Upper Otter Creek

Phase 2 Geomorphic Assessment
&
Preliminary Restoration Project Identification

Rutland County, Vermont

FINAL

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Phase 2 Geomorphic Assessment and Project Identification

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1.0 EXECUTIVE SUMMARY

The Upper Otter Creek study area is a political and geophysical boundary that extends from its headwaters near Emerald Lake in Dorset downstream to near where it enters the Brandon Swamp. The Otter Creek defines a significant valley shared by many towns and landowners. A multitude of resources, at the cost of private landowners and state taxpayers, have been spent on protecting property adjacent to the river by methods such as channel straightening, dredging, and streambank armoring. These practices are predictably temporary and often detrimental to the health of the river ecosystem as well as having negative flood and water quality impacts downstream all the way to Lake Champlain. In order to reduce the need for maintenance of traditional channel management applications along the Upper Otter Creek and to shift the focus of management projects from short term control (2 year planning) to long term equilibrium and stability (50 and even 100 year planning) the Rutland Regional Planning Commission (RRPC) retained Round River Design to complete a Phase 2 Stream Geomorphic Assessment and develop preliminary restoration project suggestions.

Stream geomorphic assessments provide information about the physical condition of streams and the factors that influence their stability. The Vermont Agency of Natural Resources (VTANR) River Management Program has developed a series of protocols (Phase 1, Phase 2, and River Corridor Planning Guide) for the statewide assessment of rivers and streams. A Phase 1 Stream Geomorphic Assessment looks at broad scale landscape data, historical data, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Otter Creek was completed in 2005 by the RRPC. A Phase 2 Assessment involves the collection of data from measurements and observations entirely in the field. In 2006, the RRPC retained South Mountain Research (consulting scientists) to conduct a Phase 2 Assessment on five reaches of the Otter Creek between Wallingford and Rutland City. In 2008 the RRPC retained Round River Design to perform Phase 2 Stream Geomorphic Assessments on the main stem of the Upper Otter Creek from the Danby/Wallingford town line downstream to reach M26 (connecting with the information gathered previously). The project also expanded the previously assessed area downstream of Rutland City (north) to just past the Proctor/Pittsford town line.

Because these assessments study the historic and current condition of the river, they are able to make predictions about how the Upper Otter Creek will continue to adjust in the future. The results provided by the assessments may be used to determine appropriate long-term management strategies. Round River Design found that the main stem of the Upper Otter Creek has been significantly impacted by historic channel straightening and floodplain encroachment by railroad tracks, roads, and commercial and residential development. In response to these and other watershed stressors, the Upper Otter Creek is undergoing varying degrees of channel adjustment, predominately planform (or lateral migration), widening, and aggradation.

In conclusion, the Danby, Wallingford, Rutland City, Rutland Town, Proctor, and Pittsford communities have the opportunity to provide long-term protection to the river corridor and encourage the reestablishment of functioning floodplain and healthy in-stream habitat through river corridor management, protection, and restoration.

2.0 PROJECT AND PROGRAM OVERVIEW

2.1 State of Vermont River Management Goals

The Vermont Agency of Natural Resources' (VTANR) goal is to, "manage toward, protect, and restore the equilibrium conditions of Vermont's rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner." The objectives of the Program include fluvial erosion hazard mitigation, sediment and nutrient load reduction, and aquatic and riparian habitat protection and restoration. The Program seeks to conduct river corridor planning, such as this Otter Creek project, in an effort to remediate the geomorphic instability that is largely responsible for flood damage and nutrient loading, as well as loss of habitat and recreational opportunities. Additionally, the Vermont River Management Program has set out to provide funding and technical assistance to facilitate an understanding of river instability and the establishment of well-developed and appropriately-scaled strategies to protect and restore river equilibrium (Vermont River Management Program, personnel communication, 2006). Ultimately it is their strategy that sound research will lead to good planning and, eventually, meaningful and long-lasting restoration and management efforts.

The VTANR River Management Program uses the "river corridor" as a primary tool in its avoidance strategy to restore and protect the natural values of rivers and to minimize flood damage. River corridors consist of lands adjacent to and including the present channel of a river. The adjacent lands included in a "corridor" are those that are capable and perhaps likely to be occupied by the channel itself as the river meanders within a valley bottom over time (For a technical description of how they are delineated see "River Corridor Protection Guide: Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality": VTANR 2008). River corridor planning is conducted in Vermont to remediate the river instability that is largely responsible for excessive erosion and flooding, increased sediment and nutrient loading to surface waters, and a reduction in habitat (VTANR 2007a). Reducing current and future near-stream investment in infrastructure and achieving natural stream stability promotes a sustainable relationship between humans and rivers over time, minimizing the costs associated with floods ($14 Million annually average in Vermont) and maximizing the benefits of clean water and healthy ecosystems (VTANR 2008).

2.2 Local Initiatives in the Upper Otter Creek Watershed

Local restoration initiatives have been largely driven by the Rutland Natural Resource Conservation District (RNRCD) conservation interests, VTANR basin planning efforts, and RRPC regional planning efforts. The Upper Otter Creek Watershed Council (UOCWC), for example, is a project initiated by the RNRCD and VTANR. The group formed in May of 2003, after a series of public forums, at which many issues and concerns were identified. Since then, the UOCWC, the RNRCD, and/or RRPC have received funding to assess riparian buffers and geomorphic conditions along the Otter Creek and many of its significant tributaries (Rutland Regional Planning Commission 2005).

Preliminary project identification for the restoration of the Upper Otter Creek is derived predominately from data collected during a stream geomorphic assessment. Stream geomorphic assessments provide information about the physical condition of streams and the factors that influence their stability. The VTANR River Management Program has developed a series of protocols (Phase 1, Phase 2, and River Corridor Planning Guide) for the statewide assessment of rivers and streams.

A Phase 1 Stream Geomorphic Assessment looks at broad scale landscape data, historical data, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Upper Otter Creek was completed in 2005 by the RRPC along with a report summarizing the findings (Rutland Regional Planning Commission 2005). A Phase 2 Geomorphic Assessment of select reaches of the Upper Otter Creek was recommended by the RRPC to gather more detailed information about the stream channel and riparian corridor in order to inform current and future planning and restoration efforts. In 2006, the RRPC retained South Mountain Consulting to conduct a Phase 2 Assessment on five reaches of the Otter Creek between Wallingford and Rutland City. The results of this study are found in a report titled "Phase 2 Stream Geomorphic Assessment Upper Otter Creek Watershed: Reaches M22-M26" (Underwood 2006). In 2008, the RRPC retained Round River Design to perform a Phase 2 Stream Geomorphic Assessment of the main stem of the Upper Otter Creek from the Danby/Wallingford town line downstream to Wallingford Village as well as from the confluence with the East Creek in Rutland City downstream to the confluence with the Furnace Brook (near Proctor/Pittsford town line) thereby expanding the previously assessed area upstream and downstream from the 2006 study.

3.0 UPPER OTTER CREEK STUDY AREA: BACKGROUND WATERSHED INFORMATION

3.1 Geographic Setting

3.1.1 Watershed Description

Located in Rutland County, Vermont, the Upper Otter Creek watershed area is 365 square miles (upstream of confluence with the Furnace Brook – the most downstream point of this study) (Figure 1). The combined length of the stream reaches targeted through this Phase 2 study is approximately 21.6 miles (Figure 2). The Upper Otter Creek Watershed is a political subdivision of the Otter Creek Watershed. The Upper Otter Creek Watershed is primarily located in Rutland County, with a small section in northern Bennington County. The Otter Creek begins in Dorset township and flows northerly through Rutland and Addison Counties to Lake Champlain. Major tributaries within the Upper Otter Phase 2 study area are the Homer Stone Brook (South Wallingford), Roaring Brook (Wallingford), Mill River (Clarendon), Cold River (Clarendon), East Creek (Rutland), and Clarendon River (Rutland).

3.1.2 Political Jurisdictions

The Otter Creek mainstem reaches focused on during this 2008 study were located in Rutland County in the Towns of Danby, Wallingford, Rutland City, Rutland Town, Proctor, and Pittsford. All towns are members of the Rutland Regional Planning Commission. The State of Vermont Water Resources Board classifies and regulates the use of all public waters. The Vermont Agency of Natural Resources issues permits regarding water and stream use. The U.S. Army Corps of Engineers also issues permits and enforces water law in the state.

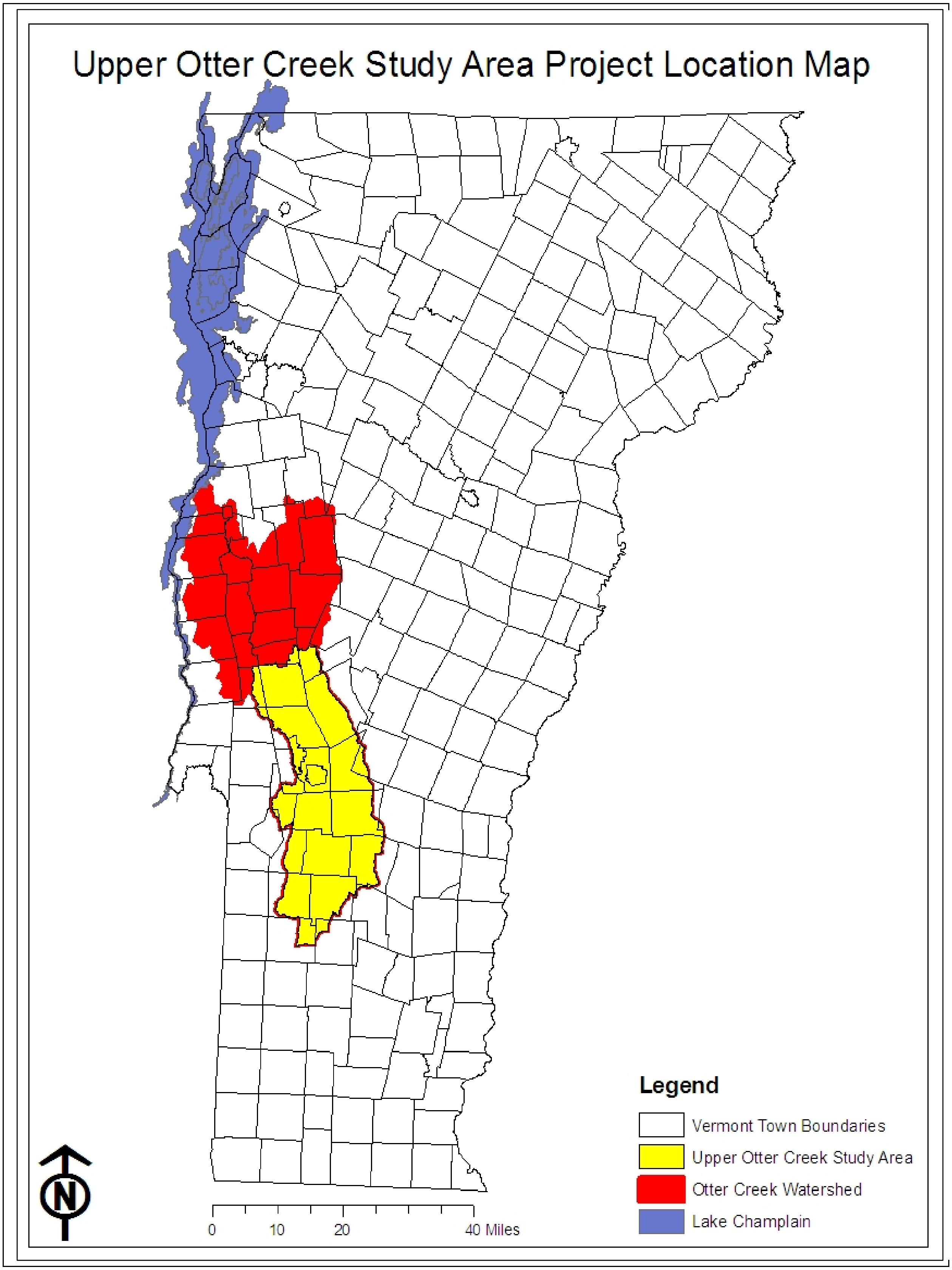


Figure 1: Phase 2 Assessment Project Location Map

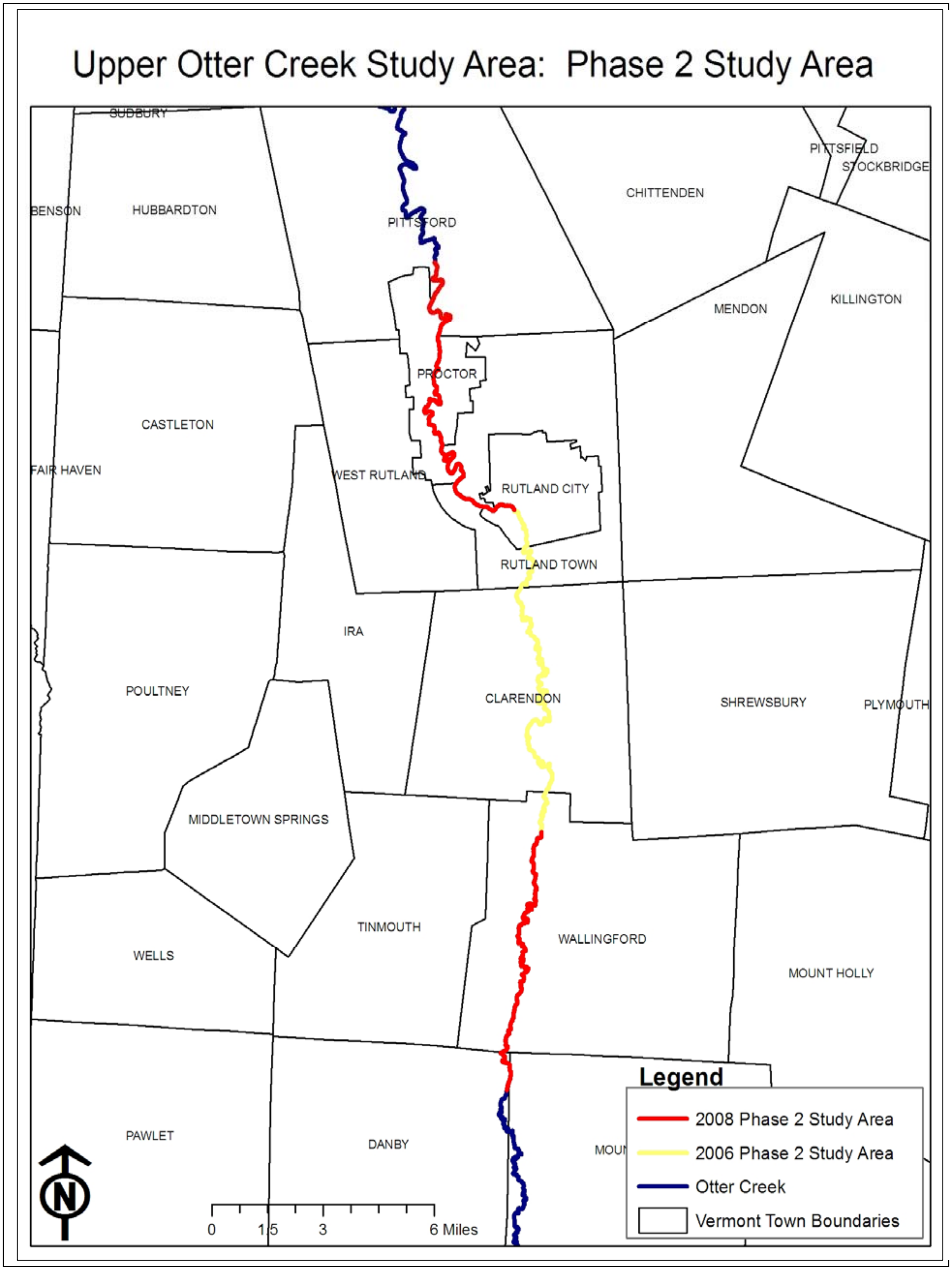


Figure 2: Target Area for the Upper Otter Creek Phase 2 Assessment.

3.1.3 Land Use History

The Otter Creek, like most waterways, has always been vitally important to the inhabitants of this land. Before the colonists arrived in Vermont, rivers, streams and lakes were a major avenue of transportation for the Algonquins and Iroquois. Colonial settlements were established in Vermont in the late 1700's and typically arose around gristmills and sawmills at suitable sites along the rivers and streams. Gristmills were of great importance in early settlements because the entire village's grain could be processed in a day and allowed the settlers the time and resources to develop their homesteads, village infrastructure, and new industry. In the village of Wallingford a gristmill, sawmill, fulling mill, and forge and iron works were all set up using water from a dam that was constructed across the Otter Creek in 1778 (and which backed up water and sediments into the 1940's). Logging was the first major industry (along with potash, created from logging byproducts) in the Otter Creek region and rivers were often used as a means of transporting logs downstream to the sawmill where many canals and holding ponds were built. Along with the intensive deforestation (that continued until the 1920's) came high levels of erosion. By 1850, over 75% of the state's forests had been cleared (Albers, 1999). Soils were rapidly washed away from the hillsides and into the river system, altering sediment transport regimes and greatly diminishing flood water retention times. Settlers along the waterways likely began to experience more pronounced flood events, perhaps culminating in the great flood of 1927.

The gristmills and sawmills were soon followed by fulling mills, carding mills, paper mills, potash mills, forges and ironworks, machine shops, marble quarries and cutting facilities, textile mills, and other manufacturing. Rivers provided a source of power as well as a repository for wastes. Pollution increased dramatically with the influx of industry and population, which saw a significant spike during the 1810's. The Otter Creek Watershed, along with the rest of the Champlain Valley and the Connecticut River Valley saw the majority of this settlement. The first four ironworks in the state were all in the Otter Creek Watershed, two of the four in the Upper Otter Creek Watershed, located in Pittsford and Rutland.

In 1822, the completion of the Champlain Canal connecting the Hudson River and Lake Champlain resulted in another dramatic increase in industry. The canal decreased the costs of transportation and created a major commercial trading route between the Hudson River Valley and the Saint Lawrence River Valley. In 1848, a railroad line was established in the Champlain Valley and provided an even less costly and more convenient means of transportation for all of the mills and factories located along the rivers that it followed and crossed (Klyza, 1999). The construction of the railway had enormous impacts on the riparian corridors that it passed through as rivers were straightened to facilitate its passage. The first hydroelectric dams in the state were constructed in 1898 in Rutland (with a 13 acre impoundment) and in 1905 in Proctor (Childs, 2007).

Mill sizes were typically kept small in order to accommodate the needs of farmers upstream and downstream of the dams. Upstream farmers wanted to ensure that their croplands would not be severely inundated and downstream farmers demanded that they receive enough water yearlong. Agriculture tended to be largely subsistence farming during the early years of settlement and then shifted to primarily growing wheat as a cash crop as demand from non-farming populations (especially southern new England) increased and transportation costs decreased. Competition with mid-western farmers, nutrient-depleted soils, demand from the growing textile mills of southern New England, and a greater need for cash income, among other reasons, caused a shift to sheep farming in the 1820's. Sheep farming enabled Vermonters to put to use the vast areas of deforested land and it became so widespread that, in 1840, during its peak, sheep out-numbered humans 6 to 1 statewide (Klyza, 1999). In the mid- to late- eighteen hundreds, falling wool prices and the availability of horse drawn mechanical farm equipment enabled farmers to develop larger tracts of land to grow feed for dairy cows and another shift in agriculture ensued. At the beginning of the 20th century, Vermont supplied 55% of United States' domestically-consumed butter and 92% of its cheese (Albers, 1999).

The great flood of 1927 led to major changes in land use in the Otter Creek Watershed and throughout the state. The flood caused massive damage to the state's railroad infrastructure (as well as bridges, homes, farms and businesses) and although much was rebuilt, the growing affordability and popularity of the automobile spurred the construction of improved roads. Commercial and residential development expanded along these transportation corridors (again, following the rivers for the most part) and the percentage of impervious surfaces in the river corridor enlarged. Roads also increased tourism, and with the construction of the highway systems in the 1960's the number of ski resorts and second homes rose sharply. The Civilian Conservation Corps also launched a huge flood control initiative following the 1927 disaster that included erosion prevention, reforestation, habitat protection, reclamation of abandoned farmlands, and the construction of recreational trail networks.

Today, the Upper Otter Creek Watershed is primarily comprised of forest and farmlands (both active and abandoned), punctuated by villages and interspersed with residential and light industrial and commercial development. The undeveloped land is mostly found on hill tops while residential, commercial, and agricultural lands are largely concentrated near the river valley bottom and along select tributaries (Figure 3). In 2005, 81% of the watershed upstream of Rutland City is in forested use, with approximately 7% in agriculture and 6.7% developed (Rutland Regional Planning Commission, 2005).

3.2 Geologic Setting

Streams are transport systems that carry *water* AND *sediment* from highlands to lowlands. The geology of a watershed determines: the source material that water will transport; the conditions that cause the material to be carried; the rate of channel adjustments in response to the energy of flowing water; and also influences the chemistry and ecology of stream systems.

3.2.1 Mountain Building and Bedrock Geology

The Upper Otter Creek watershed, in a broad geological context, spans one large physioregion, the Vermont Valley. An extension of the Champlain Valley, the Vermont Valley lies between the Green Mountains to the east and the Taconic Mountains to the west.

The bedrock of the western flank of the Green Mountains in this region is compromised of rocks created about 1,200 million years ago during the Grenville Orogeny. During this period, lasting approximately 80 million years, the proto-North American plate collided with another continent approaching from the east, creating a massive mountain chain which was later completely eroded away (Klyza, 1999). Around 575 million years ago, the plate began to separate, with proto-North America moving west, and the Iapetus Ocean was formed. During the next 100 million years, the sediments of this expansive ocean formed into the

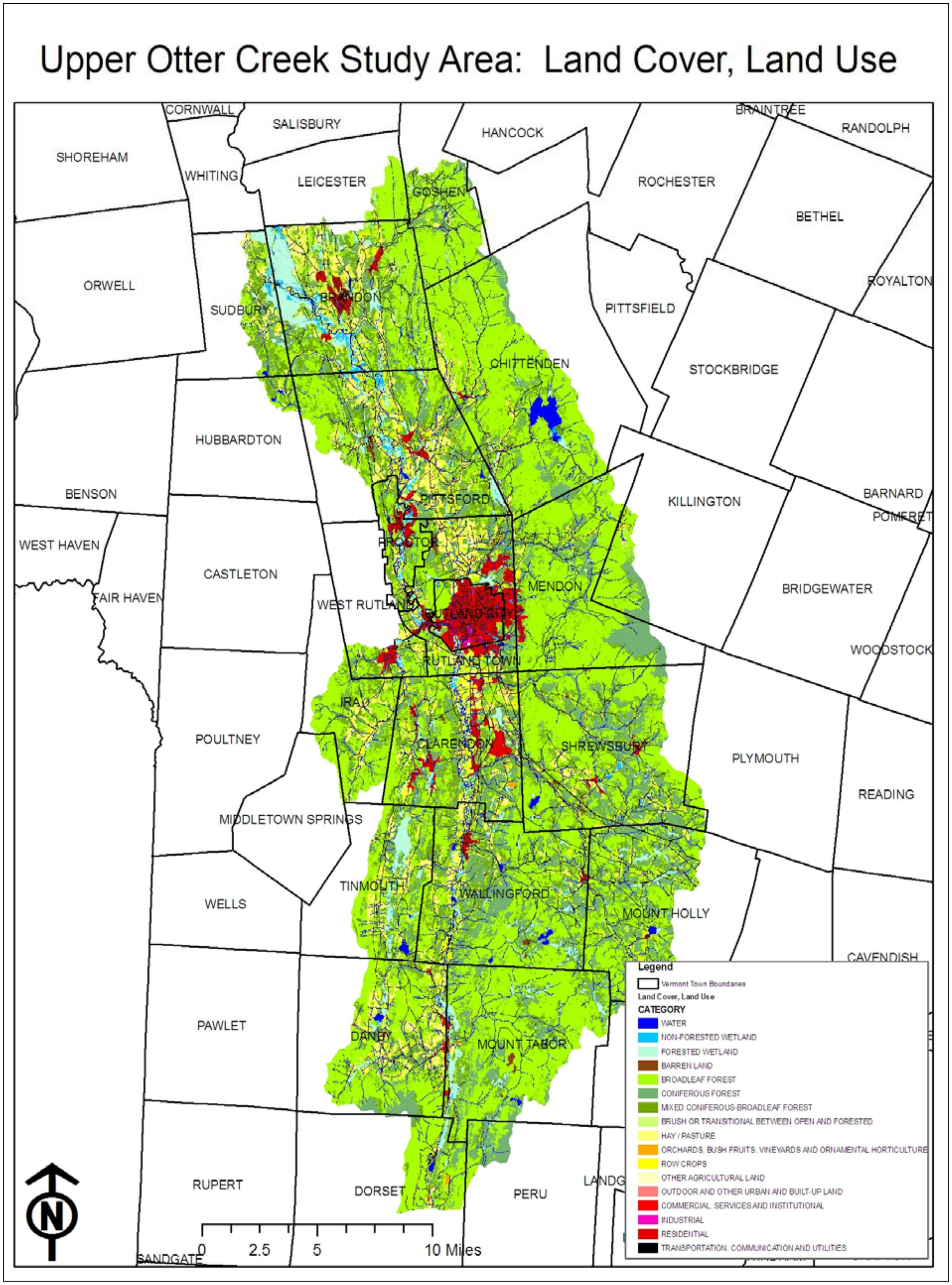


Figure 3: Present day land use and land cover of the Upper Otter Creek Watershed.

diverse sequences of limestones and shales that are today found in the lowlands of the Champlain and Vermont Valleys. The proto-North American plate then reversed directions again and, moving eastward, eventually created a massive landmass, known as the Taconic Island Arc, in the middle of the Iapetus Ocean through subduction and the resulting volcanic activity.

About 450 million years ago this landmass collided and fused with proto-North America. During this period of collision, the Taconic Orogeny, another tall chain of mountains was formed. The Taconic Mountains and the Green Mountains are both remnants of this mountain range, consisting of gneisses, phyllites, and schists. This rock is much more resistant to erosion than the limestones of the present day valley bottom. Much of this limestone in the Vermont Valley was metamorphosed into marble. The collision also caused the crust to break apart into faulted blocks along the line of contact. Due to the high temperatures and incredible pressure, much of the surrounding rock recrystalized and, through the combination of "precursor minerals in sediments, metaphoric processes, and the infusion of mineral-rich liquids into cracks in the rock", formed into the isolated mineral deposits near the surface that have been found and mined in historic times. These include "iron, gypsum, copper, talc, soapstone, and asbestos" (Klyza, 1999). Many sedimentary (and other) rocks were metamorphosed: sandstones to quartzite; shales to slates, phyllites, schists, or gneisses; limestones to marble; and basalts to greenschists or amphibolites (Van Diver, 1987). The faults created were significant and later caused the creation of the Champlain Valley and the Saint Lawrence River Valley by allowing the blocks of rock to sink relative to their surroundings.

During the Acadian Orogeny, beginning about 400 million years ago, a very small continent, known as Avalon, collided with proto-North America and merged to create what is now eastern New England. This collision had relatively minor impacts, yet did cause more uplift in the Green Mountains. The following Allegheny Orogeny saw major changes, but none of them had any significant impact on the Vermont Valley region. Further changes to the bedrock of the region were be made by purely erosive forces.

In areas where this bedrock directly underlies the river channel, the stability of the channel is typically improved. Exposed bedrock along the stream bottom and/or channel walls typically prevents rapid incision and planform adjustments. In the Upper Otter Creek, channel-spanning bedrock is found in reaches M30 (South Wallingford), M21-B (Mead Falls in Rutland) and M29-B (Sutherland Falls in Proctor). This bedrock provides a more stable stream channel in these reaches and in most cases has limited incision directly upstream and downstream as well. These channel spanning bedrock formations are known as "grade controls" since they set the grade (i.e. the slope) of the river to a certain, undynamic elevation.

3.2.2 Glacial History and Surficial Geology

According to Wright and Larsen (2004), almost all of the surficial materials in Vermont owe their origin, either directly or indirectly, to the Laurentide ice sheet. The Laurentide ice sheet was the last big continental-scale glacier that covered all of New England. It first formed in the Hudson's Bay region of Canada sometime between 80–100,000 years ago. As the climate slowly cooled, the ice sheet grew and advanced slowly towards New England flowing south and east through the Lake Champlain Valley and the many tributary valleys, including the Otter Creek valley. As the ice sheet advanced and thickened, it eventually overwhelmed and completely buried the Green Mountains (the massive weight of the ice depressing the land downwards) and, by approximately 23,000 years ago, extended as far south as Long Island. As the climate rapidly warmed, the ice sheet responded by thinning and retreating to the north creating the massive glacial Lake Vermont (and depositing lake sediments). Approximately 14,000 years ago the glaciers retreated far enough north to allow water to drain out through the St. Lawrence Valley and conversely allowed brackish water from the St. Lawrence Seaway to invade the basin creating the Champlain Sea.

Free of the massive weight of ice, the land began to rebound upwards eventually cutting off the north-south sea connection and revealing an early version of the present day Lake Champlain with an early Otter Creek flowing into it. Gradients on the northern reaches of the Otter Creek were probably low to begin with (flowing across a former lake bottom). As the uplifting continued the slope of the Otter Creek probably continued to flatten while sediment laden tributaries like the Mill and Cold River were delivering a great amount of material (at a great rate initially and likely declining exponentially in the first several thousand years) from the newly exposed barren landscape. As the material on the hills stabilized, sediment rates entering the Otter Creek probably remained low until European land clearing once again denuded the landscape creating a spike in sedimentation. All the while, post-glacial land uplift was occurring. Field evidence suggests that this uplift rate is slowing down over time creating a complex interplay of differential uplift (which decreases the gradient of the Otter Creek) with what ever incision into the deposits might be occurring. (Springston, personal communication, 2008)

As the glacial history implies, the surficial materials in the Upper Otter Creek region are composed of sediments (till) transported by glaciers or by melt water from streams or deposits made in small lakes associated with glaciation. Till (unsorted glacial debris deposited directly from melting ice) contains a wide variety of particles sizes. According to Stewart (1972), till covers the uplands of the Rutland region as a thin veneer generally less than 10 feet thick and much thicker in the valleys such as the Otter Creek). "The Otter Valley itself is filled with glacial and post-glacial deposits several tens to hundreds of feet in thickness. A seismic profile completed at a location between the Cold River and Rutland City indicates that the Otter Creek valley is filled with more than 175 feet of sediments: 100 feet of till, overlain by 50 to 85 feet of lake silts and clays, blanketed by lake sands and recent alluvial sands and silts (Underwood, 2006 citing Stewart, 1972)." At the base of the Green Mountains, near the Vermont Valley, kame terraces, kames, and valley train deposits (outwash from glacial streams) can be found – at times the Otter Creek may run up against these features where it is close to the Green Mountain complex.

The exception to the till and occasional glacial influenced deposits is the recent alluvium from postglacial floodwaters that forms a veneer on land adjacent the rivers (i.e. floodplain). *Alluvium* is sediment deposited by a stream and may include boulders, cobbles, sand or silt. Alluvial deposits in flood plains are often composed of fine sand or silt. All alluvial deposits in Vermont postdate the last glacial period. Alluvium soils are frequently flooded and have high erodibility potential.

The characteristics of the dominant soil types in the watershed show occasional flooding, and only slight to moderate erodibility. The erosion potential throughout much of the watershed may be relatively low due to the moderate slope found throughout the valley.

3.3 Geomorphic Setting

3.3.1 Description and Mapped Location of Study Reaches

The Phase 1 Assessment of the Upper Otter Creek Watershed (Rutland Regional Planning Commission, 2005) delineated geomorphic reaches (sections of river that are expected to exhibit similar characteristics). Reaches were defined according to VTANR Phase 1 Protocols based on variations in valley confinement, slope, sinuosity, and soils.

Based on the channel and watershed stressors identified during the Phase 1 Assessment, thirteen mainstem reaches of the Otter Creek were prioritized for a Phase 2 Stream Geomorphic Assessment. These targeted reaches were expected to demonstrate higher degrees of channel adjustment and sensitivity. Five of these reaches were assessed in 2006 (Underwood, 2006). Round River Design assessed an additional nine reaches in 2008. As depicted in Figures 5 and 6, several of the fourteen field-assessed reaches were further subdivided during the Phase 2 Assessment due to localized variations in stream type, channel and floodplain encroachment, and other differences observed by stream scientists while in the field.

3.3.2 Longitudinal Profile, Alluvial Fans, and Natural Grade Controls

The Upper Otter Creek drops at an average slope of less than 1% from reach M31 down to the Furnace Brook Confluence (the end of the Phase 2 study area) over a valley distance of almost 37 miles (Figure 4). The Upper Otter Creek itself does not flow through any alluvial fans, however, it is likely that the mouths of numerous tributaries coming from the adjacent hillsides form alluvial fans as they spread and flatten out to meet the gentle slope of the Otter Creek. Natural bedrock grade controls (where bedrock spans the river channel and prevents rapid incision) were located at reaches M30, M22-A, and M19-B.

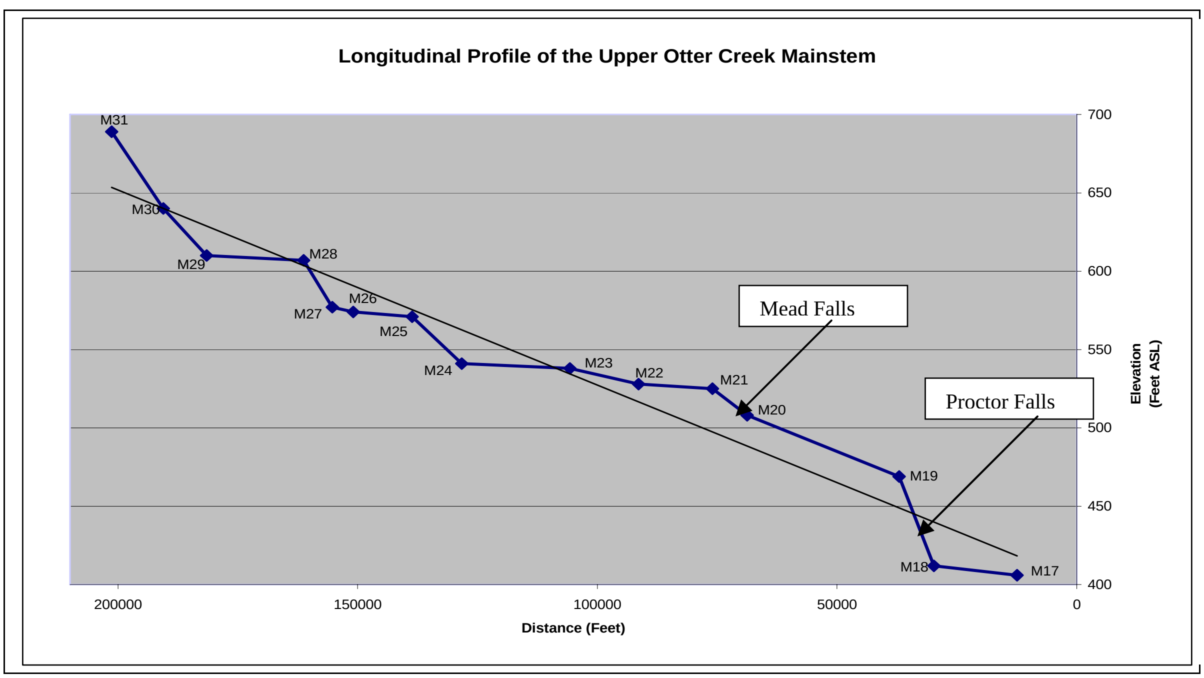


Figure 4: Longitudinal Profile of the Upper Otter Creek Phase 2 Reaches.

