Upper Winooski River:
Plainfield to Montpelier

River Corridor Management Plan

Washington County, Vermont

FINAL REPORT

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1.0 EXECUTIVE SUMMARY

The Upper Winooski watershed is a geophysical boundary that encompasses the area of land that drains into the Winooski River from its headwaters in Cabot downstream to Montpelier. The River defines a significant valley shared by many landowners. A multitude of resources, at the cost of these landowners and state taxpayers, have been spent on protecting property adjacent to the river by methods such as channel straightening, dredging, and streambank armoring. Many of these practices are predictably temporary, often ultimately do not provide protection, and almost always are detrimental to the health of the river ecosystem as well as having negative water quality and quantity impacts downstream all the way to Lake Champlain. In order to reduce the need for maintenance of traditional channel management applications along the Upper Winooski River and to shift the focus of management projects from short term control to long term equilibrium and stability (50 to 100 year planning) the Friends of the Winooski River, Winooski Natural Resource Conservation District, and Central Vermont Regional Planning Commission (collectively referred to as “Partners”) retained Round River Design to complete a Phase 2 Stream Geomorphic Assessment of select reaches between Plainfield and Montpelier and develop a River Corridor Management Plan.

Stream geomorphic assessments provide information about the physical condition of streams and the factors that influence their stability. The Vermont Agency of Natural Resources River Management Program has developed a series of protocols (Phase 1, Phase 2, and River Corridor Planning) for the statewide assessment of rivers and streams. The first part of this process looks at broad scale landscape data, historical information, and limited field reconnaissance to begin to understand watershed characteristics and potential stressors. A Phase 1 Geomorphic Assessment of the Upper Winooski River was completed in 2007 by the Partners (Willard et al. 2007). A Phase 2 Assessment involves the collection of data from measurements and observations made in the field. In 2006, the Partners retained the Johnson Company (consulting scientists) to conduct a Phase 2 Assessment on reaches of the Winooski River between Marshfield and Montpelier. In 2009 the Partners retained Round River Design to perform a Phase 2 Geomorphic Assessment of additional reaches from near the Marshfield/Plainfield town line downstream to Montpelier (connecting with the reach data gathered in 2006). This Corridor Plan addresses the mainstem of the Upper Winooski River from Plainfield downstream through the towns of East Montpelier and Berlin to the confluence with the North Branch in downtown Montpelier. This Plan is a stand alone document but may be referenced in conjunction with the River Corridor Plan developed for the Upper Winooski River that was written exclusively for the Towns of Cabot (Blazewicz and Nealon 2006) and Marshfield (Johnson Company 2008).

Geomorphic assessments study historic alteration and current watershed conditions and are therefore able to help predict how the Upper Winooski River will continue to adjust in the future. The results provided by the assessments assist in determination of appropriate long-term management strategies. In brief, Round River Design found that the main stem of the Upper Winooski River described in this Plan has been significantly impacted by historic riparian forest removal, channel straightening, and streambank armoring. Floodplain encroachment by roads, agriculture, commercial, and residential development are also significant impacts. In response to these and other watershed stressors, the Upper Winooski River is undergoing varying degrees of channel adjustment, predominately planform (or lateral migration), channel widening, and aggradation. Local communities are encouraged to take action by reforesting riparian areas, replacing undersized bridges, removing floodplain encroachments, and adopting Fluvial Erosion Hazard Zoning. These practices will help provide long-term protection to the river ecosystem as well as provide additional ecosystem services to the immediate and downstream communities including but not limited to: flood and hazard reduction, water quality improvement, ecosystem health, and recreation.

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 Upper Winooski River 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 informed planning and, eventually, meaningful long-lasting rehabilitation and management efforts.

The VTANR River Management Program uses the "river corridor" as a primary tool in its strategy to restore and protect the natural values of rivers and to minimize flood damage. River corridors extend perpendicular out from the channel as well as extend lengthwise providing important connectivity from headwaters to mouth. The adjacent lands included in the corridor are those that are capable and perhaps likely to be occupied by the channel as it meanders within a valley bottom over time (For a technical description of how corridors 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 2008). Reducing current and future near-stream investment in infrastructure and achieving 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 Assessment Initiatives in the Upper Winooski River Watershed

Local restoration initiatives have been largely driven by the Friends of the Winooski River (FWR); Winooski Natural Resource Conservation District (WNRCD); VTANR basin planning and river management programs; and ongoing planning projects of the Central Vermont Regional Planning Commission (CVRPC).

Management recommendations for the Upper Winooski River are 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. The protocols start at the watershed scale, a unique, objective, functional boundary that encompasses the area of land draining to a common water body, in this case the Winooski River. 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 Winooski River was completed in 2006 by the Partners along with a report summarizing the findings (Willard, A., et al. 2007). From this study a Phase 2 Geomorphic Assessment of select high priority reaches of the Upper Winooski River was recommended in order to gather more detailed data to inform current and future planning and restoration efforts. The Phase 2 Assessment "breaks down" a river into geomorphologically homogenous study reaches in order to obtain information that can be used to "build-up" an understanding of the sediment regime and channel morphology of the watershed by looking at the larger patterns created by the reach data. In 2006, the CVRPC retained the Johnson Company to conduct a Phase 2 Assessment on four disconnected reaches of the Upper Winooski River between Marshfield and Montpelier as well as reaches extending upstream into Marshfield. The results of this study are found in a report titled "Phase 2 Stream Geomorphic Assessment Upper Winooski Watershed: Towns of Cabot, Marshfield, Plainfield, East Montpelier, Barre, and Montpelier Washington County, Vermont" (Johnson 2007). This information was synthesized into the "Upper Winooski River Corridor Plan: Town of Marshfield" (Johnson 2008) and was complimentary to the "Upper Winooski River, River Corridor Management Plan: Cabot, Vermont" (Blazewicz and Nealon 2006). In 2008, the Partners retained Round River Design to perform a Phase 2 Stream Geomorphic Assessment of the previously non-assessed reaches along the main stem of the Upper Winooski River from the Marshfield/Plainfield town line downstream to East Montpelier thereby creating a continuous set of information about the condition of the Winooski River from Cabot to Montpelier. Round River design was then asked to synthesize these two sets of data into this River Corridor Management Plan.

3.0 UPPER WINOOSKI RIVER STUDY AREA: BACKGROUND WATERSHED INFORMATION

3.1 Geographic Setting

3.1.1 Watershed Description

The Upper Winooski River watershed is a political subdivision of the Winooski River watershed [The Winooski watershed is also sometimes referred to as a "basin" due to its large scale]. The Winooski River begins in Cabot Township and flows westerly through Washington and Chittenden Counties to reach Lake Champlain. The Upper Winooski River watershed area is 316 square miles (upstream of confluence with the North Branch – the most downstream point of this study) (Figure 1). The stream reaches targeted through this Corridor Plan are within Washington County and have a combined length of approximately 15.5 miles (Figures 2 and 3). Major tributaries within this Upper Winooski study area are Wells Brook (Marshfield), Great Brook (Plainfield), Kingsbury Branch (East Montpelier), Pond Brook (East Montpelier), Mallory Brook (East Montpelier), and the Stevens Branch (Berlin).

3.1.2 Political Jurisdictions

The Upper Winooski River mainstem reaches of this 2009 study were located in Washington County in the Towns of Marshfield, Plainfield, East Montpelier, Berlin, and Montpelier. All towns are members of the Central Vermont 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.

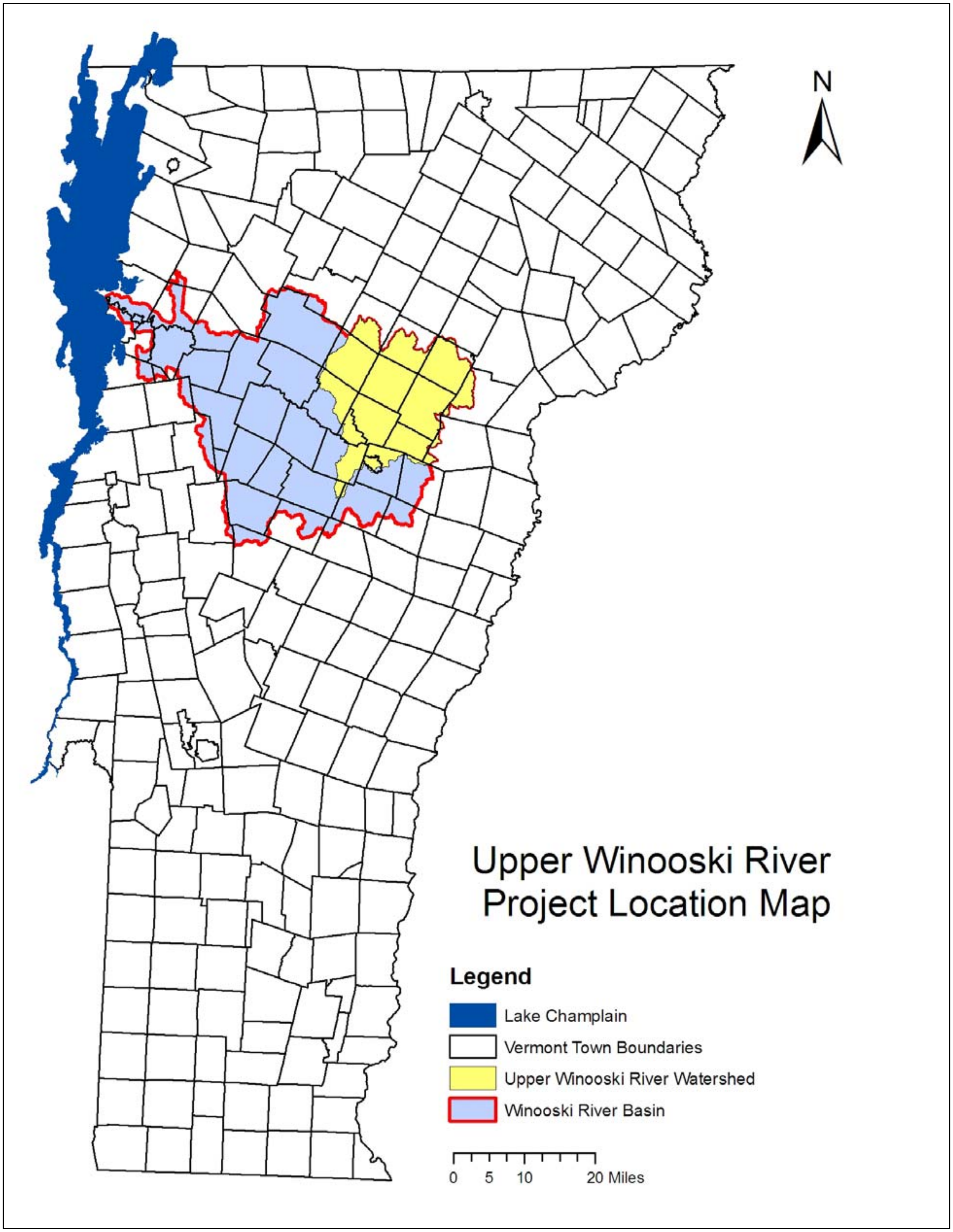


Figure 1: Upper Winooski River Project Location Map

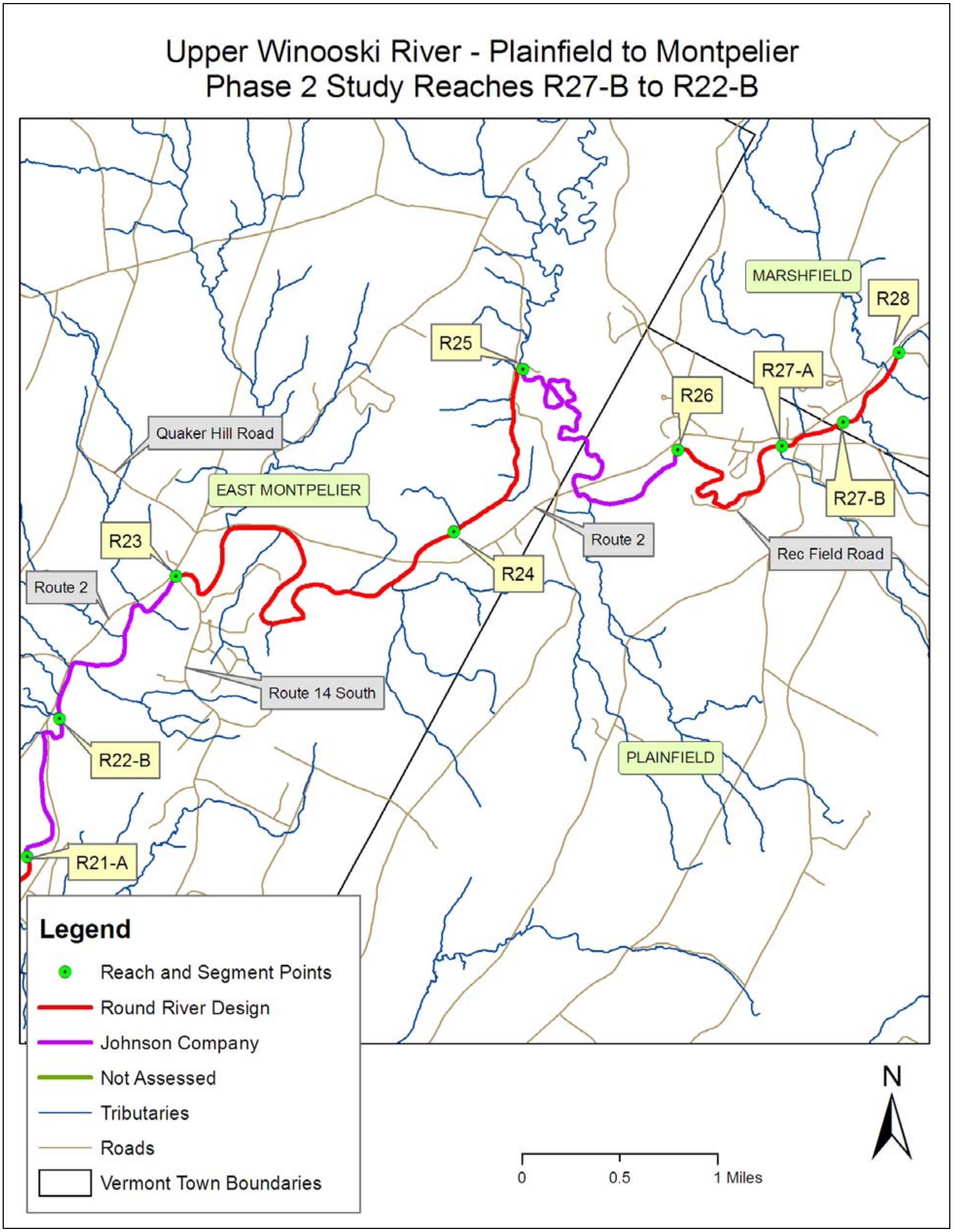


Figure 2: Reach location map for the Upper Winooski River Phase 2 Stream Geomorphic Assessment.

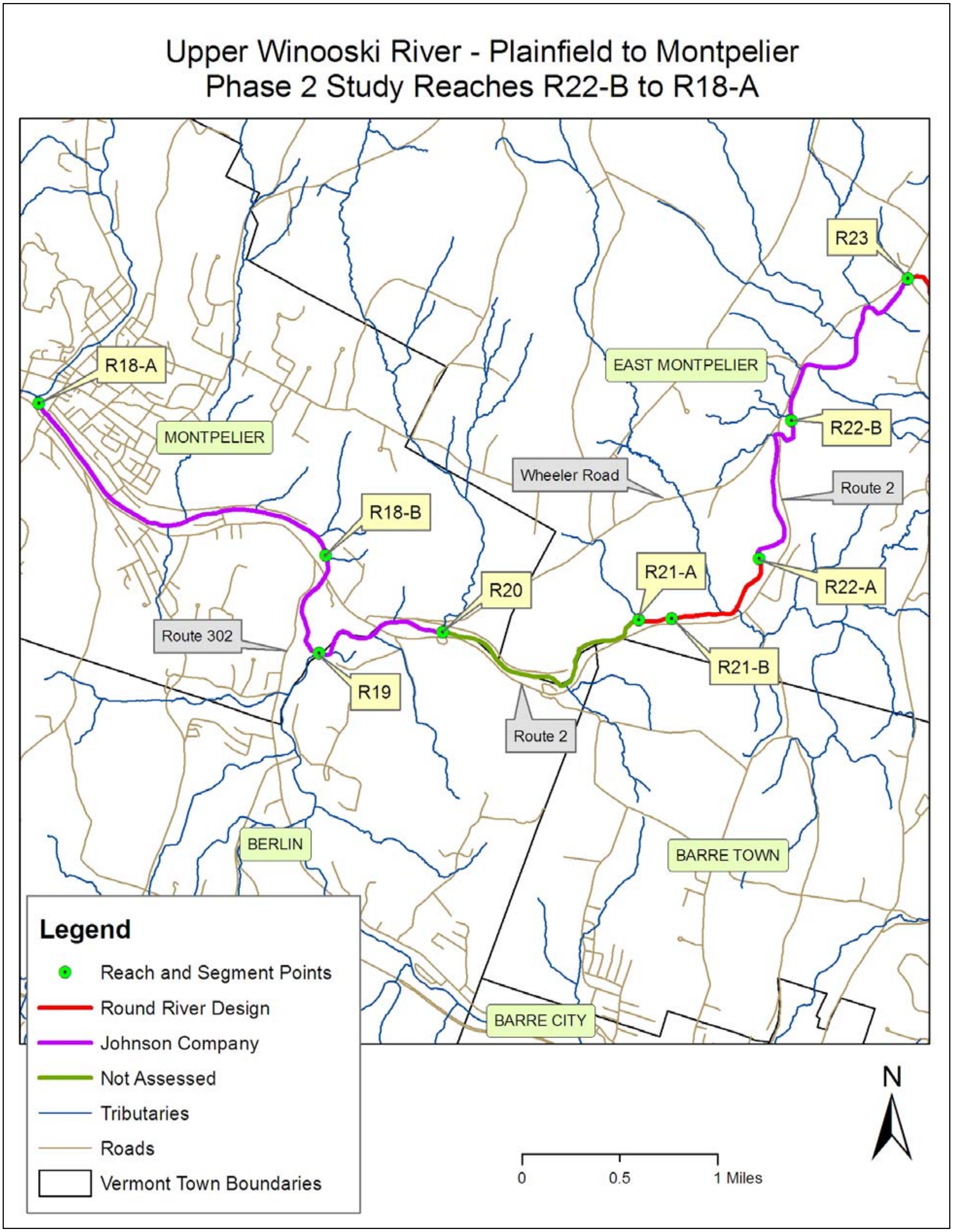


Figure 3: Reach location map for the Upper Winooski River Phase 2 Stream Geomorphic Assessment.

3.1.3 Land Use History

The Winooski River, like most waterways, has always been vitally important to the inhabitants of the watershed. Paleo-indians hunted and fished in the watershed 10,000 years ago (the oldest documented site is currently in Moretown along the Mad River). According to the WNRCD website, archeological evidence indicates agricultural clearing was occurring in 1400AD by Abenaki peoples at the mouth of the river. It was from the Abenaki that the river received its name, "*winooskik*", meaning "wild onion" and the riverine system provided food, materials, and medicines.

French explorers entered the region and began land clearing along the river in the 1600's. Colonial settlements were established in Vermont by the late 1700's and in addition to strategic defensive locations, typically arose around gristmills and sawmills at suitable sites along the rivers and its tributaries. In the then Village of Montpelier, for instance, the first cotton mill arose in 1810. In Plainfield, Jim Batchelder and Son built extensive mills in the village in 1877 manufacturing hard and soft wood lumber, chair and cab stock, and shingles. Other dams appeared and disappeared over the years (today there are four dams in the study area covered by this report, the Batchelder Dam in Plainfield Village one of them). Logging was one of the first major industries (along with potash, created from logging byproducts) in the Upper Winooski River 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 soil erosion from the surrounding hillsides. By 1850, over 75% of the state's forests had been cleared first for farming and then for wood products (Albers, 1999). Soils that were washed away from the denuded hillsides (Figure 4) entered into the river system an altering the river channel. Settlers along the waterways likely began to experience more pronounced flood events, perhaps culminating in the great flood of 1927.

Figure 4: Winooski River between Montpelier and Barre following the 1927 flood. Extensive deforestation of surrounding hillsides is seen in the photograph (courtesy: UVM Landscape Change Program).

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 Winooski River Watershed, along with the Champlain Valley and the Connecticut River Valley saw the majority of this settlement.

In 1849, a railroad line was established in the Winooski Valley from Burlington to Montpelier. In 1873 this line was extended eastwards to Wells River providing convenient means of transportation. The construction of the railway had enormous impacts on the riparian corridors that it passed through. Channel straightening and bisecting of floodplains with gravel rail beds was a common practice throughout Vermont. With exception of the most downstream reaches, much of the study area appears to have been spared from direct manipulation due to railroad development.

