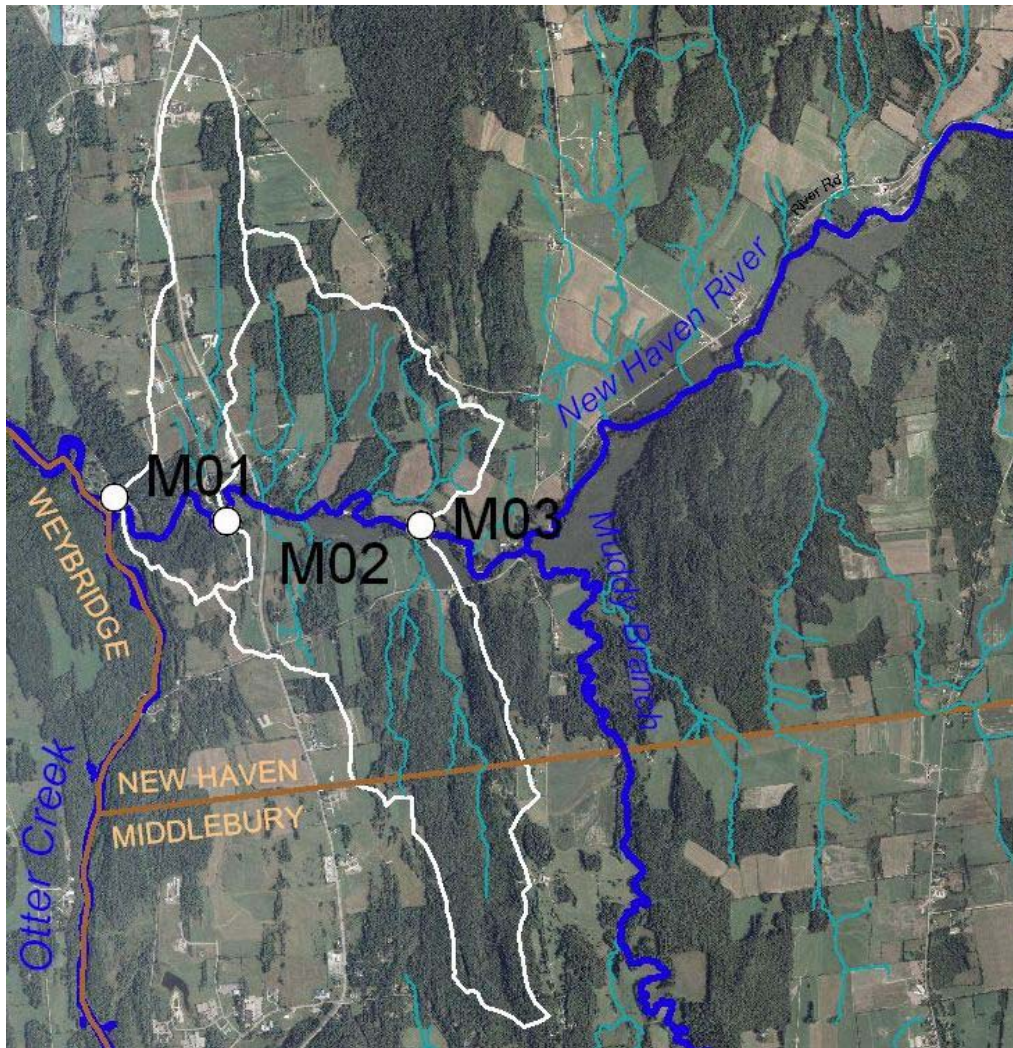


**Phase 2 Stream Geomorphic Assessment
New Haven River Watershed – Addendum
Reaches M01, M02
Town of New Haven, Addison County, Vermont
January 2008 (DRAFT)**



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Field work was conducted with the cooperation of New Haven landowners who granted permission to cross their property to access the river.



EXECUTIVE SUMMARY

Phase 2 stream geomorphic assessments were completed in 2007 on two reaches (1.9 river miles) of the New Haven River main stem in New Haven, Vermont: reaches M02 and M01. Assessments were conducted following protocols published by the Vermont Agency of Natural Resources (VTANR, 2007). Geomorphic data will be used by watershed stakeholders (including landowners, community members, watershed organizations, and state and federal resource agencies) to identify potential site-level, town-level, and watershed-level strategies for reducing streambank erosion and sediment and nutrient loading in the New Haven River watershed, by managing toward the equilibrium channel. The geomorphic condition of a given river reach or segment will help to define the short-term compatibility and long-term sustainability of various restoration or conservation projects and inform future land use or channel management choices.

Field investigations and limited historical data reviews have identified various watershed and channel disturbances that have impacted these reaches of the New Haven River, including:

Watershed-scale Modifiers:

- ◆ Historic deforestation and subsequent reforestation from the mid-1800s through the early 1900s;
- ◆ Significant flood events in 1998, 1976, 1938, 1936 and 1927; and
- ◆ Upstream erosion and tributary sources of sediment.

Reach-scale Modifiers:

- ◆ Channelization (straightening) inferred near the VT Route 7 bridge crossing;
- ◆ Berming along the banks (short lengths in M02);
- ◆ Streambank armoring (rip-rap);
- ◆ Floodplain encroachment by roads, railroads, residential development, and agricultural fields;
- ◆ Bridges which constrict channel flows at flood stage (VT Rt 7 and Dog Team Rd);
- ◆ Stormwater runoff from crop fields (one field ditch noted in M02);
- ◆ Minimal or absent forested buffers along portions of the study reaches;

The uppermost assessed reach (M02) flows through a broad to very broad valley setting (unconfined), and has been minimally constrained by human land use changes or channel and floodplain modifications. This is a natural deposition-dominated reach, positioned immediately upstream of a naturally-confined, bedrock gorge (M01-B). It shows signs of increased sediment deposition in recent years, related to the upstream and in-reach production of sediments, and likely related to the 1998 flood (an estimated 500-year event). Locally, sediment deposition has been enhanced at the Route 7 bridge, a flood-prone-width constrictor. The reach-wide prevalence of depositional bars and active lateral adjustments suggests that sediment transport capacity in reach M02 may have been further reduced by sediment loading from upstream sources.

At present, the channel has reasonable access to a broad floodplain and channel-contiguous wetlands associated with recently-abandoned meander sites (although a minor degree of historic incision persists). A channel evolution stage of IV (F-stage model) and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007). The reach appears to be near the latter stages (stage IV) of a channel evolution process which may have been initiated historically by incision related to past flood events, and/or limited channelization. The "Very High" sensitivity assigned reflects the erodible materials (gravels, silts) in the bed and banks and the high likelihood for further channel adjustments in response to future changes in water and sediment



loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Fair" – in Major Adjustment); planform adjustment is the dominant adjustment process. It would be prudent to avoid future developments and encroachments along reach M02 to protect public safety and avoid future fluvial erosion losses. Management options advised for this reach include preservation and restoration of floodplain connection and reference meander expression through passive geomorphic approaches including avoidance measures and possible corridor easements (with landowner willingness). Restoration of forested buffers (where absent) would increase streambank stability and reduce erosion in the long term.

Downstream reach (M01) flows through a Narrowly-confined valley setting; the channel is constrained, both laterally and vertically by bedrock outcroppings in the bed and bank. The higher-gradient segment of the reach, M01-B, is naturally transport-dominated. Most of the sediment and debris supplied to this segment from the upstream watershed is likely conveyed through to M01-A and the Otter Creek; there is minimal opportunity for flow and sediment attenuation. The "Low" sensitivity assigned to this segment (by protocol) reflects the stability offered by the underlying bedrock and suggests minimal likelihood of vertical and lateral adjustments. This is a segment considered "In regime" (VTANR protocols, 2007).

Similarly, segment M01-A is in a Narrowly-confined valley setting. Lateral adjustments of the channel are naturally constrained by bedrock along the left bank and an elevated post-glacial terrace along the right bank followed by a bedrock-controlled valley wall within one bankfull width. Potential vertical adjustments would be moderated by bedrock ledge exposed at the upstream end of the segment and within the Otter Creek just downstream of the New Haven River confluence. M01-A is a natural transport-dominated segment with limited opportunity for sediment and flow attenuation. Sediments and large woody debris supplied from the upstream watershed appear to be conveyed through the segment to the Otter Creek; a small tributary confluence bar was noted. The observed stream type (entrenchment ratio, channel dimensions, slope) was consistent with reference, or expected, stream type for the valley setting. A channel evolution stage of I (F-stage model) was assigned. The "High" sensitivity assigned to M01-A reflects the erodible materials (gravel-dominated) in the bed and the potential (though limited in extent) for vertical channel adjustments in response to future changes in water and/or sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Good" – minimal adjustment); a Very High or Extreme sensitivity would have been assigned if the segment were exhibiting major adjustments or a departure from reference condition.

At present, enhanced erosive energies within segment M01-A appear to be balanced by the resisting forces of the channel margins (e.g., bedrock along the left bank and occasional single-line tree buffers and armoring along the right bank). Still, Segment M01-A remains susceptible to channel adjustments and associated fluvial erosion losses in future flood events, given its naturally-entrenched status and moderately erodible streambank sediments (along right bank). Tree buffers should be preserved and enhanced, where possible, to maintain streambank stability and minimize erosion. It would be prudent to limit future, more-permanent development along this right-bank terrace to avoid fluvial erosion hazards.



1.0 INTRODUCTION

Phase 2 geomorphic assessments were completed in 2007 on 2 reaches (1.9 river miles) near the mouth of the New Haven River main stem following protocols published by the Vermont Agency of Natural Resources (VTANR, 2007a). Objectives of the Phase 2 assessments were to:

- determine the geomorphic condition of targeted reaches, and identify active vertical and lateral adjustment processes;
- identify current and historic disturbances to the channel at the reach and watershed levels; and
- evaluate the sensitivity of reaches to future channel and watershed stressors given their current geomorphic condition and inherent vulnerability (e.g., valley setting, slope, streambed and streambank sediments, vegetative buffer conditions).

Assessment data were entered into the online Data Management System (DMS), a custom database of geomorphic data developed and maintained by the Vermont Water Quality Division. This summary report has been prepared by South Mountain Research & Consulting (SMRC) of Bristol, Vermont under contract to the Addison County Regional Planning Commission (ACRPC). This report serves as an addendum to the 2004 *Phase 2 Stream Geomorphic Assessment of the New Haven River Watershed* prepared by SMRC, also under contract to the ACRPC (SMRC, 2004a).

Assessment results will be used by landowners and other watershed stakeholders to:

- support restoration and conservation project planning and design;
- plan for future development which is compatible with adjusting river channels;
- support the evaluation of Vermont rivers for listing or de-listing of waters pursuant to Part G, State of Vermont List of Priority Surface Waters Outside the Scope of Clean Water Act, Section 303(d) of the Federal Clean Water Act (VTDEC WQD, 2006a); and
- understand water quality and temperature monitoring trends in the river.

The New Haven River main stem reaches assessed were M01 and M02 located in the town of New Haven. These reaches span VT Route 7 and the Dog Team Road.

2.0 BACKGROUND

The assessed river reaches are located within the greater New Haven River watershed, which drains approximately 116 square miles of land area located in Addison, Chittenden and Washington Counties of Vermont. The New Haven River watershed is a subwatershed of the larger Otter Creek Basin that drains to the north to Lake Champlain at the western border of Vermont (Figure 1).



Figure 1. New Haven Watershed Location within the Otter Creek Basin and Vermont.

The subwatersheds draining to New Haven River main stem reaches M01 and M02 are located at the southern end of the town of New Haven and the northwestern corner of Middlebury (see Figure 2).

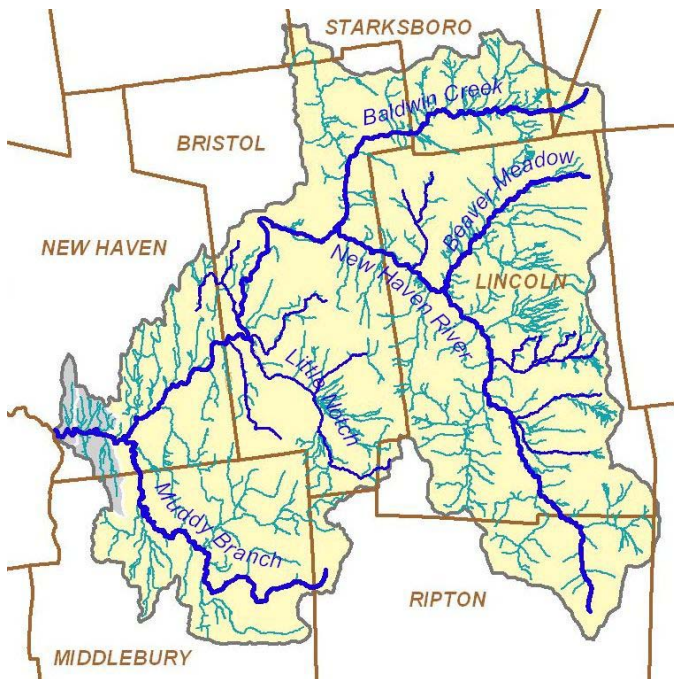


Figure 2. Location of subwatersheds (shaded gray) draining to reaches M01 and M02 in the New Haven River watershed.

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Reaches M01 and M02 are located in a section of the main stem just downstream of the Muddy Branch confluence and upstream of the New Haven River confluence with Otter Creek (Figure 3). The subwatersheds draining to reaches M01 and M02 are located in the Champlain Valley physiographic province (Stewart, 1973). Soil types in these subwatersheds are derived dominantly from glacio-lacustrine and glacial till parent materials, although soils along the immediate corridor surrounding the river in M02 are dominantly derived from alluvial and glaciofluvial sediments (USDA NRCS, 2005; USDA NRCS, 2001; Calkin, no date; Stewart & MacClintock, 1969). Bedrock (limestone, dolomite) provides lateral and vertical controls along reach M01 (and in the Otter Creek in vicinity of the New Haven River confluence) (Stewart, 1973).

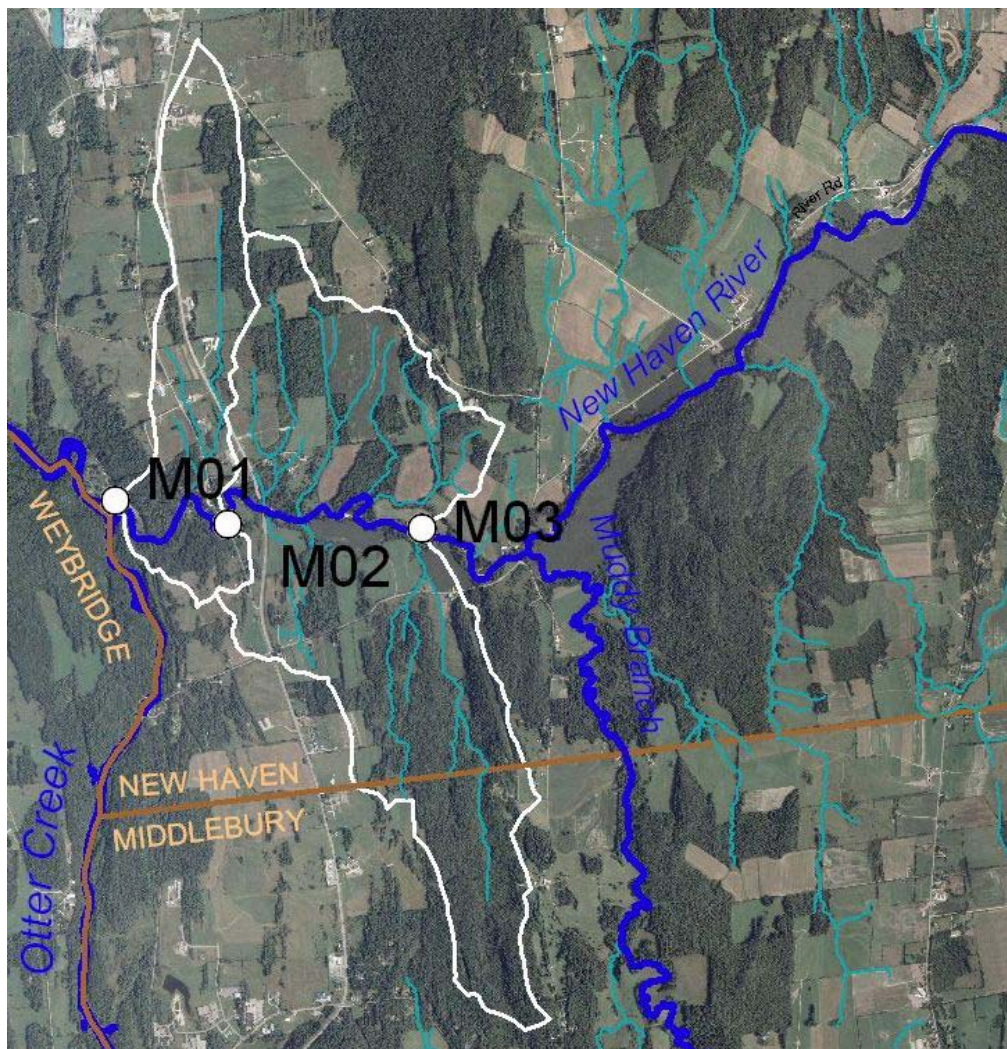
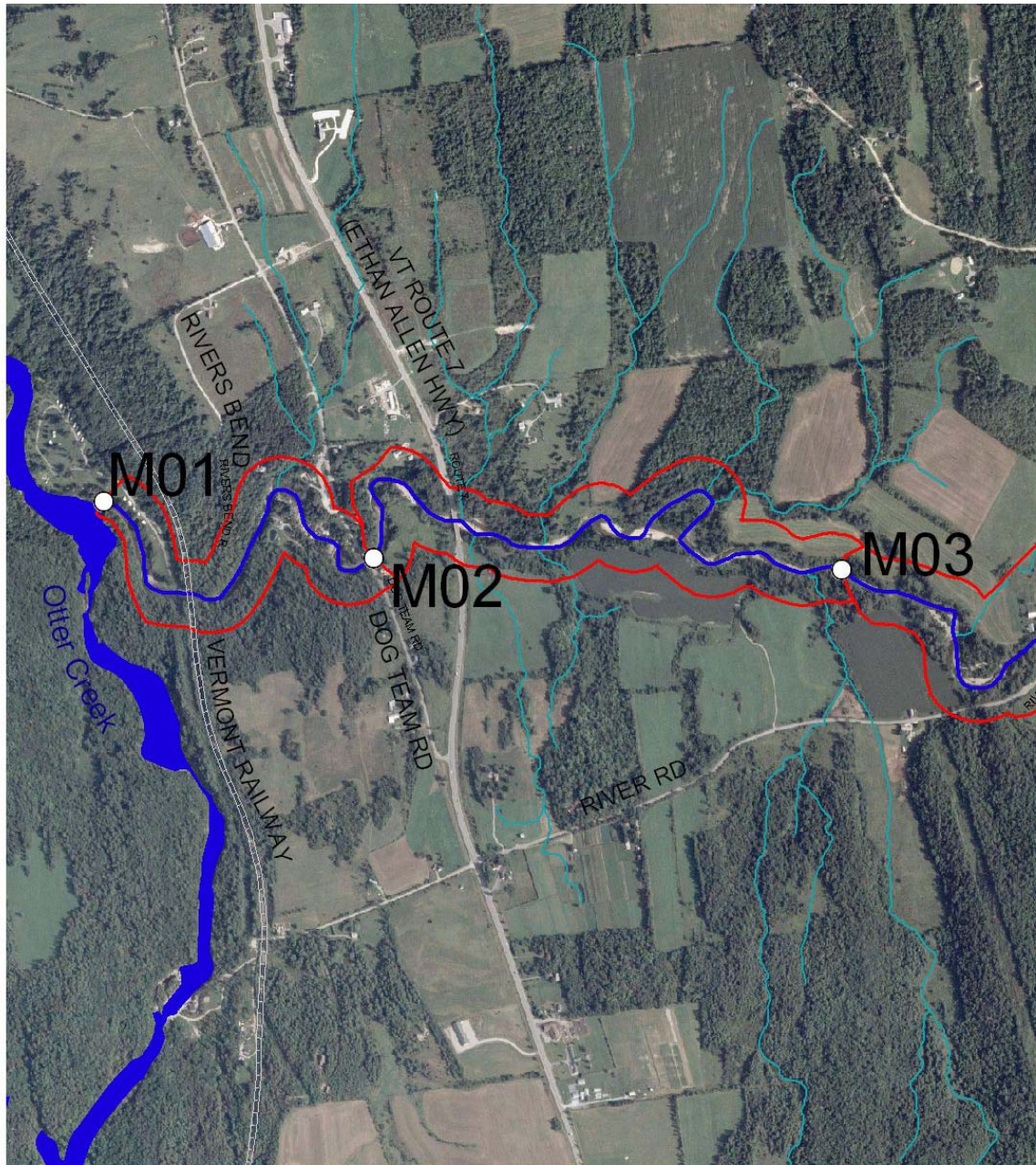


Figure 3. Location of subwatersheds (outlined in white) draining to reaches M01 and M02 in the towns of New Haven and Middlebury.

At present, land uses in these subwatersheds are comprised of low-density residential and commercial properties as well as agricultural fields and forested areas. Historically, an industrial and manufacturing center was present in Brooksville along the Dog Team Road near the New Haven River crossing and the bedrock falls approximately 500 feet downstream of this crossing (see Figure 4). A dam was first constructed at this site in the late 1700s or early 1800s (Farnsworth, 1984). At that time, industry in this area included a trip-hammer shop, wagon shop, sawmills, furnaces, blacksmith shop and (flax seed) oil



1000 0 1000 Feet

New Haven River watershed
New Haven, Addison County, VT

Reaches: M01, M02

Figure 4. New Haven River reaches, M01 and M02, New Haven, VT (red boundary indicates Phase 1 corridor [SGAT version 2; SMRC, 2004b]). (Flow in New Haven River is from right to left of the picture; flow in Otter Creek is from bottom to top of the picture).

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mill (Smith, 1886; Farnsworth, 1984). A majority of these buildings were washed out in the flood of 1830. Some of these interests were rebuilt. Beginning in the 1840s, the dam and associated mill buildings were owned and operated by the Brooks Brothers Company (later Brooks Edge Tool Company), best known for manufacture of axes which were distributed nationwide (Brooks, 2005; Beers, 1871; Farnsworth, 1984). This enterprise operated into the late 1800s. Brooksville Manufacturing Company and other interests including the Vermont Marble Company conducted manufacturing and industrial operations at the site into the early 1900s (Farnsworth, 1984; Brooks, 2005). A dam is no longer present at the site; the exact date of dam breach was not able to be ascertained in the limited historical research conducted for this assessment. It is possible that the floods of 1927, 1936 and/or 1938 may have damaged the dam.

Two dams are present on the Otter Creek within close proximity to the New Haven River confluence (Emergency_DAMS coverage: VCGI, 2005); both are owned and operated by OMYA, Inc. (formerly Vermont Marble Company):

- Huntington Falls Dam – located approximately 1.3 river miles downstream of the confluence; constructed 1910 for purposes of generating hydro-electric power.
- Beldens Dam – located approximately 0.9 river mile upstream of the confluence; constructed in 1913 for purposes of hydro-electric power generation.

Both dams are constructed on bedrock. The Huntington Falls Dam may possibly impound flows and sediments in the Otter Creek in such a way as to influence the base level of the New Haven River. Since bedrock grade controls exist in the New Haven River within one-third of a mile upstream of the Otter Creek confluence, the potential influence of this dam on water and sediment transport in the New Haven River is likely limited.

The Vermont Railway (previously the Rutland & Burlington Railroad [USGS, 1905]) crosses the New Haven River in reach M01 high above the channel (Figure 4). The exact construction date of this railroad is not known, but the railroad was present in the 1871 Beers Atlas of Addison County. The Dog Team Road crosses reach M01 near the reach break with M02. This road also predates the 1871 Beers Atlas. A USGS bridge scour report (Burns & Wild, 1998) indicates that the current bridge on this road over the New Haven River was constructed in 1927. Vermont Route 7 crosses in reach M02. Based on a review of historic aerial photographs, Vermont Route 7 was constructed sometime between 1942 and 1962. VTrans bridge and culvert databases indicate that the VT Route 7 bridge was constructed in 1960.

Major flood events which have impacted the New Haven River watershed include large events in 1998, 1976, 1938, 1936, 1927, 1869 and 1830 (SMRC, 2004a). Additional discussion of the geology, geomorphology, hydrology, and flood history of the New Haven River watershed is provided in the *Phase 2 Stream Geomorphic Assessment of the New Haven River Watershed* (SMRC, 2004a).

3.0 ASSESSMENT METHODOLOGY

Stream geomorphic assessments conducted in reaches M01 and M02 of the New Haven River utilized protocols published by the Vermont Agency of Natural Resources (2007 version) and available at: http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm. Reference is made to these protocols for a description of specific methods followed to complete Phase 2 Stream Geomorphic Assessments and Bridge and Culvert Assessments.

3.1 Phase 2 Stream Geomorphic Assessment

Phase 2 Stream Geomorphic Assessment protocols are field procedures for geomorphic and habitat assessment. Reach-specific and cross-section data gathered during Phase 2 characterize the present geomorphic condition of the river reach and the dominant process(es) of adjustment (i.e., degradation, widening, aggradation and/or planform adjustment). Phase 2 results, along with Phase 1 assessment results, define the natural and human disturbances to the watershed and channel over time and the composite response or adjustment of the channel to these stressors.

Reaches M01 and M02 were assessed by kayak (12 September 2007) and additional cross sections were measured in reach M02 on foot (11 December 2007). During Phase 2 assessments, specific features and present channel positions were located using a Garmin™ eTrex Vista global positioning system (GPS) unit. Pictures were recorded with a digital camera.

In accordance with protocols, specific features were digitized in ArcView® 3.x. Features were referenced to the Vermont Hydrography Dataset (VHD), using the Feature Indexing Tool, a component of the Stream Geomorphic Assessment Tool (SGAT, v. 4.56). The original Phase 1 Stream Geomorphic Assessment for these reaches (SMRC, 2004a) was completed using SGAT version 2. A more recent SGAT project (version 4.56) was obtained in January of 2008 from the VTDEC River Management Section to enable feature indexing of Phase 2 features (and Phase 1 updates) for this project. Certain parameters documented during the original Phase 1 Stream Geomorphic Assessment were updated based on field observations in Phase 2 (see Section 3.2).

Phase 2 assessment data were entered into the online Data Management System (DMS, v.4.56) maintained by the VTDEC WQD. Phase 2 reach summary reports, standard output from the DMS, are compiled in Appendix A.

Two road crossing structures were encountered during Phase 2 assessments. Structure spans, clearance and width measurements were conducted at each structure. The span of each crossing was compared to measured or predicted bankfull widths (VTDEC WQD, 2006b), to determine if the structure was a constrictor of flows at the bankfull stage or the flood-prone-width elevation (10-year to 50-year flood). Appendix B of this report provides a summary of the bridge and culvert assessments completed for these bridge crossings in accordance with Appendix G of the VTANR protocols (July 2007 version). Bridge and culvert data were entered into the Structures portion of the DMS (under the "New Haven River" database).

3.2 Phase 1 Updates

Phase 1 assessment data (from 2004) for reaches M01 and M02 were reviewed and verified during field work as per VTANR protocols. Necessary corrections or updates were documented on Phase 1 summary sheets for each reach (see original field data sheets). As appropriate, GIS shape files were corrected or updated (using the Feature Indexing Tool). Phase 1 data in the DMS was updated, and Phase 1 reach summary reports (standard output from the DMS) are presented in Appendix A.

Elevation data were revised slightly for both reaches following field-based observations (see Appendix D). Also, the position of the valley wall was updated, based on field observations and following clarifications to valley wall delineation procedures articulated in protocol updates between 2004 and 2007. A revised valley wall shape file is contained on the Project CD.

Valley wall revisions resulted in a change to the reference stream type for reach M02 – from a Bc channel to a C channel. In the former Phase 1 assessment, meander geometries were not estimated for this reach due to the assigned stream type of Bc. Now that the reach has been corrected to a C stream type, estimation of meander geometry and associated impact scores are required under Phase 1 Steps 6.5 and 6.6. These data were developed and are summarized in Appendix E. Shape files of the meander belt widths and wavelengths are included on the Project CD.

Other Phase 1 parameters reviewed and updated (where appropriate), included:

- presence of alluvial fans (Phase 1 Step 3.1);
- presence and location of bedrock or other grade controls (Phase 1 Step 3.2)
- steepness of valley side slopes (Phase 1 Step 3.4);
- width of riparian buffers (Phase 1 Step 4.3);
- groundwater inputs (Phase 1 Step 4.4);
- revetment lengths and locations (Phase 1 Step 5.3);
- channel straightening (Phase 1 Step 5.4);
- location and lengths of berms and roads (Phase 1 Step 6.1);
- location and lengths of development (Phase 1 Step 6.2);
- occurrence of depositional bars and bedforms (Phase 1 Step 6.3);
- occurrence of channel avulsions, neck cut-offs, flood chutes (Phase 1 Step 6.4);
- erosion lengths and heights (Phase 1 Step 7.2);
- occurrence of, or potential for, ice/debris jams (Phase 1 Step 7.3)

The above features are more comprehensively inventoried for the study reaches during field assessments, than they are able to be during a Phase 1 which is accomplished through remote sensing and limited windshield surveys. The metadata for each Phase 1 step in the database were reviewed and updated (where necessary) to reflect that data were supported by field observations.

3.3 Quality Assurance / Quality Control

Assessments were performed under a programmatic Quality Assurance Project Plan (QAPP) generated by the Vermont Water Quality Division, River Management Section (VTDEC WQD, 2003). Following completion of standard DMS Phase 2 quality control checks (X.1 through X.4), Phase 2 data were submitted to the River Management Section for a quality assurance review. Quality assurance documentation is included in Appendix C.

Select Phase 2 features (including, grade control locations, stormwater inputs, streambank erosion, revetment locations, and more) were geo-located using the Feature Indexing Tool (FIT) in SGAT. These features are indexed to the available Vermont Hydrography Dataset (VHD) for the New Haven River watershed which appears to have been generated from 1995 orthophotographs. In reach M02, the actual channel position has moved from its 1995 position as a result of a neck cutoff and meander extension and translation, as revealed by comparison of the 1995 orthophotos with the 2003 aerial imagery (NAIP, 2003), and by review of 2007 channel positions recorded with a hand-held GPS. Thus, locations and lengths of features indexed to the VHD should be considered approximate. Waypoint logs and sketch maps contained on the Project CD provide more insight into the recorded locations of these features.

4.0 PHASE 2 ASSESSMENT RESULTS

Geomorphic and habitat assessments were completed on 2 reaches (1.9 river miles) of the New Haven River main stem: M01 and M02. Phase 2 assessment results are summarized in Table 1 and are discussed below for each reach (Sections 4.1 and 4.2). Detailed Phase 2 assessment results are tabulated in Appendix A, the standard report output from the online DMS for Phase 1 & 2 Stream Geomorphic Assessment data.

A reference stream type (Phase 1) and an existing stream type (Phase 2) have been classified for each reach. Stream type designations are based on Rosgen (1996) and Montgomery & Buffington (1997). A sensitivity classification was also assigned to each reach based on the Phase 2 stream geomorphic assessment data. The sensitivity classification is intended to identify "the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes" (VTANR guidance, 11 July 2007). Inherent in the stream sensitivity rating are:

- ◆ the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification; and
- ◆ the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor) rating of the Rapid Geomorphic Assessment).

Abbreviations used in the sections below include the following (see protocols for further description):

- ◆ Left Bank, facing downstream (abbreviated, "LB")
- ◆ Right Bank, facing downstream (RB).
- ◆ Incision Ratio (IR) = Low Bank Height / Bankfull Max Depth
 - IR_{RAF} = Recently Abandoned Floodplain Incision Ratio
 - IR_{HEF} = Human-Elevated Floodplain Incision Ratio
- ◆ Entrenchment Ratio (ER) = Flood Prone Width / Bankfull Width
- ◆ Flood Prone Width (FPW) – estimated as the 10- to 50-year flood event
- ◆ Large Woody Debris (LWD)
- ◆ Debris Jams (DJs)
- ◆ Rapid Geomorphic Assessment (RGA)
- ◆ Rapid Habitat Assessment (RHA)
- ◆ Vermont Hydrography Dataset (VHD)
- ◆ National Wetlands Inventory (NWI)
- ◆ Vermont Significant Wetlands Inventory (VSWI)

Table 1. Results of Phase 2 Geomorphic Assessments, New Haven River reaches M01 and M02 completed in 2007.

Reach	Segment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)	Stream Type	Incision Ratio	RHA Condition	RGA Condition	Adjustment	Channel Evolution Stage	Stream Type Departure?	Sensitivity
M02	--	5,994	0.2	115.7	C4-R/P	1.2 (RAF)	0.65 Good	0.60 Fair	Mod PF / Aggr	IV (F)	No	Very High
M01	B	2,173	0.7	116.4	A1c-S/P *	NM	Not Assessed - Bedrock Gorge				Low	
	A	1,580	0.1		A4c-R/P	1.0 (RAF)	0.76 Good	0.83 Good	None	I (F)	No	High

Notes / Abbreviations:

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.
 Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Casc = Cascade; Ref = Reference
 Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).
 Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2007).
 Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.
 Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, 2007).

Note: Segment B of M01 is a subreach of alternate stream type (with sections of bedrock-cascade, bedrock & boulder step/pool, and plane-bed bedrock gorge.

Note: Above data are provisional; not yet quality-assured by VTDEC River Management Section.

4.1 Reach M02

Reach M02 is 1.1 mile long (5,994 feet) and extends from the vicinity of the CVPS / Velco power line crossing downstream to the Dog Team Road bridge crossing (Figure 5). The valley setting is unconfined. Estimated valley widths vary from 430 feet to 1,340 feet, averaging 820 feet. Generally, the reference valley confinement is Broad (6 to 10 times bankfull width), with localized areas of Narrow (4 to 6 times) or Very Broad (greater than 10 times) confinement. Overall channel gradient is estimated as 0.2%. Thus, a reference C4-riffle/pool stream type was assigned to reach M02.

Corridor soil types are dominated by sediments of recent alluvial origin as well as sediments of glaciolacustrine origin (USDA NRCS, 2005; USDA NRCS, 2001; Calkin, no date; Stewart & MacClintock, 1969). Generally, the contact between lacustrine sediments and recent alluvium is thought to represent the valley wall. Most often, exposed stream bank soils were layered silts with overlying fine- to medium-grained sands. Varved clays were noted in a few locations typically exposed near the thalweg on the outside of a meander bend. Bedrock offers lateral grade control along the right bank at the prominent meander bend near the downstream end of the reach between the VT Route 7 and Dog Team Road crossings. Several pockets of channel-contiguous wetlands are mapped along the reach corridor, often associated with tributary confluences and abandoned channel meanders (NWI, VSWI). Hydric soils are also prevalent within the floodplain and uplands immediately surrounding the stream valley; often areas of mapped hydric soils are coincident with crop fields (USDA NRCS, 2005; USDA NRCS, 2001).

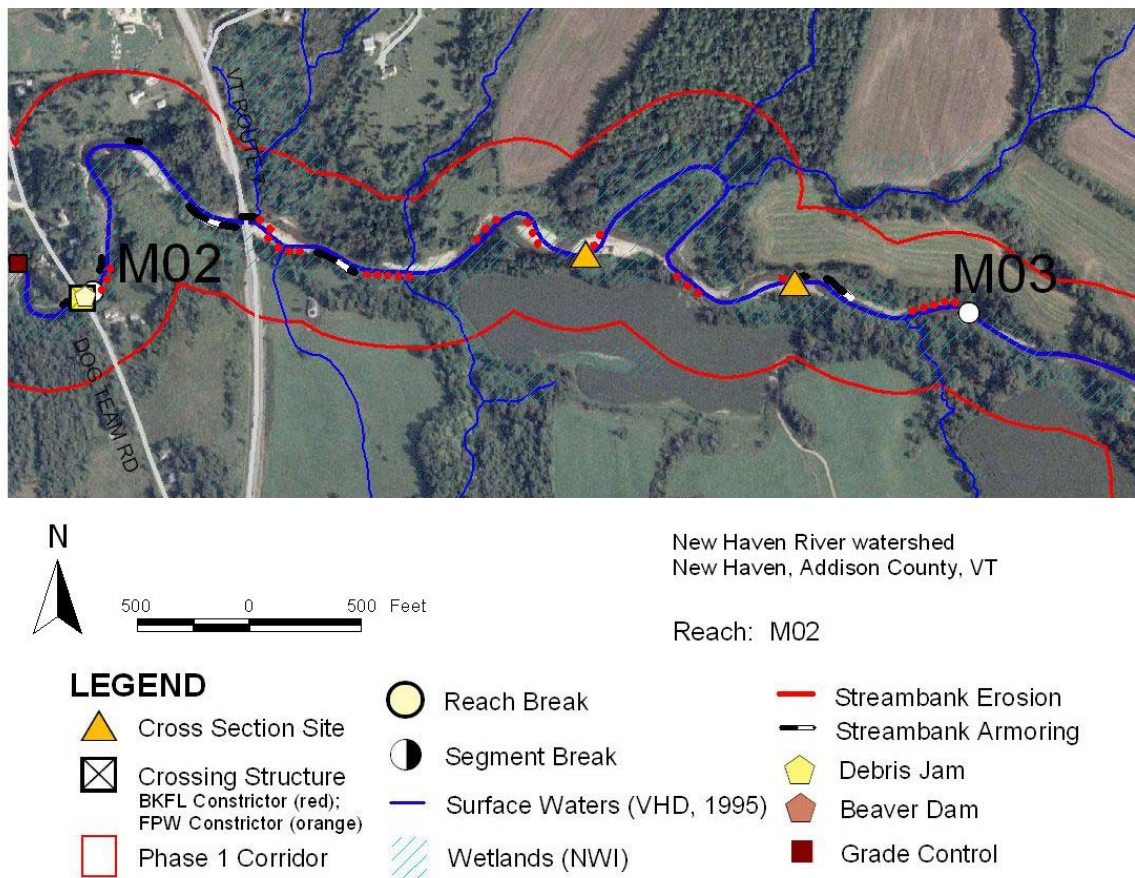


Figure 5. Reach M02 (flow is from picture right to picture left).
 (Red boundary indicates Phase 1 corridor [SGAT version 2; SMRC, 2004b]).

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Human encroachments within the reach corridor are minimal. The LB corridor is dominated by a mixture of crop (and some hay) fields, as well as limited forest and scrub/shrub cover. The RB corridor is dominated by forest cover, with some corn fields. A few residential homes and outbuildings are located along the left and right banks in the vicinity of the Route 7 and Dog Team Road crossings. Rip-rap armoring is present along the banks in the vicinity of these homes, and also at select locations elsewhere in the reach to protect adjacent crop fields. A boulder berm (apparent field stone) was noted for an approximately length of 80 feet along a former channel position (now flood chute) in the LB corridor near the mid-point of the reach. This feature varied in height and width; at one measurement site adjacent to cross section site, CS-2, the berm had a measured thalweg height of approximately 9.6 feet (higher than bankfull elevation, but not higher than the estimated flood-prone-width elevation; $IR_{HEF} = 1.5$). Fill material supporting bridge approaches fills the floodplain at the VT Route 7 crossing. The span from abutment to abutment of this bridge is wider than measured and reference bankfull width values, but is expected to constrict flood flows. A large mid-channel bar and island were noted upstream of this bridge; a small mid-channel bar was located immediately downstream of the bridge. A subtle berm was noted along the LB for a short distance downstream of the VT Route 7 crossing (thalweg height of approximately 9 feet). Historic straightening of the channel upstream and immediately downstream of this bridge crossing is inferred from the linear planform.

Depositional bars (point bars, side bars, mid-channel bars, transverse bars) are frequent within the reach; some pools are relatively shallow and bar heights are occasionally greater than the one-half bankfull height. Active recruitment of large woody debris ($LWD = 65$) is generating local scour holes, providing variability in velocity/depth patterns and contributing to morphological diversity. At the low to moderate flow stage of the assessment date (9/12/2007), many of the riffle substrates were exposed. Forested buffer widths are moderate to occasionally absent; this fact combined with the large size of the channel and its open canopy result in limited shading for the river. Moderate streambank erosion was noted, related to active meander extension and a recent (post-1995, pre-2003) neck cut-off. Active recruitment of large woody debris and detritus is occurring, providing epifaunal substrates and organic matter for instream habitats. Overall, a "Good" habitat condition rating (0.65) was assigned following the RHA (on the cusp with a "Fair" rating).



Figure 6.
Transverse depositional bars
and point bars are frequent
along Reach M02.

(View upstream,
12 September 2007).

Two cross sections were completed in reach M02 and confirmed a gravel-dominated C-riffle/pool stream type. The river has access to a wide floodplain. A minor degree of historic incision is indicated by the measured incision ratios of 1.18 and 1.22; no indications of active incision were noted in the reach (e.g., headcuts, coincident undercut banks on both LB and RB). Historic incision may be related to inferred channelization near the VT Route 7 bridge (circa 1960s). Perhaps, historic breaching of a dam(s) at Brooksville, which operated in downstream reach M01 from the 1700s through the early 1900s may have

contributed to historic incision (the construction specifications and potential impoundment heights of this former dam(s) are not known). Historic incision in M02 may also have been associated with past flood events and deforestation / reforestation cycles in the late 1800s and early 1900s. It is possible that aggradational processes and planform adjustments have offset the potential for channel incision in the reach.

Minimal indications of widening were noted. One of the cross section sites had an estimated width/depth ratio of 46.7; however, this ratio appears to be more related to aggradation and planform adjustment processes than active channel widening. (The second cross section site had a measured W/D ratio of 21). While undercut banks, exposed root systems, and leaning trees were evident along the channel, these features tended to be located along either bank (not both banks in one location) and were associated with meander extension (planform adjustment processes). Moderate aggradation and planform adjustment were indicated by the prevalence of depositional bars, meander migration sites, the recent neck cut-off, as well as several bankfull-elevation flood chutes. The channel has a different planform at present than is represented by the 1995 VHD. The blue line in Figure 5 represents the approximately 1995 channel position (VHD), superimposed on the 2003 aerial photograph.

The geomorphic condition of reach M02 was rated as "Fair" following the RGA (score of 0.60). Overall, this reach appears to be operating as a deposition-dominated reach. A reduced sediment transport capacity is inferred, due to increased sediment and debris from in-reach and upstream sources. It is likely that flood sediments associated with the 1998 flood event are still working their way through the river network; this was an estimated 500-year flood event (Olson, 2002). Also, streambank erosion is prevalent in upstream reaches (e.g., M03 through M08), due to ongoing channel adjustments, and areas of absent forest buffers in erodible soils (SMRC, 2004a). A channel evolution stage of "IV (F)" and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007).

4.2 Reach M01

Reach M01 is approximately $\frac{3}{4}$ of a mile in length (3,753 feet) and continues from the Dog Team Road crossing, over the falls at Brooksville and on to join the Otter Creek at Rivers Bend campground. Within reach M01, the New Haven River crosses north-south strike of limestone and dolomite formations; bedrock provides both lateral and vertical grade controls to the New Haven River channel. Bedrock falls are also located along the Otter Creek within close proximity to the New Haven River confluence (e.g., Huntington Falls, Beldens Falls). Reach M01 was segmented to capture a subreach of bedrock-controlled channel in the upstream 2/3 of the reach (see Figure 7): Segment B = 2,173 feet, 0.7% gradient; Segment A = 1,580 feet, 0.1% gradient.

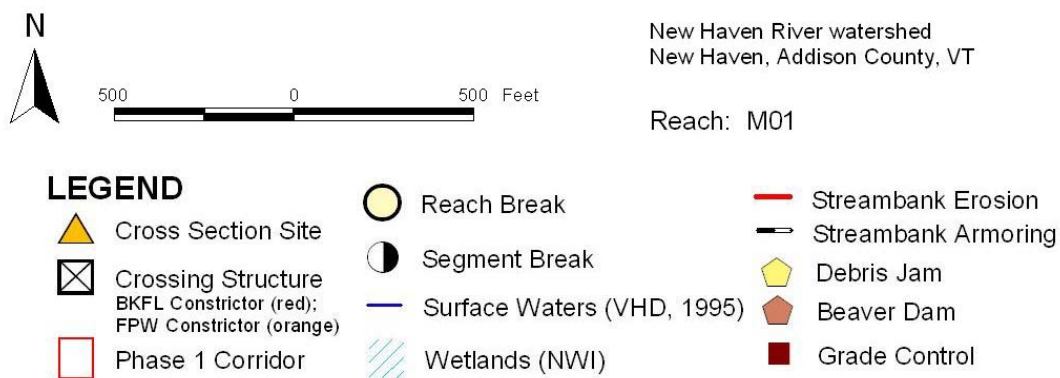
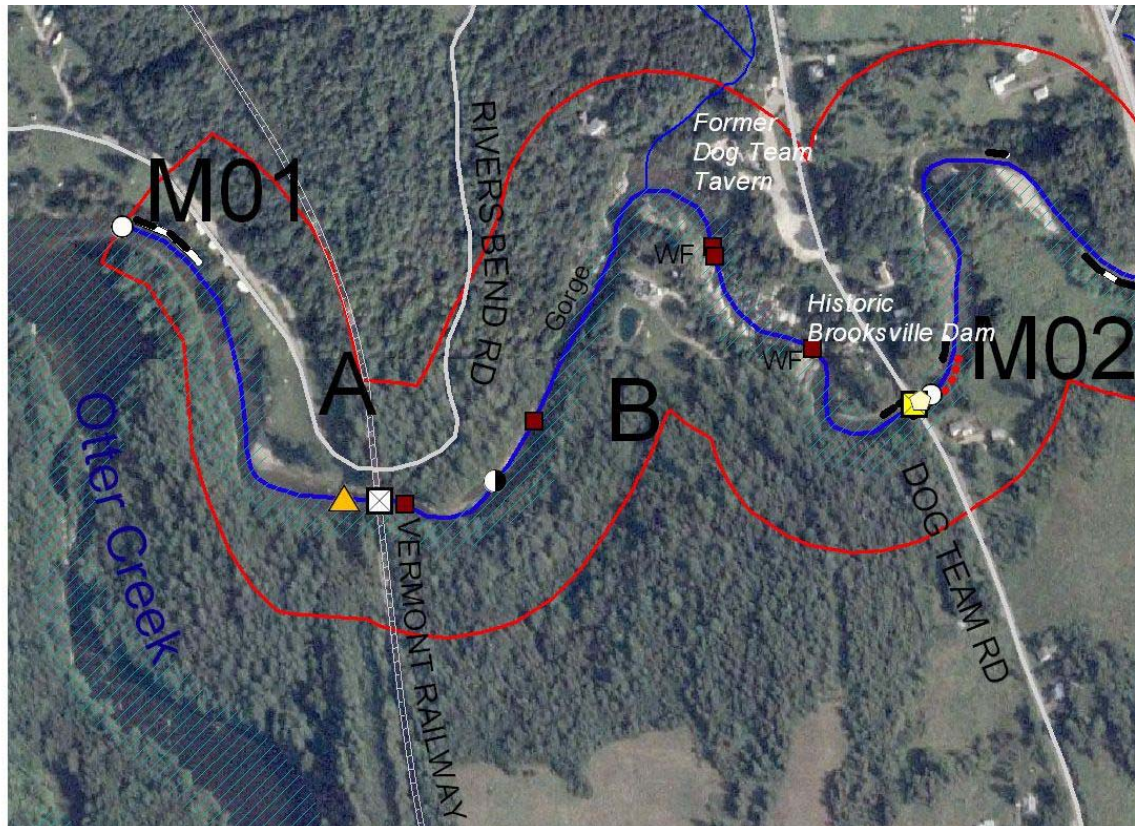


Figure 7. Segmentation and Phase 2 results for reach M01 (flow is from picture right to left). Red line represents Phase 1 corridor (SGAT v.2; SMRC, 2004b). WF = waterfall, as defined in VTANR protocols, 2007.

Segment B

Segment B of reach M01 is a 2,173-foot section of channel where bedrock dominates the channel margins. In the upstream end of the segment, cascade and step/pool bedforms dominate the channel which is flanked by moderately-sloped bedrock banks. The upstream end of this section is marked by a waterfall (at the historic site of mill operations and the Brooksville dam; Figure 8), followed by several shallower bedrock steps and a second waterfall across from the former Dog Team Tavern. In this section, an approximate drop of 13 feet occurs over a length of 450 feet (equivalent to a 3% slope). The channel then turns abruptly to the southwest and enters a short gorge with near-vertical bedrock walls (see Figures 7 and 9). Although submerged bedrock ledge forms the channel bottom in this section, the vertical drop of the channel is not as pronounced as in the upstream section (subcategory "c" slope). While individual sections of Segment B have more pronounced gradient, the overall estimated segment slope is 0.7%.

The corridor surrounding Segment B is dominated by bedrock and cohesive sediments of glacial till and lacustrine origin with an occasional pocket of glaciofluvial sediments (USDA NRCS, 2005; USDA NRCS, 2001; Stewart & MacClintock, 1969; Calkin, no date). The overall valley setting (Narrowly Confined) and the channel gradient (0.7%) of segment M01-B suggest a reference stream type of A1c-step/pool. This segment has been characterized as a "subreach" with a reference stream type different from the remainder of the reach which is classified as a reference Ac-riffle/pool gravel channel. Since this segment was characterized as a "gorge", an RGA and RHA were not completed (by protocols), and a "Low" sensitivity was assigned (page 77 of VTANR protocols, 2007 version).



*Figure 8.
Waterfall at top of bedrock
cascade and step/pool section in
the vicinity of historic Brooksville
dam.
Segment M01-B.*

*(View upstream,
12 September 2007).*



*Figure 9.
Gorge section downstream of
the former Dog Team Tavern.
Segment M01-B.*

*(View upstream,
12 September 2007).*

Segment A

Segment A of reach M01 is approximately 1,580 feet in length and extends from the vicinity of the Vermont Railway crossing downstream to the confluence with the Otter Creek. The river flows through a narrow, bedrock-controlled valley, estimated between 1.3 and 2.3 times bankfull width (dominantly, Narrowly-Confining). A reference stream type of A4c-riffle/pool is inferred from the valley setting and channel features.

The Rivers Bend Campground is located along a terrace of glaciofluvial sediments within the RB corridor (USDA NRCS, 2005; USDA NRCS, 2001). Aerial photographs indicate that this campground was developed between 1962 and 1974; prior to this (1942), the terrace was cleared and possibly in agricultural use. Seasonal development associated with this campground is located within the RB corridor of segment M01-A, including a gate house on a foundation near the right valley wall and campers during the summer months. The campground is accessed from the Dog Team Road via the Rivers Bend Road (gravel). At a few locations the Rivers Bend Road encroaches within the M01-A RB corridor. However, it is above the estimated flood-prone-width elevation; the thalweg height of this road was measured at two locations - 15.7 feet and 19.5 feet. The slight encroachment by Rivers Bend Road does not significantly change the confinement status of the channel (Narrowly Confining).



*Figure 10.
Confluence of New Haven
River with Otter Creek;
sediment deposition is evident
at the confluence, slightly left
of picture center.*

*(View downstream from New
Haven River,
12 September 2007).*

A cross section was completed near the mid-point of Segment A (Figure 11). Measured channel and floodplain dimensions suggest an A4c-riffle/pool stream type, consistent with the reference stream type for the reach. Overall, a riffle/pool bedform was apparent, with two small point bars. A plane-bed form was evident at the upstream extent of the segment where a submerged bedrock "ledge" comprised the channel bed.

Instream habitats were somewhat compromised by the minimal buffer widths along much of the RB. On the other hand, coniferous tree buffers were of ample width along the LB, offering shading, detritus and organic materials to the channel. Large woody debris was reasonably frequent in the segment (LWD = 8). Habitat was rated as "Good" (0.76) following the RHA.



*Figure 11.
Riffle cross section site just
downstream of the Vermont
Railway bridge.*

*(View upstream,
12 September 2007).*

No signs of active channel incision were observed within Segment M01-A. It is likely that bedrock grade controls within the reach and in the nearby Otter Creek have limited vertical and lateral channel adjustments. A high terrace approximately 2 to 2.6 times bankfull height is present along the RB corridor within one bankfull width of the channel. VTANR protocols state that higher terraces “that were active flood plains before historic times [greater than 200 years ago]” should be avoided in the identification of the Recently Abandoned Floodplain for measurement of Incision Ratio in Phase 2 Step 2.5 (page 27 of VTANR protocols, May 2007 version). Protocols suggest avoiding terraces that are greater than 3 times the bankfull height. While this terrace is somewhat lower than 3 times the bankfull height, USDA NRCS mapping suggests that the parent materials for soils comprising this terrace have a glaciofluvial origin (thousands of years before present), rather than a more recent alluvial origin. On the other hand, available surficial geologic mapping (Calkin, no date; Stewart & MacClintock, 1969) suggests that sediments comprising this terrace are bouldery clays of glacio-lacustrine origin. No more detailed (or more recent) surficial geologic mapping was noted for this study area in Vermont Geological Survey records. More intensive surficial geologic mapping and analysis would be required to determine with greater certainty the age of these terrace sediments and the processes which created this terrace; such analysis was beyond the scope of work for this geomorphic study. Thus, best professional judgment was applied to infer that the origin of this terrace was the result of processes occurring greater than 200 years before present. The current degree of vertical separation of the channel bed (thalweg) from the terrace surface is not believed to represent a process of incision occurring within the last 200 years.

The low width/depth ratio (23.2) and minimal streambank erosion indicate very minimal widening in Segment A. Very limited aggradation is apparent; only two minor point bars were observed. No significant changes to the channel planform appear to have occurred in recent decades based on review of historic aerial photographs (back to 1942). Overall, Segment A was rated in “Good” condition (0.83) following the RGA. Despite the presence of lateral and vertical bedrock controls, a “High” sensitivity rating was assigned, following protocols, due to the subclass slope category (“c”) and the dominance of gravel substrates. A channel evolution stage of “I” (F-stage) was assigned.

5.0 STRESSORS, DEPARTURE ANALYSIS AND SENSITIVITY

Phase 1 and Phase 2 stream geomorphic assessments of the New Haven River reaches provide for a better understanding of how human-caused disturbances at the watershed and reach level may have altered or constrained the river's ability to convey the water and sediment inputs to the watershed. Consideration of the current state of channel evolution and reach sensitivity will help to ensure that identified river management strategies and restoration or conservation projects will be successful over the long term.

Within a given reach, the watershed-level and reach-level flow and sediment load modifications, combined with reach-scale modifiers of stream power and boundary resistance, together govern adjustments in the channel dimensions, profile and planform over time. These lateral and vertical adjustments, in turn, influence how the river channel transports its sediment and water inputs.

Channel and watershed disturbances that exceed thresholds for change can upset the dynamic equilibrium of stream systems. Imbalance in the channel affects the sediment transport capacity of the stream system, and has significant consequences for erosion hazards, water quality and riparian habitats. Equilibrium can be disturbed locally and result in channel adjustments that are limited in magnitude and extent (for example, scour at an undersized culvert crossing). Alternately, the disturbance (or an overlapping combination of disturbances) can be of sufficient size, duration, or frequency to cause substantial channel adjustments that result in a system-wide imbalance extending far upstream and downstream through the river network.

Such imbalances, whether localized or systemic, can interfere with the river's ability to efficiently convey its water and sediment loads. These interruptions may be expressed as a sediment transport deficiency where sediment accumulates in the channel (which itself may lead to further imbalances - e.g., flow widens and splits to erode streambanks on either side, or flow may avulse or jump its banks in a flood event). Alternately, the imbalance can be expressed as an increase in sediment transport capacity. For example, a channel that has been straightened, dredged, armored and bermed has a local increase in channel slope and channel entrenchment, which creates higher flow velocities, and an increased power to erode the streambed. If the channel bed is scoured, this condition often leads to further channel adjustments including streambank collapse and widening.

Sediment transport capacity of the channel can be inferred from the geomorphic features observed during field work and from the identified reach-scale and watershed-scale stressors. Even a qualitative understanding of features and fluvial processes can help to identify and prioritize appropriate management strategies for the river that will facilitate a return toward a more balanced (dynamic equilibrium) condition.

5.1 Stressor Identification

Field investigations and limited historical reviews have identified various watershed and channel disturbances that have impacted reaches M01 and M02 of the New Haven River during recent decades, including:

Watershed-scale Modifiers:

- ◆ Historic deforestation and subsequent reforestation from the mid-1800s through the early 1900s;
- ◆ Significant flood events in 1998, 1976, 1938, 1936 and 1927;
- ◆ Upstream erosion and tributary sources of sediment; and

Reach-scale Modifiers:

- ◆ Channelization (straightening) inferred near the VT Route 7 bridge crossing;
- ◆ Berming along the banks (short lengths in M02);
- ◆ Streambank armoring (rip-rap);
- ◆ Floodplain encroachment by roads, railroads, residential development, and agricultural fields;
- ◆ Bridges which constrict channel flows at flood stage (VT Rt 7 and Dog Team Rd);
- ◆ Stormwater runoff from crop fields (one field ditch noted in M02);
- ◆ Minimal or absent forested buffers along portions of the study reaches;

In Table 2 (next page), significant stressors are summarized in terms of how each might be expected to modify stream power within each reach/ segment and/or modify boundary conditions, or the resistance to erosion along the channel margins.

5.2 Departure Analysis and Sensitivity

The uppermost assessed reach (M02) flows through a broad to very broad valley setting (unconfined), and has been minimally constrained by human land use changes or channel and floodplain modifications. This is a natural deposition-dominated reach, positioned immediately upstream of a naturally-confined, bedrock gorge (M01-B). It shows signs of increased sediment deposition in recent years, related to the upstream and in-reach production of sediments, and likely related to the 1998 flood (an estimated 500-year event). Locally, sediment deposition has been enhanced at the Route 7 bridge, a flood-prone-width constrictor. The reach-wide prevalence of depositional bars and active lateral adjustments suggests that sediment transport capacity in reach M02 may have been further reduced by sediment loading from upstream sources.

At present, the channel has reasonable access to a broad floodplain and channel-contiguous wetlands associated with recently-abandoned meander sites (although a minor degree of historic incision persists). A channel evolution stage of IV (F-stage) and a "Very High" sensitivity rating were assigned to reach M02 following guidance presented in the geomorphic assessment protocols (VTANR, 2007). The reach appears to be near the latter stages (stage IV) of a channel evolution process which may have been initiated historically by incision related to past flood events, and/or limited channelization. The "Very High" sensitivity assigned reflects the erodible materials (gravels, silts) in the bed and banks and the high likelihood for further channel adjustments (especially planform adjustment) as the channel responds to future changes in water and sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Fair" – in Major Adjustment); planform adjustment as the dominant adjustment process.

Downstream reach (M01) flows through a Narrowly-confined valley setting; the channel is constrained, both laterally and vertically by bedrock outcroppings in the bed and bank. The higher-gradient segment M01-A is a natural transport-dominated reach. Most of the sediment and debris supplied to this segment from the upstream watershed is likely conveyed through to M01-A and the Otter Creek; there is minimal opportunity for flow and sediment attenuation. The "Low" sensitivity assigned to this segment (by protocol) reflects the stability offered by the underlying bedrock and suggests minimal likelihood for vertical and lateral adjustments. This is a segment considered "In regime" (VTANR protocols, 2007).

Similarly, segment M01-A is in a Narrowly-confined valley setting. Lateral adjustments of the channel are naturally constrained by bedrock along the left bank and an elevated post-glacial terrace along the right bank followed by a bedrock-controlled valley wall within one bankfull width. Potential vertical adjustments would be moderated by bedrock ledge exposed at the upstream end of the segment and within the Otter Creek just downstream of the New Haven River confluence.

Table 2. River Stressor Identification Table (Reach Level)

Reach / Segment	Watershed-Scale Stressors		Reach-Scale Stressors			
	Hydrologic	Sediment Load	Stream Power		Boundary Resistance	
M02	I Flood of 1998	I Flood of 1998	I Slope	Straightening (limited, VT Rt 7 bridge crossing)		I Bank Armoring (some)
	I Deforestation (1800s)	I Deforestation (1800s)	I Depth	Berms (limited in extent, left bank)		D Bank (Limited) Removal of woody vegetation related to agricultural fields and residential use.
		I Upstream erosion & tributary sources	D Slope	Route 7 bridge is FPW constrictor; mid-channel bar / island - localized impact.		
	D Reforestation (1900s)	D Reforestation (1900s)	D Slope	Moderate constriction at downstream end of reach as channel transitions from Very Broad to Narrowly-Confined (bedrock-controlled).		
M01-B	I Flood of 1998	I Flood of 1998	D Slope	Dog Team Road bridge is FPW constrictor; absence of significant upstream deposition suggests impact is minor.		I Bed Bedrock outcroppings (waterfalls, ledge, gorge)
	I Deforestation (1800s)	I Deforestation (1800s)				I Bank Bedrock outcroppings (waterfalls, ledge, gorge)
		I Upstream erosion & tributary sources				D Bank Removal of woody buffers related to road crossings and residential/commercial development.
	D Reforestation (1900s)	D Reforestation (1900s)				
M01-A	I Flood of 1998	I Flood of 1998				I Bank Armoring (some, RB)
	I Deforestation (1800s)	I Deforestation (1800s)				D Bank Reduction of woody buffers related to campground, RB.
		I Upstream erosion & tributary sources				I Bank Bedrock outcroppings (left bank)
	D Reforestation (1900s)	D Reforestation (1900s)				I Bed Bedrock outcroppings (ledge)

Abbreviations:

I = Increase; D = Decrease

Notes:

Text in blue denotes a natural stressor or modifier. Text in black indicates a human-caused modification.

M01-A is a natural transport-dominated segment with limited opportunity for sediment and flow attenuation. Sediments and LWD supplied from the upstream watershed appear to be conveyed through the segment to the Otter Creek; a small tributary confluence bar was noted. The observed stream type (entrenchment ratio, channel dimensions, slope) was consistent with reference, or expected, stream type for the valley setting. A channel evolution stage of I (F-stage model) was assigned. The "High" sensitivity assigned to M01-A reflects the erodible materials (gravel-dominated) in the bed and the potential (though limited in extent) for vertical channel adjustments in response to future changes in water and/or sediment loading. This sensitivity rating also reflects the current geomorphic condition of the reach ("Good" – minimal adjustment); a Very High or Extreme sensitivity would have been assigned if the segment were exhibiting major adjustments or a departure from reference condition.

At present, enhanced erosive energies within this segment appear to be balanced by the resisting forces of the channel margins (e.g., bedrock along the left bank and occasional single-line tree buffers and armoring along the right bank). Still, Segment M01-A remains highly susceptible to channel adjustments and associated fluvial erosion losses in future flood events, given its naturally-entrenched status and erodible streambank sediments (along RB). Tree buffers should be preserved and enhanced, where possible, to maintain streambank stability and minimize erosion.

6.0 PRELIMINARY PROJECT IDENTIFICATION

Landowners, New Haven community members, and resource agencies, including the Addison County Regional Planning Commission, the Natural Resources Conservation Service, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies for the river corridor. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities.

The preliminary identification and prioritization of corridor restoration and protection projects and practices outlined below has been informed by:

- stream sensitivity data (Table 1 and Sections 4.1 and 4.2);
- qualitative observations of sediment transport and attenuation characteristics (summarized for each reach in Sections 4.1 and 4.2); and
- preliminary departure analysis contained in Sections 4.1 and 4.2.

This provisional listing follows the outline of management actions identified in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects* included in VTANR guidance (11 July 2007 draft). Per VTANR guidance, the listed approaches can be classified under three broad management approaches:

Active Geomorphic: Restore or manage rivers to a geomorphic state of dynamic equilibrium through an **active** approach that may include the removal or reduction of human-placed constraints or the construction of meanders, floodplains, and bank stabilization techniques. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic: Allow rivers to return to a state of dynamic equilibrium through a **passive** approach that involves the removal of constraints from a river corridor thereby allowing the river, utilizing its own energy and watershed inputs to re-establish its meanders, floodplains, and self maintaining equilibrium condition over an extended time period. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Active-Passive Combination: Use a sequenced combination of active and passive approaches to accommodate the varying constraints that typically occur along a project reach.
(VTANR, 2007; 1 June draft)

The work scope for this Phase 2 Assessment has not included public outreach or analysis to determine the technical, financial and social feasibility and relative priorities of these listed project opportunities. Instead, this listing will form the basis for future project development and implementation efforts in the context of watershed, community, and corridor planning projects. A few of these projects (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects, and will require only minimal feasibility analysis and project development activities. Other identified projects may require further evaluation and efforts to conduct alternatives analyses, conduct landowner outreach and negotiations, and identify potential stakeholders and funding sources.

Watershed stakeholders which may look to this data for guidance include (but are not necessarily limited to):

- landowners,
- town of New Haven,
- VT Department of Environmental Conservation, Water Quality Division –
 - River Management Section and
 - Wetlands Section,
- Vermont Agency of Agriculture,
- Vermont Department of Transportation,
- Vermont Land Trust,
- Vermont River Conservancy,
- Northern Vermont Resource Conservation and Development Council (Better Back Roads),
- US Fish and Wildlife, and
- US Department of Agriculture, Natural Resources Conservation Service.

6.1 Protecting River Corridors

Protection of river corridors is an essential element to all passive and active geomorphic restoration and conservation projects. River corridor protection can support multiple objectives:

- **Dynamic Equilibrium** - Preserve (or support a return to) reference sinuosity, slope, and channel dimensions through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.
- **Floodplain Access** – Preserve or restore a channel’s access to its surrounding floodplain in bankfull and higher flow events through active or passive geomorphic approaches. Refrain from future channel management, such as channelization, dredging, berming, armoring.
- **Sediment Attenuation** – Preserve, restore, or enhance the storage of sediments (from in-reach or upstream sources) within the channel margins, floodplain, and channel-contiguous wetlands.
- **Flow Attenuation** – Preserve, restore, or enhance the storage and detainment of flood flows through overbank flooding, increased channel length (sinuosity), increased channel roughness (e.g., buffers), and inundation of channel-contiguous wetlands.
- **Avoidance** – Refrain from developments and infrastructure in the corridor to minimize future fluvial erosion losses.

Under a passive geomorphic approach, the river channel is allowed to freely meander within the area defined as the belt-width-derived river corridor. For a reach that is already close to reference condition

or exhibiting only minor adjustments, preserving a river corridor will ensure the river's ability to continue to meander through the valley unconstrained by human infrastructure. In turn, human investments in the landscape will be protected from future channel adjustments. For a reach that has seen significant channel management in the past, and has lost some degree of floodplain connection and some measure of its sinuosity and balanced planform and profile, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access (where access has been lost) and adjust channel dimensions for optimum conveyance of its water and sediment loads. Restoring channel equilibrium will reduce instream production of sediment and nutrients and enhance sediment and nutrient attenuation over the long term.

Under an active geomorphic approach, protection of the river corridor will prevent future channel management that might unravel constructed features of a recently restored reach.

Higher-priority reaches/segments – **M02**

Higher-priority reaches for river corridor protection include "highly sensitive reaches critical for flow and sediment attenuation from upstream sources or sensitive reaches where there is a major departure from equilibrium conditions and threats from encroachment (11 July 2007, VTANR guidance)". Limited term or permanent corridor easements are possible mechanisms for corridor protection, with the willingness of landowners.

Very High sensitivity reach M02 is identified in this category based on the following rationale:

- ◆ Sediment attenuation areas - preservation and enhancement.
This reach has reasonable access to the surrounding floodplain ($IR_{RAF} = 1.18$), including channel-contiguous wetlands in abandoned meander sites. The channel is relatively free to adjust its planform, local gradient, and channel dimensions as it responds to increased sediment loading from upstream reaches. The reach appears to be serving an important flow and sediment (and possibly nutrient) attenuation role in the watershed. It is strategically located downstream of reaches where streambank erosion and lateral adjustments are leading to sediment loading (e.g., reaches M03 through M11 and upstream reaches along the Bristol Flats).
- ◆ Protection Upstream of Constrained Reaches
Reach M02 is located immediately upstream of a reach (M01) that is naturally constrained by the topographic setting and bedrock outcrops, unable to adjust its dimensions, planform, and profile in response to excess sediment and water loads delivered from upstream. Reach M02 is therefore a critical reach for preserving and enhancing sediment and flow attenuation functions to reduce sediment (and potential nutrient) loading to the Otter Creek and Lake Champlain.
- ◆ Fluvial Erosion Hazard protection
At present, land uses adjacent to reach M02 do not involve many buildings or other human infrastructure in conflict with channel adjustment processes. This condition represents an opportunity to protect the floodplain access, sediment and flow attenuation properties of the reach and refrain from developments within the corridor to avoid erosion losses in future flood events.

Lower-priority reaches/segments – **M01-B, M01-A**

Lower-priority reaches for river corridor protection include "wooded corridors experiencing very little threat from encroachment and less sensitive reaches not playing a significant flow or sediment load attenuation role in the watershed (11 July 2007, VTANR guidance)".

Low-sensitivity bedrock subreach, **M01-B**, adjacent to the former Dog Team Tavern site is afforded stability by the underlying bedrock, and has reasonably well-developed forested buffers along much of its length. The few residential and commercial encroachments within the segment corridor appear to be

founded on bedrock and would therefore be at reduced risk from sudden streambank erosion during a flood (as compared to development founded on unconsolidated sediments). However, refraining from infrastructure in this segment corridor is still advised to protect against risk of inundation (rising water) losses during a flood.

Segment **M01-A** has been assigned a "High" sensitivity by virtue of its gradient and the gravel sediment sizes dominating the bed. However, bedrock-controlled close valley walls confine the channel and bedrock outcrops provide lateral and vertical grade controls within the reach; thus, the potential for future channel adjustments is moderated. This segment has had much the same planform on aerial photographs dating back to 1942. The left-bank corridor has very wide, forested buffers with minimal encroachments (railroad). Along the right bank is a seasonal campground with minimal width buffers. This segment is in a narrowly-confined setting with very limited opportunities for flow or sediment attenuation. As such, the priority for river corridor protection would be lower than that of M02. There is some potential for erosion hazards (during high-magnitude floods) along the right-bank corridor consisting of a glacio-fluvial terrace developed with a seasonal campground. It would be prudent to limit future, more-permanent development along this terrace to avoid fluvial erosion hazards.

6.2 Planting Stream Buffers

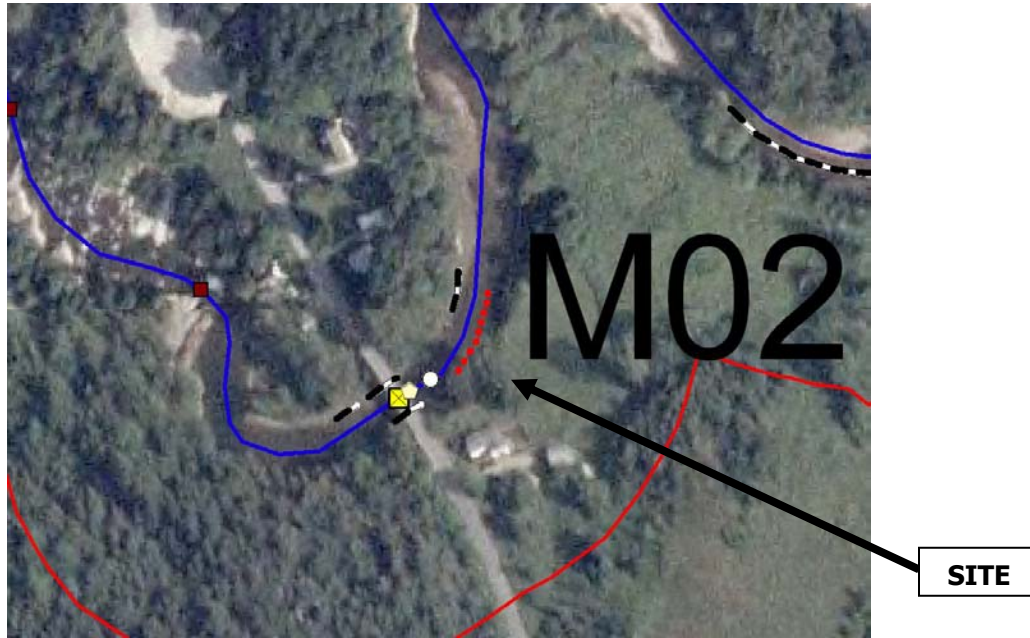
Forested riparian buffers serve to improve water quality and contribute to greater flow and sediment attenuation in the floodplain. They will also help to restore and maintain dynamic equilibrium of the channel by increasing resistance to boundary shear stresses along the channel margins. Tree buffers will provide the additional benefits of organic matter, detritus, and LWD recruitment for aquatic and riparian habitats, as well as increased shading to reduce river temperatures. Connectivity of buffer areas from reach to reach along a river network is also supportive of mammalian terrestrial habitats by providing wildlife corridors. Of the segments assessed in this project, M01-A (right-bank) and M02 would benefit most from buffer plantings.

6.3 Stabilizing Stream Banks

Streambank stabilization can be considered in "laterally unstable [but vertically stable] reaches where human-placed structures are at high risk and not taking action may result in increased risk of erosion, to not only the structure, but lands that would provide the opportunity to establish a buffer (11 July 2007 draft VTANR guidance)".

Any bank stabilization project should be considered in the broader context (both in time and space) for the channel adjustment processes such management will set in motion and for the consequences to upstream and downstream reaches. Bank stabilization projects should not be considered in highly aggradational reaches where progressive lateral adjustments, driven by sediment deposition, would be expected to increase the risk of revetment failure.

One possible bank stabilization project has been identified for further feasibility assessment along reach M02 at the downstream-most end of the reach along the left bank (see Figures 12 and 13). Landowners at this location have previously contacted the ACRPC with concern for erosion along their bank.



LEGEND

- | | | |
|---|----------------------------|---------------------|
| Cross Section Site | Reach Break | Streambank Erosion |
| Crossing Structure
BKFL Constrictor (red);
FPW Constrictor (orange) | Segment Break | Streambank Armoring |
| Phase 1 Corridor | Surface Waters (VHD, 1995) | Debris Jam |
| Wetlands (NWI) | Beaver Dam | Grade Control |

Figure 12. Location of LB erosion adjacent to residence just upstream of Dog Team Road bridge crossing at the reach break between M02 and M01.



Figure 13. Site of LB erosion upstream of Dog Team Road bridge, reaches M01 and M02. (View upstream from the bridge, 10 December 2007).

The LB is at the outside of a meander bend on approach to the Dog Team Road bridge, and streambank erosion along this bank in recent years has progressed to the southeast. The top of this undercut bank is located within 90 feet of a residence. Erosion could progress downstream to outflank the LB pier and the LB stone-filled spill-through embankment of the Dog Team Road bridge (see Figure 14).



Figure 14. Site of LB erosion upstream of Dog Team Road bridge, reaches M01 and M02. (View downstream to the bridge, 12 September 2007).

There would appear to be room for establishment of a minimal-width forested buffer between the streambank and the residence at this site, if the bank could be stabilized through some combination of toe armoring or revetments combined with bioengineering along the upper two-thirds of the bank.

Until sediment sources upstream of this site and reach M02 can be addressed, bank stabilization is considered a lower priority (from a reach and watershed perspective, following the guidance contained in the *Step-Wise Procedure for Identifying Technically Feasible River Corridor Restoration and Protection Projects*, VTANR, 11 July 2007). Success of a possible bank stabilization project at this location would be increased if corridor protection and restoration measures undertaken in upstream reaches enhanced sediment attenuation and reduced sediment mobilization to this location.

Any plans for streambank stabilization at this site should be considered for compatibility with design plans for rehabilitation or replacement of the Dog Team Road bridge. This bridge was constructed in 1927 and has been identified by the town of New Haven as a high-priority bridge in need of rehabilitation or replacement.

6.4 Arresting Head Cuts and Nick Points

No head cut / nick point sites or actively incising sections were identified in reaches M01 or M02 during September 2007 assessments.

6.5 Removing Berms / Other Constraints to Flood & Sediment Load Attenuation

Removing berms or other constraints to the full meander expression and floodplain connection of a river channel may accelerate a return to dynamic equilibrium in the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor. Further study is necessary to evaluate the feasibility of various active geomorphic and engineering techniques. The benefits of such projects would need to be evaluated in light of the costs and potential short-term consequences in terms of sediment and nutrient mobilization, and risk to infrastructure and public safety. Ideally, removal of berms or other channel constraints would be accompanied by corridor protection measures.

Only two short berms were identified during September 2007 assessments – both in reach M02. One length of boulders was noted at approximately floodprone width elevation (local $IR_{HEF} = 1.5$) along the LB corridor of reach M02. This line of boulders appeared to represent a line of protection along a former channel position at the edge of a cultivated field currently in corn. Lateral channel adjustments in recent years have now resulted in a channel position that is approximately one bankfull width to the north of this former berm. The line of boulders represents a minor constraint for the current channel. As such, removal of this berm does not appear warranted or worth the likely cost associated with removal, at this time.

A second minor berm was noted in reach M02 along the armored LB immediately downstream of the VT Route 7 bridge. This is a relatively short berm, coincident with the estimated position of the valley wall. Thus, berm removal would not result in significantly increased floodplain access at this location, and is therefore not identified as a high-priority active restoration project for the reach.

6.6 Removing / Replacing Structures

Human-placed structures which span and “constrain the vertical and lateral movement of the channel and/or result in a significant constriction of the floodplain” can be considered for removal or replacement to support dynamic equilibrium of the channel (11 July 2007 draft VTANR guidance”).

Two road bridges and one railroad bridge were encountered spanning the study reaches. The road bridge crossings were estimated as constrictors of the flood prone width. The railroad crossing is elevated high above the channel, well above the flood-prone-width elevation. Additional bridge and culvert assessment data are provided in Appendix B. These data can be utilized by VTrans, and by the New Haven road crews and Addison County Regional Planning Commissions when establishing schedules and budgets for crossing rehabilitation and replacement.

At the next opportunity for bridge rehabilitation or replacement (or if new road or driveway crossings are being considered in these reaches), the geomorphic context should be considered in crossing design.

- New or replacement bridges should ideally have openings which pass the bankfull width to flood-prone-width without constriction.
- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.
- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures.

6.7 Restoring Incised Reaches

Further study could evaluate the feasibility of various active geomorphic and engineering techniques to restore incising reaches which could accelerate a return to dynamic equilibrium of the channel, and reduce impacts to downstream segments, by creating more opportunities for sediment and flow attenuation along the corridor.

Neither reach M01 nor reach M02 was identified as an actively incising reach.

6.8 Restoring Aggraded Reaches

Further study is sometimes warranted to evaluate the feasibility of various active geomorphic and engineering techniques to restore aggraded reaches which could accelerate a return to dynamic equilibrium of the channel, by restoring equilibrium of sediment transport processes.

Neither reach M01 nor reach M02 was identified as an aggraded reach to the degree that has resulted in widespread braiding or a stream type departure. The moderate aggradation in reach M02 can be addressed through passive restoration techniques in the context of river corridor protection (Section 6.1 above). The channel in this reach is reasonably free to adjust its planform, dimensions and profile in response to changes in sediment and water loading. Active restoration of the moderately-aggraded conditions in reach M02 is not recommended at this time, because upstream (watershed-scale) sediment loading is thought to be the dominant stressor governing adjustment processes in this reach. Until such watershed-scale sediment loading can be addressed, an active geomorphic restoration project in reach M02 would be at high risk of failure.

6.9 Other Related Projects

6.9.1 Controlling Sources of Sediment

Addressing upstream sources of sediment to reach M02 would be important in the long-term objectives of restoring equilibrium and reducing sediment and nutrient mobilization to the Otter Creek and Lake Champlain. Select upstream reaches have been assessed (SMRC, 2004a) and a subset of the reaches (M06 – M11) have been addressed in a New Haven River corridor protection plan completed in November 2007 (SMRC, 2007). This corridor plan identified various channel and watershed restoration and conservation projects that will serve to reduce streambank erosion and sediment mobilization over the long term. Corridor planning recommendations are being implemented on an ongoing basis, subject to available funding and contingent upon landowner willingness.

Expanding the scope of corridor planning to reaches M02 through M05 could further reduce sources of sediment to reach M02.

6.9.2 Protection and Restoration of Channel-Contiguous Wetlands

Flow and sediment attenuation can be enhanced along reach M02 through the protection and rehabilitation of channel-contiguous wetlands. At present, the channel appears to have reasonable access to abandoned meanders (from post 1995 and post-1962 neck cut-off sites). It would be important to preserve these areas and refrain from filling or otherwise constraining channel connection to these areas.

7.0 RECOMMENDATIONS

7.1 Corridor Planning Project

Corridor planning projects should be undertaken in reach M02 to identify landowner-approved and conservation and restoration projects that will protect the river corridor and generally support the restoration or preservation of dynamic equilibrium. Public and private benefits associated with dynamic equilibrium of the river include reduced fluvial erosion hazards, and improved water quality and instream and riparian habitats. For increased efficiency and effectiveness, the scope of such a corridor planning project should be increased to include upstream reaches M03 through M05.

A corridor planning project in reaches M05 through M02 should be considered a high priority, since residential and commercial development is sparse along these river sections at this time. This condition offers a strategic opportunity for corridor protection that will help landowners and the town of New Haven to avoid erosion hazards in the future.

Corridor planning efforts would involve a combination of site-level conservation and restoration projects as well as town-and watershed-scale planning approaches. A variety of technical and financial resources are available to assist landowners and the town of New Haven with project development and planning initiatives. In reach M02, a majority of corridor lands are in agricultural use. Resources are currently available through the VT Agency of Agriculture (e.g., Conservation Reserve Enhancement Program, Best Management Practices cost-share program) and the USDA Natural Resources Conservation Service (e.g., Agricultural Management Assistance, Conservation Reserve Program, Environmental Quality Incentives Program).

Phase 2 geomorphic assessment data can be used to define a Fluvial Erosion Hazard corridor overlay district for consideration in town zoning regulations. Currently, funding and technical resources are available to New Haven for such planning processes through the Governor's Clean and Clear Action program.

7.2 Buffer Restoration

With landowner approval, buffer plantings should be implemented in reaches M01-A and M02 to preserve and support a return to dynamic equilibrium conditions, reduce erosion, and improve water quality and riparian habitats. Technical and financial resources are currently available from various regional, state and federal agencies for buffer plantings. In addition to the agricultural resource agencies of and programs listed under Section 7.1 for lands in agricultural use, the following agencies / programs can provide resources to landowners and towns for buffer plantings.

- Vermont Department of Environmental Conservation (Vermont Watershed Grant Program, Nonpoint Source Management Grant [Section 319] Program, River Corridor Grant Program)
- USDA Natural Resources Conservation Service (Wildlife Habitat Incentives Program)
- US Fish & Wildlife (Partners Program)

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APPENDIX A

Phase 1 and 2 Stream Geomorphic Assessment Reach Summary Reports

New Haven River

Phase 1 - Reach Summary Report

Basin: **Otter, Little Otter, Lewis**
 Stream Name: **New Haven River** Reach **M02**
 Topo Maps: **312**
 Date Last Edited: **Mon, January 07, 2008**
 Watershed: **Otter Creek**
 Sub-watershed: **New Haven River**
 Is Reach an Impoundment? **No** Quality Control Status: **Unknown**

Step 1. Reach Location

1.1 Reach Description: **From 2000 ft west of River Road bridge crossing (just downstream of New Haven**
 1.2 Towns: **New Haven**
 1.3 Downstream Latitude: **44.06**
 1.3 Downstream Longitude: **-73.17**

Step 2. Stream Type

2.1 Elevation Upstream: **249**
 2.1 Elevation Downstream: **238**
 2.1 Is Gradient Gentle? **No**
 2.2 Valley Length: **5150 feet. 0.98 Miles.**
 2.3 Valley Slope: **0.21 %**
 2.4 Channel Length: **5994 feet. Miles.**
 2.5 Channel Slope: **0.18 %**
 2.6 Sinuosity: **1.16**
 2.7 Watershed Area: **116 Square Miles**
 2.8 Channel Width: **106 feet.**
 2.9 Valley Width: **820 feet.**
 2.10 Confinement Ratio: **8**
 2.10 Confinement Type: **Broad**
 2.11 Reference Stream Type: **C**
 Bedform: **Riffle-Pool**
 Sub-class Slope: **None**
 Bed Material: **Gravel**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
 3.2 Grade Control: **None**
 3.3 Dominant Geologic Mat.: **Alluvial 53.7 %**
 3.3 Sub-dominant Geological Mat.: **Glacial**
 3.4 Left Valley Side **Steep**
 3.4 Right Valley Side **Very Steep**
 3.5 Soils
 Hydrologic Group: **D 36.6 %**
 Flooding: **Frequent 45.5 %**
 Water Table Deep: **3.0 41.0 %**
 Water Table Shallow: **1.0 28.3 %**
 Erodibility: **High - 29.4 %**

7.4 Comments:

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover:
 Current Dominant land Cover: **Forest 76.7 %**
 Current Sub-Dominant Land Cover: **Field**

4.2 Corridor

Historic Land Cover:
 Current Dominant land Cover: **Forest 29.5 %**
 Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer Left Bank Right Bank
 Dominant: **51-100 >100**
 Sub-dominant: **>100 51-100**
 Length w/ less than 25 ft.: **661 442**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old):

Type: **None**
 Use:

5.2 Bridges and Culverts: **1 4 %**

5.3 Bank Armoring: **700.0 6 %**
 Left **429** Right **344**

5.4 Channel Straightening: **882 14 %**

5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **483 ft. 8 %**
 One Side Both Sides
 Road: **0.0 ft. 0.0 ft.**
 Railroad: **0.0 ft. 0.0 ft.**
 Berm: **252 ft. 0.0 ft.**
 Improved Path: **0.0 ft. 0.0 ft.**

6.2 Development: **483 ft. 193 ft.**

6.3 Channel Bars: **Multiple**
 6.4 Meander Migration: **Multiple**

6.5 Meander Width: **167.0 Ratio: 1.6**

6.6 Wavelength: **668.0 Ratio: 6.3**

Step 7. Windshield Survey

7.2 Bank Erosion: **1,466.72 ft.**

7.2 Bank Height: **5.00 ft.**

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

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1	2	1	0	0	1	1	0	0	1	2	2	2	1	2	1	17
Low	High	Low	N.S.	N.S.	Low	Low	N.S.	N.S.	Low	High	High	High	Low	High	Low	

Project: **New Haven River**
 Stream: **New Haven River**
 Organization: **Addison County RPC**
 Segment Length (ft): **1,580**

January 8, 2008 SGAT Version: 4.56

Phase 2 Segment Summary page 1 of 2

Reach # **M01** Segment: **A** Completion Date: **September 12, 2007**
 Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: Rain: **Yes**
 Segment Location: **From just upstream of VT Railway crossing downstream to confluence with Otter Creek.**

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation	Grade Controls	
1.2 Alluvial Fan	None	
1.3 Corridor Encroachments		
	<u>Length (ft)</u>	<u>One</u> <u>Both</u>
Berms	0	0
height	0	0
Roads	1,554	0
height	16	0
Railroads	855	0
height	75	0
Improved Paths	0	0
height	0	0
Development	47	88
1.4 Adjacent Side	<u>Left</u>	<u>Right</u>
Hillside Slope	Extremely	Very Steep
Continuous w/	Always	Sometimes
W/in 1 Bankfill	Always	Sometimes
Texture	Bedrock	Not Evalua
1.5 Valley Features		
Valley Width (ft)	155	
Width Determination	Measured	
Confinement Type	Narrowly	
Rock Gorge?	No	

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width	107
2.2 Max Depth (ft)	6.30
2.3 Mean Depth (ft)	4.60
2.4 Floodprone Width (ft)	115

Notes:

Valley width (measured) varies from approximately 92 to 233 feet. Confinement is dominantly Narrowly-Confined, but there are brief sections of Semi-confined. The River Bend Road passes within the RB corridor near the railroad crossing and constitutes a

Provisional Step 2. (Contued)

2.5 Aband. Floodpln	6.30	ft.
Human Elev Floodpln	0.00	ft.
2.6 Width/Depth Ratio	23.24	
2.7 Entrenchment Ratio	1.08	
2.8 Incision Ratio	1.00	
Human Elevated Inc Rat	0.00	
2.9 Sinuosity	Low	
2.10 Riffles Type	Complete	
2.11 Riffle/Step Spacing (ft)	600	
2.12 Substrate Composition		
Bedrock	2%	
Boulder	10%	
Cobble	24%	
Coarse Gravel	21%	
Fine Gravel	27%	
Sand	15%	
Silt and smaller	1%	
Silt/Clay Present?	No	
Detritus	5 %	
# Large Woody	8	
2.13 Average Largest Particle on		
Bed	344.0	mm
Bar	23.0	mm
2.14 Stream Type		
Stream Type:	A	
Bed Material:	Gravel	
Subclass Slope:	c	
Bed Form:	Riffle-Pool	
Field Measured Slope:		
2.15 Reference Stream Type		
(if different from Phase 1)		
3.3 old	<u>Amount</u>	<u>Mean Height</u>
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks		
Typical Bank Slope	Steep	
Bank Texture	<u>Left</u>	<u>Right</u>
Upper		
Material Type	Bedrock	Mix
Consistency	Cohesive	Cohesive
Lower		
Material Type	Bedrock	Mix
Consistency	Cohesive	Cohesive
Bank Erosion	<u>Left</u>	<u>Right</u>
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	42	246
Near Bank Veg. Type	<u>Left</u>	<u>Right</u>
Dominant	Coniferous	Deciduous
Sub-dominant	None	Herbaceous
Bank Canopy	<u>Left</u>	<u>Right</u>
Canopy %	76-100	1-25
Mid-Channel Canopy	Open	
3.2 Riparian Buffer		
Buffer Width	<u>Left</u>	<u>Right</u>
Dominant	>100	0-25
Sub-dominant	None	26-50
W less than 25	59	1,224
Buffer Veg. Type	<u>Left</u>	<u>Right</u>
Dominant	Coniferous	Deciduous
Sub-dominant	None	Herbaceous
3.3 Riparian Corridor		
Corridor Land	<u>Left</u>	<u>Right</u>
Dominant	Forest Shrubs/Saplin	
Sub-dominant	None	Residential
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

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

Step 5. Channel Bed and Planform Changes

5.1 Bar Types			
	<u>Mid</u>	<u>Point</u>	<u>Side</u>
	0	2	0
	<u>Diagonal</u>	<u>Delta</u>	<u>Island</u>
	0	0	0
5.2 Other Features			<u>Braiding</u>
Flood	0	<u>Neck Cutoff</u>	<u>Avulsion</u>
	0	0	0

5.3 Steep Riffles and Head Cuts			
Steep Riffles	0	<u>Head Cuts</u>	<u>Trib Rejuv.</u>
	0	0	No
5.4 Stream Ford or Animal	No		
5.5 Straightening	None		
Straightening Length:	0		
5.5 Dredging	None		

Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.

Project: **New Haven River**
 Stream: **New Haven River**
 Organization: **Addison County RPC**
 Segment Length (ft): **2,173**

January 8, 2008 SGAT Version: 4.56

Phase 2 Segment Summary page 1 of 2

Reach # **M01** Segment: **B** Completion Date: **September 12, 2007**
 Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: **bedrock gorge** Rain: **Yes**
 Segment Location: **From Dog Team Rd bridge crossing downstream nearly to Vermont Railway crossing.**

QC Status - Staff: Provisional Cons			
Step 1. Valley and Floodplain			
1.1 Segmentation Grade Controls			
1.2 Alluvial Fan	None		
1.3 Corridor Encroachments			
	<u>Length (ft)</u>	<u>One</u>	<u>Both</u>
	Berms	0	0
	height	0	0
	Roads	435	1,100
	height	16	25
	Railroads	0	0
	height	0	0
	Improved Paths	0	0
	height	0	0
	Development	370	289
1.4 Adjacent Side	<u>Left</u>	<u>Right</u>	
	Hillside Slope	Very Steep	Very Steep
	Continuous w/	Sometimes	Sometimes
	W/in 1 Bankfill	Always	Sometimes
	Texture	Bedrock	Bedrock
1.5 Valley Features			
	Valley Width (ft)	150	
	Width Determination	Estimated	
	Confinement Type	Narrowly	
	Rock Gorge?	Yes	
Human-caused Change?	No		
Step 2. Stream Channel			
2.1 Bankfull Width	0		
2.2 Max Depth (ft)	0.00		
2.3 Mean Depth (ft)	0.00		
2.4 Floodprone Width (ft)	0		

Notes:
 Segment is a subreach of alternate stream type - a bedrock-controlled channel and gorge. Driveway is present within LB corridor; Dog Team Rd is present within RB corridor. However, both are elevated well above FPW. Therefore, no significant human

Provisional Step 2. (Contued)			
2.5 Aband. Floodpln		0.00	ft.
Human Elev Floodpln		0.00	ft.
2.6 Width/Depth Ratio		0.00	
2.7 Entrenchment Ratio		0.00	
2.8 Incision Ratio		0.00	
Human Elevated Inc Rat		0.00	
2.9 Sinuosity		Low	
2.10 Riffles Type		Not Applicable	
2.11 Riffle/Step Spacing (ft)		0	
2.12 Substrate Composition			
Silt/Clay Present?		No	
Detritus		2 %	
# Large Woody		11	
2.13 Average Largest Particle on			
Bed		0.0	
Bar		N/A	
Not Evaluated			
2.14 Stream Type			
Stream Type:	A		
Bed Material:	Bedrock		
Subclass Slope:	c		
Bed Form:	Step-Pool		
Field Measured Slope:			
2.15 Reference Stream Type			
(if different from Phase 1)			
A	1	c	Step-Pool
<u>3.3 old</u>	<u>Amount</u>	<u>Mean Height</u>	
Failures	None	0.00	
Gullies	None	0.00	

Step 3. Riparian Features			
3.1 Stream Banks			
Typical Bank Slope	Steep		
Bank Texture	<u>Left</u>	<u>Right</u>	
Upper			
Material Type	Bedrock	Bedrock	
Consistency	Cohesive	Cohesive	
Lower			
Material Type	Bedrock	Bedrock	
Consistency	Cohesive	Cohesive	
Bank Erosion	<u>Left</u>	<u>Right</u>	
Erosion Length (ft)	0	0	
Erosion Height (ft)	0.00	0.00	
Revetmt. Type	Rip-Rap	Multiple	
Revetmt. Length (ft)	43	85	
Near Bank Veg. Type	<u>Left</u>	<u>Right</u>	
Dominant	Coniferous	Shrubs/Saplin	
Sub-dominant	Deciduous	Coniferous	
Bank Canopy	<u>Left</u>	<u>Right</u>	
Canopy %	76-100	26-50	
Mid-Channel Canopy		Open	
3.2 Riparian Buffer			
Buffer Width	<u>Left</u>	<u>Right</u>	
Dominant	>100	51-100	
Sub-dominant	51-100	>100	
W less than 25	111	169	
Buffer Veg. Type	<u>Left</u>	<u>Right</u>	
Dominant	Coniferous	Deciduous	
Sub-dominant	Deciduous	Coniferous	
3.3 Riparian Corridor			
Corridor Land	<u>Left</u>	<u>Right</u>	
Dominant	Forest	Forest	
Sub-dominant	Residential	Residential	
Mass Failures	0	0	
Height	0	0	
Gullies	0	0	
Height	0	0	

Step 4. Flow & Flow Modifiers			
4.1 Springs / Seeps	Minimal		
4.2 Adjacent Wetlands	None		
4.3 Flow Status	Moderate		
4.4 # of Debris Jams	1		
4.5 Flow Regulation Type	None		
Flow Regulation Use			
Impoundments			
Impoundmt. Location			
4.6 Up/Down strm flow reg	None		
(old) Upstrm Flow Reg			
4.7 StormwaterInputs			
Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0
4.9 # of Beaver Dams	0		
Affected Length (ft)	0		
Step 5. Channel Bed and Planform Changes			
5.1 Bar Types			
	<u>Mid</u>	<u>Point</u>	<u>Side</u>
	0	1	0
	<u>Diagonal</u>	<u>Delta</u>	<u>Island</u>
	0	0	0
5.2 Other Features			
			<u>Braiding</u>
Flood	<u>Neck Cutoff</u>	<u>Avulsion</u>	0
0	0	0	
5.3 Steep Riffles and Head Cuts			
<u>Steep Riffles</u>	<u>Head Cuts</u>	<u>Trib Rejuv.</u>	
0	0	No	
5.4 Stream Ford or Animal			
None			
5.5 Straightening			
None			
Straightening Length:			
0			
5.5 Dredging			
None			
Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.			

Project: **New Haven River**
 Stream: **New Haven River**
 Organization: **Addison County RPC**
 Segment Length (ft): **5,994**

January 8, 2008 SGAT Version: 4.56

Phase 2 Segment Summary page 1 of 2

Reach # **M02** Segment: **0** Completion Date: **September 12, 2007**

Observers: **KLU, BOS - SMRC; AD - ACRPC** Why Not assessed: Rain: **Yes**

Segment Location: **From 2000 ft west of River Road bridge crossing (just downstream of powerline crossing)**

QC Status - Staff: Provisional Cons		
Step 1. Valley and Floodplain		
1.1 Segmentation	None	
1.2 Alluvial Fan	None	
1.3 Corridor Encroachments		
	<u>Length (ft)</u>	<u>One</u> <u>Both</u>
	Berms	252 0
	height	10 0
	Roads	0 0
	height	0 0
	Railroads	0 0
	height	0 0
	Improved Paths	0 0
	height	0 0
	Development	484 194
1.4 Adjacent Side		
	<u>Left</u>	<u>Right</u>
	Hillside Slope	Steep Very Steep
	Continuous w/	Sometimes Sometimes
	W/in 1 Bankfill	Sometimes Sometimes
	Texture	Not Evalua Not Evalua
1.5 Valley Features		
	Valley Width (ft)	820
	Width Determination	Estimated
	Confinement Type	Broad
	Rock Gorge?	No
Human-caused Change? No		
Step 2. Stream Channel		
2.1 Bankfull Width	93	
2.2 Max Depth (ft)	6.50	
2.3 Mean Depth (ft)	4.40	
2.4 Floodprone Width (ft)	553	

Notes:
 LB berm downstream of Rt 7 bridge. Also, LB berm of field boulders along corridor (old channel position) at edge of corn field in middle of reach. Residential development (sparse) along LB and RB. Revetments (rip-rap and stone walls) are present adjacent to

Provisional Step 2. (Contued)		
2.5 Aband. Floodpln		7.70 ft.
Human Elev Floodpln		0.00 ft.
2.6 Width/Depth Ratio		21.14
2.7 Entrenchment Ratio		5.95
2.8 Incision Ratio		1.18
Human Elevated Inc Rat		0.00
2.9 Sinuosity		Low
2.10 Riffles Type		Sedimented
2.11 Riffle/Step Spacing (ft)		360
2.12 Substrate Composition		
Bedrock		0%
Boulder		0%
Cobble		5%
Coarse Gravel		65%
Fine Gravel		27%
Sand		3%
Silt and smaller		0%
Silt/Clay Present?		No
Detritus		5 %
# Large Woody		65
2.13 Average Largest Particle on		
Bed	60.0	mm
Bar	40.0	mm
2.14 Stream Type		
Stream Type:		C
Bed Material:		Gravel
Subclass Slope:		None
Bed Form:		Riffle-Pool
Field Measured Slope:		
2.15 Reference Stream Type		
(if different from Phase 1)		
<u>3.3 old</u>	<u>Amount</u>	<u>Mean Height</u>
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features		
3.1 Stream Banks		
Typical Bank Slope	Steep	
Bank Texture	<u>Left</u>	<u>Right</u>
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive
Bank Erosion	<u>Left</u>	<u>Right</u>
Erosion Length (ft)	798	669
Erosion Height (ft)	5.20	4.80
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	429	344
Near Bank Veg. Type	<u>Left</u>	<u>Right</u>
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Deciduous
Bank Canopy	<u>Left</u>	<u>Right</u>
Canopy %	26-50	26-50
Mid-Channel Canopy	Open	
3.2 Riparian Buffer		
Buffer Width	<u>Left</u>	<u>Right</u>
Dominant	51-100	>100
Sub-dominant	>100	51-100
W less than 25	661	442
Buffer Veg. Type	<u>Left</u>	<u>Right</u>
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin
3.3 Riparian Corridor		
Corridor Land	<u>Left</u>	<u>Right</u>
Dominant	Crop	Forest
Sub-dominant	Shrubs/Saplin	Crop
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers		
4.1 Springs / Seeps	Abundant	
4.2 Adjacent Wetlands	Abundant	
4.3 Flow Status	Moderate	
4.4 # of Debris Jams	0	
4.5 Flow Regulation Type	None	
Flow Regulation Use		
Impoundments		
Impoundmt. Location		
4.6 Up/Down strm flow reg	None	
(old) Upstrm Flow Reg		
4.7 StormwaterInputs		
Field Ditch	1	Road Ditch 0
Other	0	Tile Drain 0
Overland Flow	0	Urb Strm Wtr Pipe 0
4.9 # of Beaver Dams	0	
Affected Length (ft)	0	
Step 5. Channel Bed and Planform Changes		
5.1 Bar Types		
<u>Mid</u>	<u>Point</u>	<u>Side</u>
2	10	2
<u>Diagonal</u>	<u>Delta</u>	<u>Island</u>
3	0	1
5.2 Other Features		
Flood	Neck Cutoff	Avulsion
4	2	0
5.3 Steep Riffles and Head Cuts		
Steep Riffles	Head Cuts	Trib Rejuv.
0	0	No
5.4 Stream Ford or Animal		
No		
5.5 Straightening		
Straightening Length: 883		
5.5 Dredging		
None		
Note: Step 1.6 - Grade Controls and Step 4.8 - Channel Constrictions are on The second page of this report - with Steps 6 through 7.		

APPENDIX B
Bridge & Culvert Assessment
Reports

Stream Geomorphic Assessment

VT DEC

Bridge Summary Report

General Information

Structure ID	200019012901132	Local Structure ID	---
VOBCIT Struct Num	990002000101131	Assessment Date	12/10/2007
Observers	KLU, BOS - SMRC	Project Name:	New Haven River
Town	New Haven	Reach VTID	M02
Location	0.54 mile north of Jct w/ River Road.	Longitude	-73.17
Latitude	44.06	Road Type	Paved
Road Name	VT Route 7	High flow stage	No
Stream Name	New Haven River	Channel width	106 ft. (Curve)

Bridge/Arch Information

Bridge Width	31 ft.	Material	Concrete
Bridge Clearance	17 ft.	Number of bridge piers/arches	2
Bridge/Arch Span	251 ft.	Skewed to roadway?	No

Geomorphic Information

General

Floodplain filled by roadway approaches	Entirely
Structure is located at significant break in valley slope	No

Upstream

Obstructions at the opening of the structure	None
Steep riffle present immediately upstream of structure	No
If channel avulses, stream will	Cross Road
Estimated distance avulsion would follow road	--- ft.
Angle of stream flow approaching structure	Mild Bend

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Stepped footers	No

More Geomorphic Information

	Upstream	Downstream	In Structure
Dominant Bed Material	Gravel	Gravel	Gravel
Bedrock Present	No	No	No
Type of Sediment Deposits	Mid-channel	Mid-channel	None
Elevation of sediment deposits greater than 1/2 bankfull	No	No	No
Bank Erosion	High	None	
Hard Bank Armoring	Intact	Intact	
Stream bed scour causing undermining around or under structure	None	None	
Beaver Dam near Structure	No	No	
Beaver Dam distance (ft.)	---	---	

Vegetation

	Upstream	Downstream	In Structure
Dominant Vegetation Type - Left	Deciduous Forest	Deciduous Forest	
Dominant Vegetation Type - Right	Deciduous Forest	Deciduous Forest	
Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?			
Vegetation Band - Left	No	No	

Vegetation Band - Right	Yes	Yes	
<hr/>			
Wildlife			
	Roadkill	Outside Structure	Inside Structure
Species	None	None	None
<hr/>			
Other Information			
Spatial location data collected with GPS?	Yes	Photos taken?	Yes
Comments	Bridge built 1960 according to Vtrans inventory table.		

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Stream Geomorphic Assessment

VT DEC

Bridge Summary Report

General Information

Structure ID	100113003001131	Local Structure ID	---
VOBCIT Struct Num	700034016401133	Assessment Date	12/10/2007
Observers	KLU, BOS	Project Name:	New Haven River
Town	New Haven	Reach VTID	M01
Location	1800 ft northwest of Jct w/ VT Route 7.	Longitude	-73.17
Latitude	44.06	Road Type	Paved
Road Name	DOG TEAM RD	High flow stage	No
Stream Name	New Haven River	Channel width	106 ft. (Curve)

Bridge/Arch Information

Bridge Width	23 ft.	Material	Concrete
Bridge Clearance	16 ft.	Number of bridge piers/arches	3
Bridge/Arch Span	178 ft.	Skewed to roadway?	No

Geomorphic Information

General

Floodplain filled by roadway approaches	Entirely
Structure is located at significant break in valley slope	No

Upstream

Obstructions at the opening of the structure	Wood debris
Steep riffle present immediately upstream of structure	No
If channel avulsed, stream will	Unsure
Estimated distance avulsion would follow road	--- ft.
Angle of stream flow approaching structure	Sharp Bend

Downstream

Pool present immediately downstream of structure	No
Downstream bank heights are substantially higher than upstream bank heights	No
Stepped footers	No

More Geomorphic Information

	Upstream	Downstream	In Structure
Dominant Bed Material	Gravel	Gravel	Gravel
Bedrock Present	No	No	No
Type of Sediment Deposits	None	None	None
Elevation of sediment deposits greater than 1/2 bankfull	No	No	No
Bank Erosion	High	Low	
Hard Bank Armoring	None	None	
Stream bed scour causing undermining around or under structure	None	None	
Beaver Dam near Structure	No	No	
Beaver Dam distance (ft.)	---	---	

Vegetation

	Upstream	Downstream	In Structure
Dominant Vegetation Type - Left	Herbaceous/Grass	Coniferous Forest	
Dominant Vegetation Type - Right	Deciduous Forest	Herbaceous/Grass	
Does a band of shrub/forest vegetation 50 ft. wide start within 25 ft. of the structure and extend at least 500 ft. up/downstream?			
Vegetation Band - Left	No	No	

Vegetation Band - Right	No	No	
Wildlife			
	Roadkill	Outside Structure	Inside Structure
Species	None	None	None
Other Information			
Spatial location data collected with GPS?	Yes	Photos taken?	Yes
Comments	Bedrock falls (at former Dog Team Tavern) located within 400 ft downstream. Site of USGS Gage at Brooksville (Stn #04282525) - downstream left bank. Bridge constructed in 1927 according to Vtrans inventory table.		

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Materials for Appendix C are found on Data Management System at:

<https://anrnode.anr.state.vt.us/ssl/sga/security/frmlogin.cfm>

APPENDIX D
Reach Segmentation

Appendix D. Reach Segmentation, Phase 2 Stream Geomorphic Assessment of reaches M01 and M02, New Haven River

<u>Reach</u>	<u>Segment</u>	<u>Feature</u>	<u>Point</u>	<u>Total Reach Length (ft)</u>	<u>Segment Lengths (ft)</u>	<u>Elevation (ft)</u>	<u>Segment Slopes</u>	<u>Reach Slope</u>	Comparison to Phase 1 Slope	
									<u>Elevation (ft)</u>	<u>Reach Slope</u>
M02	--	d/s end reach	--	5,994		238		0.2%	235	
	--	u/s end reach	--			249			249	0.23%
M01		d/s end reach				220			222	
	A	segment break	A/B		1,580	222	0.1%			
	B	u/s end reach		3,753	2,173	238	0.7%	0.5%	235	0.35%

APPENDIX E

Meander Geometry (Revised Phase 1 Steps 6.5, 6.6)