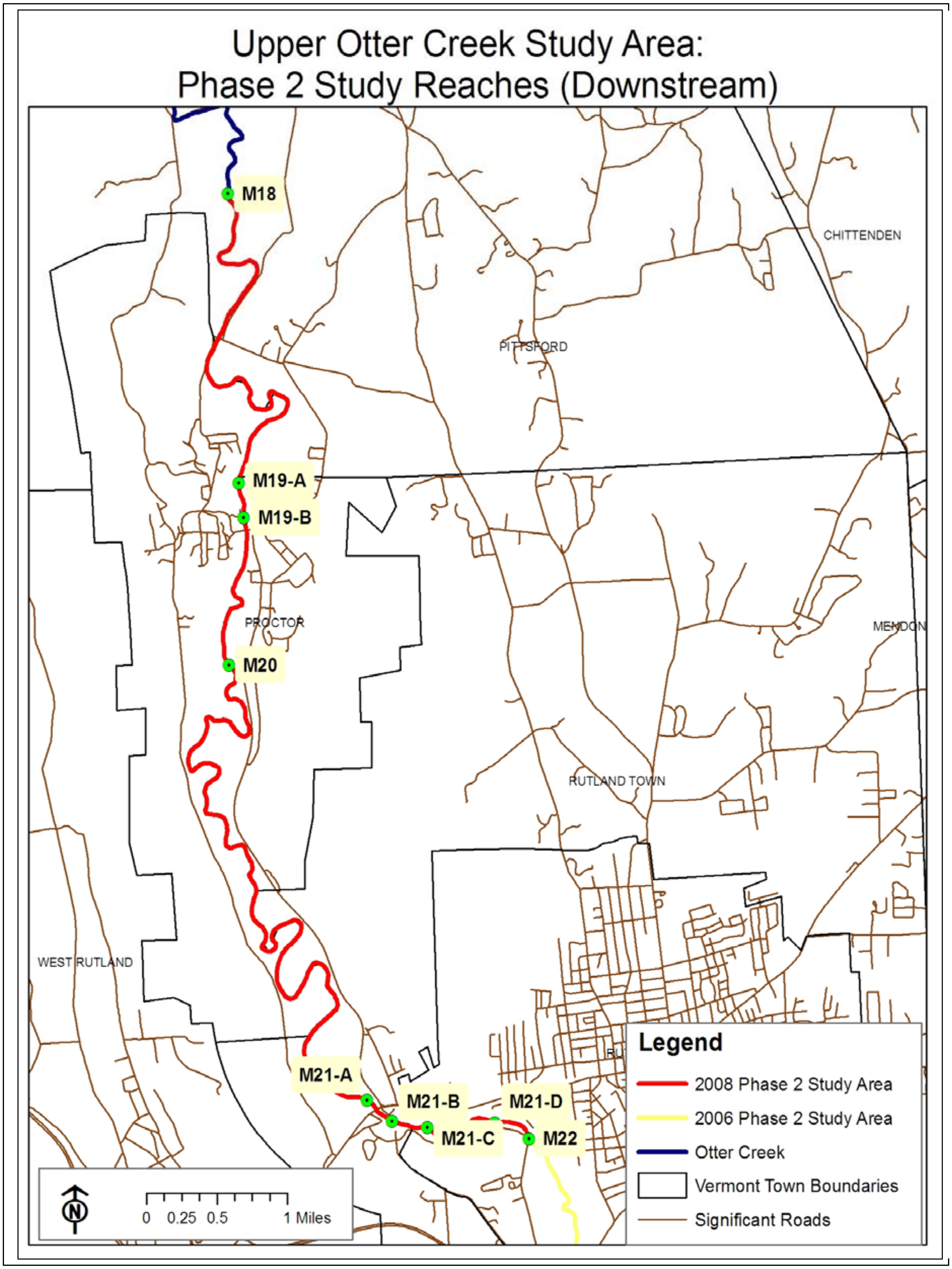


Figure 5: Reach location map for the Upper Otter Creek Phase 2 Stream Geomorphic Assessment.

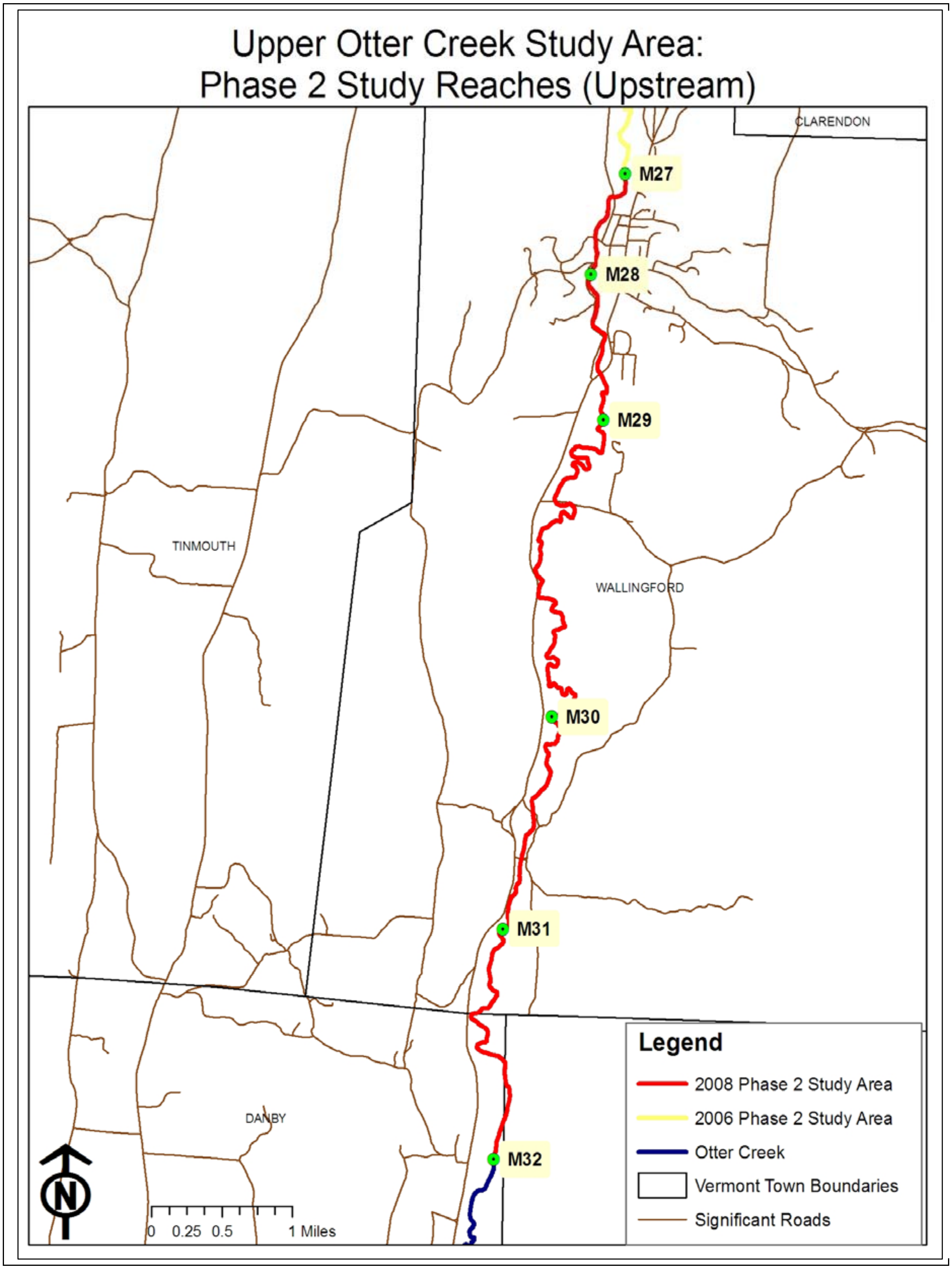


Figure 6: Reach location map for the Upper Otter Creek Phase 2 Stream Geomorphic Assessment.

3.3.3 Valley and Reference Stream Types

Reference stream and valley types are designated to describe stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Reference stream types are based largely on characteristics of the bedrock geology, soils, and hydrology of each reach and are identified using data from both the Phase 1 and Phase 2 Assessments (VTANR 2007b). Given the long history of stream channelization and human-related changes to the Vermont landscape, it is common to observe that existing stream and valley conditions are significantly different than what one would expect to find in a pristine watershed.

Table 1 describes the reference stream and valley types for the Otter Creek study reaches. The majority of the mainstem of the Otter Creek is, by reference, an "E" type channel dominated by sand substrates, an unconfined floodplain, and a ripple-dune bedform (see Rosgen, 1996 for stream type definitions). Several of the mainstem reaches are reference "C" type channels that have slightly steeper slopes, gravel substrates, an unconfined floodplain, and a riffle-pool bedform.

Table 1: Reference Valley and Stream Types for the Otter Creek

Segment Number	Valley Type	Expected Channel Width (ft.)	Channel Slope (%)	Sinuosity	Reference Stream Type	Reference Bedform
M31	Very Broad	87.7	0.45	1.17	C	Riffle-pool
M30	Narrow	91.9	0.33	1.17	C	Riffle-pool
M29	Very Broad	96.4	0.01	1.62	E	Ripple-dune
M28	Very Broad	96.9	0.50	1.26	E	Ripple-dune
M27	Very Broad	100.9	0.07	1.01	C	Riffle-pool
M26-B	*Narrow*	*103.7*	*0.02*	*1.23*	*E*	*Ripple-dune*
M26-A	*Narrow*	*103.7*	*0.02*	*1.23*	*E*	*Ripple-dune*
M25	*Very Broad*	*129.9*	*0.29*	*1.93*	*E*	*Ripple-dune*
M24	*Very Broad*	*130.9*	*0.01*	*1.81*	*E*	*Ripple-dune*
M23	*Very Broad*	*133.8*	*0.07*	*1.63*	*E*	*Ripple-dune*
M22	*Very Broad*	*147.4*	*0.02*	*1.31*	*E*	*Ripple-dune*
M21-D	Broad	163	0.23	1.00	C	Riffle-pool
M21-C	Broad	163	0.23	1.00	C	Riffle-pool
M21-B	Broad	163	0.23	1.00	C	Riffle-pool
M21-A	Broad	163	0.23	1.00	C	Riffle-pool
M20	Very Broad	174.7	0.12	1.61	E	Ripple-dune
M19-B	Very Broad	175	0.12	1.00	E	Ripple-dune
M19-A	Narrow	175	0.78	1.00	F	Ripple-dune
M18	Very Broad	175.8	0.02	1.93	E	Ripple-dune

3.4 Hydrology

As reported in the Phase 1 Assessment Report (Rutland Regional Planning Commission, 2005), most of the Otter Creek watershed is currently forested (ranging near 80% in the subwatersheds) based on an analysis of data obtained from the Vermont Center for Geographic Information. In the upstream portion of the study area "field and cropland" was the typical subdominant land use while downstream of Rutland "urban" land use was characteristic in the range of around 7%. Historically, a much higher percent of the watershed was cleared for pasture and croplands. Within the area of land adjacent to the stream, the stream corridor, the dominant land use changes to urban within the villages of Wallingford, Rutland (as much as 75%), and Proctor.

These numbers are important for many reasons because development in the watershed, both current and historic, may play a large impact on fluvial erosion, water quality, and habitat quality. For instance, according to a study conducted at the University of Maryland (Barnes et al, 2007), declines in biological integrity and habitat quality are observable in watersheds with impervious cover rates between 10 percent to 20 percent. The alteration of first-order, and in some cases, second-order channels (the small feeder streams that join to become the major tributaries to the Otter Creek) is problematic since runoff and sediments formerly distributed among many small channels become concentrated to fewer channels. The outcomes of this are more rapid flow velocities and flood peaks downstream leading to erosion and enlargement of stream channels; the washing-out of culverts and crossing structures not previously sized to handle such flows; as well as other affects.

Channel and bank instability, which leads to the physical degradation of streams, stems from the increased flooding and increased flow concentration that follows development. The signs of instability, however, may not become evident for several years following the development. Signs of instability include channel widening by bank erosion or a deepening of the channel through down-cutting. With the former, channel beds may become covered in sediment; with the latter, beds are subject to frequent scours.

The study continues to describe that, "When development occurs on floodplains not previously developed, natural flooding will inevitably threaten the people and property inhabiting those floodplains. What's more, areas that did not commonly flood before urbanization may suffer more frequent inundations due to the greater volumes of runoff and increased flood heights associated with imperviousness. Properties and structures may be threatened by bank erosion from streams' whose channels have been destabilized by upstream development (Barnes et al, 2001)."

In the context of the Upper Otter Creek, the conditions for this instability exist and the human reactions to instability such as bank-armoring, ditching of small runoff channels, and straightening appear to be a pattern that is widespread.

3.4.1 Stream Gauge Information and Flood History

According to the Vermont Agency of Natural Resources document "Municipal Guide to Fluvial Erosion Hazard Mitigation" (2006), "Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly." The guide documents that over the last 50 years, flood recovery has cost the state an average of $14 million a year and that during the period of 1995-1998 alone, flood losses in Vermont totaled almost $57 Million. Of particular concern for towns and properties near streams, it notes that, "While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by "fluvial erosion". Fluvial erosion is erosion caused by moving water and can range from gradual streambank erosion to catastrophic changes in river channel location and dimension during flood events (Figure 7)."


Figure 7: These images show the Otter Creek during the 1927 flood. Left image is from an unknown location. Right image is of the Sutherland Falls in Proctor (reach M19-A).

The Municipal Guide further documents that, "Closer study of our rivers and streams reveals that Vermont's erosion hazard problems are largely due to pervasive, human-caused alteration during the past 150 to 200 years of our waterways and landscapes they drain. By the end of the 19th century, forests had been cleared from many watersheds, resulting in major changes in watershed hydrology and sediment production. Towns and villages, the centers of commerce, grew on the banks of rivers, whose role in power generation and transportation at first outweighed flood risks. In addition, many watersheds were changed by development, agriculture, log drives, roads and railways." The legacy of this landscape manipulation is rivers and streams, such as the Upper Otter Creek, which may be unstable and prone to sudden and significant fluvial erosion (Vermont Agency of Natural Resources 2006).

To further concern streamside landowners, precipitation trend analysis suggests that intense, localized storms, which can cause flash flooding, are occurring with greater frequency (Vermont Department of Public Safety, 2006). This may be on the minds of local residents, who were reported in the Phase 1 Assessment (Rutland Regional Planning Commission 2005) to have observed flood waters have been rising more quickly than in the past and in recent years appear to be causing more damage to crop lands.

In order to better understand the flood history of the Otter Creek, long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gauge on the Otter Creek in Rutland, VT (Figure 8) was obtained (United States Geological Survey 2007). The station, #04282000, is located approximately 200 feet downstream of the Mead Falls/OMYA dam and 500 ft upstream of the Route 4A bridge (Reach M21). The gage measures flow from an approximate drainage area of 307 square miles. Seventy-nine years of record are available for this gauge, which provides a continuous record of flow from 1929 through the present.

The Otter Creek generally has good access to its floodplain and floods at least once each year at spring runoff. The long term record at the Otter Creek gauge shows a 25 year flow was recorded in 1973 and 10 year flows have been recorded in 1947, 1949, 1976, 1977 and 1987. In 1938, during the New England Hurricane, the Otter Creek reached a peak of 13,700 cfs, the only flow greater than the 50 year flood stage measured on this gauge (which was not operational during Vermont's largest flood, 1927) (Vermont Agency of Natural Resources, 2007b). For more information, a detailed analysis of flooding history was contracted by the RRPC in 2006 and can be found in the 2006 Phase 2 Stream Geomorphic Assessment of the Upper Otter Creek (Underwood 2006).

It is safe to presume that future flooding and flood damage are a certainty. Preparation for and response to flood situations may have significant and long-lasting influence on whether flooding continues to be a cause of significant financial harm or whether it becomes a natural phenomenon that is ultimately a long-term expression of river stability and dynamism. It may possibly even become something to be celebrated for, under the right conditions, flooding can replenish nutrients in agricultural fields and, where wetlands are adjacent to streams, create temporary habitat for the reproduction of many aquatic and riparian species.

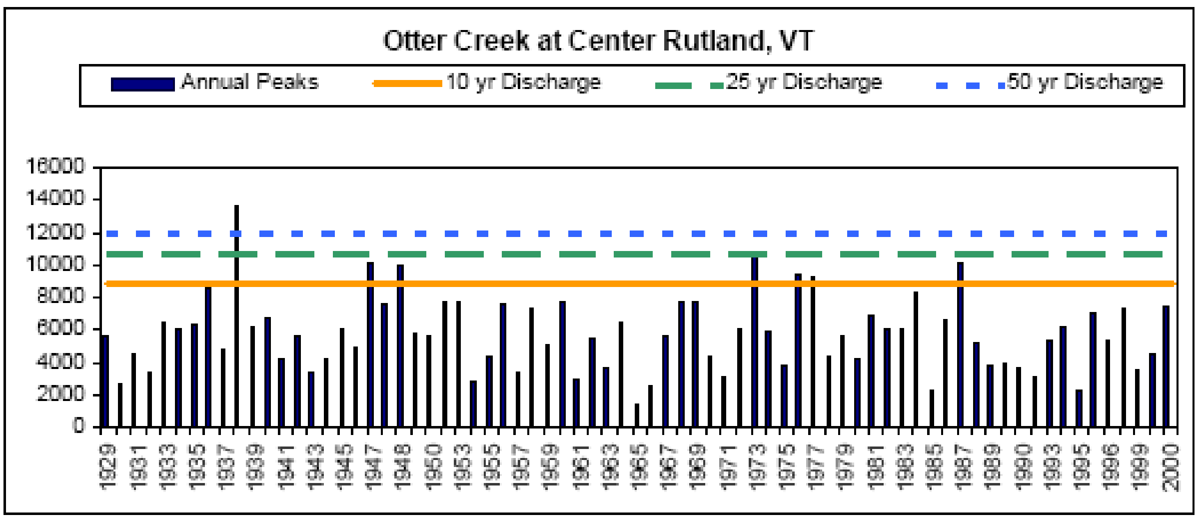


Figure 8: Flood frequency analysis for Otter Creek, Rutland, VT.

3.5 Ecological Setting

3.5.1 Distribution of In-stream, Riparian, and Wetland Habitats

Along the Upper Otter Creek and many streams throughout the Northeast forested riparian zones and buffers are crucial to maintaining stream health. They provide a variety of benefits that include human land use protection along stream banks, water quality improvement, and habitat for aquatic and terrestrial species.
Riparian habitat, the margin of transitional vegetation alongside a body of water, varies greatly in quality, diversity, and amount in the Upper Otter Creek. Impacts are heaviest in the villages due to dense residential and commercial development. In addition, where roads and railroads border the stream, vegetation tends to be disturbed and not as robust as if the

stream were meeting an unaltered floodplain. Wetland habitat, similarly, has suffered where development, roads, railroad tracks, and agriculture have altered the wetland areas that existed prior to settlement. Through these processes large woody debris in the stream is often seen as a nuisance due to its flooding potential and possible destruction of landowner property.

Much of the scientific literature, however points to the benefits of wider riparian corridors and large woody debris present in the stream. From a wildlife perspective, riparian buffers offer corridors for habitat and migration, while large woody debris provides habitat pools for aquatic life like fish (Magillian et al., 2008). From a geomorphologic perspective, forested riparian buffers improve bank stability and help control erosion (McBride et al., 2008). Also, large woody debris in streams helps maintain natural flow by providing high flow mitigation and acting as sediment traps. Finally, from a water quality perspective, riparian buffers help control nutrient cycles and shading helps control water temperatures (Figure 9) needed to sustain healthy ecosystems.

Along river corridors where human land uses are present the VTANR suggests riparian buffers that are at a minimum 50' for small streams and 100' for larger streams like the Otter Creek (Vermont Agency of Natural Resources 2005). They also make note that as riparian buffers increase in size the benefits to natural stream state and possible human benefits may also increase. A Riparian Buffer Assessment supported by the Rutland Natural Resources Conservation District was completed in 2005 on all reaches of the Upper Otter Creek in Rutland County. According to this assessment, 45% of the 56 miles assessed had buffers between 0-25 feet, 20% were between 25-50 feet, and the remaining 35% were greater then 50 feet. Clearly there exist along the Upper Otter Creek opportunities for better management and riparian restoration projects.

Habitat observations conducted during the Phase 2 Geomorphic Assessment work found that in-stream shelter varied in the Upper Otter Creek. Channel straightening and widening had in a few reaches (M28 and M27) reduced the habitat quality of the riffle-pool bedform of the channel. Additionally, fine sediments from bank erosion and surface water runoff from roads and other clearings have caused some loss of habitat as cobbles and gravels on the stream bottom become filled in. In many of the reaches with an "E" type channel, it was abundantly clear that large woody debris in the channel provided shelter, depth variation, and shade to an otherwise flat, sandy bottom. Overall, the habitat assessment results were similar to the geomorphic assessment results (indicating some declines in stream stability) implying that the ecological health of the Otter Creek is closely related to the geomorphic condition of the stream.

Figure 9: Reaches such as M18 are susceptible to thermal pollution due to lack of shading.

3.5.2 Unique Plant and Animal Communities

The Vermont Fish and Wildlife Department, Nongame and Natural Heritage Program's GIS data layer "Rare, Threatened and Endangered Species & Significant Communities" does, however, indicate the presence such in the Upper Otter Creek watershed, particularly in some of the tributaries and adjacent hillsides. Despite there being no indication of these species or communities on the main stem, care should be given by residents and developers within the Upper Otter Creek to protect local ecosystems and species, recognized or not.

4.0 METHODS AND RESULTS OF ASSESSMENT WORK

4.1 Fluvial Geomorphic and Structure Assessments

The following sections summarize the physical assessments that were carried out on the Otter Creek in support of this Phase 2 Geomorphic Assessment and Project Identification.

4.1.1 Phase 1 Geomorphic Assessment

A Phase 1 Stream Geomorphic Assessment looks at broad scale landscape data, historical data, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Upper Otter Creek was completed in 2004 by the Rutland Regional Planning Commission. The Phase 1 project report summarized the results of this work (Rutland Regional Planning Commission, 2005). The Phase 1 Assessment collected data from 27 subwatersheds. The study concluded that on these 27 reaches, floodplain modifications and land use changes were likely to have the greatest impact on stream stability. Impact scores by reach are depicted in Figure 10.

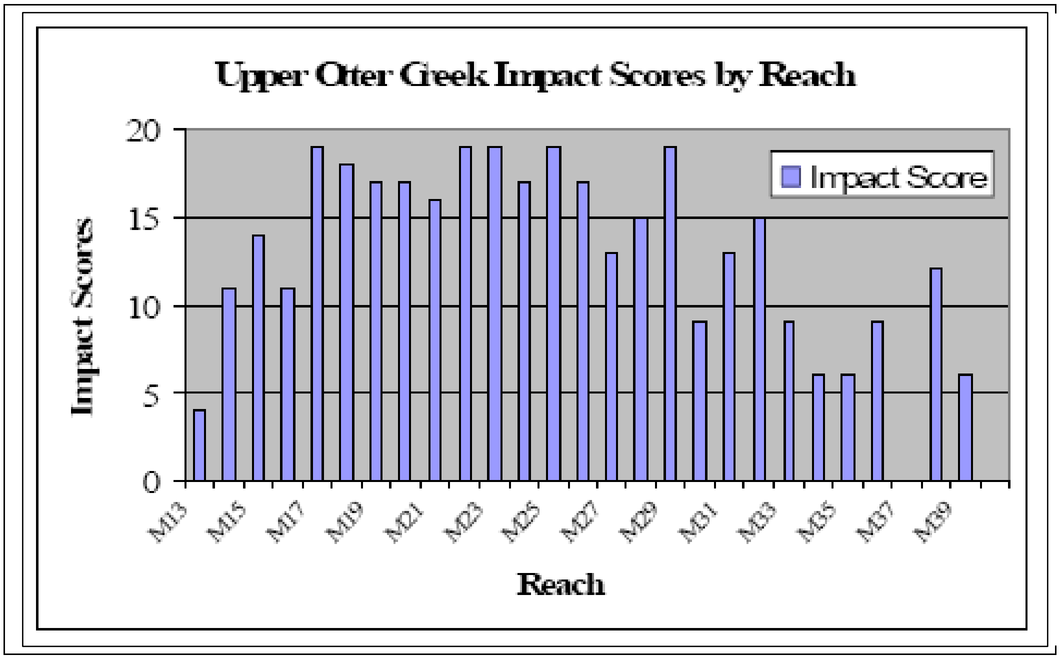


Figure 10: Phase 1 Impact Score results.

4.1.2. Phase 2 Geomorphic Assessment

The Phase 2 Fluvial Geomorphic Assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Phase 2 Handbook (Vermont Agency of Natural Resources 2007b). The Phase 2 Assessment focused on the mainstem reaches starting just south of the Danby/Wallingford town line (M31) downstream to Wallingford Village (M27) as well as the segment of river beginning at the confluence with the East Creek in Rutland (M21) downstream to the confluence with the Furnace Brook (M18). All assessment data were recorded on the Agency of Natural Resources Phase 2 field data sheets, and were entered in to the VTANR Stream Geomorphic Assessment online data management system (DMS) (https://anrnode.anr.state.vt.us/ssl/sga/index.cfm). The Phase 1 database was updated when necessary based on the field data collected during the Phase 2 assessment.

The most common adjustment processes observed in the Otter Creek during the Phase 2 Assessment were widening and planform migration as a result of channel straightening and the removal of riparian vegetation. A reach-by-reach summary of the Phase 2 data may be found in Appendix B.

4.1.3 Bridge Analysis

The need to cross the Otter Creek via bridge is imperative. The act of placing a bridge crossing over the river has historically involved constructing stone footers onto which rest timbers and later iron and steel. The footers (or abutments) were placed close enough together so that a single large timber could span from one side to the other. In a large stream such as the Otter Creek, these abutments were often narrower than the natural channel. This narrowing of the river becomes problematic when, during high flows, floodwaters back up due to the constriction. This causes flooding upstream of the bridge. This is worsened by debris that can accumulate at a constricted area including sediment which can accumulate upstream at unnatural locations further exacerbating instability. During flood conditions, pressure is altered on the downstream side of the bridge, like putting your thumb on the end of a garden hose. The extra energy causes erosion and leaves a wide scoured area downstream of the bridge

Physical changes such as straightening and constriction due to bridge supports keep a river from migrating naturally across the valley bottom. Projects which protect the banks from erosion can be successful, but often it is important to allow the river to meander and follow a natural path to restore stability. It is commonly observed that adding rock or other armor to banks at eroding sites can push erosion downstream. The river needs to migrate to dissipate energy; armoring one area will not necessarily fix an imbalance that extends up and downstream of that site. Removing constrictions will allow the river to return to natural flow paths and achieve a more stable condition. Many old bridge abutments and unused, failing bridges remain along the Upper Otter Creek today.

In order to assess the impact of these crossings, bridge assessments were completed for all permanent structures located on Phase 2 reaches in accordance with Appendix G of the Phase 2 Geomorphic Assessment Protocol (Vermont Agency of Natural Resources, 2007b). In total, twenty-one structures were assessed according to VTANR protocols for such characteristics as specific height and width, geomorphic and fish passage data, nearby vegetation, and evidence of wildlife. In addition, old bridge abutments no longer in use were identified.

During the Phase 2 Assessment, a number of bridges and culverts were observed to be considerably narrower than the existing bankfull width, subsequently causing instability in the river (Table 2). In particular need of removal, based on the problems observed and their percent bankfull width, are the numerous small iron and wood bridges that are no longer being used for farming purposes (Figure 11).

Figure 11: The abandoned bridge (M29) is similar to several nearly abandoned crossings that are likely to cause debris and ice jams and may washout and cause further damage in a future flood.

TABLE 2: UPPER OTTER CREEK BRIDGES: PROBLEMS AND POTENTIAL FAILURE MODES

Town	Reach #	Road	F1	F2	F3	F4	F5	F6	P1	P2	P3	P4	P5	P6	P7	Width
Clarendon		ALFRECHA RD	-	-	-	-	-	X	-	-	-	-	X	-	X	129 %
Clarendon		WALKER MOUNTAIN RD	-	-	-	-	-	-	-	-	-	-	-	-	X	102 %
Danby		Private	-	X	X	X	-	X	X	X	X	X	-	-	-	54 %
Pittsford		GORHAM BRIDGE RD	-	-	-	-	-	-	-	-	-	-	-	-	X	97 %
Proctor		Railroad	-	X	-	X	X	X	-	X	X	X	-	-	X	86 %
Proctor		MAIN ST	-	X	-	X	-	-	-	-	-	-	X	-	X	77 %
Rutland City		RIPLEY RD	-	-	-	X	-	X	-	X	-	-	-	-	X	104 %
Rutland Town		Railroad	-	-	-	X	-	-	-	-	X	-	X	-	X	203 %
Rutland Town		Railroad	-	-	-	-	-	-	-	-	-	-	-	-	X	99 %
Rutland Town		ROUTE 4 E	-	-	X	X	-	-	X	-	X	-	-	-	X	80 %
Wallingford		private farm road	-	X	X	X	-	X	X	X	X	X	X	-	-	32 %
Wallingford		farm access	-	X	X	X	-	X	-	X	X	-	-	-	X	37 %
Wallingford		Railroad	-	-	X	-	-	X	X	X	X	-	-	-	X	117 %
Wallingford		private farm road	-	X	X	X	-	X	-	X	X	-	-	-	-	34 %
Wallingford		private	-	X	X	X	-	X	-	X	X	X	-	-	-	39 %
Wallingford		private quarry access	-	X	X	X	-	X	-	X	X	-	-	-	X	44 %
Wallingford		Railroad	-	-	-	X	-	X	X	-	-	X	-	-	X	176 %
Wallingford		CREEK RD	-	X	X	X	X	X	X	X	X	X	X	-	X	75 %
Wallingford		ELM ST	-	X	-	X	X	-	-	-	-	-	-	-	X	70 %
Wallingford		HARTSBORO RD	-	-	-	X	-	X	X	X	-	X	-	-	X	110 %
Wallingford		HARTSBORO RD	-	X	X	X	X	-	-	X	X	-	X	-	X	73 %
Wallingford		ROUTE 140-EAST	-	-	-	-	-	-	-	-	-	-	-	-	X	108 %
Wallingford		US 7 S	-	-	-	X	-	X	-	-	-	-	X	-	X	429 %

Failure Modes

F1	Concern for structure due to fluvial condition or process
F2	Potential failure due to out-flanking
F3	Potential failure due to scour
F4	Potential failure due to ice or debris jam
F5	Structure related damage due to flooding of adjacent property
F6	Structure related damage due to erosion of adjacent property

Existing Problems

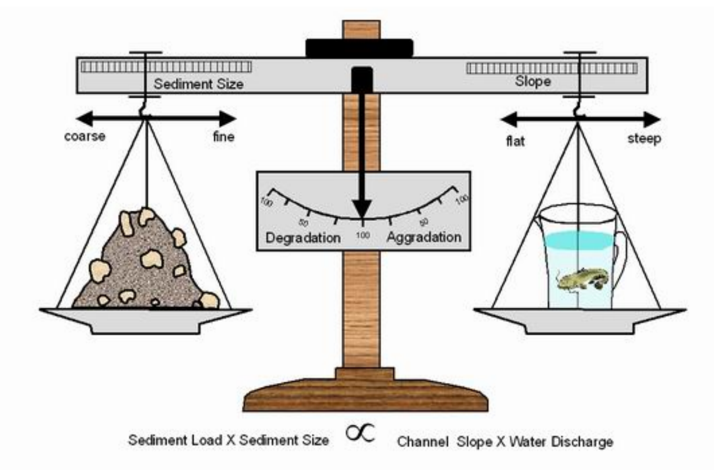
P1	Upstream sediment deposit
P2	Upstream Scour and/or erosion present
P3	Downstream Scour and/or erosion present
P4	Inlet obstruction present
P5	Poor location or alignment
P6	Beaver activity
P7	Floodplain filled entirely or partially by roadway approaches
Width	Structure width divided by channel width as a percent (% bankfull width)

4.2 Quality Assurance (QA) Review

The Phase 1 and 2 Geomorphic Assessment and Bridge and Culvert Survey were carried out in compliance with the VTANR Programmatic QAPP (VTANR, 2003). Round River Design performed a thorough in-house quality assurance (QA) review of the Phase 2 data in November of 2008. The DMS and the ArcView shapefiles for the Otter Creek Phase 2 study were submitted to Shannon Pytlik of the VTANR for a QA review in December of 2008. Shannon Bonney and Shannon Pytlik completed the QA review during the first week of December, 2008. Mapping of existing valley walls was conducted in support of fluvial erosion hazard zone development by Round River Design in accordance with the Vermont River Corridor Protection Guide (VTANR 2008).

5.0 FURTHER ANALYSIS: STRESSOR IDENTIFICATION, CHANNEL RESPONSE, AND SENSITIVITY

The science of fluvial geomorphology informs us that given consistent inputs (average annual precipitation and sediment input), every river has a single most probable form toward which it is constantly working (Leopold 1994). We also know that natural and anthropogenic impacts to a river channel or watershed may alter the equilibrium between sediment transport and water flow and may set in motion a series of morphological responses (aggradation, degradation, and widening and/or planform adjustment) as the channel works to reestablish a self-maintaining stable channel. These equilibrium-altering impacts may be small to moderate changes in slope, discharge, and/or sediment supply which can alter the size of transported sediment as well as the geometry of the channel; or they may be large-scale changes which may transform channel and floodplain interactions through entire reaches (up to several miles in length) (Ryan 2001).



The Lane Scale depicts how a change in sediment load, sediment size, channel slope, and/or the amount of water discharged may lead to channel degradation or aggradation.

Typically, channel adjustments fall into four major categories: degradation, aggradation, planform, and widening. Degradation (sometimes referred to as 'incision') is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment in the channel. The planform is the channel configuration as seen from above. Planform change may be a reaction to channel straightening (Figure 12), or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

Analysis of the impacts that have led to changes in the sediment regime, hydrology, and channel configuration and dimensions of the Upper Otter Creek, and therefore caused morphological adjustments such as those described above, is potentially useful for informing restoration and planning efforts and is the focus of section 5.1.

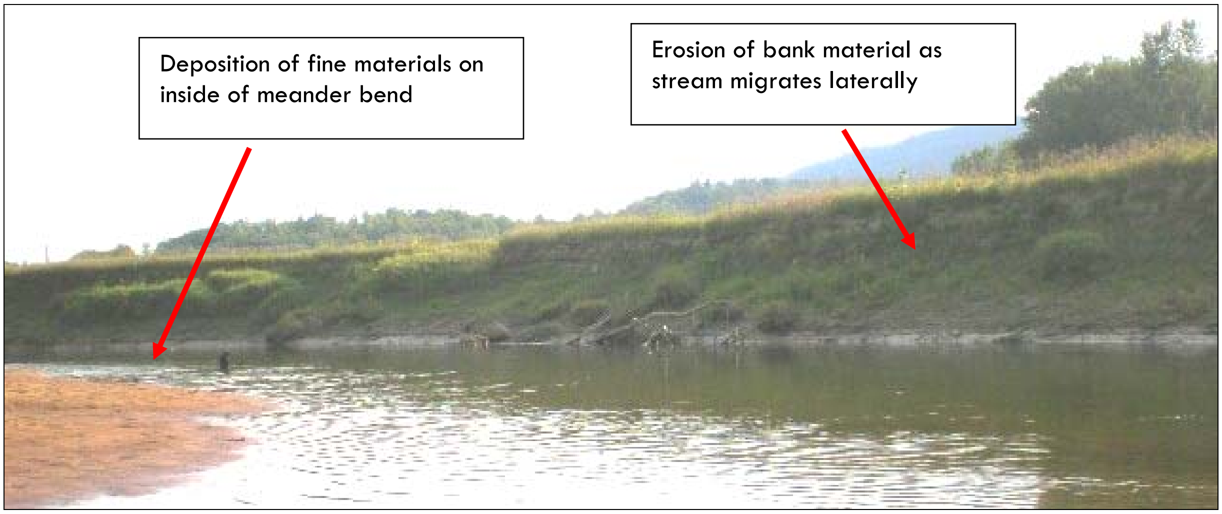


Figure 12: Planform migration associated with historic channel straightening of the Otter Creek.

5.1 Factors Influencing the Stability and Health of the Upper Otter Creek

Appendix C is comprised of maps depicting some of the factors influencing the stability of the Upper Otter Creek.

5.1.1 Alterations to the Hydrologic Regime of the Upper Otter Creek

The hydrologic regime of a watershed refers to the timing, volume, and duration of runoff events that have, over time, influenced the shape and physical form of a river channel. It is influenced by climate, soils, geology, groundwater inputs, vegetation, riparian areas, and valley and stream shape. When the hydrologic regime of a watershed is significantly altered a river channel will adjust (e.g., increased stormwater flows result in consistently higher volumes of water passing through a channel and lead to channel degradation and incision).

While the significant deforestation that occurred in Vermont watersheds in the 19th century may still be influencing the watershed, a number of more easily discernable hydrologic stressors are impacting the Upper Otter Creek today. As depicted in Appendix C, Figures 1 and 2, stormwater inputs from roads, drainage ditches, and impervious surfaces are numerous in some reaches of the Upper Otter Creek, particularly from field and road ditches and nearby the developed landscapes of Wallingford and Rutland City. These inputs hasten the timing and amount of water entering the channel during a runoff event and may contribute to localized channel enlargement and flooding (as described in section 3.4).

Another significant impact to the hydrologic regime of the Upper Otter Creek watershed may be alterations to the land use and land cover of the region. Specifically, the transition of land from forest to field and the loss of wetlands cause a decrease in soil and floodplain storage and an increase in surface water runoff (Appendix C, Figure 3). According to the VTANR River Corridor Planning Manual (VTANR 2007a), recent studies in Burlington and Saint Albans show that major channel adjustment and biological impacts are associated with watersheds that have over 5% impervious cover.

5.1.2 Alterations in the Sediment Regime of the Upper Otter Creek

Understanding sediment transport and its role in stream stability and habitat is critical for successful river corridor planning and restoration. During high flows, small sediments are easily transported and deposited where low velocities are found (typically the inside of a bend or the floodplain). When floodplains do not exist or are inaccessible and where bends have been removed through straightening, fine sediments may be transported long distances. As fine materials have the highest concentration of nutrients and organic material, the absence or overabundance of fine sediment in a stream system can have great impacts on the aquatic biology (VTANR 2007a).

Along the bottom of a stream the larger cobbles and gravels slide and tumble along during high water events. In a stable stream these larger particles are transported and sorted according to variations in stream power associated with slope, depth, and width. Disruptions in the transport of these larger particles either through increasing stream power (e.g. channel straightening, berming) or decreasing stream power (e.g. channel constricting bridges, gravel extraction) can have a significant affect on the stability and habitat of a stream and at worse may cause undesirable erosion and flood hazard issues.

Where excessive erosion, adjusting tributaries, channel widening, and/or planform adjustments are occurring, sediment deposits are often formed as a river works to transport and redistribute these excessive sediment additions. Figures 4 and 5 in Appendix C are maps depicting the number of sediment deposition features found in each reach of the study area. In the Upper Otter Creek, higher rates of depositional features (e.g. gravel bars) are found in reaches with wide floodplains and some degree of natural channel movement. Reaches locked into bedrock gorges or which have been artificially straightened tend to transport sediment through the channel rather than store it.

5.1.3 Modification of Channel Depth and Slope of the Upper Otter Creek

Historic alterations of stream channels in post-flood cleanup efforts and for land use purposes have had great impacts on most Vermont Rivers. The Upper Otter Creek is no exception. Impacts from channel straightening affect nearly all of the reaches. Three of the reaches are nearly 100% straightened (M28, M21, and M18) (Appendix C, Figures 6 and 7). Channel straightening increases the slope and therefore the power of a stream – this increase in stream power is typically followed by channel incision and eventually widening. Additionally, encroaching development onto the floodplain of the Otter Creek, as well as berming or other developments such as roads and railroads, effectively raise the bank height, which increases channel depth and thereby increases the erosive power of the stream channel. Increased erosive power creates a detriment locally as well as increases the potential for catastrophic fluvial erosion downstream. Floodplain encroachment is a common phenomenon along the Upper Otter Creek as depicted in Appendix C, Figures 8 and 9.

5.1.4 Modification of Streambank and Riparian Conditions along the Upper Otter Creek

River adjustment processes are tempered by the material (cohesiveness) of the banks themselves as well as the naturally occurring vegetation that binds soils and resists the erosive energy of a stream. Changes in the condition of a streambank from such activities as riparian vegetation removal and rock armoring may increase stream power resulting in channel adjustments such as widening and planform adjustment. Riparian forests that have been reduced to less than 25 feet in width are depicted in Appendix C, Figures 10 and 11.

5.1.5 Constraints to Sediment Transport and Attenuation

The analysis of sediment transport regimes is based on methodology outlined in the VTANR River Corridor Planning Guide (2007a) which assists in the identification of the reference and altered sediment regimes of reaches based on the Phase 2 Assessment data. The sediment regime types used in this analysis are summarized below in Table 3. Figures 19 and 20 of this report have been provided to assist in understanding where sediment transport areas have been increased and attenuation areas have been lost in the Upper Otter Creek Watershed. Table 4 has also been provided to summarize all of the stream and watershed stressors and to assist in understanding why these changes in sediment transport capacity have occurred.

TABLE 3: Sediment Regime Definitions

	Narrative Description
Transport	Steep bedrock and boulder cascade type streams; confining valley walls, comprised of bedrock, till, and large glacial erratics, do not supply appreciable quantities of sediments to downstream reaches on an annual basis; little or no mass wasting; storage of fine sediment is negligible due to high transport capacity derived from both the high gradient and/or entrenchment of the channel.
Confined Source and Transport	Cobble step pool and steep plane bed type streams; confining valley walls, comprised of erodible tills, glacial lacustrine, glacial fluvial, or alluvial materials; mass wasting and landslides common and may be triggered by valley rejuvenation processes; storage of coarse or fine sediment is limited due to high transport capacity derived from both the gradient and entrenchment of the channel. Look for streams in narrow valleys where dams, culverts, encroachment (roads, houses, etc.), and subsequent channel management may trigger incision, rejuvenation, and mass wasting processes.
Unconfined Source and Transport	Sand, gravel, or cobble plane bed type streams; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to entrenchment or incision and associated bed form changes; these streams are not a supply of sediments due to boundary resistance such as bank armoring, but may begin to experience erosion and supply both coarse and fine sediment when bank failure leads to channel widening; storage of coarse or fine sediment is negligible due to high transport capacity derived from the deep incision and little or no floodplain access for the channel. Look for straightened, incised or entrenched streams in unconfined valleys which may have been bermed and extensively armored and are in Stage II or early Stage III of channel evolution.

Fine Source and Transport **Coarse Deposition**	Sand, gravel, or cobble streams with variable bed forms; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to vertical profile and associated bed form changes; these streams supply both coarse and fine sediments due to little or no boundary resistance; storage of fine sediment is lost or severely limited as a result of deep channel incision and little or no floodplain access; an increase in coarse sediment storage occurs due to a high coarse sediment load coupled with the lower transport capacity that results from a lower gradient and/or channel depth. Look for historically straightened, incised or entrenched streams in unconfined valleys, having little or no boundary resistance, increased bank erosion, and large unvegetated bars. These streams are late Stage III and Stage IV of channel evolution.
Coarse Equilibrium (in = out) **Fine Deposition**	Sand, gravel, or cobble streams with equilibrium bed forms; at least one side of the channel is unconfined by valley walls; these streams transport and deposit coarse sediment in equilibrium (stream power—produce as a result of channel gradient and hydraulic radius—is balanced by the sediment load, sediment size, and channel boundary resistance); storage of fine sediment as a result of floodplain access for high frequency (annual) floods. Look for unconfined streams which are not incised or entrenched, have boundary resistance (woody buffers), minimal bank erosion, and vegetated bars. These streams are Stage I, late Stage IV, and Stage V of channel evolution.

Figures 19 and 20 indicate that the entire main stem of the Upper Otter Creek examined in this Phase 2 study had (in its pre-settlement state) the capacity to store fine sediments in the floodplain and to transport the normal balance of sands, gravels, and cobbles downstream at a rate that was in balance with the inputs coming from the highest sources in the watershed thus leading to long- term channel and habitat stability. Analysis of the existing sediment regime maps (on the right side of Figures 19 and 20) indicate that several sections of the Upper Otter Creek have lost their ability to store coarse and fine sediments and are now "transport" reaches.

Fortunately much of the Otter Creek does still have floodplain access and is still able to store much of its sediment. Unfortunately, this overall stable sediment regime is not the case in many of the tributaries to the Upper Otter Creek. For instance, "Excessive sediment contributions and an apparent reduction in sediment transport capacity are noted in the vicinity of the Mill River confluence with the Otter Creek." It is thought that this sediment may "tip the balance" of stable conditions in the Otter Creek if left unchecked (Underwood 2006).

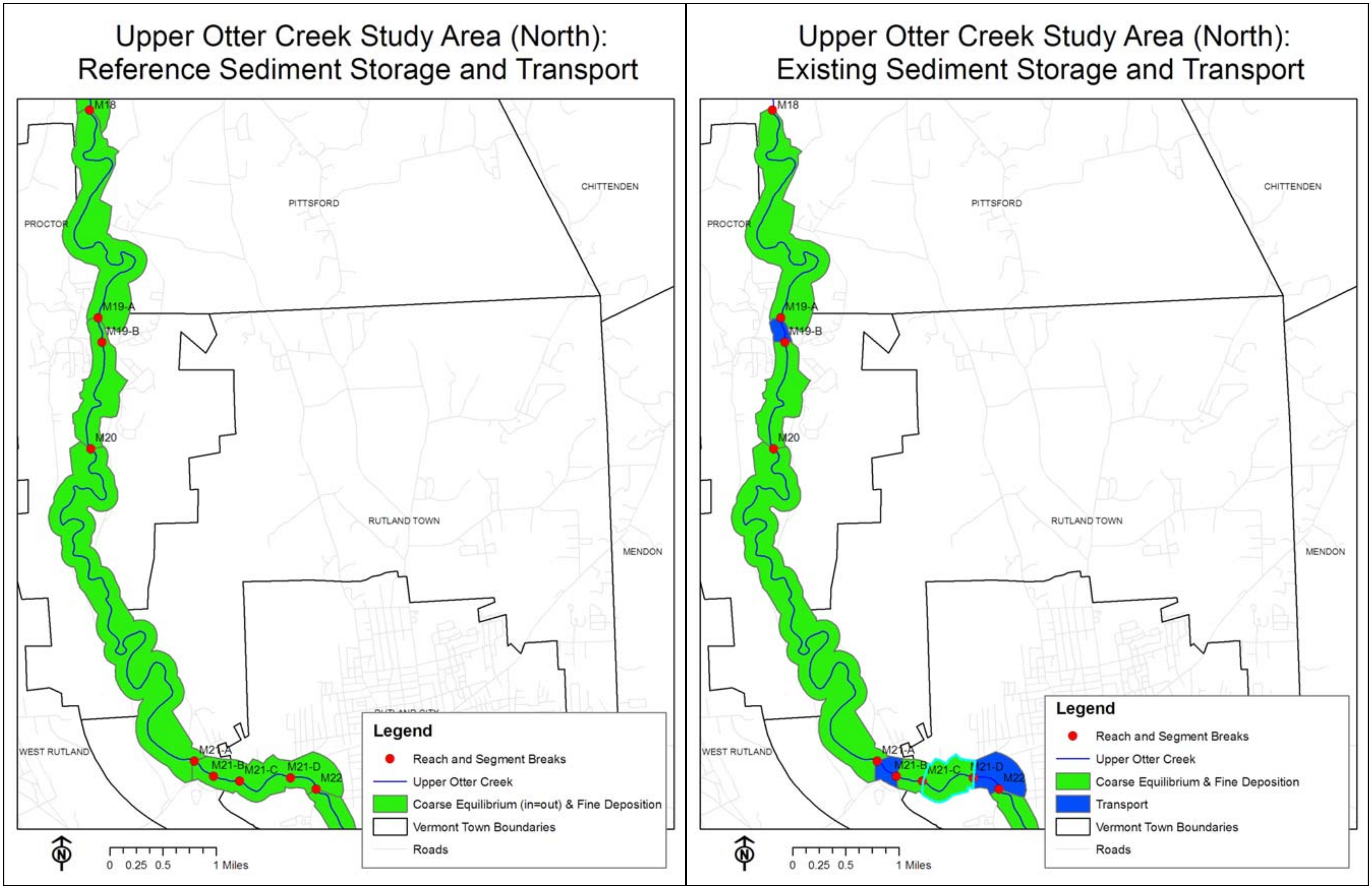


Figure 19. Sediment Transport and Attenuation Reference and Existing Upper Otter Creek conditions.

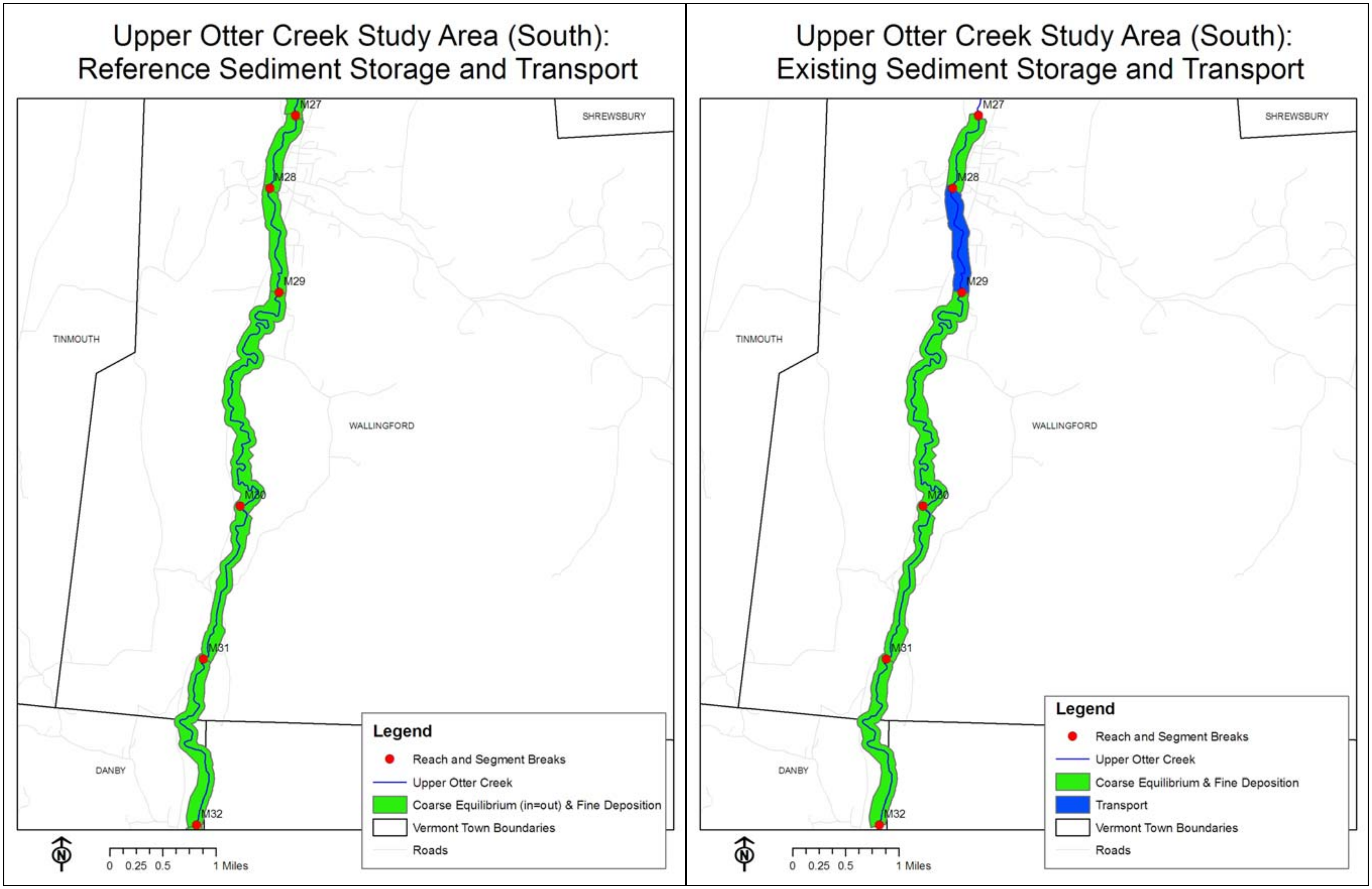


Figure 20. Sediment Transport and Attenuation Reference and Existing Upper Otter Creek conditions.

Table 4: Watershed, Floodplain, and Channel Stressors

	Watershed Stressors			Floodplain and Channel Stressors						
Segment Number	**Deforestation in the 1800's**	**Increased Road Networks (1800-1900's)**	**Historic Flood Events**	**Channelization/Straightening**	**Bank Armoring**	**Floodplain Development**	**Loss of Forested Buffers**	**Impoundment (current and historic)**	**Undersized Bridge/Culvert**	**Stormwater Inputs**
M31	↓	↓	↓	√	√	√	√		√	√
M30	↓	↓	↓	√	√	√	√	√	√	√
M29	↓	↓	↓	√	√	√	√		√	√
M28	↓	↓	↓	√	√	√	√	√	√	√
M27	↓	↓	↓	√	√	√	√	√	√	
M21-D	↓	↓	↓	√	√	√	√	√		
M21-C	↓	↓	↓	√	√	√	√			√
M21-B	↓	↓	↓	√	√	√	√	√		√
M21-A	↓	↓	↓	√	√	√	√			
M20	↓	↓	↓	√	√	√	√			√
M19-B	↓	↓	↓	√	√	√	√	√		
M19-A	↓	↓	↓		√	√	√			
M18	↓	↓	↓	√	√	√	√			√

5.2 Understanding Channel Response to Disturbance

The information presented in section 5.1 indicates that a large number of watershed and channel stressors are affecting the Upper Otter Creek. Because the stability of a stream channel is based on maintaining a certain flow of water and sediment and shape and slope of the channel, when any of these change significantly, the river channel must change, typically resulting in erosion of the stream bed or banks, or a filling of the channel with sediment.

As a result of channel straightening much of the channel slope of the Upper Otter Creek has increased. One of the most common channel responses to an increase in channel slope is degradation. Once a stream begins to incise, it will typically erode its way through a predictable evolution process until it has created a new floodplain at a lower elevation in the landscape. The common stages of channel evolution (as shown below in Figure 21 and reported in more detail in Appendix D), include:

- A pre-disturbance period (I)
- Incision – Channel degradation (cutting of stream into the channel bed) (II)
- Aggradation (sediment build up in the bed) and channel widening (III-IV)
- The gradual formation of a stable channel with access to its floodplain at a lower elevation. (V)

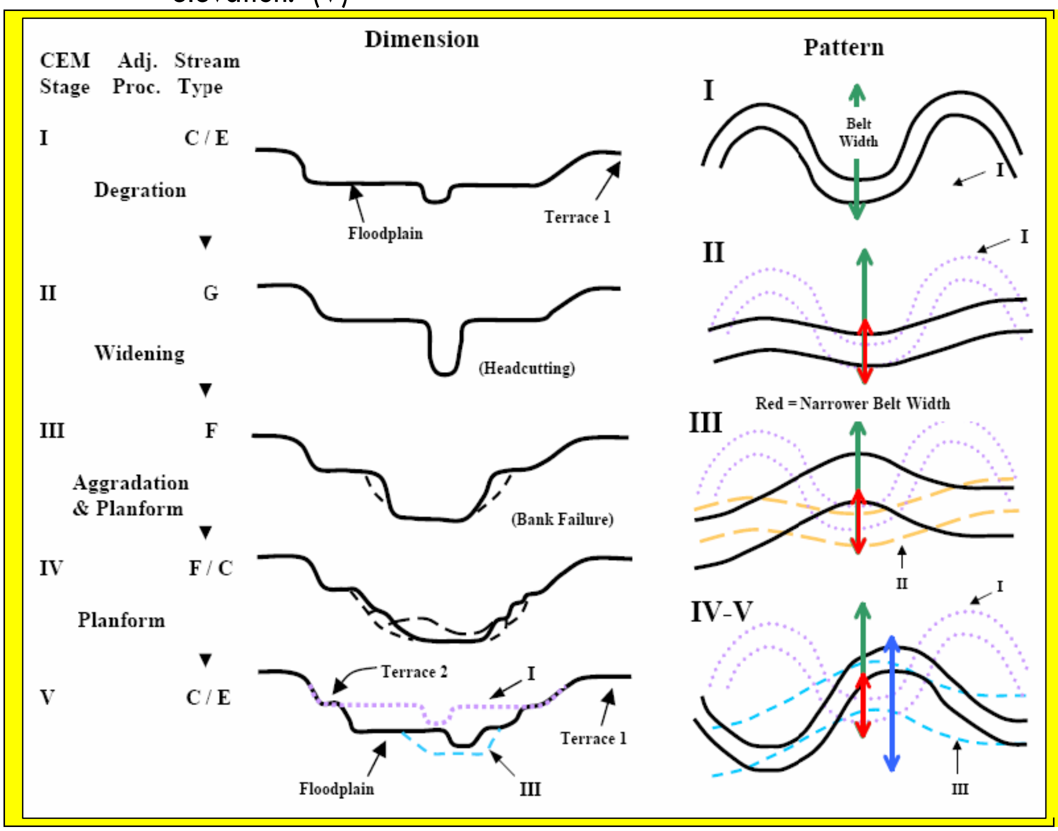


Figure 21. F-stage Channel Evolution Process (from Vermont Agency of Natural Resources, 2006)

While this bed degradation process is occurring on many of the tributaries (adding eroded sediments to the Otter Creek) bed degradation *is not a dominant process in the Upper Otter Creek mainstem study area.* Instead, where steeper stream gradients are imposed through activities such as channelization (which is prevalent here) the channel does not incise as in the previous model, but for other reasons retains access to its floodplain (remaining a "C" or "E" Stream Type). In these reaches, the channel is likely to widen and migrate laterally through bank erosion caused by the increased stream power. This increase in stream power will is likely to temporarily create a stream bed which may be a combination of poorly defined riffle-pool and plane bed features. The balance between stream power and boundary materials is re-established when the slope flattens after a process of channel lengthening (through planform migration) and increased sinuosity.

It is important to note that channel evolution processes may take decades to play out and may not only affect areas immediately adjacent to evolving channels. Even landowners that have maintained forests along their stream and riverbanks may experience eroding banks, sedimentation, and migrating channels, as the river responds to alterations up or downstream (Figure 22).

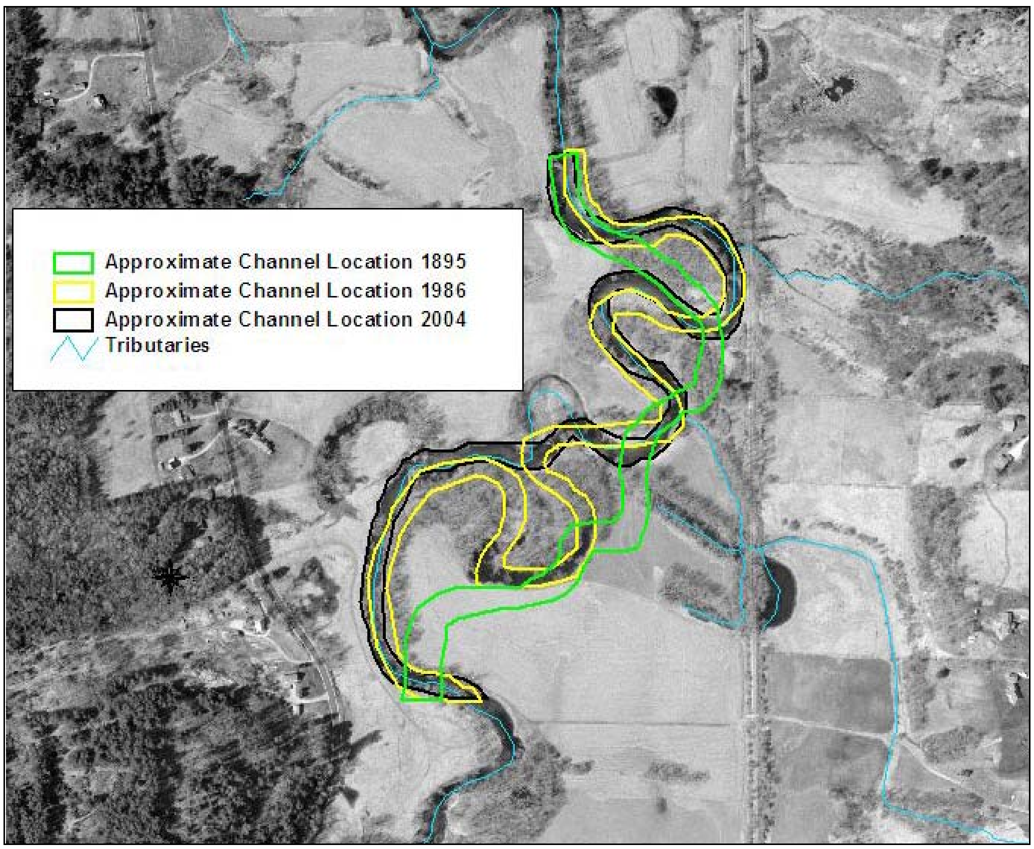


Figure 22: Meander patterns in the Upper Otter Creek in Clarendon.

After a channel straightening process it may be difficult for streams to attain equilibrium where the placement of roads and other infrastructure has resulted in little or no "wiggle room" for the stream (such as in reaches M28, M27, M21, and M19-B). Making matters worse, landowners and government agencies have repeatedly armored and bermed many of Vermont's rivers to contain floodwaters in channels. These efforts have proven to be temporary fixes at best, and in some cases have lead to disastrous property losses and natural resource degradation.
Field research conducted during the Phase 2 assessment indicates that several of the reaches are actively, or have historically, undergone a process of minor or major geomorphic

adjustment. In many reaches the channel has undergone historic straightening. As indicated, the response in the Otter Creek has been widening and planform adjustment which are both leading to another adjustment process, aggradation. Aggradation in the Otter Creek study area is likely a combination of endogenous sediment that is created as the stream widens and erodes its banks in response to channel adjustments as well as from exogenous sources such as gravel roads and land clearing. Table 5 below summarizes the channel evolution of each study reach and the primary adjustment processes that are believed to be occurring.

Table 5. Stream Type, Active Adjustment Processes, and Channel Evolution Stage

Segment Number	Incision Ratio	Entrenchment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Active Adjustment Process
M31	1.17	11.6	16.2	C	C	I	Degradation, Aggradation, Widening Planform
M30	1.09	4.02	20.87	C	C	I	Degradation, Aggradation, Widening, Planform
M29	1.06	16.88	13.3	E	E	I	Aggradation **Widening, Planform**
M28	2.2	4.22	21.9	E	C	I	**Degradation**, Aggradation **Widening**, Planform
M27	1.00	8.10	14.17	C	C	I	Degradation, Aggradation Widening, **Planform**
M26-B	ND	ND	ND	*E*	*E*	I	Aggradation, Widening Planform
M26-A	1.00	4.94	10.11	*E*	*E*	I	Aggradation, Planform
M25	1.00	8.95	9.01	*E*	*E*	I	Aggradation, Widening Planform
M24	1.00	22.73	9.50	*E*	*E*	I	**Planform**
M23	1.00	5.46	11.58	*E*	*E*	I	Widening, Planform
M22	1.00	23.13	7.90	*E*	*E*	I	None
M21-D	ND	ND	ND	C	C	I	Not Assessed
M21-C	1.14	2.92	37.17	C	C	II	**Degradation**, Aggradation Widening, Planform
M21-B	ND	ND	ND	C	C	I	Not Assessed
M21-A	2.2	1.87	22.89	C	B	I	**Degradation**, Aggradation, Widening, Planform
M20	1.09	8.03	8.16	E	E	I	Degradation, Aggradation Widening, Planform
M19-B	ND	ND	ND	E	E	I	Not Assessed
M19-A	ND	ND	ND	F	F	I	Not Assessed
M18	1.00	26.70	9.23	E	E	I	Aggradation, Widening Planform

Bold Red lettering - denotes extreme adjustment process
Bold Black lettering – denotes major adjustment process
ND = No data

5.3 Stream Sensitivity

As Section 5.1 described, there are numerous watershed and reach-level stressors that have affected the Otter Creek. In response, the Otter Creek has undergone and continues to undergo reasonably predictable channel adjustments as described in section 5.2. As we move towards managing restoration and future development in the Otter Creek watershed it is important to understand that certain areas of the river may be more or less sensitive to management and development activities in the channel and floodplain. "Stream sensitivity" refers to the likelihood that a stream will morphologically respond to a watershed level or reach level stress, such as; floodplain encroachment, channel straightening, berming, armoring, changes in sediment or flow inputs, disturbance of riparian vegetation, and even in-channel restoration efforts meant to stabilize the channel. A stream's inherent sensitivity is based on a host of factors including the relative magnitude of channel adjustments occurring together with the topographic, geologic, and vegetative context that surrounds the reach. The existing sensitivity of a given reach may be increased when human activities alter the characteristics that influence a stream's natural adjustment rate including changes to the: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially those undergoing degradation or aggradation, may become acutely sensitive to stress (Vermont Agency of Natural Resources 2007a).

In Vermont, it can be generalized that steeper mountain streams with large bottom substrates (boulders and cobbles) are less sensitive to rapid channel adjustment (such as reach M30) than those gravel and sand dominated stream channels that have low slopes (<3%) and therefore less ability to transport sediments received from upstream (such as much of the Upper Otter Creek). These more sensitive channels often have highly-erodible soils and are more sensitive to increases and decreases in stream power that may occur from channel and floodplain alterations and/or changes in sediment supply (increase or decrease).

The stream sensitivity of the Upper Otter Creek, categorized by segment according to ANR protocols, is depicted in Table 6 and in Figure 23 and 24. Predominately, the Phase 2 Geomorphic Assessment purposefully studied reaches that would be expected to exhibit a higher sensitivity and be undergoing active adjustments. It is not surprising therefore that most of the study area reaches were defined as having high or very high sensitivity. The exception being the bedrock controlled reach, M19-B, which has a greater resistance to rapid adjustment due to the bedrock bed and banks (and therefore a low sensitivity).

Incorporating stream sensitivity data into management and restoration activities is critical. In general, highly sensitive stream types should be approached with great caution before engaging in direct in-channel restoration activities. Often these highly sensitive reaches may be better protected by reducing upstream, in-channel, and corridor stressors. Less sensitive channels may be better candidates for in-stream channel restoration activities and floodplain restoration projects as these channels tend to have a high tolerance for change.

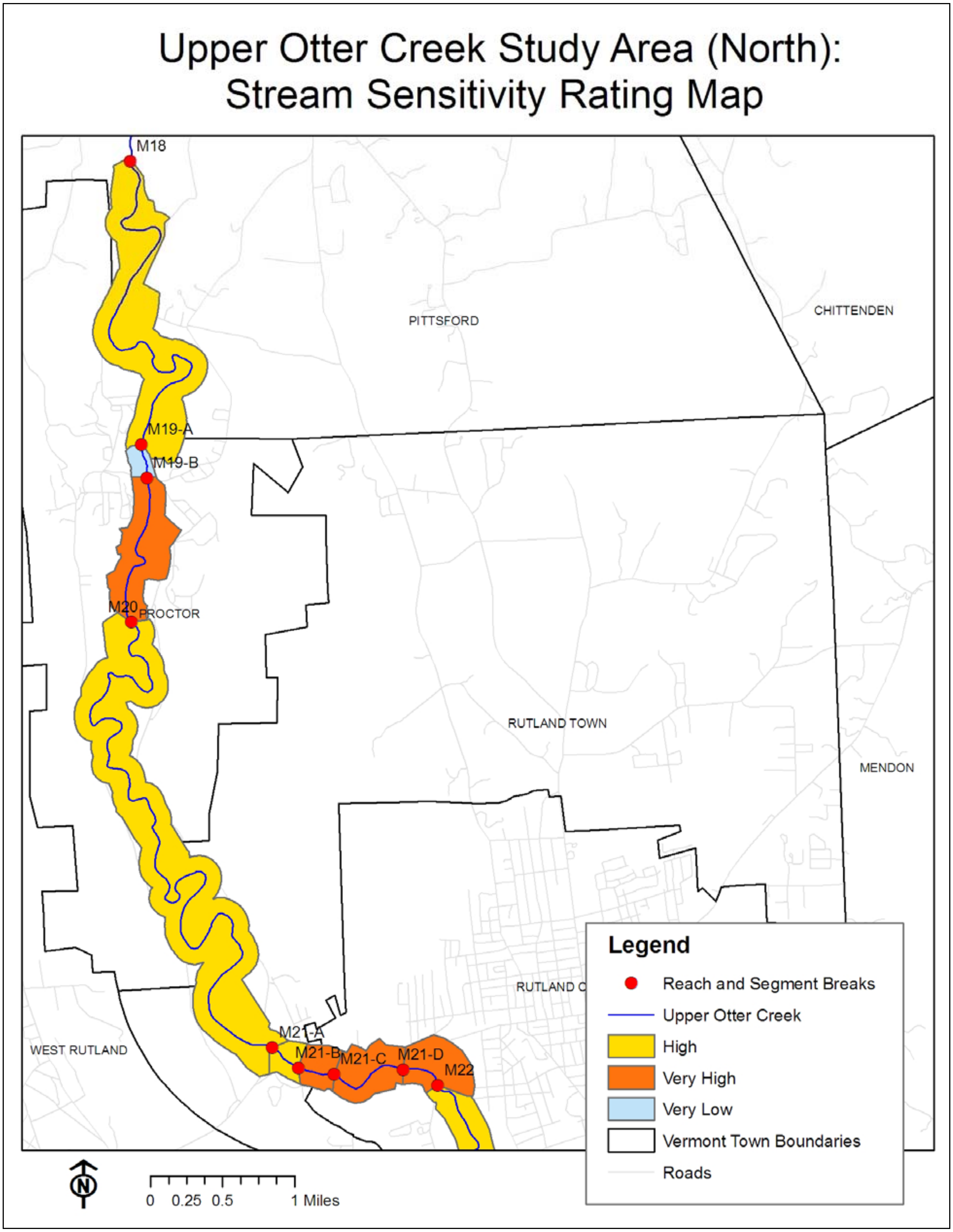


Figure 23: Upper Otter Creek (North Section) Stream Sensitivity Map

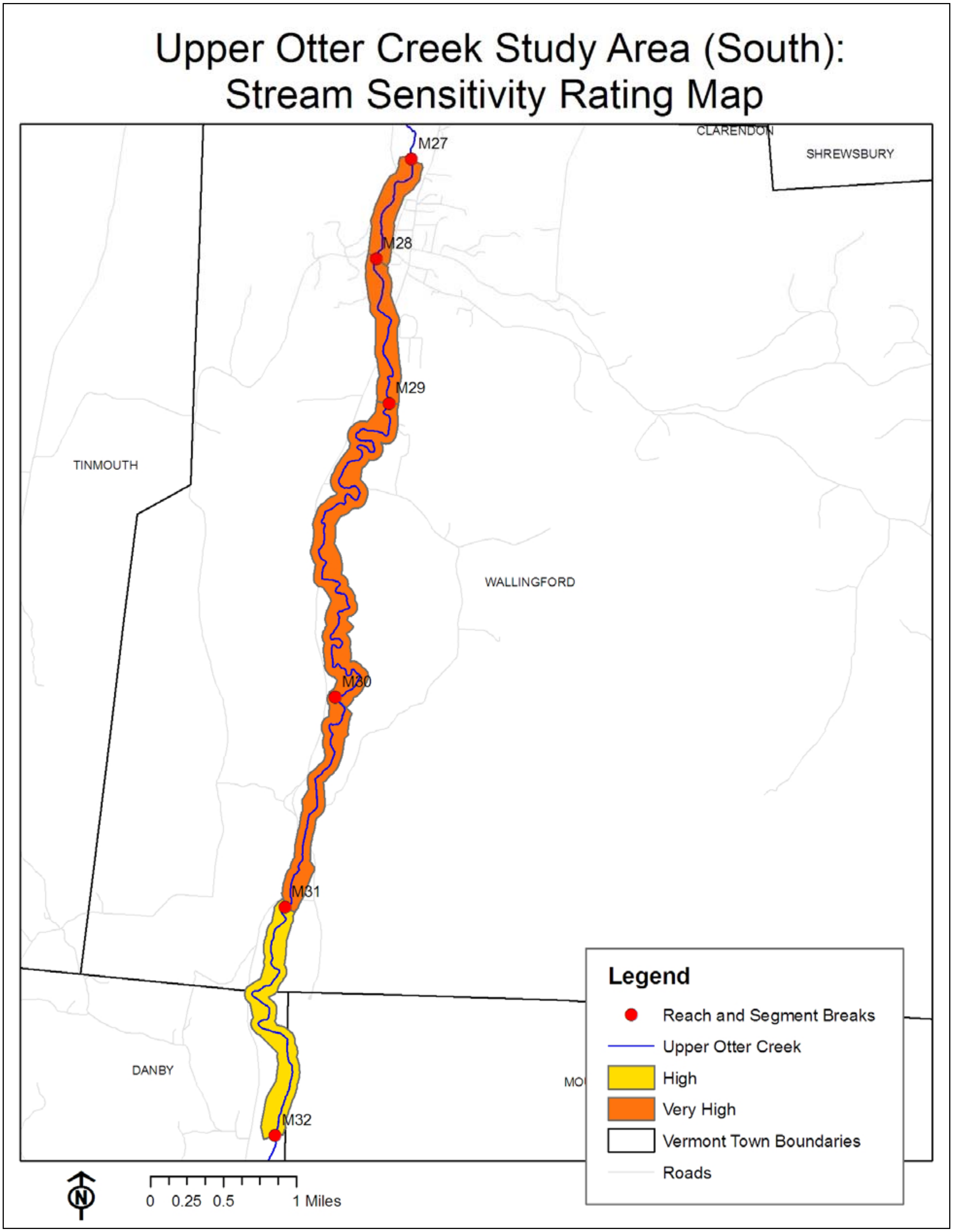


Figure 24: Upper Otter Creek (South Section) Stream Sensitivity Map

Table 6. Stream Sensitivity for Phase 2 Reaches

Segment Number	Reference Stream Type	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
M31	C	C	None	Good	High
M30	C	C	None	Fair	Very High
M29	E	E	None	Fair	Very High
M28	E	C	E to C	Fair	Very High
M27	C	C	None	Fair	Very High
M26-B	*E*	*E*	None	Good	High
M26-A	*E*	*E*	None	Good	High
M25	*E*	*E*	None	Good	High
M24	*E*	*E*	None	Good	High
M23	*E*	*E*	None	Good	High
M22	*E*	*E*	None	Reference	High
M21-D	C	C	None	Fair*	Very High*
M21-C	C	C	None	Fair	Very High
M21-B	C	C	None	Fair*	Very High*
M21-A	C	B	C to B	Fair	High
M20	E	E	None	Good	High
M19-B	E	E	None	Fair*	Very High*
M19-A	F	F	None	Reference*	Low*
M18	E	E	None	Good	High

*Partial Assessment – Administrative judgment made regarding geomorphic condition and sensitivity

6.0 PROJECT IDENTIFICATION

As outlined in the preceding sections, riparian landowners, community members, town planners, and agency personnel from State and Federal resource groups would all benefit from having a holistic perspective of watershed processes and the stressors that lead to instability in these systems. Concurrently, knowledge and awareness of factors that lend to system stability is also desired. Consideration of these complex interactions with an eye toward implementing various restoration, conservation, and planning options will affect future land use and channel management activities for the long term benefit of the community.

Recommended corridor restoration and protection initiatives have been identified based on the remotely-sensed observations of channel and floodplain stressors (Section 5.1), coupled with the field observations collected during the Phase 2 Geomorphic Assessment (summarized for each reach in Appendix A). This data was processed to determine stream types, adjustment processes, and channel evolution stages (Section 5.2). From this information, the sensitivity of each reach and segment was derived (Section 5.3). And here finally a step-wise procedure for identifying projects which would be consistent with the goal of managing a stream toward equilibrium condition (VTANR 2007a) was enacted.

It should be noted that, while the focus of this report has been on developing management decisions based on geomorphic information, social and fiscal opportunities must be taken into account as well as landowner interests. Adding this information to the equation may present possibilities for collaborative and synergistic projects not envisioned within this document.

Recommended initiatives have been prioritized for implementation yet many of the recommendations (e.g., buffer plantings) can be considered for immediate implementation, independent of other watershed projects.

6.1 Watershed Level Opportunities

Often many reach level problems may be best addressed through watershed-level, community-initiated strategies that seek to address the 'source' of a problem and consider that in watersheds, top-down problem-solving is often the only long-term solution. These large-scale watershed efforts may be initiated through local governments and/or community organizations, such as the Upper Otter Creek Watershed Council. They may also be embraced and driven by local residents that are inspired through demonstration projects or other outreach efforts.

Watershed scale strategies that would benefit the Upper Otter Creek include:

- The establishment and protection of riparian buffers along the entire river corridor.
- On-site stormwater management retrofitting for all existing residential and commercial building sites and implementation of low-impact design (LID) techniques for all future development.
- Replacing and/or retrofitting undersized bridges and culverts and ensuring all new structures are sized for geomorphic stability.
- Practicing soil conservation and erosion control practices (AMP's and BMP's) on all agricultural land, logging operations, construction and other sites where soil is disturbed.
- Floodplain and river corridor planning and protection (such as adoption of Fluvial Erosion Hazard zones, stream setbacks, wetland regulations, etc.) to reduce further floodplain encroachment.

6.2 Reach Level Projects

Reach level projects are based on conditions specific to the given reach, though they are also considered in the context of upstream and downstream impacts. These projects are especially appropriate where the disturbance extends along the entire reach and/or where land ownership is dominated by a few key stakeholders that are able to easily enact large-scale land management decisions. This Phase 2 Report includes detailed descriptions of individual reaches (Appendix B) as well as the preliminary identification of reach-specific projects (Table 7).

Reach level projects on the Upper Otter Creek fall under one of the following:

- Protect River Corridor
- Restoration of riparian buffers
- Replacement or removal of undersized structures

6.3 Site Specific Project Priorities

Site specific projects were distinguished from reach level opportunities utilizing guidance from the VTANR River Corridor Planning Guide (2007a). Compiling information from a step-wise analysis of each reach along with field observations collected during the Phase 2 Assessment, Round River Design identified seven site specific priority projects (Table 8). These projects have been briefly evaluated for technical, social, and financial feasibility.

It is important to note that these projects affect private landowners. The RNRCD and the VTANR are looking for landowners to partner with in order to implement these important projects.

7.0 NEXT STEPS AND IMPLEMENTATION

7.1 Single and Multiple Landowner Project Implementation

While historic stream protection efforts have focused on addressing individual landowner concerns, it is the hope of the watershed planning team that this document will help landowners see their land in a watershed context. Certain restoration and protection measures may be highly influenced by upstream challenges as well as important in reducing problems transferred to downstream landowners. The key to developing a mutually beneficial relationship with the river is implementing future restoration and protection efforts with system dynamics in mind. The goal is that the Upper Otter Creek will be managed to achieve a dynamic, geomorphically stable stream channel in the future that is able to attenuate and transport its sediments in balance; access floodplains adequately without causing significant damage to property or life; and maintain a healthy ecology and acceptable water quality for future generations to enjoy.

7.2 Watershed Resident Participation

Despite the efforts that may be made towards site specific riverfront projects, the long-term health and vitality of the Upper Otter Creek relies on the residents of the watershed and whether they choose to collectively engage in land use practices that care for the river. Strategies that provide incentives for landowners and residents to engage in watershed stewardship may be effective as may be educational efforts that create a community and sense of place directly connected with the Upper Otter Creek. Community-based watershed associations have a long history of successfully implementing grassroots initiatives that bolster local watershed stewardship. Such an organization may prove highly beneficial to the long-term management of the Upper Otter Creek. Additionally, town projects that ensure public access to the river may be important in developing connections between the river and the community. At the same time, educational efforts that create connections with the community youth and the watershed have also been found to be valuable in developing a long-term watershed stewardship ethic.

7.3 Town and State Implementation

Implementation of restoration activities along the Upper Otter Creek will greatly rely on the inherent ability of Towns and the State to garner expertise and funding. It will also be important for Towns and the State to develop strong collaborative relationships with streamside landowners.

At the town level, priority opportunities include:

- Management of town roads, culverts, crossings, and ditches in ways that protect water quality, prevent excess sediment from entering the Upper Otter Creek, and allow the stream to pass under without creating instability.
- Adoption of town land use policies that prevent wetland loss, floodplain development, and the further restriction of the Upper Otter Creek.

At the state level, priority opportunities include:

- Provision of scientifically informed data and management recommendations.
- Support of landowner initiatives through program recommendation and/or permitting that encourages beneficial restoration and protection efforts to move forward.

TABLE 7: Reach Level Projects

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M31 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No major structures along river	Unk.	Open land and forest remains structure free	Town, RRPC, VTANR
	Restore Riparian Buffer	Long term stability	Buffer removal on the left bank has made this reach vulnerable in the long-term.	No major structures along river. River may remain stable for years to come and allow trees to grow.	Unk.	Agriculture and Residential Land to Forest	UOCWC, RNRCD, FWS
	Remove or Replace Structures	Allow River to Adjust, Reduce Flooding	Several abandoned bridge abutments constrain the river.	Low cost to remove. Stone may be reused.	Low	Stone and old road bed converted to forest.	VTANR, Town, FWS
M30 	Remove or Replace Structures	Allow River to Adjust, Reduce Flooding	Several abandoned bridge abutments constrain the river.	Low cost to remove. Stone may be reused.	Low	Stone and old road bed converted to forest.	VTANR, Town, FWS

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M29 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No structures near the river.	Unk.	None, remains forest	Town, RRPC, VTANR
	Remove or Replace Structures	Allow River to Adjust, Reduce Flooding	Several abandoned bridge abutments constrain the river.	Low cost to remove. Stone may be reused.	Low	Stone and old road bed converted to forest.	VTANR, Town, FWS
	Restore Riparian Buffer	Long term stability	Buffer removal on both banks has made this reach vulnerable in the long-term.	Only a few major structures along river. River fairly stable	Unk.	Agriculture and Residential Land to Forest	UOCWC, RNRCD, FWS
M28 	Restore Riparian Buffer	Long term stability	Buffer removal has made this reach vulnerable in the long-term.	River may remain stable for years to come and allow trees to grow.	Unk.	Open Land to Forest	UOCWC, RNRCD, FWS
	Remove Berm	Open the river up for meandering to reduce flood pressure downstream in the village	Relocate Waldo Lane so that it does not constrict the river.	Road will need to be rerouted. Farm land currently.	High	Road to floodplain. Ag land to road.	Town, VTANR, Landowners

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M27 	Remove or Replace Structures	Improve sediment and flood water flow through the village.	Remove old dam remnants in channel. Replace Creek Road Bridge.	Dam removal would be easy, low cost. Creek Road Bridge is a major project.	High	None	Town, VTANR, VTFWS, VTRANS, Landowners
	Restore Riparian Buffer	Long term stability	Replace buffer on the west side of the river to reduce sediment and other impacts from the quarry.	River may remain stable for years to come and allow trees to grow.	Unk.	Industrial land to Forest	Quarry, RNRCD, FWS
M21-D 	Remove or Replace Structures	Improve sediment flows through Rutland City. Improve fish passage.	Remove old concrete dam.	Extensive study and permitting. River may breach dam someday on its own.	High	Dam to free flowing river.	VTANR, ACOE, Landowners

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M21-C 	Remove or Replace Structures	Improve flow through developed area	Replace Ripley Road Bridge	May already been in the works.	High	None	VTRANS, Town, VTANR, Landowners
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion of left (south) bank near residences.	Very little room for reforestation	Low	Lawn to forest	VTANR, RNRCD
M21-B 	Restore Riparian Buffer	Improve shade, water quality and habitat	Buffer has been removed along both banks due to industrial development	Industries must be willing to sacrifice land.	Low	Impervious surface to forest	VTANR, RNRCD

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M21-A 	Remove or Replace Structures	Improve flow through developed area	Replace Route 4 A Bridge	Not likely until it is in disrepair.	High	None	VTRANS, Town, VTANR, Landowners
M20 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No major structures along river	Unk.	Agricultural land and forest remains structure free	Town, RRPC, VTANR
	Restore Riparian Buffer	Long term stability	Buffer removal has made this reach vulnerable in the long-term.	No major structures along river. River may remain stable for years to come and allow trees to grow.	Unk.	Open Land to Forest	UOCWC, RNRCD, FWS
	Remove Berms	Improve Floodplain Access, Reduce Phosphorus to Lake Champlain	Abandoned railroad bed on west bank is acting as a berm and restricting flooding of the Otter Creek.	May be a VAST trail.	Low	Field to floodplain	VTANR, NRCS, FWS, UOCWC

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M19-B 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No major structures along river	Unk.	Open land and forest remains structure free	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Buffer has been removed along a good portion of right bank due to armoring along the road.	Very little room for reforestation	Low	Barren to forest	VTANR, RNRCD
M19-A 	Protect River Corridor	Public Access	Protect Access.	Possible liability	Med.	Remain forested undeveloped area.	Town, RRPC, VTANR

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS
M18 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance)	This fairly undeveloped reach is already attenuating floodwaters and sediment. Long term river corridor protection would reduce future conflict and ensure these functions are served for future generations.	No major structures along river	Unk.	Open land and forest remains structure free	Town, RRPC, VTANR
	Restore Riparian Buffer	Improve shade, stability of river, habitat	Short corner of field is lacking adequate buffer.	None.	Low	Bare to forest	VTANR, RNRCD, CREP

TABLE 8: Otter Creek Specific Sites for Restoration and Protection

Prjct #	Reach	Condition and Channel Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
1	**M20**	Good, I	Floodplain, agricultural fields, old oxbows, and residential development. Possibly a VAST trail.	Removal or relocation of abandoned railroad bed that is currently acting as a berm cutting off floodplain and preventing lateral migration.	High Priority	Increase floodplain and reduce phosphorus loading in Lake Champlain. Habitat.	Low-Medium	Abandoned Railroad bed to floodplain. Can remain trail, agriculture, or other.	VTANR, USFWS, VAST, VTPR, VTFWS, NRCS, Landowners
2	**M30**	Fair, I	Old Bridge abutment of the Jack Perry Road in South Wallingford.	Removal of stone and concrete bridge abutments from the former Jack Perry Road. Reduce flood hazard potential of residences upstream of the constriction.	High Priority	Improved access along the streambank for fishing/swimming.	Low. Stone may be able to be sold.	Concrete and stone abutment to riverbank.	VTANR, Town, Landowners
5	**M29**	Fair, I	Wet agricultural field bordered with residences.	Wetland restoration project. Possible project ranked #112 and #159 on the list of priority wetland restoration sites for phosphorus reduction to Lake Champlain.	High Priority	Improved floodplain upstream of Wallingford Village. Habitat. Phosphorus reduction to Lake Champlain.	Medium.	Agricultural field to wetland.	VTANR, USFWS, VTFWS, NRCS, L:andowners.
4	**M28**	Fair, I	Waldo Lane currently pinches the river just above Wallingford Village.	Relocate road away from river. Recreate floodplain above Wallingford Village.	Med. Priority	Possible public path along river?	High	Road to floodplain and agricultural field to road.	Town, VTANR, Landowners.
5	**M30**	Fair, I	Floodplain at tributary mouth.	Berm removal project on the Homer Stone Brook. Improve floodplain of the Otter Creek. Reduce delta bar. Reduce erosion pressure on Route 7.	Med Priority	Provide some minor floodplain upstream of South Wallingford.	Medium	Remains forest.	VTANR, landowners

6	**M29**	Fair, I	Wet agricultural field bordered with residences.	Wetland restoration project. Possible project identified through aerial photograph review by April Moulert, VTANR Wetlands Program.	Medium Priority	Improved floodplain upstream of Wallingford Village. Habitat. Phosphorus reduction to Lake Champlain.	Medium.	Agricultural field to wetland.	VTANR, USFWS, VTFWS, NRCS, L:andowners
7	**M27**	Fair, I	Replace Creek Road Bridge	Pier in Creek Road bridge appears to be a flood hazard for the Village of Wallingford.	Low Priority	None.	High	None	Town, VTRANS, VTANR, Landowners

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9.0 GLOSSARY

Adapted from:
Glossary of Stream Restoration Terms
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TERMS
Adjustment process --a type of change, that is underway due to natural causes or human activity that has, or will, result in a change to the valley, floodplain, and/or channel condition (e.g., vertical, lateral, or channel plan form adjustment processes)
Aggradation -- A progressive buildup or raising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that stream discharge and/or bed-load characteristics are changing. Opposite of degradation.
Alluvial -- Deposited by running water.
Alluvium -- A general term for detrital deposits make by streams on riverbeds, floodplains, and alluvial fans; esp. a deposit of silt or silty clay laid down during time of flood. The term applies to stream deposits of recent time. It does not include subaqueous sediments of seas or lakes.

Aquatic ecosystem -- Any body of water, such as a stream, lake, or estuary, and all organisms and nonliving components within it, functioning as a natural system.
Armoring -- A natural process where an erosion-resistant layer of relatively large particles is established on the surface of the streambed through removal of finer particles by stream flow. A properly armored streambed generally resists movement of bed material at discharges up to approximately 3/4 bank-full depth.
Avulsion -- A change in channel course that occurs when a stream suddenly breaks through its banks, typically bisecting an overextended meander arc.
Bank stability -- The ability of a streambank to counteract erosion or gravity forces.
Bankfull channel depth -- The maximum depth of a channel within a riffle segment when flowing at a bank-full discharge.
Bankfull channel width -- The top surface width of a stream channel when flowing at a bank-full discharge.
Bankfull discharge -- The stream discharge corresponding to the water stage that first overtops the natural banks. This flow occurs, on average, about once every 1 to 2 years.
Bankfull width -- The width of a river or stream channel between the highest banks on either side of a stream.
Bar -- An accumulation of alluvium (usually gravel or sand) caused by a decrease in sediment transport capacity on the inside of meander bends or in the center of an overwide channel.
Bed load -- Sediment moving on or near the streambed and transported by jumping, rolling, or sliding on the bed layer of a stream. See also suspended load.
Bed material -- The sediment mixture that a streambed is composed of.
Bed slope -- The inclination of the channel bottom, measured as the elevation drop per unit length of channel.
Berms -- mounds of dirt, earth, gravel, or other fill built parallel to the stream banks designed to keep flood flows from entering the adjacent floodplain.
Biota -- All living organisms of a region, as in a stream or other body of water.
Boulder -- A large substrate particle that is larger than cobble, 256 mm in diameter.
Braided channel -- A stream characterized by flow within several channels, which successively meet and divide. Braiding often occurs when sediment loading is too large to be carried by a single channel.
Buffer strip -- A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.
Canopy -- A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leaves, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.
Channel -- An area that contains continuously or periodically flowing water that is confined by banks and a streambed.
Channelization -- The process of changing (usually straightening) the natural path of a waterway.
Clay -- Substrate particles that are smaller than silt and generally less than 0.003 mm in diameter.
Cobble -- Substrate particles that are smaller than boulders and larger than gravels, and are generally 64-256 mm in diameter. Can be further classified as small and large cobble.
Confluence -- (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.
Cover – "cover" is the general term used to describe any structure that provides refugia for fish, reptiles or amphibians. These animals seek cover to hide from predators, to avoid warm water temperatures, and to rest, by avoiding higher velocity water. These animals come in all sizes, so even cobbles on the stream bottom that are not sedimented in with fine sands and silt can serve as cover for small fish and salamanders. Larger fish and reptiles often use large boulders, undercut banks, submerged logs, and snags for cover.
Culvert -- A buried pipe that allows flows to pass under a road.

Degradation -- (1) A progressive lowering of the channel bed due to scour. Degradation is an indicator that the stream's discharge and/or sediment load is changing. The opposite of aggradation. (2) A decrease in value for a designated use.
Ditch -- A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.
Drainage area -- The total surface area upstream of a point on a stream that drains toward that point. Not to be confused with watershed. The drainage area may include one or more watersheds.
Ecology -- The study of the interrelationships of living organisms to one another and to their surroundings.
Ecosystem -- Recognizable, relatively homogeneous units, including the organisms they contain, their environment, and all the interactions among them.
Embankment -- An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, support roads or railways, or for other similar purposes.
Embeddedness – is a measure of the amount of surface area of cobbles, boulders, snags and other stream bottom structures that is covered with sand and silt. An embedded streambed may be packed hard with sand and silt such that rocks in the stream bottom are difficult or impossible to pick up. The spaces between the rocks are filled with fine sediments, leaving little room for fish, amphibians, and bugs to use the structures for cover, resting, spawning, and feeding. A streambed that is **not** embedded has loose rocks that are easily removed from the stream bottom, and may even “roll” on one another when you walk on them.
Entrenchment ratio --The width of the floodprone area divided by the bankfull width.
Erosion -- Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.
Floodplain -- Land built of sediment that is regularly covered with water as a result of the flooding of a nearby stream.
Floodplain Function – Flood water access of floodplain which effects the velocity, depth, and slope (stream power) of the flood flow thereby influencing the sediment transport characteristics of the flood (i.e., loss of floodplain access and function may lead to higher stream power and erosion during flood).
Flow -- The amount of water passing a particular point in a stream or river, usually expressed in cubic feet per second (cfs).
Fluvial -- Migrating between main rivers and tributaries. Of or pertaining to streams or rivers.
Ford -- A shallow place in a body of water, such as a river, where one can cross by walking or riding on an animal or in a vehicle.
Geographic information system (GIS) – A computer system capable of storing and manipulating spatial data.
Geomorphology -- A branch of both physiography and geology that deals with the form of the earth, the general configuration of its surface, and the changes that take place due to erosion of the primary elements and the buildup of erosional debris.
Gradient -- Vertical drop per unit of horizontal distance.
Gravel -- An unconsolidated natural accumulation of rounded rock fragments, mostly of particles larger than sand (diameter greater than 2 mm), such as boulders, cobbles, pebbles, granules, or any combination of these.
Habitat -- The local environment in which organisms normally live and grow.
Headwater -- Referring to the source of a stream or river.
Hydrologic balance -- An accounting of all water inflow to, water outflow from, and changes in water storage within a hydrologic unit over a specified period of time.
Hydrology -- The scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship to living things.
Incised river -- A river that erodes its channel by the process of degradation to a lower base level than existed previously or is consistent with the current hydrology.
Incision ratio -- The low bank height divided by the bankfull maximum depth.
Infiltration (soil) -- The movement of water through the soil surface into the soil.
Instream cover -- The layers of vegetation, like trees, shrubs, and overhanging vegetation, that are in the stream or immediately adjacent to the wetted channel.

Islands – mid-channel bars that are above the average water level and have established woody vegetation.
Large woody debris (LWD) -- Pieces of wood at least 6 ft. long and 1 ft. in diameter (at the large end) contained, at least partially, within the bankfull channel.
Mainstem -- The principal channel of a drainage system into which other smaller streams or rivers flow.
Meander -- The winding of a stream channel, usually in an erodible alluvial valley. A series of sine-generated curves characterized by curved flow and alternating banks and shoals.
Mid-channel Bars – bars located in the channel away from the banks, generally found in areas where the channel runs straight. Mid-channel bars are caused by recent channel instability and are unvegetated.
Outfall -- The mouth or outlet of a river, stream, lake, drain or sewer.
Point bar -- The convex side of a meander bend that is built up due to sediment deposition.
Pool -- A reach of stream that is characterized by deep, low-velocity water and a smooth surface.
Reach -- A section of stream having relatively uniform physical attributes, such as valley confinement, valley slope, sinuosity, dominant bed material, and bed form, as determined in the Phase 1 Assessment.
Restoration -- The return of an ecosystem to a close approximation of its condition prior to disturbance.
Riffle -- A reach of stream that is characterized by shallow, fast-moving water broken by the presence of rocks and boulders.
Riffle/step frequency -- ratio of the distance between riffles to the stream width.
Riparian area -- An area of land and vegetation adjacent to a stream (or any other freshwater aquatic ecosystem) that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains.
Riparian buffer is the width of naturally vegetated land adjacent to the stream between the top of the bank (or top of slope, depending on site characteristics) and the edge of other land uses. A buffer is largely undisturbed and consists of the trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface. The buffer serves to protect the water body from the impacts of adjacent land uses.
Riparian corridor includes lands defined by the lateral extent of a stream's meanders necessary to maintain a stable stream dimension, pattern, profile, and sediment regime. For instance, in stable pool-riffle streams, riparian corridors may be as wide as 10-12 times the channel's bankfull width. In addition the riparian corridor typically corresponds to the land area surrounding and including the stream that supports (or could support if unimpacted) a distinct ecosystem, generally with abundant and diverse plant and animal communities (as compared with upland communities).
Riparian habitat -- The aquatic and terrestrial habitat adjacent to streams, lakes, and other freshwater aquatic ecosystems.
Riparian -- Located on the banks of a stream or other body of freshwater.
Riparian vegetation -- The plants that grow adjacent to a wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, meadow, etc., and that rely upon the hydrology of the associated water body.
Riprap -- Rock or other material with a specific mixture of sizes referred to as a "gradation," used to stabilize streambanks or riverbanks from erosion or to create habitat features in a stream.
River channels -- Large natural or artificial open streams that continuously or periodically contain moving water, or which form a connection between two bodies of water.
River reach -- Any defined length of a river.
Roads - Transportation infrastructure. Includes private, town, state roads, and roads that are dirt, gravel, or paved.
Runoff -- Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.
Scour -- The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material and can be classed as general, contraction, or local scour.
Sediment -- Soil or mineral material transported by water or wind and deposited in streams or other bodies of water.
Sedimentation -- (1) The combined processes of soil erosion, entrainment, transport, deposition, and consolidation. (2) Deposition of sediment.
Segment: A relatively homogenous section of stream contained within a reach that has the same reference stream characteristics but is distinct from other segments in the reach in one or more of the following parameters: degree of floodplain encroachment, presence/absence of grade controls, bankfull

channel dimensions (W/D ratio, entrenchment), channel sinuosity and slope, riparian buffer and corridor conditions, abundance of springs/seeps/adjacent wetlands/stormwater inputs, and degree of channel alterations.
Sensitivity --of the valley, floodplain, and/or channel condition to change due to natural causes and/or anticipated human activity.
Silt -- Substrate particles smaller than sand and larger than clay (3 to 60 mm).
Sinuosity -- The ratio of channel length to direct down-valley distance. Also may be expressed as the ratio of down-valley slope to channel slope.
Slope -- The ratio of the change in elevation over distance.
Stable channel -- A stream channel with the right balance of slope, planform, and cross section to transport both the water and sediment load without net long-term bed or bank sediment deposition or erosion throughout the stream segment.
Straightening -- the removal of meander bends, often done in towns and along roadways, railroads, and agricultural fields.
Stream banks are features that define the channel sides and contain stream flow within the channel; this is the portion of the channel bank that is between the toe of the bank slope and the bankfull elevation. The banks are distinct from the streambed, which is normally wetted and provides a substrate that supports aquatic organisms. The top of bank is the point where an abrupt change in slope is evident, and where the stream is generally able to overflow the banks and enter the adjacent floodplain during flows at or exceeding the average annual high water.
Stream channel -- A long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.
Stream condition -- Given the land use, channel and floodplain modifications documented at the assessment sites, the current degree of change in the channel and floodplain from the reference condition for parameters such as dimension, pattern, profile, sediment regime, and vegetation.
Stream morphology -- The form and structure of streams.
Stream reach -- An individual segment of stream that has beginning and ending points defined by identifiable features such as where a tributary confluence changes the channel character or order.
Stream type -- Gives the overall physical characteristics of the channel and helps predict the reference or stable condition of the reach.
Streambank armoring – The installation of concrete walls, gabions, stone riprap, and other large erosion resistant material along stream banks.
Streambank erosion -- The removal of soil from streambanks by flowing water.
Streambank stabilization -- The lining of streambanks with riprap, matting, etc., or other measures intended to control erosion.
Streambed -- (1) The unvegetated portion of a channel boundary below the baseflow level. (2) The channel through which a natural stream of water runs or used to run, as a dry streambed.
Substrate -- (1) The composition of a streambed, including either mineral or organic materials. (2) Material that forms an attachment medium for organisms.
Suspended sediment -- Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.
Tributary -- A stream that flows into another stream, river, or lake.
Urban runoff -- Storm water from city streets and gutters that usually carries a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.
Water quality -- A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Watershed -- An area of land whose total surface drainage flows to a single point in a stream.
Watershed management -- The analysis, protection, development, operation, or maintenance of the land, vegetation, and water resources of a drainage basin for the conservation of all its resources for the benefit of its residents.
Watershed restoration -- Improving current conditions of watersheds to restore degraded habitat and provide long-term protection to aquatic and riparian resources.

APPENDIX A

PHASE 2 REACH SUMMARY REPORT

PHASE 2 GEOMORPHIC ASSESSMENT RESULTS

There are four terms that are typically used to describe channel adjustment processes. Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform is the channel shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks. The most common adjustment processes observed in the Upper Otter Creek are widening and planform migration as a result of historic channel straightening and floodplain encroachment.

The results of the Phase 2 study are discussed below by reach number. In addition, four overview maps (Figures 1, 2, 10, and 11) have been included to provide a reference for location as well as to display channel straightening which has greatly affected the condition of the Upper Otter Creek.

RIVER SECTION 1: DANBY TO WALLINGFORD VILLAGE

The first section of river (illustrated in Figure 1and 2) begins in Danby and flows northerly towards Wallingford Village. The valley alternates between very broad and narrow and land use changes from predominately agricultural and forested to commercial and residential in Wallingford. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, undersized structures, and floodplain encroachment.

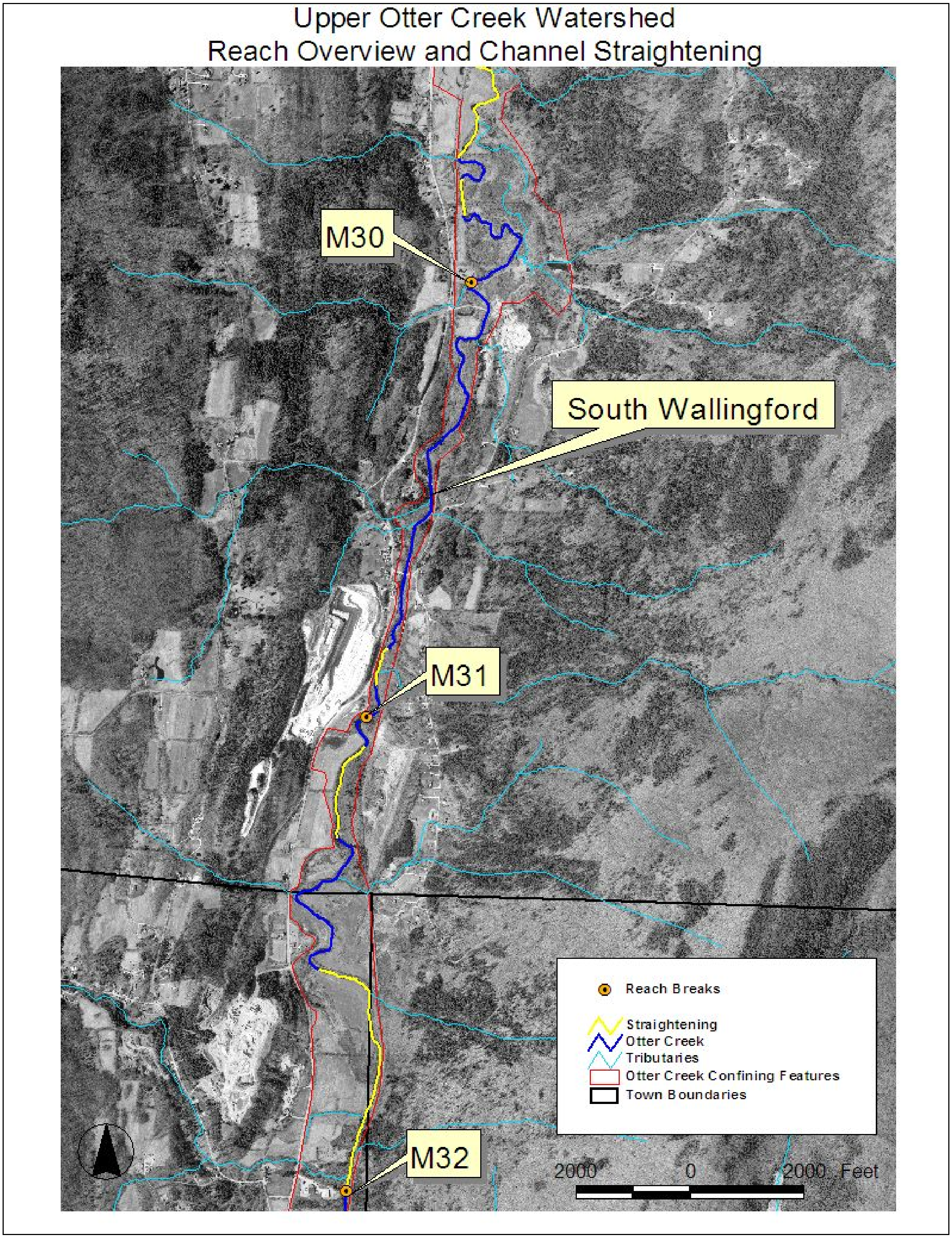


Figure 1: Overview of reaches M31 through M30 and channel straightening.

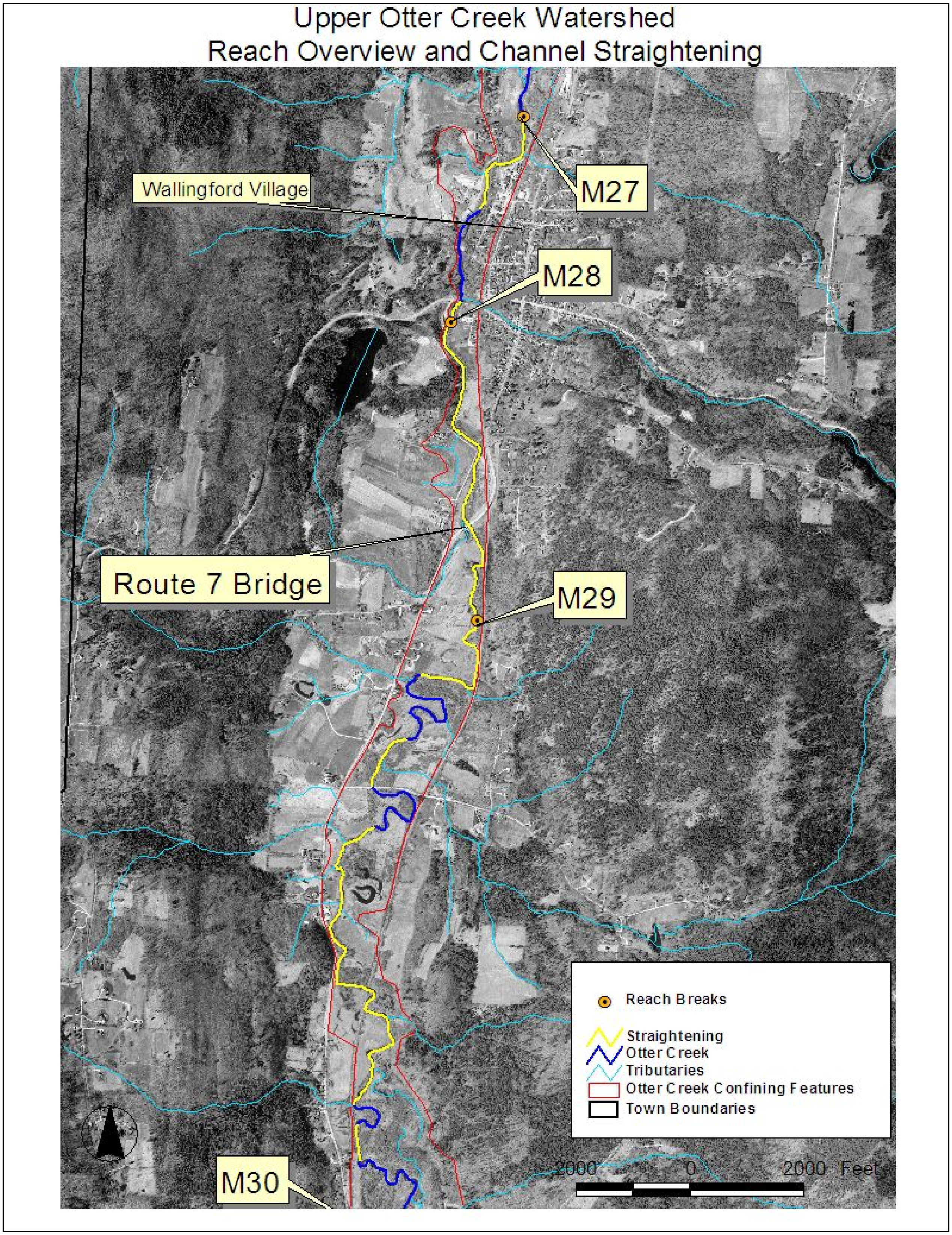


Figure 2: Overview of reaches M29 through M27 and channel straightening.

Reach M31

The most upstream reach of this Phase 2 study, M31 of the Upper Otter Creek, begins behind the Vermont Store Fixtures store off Route 7 in Danby, Vermont. Here the Baker Brook enters from the west (draining a healthy portion of residential and agricultural land in Danby). From this confluence, reach M31 flows through a very broad valley of agricultural and forested lands, crossing into the Town of Wallingford and ending where the valley walls narrow near South Wallingford. The Creek is bordered, and ultimately confined by, the Vermont Railway on the east and Route 7 on the west.

It appears that several areas of the Creek through this reach have been straightened in order to make more room for agricultural activities on the left bank and the railroad on the right. Additionally, numerous field drainage ditches indicate the naturally wet conditions of the surrounding area. It is likely that much of the valley bottom of this reach historically consisted of frequently accessed floodplain (similar to that found in the reaches south).

Despite the steeper gradient that was imposed on this reach due to channel straightening, the stream has not degraded significantly or lost access to its floodplain (remaining a “C” Stream Type). The increased stream power has, however, caused some channel widening. Moreover, the river shows signs of lateral migration through bank erosion caused by the increased stream power. As a result of this shift in slope reach M31 exhibits a combination of poorly defined riffle-pool and plane bed features. The balance between stream power and boundary materials of the Upper Otter Creek will be re-established when and if the slope flattens after a process of channel meandering that serves to lengthen the channel distance and therefore flatten the channel slope.

A major impact to this reach is several old bridge abutments and a private (no longer in use) farm bridge. The stacked stone that held these structures over the river are now functioning as constrictions to the channel and are causing localized erosion and possibly increased local flooding. The potential for these structures to create ice or debris jams is significant.

In general the reach is in good geomorphic condition. A predominately forested riparian buffer on both banks may be lending to overall stability as well as providing other benefits to the reach (Figure 3).

Figure 3. Reach M31 has been historically straightened and is impacted by several old stone bridge abutments and undersized bridges.

Reach M30

Reach M30 begins where the valley wall of the Upper Otter Creek narrows down as it approaches South Wallingford. Here to the slope of the bed of the river naturally increases as it plunges down over exposed bedrock ledges, passing under the Hartsboro Road Bridge in South Wallingford, past an abandoned road abutment, and then onwards eventually regaining a very low slope and broad valley at reach M29. The total length of this reach is approximately a mile and a half.

The overall characteristic of this reach is that of a C4 channel (with a very short B1 section near the Hartsboro Road Bridge and E-channel characteristics where it nears the reach break with M29). Land use in the M30 corridor consists of Route 7 and numerous residences on the left bank while the railroad dominates the right bank. Because of these development impacts some of the riparian vegetation in this reach has been removed. Also in order to protect these investments there has been a considerable amount of bank armoring and straightening within the reach.

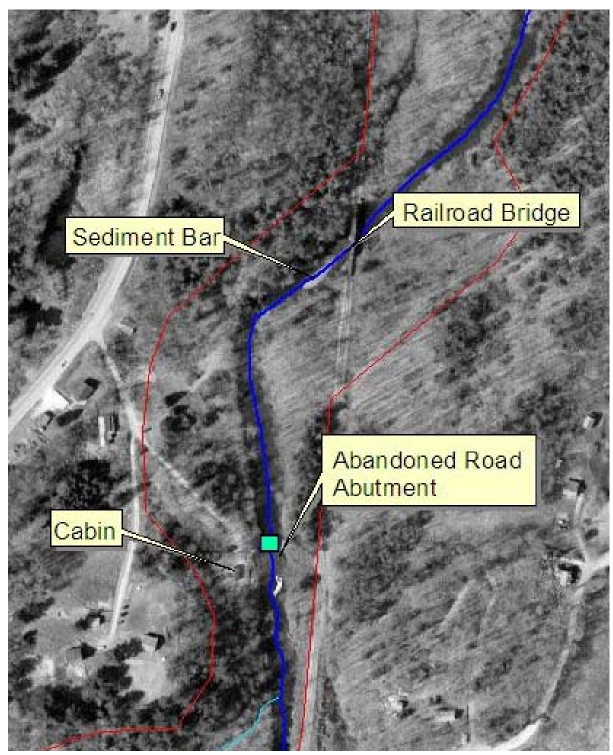


Figure 4: Examples of channel constraints, M30.

Several undersized bridges and abandoned bridge abutments are causing localized instability within reach M30 (Figure 4). The railroad bridge that bisects the channel near the middle of the reach, in particular, is disruptive. Although the total span of the structure is wide in relation to the bankfull width, a pier in the middle of the channel causes disruption to sediment flow creating an island upstream and potential for a debris jam (Figure 5).

Also of note in this reach, a large delta exists at the mouth of the Homer Stone Brook (enters from the east upstream of the bedrock ledges). The brook appears to be contributing course and fine sediment to the system. A Phase 2 assessment of this reach was not conducted, however, very large berms (~6 feet above top of bank) were observed on both sides of the mouth of the brook for a considerable distance upstream.

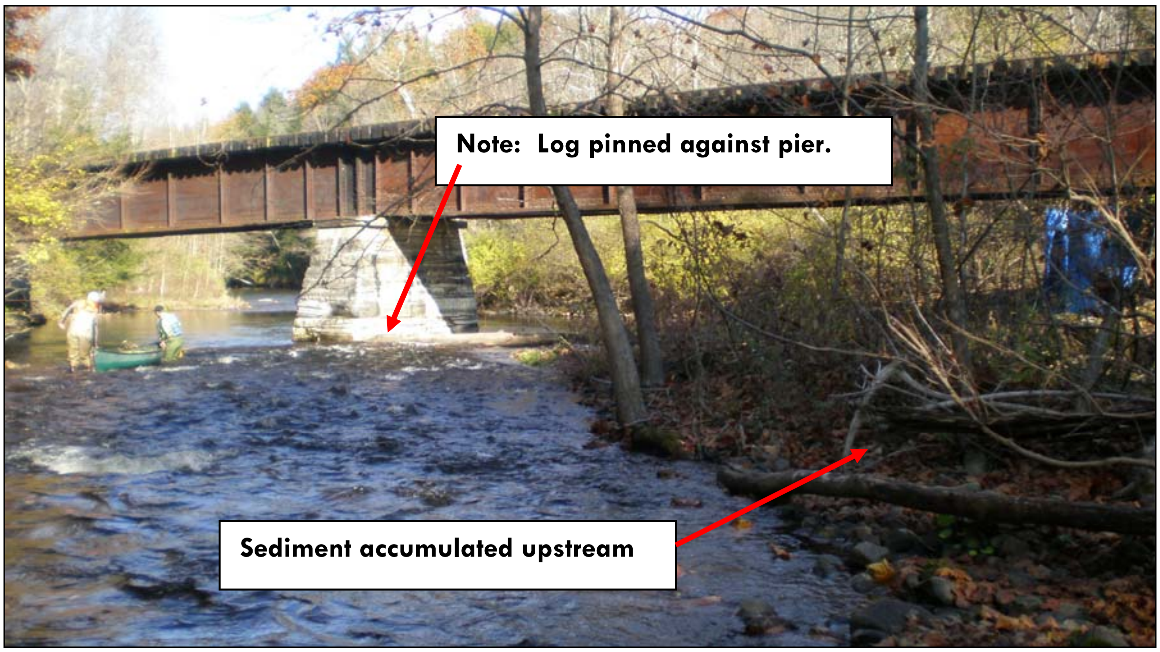


Figure 5. M30 has a steeper channel slope and is a C4 riffle-pool stream by reference. The railroad bridge is one of several disruptive structures.

Reach M29

Upper Otter Creek reach M29 begins downstream of a private bridge in South Wallingford and flows north until just downstream of the Route 7 bridge in Wallingford Village. The channel flows through predominately agricultural land and floodplain forests south of Wallingford Village. The channel is constrained by Route 7 to the west. The railroad, at first on the east, crosses over the channel, and then cuts off the floodplain on the west side of the Creek. Due to the land uses, some of the riparian forests have been impacted. More significantly, the channel planform has been impacted by these transportation constraints. Several abandoned oxbows are visible on the aerial photographs hinting that this reach was once much more sinuous than the current alignment. Despite significant straightening, the channel has excellent floodplain access and the dimensions expected for an “E” stream type. It is likely that planform adjustment will be a dominant process in the future as the channel attempts to reduce stream power through lateral migration.

The other significant impacts to this reach are the numerous undersized bridges (several of which are abandoned) and an old abutment that constrain flood flows and are causing localized erosion and instability (Figure 6).

Figure 6. The view of reach M29 from one of several undersized crossing structures. Note the very wide, deep pool that has been scoured just downstream of this structure.

Reach M28

Upper Otter Creek reach M28 begins ~1500 feet upstream of the Route 7 Bridge in Wallingford and continues northerly to behind the baseball fields and playground off Meadow Street in Wallingford Village. Most of this reach has been straightened in order to make more room for agricultural activities (a predominant land use) as well as to accommodate the railroad on the east and a road on the west. It is likely that much of the valley bottom of this reach historically consisted of frequently accessed floodplain and there is anecdotal information that a dam in Wallingford Village may have backed water well up and into this reach.

Despite the steeper gradient that was imposed on this reach due to channel straightening, the channel bed has resisted significant erosion. The increased stream power has, however, caused channel widening to a degree that the width to depth ratio of the channel is now that of a "C" type stream (a departure from the reference "E" type channel that we would expect to find pre-settlement). As a result of this shift in slope, which caused a riffle-pool bedform to become a plane bed stream, much of the habitat in this reach has degenerated in quality.

Channel migration has been resisted by streambank armoring, however, it is likely that a process of channel meandering that serves to lengthen the distance and therefore flatten the channel slope of this reach will continue (especially in areas where riparian buffers are thin or non existent). The balance between stream power and boundary materials of the Upper Otter Creek will be re-established when and if the slope flattens through increased sinuosity.

Figure 6. M28 has been significantly straightened leaving a wide, habitat-poor stream.

Reach M27

Upper Otter Creek reach M27 begins just upstream of the Route 140 West Bridge in Wallingford Village and continues downstream past two former dam sites to ~1000 feet north of the Creek Road Bridge to where the channel slope flattens and the valley widens.

This reach has been significantly altered by the history of village industry and damming (evident in the historic diversion ditches and abutment remnants visible in the channel) (Figures 7 and 8). Extensive straightening, riprap, and bridge crossings also control and hinder the river (Figure 9). Despite these alterations, no incision was observed.

Currently the channel is functioning as a "C" type stream dominated by gravel substrates (its reference condition). The extent of floodplain has certainly been significantly altered by development in the village and this reach is now acting as more of a transport reach than in its pre-settlement condition with a more poorly defined riffle-pool bedform. Future widening and planform adjustments may be expected as the channel attempts to decrease stream power through increased sinuosity.

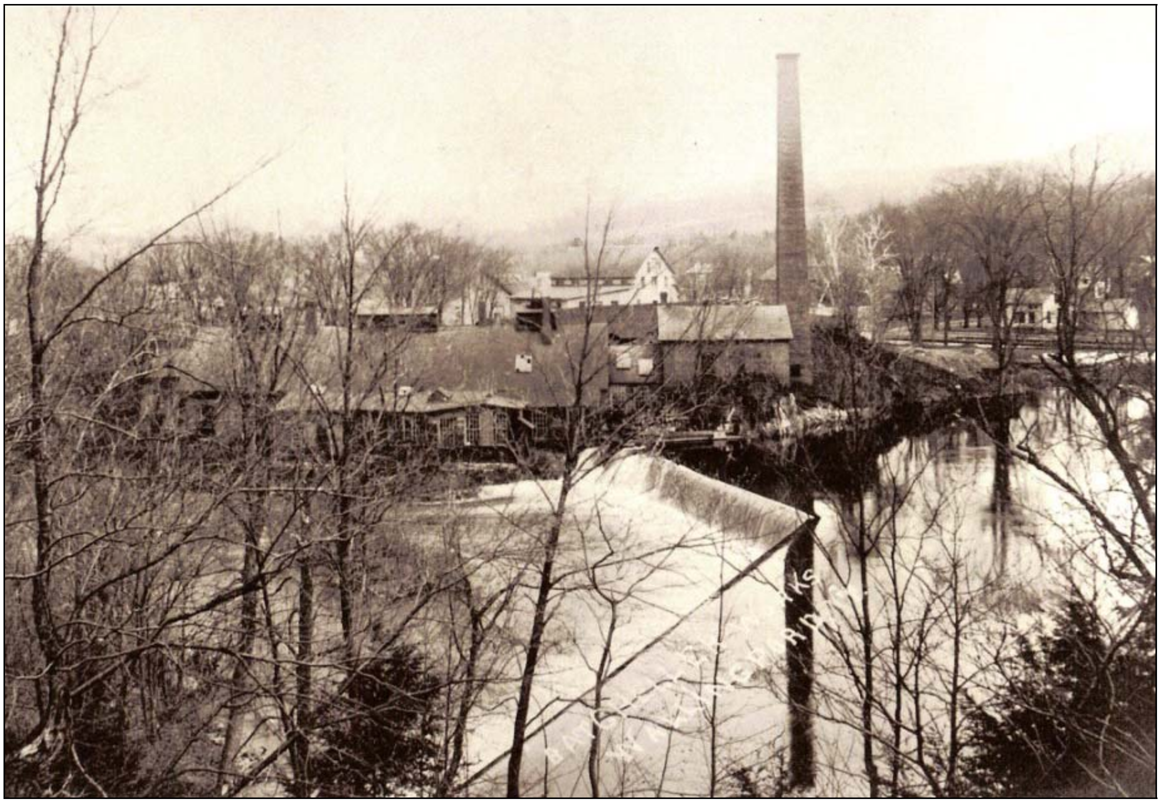


Figure 7. Historic photograph of a dam that existed in reach M27, Wallingford Village.

Figure 8. Recent photograph of the lower dam remnants in Wallingford Village reach M27.

Figure 9. Bedrock and a pier block flow at the Creek Road Bridge on M27.

RIVER SECTION 2: RUTLAND CITY TO PITTSFORD

The second section of river (illustrated in Figures 10 and 11) begins where the East Creek enters the Upper Otter Creek from the east in Rutland City. The study area continues downstream through Proctor ending in the town of Pittsford where the Furnace Brook joins the Upper Otter Creek. The valley alternates between very broad and narrow and the land use changes from commercial and residential in Rutland City and Rutland Town to agricultural and then back to residential in Proctor before becoming almost entirely agricultural in Pittsford. Major significant impacts in this section include removal of riparian vegetation, channel straightening, wetland removal, channel armoring, damming, and floodplain encroachment.

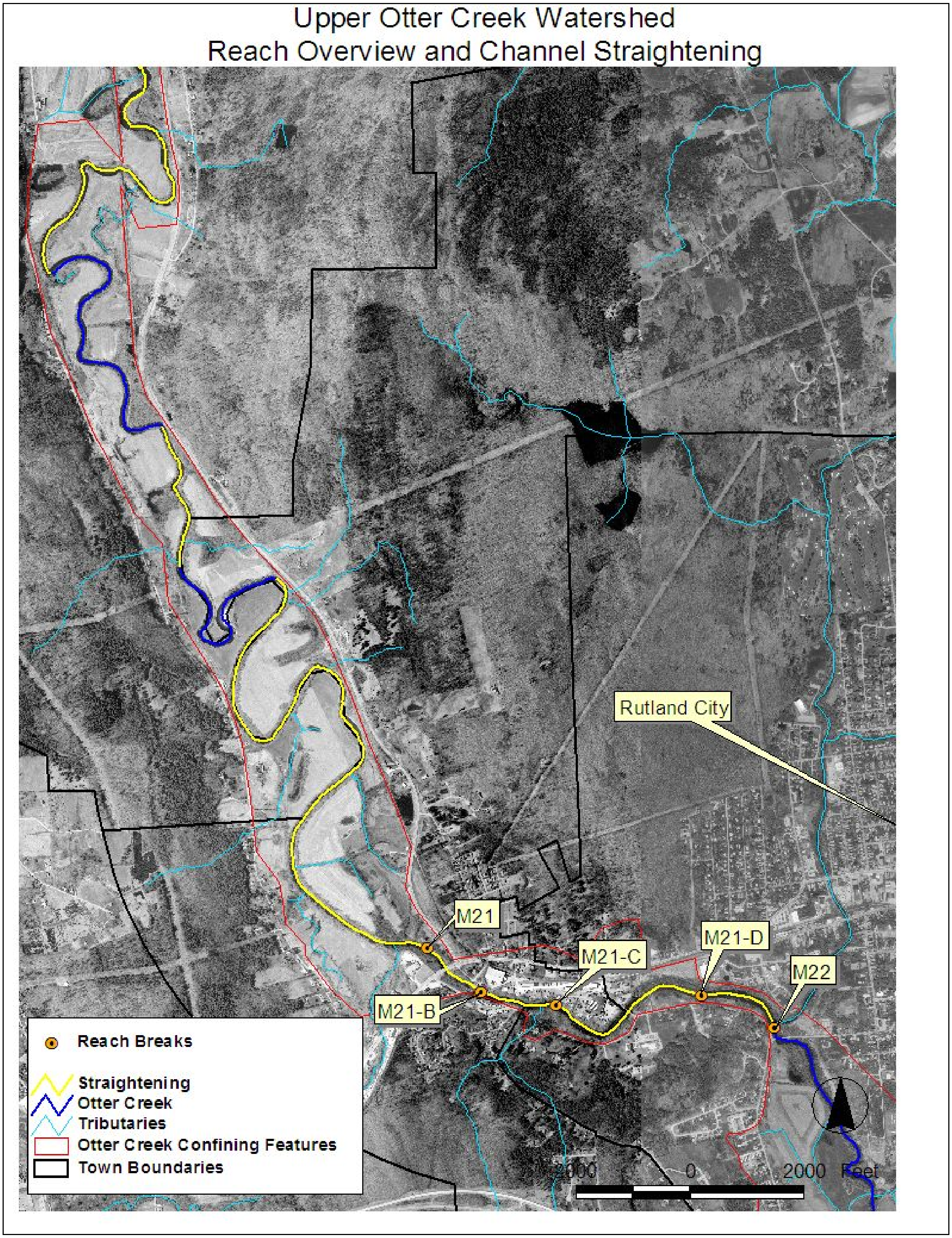


Figure 10: Overview of reaches M21 through M20 and channel straightening.

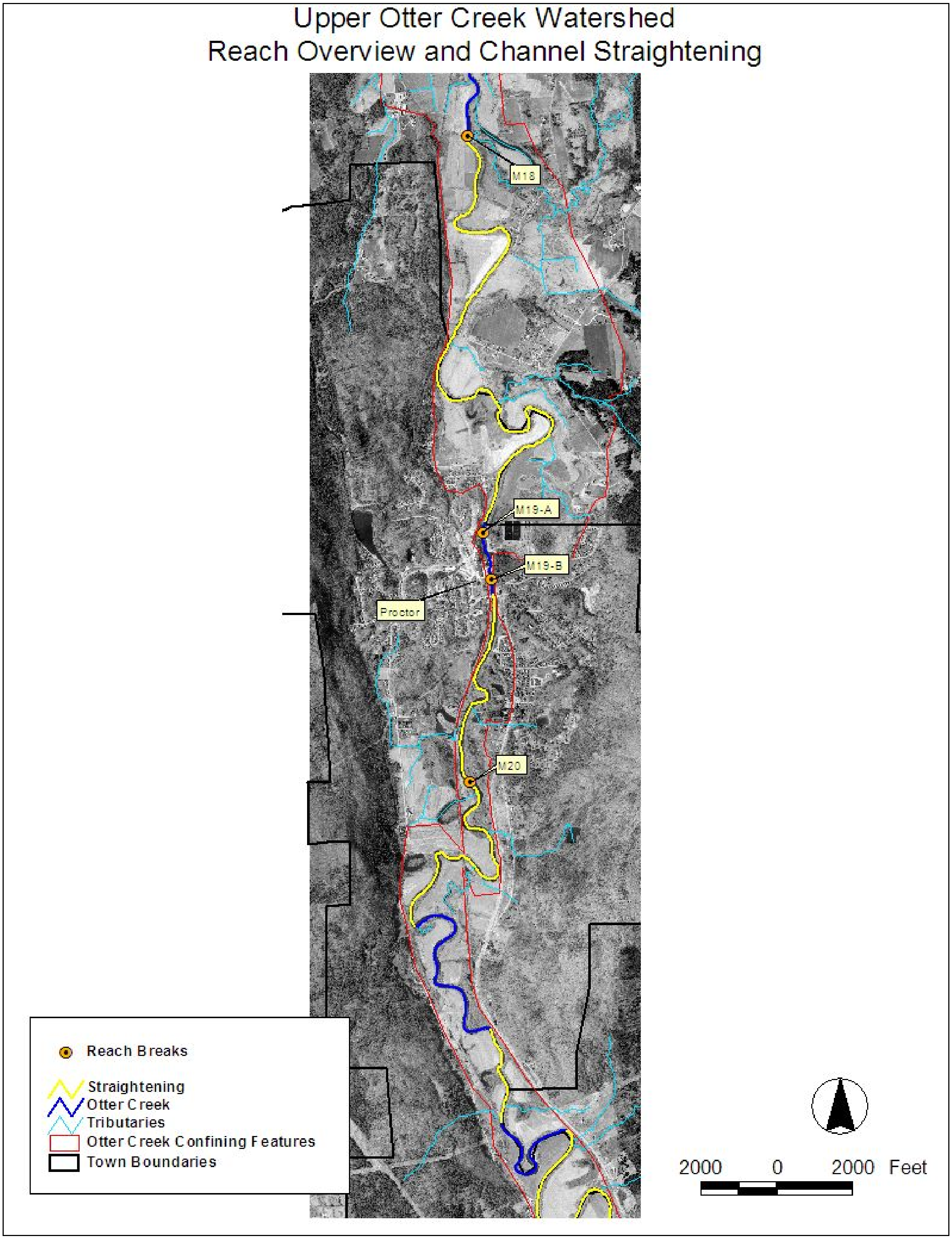


Figure 11: Overview of reaches M20 through M18 and channel straightening.

Reach M21

Upper Otter Creek reach M21 is a short reach that begins at the mouth of the East Creek in Rutland City and extends to just downstream of the Route 4A Bridge in Rutland Town. The reach is impacted by two dams which significantly alter the flow patterns of the river. Because of this diversity in flow conditions, this reach was separated into four segments.

M21-D

M21-D beings at the mouth of the East Creek in Rutland City and continues for ~1500 feet to the Ripley Mills Dam. The dam is a ~5 foot high concrete channel spanning structure that is run-of-the-river (Figure 12). The dam alters the natural slope of the channel which would be a "C" type stream by reference. A geomorphic assessment was ruled impractical on this reach due to the dam influence on the stream flow. The dam owner has stated that the dam is not in use for any industrial purposes.

Figure 12. A small concrete dam, Ripley'sMills impedes sediment transport and alters flow at the upstream end of reach M21.

M21-C

Upper Otter Creek segment M21-C is a broad section of riffle-dominated water (Figure 13). The segment begins at the Ripley Mills Dam and continues downstream for over 3000 feet ending where the stream flow is altered by the Mead Falls and Omya Hydropower dam. The channel is incised very slightly due to historic straightening and floodplain fill. Channel widening and planform adjustment appear to be limited due to streambank materials (armoring and trees). By reference this section is likely a "C" type channel dominated by gravel. Channel straightening and floodplain encroachment appear to have caused some loss of bedform and increased transport power so that cobble is now the dominant bed substrate. Overall the stream does not appear to be undergoing significant adjustments within this section.

Figure 13. Segment M21-C is a broad riffle-filled stretch of the Upper Otter Creek.

M21-B

Segment M21-B is a very short section (~1400 feet) of very low energy stream (Figure 14). It extends from where the surface water elevation flattens downstream of the Ripley Road Bridge to where the cause of that backwatering exists, the Meads Falls (a natural bedrock waterfall) and Omya Marble Dam (which was built on top of this bedrock feature). The riparian corridor of this reach has been significantly impacted by floodplain encroachment on the right and left bank. The channel in this segment appears stable due to impoundment which limits stream power and therefore the possibility of erosive forces on the banks and bed. Only a partial geomorphic assessment was conducted on this segment due to the dam.

Figure 14. Dual railroad bridge crossings upstream of the Mead Falls and Omya dam which create a backwatered segment with a very low water surface slope.

M21-A

Upper Otter Creek segment M21-A is another short segment (~1220 feet) flowing from the Mead Falls and Omya Hydro Dam in Rutland Town downstream to where the channel changes from a reference "C" to an "E" channel. Channel straightening and streambank armoring along with extensive floodplain filling have increased the entrenchment ratio of the river leading to a stream type departure from a “C” to a "B" type channel. This channel straightening and floodplain fill has caused widening and loss of bedform; however, there was no evidence of channel incision. Widening and planform adjustments are limited due to the resistive bank materials (armoring and trees) (Figure 15).

Figure 15. Upper Otter Creek segment M21-A has been altered from a C to a B channel.

Reach M20

Upper Otter Creek reach M20 begins just north of the Route 4A Bridge in Rutland Town and flows north for almost six river miles to where the channel flow changes as a result of the Sutherland Falls and the Omya dam in Proctor. The dominant land use in the river corridor is agriculture. Land clearing has significantly affected the robustness of the riparian buffer in this reach; however, great silver maples (*Acer saccharinum*) still line the banks and are likely contributing to the overall stability of the Creek.

Review of aerial photographs and in-stream observation of channel armoring indicate a great degree of historic channel straightening for agriculture and to allow for the railroad to maintain a straight course through the valley (Figure 16). Although there was extensive historic channel straightening, the Creek has excellent floodplain access and dimensions expected for an "E" stream type within this reach. Despite the increased stream power, channel incision may be offset by silts in channel bed, aggradation from upstream sources, and/or a post glacial slope decrease. Field observations indicate that M20 is exhibiting evidence of planform adjustment, minor widening, and aggradation and may be expected to continue to adjust in the future.

Figure 16. Two major impairments to reach M20; the railroad track and riparian forest removal for agriculture.

Reach M19

Reach M19 begins south of Proctor Village where the flow of the Upper Otter Creek dissipates due to the dam across Sutherland (Great) Falls. It ends at the downstream end of the falls. Due to the extreme change in the channel condition – from a flat, slow moving impoundment to a steep bedrock waterfall feature, this reach was divided into two segments.

M19-B

Otter Creek segment M19-B encompasses the area upstream of the Sutherland (Great) Falls and Omya hydroelectric dam in Proctor (Figure 17). It is an area of impounded water and in following with the VTANR protocol was not included for a full geomorphic assessment. The slope and valley width of the stream upstream of the falls indicate that the river would likely be an "E" type channel without the impoundment. The railroad bed has severed at least one historic oxbow in this reach. Bank armoring, floodplain encroachment, and riparian vegetation removal are all impacts that are prevalent in this reach as a result of the railroad and development in Proctor Village.

Figure 17. Otter Creek segment M19-B looking downstream to the Marble Bridge in Proctor and the Omya dam (at the horizon).

M19-A

Upper Otter Creek segment M19-A is dominated by the Sutherland (Great) Falls and the hydroelectric dam for the Proctor Omya quarry downstream to the start of the next reach (Figure 18). The segment consists mostly of a large bedrock waterfall (F1 stream), and therefore in accordance with the VTANR protocol only a partial Phase 2 assessment was conducted.

Figure 18. M19-A is a very short reach dominated by the bedrock of Sutherland Falls.

Reach M18

Reach M18 of the Upper Otter Creek begins just downstream of the Sutherland Falls in Proctor and flows northerly through agricultural and residential lands eventually meeting the mouth of the Furnace Brook in Pittsford (~3 miles downstream). This is an "E" type stream channel dominated by sand substrates and a ripple-dune bedform. The reach has excellent floodplain access and similar to M20 great silver maples line much of the banks (Figure 19).

The greatest impacts to this reach have been the removal of riparian vegetation for agriculture, the draining of fields and wetlands, and historic channel straightening. Field observations indicate that M18 is exhibiting evidence of planform adjustment, minor widening, and aggradation and may be expected to continue to adjust in the future.

Figure 19. M18 is an "E" channel with sand substrates and silver maples providing stability to the banks.

APPENDIX B

PHASE 2 DATA

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M18** Segment: **0** Completion Date: **September 3, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **No**

Segment Length (ft): **17,329** Segment Location: **From the confluence with Furnace Brook upstream to just below the Great Falls in Proctor,**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	2,235	0
height	15	0
Railroads	4,443	556
height	23	15
Improved Paths	0	0
height	0	0
Development	1,720	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Not Evalua	Not Evalua

1.5 Valley Features

- Valley Width (ft) **2,750**
- Width Determination **Measured**
- Confinement Type **Very Broad**
- Rock Gorge? **No**
- Human-caused Change? **Yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **103**
- 2.2 Max Depth (ft) **13.50**
- 2.3 Mean Depth (ft) **11.16**
- 2.4 Floodprone Width (ft) **2,750**

Notes:

An E5 Ripple-dune system flowing through agricultural land downstream of the Great Falls in Proctor to the confluence with Furnace Brook in Pittsford. The reach has excellent floodplain access. Great silver maples line much of the banks. Removal of

Step 2. (Contued)

- 2.5 Aband. Floodpln **13.50** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **9.23**
- 2.7 Entrenchment Ratio **26.70**
- 2.8 Incision Ratio **1.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Oxbows**
- 2.10 Riffles Type **Not Applicable**
- 2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	10 %
Sand	60 %
Silt and smaller	30 %

- Silt/Clay Present? **Yes**
- Detritus **20** %
- # Large Woody **158**

2.13 Average Largest Particle on

- Bed **N/A**
- Bar **N/A**

2.14 Stream Type

- Stream Type: **E**
- Bed Material: **Sand**
- Subclass Slope: **None**
- Bed Form: **Dune-Ripple**
- Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	1,789	1,385
Erosion Height (ft)	12.29	10.70
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	2,072	1,202

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

Bank Canopy	Left	Right
Canopy %	26-50	26-50
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	10,648	9,496

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Crop
Sub-dominant	Hay	Hay
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 **Abundant**
- 4.3 Flow Status **Low**
- 4.4 # of Debris Jams **2**
- 4.5 Flow Regulation Type **None**
- Flow Regulation Use
- Impoundments **Small**
- Impoundmt. Location **Upstream**
- 4.6 Up/Down strm flow reg **None**
- (old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

Field Ditch	6	Road Ditch	2
Other	0	Tile Drain	0
Overland Flow	2	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

Mid	Point	Side
1	2	1
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	1	0	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**
- Straightening Length: **17,040**
- 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.

Stream: **Upper Otter Creek** Reach # **M18** Segment: **0** Completion Date: **September 3,**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **17,329** Segment Location: **From the confluence with Furnace Brook upstream to just below the Great Falls in**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**100.**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**14**		**No**
7.4 Change in Planform	**12**		**No**
Total Score	**57**		
Geomorphic Rating	**0.7125**		

Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Good**
Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**11**
6.2 Pool Substrate	**11**
6.3 Pool Variability	**11**
6.4 Sediment Deposition	**11**
6.5 Channel Flow Status	**16**
6.6 Channel Alteration	**8**
6.7 Channel Sinuosity	**13**
6.8 Bank Stability	**Left: 8 Right: 7**
6.9 Bank Vegetation Protection	**Left: 4 Right: 4**
6.10 Riparian Vegetation Zone Width	**Left: 2 Right: 2**
Total Score	**108**
Habitat Rating	**0.54**

Habitat Stream Condition **Fair**

Narrative:

Despite straightening, channel has excellent floodplain access and dimensions expected for E stream type. Incision may be offset by silts in channel bed, aggradation from upstream, and post-glacial slope adjustment. Expect future planform adjust.

January 22, 2009 SGAT Version: 4.56

Phase 2 Segment Summary

Project: **Upper Otter Creek**
Stream: **Upper Otter Creek** Reach # **M19** Segment: **A** Completion Date: **August 27, 2008**
Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: **bedrock gorge** Rain: **No**
Segment Length (ft): **1,230** Segment Location: **A short segment from the reach break just below the Great Falls in Proctor upstream to the**

QC Status - Staff: **Provisional Cons**

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**
1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	1,216	0
height	25	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side

	Left	Right
Hillside Slope	Extremely	Extremely
Continuous w/	Always	Sometimes
W/in 1 Bankfill	Always	Always
Texture	Bedrock	Bedrock

1.5 Valley Features

Valley Width (ft) **150**
Width Determination **Measured**
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:

This segment encompasses the area from Great Falls and the hydroelectric dam for the Proctor Omya quarry downstream to the start of the next reach. Because it consists mostly of a large bedrock waterfall (F1 stream), only a partial assessment was conducted.

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
2.10 Riffles Type
2.11 Riffle/Step Spacing (ft) **0**
2.12 Substrate Composition

Silt/Clay Present?
Detritus **0** %
Large Woody **0**

2.13 Average Largest Particle on
Bed **0.0**
Bar **0.0**

2.14 Stream Type
Stream Type: **F**
Bed Material: **Bedrock**
Subclass Slope: **a**
Bed Form: **Cascade**
Field Measured Slope:

2.15 Reference Stream Type
(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks
Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Bedrock	Gravel
Consistency	Cohesive	Non-cohesive
Lower		
Material Type	Bedrock	Bedrock
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	108
Erosion Height (ft)	0.00	4.00
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	290	0

Near Bank Veg. Type	Left	Right
Dominant	Bare	Bare
Sub-dominant	Coniferous	Coniferous

Bank Canopy	Left	Right
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	51-100
Sub-dominant	26-50	None
W less than 25	691	0

Buffer Veg. Type	Left	Right
Dominant	Coniferous	Coniferous
Sub-dominant	Deciduous	Deciduous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Industrial	Forest
Sub-dominant	None	Commercial
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 **Low**
4.4 # of Debris Jams **0**
4.5 Flow Regulation Type **None**
Flow Regulation Use
Impoundments **Small**
Impoundmt. Location **Upstream**
4.6 Up/Down strm flow reg **None**
(old) Upstrm Flow Reg **Run-of-river**

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

Mid	Point	Side
0	0	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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 **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:	**Upper Otter Creek**		**Phase 2 Reach Summary**	page 2 of 2	January 22, 2009
Stream:	**Upper Otter Creek**	Reach #	**M19**	Segment: **A**	Completion Date: **August 27, 2008**
Organization:	**Rutland NRCD**	Observers:	**Michael Blazewicz, Ryan Case**		Rain: **No**
Segment Length (ft):	**1,230**	Segment Location:	**A short segment from the reach break just below the Great Falls in Proctor upstream to**		

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam	**Mid-segment**	**5.00**	**5.00**	**Yes**	

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bedrock	**50.0**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Referenc**

Stream Sensitivity **Very Low**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Narrative:

Project:	Upper Otter Creek	**Phase 2 Segment Summary**	page 1 of 2	January 22, 2009	SGAT Version: 4.56
Stream:	**Upper Otter Creek**	Reach # **M19**	Segment: **B**	Completion Date:	**August 27, 2008**
Organization:	**Rutland NRCD**	Observers: **Michael Blazewicz, Ryan Case**	Why Not assessed: **impounded**	Rain: **No**	
Segment Length (ft):	**6,052**	Segment Location: **An impounded reach that begins at the hydroelectric dam in Proctor (above Great Falls)**			

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	**0**	**0**
height	**0**	**0**
Roads	**0**	**0**
height	**0**	**0**
Railroads	**2,150**	**3,825**
height	**20**	**15**
Improved Paths	**0**	**0**
height	**0**	**0**
Development	**0**	**0**

1.4 Adjacent Side	Left	Right
Hillside Slope	**Very 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) **660**
- Width Determination **Estimated**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**

Human-caused Change? **Yes**

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:

This reach encompasses the area upstream of the Great Falls and hydroelectric dam in Proctor. It is an area of impounded water and therefore was not included for a full geomorphic assessment. The slope and valley width of the stream upstream of the

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
- 2.10 Riffles Type
- 2.11 Riffle/Step Spacing (ft) **0**
- 2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

Large Woody **0**

2.13 Average Largest Particle on

- Bed **0.0**
- Bar **0.0**

2.14 Stream Type

- Stream Type: **E**
- Bed Material: **Sand**
- Subclass Slope: **None**
- Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	**None**	**0.00**
Gullies	**None**	**0.00**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	**Silt**	**Silt**
Consistency	**Cohesive**	**Cohesive**
Lower		
Material Type	**Silt**	**Silt**
Consistency	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft)	**260**	**230**
Erosion Height (ft)	**5.00**	**5.45**
Revetmt. Type	**Multiple**	**Multiple**
Revetmt. Length (ft)	**1,110**	**382**

Near Bank Veg. Type	Left	Right
Dominant	**Herbaceous**	**Herbaceous**
Sub-dominant	**Shrubs/Saplin**	**Shrubs/Saplin**

Bank Canopy	Left	Right
Canopy %	**1-25**	**1-25**

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-dominant	**26-50**	**0-25**
W less than 25	**1,331**	**1,011**

Buffer Veg. Type	Left	Right
Dominant	**Deciduous**	**Deciduous**
Sub-dominant	**Shrubs/Saplin**	**Shrubs/Saplin**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Industrial**	**Shrubs/Saplin**
Sub-dominant	**Shrubs/Saplin**	**Residential**
Mass Failures	**0**	**0**
Height	**0**	**0**
Gullies	**0**	**0**
Height	**0**	**0**

Step 4. Flow & Flow Modifiers

- 4.1 Springs / Seeps
- 4.2 Adjacent Wetlands
- 4.3 Flow Status
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type **Large Run of**
  - Flow Regulation Use **Hydro-electric**
  - 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

Mid	Point	Side
0	**0**	**0**
Diagonal	Delta	Island
0	**0**	**0**

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	**0**	**0**	**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**
  - Straightening Length: **5,632**
- 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:	**Upper Otter Creek**		**Phase 2 Reach Summary**	page 2 of 2	January 22, 2009
Stream:	**Upper Otter Creek**	Reach #	**M19**	Segment: **B**	Completion Date: **August 27, 2008**
Organization:	**Rutland NRCD**	Observers:	**Michael Blazewicz, Ryan Case**		Rain: **No**
Segment Length (ft):	**6,052**	Segment Location:	**An impounded reach that begins at the hydroelectric dam in Proctor (above Great**		

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Narrative:

Project: Upper Otter Creek | **Phase 2 Segment Summary** | January 22, 2009 | SGAT Version: 4.56

Stream: **Upper Otter Creek** | Reach # **M20** | Segment: **0** | Completion Date: **August 27, 2008**

Organization: **Rutland NRCD** | Observers: **Michael Blazewicz, Ryan Case** | Why Not assessed: | Rain: **No**

Segment Length (ft): **31,693** | Segment Location: **From where the valley widens upstream of Proctor Falls upstream to just below the Route**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,522	0
height	15	0
Railroads	2,430	28,435
height	18	20
Improved Paths	0	0
height	0	0
Development	682	0

1.4 Adjacent Side

	Left	Right
Hillside Slope	Very Steep	Very Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Not Evalua	Bedrock

1.5 Valley Features

Valley Width (ft) **773**

Width Determination **Measured**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **96**

2.2 Max Depth (ft) **18.40**

2.3 Mean Depth (ft) **11.80**

2.4 Floodprone Width (ft) **773**

Notes:

An E5 Ripple-dune system flowing through agricultural land downstream of the Mead Falls in Rutland to where the flow changes upstream of the dam in Proctor. The reach has excellent floodplain access. Great silver maples line much of the banks. Removal of

Step 2. (Contued)

2.5 Aband. Floodpln **20.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **8.16**

2.7 Entrenchment Ratio **8.03**

2.8 Incision Ratio **1.09**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Oxbows**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	2%
Coarse Gravel	5%
Fine Gravel	13%
Sand	40%
Silt and smaller	40%

Silt/Clay Present? **Yes**

Detritus **20** %

Large Woody **1057**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Silt	Silt
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive
Bank Erosion	**Left**	**Right**
Erosion Length (ft)	5,605	5,203
Erosion Height (ft)	9.02	8.82
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	2,222	1,871
Near Bank Veg. Type	**Left**	**Right**
Dominant	Herbaceous	Herbaceous
Sub-dominant	Deciduous	Deciduous
Bank Canopy	**Left**	**Right**
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	19,969	8,902
Buffer Veg. Type	**Left**	**Right**
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Crop
Sub-dominant	Forest	Forest
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 **Abundant**

4.3 Flow Status **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	7	Road Ditch	5
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

Mid	Point	Side
2	2	7
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	1	0	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**

Straightening Length: **22,410**

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.

Stream: **Upper Otter Creek** Reach # **M20** Segment: **0** Completion Date: **August 27, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **31,693** Segment Location: **From where the valley widens upstream of Proctor Falls upstream to just below the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**150.**	**Yes**	**Yes**	**No**	**Yes**
	Problem **Deposition Above,Scour Above,Scour**				
Old	**102.**	**Yes**	**Yes**	**No**	**Yes**
	Problem **Deposition Above**				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**15**	**None**	**No**
7.2 Channel Aggradation	**14**	**None**	**No**
7.3 Widening Channel	**14**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**54**		
Geomorphic Rating	**0.675**		

Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Good**
Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**10**
6.2 Pool Substrate	**13**
6.3 Pool Variability	**13**
6.4 Sediment Deposition	**13**
6.5 Channel Flow Status	**16**
6.6 Channel Alteration	**6**
6.7 Channel Sinuosity	**12**
6.8 Bank Stability	**Left: 7 Right: 7**
6.9 Bank Vegetation Protection	**Left: 5 Right: 5**
6.10 Riparian Vegetation Zone Width	**Left: 3 Right: 3**
Total Score	**113**
Habitat Rating	**0.565**

Habitat Stream Condition **Fair**

Narrative:

Despite straightening, channel has excellent floodplain access and dimensions expected for E stream type. Incision may be offset by silts in channel bed, aggradation upstream, or post glacial slope decrease. Expect future planform adjust.

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M21** Segment: **A** Completion Date: **September 3, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz** Why Not assessed: Rain: **No**

Segment Length (ft): **1,230** Segment Location: **From just downstream of the Route 4A bridge in Rutland Town (confluence of the Clarendon**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	1,189
height	0	10
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Always	Always
Texture	Bedrock	Bedrock

1.5 Valley Features

Valley Width (ft) **258**

Width Determination **Measured**

Confinement Type **Narrowly**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **138**

2.2 Max Depth (ft) **7.80**

2.3 Mean Depth (ft) **6.03**

2.4 Floodprone Width (ft) **258**

Notes:

A very short segment from the Mead Falls and Omya Hydro Dam in Rutland downstream to where the channel changes from a reference "C" to an "E" channel. Channel straightening and armoring along with extensive floodplain filling have caused a

Step 2. (Contued)

2.5 Aband. Floodpln **7.80** ft.

Human Elev Floodpln **17.00** ft.

2.6 Width/Depth Ratio **22.89**

2.7 Entrenchment Ratio **1.87**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **2.18**

2.9 Sinuosity **Low**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **600**

2.12 Substrate Composition

Bedrock	0 %
Boulder	23 %
Cobble	34 %
Coarse Gravel	19 %
Fine Gravel	8 %
Sand	16 %
Silt and smaller	0 %

Silt/Clay Present? **No**

Detritus **1** %

Large Woody **5**

2.13 Average Largest Particle on

Bed **12.0** **inches**

Bar **4.0** **inches**

2.14 Stream Type

Stream Type: **B**

Bed Material: **Cobble**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Boulder/Cobbl	Boulder/Cobbl
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	114	0
Erosion Height (ft)	7.04	0.00
Revetmt. Type	Multiple	Rip-Rap
Revetmt. Length (ft)	666	723

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

Bank Canopy	Left	Right
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	51-100	51-100
Sub-dominant	>100	>100
W less than 25	87	265

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Commercial
Sub-dominant	None	None
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 **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **Small**

Impoundmt. Location **Upstream**

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Run-of-river**

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

Mid	Point	Side
0	0	0
Diagonal	Delta	Island
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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**

Straightening Length: **1,230**

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:	**Upper Otter Creek**		**Phase 2 Reach Summary**	page 2 of 2	January 22, 2009
Stream:	**Upper Otter Creek**	Reach #	**M21**	Segment: **A**	Completion Date: **September 3,**
Organization:	**Rutland NRCD**	Observers:	**Michael Blazewicz**		Rain: **No**
Segment Length (ft):	**1,230**	Segment Location:	**From just downstream of the Route 4A bridge in Rutland Town (confluence of the**		

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Old	**105.**	**Yes**	**Yes**	**Yes**	**Yes**
	Problem	**Deposition Above**			
Bridge	**114.**	**Yes**	**Yes**	**Yes**	**Yes**
	Problem	**Deposition Above**			

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**C to B**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**13**		**No**
Total Score	**46**		
Geomorphic Rating	**0.575**		

Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Fair**
Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**13**
6.2 Embeddedness	**11**
6.3 Velocity/Depth Patterns	**13**
6.4 Sediment Deposition	**10**
6.5 Channel Flow Status	**13**
6.6 Channel Alteration	**5**
6.7 Frequency of Riffles/Steps	**16**
6.8 Bank Stability	**Left: 8 Right: 9**
6.9 Bank Vegetation Protection	**Left: 5 Right: 5**
6.10 Riparian Vegetation Zone Width	**Left: 4 Right: 4**
Total Score	**116**
Habitat Rating	**0.58**

Habitat Stream Condition **Fair**

Narrative:

Major channel straightening has caused widening and reduction in pool qlty. incision manmade. Shift from C to B stream type due to filling of floodplain which has caused entrenchment. Widening and planform limited due to bank materials (armoring/veg

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M21** Segment: **B** Completion Date: **September 18, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: **impounded** Rain: **No**

Segment Length (ft): **1,400** Segment Location: **From the Center Rutland Dam (operated by OMYA) upstream to where the impoundment is**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	1,377
height	0	10
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Hilly	Hilly
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Not Evalua	Not Evalua

1.5 Valley Features

- Valley Width (ft) **530**
- Width Determination **Estimated**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**
- Human-caused Change? **Yes**

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:

A short section from the hydro dam at Meads Falls upstream to where the impoundment influence ends. This section has been significantly impacted by floodplain encroachment. Channel is stable, however, due to impoundment which limits stream

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
- 2.10 Riffles Type
- 2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

- Silt/Clay Present?
- Detritus **0** %
- # Large Woody **0**

2.13 Average Largest Particle on

- Bed **0.0**
- Bar **0.0**

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)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Boulder/Cobbl	Boulder/Cobbl
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Multiple	Rip-Rap
Revetmt. Length (ft)	477	380

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	>100	None
W less than 25	771	157

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Industrial	Industrial
Sub-dominant	None	None
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 **Low**
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type **Large Run of**
- Flow Regulation Use **Hydro-electric**
- Impoundments **Small**
- Impoundmt. Location **In Reach**
- 4.6 Up/Down strm flow reg **None**
- (old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	1

4.9 # of Beaver Dams **0**

Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
0	0	0
Diagonal	Delta	Island
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	

- 5.4 Stream Ford or Animal **No**
- 5.5 Straightening **Straightening**
- Straightening Length: **1,377**
- 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.

Stream: **Upper Otter Creek** Reach # **M21** Segment: **B** Completion Date: **September 18,**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **1,400** Segment Location: **From the Center Rutland Dam (operated by OMYA) upstream to where the**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam	**Mid-segment**	**20.00**	**20.00**	**Yes**	

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**162.**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Narrative:

Project: Upper Otter Creek | **Phase 2 Segment Summary** | | January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** | Reach # **M21** | Segment: **C** | Completion Date: **September 18, 2008**

Organization: **Rutland NRCD** | Observers: **Michael Blazewicz, Ryan Case** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **3,097** | Segment Location: **From the Ripley Mills Dam in Rutland City downstream to where the Center Rutland Dam is**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	3,053
height	0	10
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Hilly	Hilly
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Gravel	Gravel

1.5 Valley Features

- Valley Width (ft) **490**
- Width Determination **Measured**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**
- Human-caused Change? **Yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **168**
- 2.2 Max Depth (ft) **6.90**
- 2.3 Mean Depth (ft) **4.52**
- 2.4 Floodprone Width (ft) **490**

Notes:

A segment of moving water between two impounded segments. This segment is downstream of a small dam (Ripley Mills Dam) and upstream of the Mead Falls and Omya Hydro dam. Floodplain development has significantly impacted this reach.

Step 2. (Contued)

- 2.5 Aband. Floodpln **7.90** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **37.17**
- 2.7 Entrenchment Ratio **2.92**
- 2.8 Incision Ratio **1.14**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Complete**
- 2.11 Riffle/Step Spacing (ft) **1,790**

2.12 Substrate Composition

Bedrock	0%
Boulder	35%
Cobble	31%
Coarse Gravel	16%
Fine Gravel	10%
Sand	8%
Silt and smaller	0%

- Silt/Clay Present? **No**
- Detritus **1** %
- # Large Woody **30**

2.13 Average Largest Particle on

- Bed **12.0** inches
- Bar **4.0** inches

2.14 Stream Type

- Stream Type: **C**
- Bed Material: **Cobble**
- Subclass Slope: **None**
- Bed Form: **Riffle-Pool**
- Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Boulder/Cobbl	Boulder/Cobbl
Consistency	Non-cohesive	Non-cohesive
Bank Erosion	**Left**	**Right**
Erosion Length (ft)	183	111
Erosion Height (ft)	5.00	5.00
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	594	1,373
Near Bank Veg. Type	**Left**	**Right**
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives
Bank Canopy	**Left**	**Right**
Canopy %	1-25	1-25
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	660	545
Buffer Veg. Type	**Left**	**Right**
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Residential	Industrial
Sub-dominant	Commercial	None
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 **Low**
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type **None**
- Flow Regulation Use
- Impoundments **Small**
- Impoundmt. Location **Upstream**
- 4.6 Up/Down strm flow reg **None**
- (old) Upstrm Flow Reg **Run-of-river**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	2

- 4.9 # of Beaver Dams **0**
- Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
0	0	0
Diagonal	**Delta**	**Island**
0	0	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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**
- Straightening Length: **3,053**
- 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:	**Upper Otter Creek**		**Phase 2 Reach Summary**	page 2 of 2	January 22, 2009
Stream:	**Upper Otter Creek**	Reach #	**M21**	Segment: **C**	Completion Date: **September 18,**
Organization:	**Rutland NRCD**	Observers:	**Michael Blazewicz, Ryan Case**		Rain: **Yes**
Segment Length (ft):	**3,097**	Segment Location:	**From the Ripley Mills Dam in Rutland City downstream to where the Center Rutland**		

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**170.**	**Yes**	**Yes**	**No**	**Yes**

Problem **Deposition Below**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**9**	**None**	**Yes**
7.2 Channel Aggradation	**14**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**14**		**No**
Total Score	**50**		
Geomorphic Rating	**0.625**		

Channel Evolution Model **F**
Channel Evolution Stage **II**
Geomorphic Condition **Fair**
Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**13**
6.2 Embeddedness	**13**
6.3 Velocity/Depth Patterns	**13**
6.4 Sediment Deposition	**11**
6.5 Channel Flow Status	**13**
6.6 Channel Alteration	**8**
6.7 Frequency of Riffles/Steps	**11**
6.8 Bank Stability	**Left: 8 Right: 9**
6.9 Bank Vegetation Protection	**Left: 5 Right: 5**
6.10 Riparian Vegetation Zone Width	**Left: 4 Right: 4**
Total Score	**117**
Habitat Rating	**0.585**

Habitat Stream Condition **Fair**

Narrative:

Channel incised moderately due to historic straightening and floodplain alterations. Widening and planform limited due to streambank materials (armoring and trees). Some loss of bedform and probably gravel dominated by reference.

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M21** Segment: **D** Completion Date: **September 18, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: **impounded** Rain: **Yes**

Segment Length (ft): **1,570** Segment Location: **From the East Creek Confluence downstream to the Ripley Mills dam.**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Flow Status**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	1,568
height	0	10
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Always	Always
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **300**

Width Determination **Measured**

Confinement Type **Narrowly**

Rock Gorge? **No**

Human-caused Change? **Yes**

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:

A short segment from the confluence with the East Creek in Rutland City downstream to the Ripley Mills Dam. A geomorphic assessment was not possible on this reach due to the dam influence on the stream flow. Would likely be a C3/4 reach by reference. Dam is

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

2.10 Riffles Type

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Silt/Clay Present?

Detritus **0** %

Large Woody **0**

2.13 Average Largest Particle on

Bed **0.0**

Bar **0.0**

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)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Boulder/Cobbl	Boulder/Cobbl
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	58	432

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	257	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Invasives	Invasives

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Industrial
Sub-dominant	Residential	None
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 **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **Small Run of**

Flow Regulation Use **Other**

Impoundments **Small**

Impoundmt. Location **In Reach**

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg **Run-of-river**

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

Mid	Point	Side
0	0	0
Diagonal	Delta	Island
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,561**

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.

Stream: **Upper Otter Creek** Reach # **M21** Segment: **D** Completion Date: **September 18,**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **Yes**

Segment Length (ft): **1,570** Segment Location: **From the East Creek Confluence downstream to the Ripley Mills dam.**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam	**Mid-segment**	**5.00**	**5.00**	**Yes**	

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bedrock	**180.**	**Yes**	**Yes**	**No**	**Yes**

Problem **Deposition Above**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Narrative:

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M22** Segment: **0** Completion Date: **November 29, 2005**

Organization: **Rutland NRCD** Observers: **KLU, HS** Why Not assessed: Rain: **Yes**

Segment Length (ft): **15,383** Segment Location: **From Cold River confluence downstream to East Creek confluence**

QC Status - Staff: **Provisional Cons Provisional**

Step 1. Valley and Floodplain

1.1 Segmentation

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Hilly	Hilly
Continuous w/	Never	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **2,000**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **74**

2.2 Max Depth (ft) **13.00**

2.3 Mean Depth (ft) **9.30**

2.4 Floodprone Width (ft) **1,700**

Notes:

Str (5.5) historic inferred fr planform. Channel likely flowing through alluv fan / delta deposits of Cold River near u/s end. Cross section measurements approx only: 2.2, 2.3, 2.5 are minimum values; 2.6 is max value - channel depth exceeded measuring staff.

Step 2. (Contued)

2.5 Aband. Floodpln **13.00** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **7.90**

2.7 Entrenchment Ratio **23.13**

2.8 Incision Ratio **1.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **N/A**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	0 %
Sand	100 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**

Detritus **0** %

Large Woody **37**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Moderate**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	980	1,730
Erosion Height (ft)	5.00	5.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	980	1,100

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	None	None

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Crop
Sub-dominant	Pasture	Pasture
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 **Minimal**

4.3 Flow Status **High**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	3	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

Mid	Point	Side
0	1	0
Diagonal	**Delta**	**Island**
0	0	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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**

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.

Stream: **Upper Otter Creek** Reach # **M22** Segment: **0** Completion Date: **November 29,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **15,383** Segment Location: **From Cold River confluence downstream to East Creek confluence**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**0.00**	**Yes**	**No**	**No**	**Yes**
Problem **Scour Above**					
Bridge	**0.00**	**Yes**	**No**	**No**	**Yes**
Problem **Scour Above**					
Old	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**
Problem **Scour Below**					
Bridge	**0.00**	**No**	**No**	**No**	**Yes**
Problem **Alignment**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**18**	**None**	**No**
7.3 Widening Channel	**18**		**No**
7.4 Change in Planform	**16**		**No**
Total Score	**68**		
Geomorphic Rating	**0.85**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Referenc**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**11**
6.2 Pool Substrate	**16**
6.3 Pool Variability	**15**
6.4 Sediment Deposition	**18**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**13**
6.7 Channel Sinuosity	**8**
6.8 Bank Stability	**Left: 8 Right: 8**
6.9 Bank Vegetation Protection	**Left: 8 Right: 8**
6.10 Riparian Vegetation Zone Width	**Left: 2 Right: 2**
Total Score	**135**
Habitat Rating	**0.675**

Habitat Stream Condition **Good**

Narrative:

If hist straight (inferred from linear PF) resulted in incis, it was very minor in extent. Mod. by silts in chann bed or offset by simult. aggrad fr u/s erosion. Channel has excell. floodplain access, and dimensions expected for E str type.

Stream: Upper Otter Creek	Reach # M23	Segment: 0	Completion Date: November 29, 2005
Organization: Rutland NRCD	Observers: KLU, HS	Why Not assessed:	Rain: Yes
Segment Length (ft): 14,330	Segment Location: From vicinity of lumber yard downstream to Cold River confluence, spanning Alfrecia Road.		

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Flat
Continuous w/	Never	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Bedrock	Not Evalua

1.5 Valley Features

Valley Width (ft)	2,500
Width Determination	Estimated
Confinement Type	Very Broad
Rock Gorge?	No
Human-caused Change?	Yes

Step 2. Stream Channel

2.1 Bankfull Width	92
2.2 Max Depth (ft)	11.00
2.3 Mean Depth (ft)	7.90
2.4 Floodprone Width (ft)	500

Notes:

Str (5.5) historic inferred fr planform. Channel likely flowing through alluv fan / delta deposits of Cold River near d/s end. Cross section measurements approx only. High water conditions limited observations.

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln	11.00 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	11.58
2.7 Entrenchment Ratio	5.46
2.8 Incision Ratio	1.00
Human Elevated Inc Rat	0.00
2.9 Sinuosity	Oxbows
2.10 Riffles Type	Not Applicable
2.11 Riffle/Step Spacing (ft)	N/A

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	0%
Coarse Gravel	0%
Fine Gravel	0%
Sand	100%
Silt and smaller	0%

Silt/Clay Present?	Yes
Detritus	0 %
# Large Woody	39

2.13 Average Largest Particle on

Bed	N/A
Bar	N/A

2.14 Stream Type

Stream Type:	E
Bed Material:	Sand
Subclass Slope:	None
Bed Form:	Dune-Ripple

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Moderate**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	2,830	4,200
Erosion Height (ft)	5.00	5.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,500	890

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Pasture	Pasture

Bank Canopy	Left	Right
Canopy %	1-25	1-25
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	26-50
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	None	None

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Pasture	Crop
Sub-dominant	Crop	Pasture
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	Minimal
4.3 Flow Status	High
4.4 # of Debris Jams	2
4.5 Flow Regulation Type	None
Flow Regulation Use	
Impoundments	None
Impoundmt. Location	
4.6 Up/Down strm flow reg	
(old) Upstrm Flow Reg	None

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

Mid	Point	Side
0	2	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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
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.

Stream: **Upper Otter Creek** Reach # **M23** Segment: **0** Completion Date: **November 29,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **14,330** Segment Location: **From vicinity of lumber yard downstream to Cold River confluence, spanning Alfrecia**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**0.00**	**Yes**	**Yes**	**No**	**Yes**
Problem **Scour Below**					
Bridge	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**
Problem **Scour Below**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**18**	**None**	**No**
7.2 Channel Aggradation	**16**	**None**	**No**
7.3 Widening Channel	**15**		**No**
7.4 Change in Planform	**15**		**No**
Total Score	**64**		
Geomorphic Rating	**0.8**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**11**
6.2 Pool Substrate	**15**
6.3 Pool Variability	**15**
6.4 Sediment Deposition	**18**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**13**
6.7 Channel Sinuosity	**8**
6.8 Bank Stability	**Left: 7 Right: 6**
6.9 Bank Vegetation Protection	**Left: 6 Right: 6**
6.10 Riparian Vegetation Zone Width	**Left: 2 Right: 2**
Total Score	**127**
Habitat Rating	**0.635**

Habitat Stream Condition **Fair**

Narrative:

Minor wid, PF change (local). If hist straight (inferred from linear PF) resulted in incis, it was very minor in extent. Mod. by silts in chann bed or offset by simult. aggrad fr u/s erosion. Channel has excell. floodplain access.

Project: Upper Otter Creek | **Phase 2 Segment Summary** | | January 22, 2009 | SGAT Version: 4.56

Stream: **Upper Otter Creek** | Reach # **M24** | Segment: **0** | Completion Date: **November 9, 2005**

Organization: **Rutland NRCD** | Observers: **KLU, HS** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **22,541** | Segment Location: **From vicinity of intersection between Creek Road and Walker Mountain Road, downstream**

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Hilly
Continuous w/	Never	Sometimes
W/in 1 Bankfill	Never	Sometimes
Texture	Bedrock	Not Evalua

1.5 Valley Features

Valley Width (ft)	1,900
Width Determination	Estimated
Confinement Type	Very Broad
Rock Gorge?	No
Human-caused Change?	Yes

Step 2. Stream Channel

2.1 Bankfull Width	84
2.2 Max Depth (ft)	10.70
2.3 Mean Depth (ft)	8.80
2.4 Floodprone Width (ft)	1,900

Notes:

Hist Str inferred from linear planform and encroachment of railroad along RB. Much beaver activity incl LWD recruitment and tree girdling d/s of Walker Mtn Rd

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln	10.70 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	9.50
2.7 Entrenchment Ratio	22.73
2.8 Incision Ratio	1.00
Human Elevated Inc Rat	0.00
2.9 Sinuosity	High
2.10 Riffles Type	Not Applicable
2.11 Riffle/Step Spacing (ft)	N/A

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	0 %
Sand	100 %
Silt and smaller	0 %

Silt/Clay Present?	Yes
Detritus	1 %
# Large Woody	137

2.13 Average Largest Particle on

Bed	20.0	mm
Bar	0.0	mm

2.14 Stream Type

Stream Type:	E
Bed Material:	Sand
Subclass Slope:	None
Bed Form:	Plane Bed
Field Measured Slope:	

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	7,050	7,620
Erosion Height (ft)	5.00	5.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,040	2,310

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

Bank Canopy	Left	Right
Canopy %	1-25	1-25
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	26-50	26-50
Sub-dominant	51-100	>100
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	None	None

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Crop
Sub-dominant	None	None
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	Minimal
4.3 Flow Status	High
4.4 # of Debris Jams	4
4.5 Flow Regulation Type	None
Flow Regulation Use	
Impoundments	None
Impoundmt. Location	
4.6 Up/Down strm flow reg	
(old) Upstrm Flow Reg	None

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

Mid	Point	Side
0	2	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
2	2	0	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
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.

Stream: **Upper Otter Creek** Reach # **M24** Segment: **0** Completion Date: **November 9,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **22,541** Segment Location: **From vicinity of intersection between Creek Road and Walker Mountain Road,**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **Scour Above,Scour Below**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**18**	**None**	**No**
7.3 Widening Channel	**16**		**No**
7.4 Change in Planform	**5**		**No**
Total Score	**55**		
Geomorphic Rating	**0.6875**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**10**
6.2 Pool Substrate	**15**
6.3 Pool Variability	**15**
6.4 Sediment Deposition	**15**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**13**
6.7 Channel Sinuosity	**13**
6.8 Bank Stability	**Left: 5 Right: 4**
6.9 Bank Vegetation Protection	**Left: 4 Right: 4**
6.10 Riparian Vegetation Zone Width	**Left: 4 Right: 5**
Total Score	**125**
Habitat Rating	**0.625**

Habitat Stream Condition **Fair**

Narrative:

PF adjust (meand migr). Local wid at DJs. If hist straight (inferred from linear PF & rr) resulted in incis, it was v min in extent. Mod. by silts in chann bed or offset by simult. aggrad fr u/s erosion. Channel has excell floodplain access.

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M25** Segment: **0** Completion Date: **November 4, 2005**

Organization: **Rutland NRCD** Observers: **KLU, HS** Why Not assessed: Rain: **Yes**

Segment Length (ft): **10,369** Segment Location: **From just upstream of the Mill River confluence, downstream to the vicinity of the Creek**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Very Steep	Hilly
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Bedrock	Not Evalua

1.5 Valley Features

- Valley Width (ft) **500**
- Width Determination **Estimated**
- Confinement Type **Broad**
- Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **84**
- 2.2 Max Depth (ft) **13.00**
- 2.3 Mean Depth (ft) **9.30**
- 2.4 Floodprone Width (ft) **750**

Notes:

Poss Str (historic) inferred fr planform. However, channel likely pushed to west valley wall by alluv fan / delta deposits of Mill River. Cross section measurements approx only: 2.2, 2.3, 2.5 are minimum values; 2.6 is max value - channel depth exceeded

Step 2. (Contued)

- 2.5 Aband. Floodpln **13.00** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **9.01**
- 2.7 Entrenchment Ratio **8.95**
- 2.8 Incision Ratio **1.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Oxbows**
- 2.10 Riffles Type **Not Applicable**
- 2.11 Riffle/Step Spacing (ft) **N/A**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	0 %
Sand	100 %
Silt and smaller	0 %

- Silt/Clay Present? **Yes**
- Detritus **1** %
- # Large Woody **13**

2.13 Average Largest Particle on

- Bed **N/A**
- Bar **N/A**

2.14 Stream Type

- Stream Type: **E**
- Bed Material: **Sand**
- Subclass Slope: **None**
- Bed Form: **Plane Bed**
- Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	3,730	3,200
Erosion Height (ft)	3.00	3.00
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	420	0

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

Bank Canopy	Left	Right
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	51-100	0-25
Sub-dominant	0-25	>100
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Coniferous	Coniferous
Sub-dominant	None	None

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Crop
Sub-dominant	Pasture	Forest
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 **Minimal**
- 4.3 Flow Status **High**
- 4.4 # of Debris Jams **1**
- 4.5 Flow Regulation Type **None**
- Flow Regulation Use
- Impoundments **None**
- Impoundmt. Location
- 4.6 Up/Down strm flow reg
- (old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	3	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

Mid	Point	Side
1	1	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	2	0	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**
- 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.

Stream: **Upper Otter Creek** Reach # **M25** Segment: **0** Completion Date: **November 4,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **10,369** Segment Location: **From just upstream of the Mill River confluence, downstream to the vicinity of the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Old	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **Scour Below**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**55**		
Geomorphic Rating	**0.6875**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**8**
6.2 Pool Substrate	**15**
6.3 Pool Variability	**16**
6.4 Sediment Deposition	**15**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**13**
6.7 Channel Sinuosity	**8**
6.8 Bank Stability	**Left: 5 Right: 5**
6.9 Bank Vegetation Protection	**Left: 7 Right: 7**
6.10 Riparian Vegetation Zone Width	**Left: 7 Right: 2**
Total Score	**126**
Habitat Rating	**0.63**

Habitat Stream Condition **Fair**

Narrative:

Widening, PF (localized)

Project: **Upper Otter Creek**
Stream: **Upper Otter Creek** Reach # **M26** Segment: **A** Completion Date: **November 4, 2005**
Organization: **Rutland NRCD** Observers: **KLU, HS** Why Not assessed: Rain: **Yes**
Segment Length (ft): **9,948** Segment Location: **From segment break approximately 1500 feet downstream of Wallingford WWTF,**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Not Evalua	Not Evalua

1.5 Valley Features

- Valley Width (ft) **600**
- Width Determination **Estimated**
- Confinement Type **Broad**
- Rock Gorge? **No**
- Human-caused Change? **Yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **71**
- 2.2 Max Depth (ft) **8.50**
- 2.3 Mean Depth (ft) **7.00**
- 2.4 Floodprone Width (ft) **350**

Notes:

Cross section / pebble count limited by high water conditions and fast velocities. Likely some % of sand (not able to be quantified) but fine gravel appears dominant from visual estimate. Straightening (historic) inferred from linear planform and close encroachment

Step 2. (Contued)

- 2.5 Aband. Floodpln **8.50** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **10.11**
- 2.7 Entrenchment Ratio **4.94**
- 2.8 Incision Ratio **1.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Not Applicable**
- 2.11 Riffle/Step Spacing (ft) **N/A**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	100 %
Sand	0 %
Silt and smaller	0 %

- Silt/Clay Present? **Yes**
- Detritus **0** %
- # Large Woody **50**

2.13 Average Largest Particle on

- Bed **N/A** mm
- Bar **N/A** mm

2.14 Stream Type

- Stream Type: **E**
- Bed Material: **Gravel**
- Subclass Slope: **None**
- Bed Form: **Plane Bed**
- Field Measured Slope:

2.15 Reference Stream Type (if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	1,574	1,703
Erosion Height (ft)	3.00	3.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	104	107

Near Bank Veg. Type	Left	Right
Dominant	Herbaceous	Herbaceous
Sub-dominant	None	None

Bank Canopy	Left	Right
Canopy %	1-25	1-25
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	None	None
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Forest
Sub-dominant	None	Pasture
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 **Minimal**
- 4.3 Flow Status **High**
- 4.4 # of Debris Jams **1**
- 4.5 Flow Regulation Type **None**
- Flow Regulation Use
- Impoundments **None**
- Impoundmt. Location
- 4.6 Up/Down strm flow reg
- (old) Upstrm Flow Reg **None**

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

Mid	Point	Side
2	0	0
Diagonal	Delta	Island
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
2	0	0	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**
- 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.

Stream: **Upper Otter Creek** Reach # **M26** Segment: **A** Completion Date: **November 4,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **9,948** Segment Location: **From segment break approximately 1500 feet downstream of Wallingford WWTF,**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Old	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**
Problem **Scour Below**					
Bridge	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**
Problem **None**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**16**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**56**		
Geomorphic Rating	**0.7**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**8**
6.2 Pool Substrate	**13**
6.3 Pool Variability	**15**
6.4 Sediment Deposition	**16**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**8**
6.7 Channel Sinuosity	**8**
6.8 Bank Stability	**Left: 7 Right: 7**
6.9 Bank Vegetation Protection	**Left: 4 Right: 4**
6.10 Riparian Vegetation Zone Width	**Left: 2 Right: 3**
Total Score	**113**
Habitat Rating	**0.565**

Habitat Stream Condition **Fair**

Narrative:

PF adjust, wid, & aggrad (localized to undersized crossings, and minimal buffers). If hist straight (inferred from linear PF & rr) resulted in incis, it was v min in extent. Mod. by silts in chann bed or offset by simult. aggrad fr u/s erosion.

January 22, 2009 SGAT Version: 4.56

Phase 2 Segment Summary

Project: **Upper Otter Creek**
Stream: **Upper Otter Creek** Reach # **M26** Segment: **B** Completion Date: **November 4, 2005**
Organization: **Rutland NRCD** Observers: **KLU, HS** Why Not assessed: Rain: **Yes**
Segment Length (ft): **2,330** Segment Location: **Upstream 2330 feet of reach M26 extending from approximately 700 feet upstream to 1500**

QC Status - Staff: **Provisional** Cons **Provisional**

Step 1. Valley and Floodplain

1.1 Segmentation
1.2 Alluvial Fan **None**
1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Sometimes	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Not Evalua	Not Evalua

1.5 Valley Features
Valley Width (ft) **300**
Width Determination **Estimated**
Confinement Type **Semi-confined**
Rock Gorge? **No**
Human-caused Change? **Yes**

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:
Brief subreach of C-stream type at upstream end of reach. Cross section / pebble count prevented by high water conditions and fast velocities. Straightening (historic) inferred from linear planform and encroachment of roads / railroad along LB / RB.

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
2.10 Riffles Type
2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	0 %
Fine Gravel	0 %
Sand	0 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**
Detritus **0** %
Large Woody **5**

2.13 Average Largest Particle on
Bed **0.0**
Bar **0.0**

2.14 Stream Type
Stream Type: **E**
Bed Material:
Subclass Slope:
Bed Form:
Field Measured Slope:

2.15 Reference Stream Type
(if different from Phase 1)
C **4** **c** **Riffle-Pool**

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies		0.00

Step 3. Riparian Features

3.1 Stream Banks
Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type		
Consistency		
Lower		
Material Type		
Consistency		

Bank Erosion	Left	Right
Erosion Length (ft)	0	545
Erosion Height (ft)	0.00	3.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	350	172

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Deciduous

Bank Canopy	Left	Right
Canopy %	26-50	26-50
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	26-50	>100
Sub-dominant	>100	26-50
W less than 25	0	0

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Forest
Sub-dominant	Forest	Pasture
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 **Minimal**
4.3 Flow Status **High**
4.4 # of Debris Jams **0**
4.5 Flow Regulation Type **None**
Flow Regulation Use
Impoundments **None**
Impoundmt. Location
4.6 Up/Down strm flow reg
(old) Upstrm Flow Reg **None**

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

Mid	Point	Side
2	1	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
2	0	0	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**
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.

Stream: **Upper Otter Creek** Reach # **M26** Segment: **B** Completion Date: **November 4,**

Organization: **Rutland NRCD** Observers: **KLU, HS** Rain: **Yes**

Segment Length (ft): **2,330** Segment Location: **Upstream 2330 feet of reach M26 extending from approximately 700 feet upstream to**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**0.00**	**Yes**	**Yes**	**Yes**	**Yes**

Problem **Deposition Above,Scour Below**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**18**	**None**	**No**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**13**		**No**
Total Score	**57**		
Geomorphic Rating	**0.7125**		

Channel Evolution Model

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**8**
6.2 Embeddedness	**15**
6.3 Velocity/Depth Patterns	**16**
6.4 Sediment Deposition	**13**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**11**
6.7 Frequency of Riffles/Steps	**10**
6.8 Bank Stability	**Left: 9 Right: 6**
6.9 Bank Vegetation Protection	**Left: 7 Right: 7**
6.10 Riparian Vegetation Zone Width	**Left: 4 Right: 8**
Total Score	**132**
Habitat Rating	**0.66**

Habitat Stream Condition **Good**

Narrative:

Aggradation, PF adjustment, widening localized to undersized crossing.

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Project: **Upper Otter Creek**
Stream: **Upper Otter Creek** Reach # **M27** Segment: **0** Completion Date: **August 26, 2008**
Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **No**
Segment Length (ft): **4,356** Segment Location: **Runs through the village of Wallingford.**

QC Status - Staff: **Provisional Cons**

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	494	0
height	10	0
Roads	0	3,012
height	0	8
Railroads	0	489
height	0	8
Improved Paths	0	0
height	0	0
Development	0	743

1.4 Adjacent Side	Left	Right
Hillside Slope	Very Steep	Steep
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Bedrock	Not Evalua

1.5 Valley Features

Valley Width (ft) **610**
Width Determination **Estimated**
Confinement Type **Broad**
Rock Gorge? **No**
Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **68**
2.2 Max Depth (ft) **5.70**
2.3 Mean Depth (ft) **4.80**
2.4 Floodprone Width (ft) **550**

Notes:

Reach has been significantly altered by history of village industry and dams. Extensive straightening, riprap, and bridge crossings. Historic diversions and dam remnants in channel and on banks. Current channel is functioning as an unincised C4,

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln **5.70** ft.
Human Elev Floodpln **0.00** ft.
2.6 Width/Depth Ratio **14.17**
2.7 Entrenchment Ratio **8.09**
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) **900**

2.12 Substrate Composition

Bedrock	0%
Boulder	1%
Cobble	21%
Coarse Gravel	40%
Fine Gravel	16%
Sand	15%
Silt and smaller	7%

Silt/Clay Present? **Yes**
Detritus **5** %
\# Large Woody **54**

2.13 Average Largest Particle on

Bed **8.0** **inches**
Bar **3.0** **inches**

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)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Gravel	Gravel
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	252	170
Erosion Height (ft)	3.72	5.06
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	411	979

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Deciduous

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	51-100	26-50
Sub-dominant	0-25	0-25
W less than 25	533	593

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Residential
Sub-dominant	Residential	Industrial
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 **Minimal**
4.3 Flow Status **Low**
4.4 # of Debris Jams **0**
4.5 Flow Regulation Type **None**
Flow Regulation Use
Impoundments **None**
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

Mid	Point	Side
2	0	0
Diagonal	Delta	Island
0	1	3

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
2	0	0	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**
Straightening Length: **2,509**
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: **Upper Otter Creek** | **Phase 2 Reach Summary** | January 22, 2009

Stream: **Upper Otter Creek** Reach # **M27** Segment: **0** Completion Date: **August 26, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **4,356** Segment Location: **Runs through the village of Wallingford.**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**108.**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Deposition Below,Scour Above,Alignment**				
Bridge	**70.0**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Deposition Below**				
Old	**50.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Deposition Above,Scour Below**				
Bridge	**75.0**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Deposition Above**				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**15**	**None**	**No**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planform	**9**		**No**
Total Score	**48**		
Geomorphic Rating	**0.6**		

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**13**
6.2 Embeddedness	**10**
6.3 Velocity/Depth Patterns	**15**
6.4 Sediment Deposition	**8**
6.5 Channel Flow Status	**13**
6.6 Channel Alteration	**6**
6.7 Frequency of Riffles/Steps	**13**
6.8 Bank Stability	**Left: 8 Right: 9**
6.9 Bank Vegetation Protection	**Left: 8 Right: 8**
6.10 Riparian Vegetation Zone Width	**Left: 3 Right: 3**
Total Score	**117**
Habitat Rating	**0.585**

Habitat Stream Condition **Fair**

Narrative:

C type stream has been straightened. No incision due to bed resistance and/or upstream sediments. Beltwidth is narrow - expected future widening and planform adjustments as the channel attempts to decrease stream power through increased sinuosity.

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M28** Segment: **0** Completion Date: **August 25, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **No**

Segment Length (ft): **6,024** Segment Location: **From behind the ballfields in Wallingford upstream to where the valley broadens south of**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	1,866	4,146
height	8	8
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Extremely	Steep
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **480**

Width Determination **Estimated**

Confinement Type **Narrowly**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **90**

2.2 Max Depth (ft) **5.10**

2.3 Mean Depth (ft) **4.11**

2.4 Floodprone Width (ft) **380**

Notes:

Significant historic channel straightening has drastically reduced habitat within this reach. Channel has gone from an E to a C type channel due to channel widening. classified as stage 1 despite slight incision because overall trend does not indicate further incision

Step 2. (Contued)

2.5 Aband. Floodpln **5.90** ft.

Human Elev Floodpln **11.00** ft.

2.6 Width/Depth Ratio **21.90**

2.7 Entrenchment Ratio **4.22**

2.8 Incision Ratio **1.16**

Human Elevated Inc Rat **2.16**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	17%
Coarse Gravel	30%
Fine Gravel	10%
Sand	39%
Silt and smaller	4%

Silt/Clay Present? **Yes**

Detritus **5** %

Large Woody **91**

2.13 Average Largest Particle on

Bed **5.0** inches

Bar **N/A** inches

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Plane Bed**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Gravel	Gravel
Consistency	Non-cohesive	Non-cohesive
Bank Erosion	**Left**	**Right**
Erosion Length (ft)	512	767
Erosion Height (ft)	4.65	4.31
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	300	494
Near Bank Veg. Type	**Left**	**Right**
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Herbaceous
Bank Canopy	**Left**	**Right**
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	26-50	0-25
Sub-dominant	0-25	>100
W less than 25	2,644	1,792
Buffer Veg. Type	**Left**	**Right**
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Hay	Hay
Sub-dominant	Forest	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 **Minimal**

4.3 Flow Status **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	2	Road Ditch	1
Other	0	Tile Drain	0
Overland Flow	1	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

Mid	Point	Side
0	0	0
Diagonal	**Delta**	**Island**
0	0	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	0	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**

Straightening Length: **6,024**

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.

Stream: **Upper Otter Creek** Reach # **M28** Segment: **0** Completion Date: **August 25, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **6,024** Segment Location: **From behind the ballfields in Wallingford upstream to where the valley broadens south**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**235.**	**Yes**	**Yes**	**No**	**Yes**

Problem **None**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**Other**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**8**		**No**
7.4 Change in Planform	**15**		**No**
Total Score	**43**		
Geomorphic Rating	**0.5375**		

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**8**
6.2 Pool Substrate	**10**
6.3 Pool Variability	**10**
6.4 Sediment Deposition	**13**
6.5 Channel Flow Status	**15**
6.6 Channel Alteration	**5**
6.7 Channel Sinuosity	**8**
6.8 Bank Stability	**Left: 8 Right: 7**
6.9 Bank Vegetation Protection	**Left: 4 Right: 4**
6.10 Riparian Vegetation Zone Width	**Left: 4 Right: 2**
Total Score	**98**
Habitat Rating	**0.49**

Habitat Stream Condition **Fair**

Narrative:

Major channel straightening has caused widening and loss of bedform. Only slight incision. Shift from E to C stream type. Future widening and planform changes expected. Incision not major, stage 1 is best fit, new fldplain development not expected

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M29** Segment: **0** Completion Date: **August 21, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **No**

Segment Length (ft): **20,209** Segment Location: **From where the valley widens upstream of the Route 7 Bridge in Wallingford upstream to**

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	2,212	0
height	9	0
Railroads	9,210	1,251
height	8	8
Improved Paths	0	0
height	0	0
Development	384	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Very Steep	Very Steep
Continuous w/	Never	Never
W/in 1 Bankfill	Sometimes	Never
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **1,300**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **77**

2.2 Max Depth (ft) **8.80**

2.3 Mean Depth (ft) **5.79**

2.4 Floodprone Width (ft) **1,300**

Notes:

Channel is predominately in agricultural land south of Wallingford village. Numerous undersized bridges and old abutments are impacting the channel. Riparian forests have been impacted. The channel planform has been significantly impacted by straightening

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln **9.30** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **13.30**

2.7 Entrenchment Ratio **16.88**

2.8 Incision Ratio **1.06**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Oxbows**

2.10 Riffles Type **Not Applicable**

2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	5%
Coarse Gravel	10%
Fine Gravel	35%
Sand	40%
Silt and smaller	10%

Silt/Clay Present? **Yes**

Detritus **10** %

Large Woody **311**

2.13 Average Largest Particle on

Bed **N/A**

Bar **N/A**

2.14 Stream Type

Stream Type: **E**

Bed Material: **Sand**

Subclass Slope: **None**

Bed Form: **Dune-Ripple**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	3,982	4,837
Erosion Height (ft)	5.47	5.42
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,750	1,771

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Deciduous	Deciduous

Bank Canopy	Left	Right
Canopy %	1-25	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	>100
Sub-dominant	>100	0-25
W less than 25	9,607	2,964

Buffer Veg. Type	Left	Right
Dominant	Herbaceous	Shrubs/Saplin
Sub-dominant	Shrubs/Saplin	Deciduous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Forest
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin
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 **Abundant**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **1**

4.5 Flow Regulation Type **None**

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **None**

(old) Upstrm Flow Reg

4.7 StormwaterInputs

Field Ditch	6	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

Mid	Point	Side
2	4	2
Diagonal	Delta	Island
0	1	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
3	3	0	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**

Straightening Length: **10,975**

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:	Upper Otter Creek	Phase 2 Reach Summary	January 22, 2009
Stream:	**Upper Otter Creek**	Reach # **M29**	Segment: **0** Completion Date: **August 21, 2008**
Organization:	**Rutland NRCD**	Observers: **Michael Blazewicz, Ryan Case**	Rain: **No**
Segment Length (ft):	**20,209**	Segment Location: **From where the valley widens upstream of the Route 7 Bridge in Wallingford upstream**	

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**30.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Deposition Above,Scour Above,Scour**				
Bridge	**26.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Above,Scour Below**				
Bridge	**90.0**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Scour Above,Scour Below**				
Bridge	**28.5**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Above,Scour Below**				
Bridge	**85.0**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Deposition Above,Scour Above**				
Bridge	**25.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Above,Scour Below**				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**16**	**None**	**No**
7.2 Channel Aggradation	**14**	**None**	**No**
7.3 Widening Channel	**10**		**No**
7.4 Change in Planform	**10**		**No**
Total Score	**50**		
Geomorphic Rating	**0.625**		

Channel Evolution Model **F**
Channel Evolution Stage **I**
Geomorphic Condition **Fair**
Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **Low**

	Score
6.1 Epifaunal Substrate - Available Cover	**13**
6.2 Pool Substrate	**18**
6.3 Pool Variability	**18**
6.4 Sediment Deposition	**16**
6.5 Channel Flow Status	**18**
6.6 Channel Alteration	**8**
6.7 Channel Sinuosity	**13**
6.8 Bank Stability	**Left: 7 Right: 6**
6.9 Bank Vegetation Protection	**Left: 4 Right: 4**
6.10 Riparian Vegetation Zone Width	**Left: 2 Right: 6**
Total Score	**133**
Habitat Rating	**0.665**

Habitat Stream Condition **Good**

Narrative:

Despite straightening, channel has excellent floodplain access and dimensions expected for E stream type. Incision may be offset by silts in channel bed, aggradation from upstream, or post glacial slope changes. Expect future planform adjust.

Project: **Upper Otter Creek**
Stream: **Upper Otter Creek** Reach # **M30** Segment: **0** Completion Date: **August 20, 2008**
Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **No**
Segment Length (ft): **9,027** Segment Location: **From where the valley walls narrow upstream of South Wallingford downstream to where**

QC Status - Staff: **Provisional Cons** **Provisional**

Step 1. Valley and Floodplain

1.1 Segmentation **None**
1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	0
height	0	0
Railroads	5,952	3,052
height	8	8
Improved Paths	0	0
height	0	0
Development	0	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Very 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) **346**
Width Determination **Measured**
Confinement Type **Semi-confined**
Rock Gorge? **No**
Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **86**
2.2 Max Depth (ft) **5.40**
2.3 Mean Depth (ft) **4.12**
2.4 Floodprone Width (ft) **346**

Notes:
A C4 channel through a narrow and semi-confined valley with a natural bedrock grade control section in the middle. Bank armoring and straightening have impacted much of the reach. The reach begins to look like an E channel as the slope flattens near the end of

Step 2. (Contued)

2.5 Aband. Floodpln **5.90** ft.
Human Elev Floodpln **0.00** ft.
2.6 Width/Depth Ratio **20.87**
2.7 Entrenchment Ratio **4.02**
2.8 Incision Ratio **1.09**
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	0 %
Boulder	0 %
Cobble	22 %
Coarse Gravel	46 %
Fine Gravel	26 %
Sand	1 %
Silt and smaller	5 %

Silt/Clay Present? **Yes**
Detritus **1** %
Large Woody **46**

2.13 Average Largest Particle on
Bed **15.0** inches
Bar **5.0** inches

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)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks
Typical Bank Slope **Moderate**

Bank Texture	Left	Right
Upper		
Material Type	Gravel	Gravel
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Boulder/Cobbl	Boulder/Cobbl
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	404	565
Erosion Height (ft)	3.85	6.38
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	2,254	1,881

Near Bank Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

Bank Canopy	Left	Right
Canopy %	26-50	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	>100
Sub-dominant	0-25	0-25
W less than 25	1,766	586

Buffer Veg. Type	Left	Right
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
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 **Minimal**
4.3 Flow Status **Low**
4.4 # of Debris Jams **0**
4.5 Flow Regulation Type **None**
Flow Regulation Use
Impoundments **None**
Impoundmt. Location
4.6 Up/Down strm flow reg **None**
(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	2
Other	0	Tile Drain	0
Overland Flow	0	Urb Strm Wtr Pipe	0

4.9 # of Beaver Dams **0**
Affected Length (ft) **0**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid	Point	Side
0	0	0
Diagonal	**Delta**	**Island**
0	1	2

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
4	0	0	1

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**
Straightening Length: **697**
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.

Stream: **Upper Otter Creek** Reach # **M30** Segment: **0** Completion Date: **August 20, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **No**

Segment Length (ft): **9,027** Segment Location: **From where the valley walls narrow upstream of South Wallingford downstream to**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Ledge	**Mid-segment**	**0.00**	**0.00**	**Yes**	
Ledge	**Mid-segment**	**0.00**	**0.00**	**Yes**	
Ledge	**Mid-segment**	**0.00**	**0.00**	**Yes**	

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	**66.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Below**				
Old	**57.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Deposition Above,Scour Above,Scour**				
Bridge	**160.**	**Yes**	**Yes**	**No**	**Yes**
Problem	**Deposition Above,Scour Below**				
Old	**40.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Deposition Above,Scour Below**				
Bridge	**40.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Below**				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**13**	**None**	**No**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**12**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**49**		
Geomorphic Rating	**0.6125**		

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**15**
6.2 Embeddedness	**15**
6.3 Velocity/Depth Patterns	**15**
6.4 Sediment Deposition	**15**
6.5 Channel Flow Status	**15**
6.6 Channel Alteration	**15**
6.7 Frequency of Riffles/Steps	**15**
6.8 Bank Stability	**Left: 9 Right: 8**
6.9 Bank Vegetation Protection	**Left: 7 Right: 7**
6.10 Riparian Vegetation Zone Width	**Left: 7 Right: 7**
Total Score	**150**
Habitat Rating	**0.75**

Habitat Stream Condition **Good**

Narrative:

Channel has reacted to a healthy amount of straightening, bank armoring, and encroachment. Also there are numerous undersized bridges and old abutments that are constricting flows. Bedrock grade control in middle of reach. Narrow to Semi-confined.

Project: Upper Otter Creek

Phase 2 Segment Summary

January 22, 2009 SGAT Version: 4.56

Stream: **Upper Otter Creek** Reach # **M31** Segment: **0** Completion Date: **August 20, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Why Not assessed: Rain: **Yes**

Segment Length (ft): **10,790** Segment Location: **From where the valley narrows in South Wallingford upstream to just south of the**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	594	0
height	10	0
Railroads	6,968	0
height	8	0
Improved Paths	0	0
height	0	0
Development	166	0

1.4 Adjacent Side

	Left	Right
Hillside Slope	Extremely	Extremely
Continuous w/	Never	Sometimes
W/in 1 Bankfill	Sometimes	Sometimes
Texture	Not Evalua	Not Evalua

1.5 Valley Features

Valley Width (ft) **950**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width	70
2.2 Max Depth (ft)	5.80
2.3 Mean Depth (ft)	4.32
2.4 Floodprone Width (ft)	810

Notes:

Channel appears to have been historically straightened for agriculture and the railroad. Some incision was noted and the w/d ratio indicates a C type riffle pool system. Numerous undersized structures and old abutments are constricting channel and

Step 2. (Contued)

2.5 Aband. Floodpln	6.80 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	16.20
2.7 Entrenchment Ratio	11.57
2.8 Incision Ratio	1.17
Human Elevated Inc Rat	0.00
2.9 Sinuosity	Low
2.10 Riffles Type	Complete
2.11 Riffle/Step Spacing (ft)	800

2.12 Substrate Composition

Bedrock	0%
Boulder	15%
Cobble	37%
Coarse Gravel	28%
Fine Gravel	13%
Sand	7%
Silt and smaller	0%

Silt/Clay Present? **No**

Detritus **3** %

Large Woody **61**

2.13 Average Largest Particle on

Bed	10.0	inches
Bar	1.0	inches

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)

3.3 old	Amount	Mean Height
Failures	None	0.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

Bank Texture	Left	Right
Upper		
Material Type	Silt	Silt
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Gravel	Gravel
Consistency	Non-cohesive	Non-cohesive
Bank Erosion	**Left**	**Right**
Erosion Length (ft)	848	1,358
Erosion Height (ft)	4.48	4.76
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	305	503
Near Bank Veg. Type	**Left**	**Right**
Dominant	Deciduous	Deciduous
Sub-dominant	Shrubs/Saplin	Shrubs/Saplin
Bank Canopy	**Left**	**Right**
Canopy %	51-75	51-75
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	>100	>100
W less than 25	5,322	3,589
Buffer Veg. Type	**Left**	**Right**
Dominant	Herbaceous	Mixed Trees
Sub-dominant	Shrubs/Saplin	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Pasture	Pasture
Sub-dominant	None	Forest
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	Abundant
4.3 Flow Status	Moderate
4.4 # of Debris Jams	1
4.5 Flow Regulation Type	None
Flow Regulation Use	
Impoundments	None
Impoundmt. Location	
4.6 Up/Down strm flow reg	None
(old) Upstrm Flow Reg	

4.7 StormwaterInputs

Field Ditch	4	Road Ditch	1
Other	0	Tile Drain	0
Overland Flow	1	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

Mid	Point	Side
0	0	1
Diagonal	**Delta**	**Island**
0	1	0

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
2	0	0	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	0	No

5.4 Stream Ford or Animal **Yes**

5.5 Straightening **Straightening**

Straightening Length: **6,423**

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.

Stream: **Upper Otter Creek** Reach # **M31** Segment: **0** Completion Date: **August 20, 2008**

Organization: **Rutland NRCD** Observers: **Michael Blazewicz, Ryan Case** Rain: **Yes**

Segment Length (ft): **10,790** Segment Location: **From where the valley narrows in South Wallingford upstream to just south of the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Old	**26.0**	**No**	**Yes**	**Yes**	**Yes**
Problem	**Scour Below**				
Bridge	**38.0**	**Yes**	**Yes**	**Yes**	**Yes**
Problem	**Scour Above,Scour Below**				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**15**	**None**	**No**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**14**		**No**
Total Score	**57**		
Geomorphic Rating	**0.7125**		

Channel Evolution Model **F**

Channel Evolution Stage **I**

Geomorphic Condition **Good**

Stream Sensitivity **High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	**15**
6.2 Embeddedness	**15**
6.3 Velocity/Depth Patterns	**18**
6.4 Sediment Deposition	**15**
6.5 Channel Flow Status	**15**
6.6 Channel Alteration	**8**
6.7 Frequency of Riffles/Steps	**13**
6.8 Bank Stability	**Left: 8 Right: 7**
6.9 Bank Vegetation Protection	**Left: 7 Right: 7**
6.10 Riparian Vegetation Zone Width	**Left: 3 Right: 3**
Total Score	**134**
Habitat Rating	**0.67**

Habitat Stream Condition **Fair**

Narrative:

Channel planform has seen extensive straightening, however, no evidence of significant incision. Channel has some minor widening and planform adjustment evidence. Likely to continue this as it attempts to decrease slope, and decrease stream power.

APPENDIX C

STRESSOR IDENTIFICATION MAPS

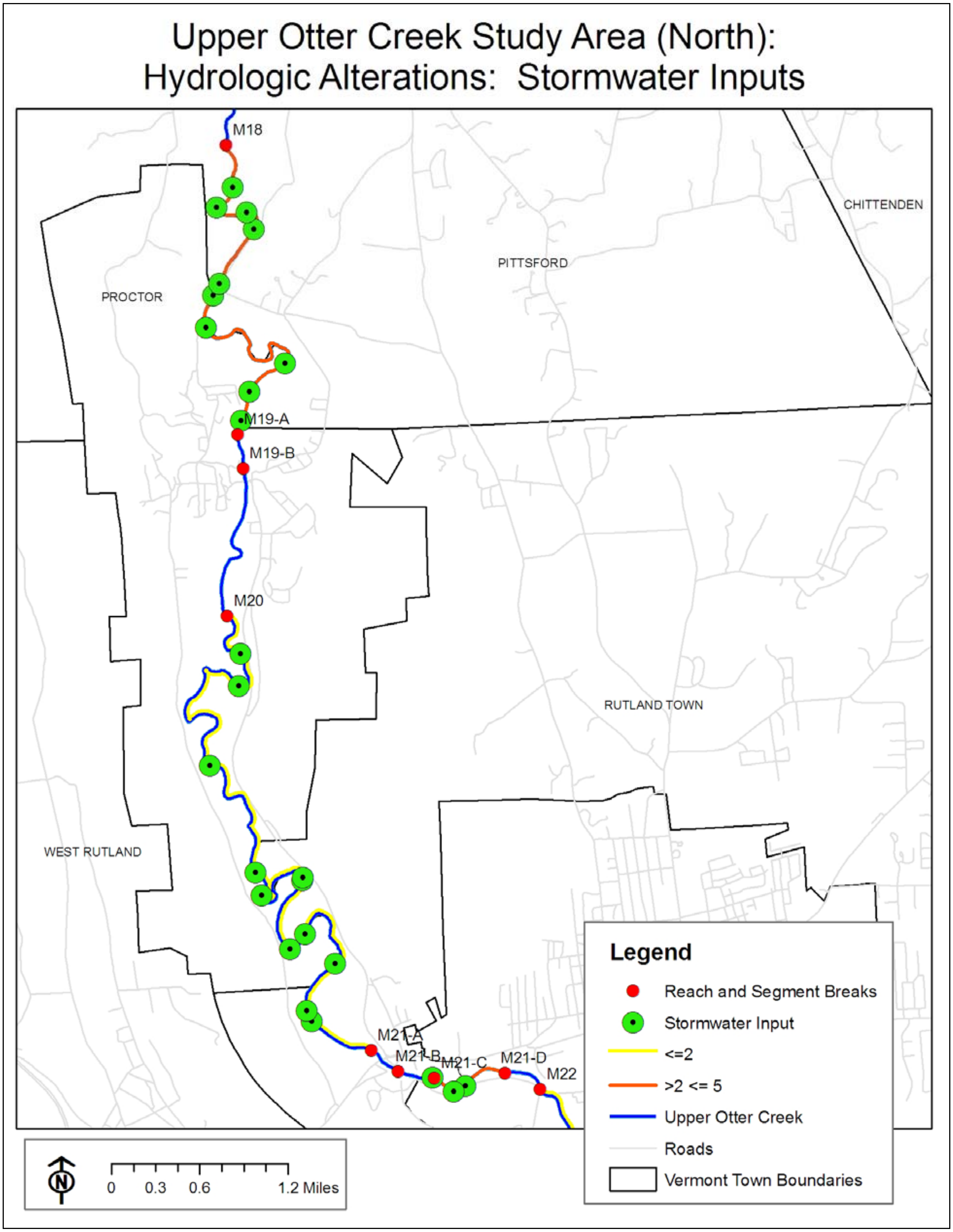


Figure 1: Stormwater Inputs: North Section of Upper Otter Creek (M22-M18)

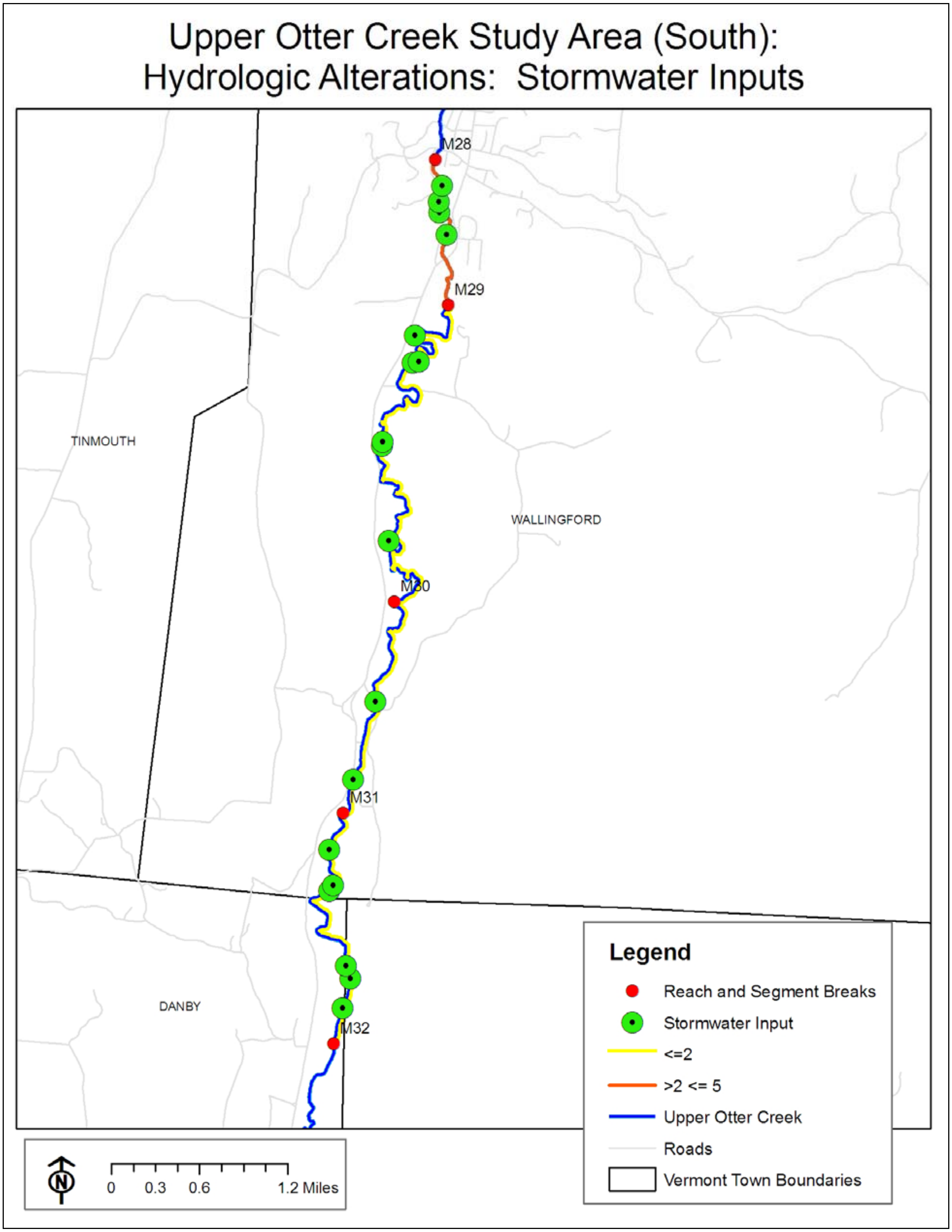


Figure 2: Stormwater Inputs: South Section of Upper Otter Creek (M31-M27)

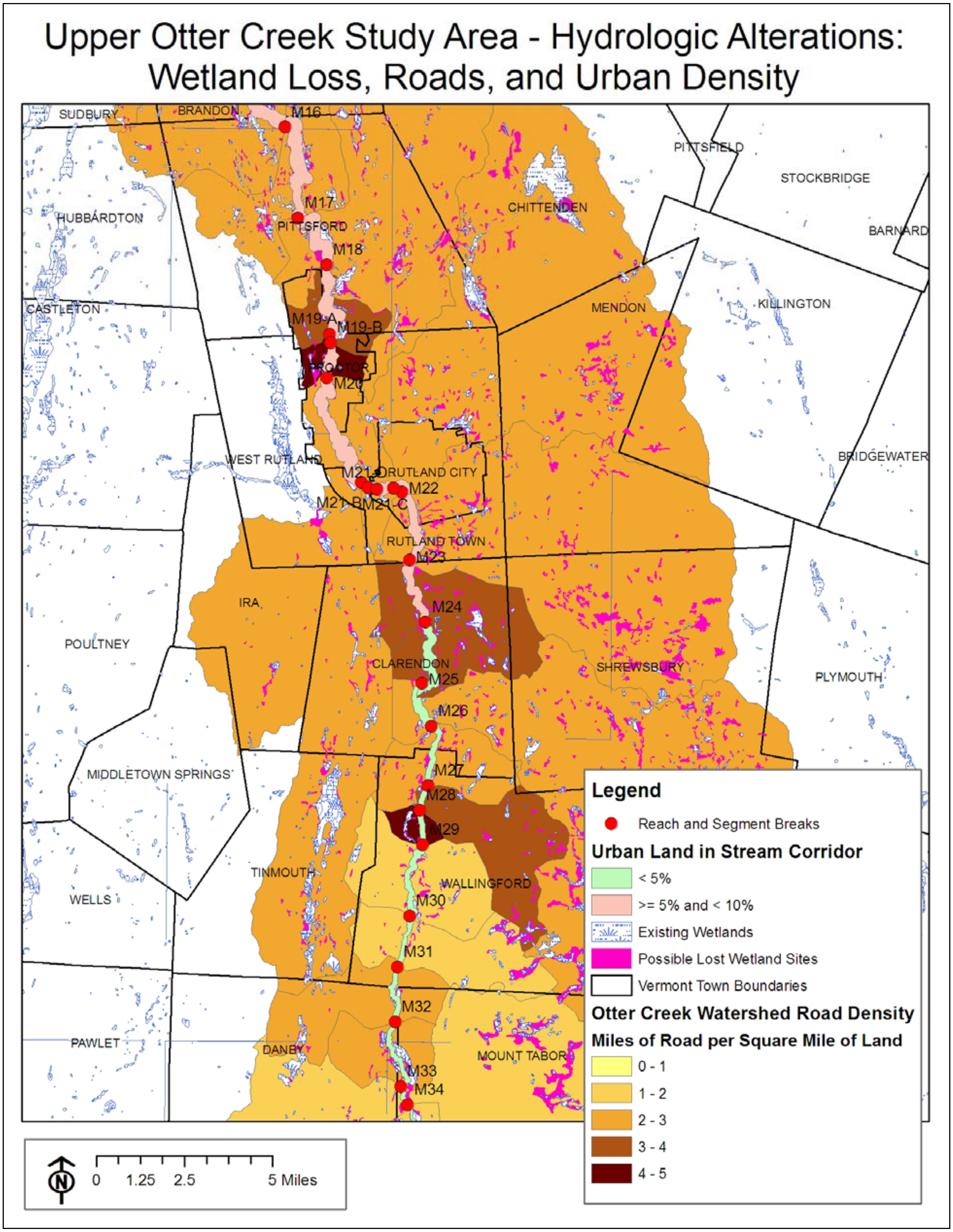


Figure 3: Hydrologic Alterations: Changes in the Land Use/Land Cover of the Upper Otter Creek

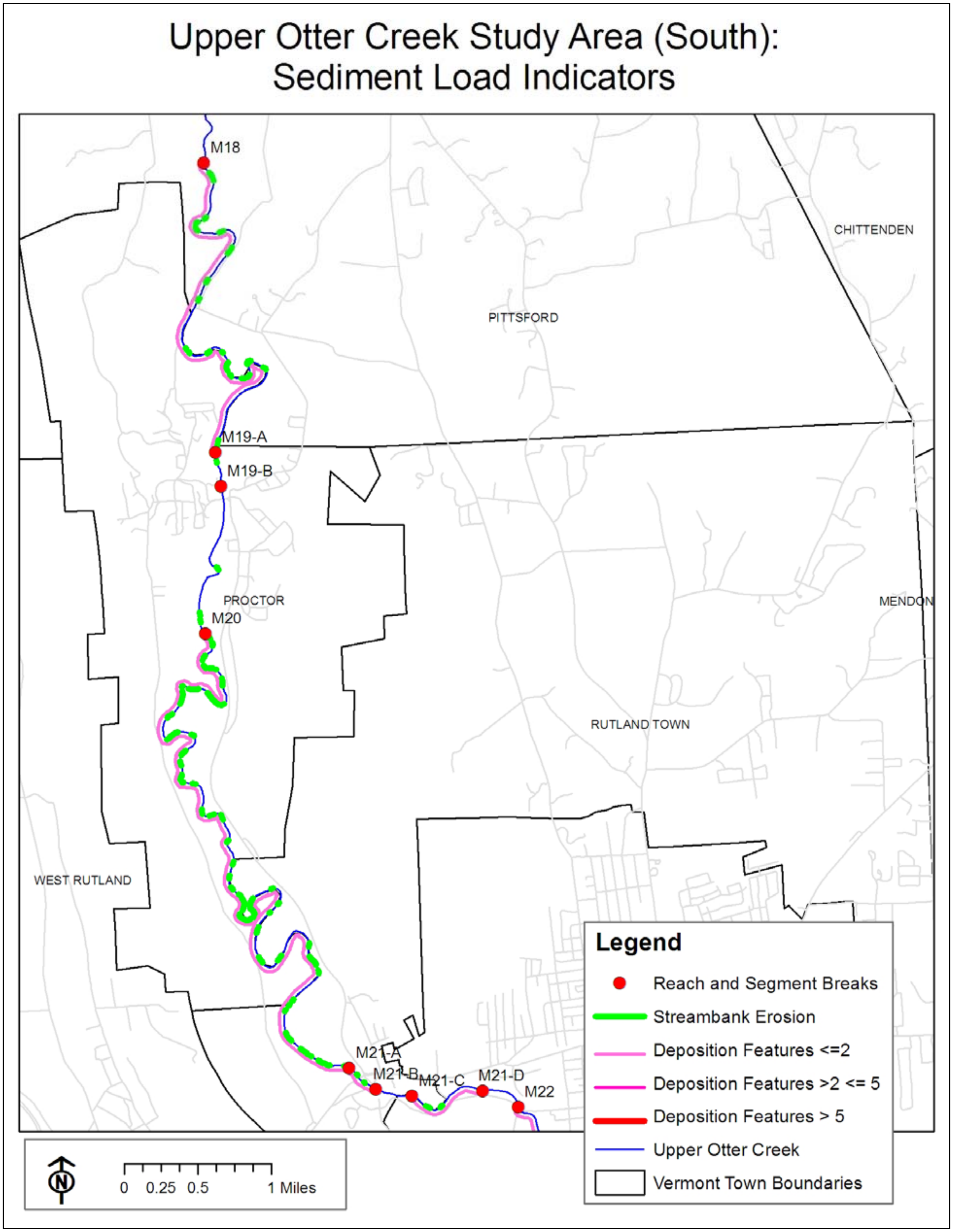


Figure 4: Sediment Inputs: North Section of Upper Otter Creek (M22-M18)

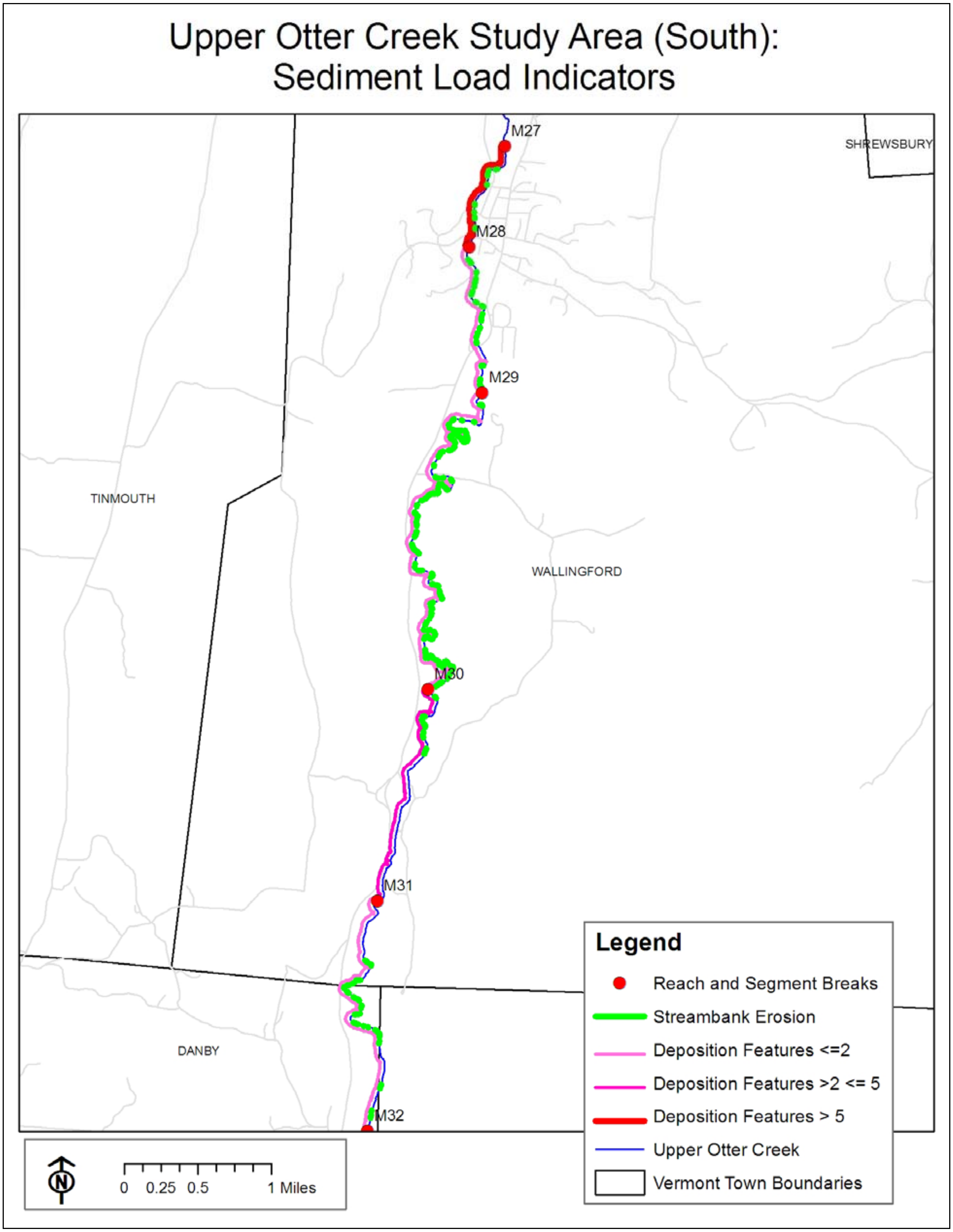


Figure 5: Sediment Inputs: South Section of Upper Otter Creek (M31-M27)

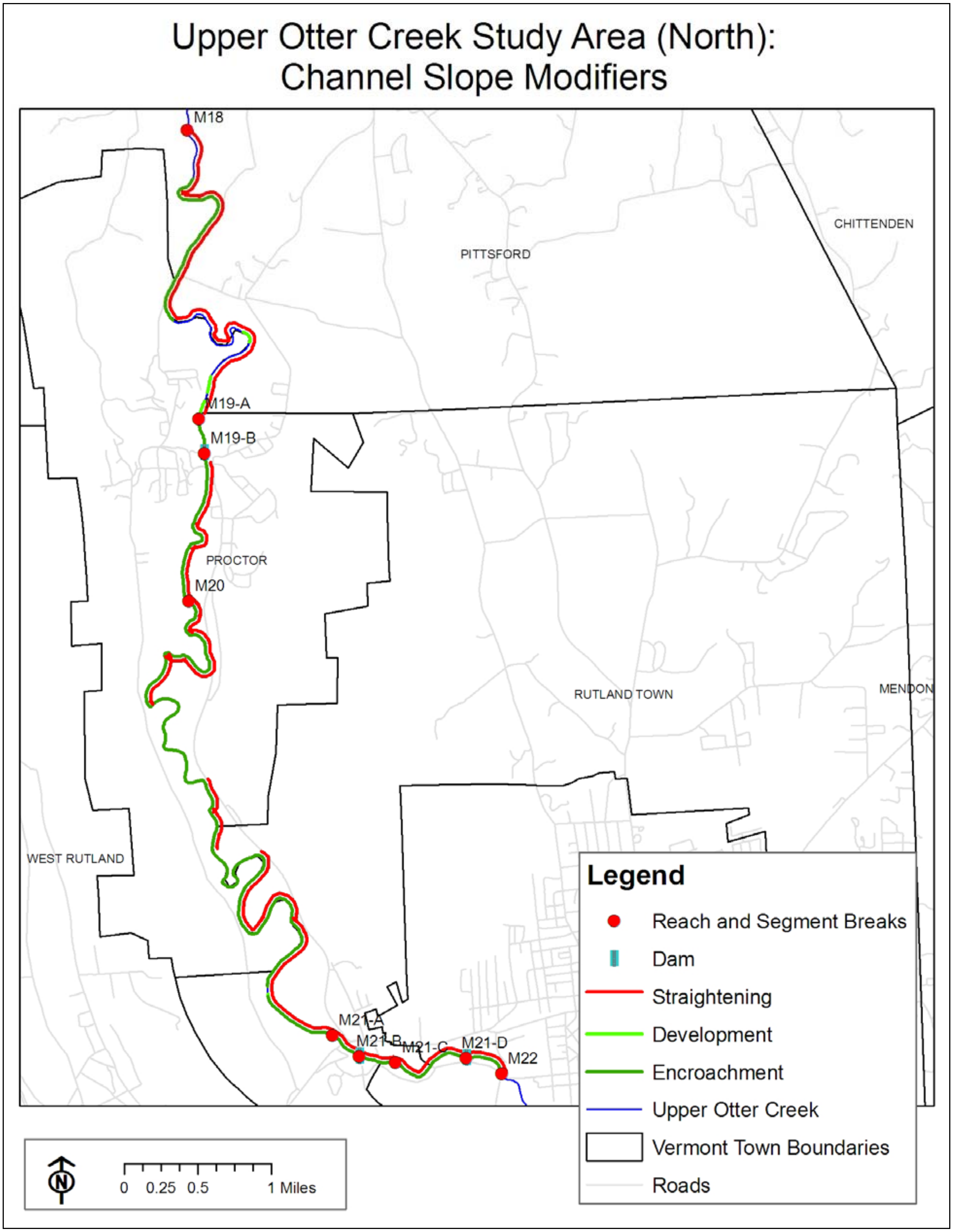


Figure 6: Slope Modifiers: North Section of Upper Otter Creek (M22-M18)

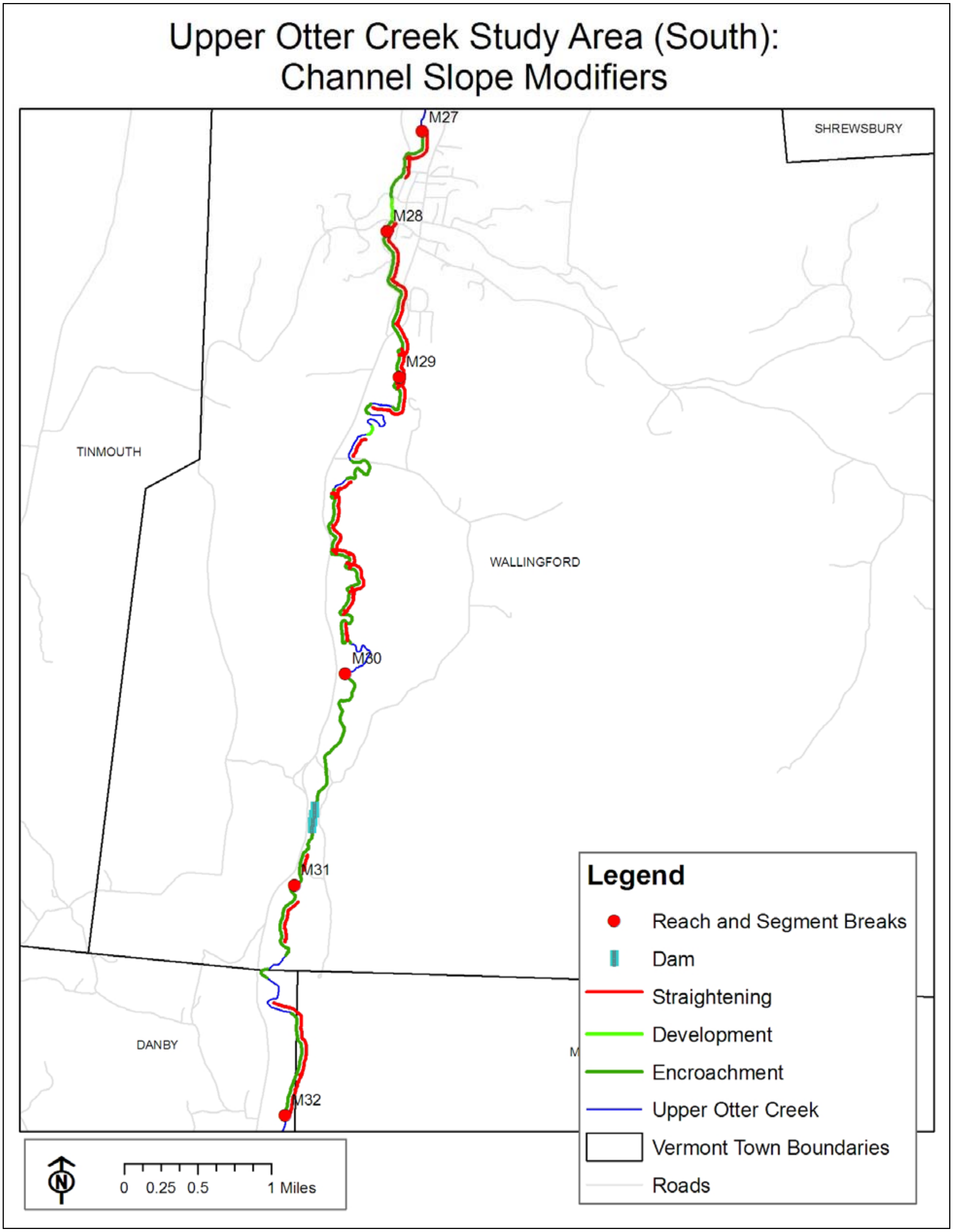


Figure 7: Slope Modifiers: South Section of Upper Otter Creek (M31-M27)

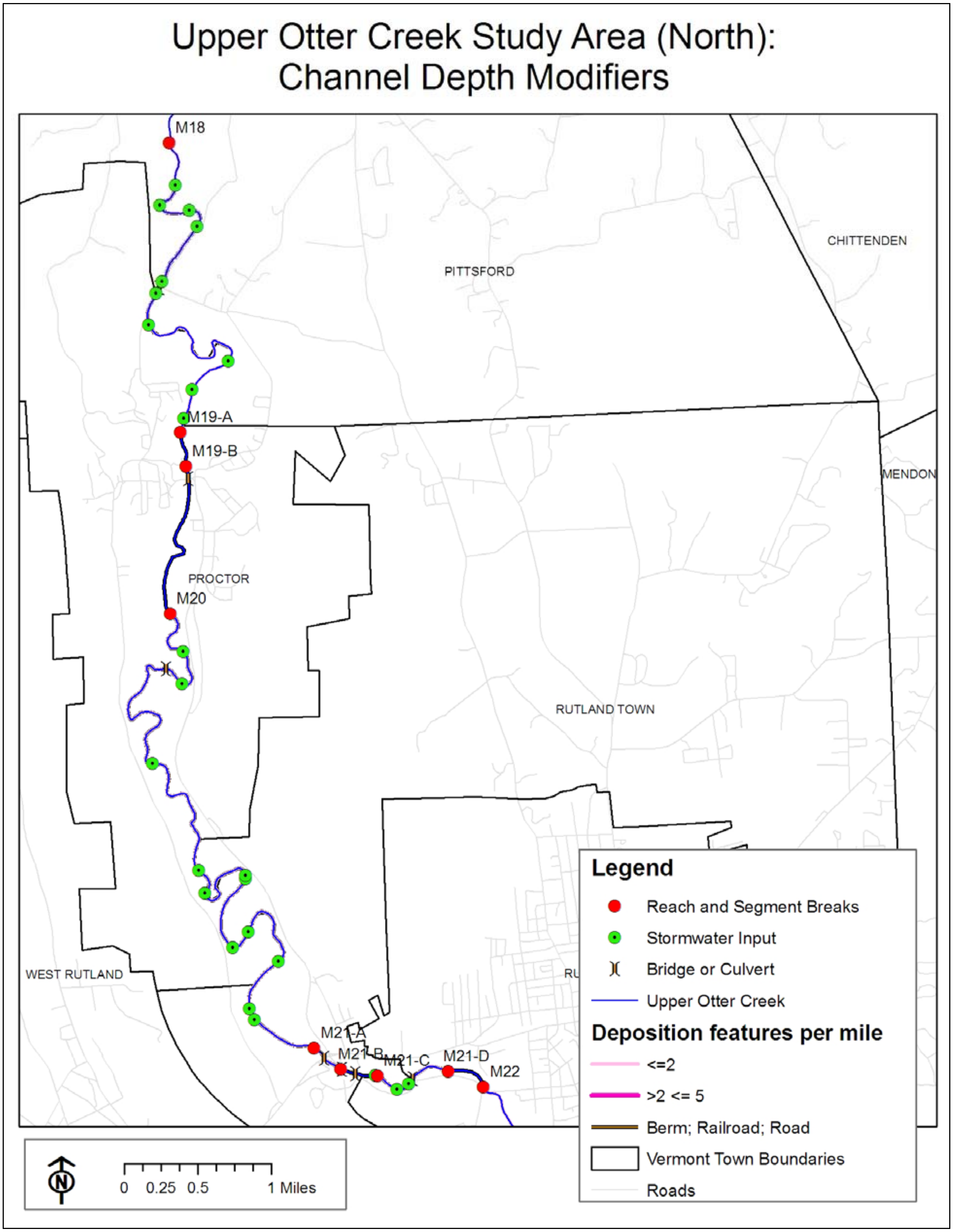


Figure 8: Depth Modifiers: North Section of Upper Otter Creek (M22-M18)

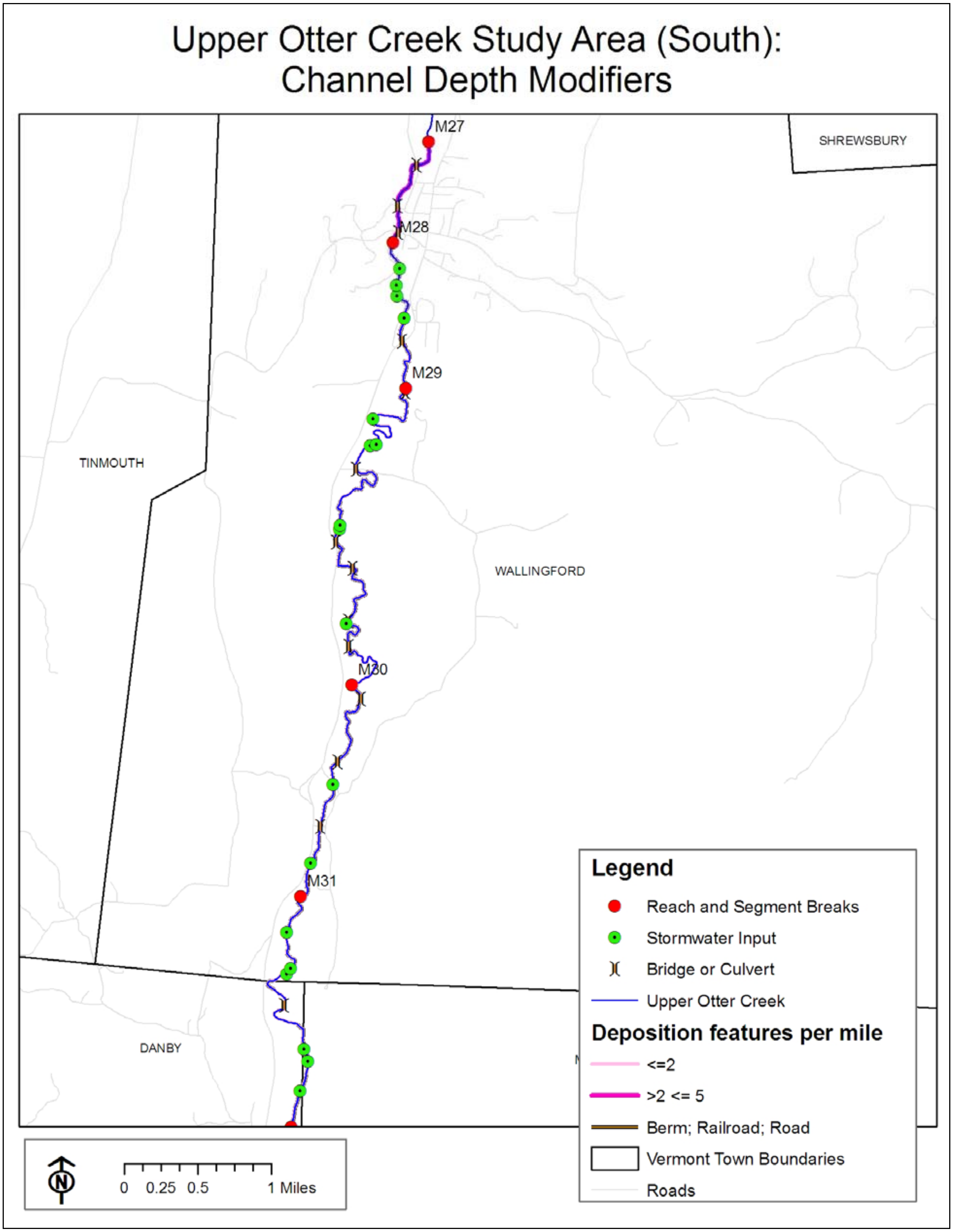


Figure 9: Depth Modifiers: South Section of Upper Otter Creek (M31-M27)

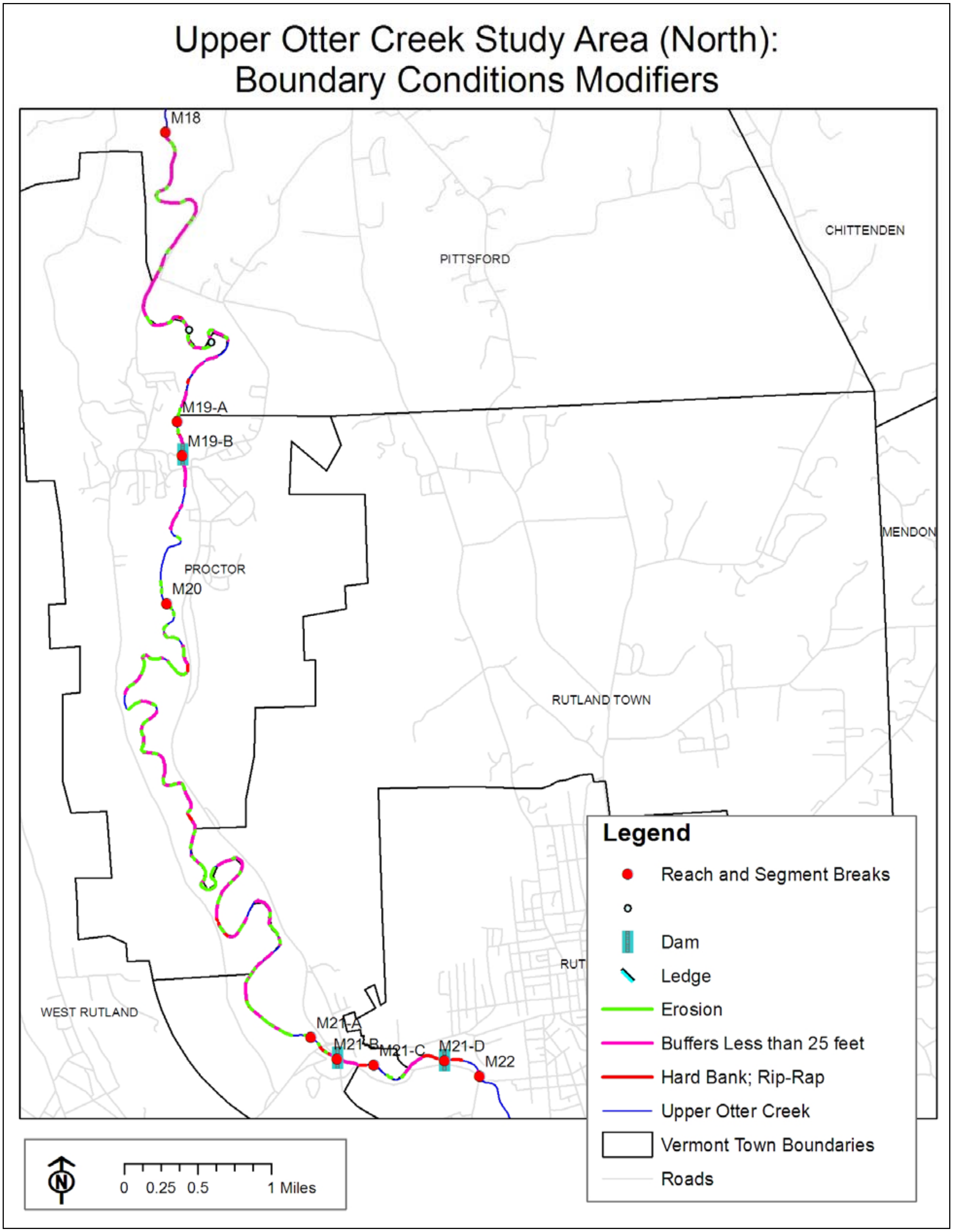


Figure 10: Boundary Condition Alterations: North Section of Upper Otter Creek (M22-M18)

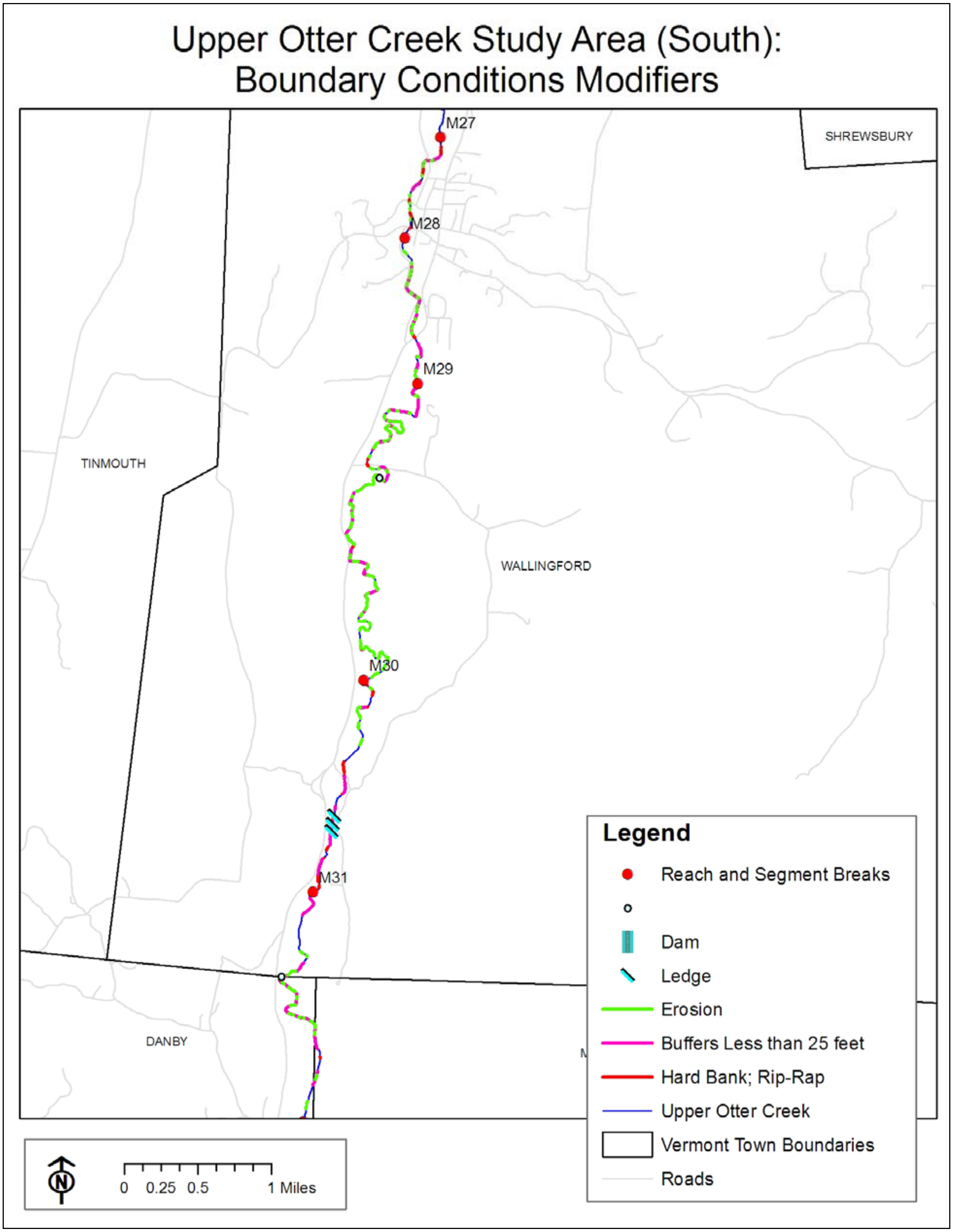


Figure 11: Boundary Condition Alterations: South Section of Upper Otter Creek (M31-M27)

APPENDIX D

Channel Evolution Models

(Vermont Agency of Natural Resources, Appendix C, May 2007)

Channel Evolution Models

F-stage Channel Evolution Process

The capital letters used throughout the following discussions refer to the stream types (Rosgen, 1996) typically encountered as the channel form passes through the different stages of channel evolution. The F-stage adjustment process begins where the streams are not entrenched and have access to a floodplain at the 1-2 year flood stage. Moderately entrenched, semi-confined "B" streams may also go through an F-stage channel evolution. This channel evolution model (CEM) is based on the assumption that the stream has a bed and banks that are sufficiently erodible so that they can be shaped by the stream over the course of years or decades. Streams beginning this process are typically flowing in alluvium or other materials that may be eroded by an increase in stream power. As the incision process continues, they may degrade to bedrock or glacial till materials. When a stream with a low width to depth ratio ("E" stream types) goes through this process, the sequence of stream types may be **E-C-F-C-E** (other forms may include **E-C-G-F-C-E** or **C-G-F-C** or **C-F-C** or **C-B-F-B-C** or **B-G-F-B** or **B-G-F** or **C-B-C**).

Stage I - Channel in regime with access to floodplain or flood prone area at discharges at and above the average annual high flow. Planform is moderate to highly sinuous; supportive of energy dissipating bed features (steps, riffles, runs, pools) essential to channel stability (B, C and E Stream Types). Channel slope (vertical drop in relation to length) generates flow velocities and stream power in balance with the resistance of stream bed and bank materials. Sediment transport capacity in equilibrium with sediment load.

Stage II - Channel has lost access to its floodplain or flood prone area, at its historic bankfull discharge, through a bed degradation process or floodplain build up. Stream has become more entrenched as discharges in excess of the annual high flow are now contained in the channel (B or G or F Stream Type). Channel slope is increased with commensurate increase in velocity and power to erode the stream bed and banks (boundary materials). The result of preventing access to the floodplain and containing greater flows in the channel is to increase the stream's power that must be resisted by the channel boundary materials; i.e., the rocks, soil, vegetation or man-made structures that make up the bed and banks of the river. Plane bed may begin to form as head cuts move upstream and step/riffle materials are eroded.

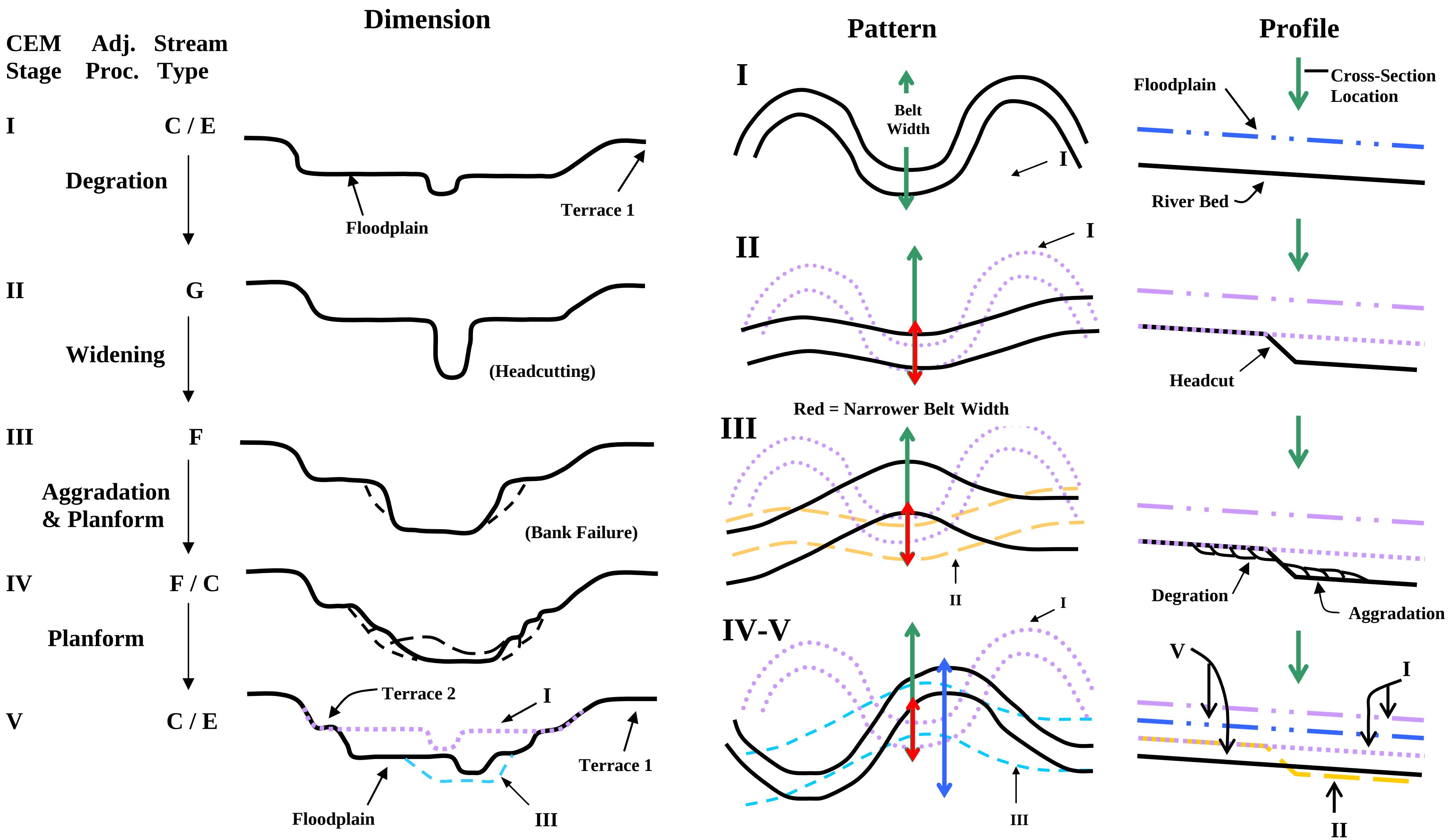
Stage III - Channel is still entrenched, widening and migrating laterally through bank erosion caused by the increased stream power (B or G or F Stream Type). The system regains balance between the power produced and the boundary materials as sinuosity increases and slope decreases. There are profound physical adjustments that occur upstream and downstream from the site of alteration as bed degradation (head cuts) migrates up through the system and aggradation in the form of sedimentation occurs downstream. Stream bed largely becomes a featureless plane bed.

Stage IV - Channel dimension and plan form adjustment process continues. Channel width begins to narrow through aggradation and the development of bar features. The main channel may shift back and forth through different flood chutes, continuing to erode terrace side slopes as a juvenile floodplain widens and forms. Weak step/riffle-pool bed features forming. Transverse bars may be common as planform continues to adjust. At Stage IV, erosion may be severe. Historically, channels have been dredged, bermed, and/or armored at this Stage pushing the process back to Stage II or III.

Stage V - Channel adjustment process is complete. Channel dimension, pattern, and profile are similar to the pre-adjustment form but at a lower elevation in the landscape (B, C and E Stream Types). Planform geometry, longitudinal profile, channel depth, and bed features produce an energy grade that is in balance with the sediment regime produced by the stream's watershed.

Higher gradient, more entrenched streams ("A" or "B" stream types) with erodible beds also go through channel evolution processes that involves bed degradation. In these cases, the floodplain forming stages may be comparatively minor. A lowering of the bed elevation is more quickly followed by a re-sloping of the banks until the appropriate energy grade is achieved.

F-stage Channel Evolution Process (VTDEC-Modified from Schumm, 1977 & 1984 and Thorne et al, 1997)



D-stage Channel Evolution Process

Only use the D stage CEM where the stream has no opportunity to incise. If the stream has incised and has now hit bedrock or clay and is currently widening, you would still use the F stage CEM.

The capital letters used throughout the following discussions refer to the stream types (Rosgen, 1996) typically encountered as the channel form in the different stages of channel evolution. The difference between F and D-stage channel evolution processes is the degree of channel incision. In D-stage channel evolution, the dominant, active adjustment processes is **aggradation**, widening, and plan form change. In some situations, the stream may not experience any degradation because its bed is significantly more resistant to erosion than its banks. The process may start with limited vertical adjustment and goes right into aggradation and a lateral adjustment processes. Stream with low width to depth ratios ("E" Stream Types) may also go through this process.

Stage I - Channel in regime with access to floodplain or flood prone area at discharges at and above the average annual high flow (B, C and E Stream Types). Plan form is moderate to highly sinuous; supportive of energy dissipating bed features (steps, riffles, runs, pools) essential to channel stability. Channel slope (vertical drop in relation to length) generates flow velocities and stream power in balance with the resistance of stream bed and bank materials. **Then either of the following Stage II scenarios may occur:**

Stage IIc Steeper gradient may be imposed through activities such as channelization, but due to the resistance of the bed material, the stream has not incised significantly or lost access to its floodplain (remaining a "C" Stream Type). Channel is widening and migrating laterally through bank erosion caused by the increased stream power. The balance between stream power and boundary materials is re-established when the slope flattens after a process of channel lengthening and increased sinuosity. Stream bed may be a combination of poorly defined riffle-pool and plane bed features.

Stage IId Channel becomes extremely depositional and becomes braided with water flowing in multiple channels at low flow stage ("D" stream type). Dimension and plan form adjustment processes continue. Channel width begins to narrows through aggradation and the development of bar features. The main channel may shift back and forth through different channels and chute cut-offs, continuing to erode banks or terrace side slopes. Riffle-pool bed features develop as single thread channel begins forming. Transverse bars may be common as planform continues to adjust.

Stage III Channel adjustment process is complete (back to a B, C or E stream type). Channel dimension, pattern, and profile are similar to the pre-adjustment form. May or may not be at a lower elevation in the landscape. Planform geometry, longitudinal profile, channel depth, and bed features produce an energy grade (sediment transport capacity) that is in balance with the sediment regime produced by the stream watershed.

Important Notes: 1) The imposition of new constraints or changes at watershed, reach, or local scales, especially those related to large floods that energize the stream system with high flows of water, sediment, and debris, will affect the time scales associated with each stage of channel evolution. They may also have dramatic effects on the direction of a channel evolution process. The overlapping pulses of channel adjustment moving upstream and downstream in a watershed often makes the pinpointing of a specific channel evolution stage complicated. 2) Bedrock-controlled reaches in Vermont are presumed to be relatively fixed for the purposes of these protocols as little bed or back erosion can be expected even over a century. Such reaches may, however, dramatically change or evolve due to rapid or catastrophic avulsions of the flow onto more erodible sediments nearby, leaving the bedrock channel wholly or partially abandoned.

C-D-C Channel Evolution Process (VTDEC-Modified from Schumm, 1977 & 1984 and Thorne et al, 1997)