The great flood of 1927 led to major changes in land use in the Upper Winooski River 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. New England Interstate Route 18 (later to be renamed Route 2) was designated in the early 1900’s further increasing the mobility of goods and services and having unintended negative impacts on the stability and health of the Upper Winooski River which was straightened and armored in places to protect the roads and its bridges. Roads also increased tourism including development of ski resorts and vacation homes, although the study area has largely been spared from this development. In response to the 1927 flood the Civilian Conservation Corps launched a huge flood control initiative that included dam building (starting with the East Barre Dam in 1933), erosion prevention, reforestation, habitat protection, reclamation of abandoned farmlands, and the construction of recreational trail networks.

Today, the Upper Winooski River 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 5). In 2005, 74% of the watershed upstream of Montpelier was recorded as being in forested use (although residences likely occupy much of this) with approximately 5% in agriculture and 8% developed for commercial purposes (Willard et al., 2007). Impacts from the surrounding landscape (the watershed) continue to impact the river. According to the WNRCD website in 1999, for example, during the Winooski River clean up project sponsored by the Friends of the Winooski River and the Central Vermont Solid Waste Management District, volunteers picked up the following items in a section approximately 1.6 miles long: 2.5 tons of metal, 65 tires and 5.28 tons of garbage.

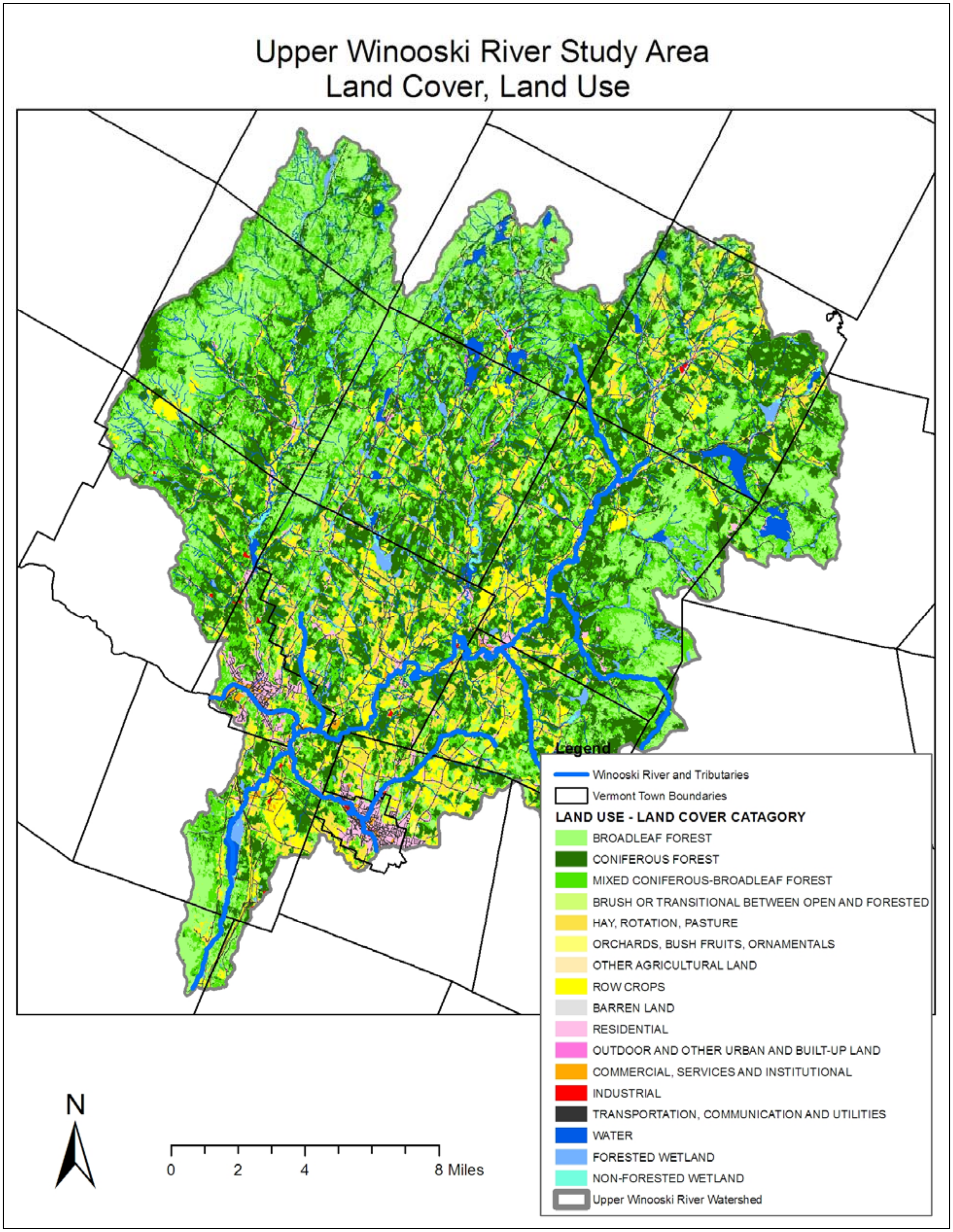


Figure 5: Present day land use and land cover of the Upper Winooski River Watershed.

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 the chemistry and ecology of stream systems.

3.2.1 Mountain Building and Bedrock Geology

The Upper Winooski River watershed, in a broad geological context, spans one large bio-physioregion, the Northern Vermont Piedmont. The Northern Vermont Piedmont lies between the Northern Green Mountains to the west, the Northeastern Highlands, and the Southern Vermont Piedmont to the southeast.

The bedrock of the Green Mountains in this region is comprised of rocks created about 1,200 million years ago during the Grenville Orogeny with uplift and folding occurring about 450 million years ago during the Taconic Orogeny (forming many of the central ridges) and again later during the Acadian Orogeny (leading to formation of many of the granite formations in the eastern portions of the watershed and around Barre where hot magma pushed up to form large monoliths) (Kylza 1999)(Fish 2006). Bedrock maps indicate that the study area is underlain predominately by metamorphosed shale (phyllite, schist, and gneiss of varying mineral content) of the Waits River and Gile Mountain Formations (Doll 1961). Interestingly, because the Winooski generally flows from east to west cutting across the main folds and ridges of the Green Mountain spine it is thought to have existed before their uplift. Perhaps too there was a natural east-west weakness in the bedrock that helped the river to down-cut and keep pace with the uplift (Fish 2006).

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 lateral migration. 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, fixed elevation. In the Upper Winooski River study area, channel-spanning bedrock was not found, however concrete dams in reaches R20 and R27-A may be covering over such features.

3.2.2 Glacial History and Surficial Geology

According to geologists Stephen Wright and Frederick Larsen, “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 80,000 – 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 Winooski River Valley.” In the Winooski River valley its advance dammed the west-flowing river. With its outlet blocked, a lake formed in the upper Winooski River valley (Glacial Lake Merwin). Mud accumulated in the lake bottom while sand and gravel was carried into the shallower water by streams forming hanging deltas (Wright and Larsen 2004).

As the ice sheet advanced and thickened, it eventually overwhelmed Glacial Lake Merwin 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. Eventually the climate began to warm again and the ice sheet responded by thinning and retreating to the north. During the retreat the Winooski River was again blocked and dammed forming the massive Glacial Lake Winooski which shoreline extended to approximately 1000' elevation into all of the tributaries and depositing lake sediments throughout the valley.

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 Winooski River flowing into it. This morphologically young river began to cut through lake sediments, eskers sediments, and till that had accumulated in its previous valley bottom. According to Wright and Larsen, the Winooski River never found its old valley between East Montpelier and Barre and instead began flowing west towards Montpelier (reaches R22 through R18). "The relatively steep gradient and many rock outcrops across the river valley suggest that this channel is relatively new" (Wright 2004). At the base of the Green Mountains, near the Winooski Valley, kame terraces, kames, and valley train deposits (outwash from glacial streams) can be found – at times the Upper Winooski River may run up against these features causing massive hill-slope slumping (mass failures).

As the glacial melting continued sediment laden tributaries were delivering a significant amount of material (at a great rate initially and likely declining exponentially in the first several thousand years as plants began to colonize and stabilize exposed till) from the newly exposed barren landscape. As the material on the hills stabilized, sediment rates entering the Upper Winooski River probably remained low until European land clearing once again denuded the landscape creating a spike in sedimentation. Today's modern river sediments form a thin veneer over the older glacial sediments in most of the river valley. Alluvial deposits in flood plains are often composed of fine sand or silt and in Vermont are composed almost entirely of recycled glacial sediments. These alluvial soils are frequently flooded and have high erodibility potential.

3.3 Geomorphic Setting

3.3.1 Description and Mapped Location of Study Reaches

The Phase 1 Assessment of the Upper Winooski River Watershed (Willard et al., 2007) delineated geomorphic reaches (sections of river that are expected to exhibit similar characteristics). The purpose of delineating reaches is to "break down" river networks into geomorphologically homogenous reaches in order to obtain information that can be used to "build-up" an understanding of the sediment regime and channel morphology of the watershed. Reaches were defined according to VTANR Phase 1 Protocols based on variations in valley confinement, slope, sinuosity, and soils.

Based on the high degree of channel and watershed stressors identified during the Phase 1 Assessment, all mainstem reaches of the Upper Winooski River were prioritized for a Phase 2 Stream Geomorphic Assessment (with the exception of reach R20 where geomorphic conditions are unnaturally altered by hydropower dam). The Cabot and Marshfield stretches were assessed during earlier studies (see Blazewicz and Nealon 2006 and Johnson 2007). However, in the Plainfield to Montpelier stretch, only four of these reaches were assessed in 2006. In

2009, Round River Design assessed five additional reaches in order to complete the dataset from Plainfield to Montpelier. As depicted previously in Figures 2 and 3, several of the nine 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 Winooski River drops at an average slope of less than 1% from reach R28 down to the North Branch Confluence (the end of the Phase 2 study area) over a valley distance of just over 12 miles (Figure 6). The Upper Winooski River 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 Upper Winooski River. Natural bedrock grade controls (where bedrock spans the river channel and prevents rapid incision) are likely located at reaches R27 and R20, however today these natural features are hidden by concrete dams that span the Winooski channel.

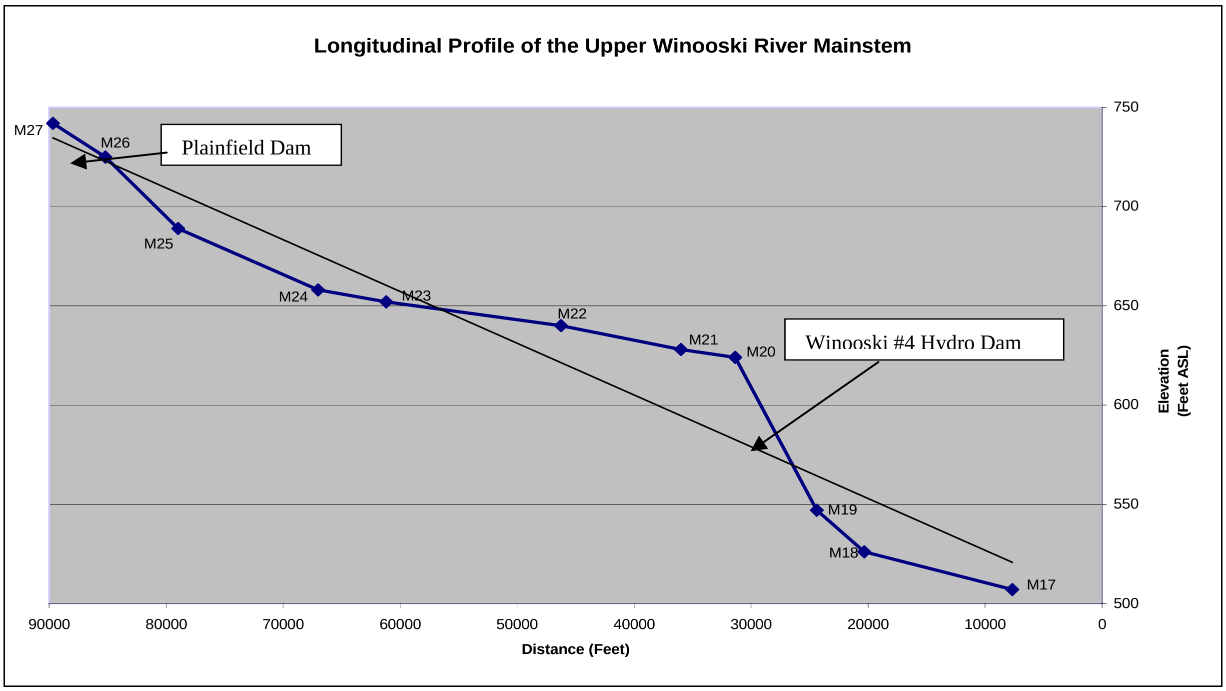


Figure 6: Longitudinal Profile of the Upper Winooski River Phase 2 Reaches.

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 Upper Winooski River study reaches. Several reaches of the mainstem of the Upper Winooski River are, by reference, "E"-type channels. E-type channels typically develop in low-sloped valleys with wide floodplains, gravel, sand, and silt dominated substrates and have either ripple-dune or riffle-pool bedforms (see Rosgen, 1996 and Montgomery and Buffington, 1997 for further information on 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. One reach, R21, is a "B" reference channel type with a steeper slope and more confined valley. This reach naturally has only a small amount of lateral room in which to migrate across the valley floor and tends to transport sediment and water with only minor storage capability.

Table 1: Reference Valley and Stream Types for the Upper Winooski River

Segment Number	Valley Type	Expected Channel Width (ft.)	Channel Slope (%)	Sinuosity	Reference Stream Type	Reference Dominant Channel Sediment	Reference Bedform
R27-B	Broad	80	0.38	Low	E	Sand	Dune-ripple
R27-A	Broad	80	0.38	Low	E	Sand	Dune-ripple
R26	Broad	95	0.58	High	C	Gravel	Riffle-pool
R25	Very Broad	60	0.26	High	E	Gravel	Riffle-pool
R24	Narrow	75	0.10	Moderate	E	Gravel	Riffle-pool
R23	Broad	128	0.08	Moderate	E	Gravel	Riffle-pool
R22-B	Broad	131	0.12	Low	C	Gravel	Riffle-pool
R22-A	Broad	131	0.12	Low	C	Gravel	Riffle-pool
R21-B	Semi-Confined	133	0.09	Low	Bc	Cobble	Plane-bed
R21-A	Semi-Confined	133	0.09	Low	Bc	Cobble	Plane-bed
R20	Semi-Confined	133	1.1	Low	C	Cobble	Riffle-pool
R19	Very Broad	134	0.52	Moderate	C	Cobble	Riffle-pool
R18-B	Narrow	165	0.15	Low	C	Gravel	Riffle-pool
R18-A	Narrow	165	0.15	Low	C	Gravel	Riffle-pool

3.4 Hydrology

Based on an analysis of land use data obtained from the Vermont Center for Geographic Information and as reported in the Phase 1 Assessment Report (Willard et al., 2007), most of the Upper Winooski River watershed is currently forested (see Figure 4). In all subwatersheds of the study area, "forest" was the dominant land cover and "cropland" the subdominant (next highest percentage). Historically (as discussed in Section 3.1.3), a much higher percent of the watershed was cleared for pasture and croplands. Within the river corridor the dominant land use is forest or crop except within the villages where urban land use dominates: Plainfield (43% in R27); East Montpelier (27% in R24); and Montpelier (55% in reach R18).

These numbers are important for many reasons because development and clearing of forests in the watershed, both current and historic, has a significant impact on fluvial erosion, water quality, and habitat quality (Sweeney, et. al. 2004; National Academy of Sciences, 2002; Riley 1998). 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 to 20 percent. Much of the impact occurs when first-order, and in some cases, second-order channels (the small feeder streams that join to become the major tributaries to the Upper Winooski River) are altered. The disturbance of these channels 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 such as reduced habitat.

The University of Maryland 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).

Channel and bank instability, which leads to the physical degradation of streams, stems from increased runoff, clearing of riparian forests, and sedimentation associated with development [Note: Low-impact development techniques and stormwater retrofits are beginning to address these problems]. The signs of instability, however, may not become evident for several years following the development. Response to changes in hydrology and riparian vegetation 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 (Sweeny et al. 2004).

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

3.4.1 Stream Gauge Information and Flood History

Flooding is a natural can replenish nutrients to floodplains and create important habitat for the reproduction of many aquatic and riparian species. According to the Vermont Agency of Natural Resources document *Municipal Guide to Fluvial Erosion Hazard Mitigation*, "Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly" (VTANR 2006). 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).

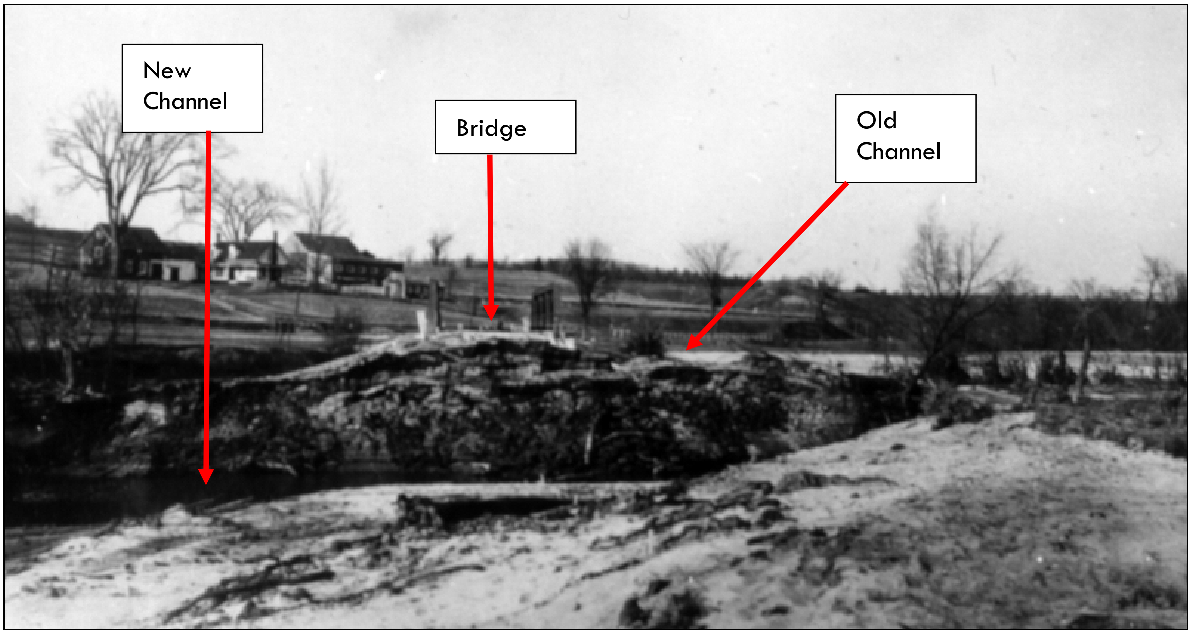


Figure 7: Land eroded next to bridge on Winooski River between Montpelier and Plainfield where the channel constriction likely caused water to back up and avulse around the structure during the 1927 flood (Source: UVM Landscape Change Program).

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 Winooski River, 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). Additionally, precipitation data collected by the National Oceanic and Atmospheric Association (NOAA) shows a 0.23 inch increasing trend per decade of average annual rainfall over the past 100 years (Figure 8). Rain events, as Montpelier residents know all too well, are not the only cause of flooding. Ice and debris jams can back water up causing significant and dangerous localized flooding. Historical accounts of flood events are a good starting point for understanding events and frequency of events that have shaped the condition of the Upper Winooski River. The Montpelier Flood Hazard Mitigation Plan (1998) provides an overview of some of these major events. According to the Montpelier Plan, rain related flood events inundated downtown Montpelier in 1830, 1869 (respectively the second and third largest flood events known to have occurred in the study area) and again in

1912. November 1927 brought the largest flooding event known to have occurred in recorded history to the entire state of Vermont flooding downtown Montpelier with 8 feet of water. Following the 1927 flood the Civilian Conservation Corps built two flood control dams upstream of Montpelier at Wrightsville (North Branch) and East Barre (Jail Branch).

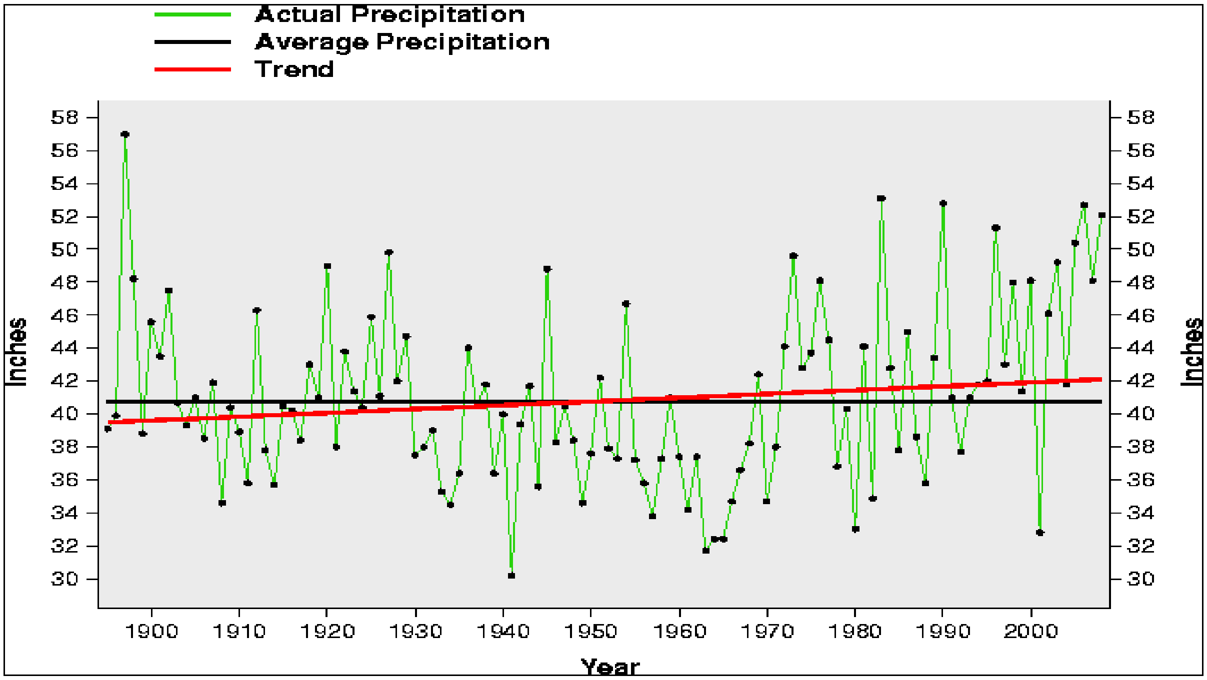


Figure 8: Vermont average annual rainfall 1895-2008. Annual Trend = 0.23 Inches / Decade.

Source: http://www.ncdc.noaa.gov/oa/climate/research/cag3/vt.html

Another useful tool for understanding the flood history of the Upper Winooski River is the long term data collected by the U.S. Department of the Interior, U.S. Geological Survey (USGS) gauge on the Upper Winooski River in Montpelier, VT (Figure 9). The USGS gauging station, #04286000, is located approximately 2000 feet upstream of confluence with the Dog River in Montpelier (several thousand feet downstream of the end of this study area: reach R18). The gage measures flow from an approximate drainage area of 397 square miles. Records begin as early as 1909, although a continuous record of flow only exists from 1928 through the present. Significant fluvial events can be seen (and corroborated in the Montpelier Flood Hazard Mitigation Plan) in 1936 and 1973, however it is evident that gauge level readings in Montpelier have been significantly influenced by the aforementioned flood control projects on the North and Jail Branch tributaries, which appear to have successfully prevented major flows from reaching the gauge. Flow related events, are however not Montpelier's only concern. As many residents know, ice jams have caused significant flooding in the downtown area. For more information, regarding significant flooding events and floodplain mitigation planning see the "Montpelier Flood Hazard Mitigation Plan" (City of Montpelier 1998).

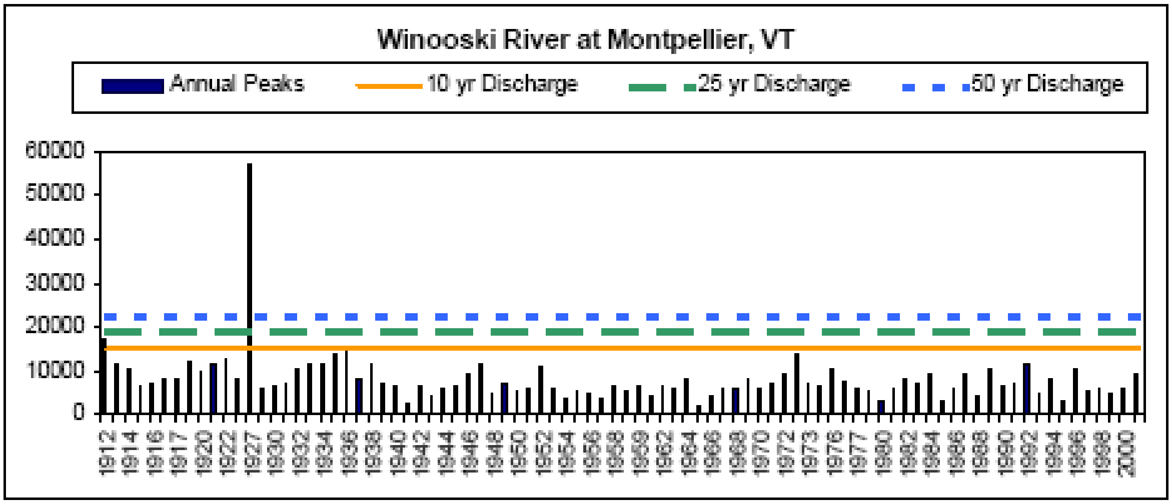


Figure 9: Flood frequency analysis for Upper Winooski River gauge, Montpelier, VT. Source: VTANR

3.5 Ecological Setting

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

Habitat observations conducted during the Phase 2 Geomorphic Assessment found that the quality of in-stream shelter and the condition of the riparian area varied in the Upper Winooski River. The assessment documented that the habitat assessment results were similar to the geomorphic assessment results (which indicate a decline in stream condition) implying that the ecological health of the Upper Winooski River is closely related to the geomorphic condition of the stream.

Riparian habitat, the margin of transitional vegetation alongside a body of water, varies greatly in quality, diversity, and amount in the study area. Impacts to riparian areas are heaviest in the villages due to dense residential and commercial development as well as along agricultural fields where production has taken precedence over water quality. 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 forest. Wetland habitat, similarly, has suffered where development, roads, railroad tracks, and agriculture have altered the wetland areas that existed prior to settlement.

In-stream channel habitat has declined following European settlement of the Winooski Valley due to rock armoring of streambanks (which removes shelter provided by roots and undercut banks); channel mining for gravel; and removal of large pieces of wood. Furthermore significant sedimentation of the stream channel bottom has filled many of the interstitial spaces between the gravel and cobble bottom that would otherwise provide habitat for macroinvertebrate insects. Channel widening as a result of channel and watershed alterations (described further in section 5.1) as well as the backwater ponding affect of the multiple dams in the study area have opened the channel to increased solar radiation and possibly warming water temperature beyond some species tolerable limits. Channel widening, riparian buffer removal, and stormwater runoff are all sources of “thermal pollution”, a particular problem for brook trout survival.

In order to address some of these issues, much of the scientific literature 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). Large wood debris in streams helps increase the retention of nutrients and materials within a stream by creating micro zones of storage and flowpath complexity (Bilby & Linkins, 1980; Diez et al., 2000). Wood also maintains natural flows pooling and spreading water out into the hyporheic zone (water under the channel and banks) and acting as a sediment trap. Finally, from a water quality perspective, riparian buffers capture and store nutrients and provide shade limiting thermal pollution (Figure 10).

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 Upper Winooski River (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. While width is important, these areas do not all necessarily need to be left unmanaged. Certain sensitively conducted silvicultural practices may in fact be beneficial for meeting various management goals such as nutrient uptake, fish productivity, and/or large woody debris recruitment while providing minimal economic opportunities to landowners (Nislow 2005).

Figure 10: Reaches such as R23 are susceptible to thermal pollution due to lack of shading on some of the banks.

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" indicates the presence of several important such communities in the Upper Winooski River watershed, particularly in some of the tributaries and adjacent forested hillsides. Of note are several natural communities, plants, and animals in downtown Montpelier (reach R18) as well as communities located near the mouth of the Kingsbury Branch (R24) (see Figure 11). Since the mapping project is by no means comprehensive, care should be given by residents within the Upper Winooski River to protect local ecosystems and species, recognized or not.

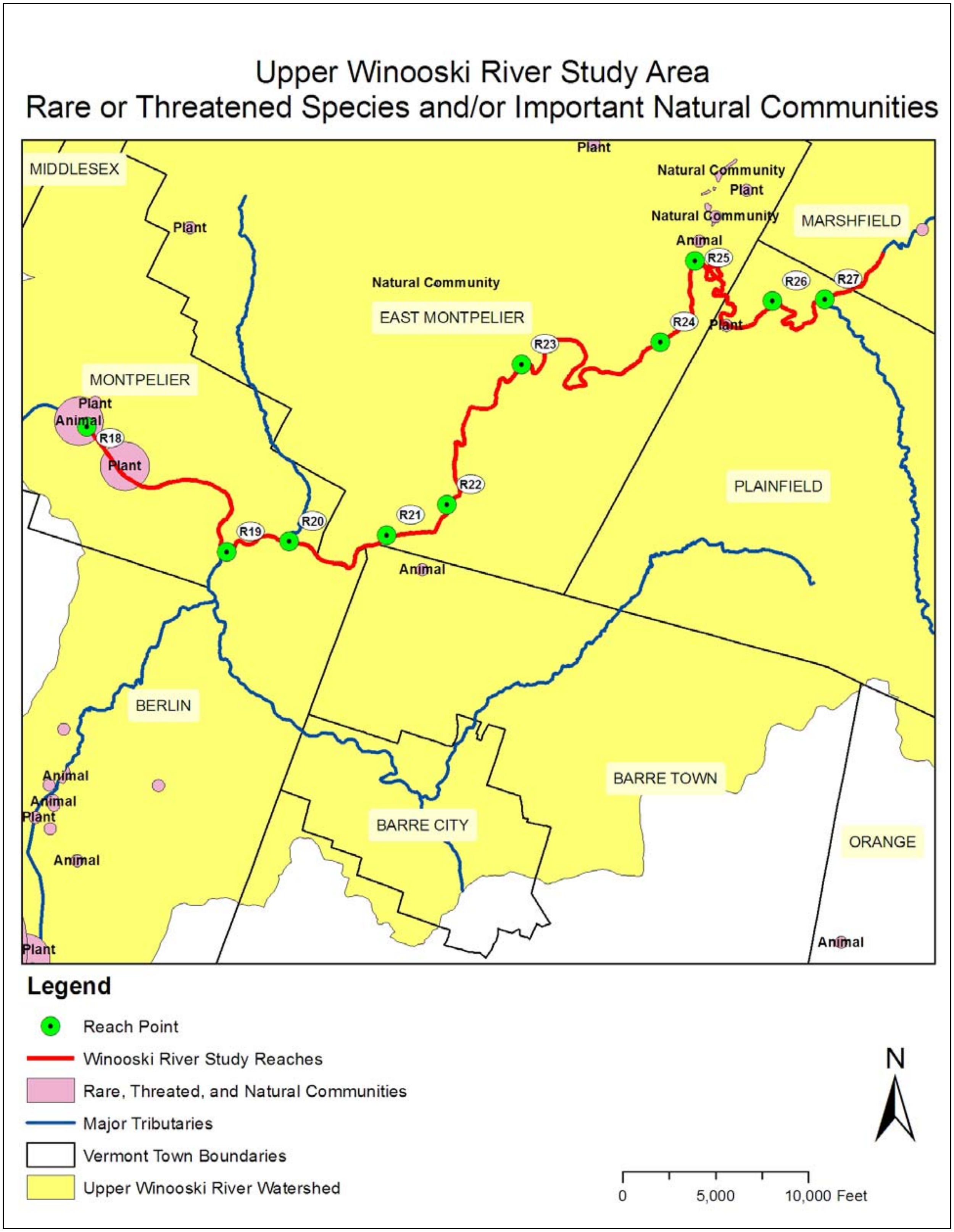


Figure 11: Rare and Threatened Species and/or Significant Natural Communities.

4.0 METHODS AND RESULTS OF ASSESSMENT WORK

4.1 Fluvial Geomorphic and Bridge Assessments

The following sections summarize the physical assessments that were carried out on the Upper Winooski River in support of this River Corridor Plan.

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 Winooski River was completed in 2007 by the Central Vermont Regional Planning Commission, Winooski Natural Resource Conservation District, and Friends of the Winooski River. A project report summarized the results of this work (Willard et al., 2007). The Phase 1 Assessment collected data from 71 reaches within the watershed. Initial reach condition scores generated by the Phase 1 Assessment are depicted in Table 2.

Phase 1 Impact Scores	
Reach Condition	***% of Reaches in North Branch Watershed***
Reference	32%
Good	13%
Fair	45%
Poor	3%
Reach Condition	***% of Reaches in Upper Winooski Watershed***
Reference	35%
Good	25%
Fair	40%
Poor	0%

Table 2: Phase 1 Impact Score results as reported by Willard et al., 2007.

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 east of the Marshfield/Plainfield town line at the John Fowler Road Bridge (reach R27) downstream to Montpelier (reach R18). All assessment data were recorded on the Vermont 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 Upper Winooski River during the Phase 2 Assessment were widening, aggradation, and planform migration that are following historic channel incision. A reach-by-reach summary of the Phase 2 data may be found in Appendix B.

4.1.3 Bridge Analysis

The need to span the Upper Winooski River via bridge is imperative. The process of placing a bridge over the river has historically involved constructing stone or timber footers onto which rest timbers and later iron and steel. Early on the footers (or abutments) were (when possible) placed close enough together so that a single large timber could span from one side of the channel to the other. In a large stream such as the Upper Winooski River, these abutments were often built narrower than the natural channel bankfull width. This narrowing of the river from bridge abutments becomes problematic when, during high flows, floodwaters back up due to the constriction thus causing flooding upstream of the bridge. This is worsened by debris and sediment that can accumulate at a constriction which typically further exacerbate upstream instability. During flood conditions, stream power is increased on the downstream side of the constriction (like putting your thumb on the end of a garden hose). The extra energy causes erosion and typically leaves a wide scoured area downstream of the bridge.

Physical changes to the river channel such as straightening and armoring of the banks in order to protect bridge abutments keeps a river from migrating naturally across the valley bottom. Projects which protect the banks from erosion often lead to other unintended negative consequences. Ideally it is important to allow the river to meander and follow a natural path to restore functional 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. Additionally, armoring is often temporary; old stone piles can be found in the middle of the Winooski River where eventually the river won out. Removing channel constrictions by significantly expanding the width of bridge abutments will allow the river to return to natural flow paths and reduce long-term instability.

In order to assess the impact of 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, sixteen structures were assessed according to VTANR protocols for such characteristics as specific height, width, span, geomorphic and fish passage data, nearby vegetation, and evidence of wildlife. In addition, old bridge abutments no longer in use were also identified.

During the Phase 2 Assessment, several bridges and culverts were observed to be considerably narrower than the existing bankfull width, subsequently causing instability in the river (Table 3). In particular need of retrofit, based on the problems observed and their width as a percentage of bankfull width, are the Route 2 bridges spanning reaches R19, R22-A and R25, the railroad bridge at R19, and the Coburn Covered Bridge on R24 (Figure 12).

Figure 12: The Coburn Covered bridge (R24) was elevated to increase the area through which water can flow. Despite this, the bridge abutments still constrict the channel and upstream and downstream erosion is a result (see fallen tree on right bank).

TABLE 3: UPPER WINOOSKI RIVER BRIDGES: PROBLEMS AND POTENTIAL FAILURE MODES

Town	Reach #	Road	F1	F2	F3	F4	F5	F6	P1	P2	P3	P4	P5	P6	P7	Width
Marshfield	R27-B	Stephen Fowler	-	-	-	-	X	X	-	-	-	X	X	-	X	94 %
Plainfield	R27-A	Main Street	-	X	X	X	X	X	-	X	-	X	X	-	X	71 %
Plainfield	R25	Route 2	-	X	-	X	X	X	-	-	-	X	X	-	X	87 %
East Montpelier	R24	Coburn Road	-	X	X	X	-	X	-	X	X	-	-	-	X	80%
East Montpelier	R23	Route 2	-	-	-	-	X	X	-	-	-	X	-	-	X	95%
East Montpelier	R23	Route 14 S	-	X	X	X	-	X	-	X	-	-	X	-	X	98%
East Montpelier	R22-A	Route 2	-	X	-	X	X	X	-	-	-	X	X	-	X	82%
East Montpelier	R22-A	Hanging Bridge	-	-	-	-	-	X	-	X	X	X	-	-	-	103%
Montpelier	R19	Route 2	-	-	-	X	X	X	X	X	X	X	-	-	X	81%
Montpelier	R19	Railroad	-	X	X	X	X	X	-	-	-	X	X	-	X	85%
Montpelier	R18-B	Route 2	-	-	-	X	-	X	-	-	-	X	-	-	-	75%
Montpelier	R18-B	Railroad	-	-	-	-	-	X	-	-	-	X	-	-	-	87%
Montpelier	R18-A	Pioneer St.	-	-	-	X	X	X	-	-	-	X	-	-	X	93%
Montpelier	R18-A	Railroad	-	-	-	X	-	X	-	-	-	X	-	-	X	103%
Montpelier	R18-A	Granite St.	-	-	-	-	-	X	-	-	-	X	-	-	X	103%
Montpelier	R18-A	Main Street.	-	-	-	X	X	X	-	-	-	X	-	-	X	91%

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 collected during the summer of 2009. The DMS and the ArcView shapefiles for the Upper Winooski River Phase 2 study were submitted to Gretchen Alexander of the VTANR for a QA review in September of 2009. Mapping of existing valley walls was conducted in support of fluvial erosion hazard zone development by Round River Design and the Central Vermont Regional Planning Commission 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) (and as depicted in the Lane Scale, Figure 13 and further described in Figure 14). We also know that natural and anthropogenic impacts to a river channel or watershed may so drastically alter the equilibrium between sediment transport and water flow that a threshold may be exceeded and a series of morphological responses (aggradation, degradation, and widening and/or planform adjustment) set into motion as the channel works to reestablish a self-maintaining channel (Figure 13). 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) (Montgomery and Buffington,1997).

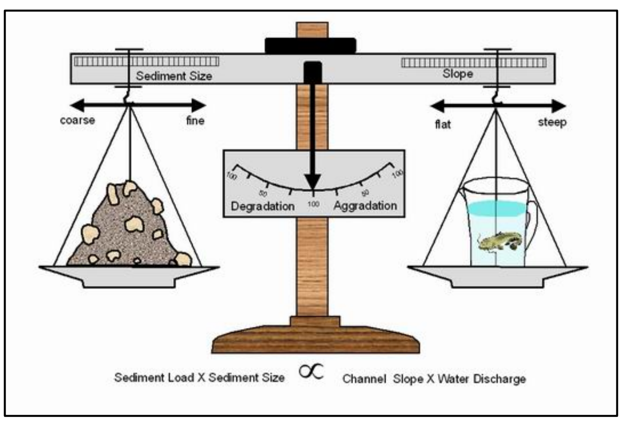


Figure 13: The Lane Scale depicts how a change in sediment load, sediment size, channel slope, and/or the amount of water discharged may lead to channel degradation or aggradation.

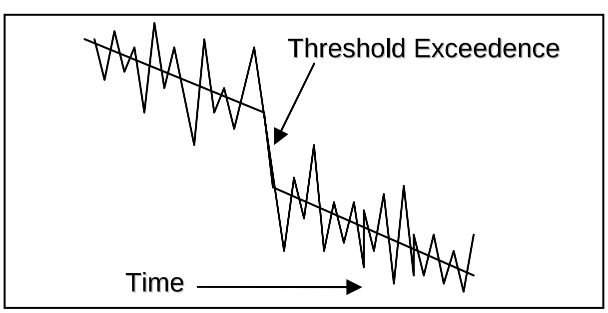


Figure 14: Streams will adjust their elevation and boundaries in accordance with local precipitation and geology and react to floods and minor land use changes until significant stress exceeds the capacity of the channel to maintain equilibrium.

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 15), 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 Winooski River, 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.

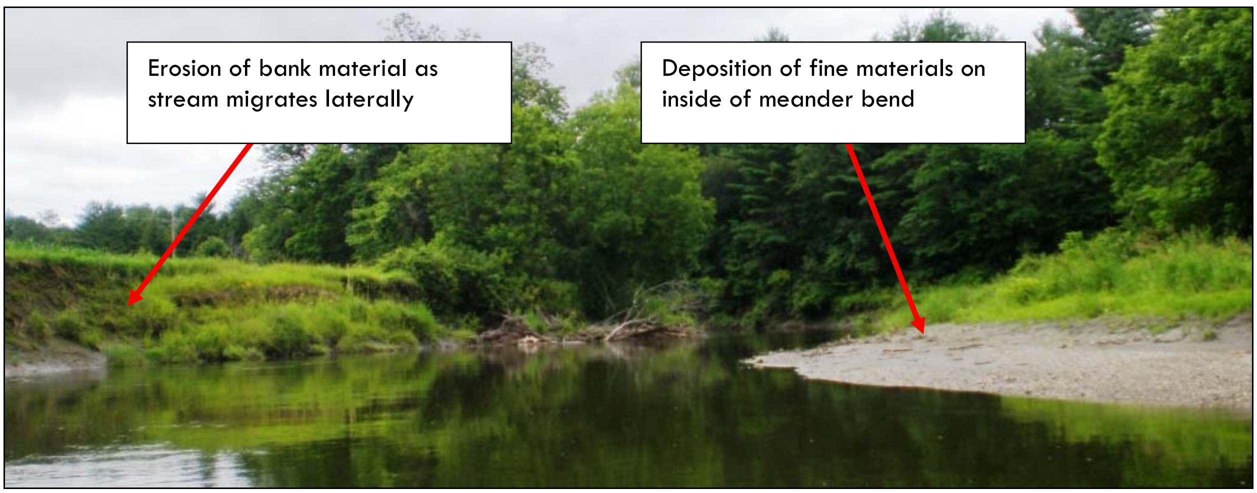


Figure 13: Planform migration as reaction to historic channel straightening (R23) of the Upper Winooski River.

5.1 Factors Influencing the Stability and Health of the Upper Winooski River

Appendix C is comprised of maps depicting many of the factors influencing the stability of the Upper Winooski River. The following sections detail and summarize these factors.

5.1.1 Alterations to the Hydrologic Regime of the Upper Winooski River

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 will lead to channel widening and incision).

While the significant deforestation that occurred in Vermont watersheds in the 19th century may still be influencing the Winooski River, a number of more easily discernable hydrologic stressors are at work today. As depicted in Appendix C, Figure 1, stormwater inputs from roads, drainage ditches, and impervious surfaces are numerous in some reaches of the Upper Winooski River, particularly from field and road ditches and nearby the developed landscapes of Plainfield, East Montpelier, and Montpelier. 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 previously in section 3.4). Four dams within the study area are also depicted on this map. Dams typically alter the hydrology of the river by locally raising the river's surface elevation during a flood event.

Another significant impact to the hydrologic regime of the Upper Winooski River watershed may be alterations to the land use and land cover of the region. Specifically, the transition of land from forest to field, the crisscrossing of watersheds with roads, and the draining of wetlands cause a decrease in water storage capacity of the landscape as water is quickly and effectively transferred from less pervious surfaces into conveyance ditches. These land use changes decrease the time it takes water to enter the channel and then increase the peak volume of water. The implications of such landscape scale changes were recently reported in Burlington and Saint Albans where major stream channel adjustment and biological impacts were shown to be associated with watersheds that have over 5% impervious cover (Fitzgerald 2007). Appendix C, Figure 2 depicts high road density and urban development near the village centers of Montpelier and Plainfield as well as the possibility that a significant amount of wetlands have been lost in the study area.

5.1.2 Alterations in the Sediment Regime of the Upper Winooski River

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 later 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 in the immediate and downstream receiving water (Lake Champlain) (VTANR 2008).

Along the bottom of a stream the larger cobbles and gravels slide and tumble along during high water events, this is referred to as the bedload. 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, dams, 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 sediment contributions. In some cases, sediment deposition is a sign of returning stability as a river begins to reform meanders and deposit sediment in appropriate areas. These sediment deposits are usually best left undisturbed as gravel mining to extract channel and floodplain sediments is well documented to have detrimental affects to river stability and ecology (Galay, 1983; Brown et al, 1998). Figure 3 in Appendix C is a map depicting the number of sediment deposition features found in each reach of the study area. In the Upper

Winooski River, higher rates of depositional features (e.g. gravel bars) are found in reaches with wide floodplains and some degree of natural channel movement (such as reaches R25 and R26). Reaches naturally locked into narrow valleys or which have been artificially straightened or otherwise anthropologically altered tend to transport sediment through the channel rather than store it.

5.1.3 Modification of Channel Depth and Slope of the Upper Winooski River

Historic alterations of stream channels during post-flood cleanup efforts and for land reclamation purposes have had great impacts on most Vermont Rivers. The Upper Winooski River is no exception. Impacts from channel straightening affect nearly all of the reaches. Three of the study reaches are nearly 100% straightened (R18, R21, and R27) (Appendix C, Figure 4). 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 Upper Winooski River, 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 Winooski River as depicted in Appendix C, Figure 5.

5.1.4 Modification of Streambank and Riparian Conditions

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 (Brierley and Fryirs 2005). Riparian forests that have been reduced to less than 25 feet in width are depicted in Appendix C, Figure 6. These woodlands appear to have been cleared both from agricultural endeavors as well as from development pressures that install roads and buildings and cut down riparian vegetation.

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 (2008) 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 4. Figure 16 of this report has been provided to assist in understanding where sediment transport areas have been increased and attenuation areas have been lost in the Upper Winooski River Watershed. Table 5 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.

Figure 16 indicates that the entire main stem of the Upper Winooski River 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 current existing sediment regime map (on the right side of Figure 16) indicates that most of the upper reaches of the Upper Winooski River are storing coarse sediments, yet have lost their ability to store fine sediments in their floodplain. The storage of these coarse sediments may be related to an increase in sediment load from upstream bank erosion and channel alteration, as well as a decrease in sediment transport capacity of the river due to localized channel widening, channel constricting structures, and meandering. The lowest reaches, R18 and R19, are considered "transport" reaches because the extensive straightening and floodplain encroachment within the river corridor creates a zone of powerful erosive flow that minimizes the settling and storage of sediment in the channel or floodplain. Instead, these sediments are "transported" downstream to where floodplain access and channel meander conditions allow for sediments to settle out. Unfortunately after a long zone of transport, a "dumping" of sediments can occur at the first place a river has an opportunity which often creates localized channel instability and other problems for those landowners downstream.

TABLE 4: 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.

Table 5: 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
R27-B				√	√	√	√			√
R27-A				√	√	√	√	√	√	
R26				√	√	√	√			
R25				√	√	√	√		√	
R24				√	√	√	√		√	
R23				√	√	√	√		√	√
R22-B				√	√	√	√			√
R22-A				√	√	√	√		√	√
R21-B				√	√	√	√			√
R21-A				√	√		√	√		
R20				√	√	√	√	√		√
R19				√	√	√	√		√	√
R18-B				√	√	√	√	√	√	√
R18-A				√	√	√	√		√	√

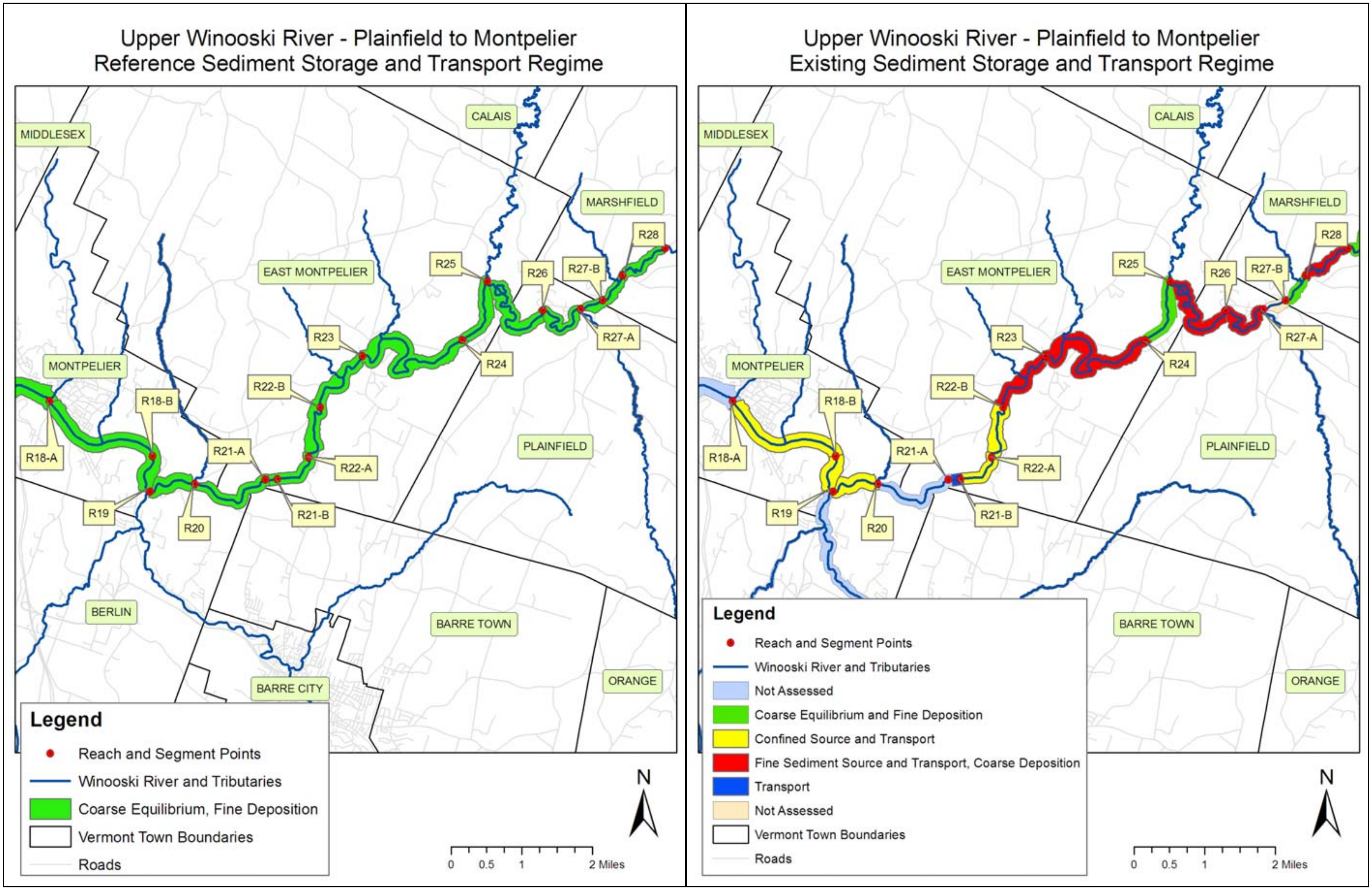


Figure 14: Sediment transport and attenuation: reference (left) and existing (right) conditions in the Upper Winooski River.

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 Winooski River. As a result of historic channel straightening much of the channel slope of the Upper Winooski River has increased (a meandering stream has a longer length and therefore lower slope). 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 17 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)

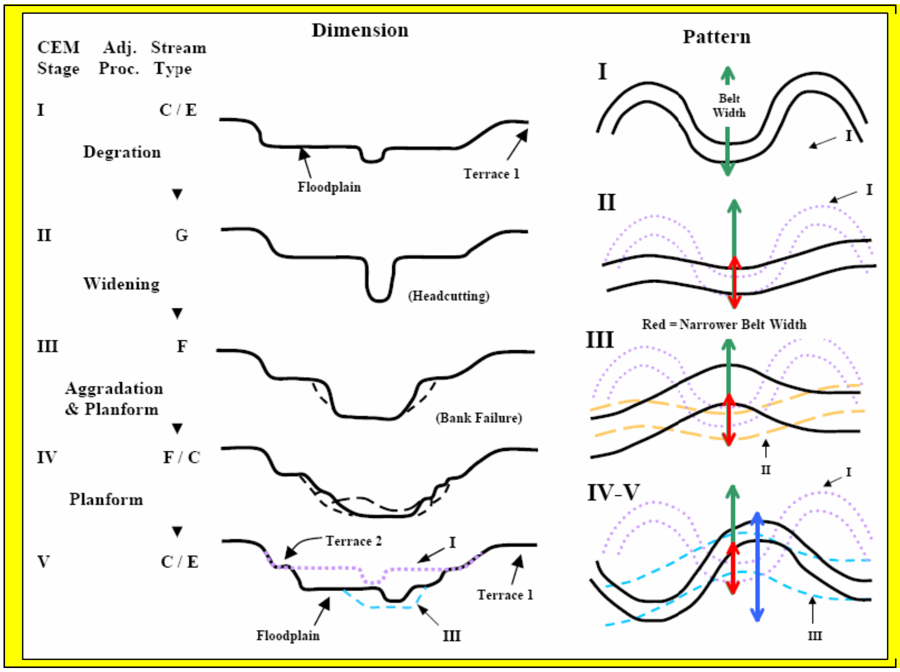


Figure 15: F-stage Channel Evolution Process (from Vermont Agency of Natural Resources, 2006).

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 18).

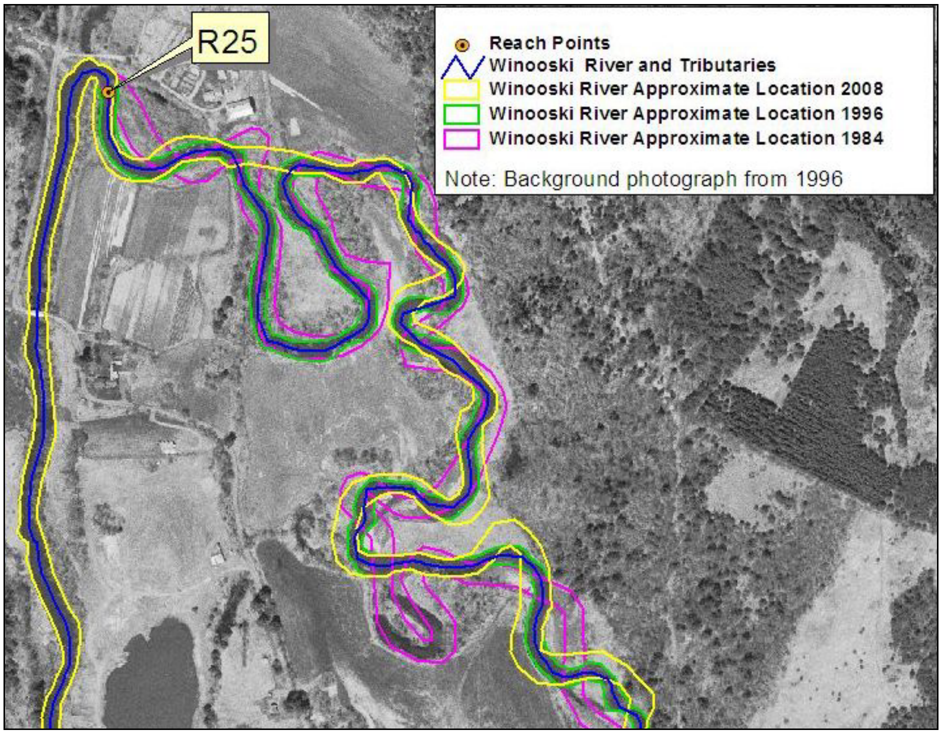


Figure 16: Meander patterns in the Upper Winooski River in East Montpelier.

After a channel straightening process it may be difficult for streams to attain equilibrium where the placement of roads and other infrastructure prevent lateral movement of the stream. Making matters worse, landowners and government agencies have repeatedly armored and bermed many of Vermont's rivers to contain floodwaters in channels (elevated road ways have often had similar affects). 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. As indicated, the major response in the Upper Winooski River has been widening and planform adjustment which are both leading to another adjustment process, aggradation. Aggradation in the Upper Winooski River 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, unstable tributaries, and land clearing. Table 6 below summarizes the channel evolution of each study reach and the primary adjustment processes that are believed to be occurring.

Table 6. 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
R27-B	1.0	7.5	13.2	E5	E5	I	Widening
R27-A	*Not Assessed due to Dam*						
R26	1.5	2.4	19.6	C4	C3	IV	**Planform**
R25	1.3	15.6	22.1	E4	C4	III	**Aggradation** **Widening** **Planform**
R24	1.2	8.0	11.5	E4	E4	III	Widening
R23	1.7	1.7	29.3	E4	B4c	III	Aggradation **Widening** **Planform**
R22-B	2.1	1.2	28.4	C4	F4	III	**Aggradation** **Widening** Planform
R22-A	2.0	1.2	30.8	C4	F5	III	**Aggradation** **Widening** **Planform**
R21-B	2.0	1.3	17.5	B3c	F3c	III	Widening
R21-A	*Not Assessed due to Dam*						
R20	*Not Assessed due to Dam*						
R19	1.4	1.5	44.8	C3	F3	III	**Aggradation** **Widening** Planform
R18-B	1.9	1.7	22.3	C4	B5c	III	**Aggradation** **Widening** Planform
R18-A	1.5	1.2	40.5	C4	F4	II	**Degradation** **Widening** **Aggradation** **Planform**
Bold Red lettering - denotes extreme adjustment process **Bold Black lettering** – denotes major adjustment process Black lettering – denotes minor adjustment process							

5.3 Stream Sensitivity

As Section 5.1 described, there are numerous watershed and reach-level stressors that have affected the Upper Winooski River. In response, the River has undergone and continues to undergo reasonably predictable channel adjustments as described in section 5.2. As we move towards managing restoration goals and future development expectations in the Upper Winooski River 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 or 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 and may have highly unpredictable activity during flood events (Vermont Agency of Natural Resources 2008).

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 R21) 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 Winooski River). 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 Winooski River, categorized by segment according to ANR protocols, is depicted in Table 7 and in Figure 19. 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 very high or even extreme 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.

Table 7. Stream Sensitivity for Phase 2 Reaches

Segment Number	Reference Stream Type	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
R27-B	E5	E5	No	Good	High
R27-A*	*Not Assessed due to Dam*				
R26	C4	C3	No	Fair	**Very High**
R25	E4	C4	E to C	Fair	**Very High**
R24	E4	E4	No	Fair	**Very High**
R23	E4	B4c	E to B	Fair	High
R22-B	C4	F4	C to F	Fair	**Extreme**
R22-A	C4	F5	C to F	Poor	**Extreme**
R21-B	B3c	F3c	B to F	Fair	**Very High**
R21-A*	*Not Assessed due to Dam*				
R20*	*Not Assessed due to Dam*				
R19	C3	F3	C to F	Poor	**Extreme**
R18-B	C4	B5c	C to B	Poor	**Extreme**
R18-A	C4	F4	C to F	Poor	**Extreme**

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

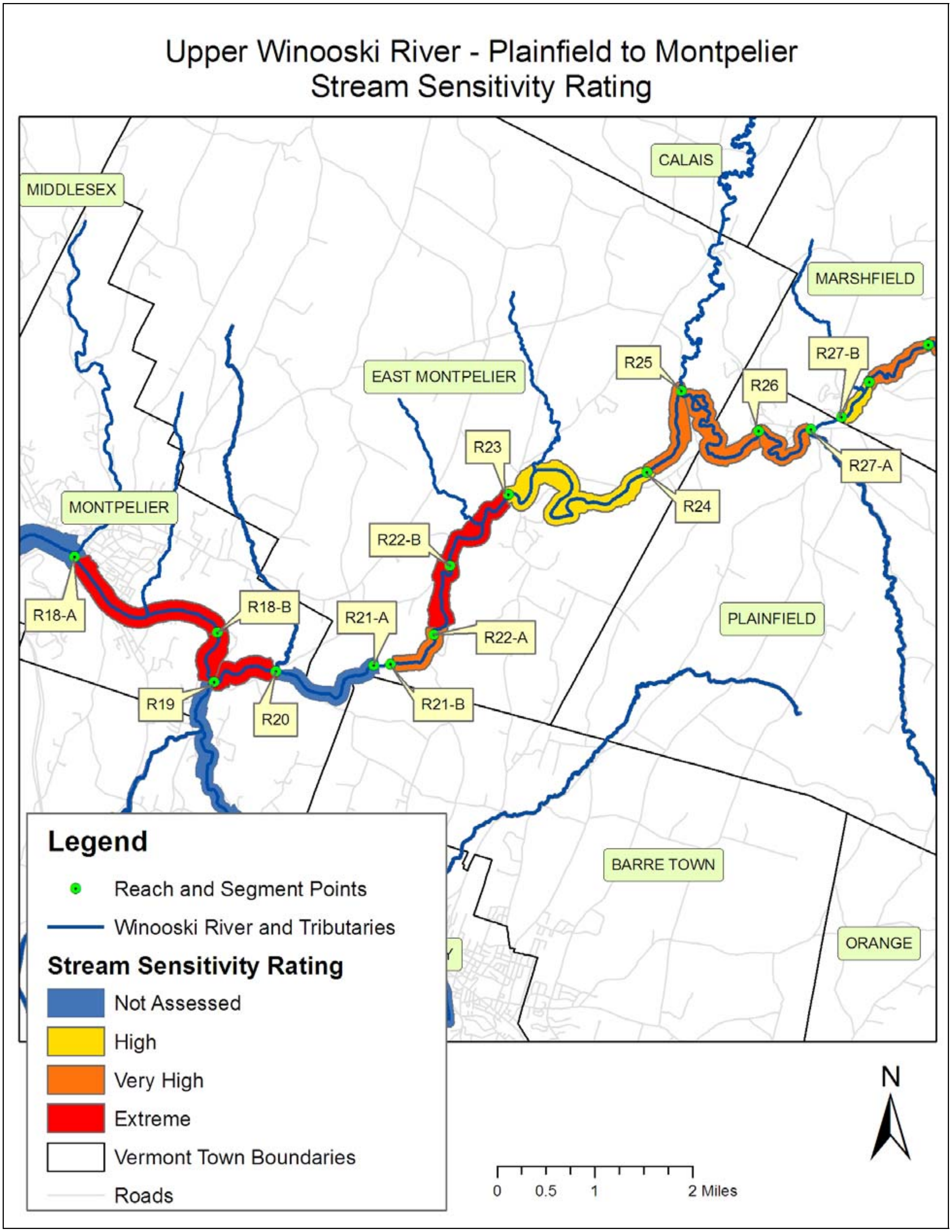


Figure 17: Upper Winooski River Stream Sensitivity Map.

6.0 PROJECT IDENTIFICATION

As outlined in the preceding sections, restoration and/or rehabilitation of the Winooski River requires 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 imperative. Consideration of these complex interactions while attempting restoration, rehabilitation, and/or conservation projects will work to ensure success and long term benefit to the community.

In review, recommended corridor rehabilitation and protection initiatives have been identified based on the remotely-sensed observations (Phase 1) 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 individual project identification consistent with the goal of managing the river toward equilibrium condition (VTANR 2008) is presented.

Note: While the focus of this report has been on developing management decisions based on geomorphic information, practical watershed management is improved when consultation and participation by major stakeholders occurs, especially at the earliest stages of project planning. Indeed individual landowners are the key to the success of long-term management, and social and fiscal opportunities must be taken into account in this process. Adding this information to the equation may present possibilities for collaborative and synergistic projects not envisioned within this document. Also, while recommended initiatives have been prioritized for implementation, 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 are best addressed through watershed-level, community-initiated strategies that seek to address the 'source' of a problem. These large-scale watershed efforts may be initiated through local governments and/or community organizations, such as the Friends of the Winooski River. 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 Winooski River include:

- The establishment and maintenance of riparian forests 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 as well as habitat connectivity along the river corridor.
- 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 eliminate future floodplain encroachment.

- Development of an ecosystem services analysis of the Upper Winooski River and development of mechanisms (i.e. social, market, regulatory) that will allow these services to be appropriately valued and recognized by the watershed community.

6.1.1 Fluvial Erosion Hazard Zones

Fluvial Erosion Hazard Zone development is a priority of the Vermont River Management Program. The reason is straightforward; of all types of natural hazards experienced in Vermont, flash flooding represents the most frequent disaster mode and has resulted in by far the greatest magnitude of damage suffered by private property and public infrastructure. While inundation-related flood loss is a significant component of flood disasters, the predominate mode of damage is associated with the dynamic, and oftentimes catastrophic, physical adjustment of stream channel dimensions and location during storm events due to bed and bank erosion, debris and ice jams, structural failures, flow diversion, or flow modification by man made structures. These channel adjustments and their devastating consequences are related to historic channel management activities, floodplain encroachments, adjacent land use practices and/or changes to watershed hydrology associated with land use and drainage.

The purpose of defining Fluvial Erosion Hazard Zones is to: prevent increases in fluvial erosion resulting from uncontrolled development in identified fluvial erosion hazard areas; minimize property loss and damage due to fluvial erosion; prohibit land uses and development in fluvial erosion hazards areas that pose a danger to health and safety; and discourage the acquisition of property that is unsuited for the intended purposes due to fluvial erosion hazards (VTANR 2006).

The basis of a Fluvial Erosion Hazard Zone is a defined river corridor which includes lands adjacent to and including the course of a river. The width of the corridor is defined by the lateral extent of the river meanders, called the meander belt width, which is governed by valley landforms, surficial geology, and the length and slope requirements of the river channel. The width of the FEH Zone is also governed by the stream type and sensitivity of the stream. Figure 20 represents a draft FEH Zone developed by the Central Vermont Regional Planning Commission and Round River Design.

NOTE: It should be noted that the glacial history of the Upper Winooski River may have created soils along valley side slopes and river terraces that are extremely erodable. Although a Fluvial Erosion Hazard Zone may protect against hazards in the beltwidth and floodplain of the river, where the Upper Winooski River runs up against its valley walls, there may be danger of landslide hazard. Evidence of such risk is apparent in the many mass failures found throughout the project area. Therefore it is recommended that a discussion of landslide hazard be included with any discussion of adoption of Fluvial Erosion Hazard Zones.

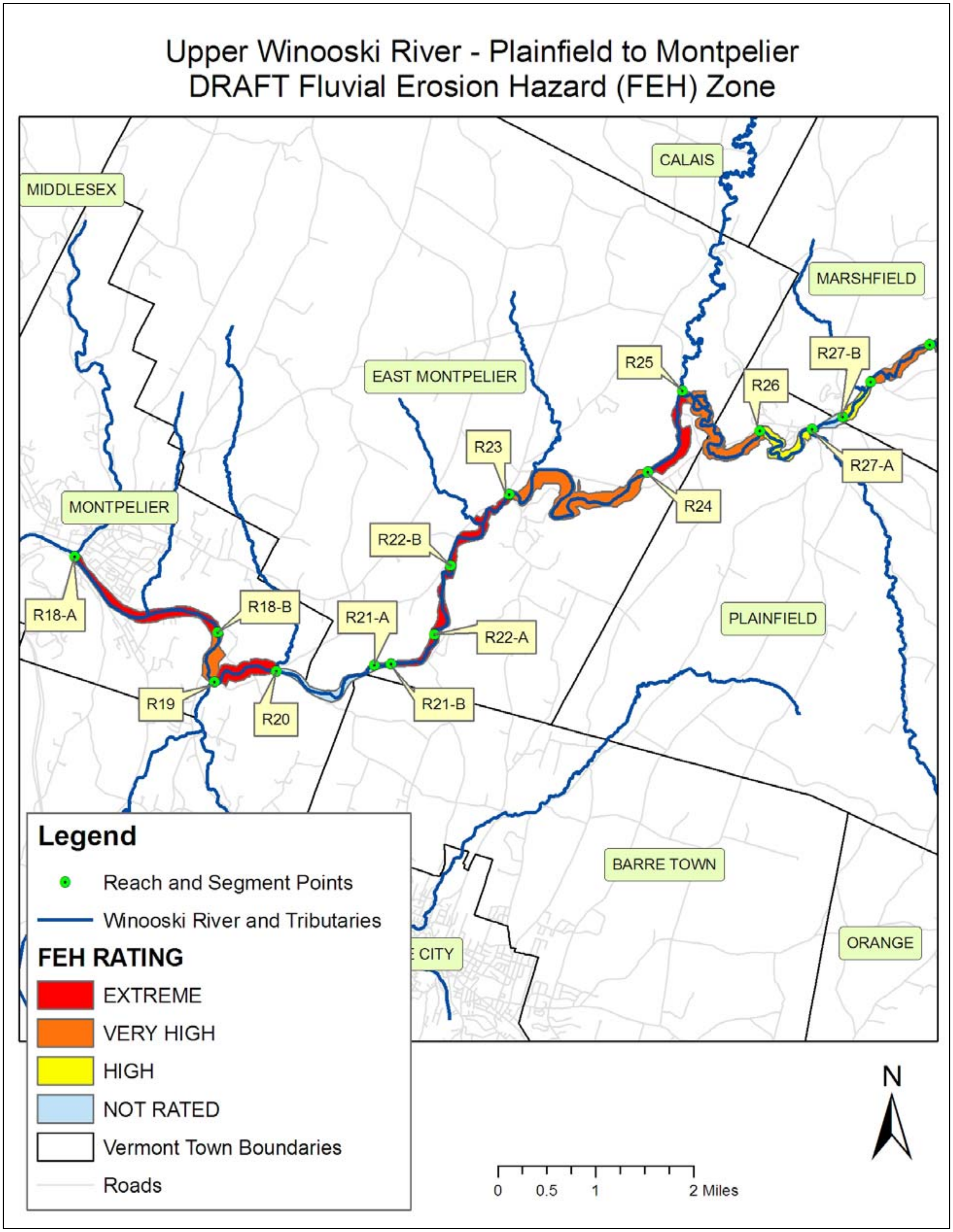


Figure 18: DRAFT FEH Zone for the Upper Winooski River from Plainfield to Montpelier.

6.2 Reach and Site Level Projects

Reach level projects are based on conditions specific to the given reach, although 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. Site level projects are more specific but may go a long way towards alleviating causes of instability that can be either localized or extend great distances up and down river.

This River Corridor Plan includes detailed descriptions of the current state of individual reaches (Appendix B) as well as the preliminary identification of reach and site specific projects (Table 8). It is important to note that these projects affect private landowners. The Partners and the VTANR are looking for landowners to collaborate with in order to implement these important projects.

Reach level projects on the Upper Winooski River fall under one of the following categories:

- River corridor protection
- Restoration of riparian buffers
- Replacement or removal of undersized structures
- Removal of berms and/or barriers to lateral migration and flooding

7.0 NEXT STEPS AND IMPLEMENTATION

The reach and site level projects outlined in Table 8 provide an excellent addendum to ongoing corridor planning and restoration efforts in the Upper Winooski watershed. The projects are listed from upstream reach to downstream and have no other significance in their order. The projects were prioritized for the table based on considerations outlined in Section 6, as well as the feasibility of implementation, existing constraints, cost, landownership, and whether partner sponsorship seemed likely. These projects were outlined based on the judgment of the project Partners and consultant, however, further refinement by the community is likely.

In general, efforts which work to reestablish reference sediment transport conditions (of equilibrium storage of coarse sediments and the deposition of fine materials) as well as those that reduce future flood hazards are most important for reestablishing a healthy river and healthy human relationship with the river. Some projects, such as riparian buffer planting, can begin without significant further planning, while some projects, such as the replacement of undersized bridges, may take considerable time to plan and implement. Other projects, such as the adoption of FEH zoning would need time and consideration, but are implementable by a motivated community within a reasonable amount of time.

7.1 Single and Multiple Landowner Project Implementation

While historically stream protection efforts have focused on addressing individual landowner concerns, it is the hope of the Partners that this document will help landowners see their property in a watershed context. Certain restoration and protection measures may be highly influenced by upstream challenges as well as be 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 Winooski River will be managed to achieve a stable equilibrium in the future that is able to provide important ecosystem services such as attenuation of sediments; floodwater storage; water quality protection; and ecological habitat.

7.2 Watershed Resident Participation

Despite the efforts that have and will be focused on site specific riverfront problem solving, the long-term health and vitality of the Upper Winooski River also relies on the many residents without waterfront property. Strategies that provide incentives for landowners and residents to practice watershed stewardship across the entire landscape will be helpful as will be the continued educational efforts of FWR to create and enhance community and sense of place directly connected with the Upper Winooski River. Additionally, projects that ensure public access to the river may be important to further develop connections between the river and the community. At the same time, educational efforts that create connections with the community youth and elders of 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 Winooski River 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 Winooski River, and allow the stream to pass under without creating instability.
- Adoption of town land use policies that prevent wetland loss and floodplain development, and prohibit the further restriction of the Upper Winooski River.

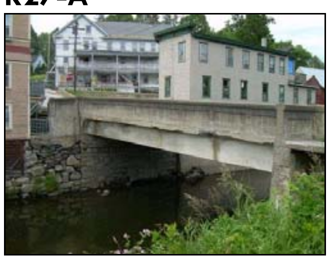
At the state level, priority opportunities include:

- 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.

7.4 Precedence for River Corridor and Floodplain Rehabilitation and Management

As a conclusion to this report it may be helpful to mention several examples where river corridor restoration was enacted in order to protect and improve long term conditions of the watershed in regards to water quality and flood reduction. These efforts have been largely conducted by the Winooski Conservation District, the Friends of the Winooski River, willing landowners, and volunteer energy although numerous other agencies and groups have been involved. For example, in Marshfield, native riparian trees and shrubs were planted along 5.6 acres of riparian land over the past two years. Several conservation easements were also established by the Vermont River Conservancy along part of the riparian corridor in Marshfield in order to secure long-term protection. At the Food Works Project in Montpelier riparian and floodplain restoration efforts have begun as have numerous other smaller planting efforts that have been carried out within the study area. Future efforts are building off of these successes.

TABLE 8: Reach and Site Level Projects

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR -ITY
R27-B 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) and Fluvial Erosion Hazard Reduction	This fairly undeveloped reach is already attenuating floodwaters and fine sediment. Due to its proximity upstream of Plainfield Village and along Route 2 it is conceivable that development may occur in the future in the river corridor. Long term river corridor protection would reduce future conflict and ensure these watershed services are served for future generations.	Few major structures along river. Relatively few landowners.	Unk.	Open land and forest remains structure free	Landowners Town, CVRPC, VTANR	Low
	Restore Riparian Buffer	Long term channel stability, reduced flood velocities, nutrient uptake, habitat and other ecosystem services.	Buffer on the right and left bank could be improved to protect water quality (especially thermal pollution in this slow moving reach). Additionally roughness in the floodplain will slow floodwaters and alleviate potential flows downstream.	Few major structures along reach. River stability is good overall which will allow trees to grow.	Low	Unforested land to forest. Productivity shift to other economic, ecologic, and social gains.	Landowners FWR, WNRCD, FWS	Low
R27-A 	Protect River Corridor	Fluvial Erosion Hazard Reduction	High development in the corridor contributes stormwater, reduces, habitat and is a potential hazard for property owners due to flooding. Long-term reduction of building impacts and possible further protection of land along the banks would provide numerous community and ecosystem benefits.	Would need to be coordinated in town-wide planning effort.	High	Commercial/residential land to public space.	Landowners Town, CVRPC, VTANR FWR FEMA	Low

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR -ITY
R26 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) And Fluvial Erosion Hazard Reduction	This mostly undeveloped reach is already attenuating floodwaters and coarse sediment. Due to its proximity downstream of Plainfield Village and along Route 2 it is conceivable that further development may occur in the future in the river corridor. Long term river corridor protection would reduce future conflict and ensure these watershed services are served for future generations.	Few structures near the river. Driveway on left bank in river corridor. Water treatment is on the left bank and rec fields. Housing development on the right bank on valley wall. Agricultural field on left bank near end of reach.	High	Open land and forest remains structure free	Landowners Town, CVRPC, VTANR	Med
	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	Buffer on the left bank could be improved to protect water quality and improve habitat in this already important recreational fishing reach. Relocation of the road should be investigated as part of a comprehensive restoration project.	Recreational field requires certain size, Recreation Field Road on left bank and agricultural activities on left bank.	Low	Agriculture and Residential Land to Forest	Landowners FWR, WNRCD, FWS	Med
	Remove Berms	Allow for flood flows to disperse and move laterally across a forested floodplain	A channel blocking berm lays perpendicular to the channel across from the Wastewater treatment facility. Its origin and purpose are unknown, however it appears to have the potential to cut off flood flows from accessing the right bank and should be examined as its removal may have potential benefit.	Access through private land. May be a very simple project or may be more involved depending on further analysis.	Unk.	Opening forest back to floodplain.	Landowners Town VTANR	High

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR -ITY
R26 (cont.) 	Remove Berms	Allow for flood flows to disperse and move laterally across a forested floodplain. Allow for trees to develop on bank and shade river and provide habitat.	A second separate berm removal project would be the relocation, reconfiguration of the Rec. Field Road/private driveway. Investment in maintaining this driveway has been historically high (based on the extensive armoring) and is likely to continue with detrimental effects to channel stability, fish habitat, and the ability of the river to access historic floodplain on the left bank.	This road appears to serve a single residence/farm which would need to have viable access for maintaining its operation/ occupancy.	Unk.	Road/berm to floodplain forest.	Landowners Town VTANR	High
R25 	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	This is a highly dynamic reach whose movement has likely been exacerbated by the historic removal of riparian vegetation. Long term management towards equilibrium condition as well as provision of ecosystem services to the community and towns downstream would be improved through reforestation.	Plantings should be at the margin of the river corridor and where oxbows are being formed as this reach is still actively adjusting laterally.	Mod.	Open Land and Ag fields to Forest	Landowners FWR, WNRCD, FWS	High
	Replace Undersized Structure	Open the river channel to allow for sediment transport, channel migration, and riparian habitat connectivity.	Replace highly undersized Route 2 bridge which is currently creating excessive instability upstream.	Project will need to ensure protection of house downstream.	High	Remains a bridge crossing, opens up transport and riparian area connectivity which is currently pinched by the structure.	Landowners VTRANS, Town, VTANR	High

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR-ITY
R25 (cont.)	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) and Fluvial Erosion Hazard Reduction	This mostly undeveloped reach is already attenuating floodwaters and coarse sediment. Due to its proximity along the Route 2 corridor it is conceivable that further development may be proposed in the river corridor. Long term river corridor protection would reduce future conflict and ensure that valuable watershed services are secured for future generations.	Currently few structures near the river. Habitat and flood storage value of oxbow wetlands are important features to protect from fill/drainage.	High	Open land and forest remains structure free	Landowners Town, CVRPC, VTANR	High
R24 	Remove or Replace Structures	Improve sediment and flood water flow under Coburn Covered Bridge	Expand bridge abutment widths to allow for sediment transport under structure.	Bridge was recently raised, more investment may be difficult to gather.	High	None	Landowners Town, VTANR, FWS, VTRANS,	Low
	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	This is a predominately stable reach with already large sections of intact riparian forest. Improving connectivity on the left bank especially will ensure ecosystem services and habitat improvement for this reach.	Few major structures along reach. River stability is good overall which will allow trees to grow.	Low	Unforested land to forest.	Landowners FWR, WNRCD, FWS	Low

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR-ITY
R24 (cont.)	Remove Berm	Open up floodplain to receive extreme high water flows.	Tailings piles left over from gravel mining operations on the left bank form a berm that would hinder floodplain access and potential floodwater storage in the quarry pond. Flood water access to the pond is acceptable, however, lateral migration of the river into the pond itself must be prevented.	State owned property. Lateral migration of river into pond must be prevented due to potential disruption of sediment transport and downstream affects.	Low	Restoration of riparian forest in conjunction with berm removal.	Landowners VTANR FWR, WNRCD, FWS	High
	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) and Fluvial Erosion Hazard Reduction	A large portion of the corridor is currently forested and or marginal land. Protection of the relatively thin strip of land that encompasses the river corridor in this reach would reduce future conflict and ensure that valuable watershed services are secured for future generations.	Currently few structures near the river.	High	Open land and forest remains structure free	Landowners Town, CVRPC, VTANR	Low
R23 	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	This is a dynamic reach whose movement has likely been exacerbated by the historic removal of riparian vegetation and straightening. Long term management towards equilibrium condition as well as provision of ecosystem services to the community and towns downstream would be improved through reforestation.	Plantings should be at the margin of the river corridor and where oxbows are being formed as this reach is still actively adjusting laterally.	Mod.	Open Land and Ag fields to Forest	Landowners FWR, WNRCD, FWS	Med

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR-ITY
R23 (cont.) 	Remove Berm	Restore floodplain and channel meander ability	Future road work and intersection work at the Route 2 and 14 intersections in East Montpelier should consider a realignment of Route 2 which has cut off the floodplain on the right bank in the lower end of the reach. Rock armoring along the road bank has reduced habitat quality of this reach. Wetlands/floodplain on the north side of Route 2 have been cut-off from the river channel.	Considerable planning and community discussion would need to occur before a major road realignment would take place.	High	Relocation of road would impact undeveloped land while rehabilitating currently impacted land.	Landowners Town, VTRANS, CVRPC, VTANR	Low
	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) and Fluvial Erosion Hazard Reduction	This mostly undeveloped reach has significant potential for future river corridor ecosystem services. A large portion or the channel is currently forested. Annual crop fields would be reduced or possibly converted to perennial crops that would provide similar function as a riparian buffer. Protection of this reach from development would reduce future conflict and ensure that valuable watershed services are secured for future generations.	Currently few structures near the river.	Unk.	Open land and forest remains structure free	Landowners Town, CVRPC, VTANR	High

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR-ITY
R22-A 	Replace Undersized Structure	Open the river channel to allow for sediment transport, channel migration, and riparian habitat connectivity.	Replace highly undersized Route 2 bridge which is currently creating instability upstream.	Project will need to ensure protection of houses upstream and downstream.	High	Remains a bridge crossing, opens up for sediment transport.	Landowners VTRANS, Town, VTANR	High
	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	This is an incised and historically straightened reach. The left bank is predominately a road (Route 2), and the right bank has had significant riparian deforestation. Efforts to improve the riparian forest on the right bank may help improve instream channel condition and habitat along this reach. As well as provide long term ecosystem services for the community.	Few major structures along reach. River stability is good overall which will allow trees to grow.	Low	Pasture land to forest. Productivity shift to other economic, ecologic, and social gains.	Landowners FWR, WNRCD, FWS	Low
R21-A 	Remove or Replace Structures	Improve sediment flows upstream. Improve fish passage.	Remove old concrete dam. Provide slope control to channel to prevent channel incision.	Extensive study and permitting. River will breach dam someday on its own. A controlled breach may prevent a nickpoint from migrating upstream uncontrolled.	Unk.	Dam to free flowing river.	Landowners VTANR, ACOE	Low

REACH NUMBER	METHOD	BENEFIT	DESCRIPTION	FEASIBILITY/ CONSTRAINTS	COST	LANDUSE CONVERSION	PARTNERS	PRIOR-ITY
R19 	Protect River Corridor	Sediment Attenuation Area (Conserve and Enhance) and Fluvial Erosion Hazard Reduction	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	Landowners Town, CVRPC, VTANR	High
	Replace Undersized Structure	Open the river channel to allow for sediment transport	Replace undersized Route 2 bridge and railroad bridge at the bottom of R19 both of which are undersized.	Project will need to ensure protection of infrastructure upstream and downstream.	High	Remains a bridge crossing, opens up water and sediment transport.	Landowners VTRANS, Town, VTANR	High
R18-B 	Restore Riparian Buffer	Long term channel stability, reduce flood velocities, nutrient uptake, habitat and other ecosystem services.	This is an incised and historically straightened reach. There are commercial industries on both banks. Efforts to improve the riparian forest may help improve in-stream channel condition and habitat along this reach. As well as provide long term ecosystem services for the community downstream.	Some structures along reach, but predominately undeveloped land that could be reforested.	Low	Reversion to forested riparian area.	Landowners FWR, WNRCD, FWS	Med

	Protect River Corridor	Attenuation Area (Rehabilitate and Enhance) and Fluvial Erosion Hazard Reduction	This is a potentially highly dynamic area where the Stevens Branch feeds into the Winooski River. Restoration study has recently been conducted along with some streambank stabilization and riparian enhancement work.	Existing structures and private landowner investments.	High	Conversion of land from commercial to public.	Landowners Town, CVRPC, VTANR, FWR, WNRCD	High
REACH NUMBER	**METHOD**	**BENEFIT**	**DESCRIPTION**	**FEASIBILITY/ CONSTRAINTS**	**COST**	**LANDUSE CONVERSION**	**PARTNERS**	**PRIOR-ITY**
R18-A 	Protect River Corridor	Fluvial Erosion Hazard Reduction	This highly developed river corridor is both a detriment to water quality as well as a potential hazard for property owners due to flooding. Long-term acquisition of buildings and conversion of land along the right bank into public, seasonally flooded open space would provide numerous community and ecosystem benefits.	Significant land use conversion, cost, and resources.	High	Commercial land to public space.	Landowners Town, CVRPC, VTANR FWR	High

8.0 REFERENCES

Albers, J. Hands on the Land: A History of the Vermont Landscape. 1999. MIT Press, Cambridge Massachusetts.

Barnes, Kent and John Morgan III and Martin Roberge. 2001. Impervious Surfaces and the Quality of Natural and Built Environments. Department of Geography and Environmental Planning, Towson University. Baltimore, Maryland.

Bilby, R. E. and Linkens, G. E. 1980. Importance of organic debris dams in the structure and function of stream ecosystems. Ecology. 61: p. 1107-1113.

Blazewicz, Michael and Mary Nealon. 2006. Upper Winooski River, River Corridor Management Plan: Cabot, Vermont.

Brierley, Gary and Kirstie Fryirs. 2005. Geomorphology and River Management: Application of the River Styles Framework. Blackwell Publications, Oxford, UK.

Brown, Arthur V., Madeleine Lyttle, and Kristine Brown. 1998. Impacts of gravel mining on gravel bed streams. Transactions of the American Fisheries Society 127:979–994, 1998

City of Montpelier. 1998. Montpelier Flood Hazard Mitigation Plan. Montpelier, VT.

Diez, J. R., Santiago Larranaga, Arturo Elosegi, Jesus Pozo. 2000. Effect of removal of wood on streambed stability and retention of organic matter. Journal of North American Benthological Society. 19:4: p. 621-632.

Doll, Charles. 1961. Centennial Geologic Map of Vermont, State of Vermont Geologic Survey.

Fish, Charles. 2006. In the Land of the Wild Onion: Travels along Vermont's Winooski River. University Press of New England, Lebanon, NH.

Fitzgerald, Evan. 2007. Stream ecosystem response to watershed development. Master's thesis research project in Natural Resources at the University of Vermont.

Galay, V. J. 1983. Causes of river bed degradation. Water Resources Research. 19 (5): 1057-1090

Johnson Company. 2007. Phase 2 Stream Geomorphic Assessment Upper Winooski Watershed: Towns of Cabot, Marshfield, Plainfield, East Montpelier, Barre, and Montpelier Washington County, Vermont. The Johnson Company, Montpelier, Vermont.

Johnson Company. 2008. Upper Winooski River Corridor Plan: Town of Marshfield. The Johnson Company, Montpelier, Vermont.

Klyza, Christopher McGrory and Stephen C. Trombulak. 1999. The Story of Vermont: A Natural and Cultural History. Middlebury College Press, Hanover, New Hampshire.

Leopold, Luna. 1994. A View of the River. Harvard University Press. Massachusetts.

Magillian, F.J., K.H. Nislow, G.B. Fisher, J. Wright, G. Mackey, M. Laser. 2008. The geomorphic function and characteristics of large woody debris in low gradient rivers, coastal Maine, USA. Geomorphology 97: 467-482

McBride, Maeve, W.C. Hession, D.M. Rizzo. 2008. Riparian reforestation and channel change: A case study of two small tributaries to Sleepers River, northeastern Vermont, USA. Geomorphology 102: 445-459

Montgomery, David and John Buffington. 1997. Channel-reach morphology in mountain drainage basins. Geological Society of America Bulletin, v. 109. p. 596-611

National Academy of Sciences. 2002. Riparian Areas: Functions and Strategies for Management. Washington, D.C.

Nislow, K. H. 2005. Forest change and stream fish habitat: lessons from 'Olde' and New England. Journal of Fish Biology. Supplement B, Vol. 67. p186-204

Riley, Ann. 1998. Restoring Streams in Cities: A guide for planners, policymakers, and citizens. Island Press. Washington, D.C.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Sweeney, Bernard, et al. 2004. Riparian deforestation, stream narrowing, and loss of stream ecosystem services. Proceedings of the National Academy of Sciences. v.101, 39.

Vermont Agency of Natural Resources. 2005. Guidance for Agency Act 250 and Section 248 Comments Regarding Riparian Buffers. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2006. Fluvial Erosion Municipal Guide. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2008. Vermont Agency of Natural Resources River Corridor Protection Guide: Fluvial Geomorphic-Based Methodology to Reduce Flood Hazards and Protect Water Quality. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2007b. Vermont Stream Geomorphic Assessment Phase 2 Handbook. Rapid Stream Assessment, Field Protocols and Appendices. Waterbury, Vermont.

Vermont Agency of Natural Resources. (undated). Defining River Corridors Fact Sheet. Vermont DEC River Management Program. Waterbury, Vermont.

Vermont Department of Public Safety. 2006. Appendix 5. Mutual Aid Agreements. http://www.dps.state.vt.us/vem/emd/Appendix/appendix_3_05.pdf Waterbury, Vermont.

Vermont Geologic Survey. 1952. Map: Areal Geology of the Montpelier Area. Montpelier, VT.

Wright, Stephen and Fredrick Larsen. 2004. Surficial Geology of the Barre-Montpelier Region.

Willard, Abbey, Dan Currier, and Ann Smith. 2007. Phase 1 Stream Geomorphic Assessment Upper Winooski River Watershed and North Branch & Lower Stevens Branch subwatershed. Montpelier, VT.

9.0 GLOSSARY

Adapted from:
Glossary of Stream Restoration Terms
by Craig Fischenich.. February 2000
USAE Research and Development Center,
Environmental Laboratory, 3909 Halls Ferry
Rd., Vicksburg, MS 39180

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. Planform change refers to the shifting of a channel laterally across a valley bottom. Planform adjustment 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 on the main stem of the Upper Winooski River are widening and planform migration as a result of historic channel straightening and floodplain encroachment which caused degradation and reduced floodplain access within the channel.

The results of the Phase 2 geomorphic assessment are discussed below by reach number from upstream to downstream. Reaches that were assessed in a previous study were included here (descriptions quoted from the original author) in order to document a complete description of the Upper Winooski River from reach R27 to R18 (the length of which is documented in this River Corridor Management Plan). Six overview maps (Figures 1, 5, 8, 10, 13, and 16) have been included to provide a reference for location as well as to display riparian buffer impacts and channel straightening both of which have greatly affected the condition of the Upper Winooski River.

RIVER REACHES R27 AND R26: MARSHFIELD TO PLAINFIELD VILLAGE

The first section of river (illustrated in Figure1) begins in Marshfield and flows westerly towards Plainfield Village. The valley alternates between broad and narrow and land use changes from predominately agricultural and forested to commercial and residential in Plainfield. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, a dam, and floodplain encroachment.

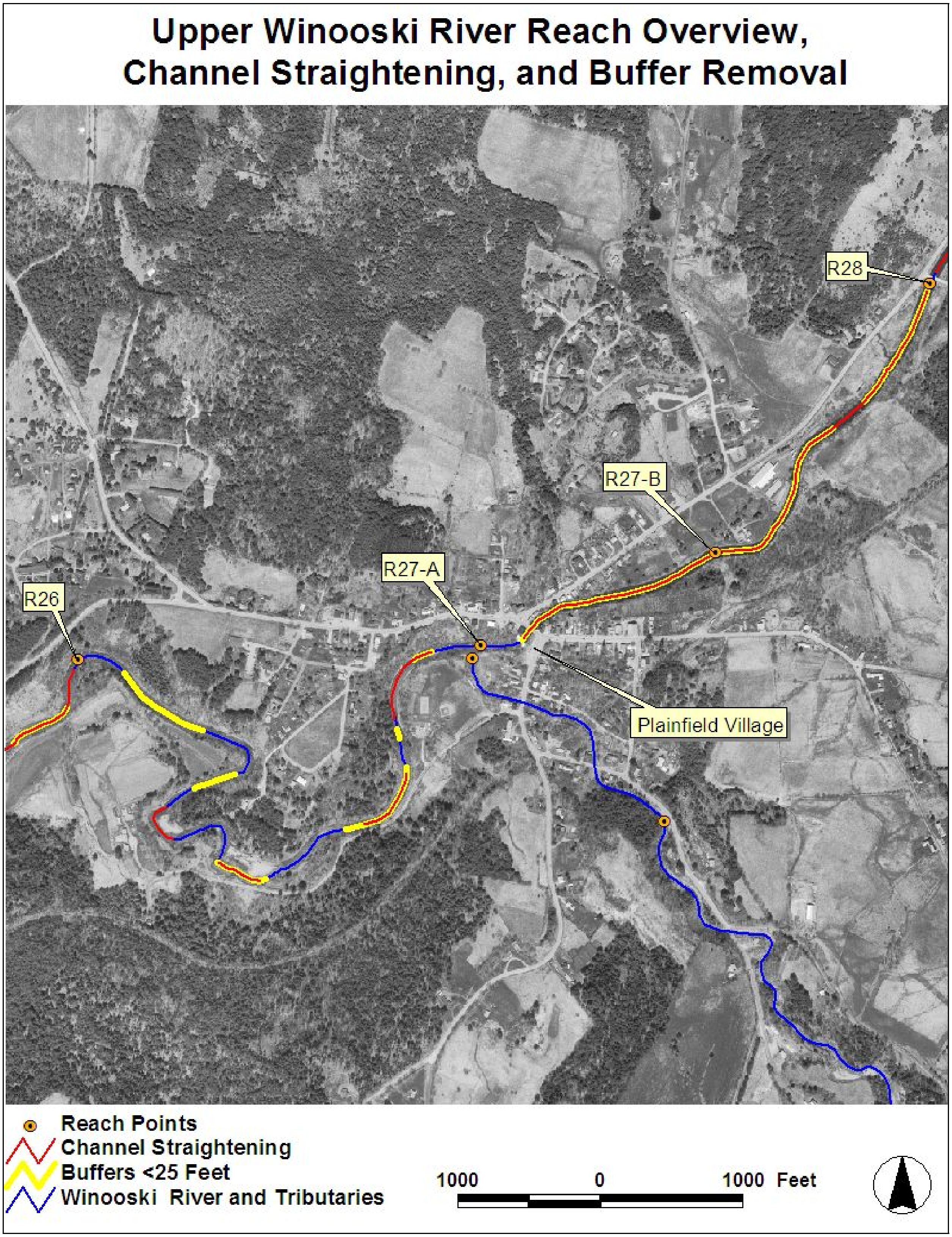


Figure 1: Reaches R27 through R26 with channel straightening and riparian buffers <25 feet wide.

Reach R27

Upper Winooski River reach R27 begins in the town of Marshfield, close to the Plainfield town line. It is the uppermost reach of this study area (upstream reaches are included in separate reports). The reach begins at the John Fowler Road bridge and continues downstream into the Village of Plainfield where it ends near the mouth of Great Brook, just below the dam in Plainfield. The dam affects the river by reducing the slope of the channel, thereby disrupting sediment transport and geomorphic processes. R27 was segmented into two study sections, A and B, in order to account for the dams influence on the channel. R27-B is the upstream segment and represents a free-flowing stream. R27-A is the downstream segment and represents the area impeded by the dam as well as a very small area of cobble bottomed fast moving water (that closely resembles reach R26) just below the dam.

R27-B

Upper Winooski segment R27-B begins at the John Fowler Bridge and flows downstream to approximately 1500 feet upstream of the Plainfield dam. The reach is characterized by a very straight E-type stream channel dominated by a ripple-dune sand bottom. The channel appears straight due to historic manipulation. This straightened channel has widened and there is evidence of some minor planform adjustment as the river attempts to erode an outside bank. Lack of significant adjustment may be attributed to the low slope and excellent floodplain access and a moderately healthy riparian buffer (see Figure 2). The straightening and widening have, however, greatly reduced instream habitat quality. Forest clearing for residential and recreational use has significantly impacted the right bank as well as a portion of the left riparian area which has been cleared for agriculture. Route 2, several residences, and a commercial operation impede on the right corridor while the left corridor has no significant development.

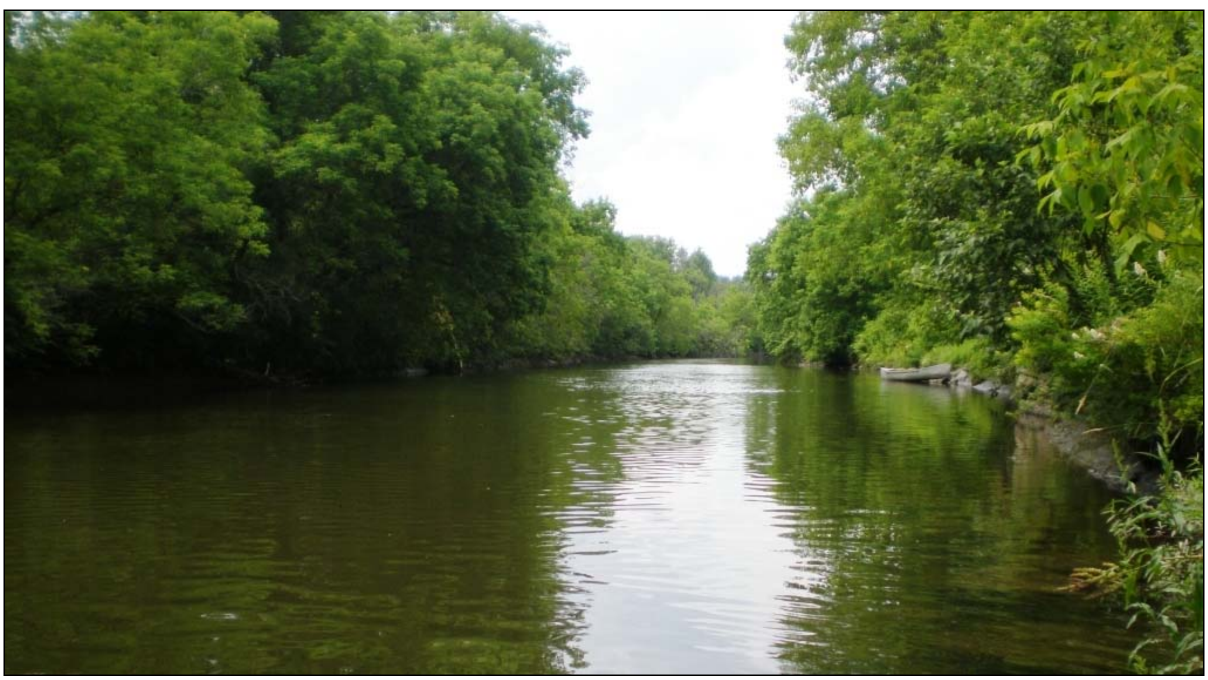


Figure 2: Typical perspective of segment R27-B, a ripple-dune channel with a very low slope.

R27-A

Upper Winooski River segment R27-A begins ~1500 feet upstream of the Plainfield Dam and ends at the confluence with the Great Brook. Only a partial Phase 2 Assessment was conducted for this segment due to the disruptive influence of the dam on the sediment transport of the river. Because velocity and water surface slopes are reduced, pooling of water occurs during a high flow event leading to settling of gravels, sands, and silts on the river bottom. As the river goes through the Village impacts associated with urbanization affect the river including significant disturbance to the riparian buffer, excessive riprap and concrete walls (which offer little habitat value), and stormwater runoff sources (from rooftops, driveways, and lawns).

The Plainfield Dam is owned by the Town of Plainfield and has recently been considered for hydropower development (Figure 3).

Figure 3: Dam in Plainfield Village on Reach R27-A.

Reach R26

Winooski River reach R26 begins at the confluence with the Great Brook next to the recreation fields in Plainfield Village. The reach continues downstream for over a mile in a broad valley with a greater slope (valley slope = 1.04%) than both the upstream and downstream reaches. This steeper slope influences the stream type, bedform, and dominant bottom substrates found in R26. The reach is a C-type channel with a riffle-pool form dominated by cobble and gravel material. It is evident from terraces in the floodplain and the mouth of Great Brook that historic channel incision has occurred in this reach (current incision ratio is 1.5). Presently it appears that planform migration is the most significant adjustment occurring within this reach (see Figure 4). This was especially evident in 1980 when according to a local fisherman the stream underwent a major adjustment in location. As a result of this channel movement, and perhaps influenced by material moving in from the Great Brook, channel aggradation and widening are also occurring in minor amounts.

A road on the left bank has severed some potential floodplain access for the river. Riparian buffer removal on the left bank has also occurred in significant amounts. On the right bank some minor encroachment by residential development has occurred, however, overall the buffer is in better condition. The Plainfield Water Treatment facility, located within the river channel corridor is on the left bank next to the recreation fields. Future continued planform adjustment can be expected in this reach as the river works to develop accessible floodplain and to transport sediments arriving from Great Brook.

Figure 4: Dynamic channel movement in reach R26. New floodplain development and sediment deposition on inside bend (right), erosion and prevention (rip-rap) on left bank.

RIVER REACHES R25 TO R24: PLAINFIELD / EAST MONTPELIER TOWN LINE

The second section of river (illustrated in Figure5) begins in Plainfield at R25 and flows westerly crossing into East Montpelier near Coburn Road, the start of R24. The valley alternates between very broad and narrow and land use is dominated by forest, agriculture and residences. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

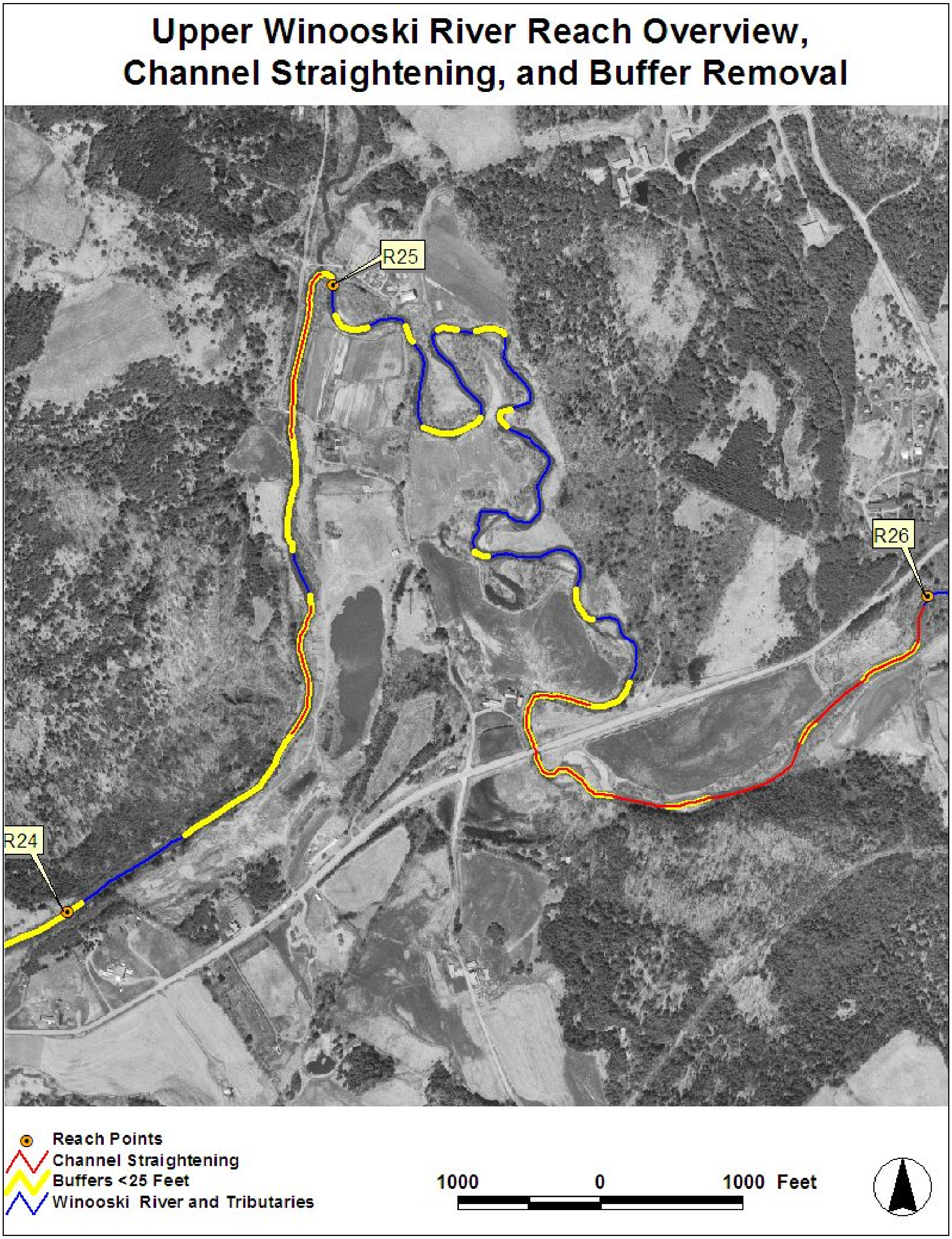


Figure 5: Reaches R25 through R24 with channel straightening and riparian buffers <25 feet wide.

Reach R25 (As reported by the Johnson Company)

R25 is located from 600 feet upstream from the upper corner of a corn field along Route 2 in Plainfield to the confluence with Kingsbury Branch in East Montpelier near Coburn Road (Figure 6).

> "R25 has undergone a stream type departure from its reference E type stream to the current C type channel. The reach is not highly entrenched and is moderately incised, which means that it still has access to the flood plain during high flow events. The reach was found to be in Stage III of evolution. The major adjustment processes are planform and widening evidenced by the bank erosion, and flood chutes. Evidence of channel avulsion was found on the mid-portion of the reach. There is also some aggradation occurring as shown by the enlargement of depositional features such as point, mid, side, and diagonal bars, and islands. Multiple eroding banks on both sides (approximately 9 feet high and 250 feet long) and mass failures with an average failure height of 40 feet are present mainly on the right bank at the valley wall. Some of the factors increasing the sediment input to this reach are glacial geology, highly erodable soils, lack of riparian buffer, and the relocation of the channel to accommodate Route 2, which has moved the channel close to the valley wall. This reach contributes a significant sediment and nutrient load to the downstream reaches. The right riparian corridor was dominated by forest, but this vegetation did not extend to the river bank. The buffer width was generally less than 5 feet. The left riparian corridor consisted of hay fields with a narrow wooded buffer of <5 feet. Rip-rap is present for approximately 500 feet upstream and downstream from the bridge on Route 2. The downstream stretch is primarily farm land."

Figure 6: Widening and planform adjustment in Reach R25. Photo credit: Johnson Company

Reach R24

Winooski River reach R24 begins at the confluence with the Kingsbury Branch where the valley narrows and flows downstream to where the valley naturally reopens just upstream of a new Route 2 bridge in East Montpelier. The reach is just over a mile long with a channel slope of under 1%. Mining of gravel along an adjacent hillside (now floodplain) has changed the entrenchment in the middle of the reach. Despite its location in a narrow valley this reach appears to be an "E" type channel based on the width to depth ratio of 11.5.

Current conditions in the channel include some encroachment in the floodplain by the Coburn Road. The covered Coburn Bridge rests on narrow abutments that are causing streambank scour both upstream and downstream of the structure (this despite the bridge itself having been elevated several years ago in order to improve flood flow capacity under the structure). Streambank erosion and rip-rapping are common along much of the reach (less riprap in the more remote downstream area). The riparian buffer has been disturbed along much of the river (particularly upstream) due to agricultural activities, the road, and the mining operation. Some berming along the left bank exists at the mining operation and reduces access to a potential floodplain area.

R24 is slightly incised. Excessive energy in the channel may have caused a large mass failure on the right bank as well as other intermittent erosion patches that exist commonly on both the right and left banks. It also may have reduced the habitat complexity which is dominated by a plane bed bottom and only two riffles over the course of the mile long reach (sediment contributions from R25 and the Kingsbury branch may also have filled in some of the bottom topography) (see Figure 7).

Figure 7: Measuring channel incision along reach R24.

RIVER REACH R23 : EAST MONTPELIER VILLAGE AND UPSTREAM

The third section of river (illustrated in Figure 8) begins in East Montpelier downstream of the Coburn covered bridge and flows westerly into East Montpelier Center ending at the Route 14 South Bridge. The valley is predominately broad and land use is dominated by forest, agriculture and residences. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

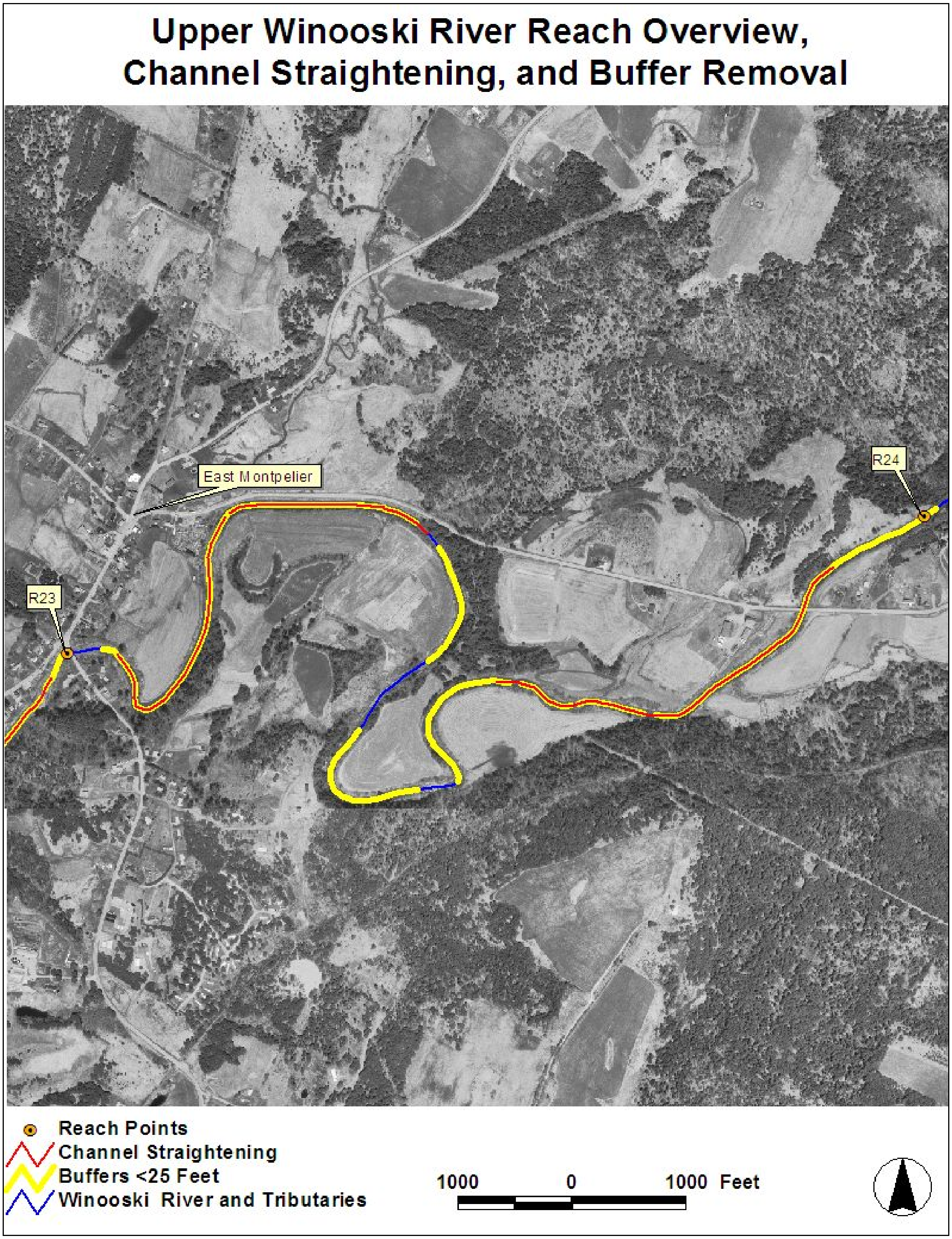


Figure 8: Reach R23 with channel straightening and riparian buffers <25 feet wide.

Reach R23

Upper Winooski River reach R23 starts just upstream of the new Route 2 Bridge in East Montpelier and flows downstream to just below the Route 14 south bridge in East Montpelier. This is a long meandering reach with a total length of 2.8 miles. The reach flows through predominately farm fields and forests before reaching the more developed residential lands near the East Montpelier Village. Significant impacts have occurred in this reach historically. First, channel straightening has occurred in several areas where the stream was channeled in order to maximize cultivated land and for the placement of Route 2. Secondly, the channel has been significantly affected by the removal of forested riparian buffers (see Figure 9). A number of stormwater inputs and two channel constricting bridges were also recorded in this reach.

R23 is an "E" type channel by reference and should by nature be sinuous, narrow, and deep with excellent floodplain access. The reach is, however, severely incised. Excess erosive energy is widening the stream channel and exacerbating planform adjustment. These processes may have contributed to triggering several mass failures which are found in the lower part of the reach. Incision is so excessive that the entrenchment of the channel has been reduced and the channel is now best described as a "B" type channel having departed from reference channel conditions. As the stream widens and adjusts laterally it is already building new floodplain benches on the inside of some meander bends. These floodplain benches will colonize with vegetation and may, over time, become part of the functioning floodplain for the Winooski. The geomorphic adjustment processes are, however, causing excessive streambank erosion along much of the reach and sending these sediments downstream into other reaches reducing stream bottom habitat and transporting nutrients towards Lake Champlain.

Figure 9: Significant streambank erosion through alluvial soils in reach R23.

RIVER REACH R22: EAST MONTPELIER VILLAGE TOWARDS MONTPELIER

The fourth section of river (illustrated in Figure 10) begins from the Route 14 South Bridge in East Montpelier and continues downstream towards Montpelier. The valley is predominately broad and land use is dominated by forest, agriculture, residences and some commercial use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

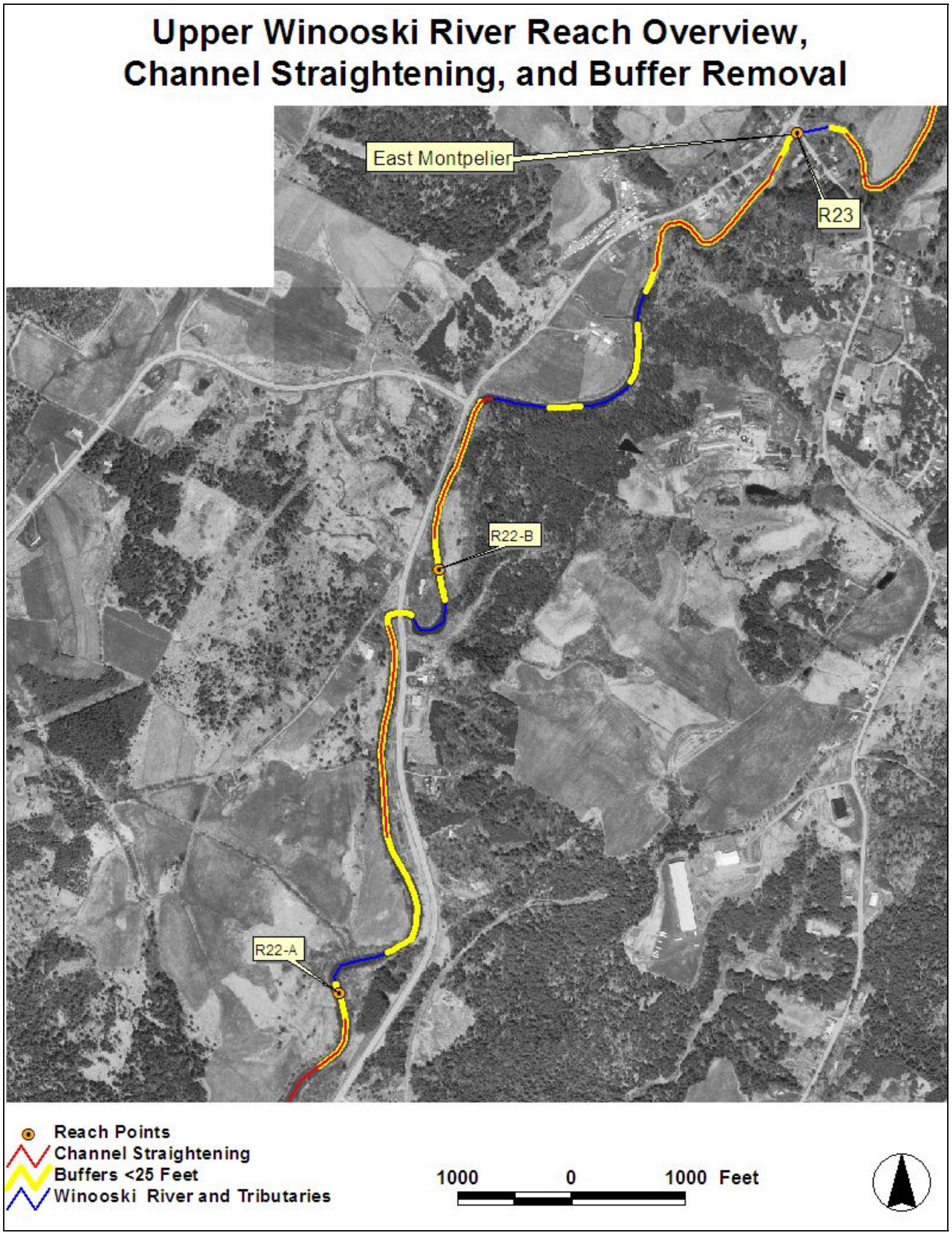


Figure 10: Reach R22 with channel straightening and riparian buffers <25 feet wide.

Reach R22 (As reported by the Johnson Company)

R-22 is located 100 feet downstream from the bridge on Route 14 South to approximately 1500 feet downstream of the hanging bridge. The reach was segmented into R22B (Figure 11) and R22A (Figure 12).

"Both reaches are highly entrenched and incised related to the development of East Montpelier and straightening along Route 2. R22B was segmented from due to its grade control and the proximity to the valley wall. Segment B was found to be an F gravel stream. R22A consists of the lower 1/3 of the reach and was found to be an F sandy stream."

R22B

"R22B also may have also been straightened in the past because of development in East Montpelier. The geomorphic and habitat assessment scores were 0.45 and 0.43 respectively, both "fair" conditions. The segment was found to be in Stage III of evolution and has lost access to its historic floodplain. The dominant adjustment processes are widening and historic degradation. Active channel migration evidenced by flute chutes was observed. There is aggradation at the mouth of the tributary, Mallory Brook, as is evident by depositional features such as delta, side, point and mid-channel bars. The right riparian corridor was dominated by a hay field on the right, and had a narrow buffer of less than 5 feet. The left riparian corridor consisted of forest with a buffer of more than 100 feet."

Figure 11: Cross section on reach R22-B. Photo credit: Johnson Company

R22A

"R22A had undergone a stream type departure from its reference C type stream to the current F type channel due to historic degradation, which has lowered the entrenchment to 1.2 and increased the incision ratio to 2.1. The segment no longer has access to its original floodplain and was found to be in Stage III of evolution. The dominant adjustment process was found to be widening as evident by steep to vertical eroding banks (approximately 7 feet high and 150 feet long) and the development of new terraces. One mass failure, approximately 40 feet high, is located on the left bank, approximately 350 feet upstream from the bridge on Route 2. The habitat and geomorphic assessment scores were 0.27 and 0.34 respectively, both "poor" conditions. The riparian corridor was dominated by commercial development on the left side and crops on the right side with a very narrow buffer of < 5 feet on both sides. The bridge on Route 2 is located in a meandering river area, which could potentially cause some stress to the structure in the future (Figure 12). Route 2 presents an encroachment to the historic river corridor along a significant portion of the reach."

Figure 12: Route 2 Bridge with difficult alignment, R22-A. Photo credit: Johnson Company

RIVER REACHES R21 AND R20: EAST MONTPELIER TO MONTPELIER, BERLIN, BARRE CORNER

The fifth section of river (illustrated in Figure 13) begins from below the hanging bridge in East Montpelier and continues downstream towards Montpelier flowing over three dams including the near 100 year old Winooski #4 dam operated by Winooski Hydroelectric Company. The valley is predominately semi-confined and use is dominated by forest, agriculture, and commercial use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, two dams, and floodplain encroachment.

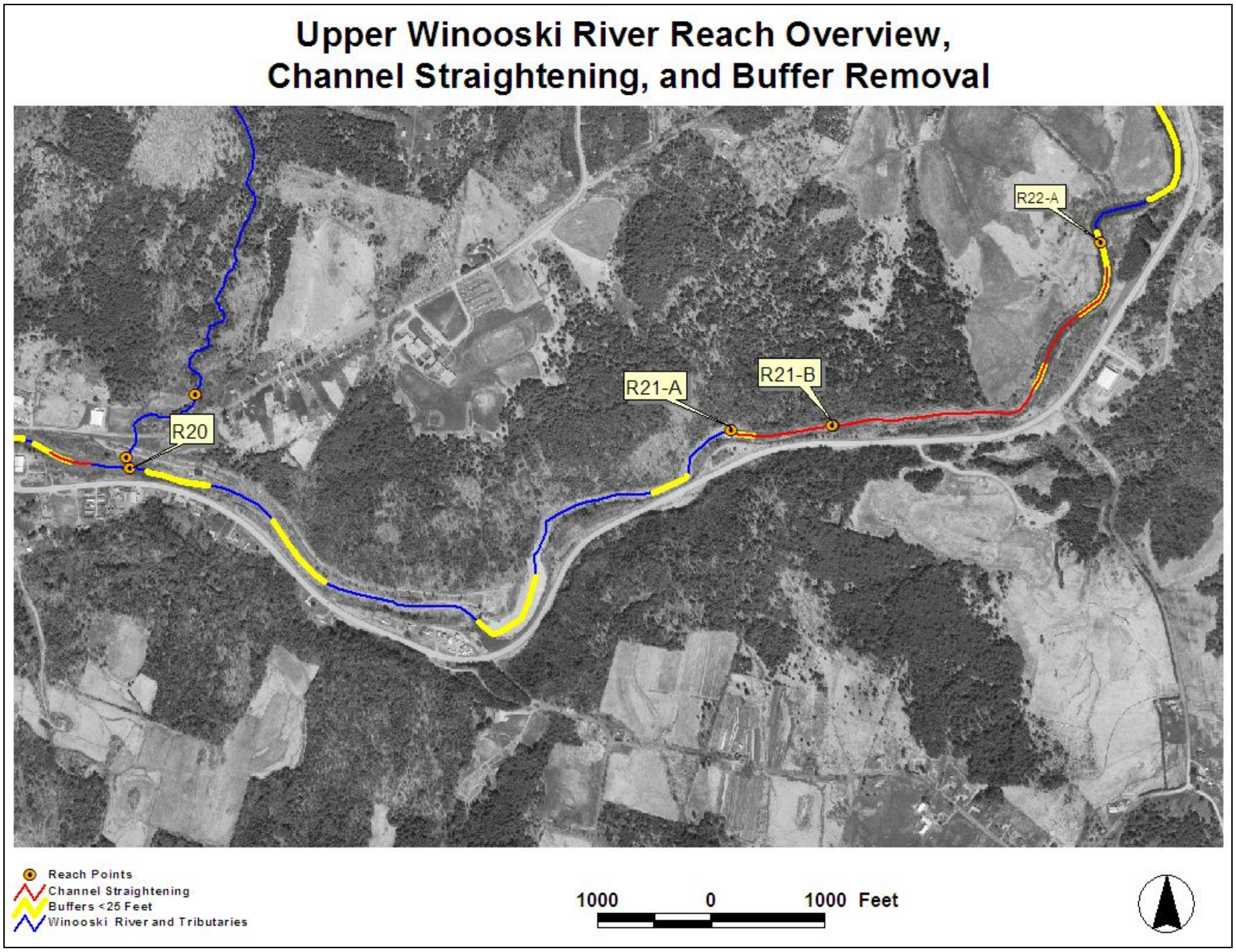


Figure 13: Reaches R21 and R20 with channel straightening and riparian buffers <25 feet wide.

Reach R21

Upper Winooski River reach R21 begins approximately 1500 feet downstream of the hanging bridge in East Montpelier and continues to an old concrete dam several hundred feet upstream of the Montpelier #4 hydro dam. The reach was segmented due to the influence of the concrete dam on the flow and sediment transport capacity of the lower end of this reach.

R21-B

Winooski River segment R21-B begins just upstream from Packard Road in East Montpelier where the channel bends away from Route 2. The valley and channel slope of the Winooski become steeper as the valley becomes semi-confined and dominated by agriculture on the right bank and the old Route 2 corridor on the left bank. The reach is characterized by a fairly straight channel with little room to adjust laterally. There exists significant rip rap on left bank (concrete and quarried stone) that was likely put in place to protect the historic route 2 road bed. Large boulders exist in stream channel indicating the rivers greater ability to transport fine materials in this narrow, steeper reach (Figure 14). Because of this natural and enhanced (due to the old Route 2 roadbed) condition, very little sediment storage potential exists in this reach. The dominant channel adjustment processes are historic channel incision and current channel widening.

Figure 14: R21-B flows over boulders and cobbles alongside the old route 2 roadbed which flanks the left bank (right side of photo).

R21-A

Winooski River segment R21-A was only partially assessed due to the impact of the concrete dam that exists at its lower end (Figure 15). The dam reduces water surface slope and changes the channel bottom from cobble/gravel to sand/silt. The dam is no longer in use but still impacts the channel. Just on the downstream side of the old dam a large alluvial fan has developed where a tributary affected from upstream disturbance is carrying a significant amount of sediment towards the river.

Figure 15: An old concrete dam disrupts water and sediment transport at reach R21-A (looking upstream).

Reach R20

Reach R20 drains from below the small concrete dam described in Segment R21-B downstream through the Winooski #4 hydro dam to a point 1500 feet downstream of the Montpelier/East Montpelier town line where an unnamed tributary enters from the north (right) bank. Due to the influence of the dam on the condition of this reach a Phase 2 assessment was not conducted here.

RIVER REACHES R19 AND R18: MONTPELIER, BERLIN, BARRE TO DOWNTOWN MONTPELIER

The sixth section of river (illustrated in Figure 16) begins from the confluence with an unnamed tributary downstream of the Winooski #4 dam to the confluence with the North Branch in downtown Montpelier. The valley alternates from semi-confined to broad and is dominated commercial land use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, two dams, and floodplain encroachment due to urban development.

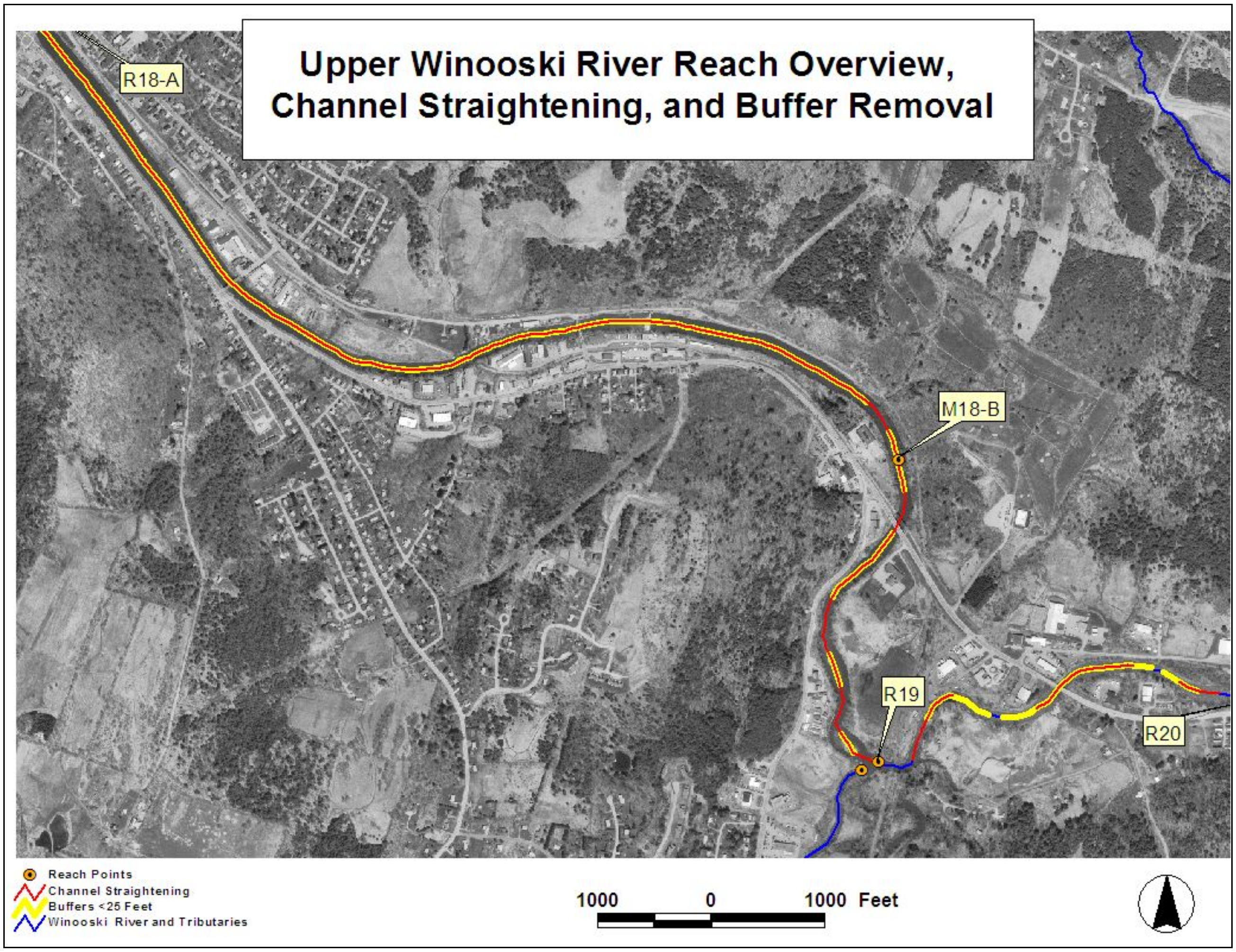


Figure 16 Reaches R20, R19, and R18 with channel straightening and riparian buffers <25 feet wide.

Reach R19 (As reported by the Johnson Company)

R-19 (Figure 17 is located from the unnamed tributary on the right approximately 50 feet north of Route 2 and approximately 1800 feet upstream of the Route 2 bridge to R-18B, approximately 125 feet downstream of a railroad bridge.

“It was found to be an F boulder stream, which was a stream type departure from the Phase 1 reference C stream type. The stream type departure is due to historic degradation and the commercial and industrial development along Route 2. These stressors have lowered the entrenchment to 1.5 and increased the incision ratio to 1.4. The major active adjustment process is widening, as evidenced by rip-rap failure of approximately 160 feet long located upstream from the railroad bridge on the left bank. The two bridges are channel constrictions. Although bank instability was clear near the two bridges, no active head cuts were documented. The reach was found to be in Stage III of evolution. Historically, the reach has been straightened. The habitat score was 0.48, or “fair,” and geomorphic score 0.34 or in “poor” condition. Relatively minor bank erosion was noted along both the right and left bank with a total length of 185 feet and an average height of 10 feet. The right bank erosion is located upstream from the bridge on Route 2 and adjacent to a parking lot. The left bank erosion is located downstream and adjacent to the railroad bridge. The erosion is related to constriction by the bridge. The riparian corridor was dominated by development. Buffers ranged from <5 to 25 feet along the left and <5 feet along the right. This reach may be affected by the water release coming from the Levesque Station-Montpelier Hydroelectric Dam #4. The lower portion of the reach is connected to the mouth of the Steven Branch and the Food Works site described above."

Figure 17: Typical channel conditions along reach R19. Photo credit: Johnson Company

Reach R18 (As reported by the Johnson Company)

R18 is the most downstream reach in the Upper Winooski assessment area and extends from the confluence with the Stevens Branch downstream to the confluence with the North Branch at the Main Street Bridge in Montpelier.

"The reach was segmented into R18-A and R18-B. R18-B was segmented due to its channel dimensions and historic stream channel management and encroachment through the City of Montpelier. R18-A and R18-B were highly incised due to historic degradation caused by historic channel management activities. R18-A consists of the lower 2/3 of the reach and was found to be an F gravel stream. Segment B was found to be a B sandy stream with a sub-slope of <2%."

R18-B

"R18-B may have also been straightened in the past. The geomorphic and habitat assessment scores were 0.33 and 0.34 respectively, both "poor" conditions. The dominant adjustment process was [historic] degradation and widening (see Figure 18), with an incision ratio of 1.9 and enrichment ration of 1.6. The segment was found to be in Stage III of evolution and has lost access to its historic floodplain. Evidence of channel avulsion was found on the upper portion of the segment near the confluence with the Stevens Branch. The right riparian corridor was dominated by agricultural crops managed by the Food Works project, and had a buffer from 5-25 feet. An eroding bank approximately 10 feet high and 320 feet long exists on this property. The left riparian corridor consisted of a narrow wooded buffer of <5 to 25 feet. A mobile home sales business is located on the top of the left bank. A river meander is cutting the bottom of the left bank creating some serious instability on the steep slope of the bank."

Figure 18: Typical channel conditions along reach R18-B. Photo credit: Johnson Company

R18-A

"R18-A had undergone a stream type departure from its reference C type stream to the current F type due to historic degradation and the development of Montpelier within the historic river corridor, which has lowered the entrenchment to 1.2 and increased the incision ratio to 1.5. The actual conditions show a highly entrenched stream with a moderate incision ratio (Figure 19). The segment no longer has access to its original floodplain and was found to be in evolution stage II. Historically, it has been channelized as a flood control measure for the City of Montpelier. R18A had a habitat score of 0.44 "fair" and a geomorphic assessment score of 0.30 "poor". Despite the incision, there was relatively no erosion noted in the segment due to the significant amount of rip-rap. The riparian corridor was dominated by commercial development on both sides with a very narrow buffer of < 5 feet on both sides. An old dam located at the upper portion of the segment on a bedrock constriction serves as a grade control. The dam was found to be partially breached and does not impound much more water than the naturally occurring bedrock grade control upon which it is constructed."

Figure 19: Typical channel conditions along reach R18-A. Photo credit: Johnson Company

APPENDIX B

PHASE 2 DATA

Project: Winooski - Montpelier to Cabot — **Phase 2 Segment Summary** — November 13, 2009 SGAT Version: 3

Stream: **Winooski River** Reach # **R18** Segment: **A** Completion Date: **September 22, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez,Sonja** Why Not assessed: Rain: **Yes**

Segment Length (ft): **9,525** Segment Location: **R18-A begins at the bridge on Main Street to ~ 500ft downstream from the Railroad Bridge,**

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

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	2,039	7,101
height	0	0
Railroads	7,277	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,617	4,850

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) **190**

Width Determination **Measured**

Confinement Type **Narrowly**

Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

2.1 Bankfull Width **126**

2.2 Max Depth (ft) **3.90**

2.3 Mean Depth (ft) **3.10**

2.4 Floodprone Width (ft) **155**

Notes:

Historic straightening related with development of downtown Montpelier. Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the segment as a Plane Bed.

Step 2. (Contued)

2.5 Aband. Floodpln **5.90** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **40.55**

2.7 Entrenchment Ratio **1.23**

2.8 Incision Ratio **1.51**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

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

2.12 Substrate Composition

Bedrock	0%
Boulder	4%
Cobble	43%
Coarse Gravel	17%
Fine Gravel	13%
Sand	23%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **5** %

Large Woody **5**

2.13 Average Largest Particle on

Bed **200.0** mm

Bar **60.0** mm

2.14 Stream Type

Stream Type: **F**

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)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	7,776	6,758

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

Bank Canopy	Left	Right
Canopy %	26-50	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	0-25
W less than 25	8,197	7,275

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Commercial
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 **None**

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	9	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	1
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: **9,522**

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: **Winooski River** Reach # **R18** Segment: **A** Completion Date: **September 22,**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez,Sonja** Rain: **Yes**

Segment Length (ft): **9,525** Segment Location: **R18-A begins at the bridge on Main Street to ~ 500ft downstream from the Railroad**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam	Mid-Segment	10.00	5.00		

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Other	155.	Yes	Yes	Yes	Yes
Problem	Deposition Above,Scour Below				
Bridge	153.	Yes	Yes	Yes	Yes
Problem	None				
Bridge	170.	Yes	Yes	No	Yes
Problem	None				
Bridge	170.	Yes	Yes	No	Yes
Problem	None				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**4**	**C to F**	**No**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**7**		**No**
Total Score	**24**		
Geomorphic Rating	**0.3**		

Channel Evolution Model **F**

Channel Evolution Stage **II**

Geomorphic Condition **Poor**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	6
6.2 Embeddedness	11
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	16
6.5 Channel Flow Status	15
6.6 Channel Alteration	3
6.7 Frequency of Riffles/Steps	3
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 3 Right: 4
6.10 Riparian Vegetation Zone Width	Left: 2 Right: 1
Total Score	88
Habitat Rating	0.44

Habitat Stream Condition **Fair**

Narrative:

In terms of channel evolution remains in Stage II because of the encroachment.

Project: Winooski - Montpelier to Cabot
Stream: Winooski River Reach # R18 Segment: B Completion Date: July 24, 2006
Organization: Winooski Conservation District Observers: Noelia Báez Rodríguez, Abbey Why Not assessed: Rain: Yes
Segment Length (ft): 3,131 Segment Location: R18-B begins ~ 500ft downstream from the Railroad Bridge, which runs parallels to Route 2

QC Status - Staff: Provisional Cons Passed

Step 1. Valley and Floodplain

1.1 Segmentation: Channel Dimensions
1.2 Alluvial Fan: None

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,883	407
height	0	0
Railroads	444	0
height	0	0
Improved Paths	0	0
height	0	0
Development	995	327

1.4 Adjacent Side

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

1.5 Valley Features

Valley Width (ft): 500
Width Determination: Measured
Confinement Type: Semi-confined
Rock Gorge?: No
Human-caused Change?: yes

Step 2. Stream Channel

2.1 Bankfull Width	130
2.2 Max Depth (ft)	7.40
2.3 Mean Depth (ft)	5.84
2.4 Floodprone Width (ft)	220

Notes:

Segmentation due to Channel Dimension and Corridor Management options. Food Works segment and irrigation water withdrawal. Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the

Step 2. (Contued)

2.5 Aband. Floodpln	14.24 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	22.29
2.7 Entrenchment Ratio	1.69
2.8 Incision Ratio	1.92
Human Elevated Inc Rat	0.00
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	0 %
Coarse Gravel	15 %
Fine Gravel	15 %
Sand	70 %
Silt and smaller	0 %

Silt/Clay Present?: No
Detritus: 1 %
Large Woody: 8

2.13 Average Largest Particle on

Bed	200.0	mm
Bar	160.0	mm

2.14 Stream Type

Stream Type: B
Bed Material: Sand
Subclass Slope: c
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	Clay
Consistency	Non-cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	241	958
Erosion Height (ft)	25.00	10.42
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,463	1,264

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

Bank Canopy	Left	Right
Canopy %	1-25	26-50

Mid-Channel Canopy: Open

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	0-25	26-50
W less than 25	1,487	812

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Crop
Sub-dominant	Commercial	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	None
4.3 Flow Status	Moderate
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	2	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	1
Diagonal	Delta	Island
0	0	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	1	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: 3,126
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: **Winooski River** Reach # **R18** Segment: **B** Completion Date: **July 24, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Abbey Willard** Rain: **Yes**

Segment Length (ft): **3,131** Segment Location: **R18-B begins ~ 500ft downstream from the Railroad Bridge, which runs parallels 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	144.	Yes	Yes	No	Yes
Problem	None				
Bridge	124.	Yes	Yes	Yes	Yes
Problem	None				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**4**	**C to B**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**6**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Poor**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	6
6.2 Embeddedness	5
6.3 Velocity/Depth Patterns	7
6.4 Sediment Deposition	6
6.5 Channel Flow Status	11
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	5
6.8 Bank Stability	Left: 5 Right: 3
6.9 Bank Vegetation Protection	Left: 4 Right: 3
6.10 Riparian Vegetation Zone Width	Left: 5 Right: 3
Total Score	68
Habitat Rating	0.34

Habitat Stream Condition **Poor**

Narrative:

A midchannel island is enlarging, and its elevation is above bankfull; the island is deflecting flow into the right bank; the stream is overwidening.

Project: **Winooski - Montpelier to Cabot** | **Phase 2 Segment Summary** | | November 13, 2009 | SGAT Version: 3

Stream: **Winooski River** | Reach # **R19** | Segment: **0** | Completion Date: **August 8, 2006**

Organization: **Winooski Conservation District** | Observers: **Noelia Báez Rodríguez, Kelsey** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **4,057** | Segment Location: **R19 starts at the confluences of the Stevens with the Winooski ~100ft downstream from the**

QC Status - Staff: Provisional Cons Passed

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	628	1,485
height	0	0
Railroads	815	0
height	0	0
Improved Paths	0	0
height	0	0
Development	990	2,121

1.4 Adjacent Side

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

1.5 Valley Features

Valley Width (ft) **416**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

2.1 Bankfull Width **112**

2.2 Max Depth (ft) **3.40**

2.3 Mean Depth (ft) **2.50**

2.4 Floodprone Width (ft) **169**

Notes:

The physical characteristic of the cross section indicated an F Stream Type. The entrenchments values calculated in the field have been modified using the adjusting factor of +/- 0.2. This is Semi-confine section characterize by high revetment bank on both

Step 2. (Contued)

2.5 Aband. Floodpln **4.70** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **44.80**

2.7 Entrenchment Ratio **1.51**

2.8 Incision Ratio **1.38**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Eroded**

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

2.12 Substrate Composition

Bedrock	0%
Boulder	39%
Cobble	37%
Coarse Gravel	7%
Fine Gravel	6%
Sand	11%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **1** %

Large Woody **12**

2.13 Average Largest Particle on

Bed	300.0	mm
Bar	160.0	mm

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

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	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)	75	109
Erosion Height (ft)	8.00	10.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,440	2,297

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	0-25
Sub-dominant	0-25	0-25
W less than 25	683	1,954

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Industrial	Industrial
Sub-dominant	Pasture	Commercial
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 **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

(old) Upstrm Flow Reg **Store-release**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	2	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	2
Diagonal	**Delta**	**Island**
2	0	2

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: **2,076**

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: **Winooski River** Reach # **R19** Segment: **0** Completion Date: **August 8, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Kelsey** Rain: **Yes**

Segment Length (ft): **4,057** Segment Location: **R19 starts at the confluences of the Stevens with the Winooski ~100ft downstream**

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	110.	Yes	Yes	Yes	No
Problem	Deposition Below,Scour Below				
Bridge	108.	Yes	Yes	No	Yes
Problem	Deposition Above				
Bridge	114.	Yes	Yes	No	Yes
Problem	Deposition Above,Deposition Below,Scour				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**C to F**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Poor**
Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	12
6.2 Embeddedness	11
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	11
6.5 Channel Flow Status	13
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	5
6.8 Bank Stability	Left: 7 Right: 6
6.9 Bank Vegetation Protection	Left: 4 Right: 2
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 2
Total Score	95
Habitat Rating	0.475

Habitat Stream Condition **Fair**

Narrative:

Active widening evidently by failure rip-rap and bank of erosion. Some degradation on the lower section evidently by bar with steep faces and deep pool.

Project: **Winooski - Montpelier to Cabot** | **Phase 2 Segment Summary** | | November 13, 2009 | SGAT Version: 3

Stream: **Winooski River** | Reach # **R21** | Segment: **A** | Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** | Observers: **Michael Blazewicz** | Why Not assessed: **impounded** | Rain: **Yes**

Segment Length (ft): **900** | Segment Location: **Upstream from an old concrete dam (no longer in use) to the west of Route 2 in East**

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	867	0
height	30	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	Extremely	Very Steep
Continuous w/	Always	Sometimes
W/in 1 Bankfill	Always	Always
Texture	Not Evalua	Not Evalua

1.5 Valley Features

- Valley Width (ft) **240**
- Width Determination **Estimated**
- 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:

Segment only partially assessed due to the impact of the concrete dam on the sediment transport of the Winooski. The dam reduces water surface slope and changes the channel bottom from cobble/gravel to sand/silt. Dam is no longer in use. Tributary on right bank

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? **No**
- Detritus **50** %
- # Large Woody **12**

2.13 Average Largest Particle on

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

2.14 Stream Type

- Stream Type:
- Bed Material:
- Subclass Slope:
- Bed Form:
- 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)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	896	0

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

Bank Canopy	Left	Right
Canopy %	1-25	26-50
Mid-Channel Canopy	Open	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	>100
Sub-dominant	26-50	None
W less than 25	162	0

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Forest
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 **Moderate**
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type
  - Flow Regulation Use
  - Impoundments **Small**
  - