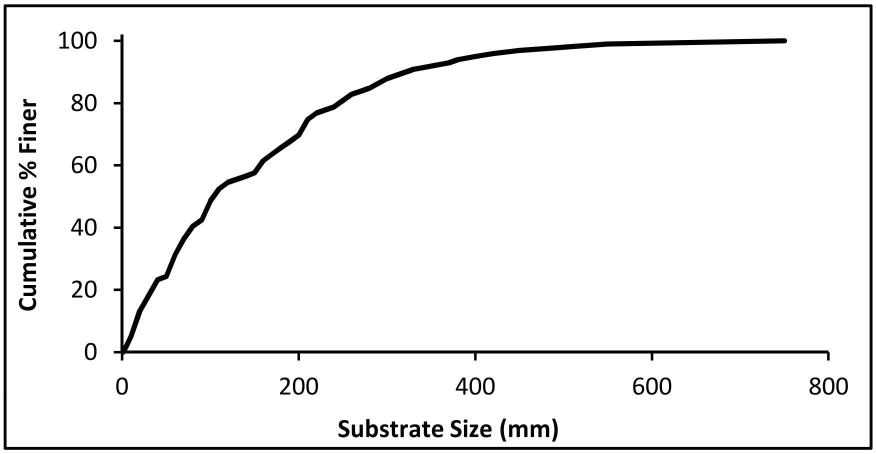
Reach/Segment Information	
SGA ID:	T7.01
Length (ft):	3,075
Reference Bedform Type:	Riffle-pool
Total RHA Score:	80
RHA Percentage:	50%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	2
F. Gravel	2 - 16	14
C. Gravel	16 - 64	17
Cobble	64 - 256	47
Boulder	256 - 4096	20
Bedrock	> 4096	0

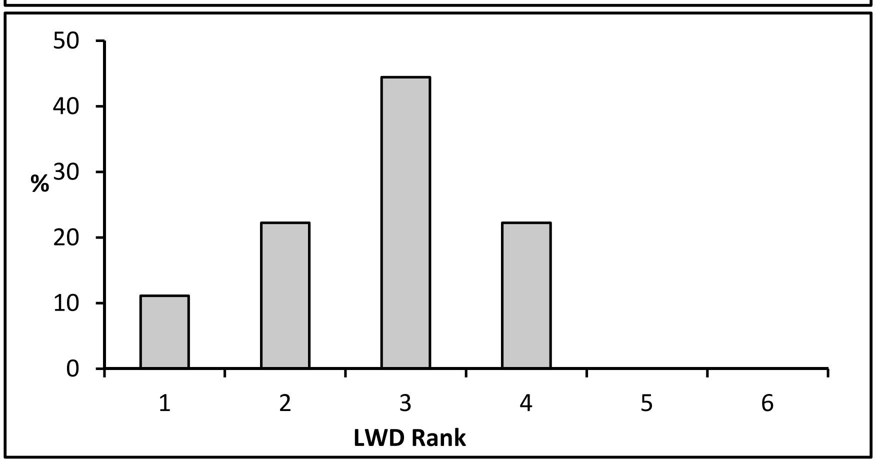
Median Substrate Size:	115	mm
Avg. Largest Particle (Bar):	180	mm
Riffle Stability Index (RSI):	66	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	1
2	0.5 ≤ D < 1.0	≥ 0.5	2
3	1.0 ≤ D < 2.0	< 0.5	4
4	1.0 ≤ D < 2.0	≥ 0.5	2
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

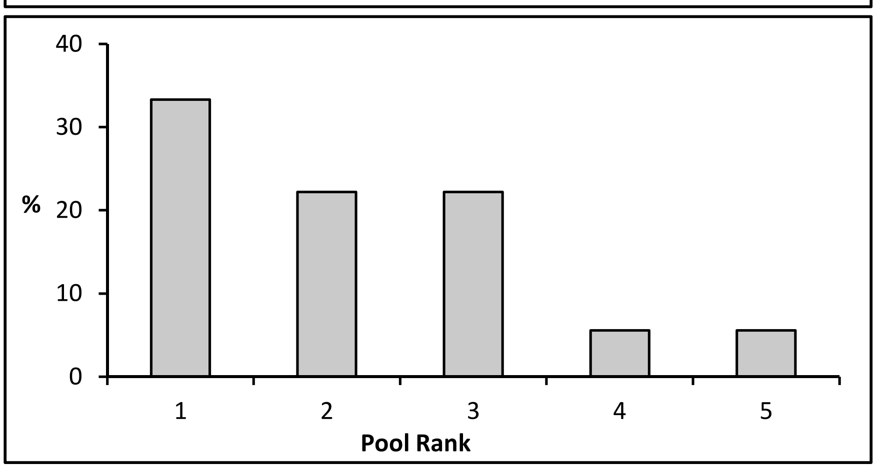
 # LWDs/mile: 15



Pools

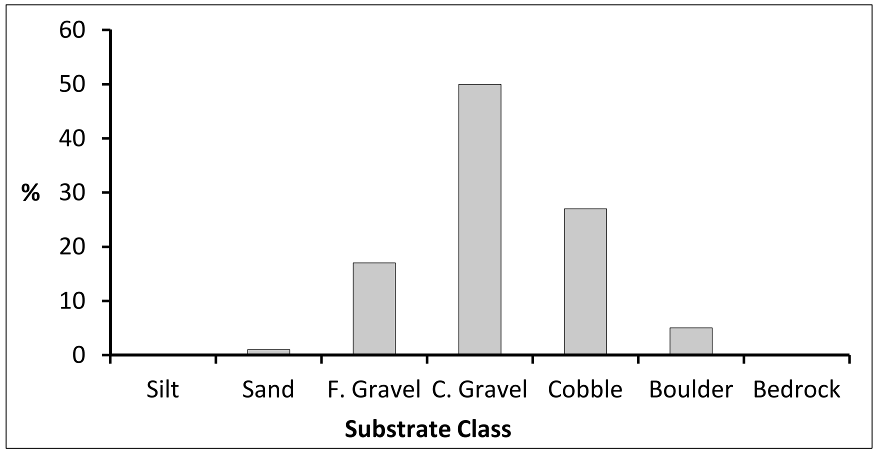
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	6
2	1.0 ≤ D < 2.0	≥ 0.5	4
3	2.0 ≤ D < 3.0	< 0.5	4
4	2.0 ≤ D < 3.0	≥ 0.5	1
5	D ≥ 3.0	< 0.5	1
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	1

 # Pools/mile: 31



Reach/Segment Information

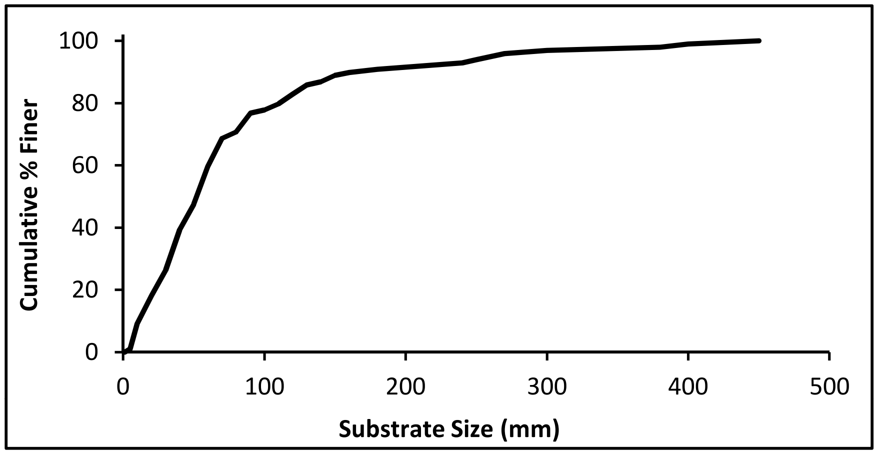
SGA ID:	T7S1.01
Length (ft):	1,385
Reference Bedform Type:	Riffle-pool
Total RHA Score:	49
RHA Percentage:	31%
Overall Habitat Condition:	Poor



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	1
F. Gravel	2 - 16	17
C. Gravel	16 - 64	50
Cobble	64 - 256	27
Boulder	256 - 4096	5
Bedrock	> 4096	0

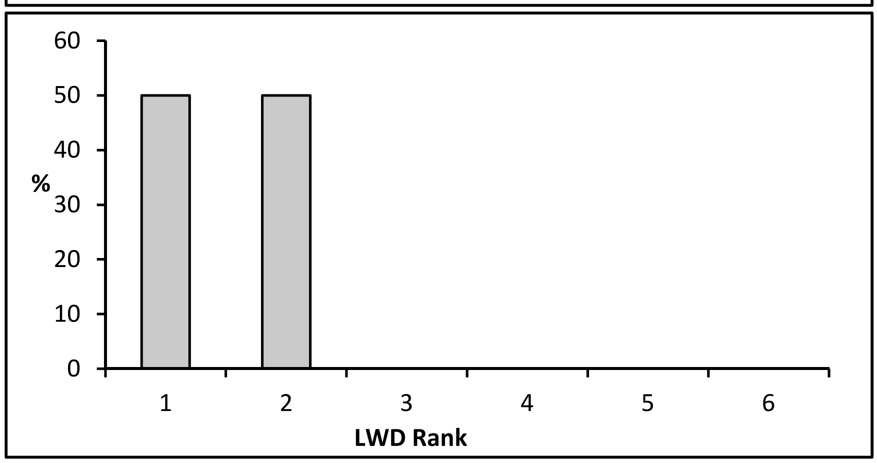
Median Substrate Size:	50	mm
Avg. Largest Particle (Bar):	50	mm
Riffle Stability Index (RSI):	47	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	2
2	0.5 ≤ D < 1.0	≥ 0.5	2
3	1.0 ≤ D < 2.0	< 0.5	0
4	1.0 ≤ D < 2.0	≥ 0.5	0
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	0

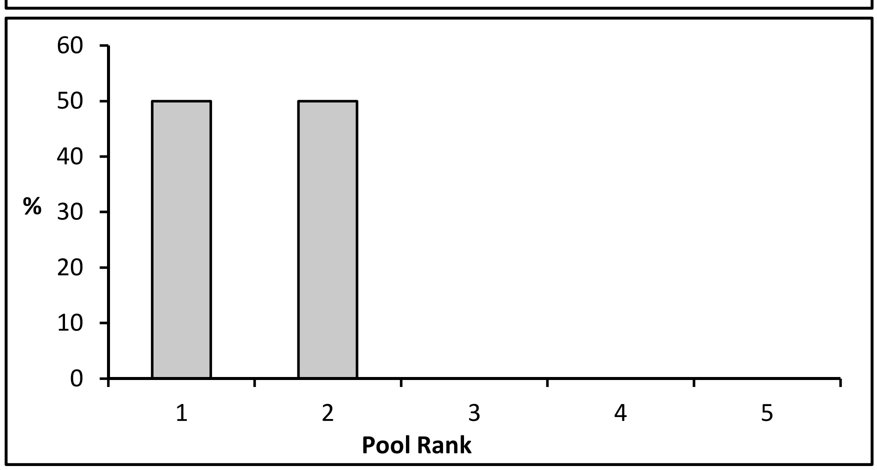
 # LWDs/mile: 15



Pools

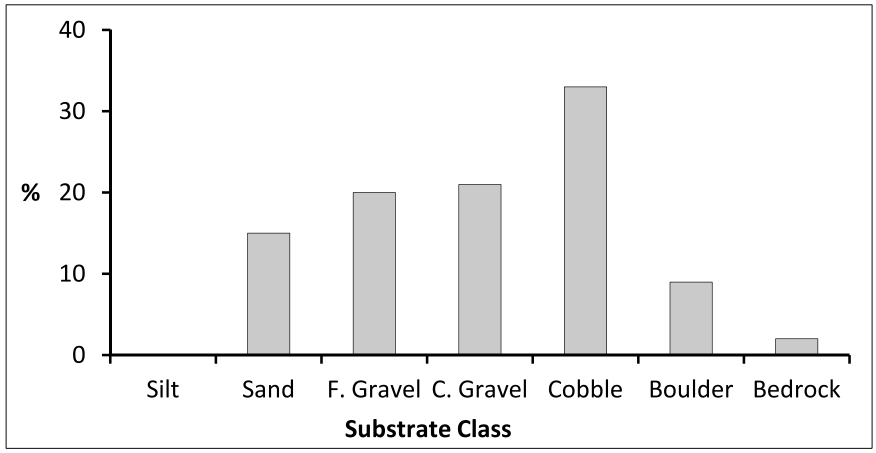
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	2
2	1.0 ≤ D < 2.0	≥ 0.5	2
3	2.0 ≤ D < 3.0	< 0.5	0
4	2.0 ≤ D < 3.0	≥ 0.5	0
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 15



Reach/Segment Information

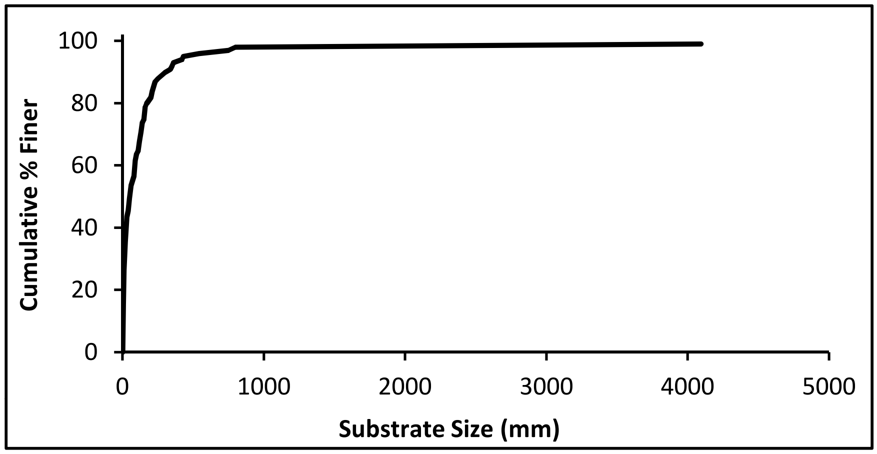
SGA ID:	T7S1.02
Length (ft):	1,645
Reference Bedform Type:	Step-pool
Total RHA Score:	86
RHA Percentage:	54%
Overall Habitat Condition:	Fair



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	15
F. Gravel	2 - 16	20
C. Gravel	16 - 64	21
Cobble	64 - 256	33
Boulder	256 - 4096	9
Bedrock	> 4096	2

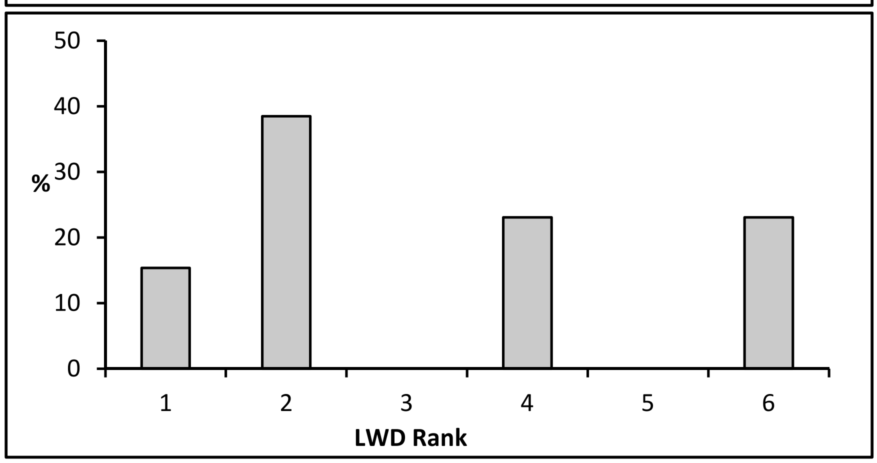
Median Substrate Size:	50	mm
Avg. Largest Particle (Bar):	100	mm
Riffle Stability Index (RSI):	64	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	2
2	0.5 ≤ D < 1.0	≥ 0.5	5
3	1.0 ≤ D < 2.0	< 0.5	0
4	1.0 ≤ D < 2.0	≥ 0.5	3
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	3

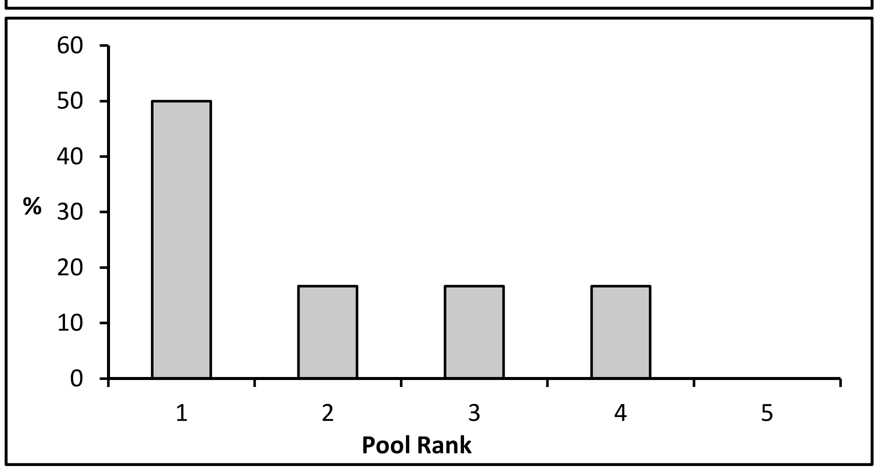
 # LWDs/mile: 42



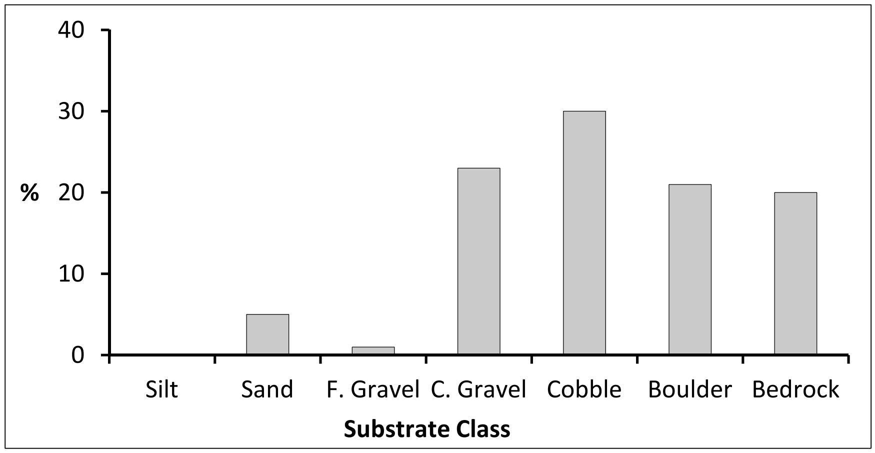
Pools

Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	3
2	1.0 ≤ D < 2.0	≥ 0.5	1
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	1
5	D ≥ 3.0	< 0.5	0
6	D ≥ 3.0	≥ 0.5	0
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 19



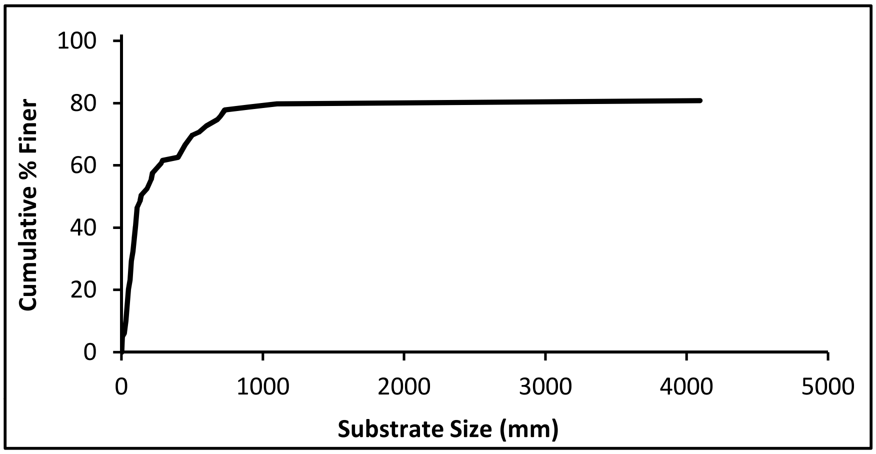
Reach/Segment Information	
SGA ID:	T7S4.02.01
Length (ft):	756
Reference Bedform Type:	Cascade
Total RHA Score:	118
RHA Percentage:	74%
Overall Habitat Condition:	Good



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	5
F. Gravel	2 - 16	1
C. Gravel	16 - 64	23
Cobble	64 - 256	30
Boulder	256 - 4096	21
Bedrock	> 4096	20

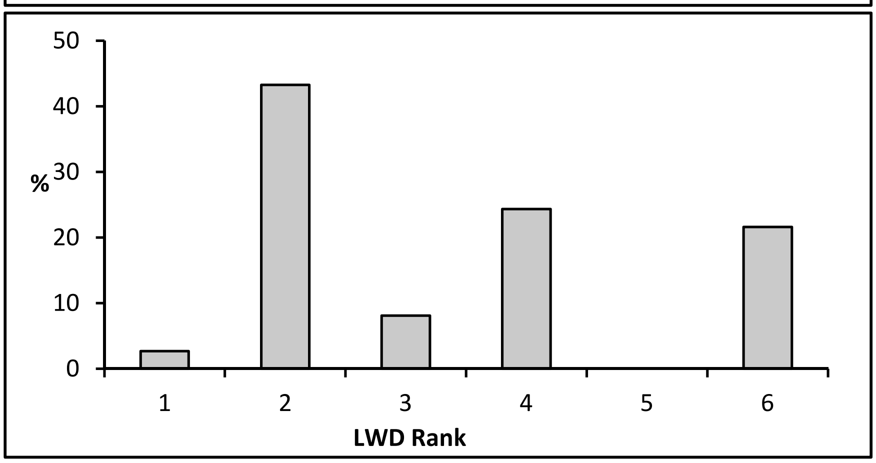
Median Substrate Size:	50	mm
Avg. Largest Particle (Bar):	N/A	mm
Riffle Stability Index (RSI):	N/A	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	1
2	0.5 ≤ D < 1.0	≥ 0.5	16
3	1.0 ≤ D < 2.0	< 0.5	3
4	1.0 ≤ D < 2.0	≥ 0.5	9
5	D ≥ 2.0	< 0.5	0
6	D ≥ 2.0	≥ 0.5	8

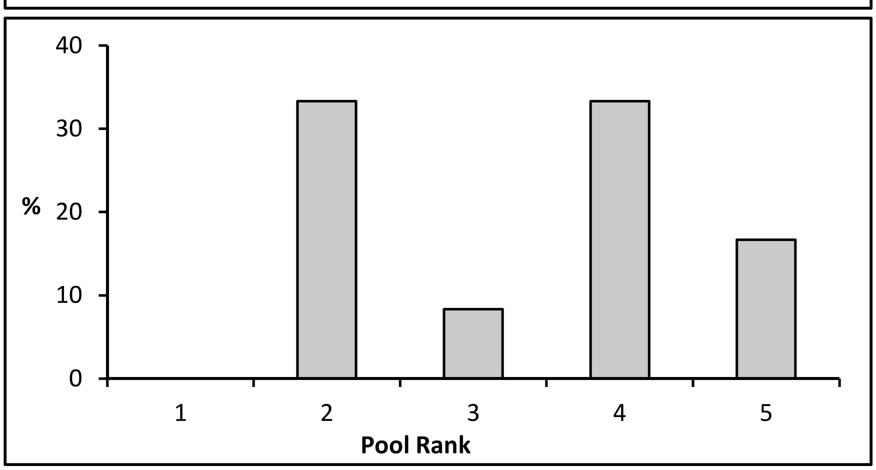
 # LWDs/mile: 258



Pools

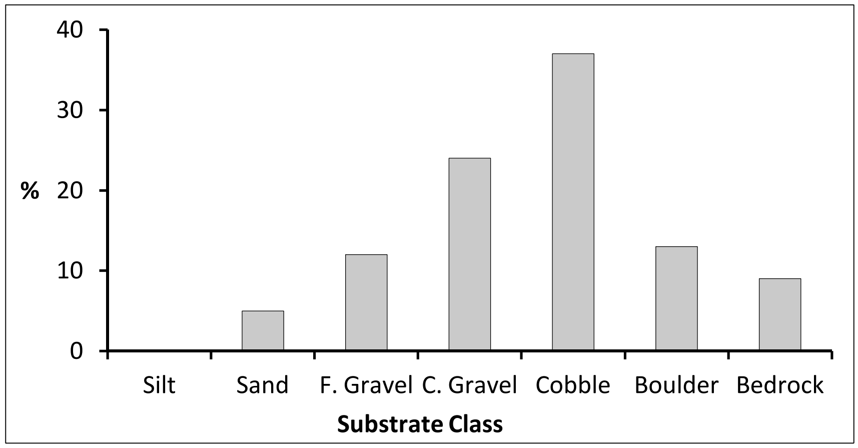
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	0
2	1.0 ≤ D < 2.0	≥ 0.5	4
3	2.0 ≤ D < 3.0	< 0.5	1
4	2.0 ≤ D < 3.0	≥ 0.5	4
5	D ≥ 3.0	< 0.5	2
6	D ≥ 3.0	≥ 0.5	1
7	D ≥ 3.0	≥ 1.0	0

 # Pools/mile: 84



Reach/Segment Information

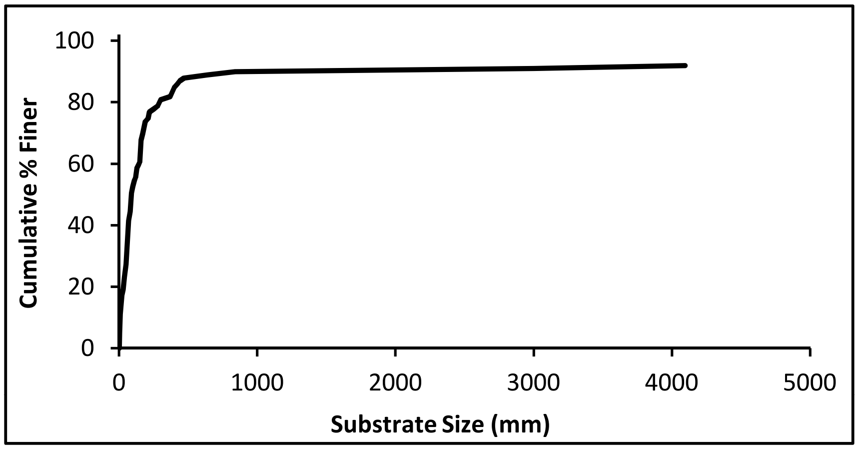
SGA ID:	T7S4.03
Length (ft):	2,403
Reference Bedform Type:	Cascade
Total RHA Score:	124
RHA Percentage:	78%
Overall Habitat Condition:	Good



Sediment Composition and Mobility

Class	Range (mm)	Percent
Silt	< 0.06	0
Sand	0.06 - 2	5
F. Gravel	2 - 16	12
C. Gravel	16 - 64	24
Cobble	64 - 256	37
Boulder	256 - 4096	13
Bedrock	> 4096	9

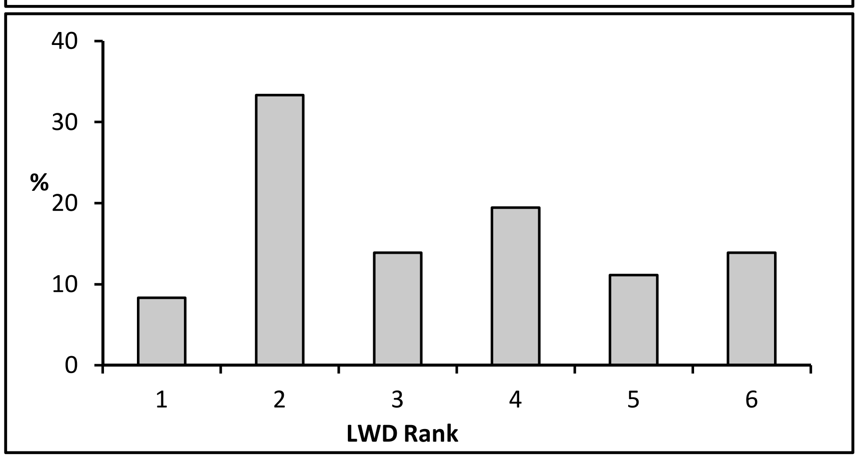
Median Substrate Size:	50	mm
Avg. Largest Particle (Bar):	160	mm
Riffle Stability Index (RSI):	68	%



Large Woody Debris (LWD)

Rank	Diameter (ft)	L (W_{bkf})	#
1	0.5 ≤ D < 1.0	< 0.5	3
2	0.5 ≤ D < 1.0	≥ 0.5	12
3	1.0 ≤ D < 2.0	< 0.5	5
4	1.0 ≤ D < 2.0	≥ 0.5	7
5	D ≥ 2.0	< 0.5	4
6	D ≥ 2.0	≥ 0.5	5

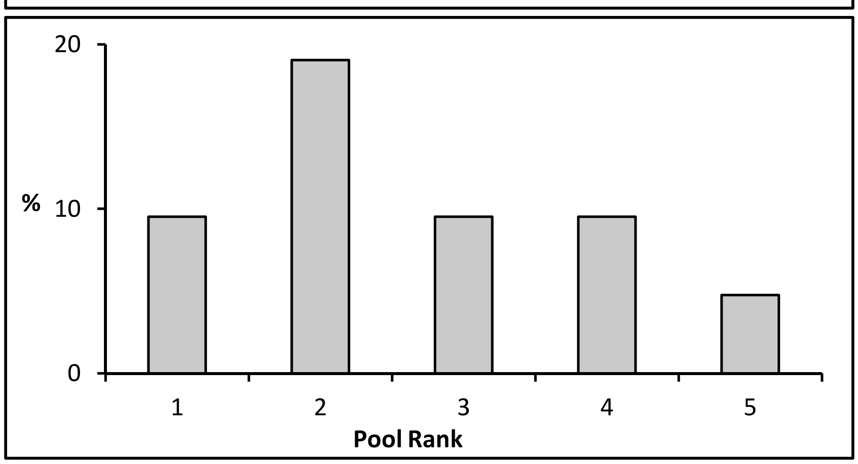
 # LWDs/mile: 79



Pools

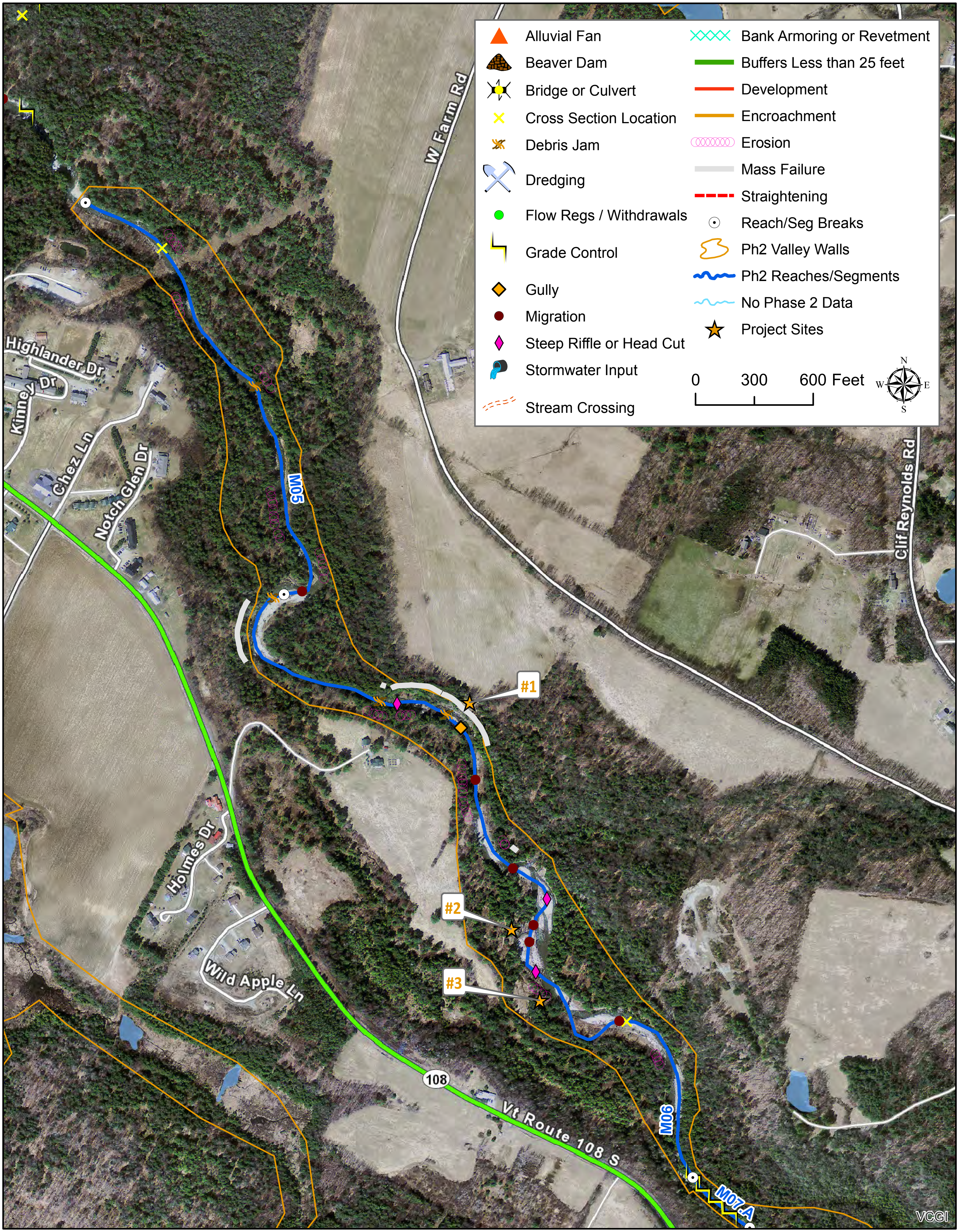
Rank	Depth (ft)	L (W_{bkf})	#
1	1.0 ≤ D < 2.0	< 0.5	2
2	1.0 ≤ D < 2.0	≥ 0.5	4
3	2.0 ≤ D < 3.0	< 0.5	2
4	2.0 ≤ D < 3.0	≥ 0.5	2
5	D ≥ 3.0	< 0.5	1
6	D ≥ 3.0	≥ 0.5	2
7	D ≥ 3.0	≥ 1.0	8

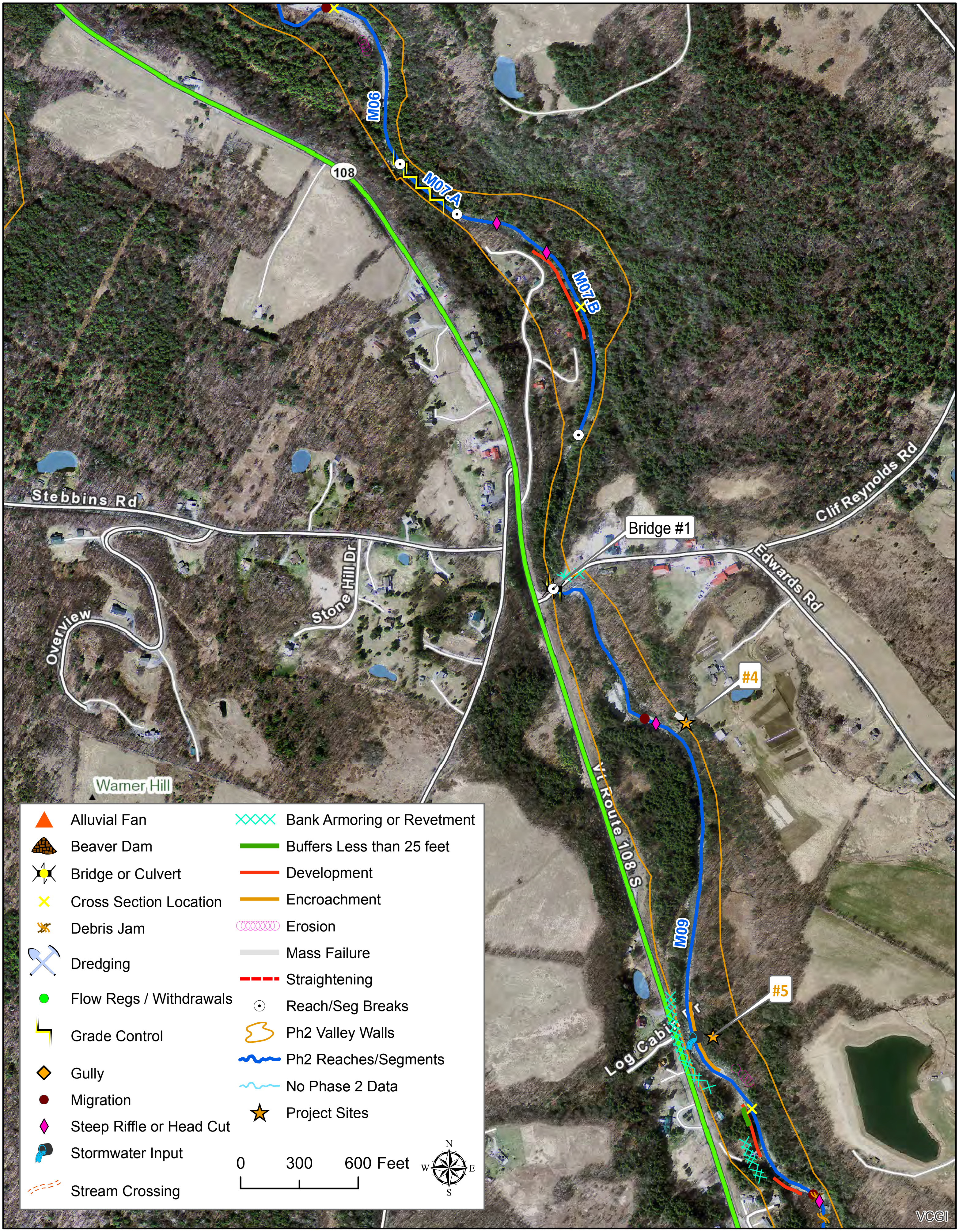
 # Pools/mile: 46

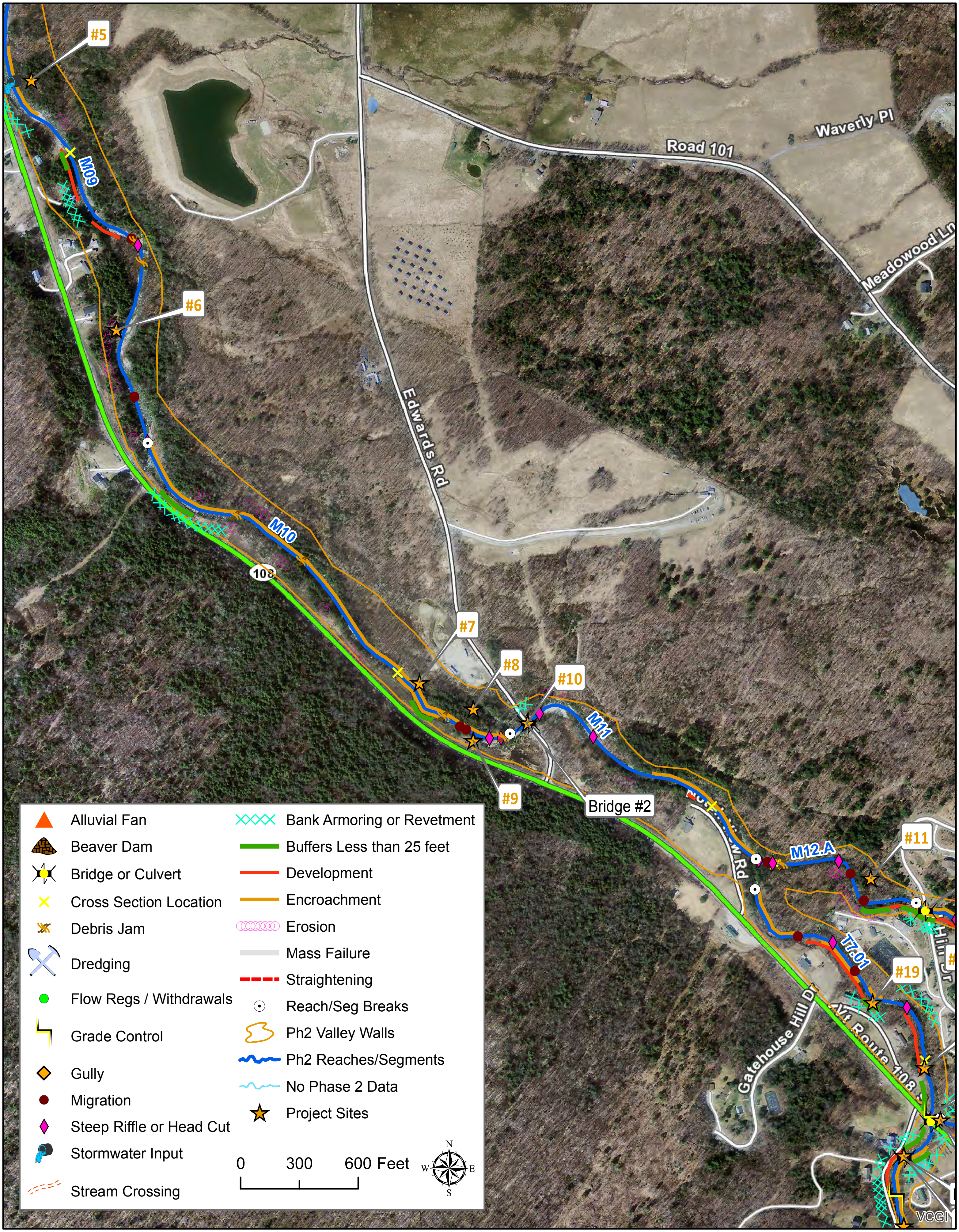


APPENDIX D

Reach Stressor and Project Identification Maps


Alluvial Fan
Beaver Dam
Bridge or Culvert
Cross Section Location
Debris Jam
Dredging
Flow Regs / Withdrawals
Grade Control
Gully
Migration
Steep Riffle or Head Cut
Stormwater Input
Stream Crossing
Bank Armoring or Revetment
Buffers Less than 25 feet
Development
Encroachment
Erosion
Mass Failure
Straightening
Reach/Seg Breaks
Ph2 Valley Walls
Ph2 Reaches/Segments
No Phase 2 Data
Project Sites
0 300 600 Feet
N
W
E
S
W Farm Rd
Highlander Dr
Kinney Dr
Chez Ln
Notch Glen Dr
Clif Reynolds Rd
Holmes Dr
Wild Apple Ln
108
Vt Route 108 S
M05
M06
M07.A
#1
#2
#3
VCGI


M06
M07-A
M07-B
108
Stebbins Rd
Stone Hill Dr
Overview
Bridge #1
Clif Reynolds Rd
Edwards Rd
#4
Warner Hill
Vt Route 108 S
M09
#5
Log Cabin Dr
VCGI
Alluvial Fan
Beaver Dam
Bridge or Culvert
Cross Section Location
Debris Jam
Dredging
Flow Regs / Withdrawals
Grade Control
Gully
Migration
Steep Riffle or Head Cut
Stormwater Input
Stream Crossing
Bank Armoring or Revetment
Buffers Less than 25 feet
Development
Encroachment
Erosion
Mass Failure
Straightening
Reach/Seg Breaks
Ph2 Valley Walls
Ph2 Reaches/Segments
No Phase 2 Data
Project Sites
0
300
600 Feet
N
W
E
S


#5
#6
#7
#8
#9
#10
#11
#19
M09
M10
M11
M12.A
T7.01
Bridge #2
Road 101
Waverly Pl
Meadowood Ln
Edwards Rd
108
Gatehouse Hill Dr
Vt Route 108
Alluvial Fan
Beaver Dam
Bridge or Culvert
Cross Section Location
Debris Jam
Dredging
Flow Regs / Withdrawals
Grade Control
Gully
Migration
Steep Riffle or Head Cut
Stormwater Input
Stream Crossing
Bank Armoring or Revetment
Buffers Less than 25 feet
Development
Encroachment
Erosion
Mass Failure
Straightening
Reach/Seg Breaks
Ph2 Valley Walls
Ph2 Reaches/Segments
No Phase 2 Data
Project Sites
0 300 600 Feet
N
W
E
S
VCGI


M12.A
#11
Bridge #3
Bridge #4
#28
#29
T7.01
#29
#12
Bridge #5
M13
#15
#19
Mountain View Dr
Wood Run Dr
#16
#28
#17
M14
#20
Morse Dr
#13
#14
Bridge #7
#18
Bridge #8
#29
#29
Bridge #6
Culvert #1
Morse Dr Ext
Aspens Dr
#23
Mount View Dr Ext
#24
Bridge #9
#21
Bridge #10
#28
#28
#29
#25
#22
#29
108
W Hill Dr
T7S1.02
#28
Culvert #2
Desjardins Rd
#26
Alluvial Fan
Beaver Dam
Bridge or Culvert
Cross Section Location
Debris Jam
Dredging
Flow Regs / Withdrawals
Grade Control
Gully
Migration
Steep Riffle or Head Cut
Stormwater Input
Stream Crossing
Bank Armoring or Revetment
Buffers Less than 25 feet
Development
Encroachment
Erosion
Mass Failure
Straightening
Reach/Seg Breaks
Ph2 Valley Walls
Ph2 Reaches/Segments
No Phase 2 Data
Project Sites
0 300 600 Feet
N
W
E
S
VCGI


108
T7S4.03
Bridge #12
#28
Bridge #13
Culvert #3
Bridge #11
#28
#29
Culvert #4
#27
Vt Route 108 S
Alluvial Fan
Beaver Dam
Bridge or Culvert
Cross Section Location
Debris Jam
Dredging
Flow Regs / Withdrawals
Grade Control
Gully
Migration
Steep Riffle or Head Cut
Stormwater Input
Stream Crossing
Bank Armoring or Revetment
Buffers Less than 25 feet
Development
Encroachment
Erosion
Mass Failure
Straightening
Reach/Seg Breaks
Ph2 Valley Walls
Ph2 Reaches/Segments
No Phase 2 Data
Project Sites
0 300 600 Feet
N
W E
S
VCGI

APPENDIX E

Project Development Summaries

Brewster River Corridor Plan - Project Development

The corridor planning partners reviewed and commented on the list of preliminary projects via email in October and November of 2014. Three project "bundles" from the initial list of 29 total projects were chosen for further development. Project summaries are included in this appendix for the three highest priority project bundles. Each summary includes:

- A description of the site location and river reach
- A brief technical summary of the stressors on channel stability and aquatic habitat
- A description of restoration and/or stabilization measures
- A list of current and potential technical partners and funding
- Preliminary cost estimates (as necessary)
- A review of regulatory requirements

The three project bundles chosen for further investigation were:

1. Project 6: Reach M09 - Left bank along the Austin Property
    - *Active Restoration: Bank Stabilization*
2. Project 10: Reach M11 -Edwards Road bridge near the M10/M11 reach break
    - *Active Restoration: Bridge replacement/retrofit*
3. Project 30: Reach T1.01 - Canyon Road
    - *Active and Passive Restoration: Slope stabilization, buffer planting, road and ditch maintenance, stormwater management*

Project 6, Brewster River Reach M09

Introduction

During LCPC's preliminary outreach to landowners along the Brewster notifying them about the geomorphic assessment and requesting access to conduct the Phase 2 field surveys, a landowner in Reach M09 contacted LCPC to raise concerns about erosion on her property. During a subsequent site visit and meeting with the landowner, we observed major bank erosion and the loss of several large trees. Erosion will likely continue and possibly increase once these trees are lost. An additional concern is posed by a well-head in close proximity to the eroding bank. This project development summary proposes a mix of traditional stream bank stabilization and alternative mitigation options that would allow the river to continue to adjust and store sediment for the benefit of this landowner and other landowners downstream.

Reach Location and Condition

Reach M09 is found along Route 108 located in between the two crossings with Edwards Road. During the Phase 2 geomorphic assessment in 2014 we observed evidence of recent widening from two large flood events in 2011, followed by ongoing aggradation and planform adjustment as the channel adjusts to the large volumes of flood-related gravel and cobbles working through the reach. Route 108 is located along the left valley wall for the entire reach and an intact forested buffer was observed through most of the reach, including the project area. Large forested floodplain areas were observed along one or both banks throughout the reach, however due to moderate/high incision, this floodplain is only accessible during large events.

Figure 1: Point bar building along the right bank is pushing thalweg into the Austin property.

Figure 2: Major bank erosion towards the well head and undermining of large trees.

Post-Flood Channel Stressors

During spring flooding and Tropical Storm Irene in 2011, large volumes of coarse sediment were carried from upstream reaches and deposited throughout the middle and lower reaches of the Brewster River. These large volumes of sediment, coupled with high flows, caused the channel to over-widen up to four times the reference bankfull width. Cobble deposits filled the channel leading to numerous flood chutes and a large channel avulsion. Following the storms, the channel is adjusting planform within these widened areas and building large point and side bars (Figure 1). The project area is located at one of the planform adjustment sites. A large bar building along the right bank is pushing the thalweg into the Austin property. A bank several feet tall eroded and collapsed into the stream, taking with it numerous large hemlock and white pine trees (Figure 2). Many of the existing trees are completely undermined and will likely fall into the channel during successive events. A concrete well head for the Austin property is located approximately 20 feet from the eroding bank.

Figure 3: Site Map for the Austin property bank stabilization along the Brewster River.

Bank Stabilization and Protection

As described above, the thalweg is pushing against the left bank along the project area causing erosion and the loss of several large trees (Figure 3). This will likely progress as the channel adjusts planform and continues to build cobble bars along the right margin. The erosion is threatening a well head for the Austin property and contributing large volumes of sediment to the channel. Below is a summary of the recommended project approach to stabilize and protect the left bank along the Austin property.

<u>Bank Stabilization</u>

The stony alluvial soils that comprise the eroding banks are highly susceptible to further erosion, especially as large trees and stabilizing root balls fall in to the channel. We surveyed a cross-section of the channel just downstream of a downed hemlock in December, 2014 (Figure 4). During our field visit we also surveyed the channel slope and evaluated substrate and channel roughness. Using this information, we estimated the hydraulics of the channel using StreamStats for flood estimates, and the manning's equation for conveyance. Due to the over-widening of the channel in this location in response to the 2011 floods, most floods are projected to be contained within the channel; however some flood flows can access the right floodplain from upstream of the project site where the channel is less incised.

A short section of armor slope (1V:2H) for approximately 50 linear feet along the downstream end of the project area would limit the progression of erosion towards the well head. A proposed sketch of this cross-section and armor slope is provided in Figure 5. Based on the estimated velocity during larger floods, Type III stone (median diameter of 16 inches) would be required, with a thickness of approximately 3 feet. The armor slope would be keyed into the channel bed 2 feet below the thalweg to prevent the slope from being undermined by scour. The top of the bank would be sloped back to 1V:3H and seeded with a conservation mix, mulched, and planted with willow stakes and/or fascines.

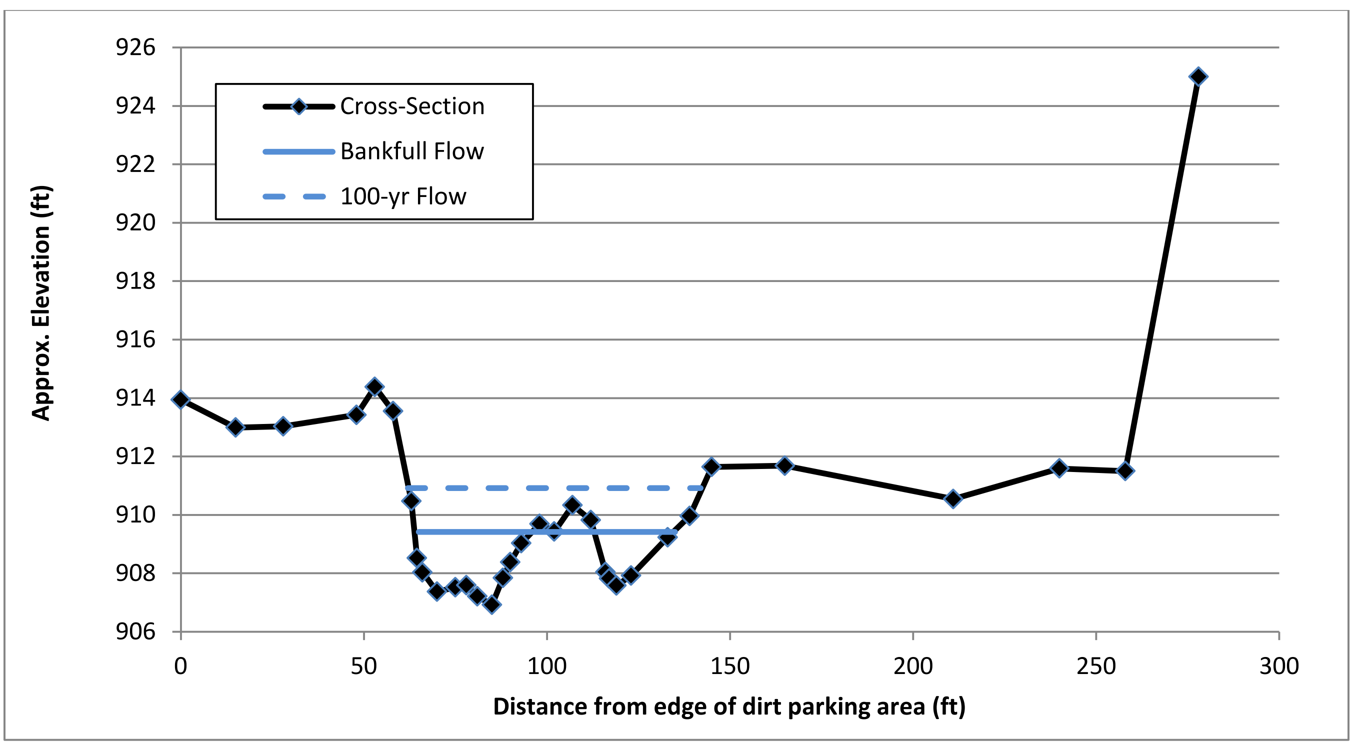


Figure 4: Survey cross-section data from the Austin bank erosion site (looking downstream, north).

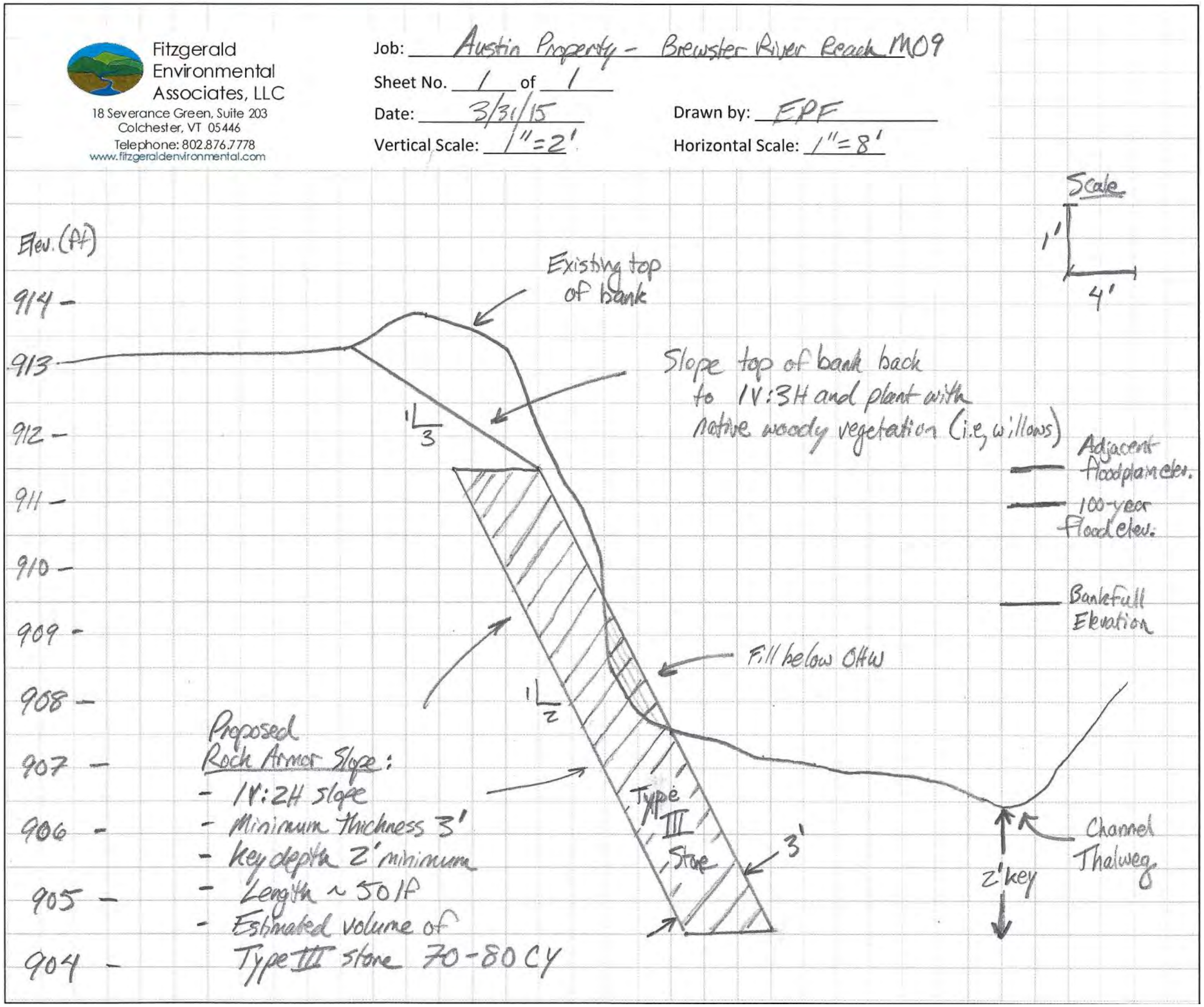


Figure 5: Proposed Bank Stabilization for Austin Property.

Bank Protection

The channel thalweg is currently pushed against the base of the eroding bank. The construction of at least two boulder vanes angled upstream towards the center of the channel will help re-center the thalweg and reduce scour along the left bank. Boulder vanes also increase sediment deposition along the bank adding further protection against future erosion. The over-widened channel has more than sufficient capacity to adjust away from the eroding bank (Figure 4). The vanes would extend approximately 30 to 35 feet off the bank at a 25-30° angle with an average width and depth of 4 feet and 2.5 feet.

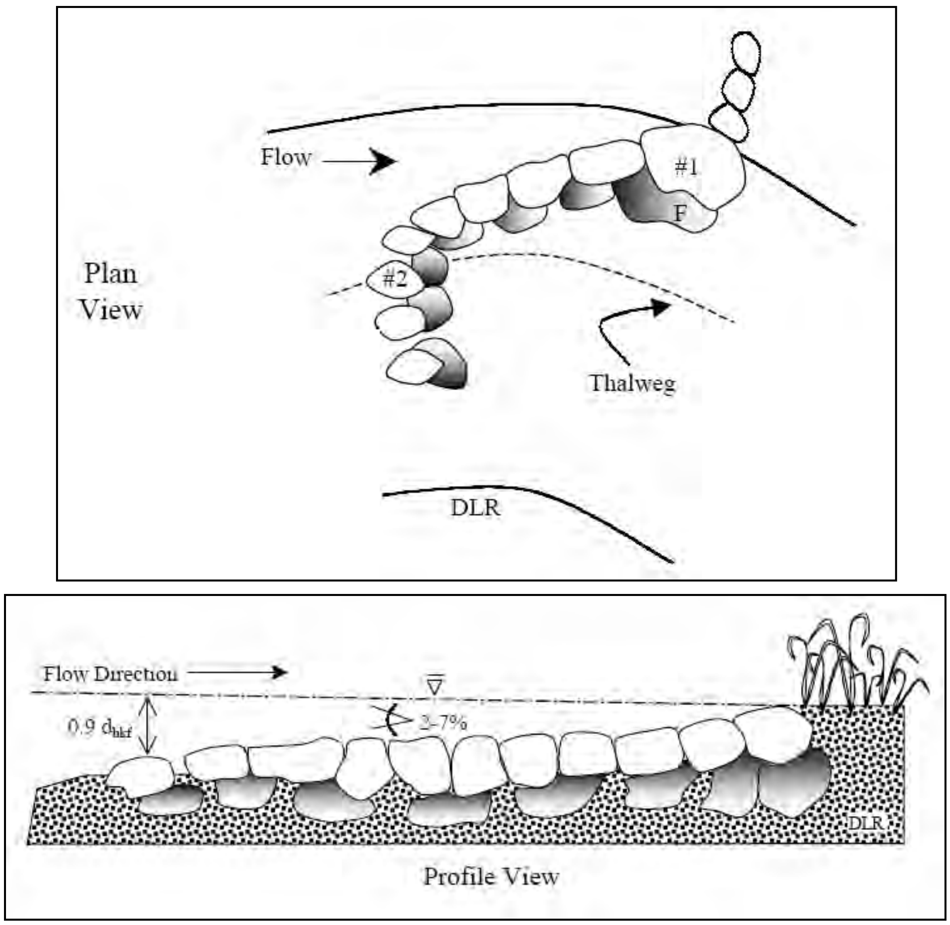


Figure 6: Example plan (top) and profile (bottom) views of vanes to lower velocity along the outside bank and push the channel thalweg away from the eroded bank (Rosgen, 2001).

Cost Estimates:

Additional technical assistance will be needed to finalize the design and secure permits for in-stream work. Between the armor slope and the two rock vanes, we estimate 120 cubic yards of Type III stone will be needed. Below is a rough cost estimate based on the materials and design presented above.

Final Design and Permitting:	$1,500
Materials Delivered (stone, plants):	$4,000
Equipment and Labor:	$3,000
Construction Oversight:	$500
Estimated Total Costs:	**$9,000**

Funding and Technical Partners

Potential funding opportunities for the bank stabilization work and the rock vanes include the private landowner and the NRCS Emergency Watershed Protection. Lamoille County Natural Resource Conservation District (LCNRCD) Trees for Streams is a potential funding opportunity for tree and shrub plantings along the bank. VTANR and LCPC staff can provide assistance regarding other potential grant sources and required steps with the regulatory process.

Regulatory Requirements

Boulder vane installation and bank stabilization will involve in-stream work with fill in the bankfull channel, therefore environmental clearances will be required from VTDEC and Army Corps of Engineers.

Project 10, Brewster River Reach M11

Introduction

Both the Town of Cambridge and the Smuggler's Notch Resort have identified the Edwards Road bridge as a priority for rehabilitation or replacement. The Town has noted that the bridge's condition is deteriorating due to scour along the wing walls; Smuggler's Notch proposed expansion and relocation of its main entrance will reroute visitors over this bridge. The combination of a deteriorating structure and increased future use has underscored the need to plan for future upgrades. The bridge is also contributing to geomorphic instability. These considerations warranted further exploration of this structure, including collection of more detailed data upstream and downstream to quantify the sediment deposits, get a localized bankfull width value, and come up with a recommendation for the bridge opening based on the VTANR guidance.

Reach Location and Condition

Reach M11 is found along Route 108 located in between confluence of Tributary 7 and the Edwards Road bridge immediately upstream of the M10 reach break. During the Phase 2 geomorphic assessment in 2014 we observed evidence of recent widening and bank scour from two large flood events in 2011. The channel is currently continuing to widen and is slowly rebuilding bed features as flood sediments work through the reach. Small floodplain benches were accessible for much of the reach, however, due to incision, large floodplain areas were typically elevated and not accessible. The over-widening of the channel and the loss of floodplain access through incision and scouring of floodplain benches resulted in a stream type departure from C to B.

Figure 7: Huge cobble bar immediately upstream of the bridge

Figure 8: Bankfull constriction and downstream deposition

Post-Flood Channel Stressors

During spring flooding and Tropical Storm Irene, large volumes of coarse sediment were carried from upstream reaches and deposited throughout the middle and lower reaches of the Brewster River. These large volumes of sediment, coupled with high flows, caused the channel to widen, including areas that widened to 100 feet within the reach. Deposition was lower within this reach, likely due to increased incision. A huge cobble point bar formed at the sharp bend immediately upstream of the project area (Figure 7). The span of the historic Edwards Road bridge - at 30 feet (90% of predicted bankfull width of 34 feet) indicates relatively minor constriction; however the sediment deposition on both sides of the bridge indicate that the constriction is sufficient to interrupt sediment transport through the reach (Figure 8). This is likely due to a combination of the channel and floodplain constriction, a sharp bend in the channel, and the high volume of flood related sediments working through the reach. Deposition downstream of the bridge likely contributed to a full channel avulsion to a historic channel (Figure 9).

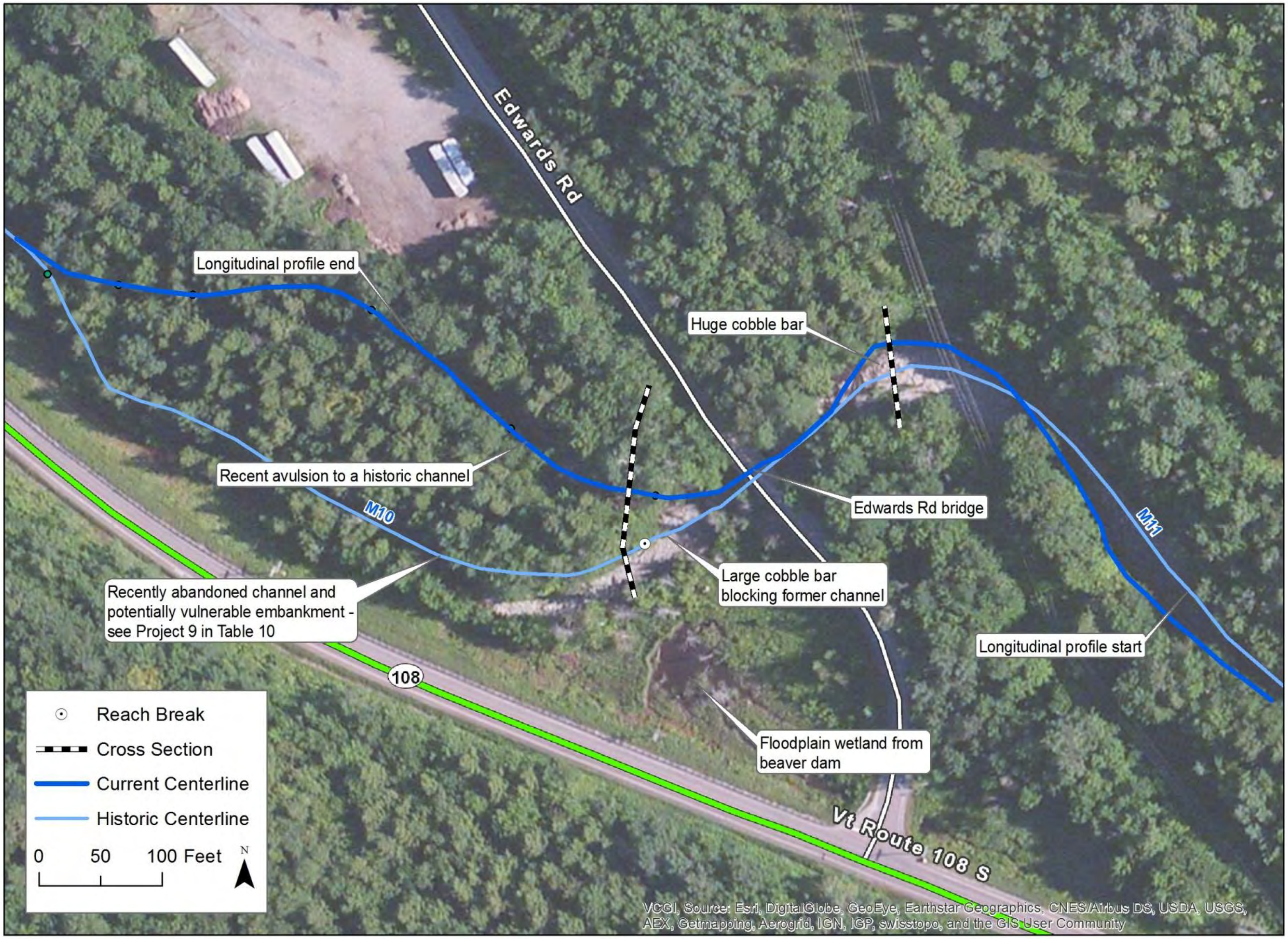


Figure 9: Site Map for the Edwards Road bridge project area.

Bridge Replacement Guidance

FEA conducted a longitudinal survey and two cross-sectional surveys through the project area (Figure 9). The cross-sections and bankfull width measurements collected along the longitudinal profile indicate that the average bankfull width is approximately 65 feet upstream of the bridge and 55 feet downstream of the bridge. The bridge width of 29.5 feet is not a major constriction based on the calculated curve width (34 feet); however it is a major constriction compared to the observed bankfull widths through the project area. The longitudinal profile indicates an area of sediment accumulation both upstream and downstream of the bridge, leading to increased scour under and through the bridge (Figure 10). The upstream cross-section includes the very large cobble bar separating the main channel along the right bank from a flood chute along the left bank. The downstream cross-section shows the recently abandoned channel along Route 108 and the newly accessed channel with some floodplain availability (Figure 11).

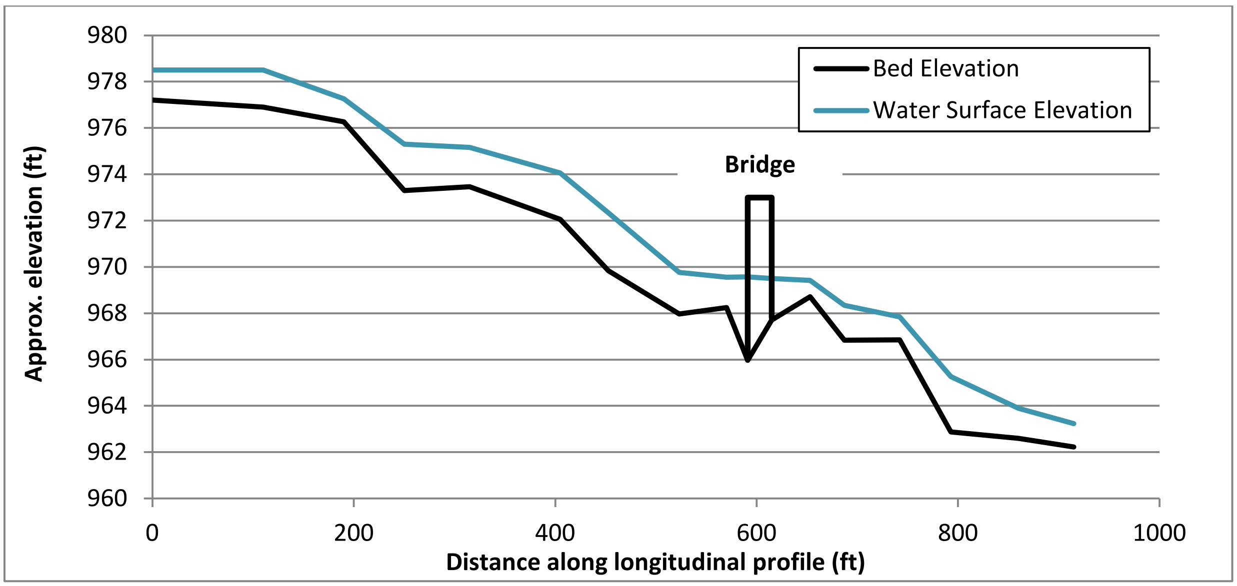


Figure 10: Longitudinal profile through the Edwards Road Bridge project area.

The characteristics of this reach, and in particular the area immediately around the Edwards Road crossing, indicate a channel with a very high bedload that is prone to migration and avulsion. In addition, many areas of the channel upstream of the bridge are actively incising, leading to the production of large amounts of sediment and woody debris. The reach fits the profile of river settings where a bridge span greater than the predicted bankfull width is recommended (Schiff *et al.*, 2014). These characteristics include:

- Sediment transport dominated reaches with a large volume of coarse bedload
- Actively incising sediment production reaches
- Wandering, braided, or fan stream types with frequently adjusting alignment

Based on these characteristics, and the evidence of severe channel adjustments upstream and downstream of the reach due to the bridge constriction, we recommend a bridge span with a minimum of width of 1.2 times the bankfull channel width, or 41 feet. Ideally, the structure span would be in the 50 to 60 foot range to accommodate the reach sediment regime, but a benefit-cost analysis can determine the most cost-effective size. As part of the design, hydraulic and sediment transport modeling and scour analysis will be required to comprehensively evaluate the reach and determine the appropriate bridge span and alignment.

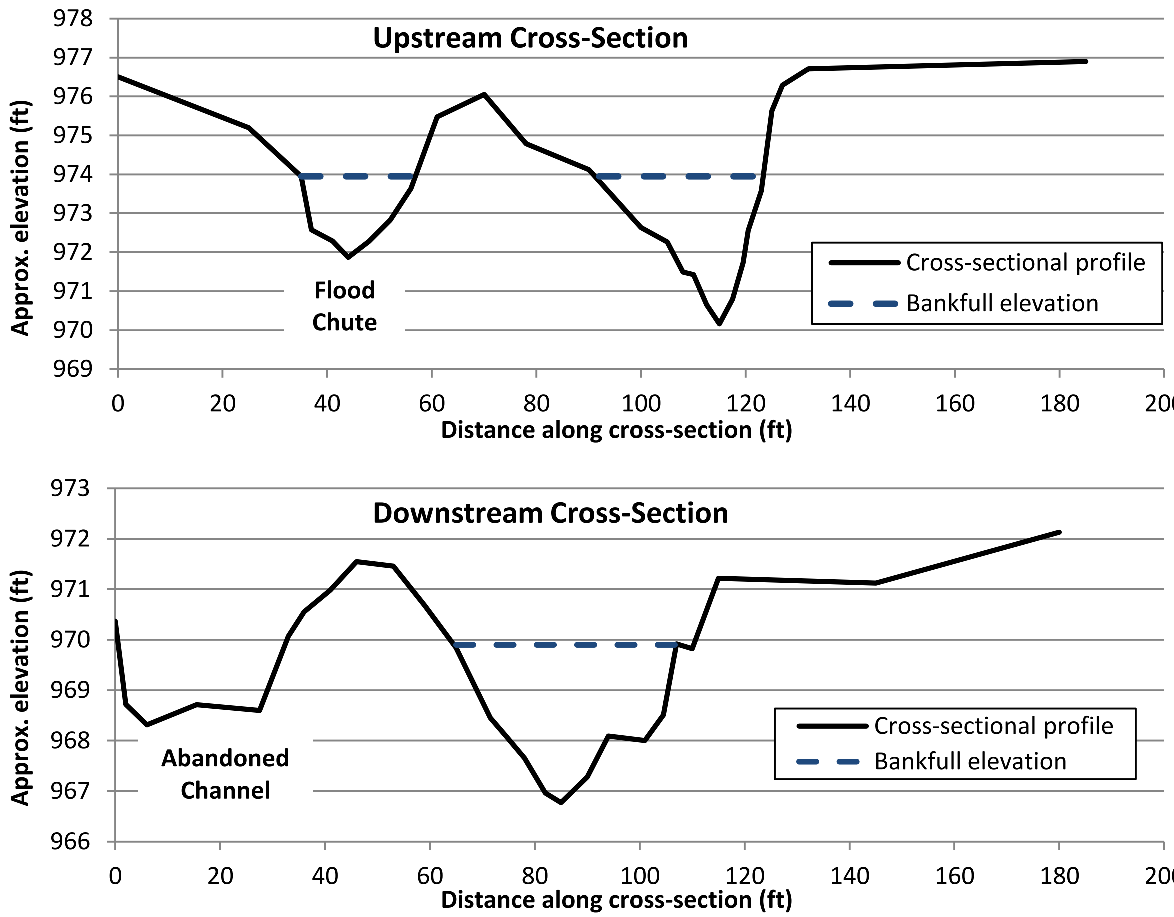


Figure 11: Cross-sectional profiles showing the upstream cross-section with flood chute (top) and the downstream cross-section (bottom) with the abandoned channel.

Funding and Technical Partners

Potential funding opportunities for the bridge design and installation include the VTrans Structures Grant program. VTrans can provide a hydraulic study for the site and preliminary recommendations for structure size. VTrans, VTANR, and LCPC staff can provide assistance regarding other potential grant sources and required steps with the regulatory process.

Regulatory Requirements

A significant amount of in-stream work would be required for this project, therefore environmental clearances would be needed from VTDEC or Army Corps of Engineers.

Project 30, Canyon Road Tributary, Reach T1.01

Introduction

In Summer 2013 LCPC conducted a road erosion assessment in Cambridge. During the assessment, LCPC noted several erosion problem areas along the Canyon Road. These erosion sites are contributing significant sediment to the stream and also require a high level of maintenance by the Town. Because of these considerations, there is an opportunity to develop and implement stormwater management solutions along the road to reduce the impacts to the stream.

Reach Location and Condition

The first major tributary to the Brewster River (T1) follows Canyon Road for approximately ½ mile above the confluence near the Grist Mill Covered Bridge. This tributary has a drainage area of 2.7 square miles with a corresponding predicted bankfull width of 20 feet. The channel is confined in a narrow to semi-confined valley with moderate to severe encroachment from Canyon Road. The channel slope is very high (8-10%) in the lower reach (Figure 12) but moderates (4-5%) in the upper reach (Figure 13) near the intersection of Canyon Road and Robtoy Road. Numerous bedrock grade controls were noted throughout the reach, including a waterfall approximately 20 feet high mid-reach. The reach was classified as a C-type channel with a broad valley in the Phase 1 assessment, but has been updated to a B-type channel with a semi-confined valley (by reference) following field observations. With the exception of some fine sedimentation in the channel from road runoff in specific areas, habitat quality was observed to be good throughout the reach. The density of large woody debris (135 pieces/mile) and pools (60/mile) are both within the "good" range for step-pool channels in Vermont.

Stressors on Channel Stability, Habitat, and Water Quality

Channel downcutting (incision) appears to be limited by bedrock, but debris jams and channel pinch points at areas of more severe encroachment from Canyon Road have led to high velocity flow and scour along the roadway embankment during recent floods. One area of severe embankment erosion was noted mid-reach and will need to be addressed in the near future to prevent roadway failure (see discussion on following page). The 8 foot diameter corrugated metal culvert at the bottom of the reach is problematic both in terms of aquatic habitat and geomorphic stability. The culvert outlet is perched 2 feet above the water surface, resulting in the blocking of all upstream aquatic organism passage (AOP). The culvert was assessed as "mostly incompatible" with geomorphic channel stability; it appears that debris clogging has been an issue at the culvert inlet during recent large floods.

Figure 12: Lower reach with steep channel slope and large boulder substrate

Figure 13: Upper reach with lower slope and numerous bedrock grade controls

Due to the steep grade of Canyon Road and the close proximity to the stream, stormwater runoff delivers large volumes of fine sediment directly to the channel during storm events. There are several opportunities for best management practices (BMPs) that would mitigate stormwater runoff along the road which would improve both the flood resiliency of the road and stream habitat. These opportunities are outlined on a map (Figure 25) provided on page 19, and are described in detail below.

River and Bank Restoration Opportunities

Downstream 8ft Culvert

The 8 foot diameter corrugated metal culvert along lower Canyon Road is perched 2 feet above the downstream water surface preventing AOP (Figure 14). Restoration of AOP with the existing culvert outlet and slope would be challenging. Boulder weirs could be installed downstream of the culvert to raise the tailwater, however the depth and velocity of water through the culvert barrel would likely be too high to allow AOP, even under low flow conditions. Baffles could be installed throughout the culvert to create steps, which could potentially restore AOP.

Figure 14: Perched culvert beneath lower Canyon Road

The culvert width is 40% of the bankfull channel width. This severe constriction leads to debris clogging at the inlet during moderate and large floods. Some rust was observed in the bottom, but the structure appears to have many more years of service life before needing replacement. When the structure comes up for replacement, a larger spanning bridge like the one upstream should be considered. If the Town considers rehabilitating the culvert to extend its service life (e.g., slip-lining), the AOP issues could be addressed at that time.

Road Embankment Repairs

At the first bend of Canyon Road, there is approximately 170 linear feet of stacked stone wall embankment that is failing (Figure 15). The wall is made of flat, unmortared stone ("laid up stone") that appears to be many decades old in most places. During recent floods, scour along the embankment toe has led to undermining of the wall. The road is at risk of failing in the next large flood.

Figure 15: Failing stone wall embankment

There is limited room on the south side of the road to shift the road alignment away from the river. Therefore, the bank should be repaired with a stacked stone wall (i.e., placed riprap wall) approach to minimize encroachment and ensure the stability of the road. This approach is outlined in the Vermont Standard River Management Principles and Practices (Schiff *et al.*, 2014) and shown below in Figure 16. If there is sufficient room to achieve a 1V:1.5H slope on the upper bank, native shrub species (willows, dogwoods) could be planted in the grubbing to further stabilize and naturalize the bank.

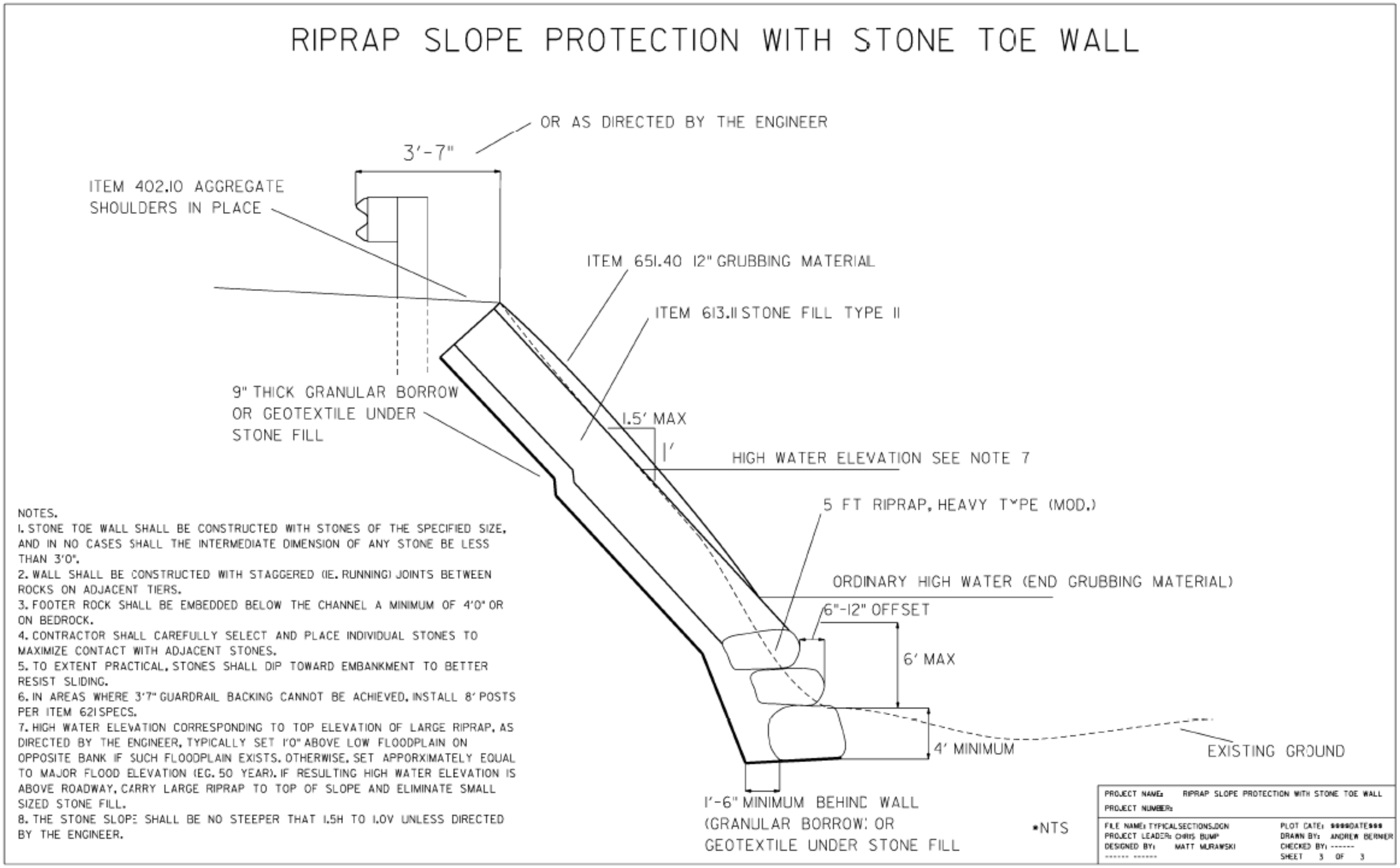


Figure 16: Placed riprap wall typical detail. (Source: Dubois & King, VTrans, Fitzgerald Environmental Associates, Milone & MacBroom, Inc., 8/30/2012)

Road and Ditch BMP Opportunities

Road Grading and Widening

There are two areas along Canyon Road where changes to road grading would reduce the impacts of stormwater and fine sediment delivery to the channel. It appears that the routine grading of the road has widened the road shoulder along the steep north bank and directly contributes to sediment loading to the channel. The Town could reduce these impacts by avoiding continued widening each time the road is graded. Additionally, there are two locations where road regrading would encourage stormwater to funnel into the ditches across the road from the stream channel (see Figure 25 on page 19).

Ditch Stabilization and Maintenance

There are two areas of unstable ditches (see Figure 25 map) that were previously identified by LCPC and another consultant in 2013. In 2014 we followed up on these areas to provide more specific guidance and locations for stabilization. In both cases, at a minimum we recommend the ditches be stabilized with stone check dams following the specifications shown in Figure 17. One of the two sites would also benefit from a sedimentation basin, which is described on the following page.

- The first area, ditch #1 shown on Figure 25, is located immediately up from the first road bend on the west side of the road (Figure 18). The road and ditch are very steep (approx. 10%) and the ditch is narrow (4-5ft) with steep side slopes and no rock armor protection. Approximately 150 feet of ditch would benefit from stabilization, with approximately 10 check dams required. Currently the ditch receives significant stormwater runoff from the road and carries a large amount of sand and fine gravel down to a natural sump prior to crossing the road to the stream through an old stone culvert.
- Ditch #2 is located just west of the intersection with Robtoy Road (Figure 19). The road and ditch grade are less than 5%, but the ditch is narrow (4-5ft) with steep side slopes and conveys runoff from a longer stretch of the road. The ditch outlets to the stream through an 18 inch culvert. Approximately 300 feet of ditch would benefit from stabilization, but the most important area would be towards the downstream end before the culvert inlet. Approximately 10 check dams would be required.

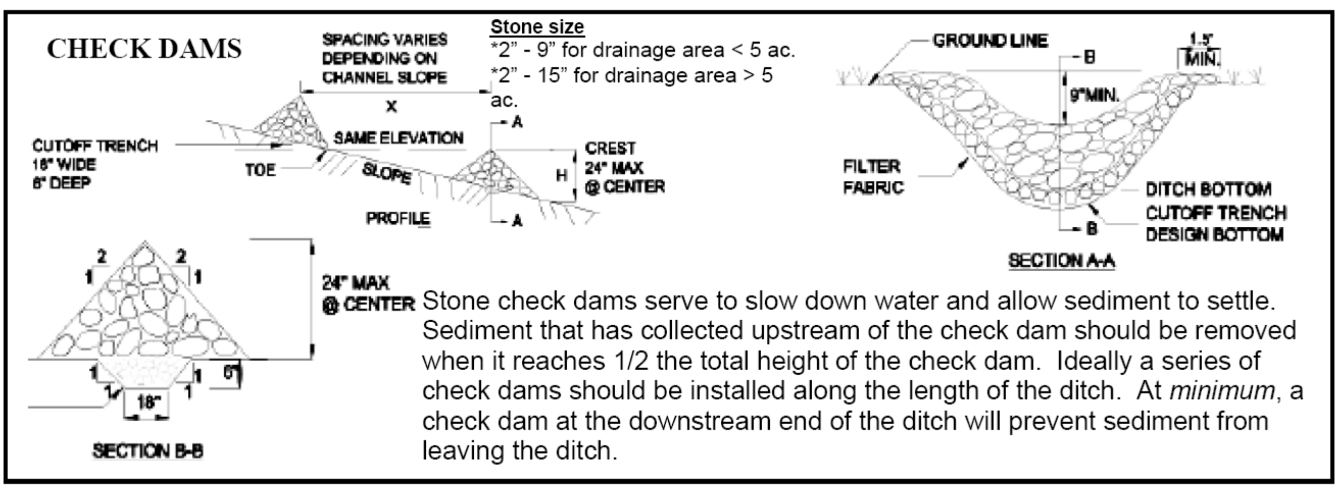


Figure 17: Standard specifications for stone check dams in ditches.

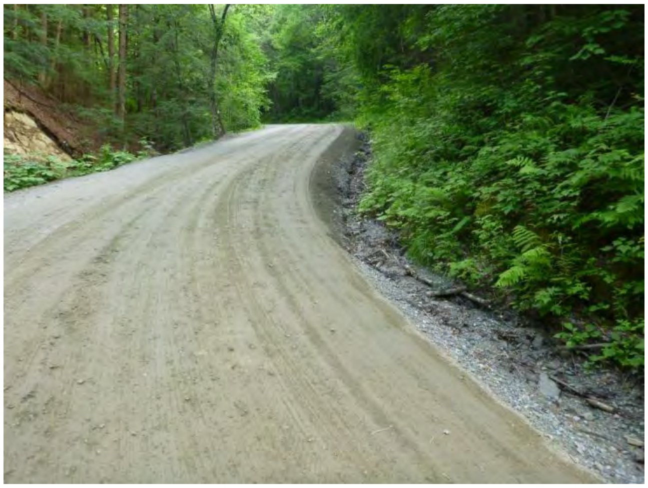


Figure 18: Unstable ditch #1 just uphill from first bend in Canyon Road

Figure 19: Unstable ditch #2 west of intersection with Robtoy Road (photo by LCPC)

Sedimentation Basins

There are two areas where stormwater and sediment is conveyed through steep ditches into the stream that could benefit from sedimentation basins. Given the high velocity of the water, the sand and gravel loading, and winter snow plowing, these areas are not well suited to intentional plantings in the basins given the harsh environment. Simple, baffled sedimentation basins would be the most effective at trapping sediments. An example design from a previous FEA project is provided in Figure 22.

- Sediment basin #1: A sump on the south side of the first bend in Canyon Road (Figure 20) collects stormwater and sediment from ditch #1. Sediment trapping could be enhanced with a baffled stormwater basin. Plants may volunteer over time but the conditions are harsh.
- Sediment basin #2: A low point on the north side of the second bend in Canyon Road receives stormwater and sediment from an 18” diameter culvert draining a ditch (Figure 21). This area is much smaller than the footprint for basin #1; a similar but smaller baffled stormwater basin could be installed to trap sediment if room allows. Alternatively, a series of horseshoe shaped check dams could be installed at the outlet to slow velocity, trap sediment, and prevent scour in the small downstream channel leading to the stream.

Figure 20: Low point along first bend in road approximately 15ft x 30ft

Figure 21: Outlet of an 18” culvert to the north side of Canyon Road just west of waterfall.

Figure 22: Example of baffled sediment basin.

Sediment basins would require frequent maintenance by the Town. This could be completed by hand by shoveling out captured sediment, or by a mini-excavator and dump truck. Maintenance would likely be required every 2-3 years, although check dam installation would reduce maintenance frequency.

Brewster River Trail

The entrance to the Brewster River from Canyon Road (Figure 23) is eroding, and the steeper section of the trail leading down to the river is gullying and eroding (Figure 24). Runoff from uphill sections of Canyon Road appears to funnel into the trail entrance. Some potential remediation ideas are listed on the following page.

Figure 23: Entrance to Brewster River Trail from Canyon Road (photo by LCPC)

Figure 24: Erosion along steeper section of Brewster River Trail (photo by LCPC)

- The first priority solution would be for the Town to regrade Canyon Road to the east leading up to the trail entrance to encourage runoff to shed off the road shoulder in more of a dispersed manner.
- A series of stairs down through the steeper section of the trail would slow the velocity of runoff going down the trail. These stairs could be constructed out of pressure treated lumber and stone, with water bars as needed to shed water to the edges. A larger gravel pad at the entrance of the trail (i.e., a landing step at or just below road grade) would help to disperse runoff off the sides of the trail.

Cost Estimates:

Additional technical assistance will be needed to finalize the designs and refine the costs for the stormwater basins and embankment repairs, and to secure permits for in-stream work. Below are order of magnitude cost estimates based on the conceptual designs presented above. Some assumptions are listed in parentheses.

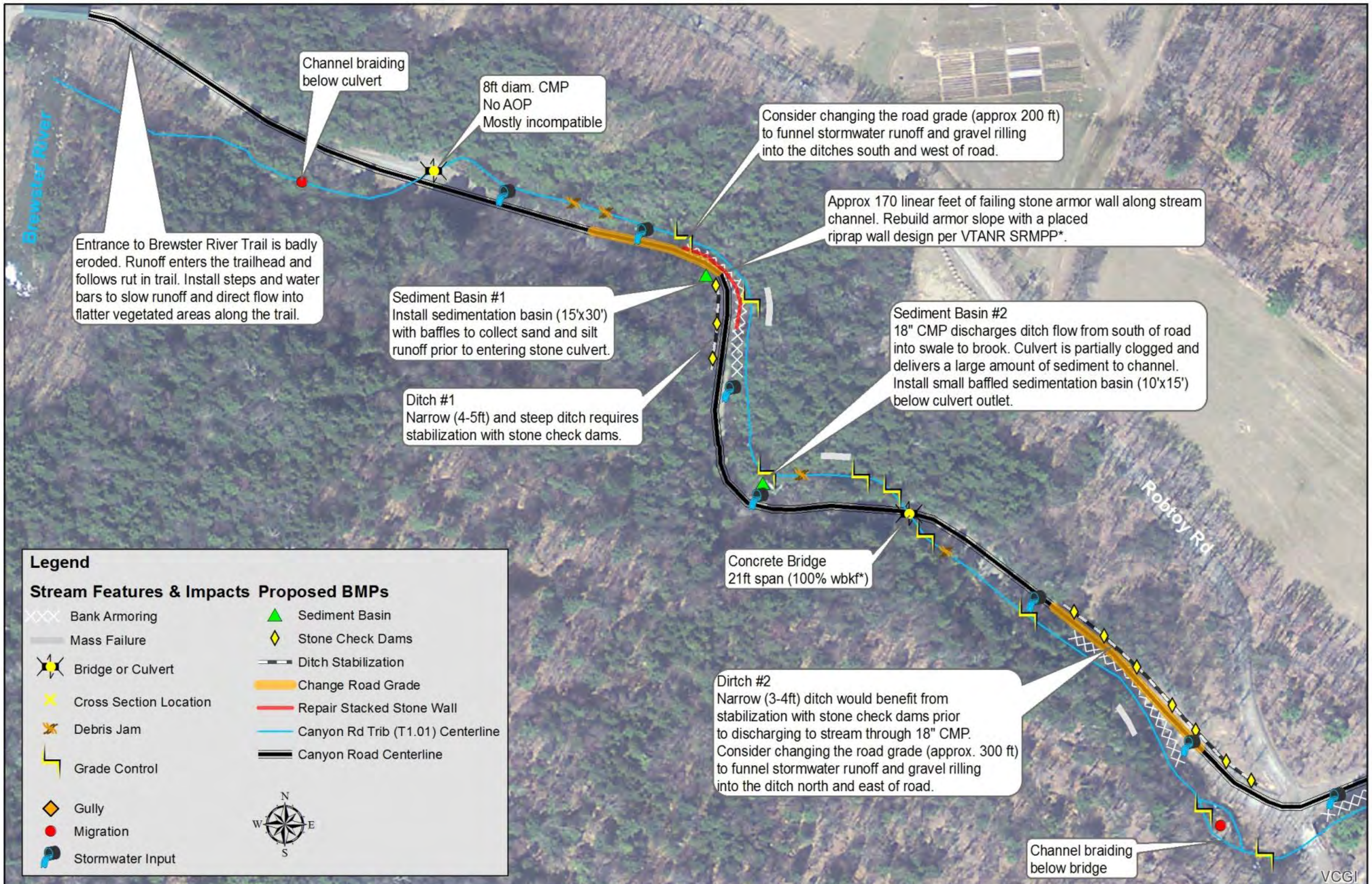
<u>Road Embankment Repairs</u>	
Final Design and Permitting:	$10,000
Equipment, Labor, Materials:	$75,000 (based on costs of $400/lf)
<u>Stormwater Mitigation</u>	
Final Design:	$500 (1 consultant site visit with Town)
Check Dams	
Equipment, Labor, Materials:	$2,000 (20 check dams, $50/CY placed stone)
Sediment Basins (2)	
Equipment, Labor, Materials:	$1,500 ($50/CY placed stone)
Trail Improvements	
Equipment, Materials:	$1,000 ($500 lumber; $500 stone)
Labor:	$2,000 (1-2 days VYCC crew)

Funding and Technical Partners

Potential funding opportunities for the road embankment stabilization work include the Town and FEMA Hazard Mitigation Grant Program if there has been repeat damage at the site. The VTANR Ecosystem Restoration Program and the Better Backroads Program could also support the stormwater mitigation work carried out by the Town.

Regulatory Requirements

The bank stabilization will involve in-stream work with fill in the bankfull channel, therefore environmental clearances will be required from VTDEC and Army Corps of Engineers.



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Brewster River Corridor Plan Project Packets

Canyon Road BMP Map

0 100 200 Feet

1 inch = 200 ft

Figure 25

Date: July 10, 2015
Drawn: EPF

Notes:
- Channel survey and BMP identification completed during July, 2014.

* SRMPP = Standard River Management Principles and Practices
wbkf = bankfull width

References

Rosgen, D., 2001. The Cross-Vane, W-Weir and J-Hook Vane Structures…Their Description, Design and Application for Stream Stabilization and River Restoration. *Presented at the:* Wetlands Engineering and River Restoration Conference 2001, D. F. Hays (Editor). American Society of Civil Engineers, Reno, Nevada.

Schiff, R., E. Fitzgerald, J. MacBroom, M. Kline, and S. Jaquith, 2014. Vermont Standard River Management Principles and Practices (Vermont SRMPP): Guidance for Managing Vermont's Rivers Based on Channel and Floodplain Function. Prepared by Milone & MacBroom, Inc. and Fitzgerald Environmental Associates, LLC for and in collaboration with Vermont Rivers Program, Montpelier, Vermont.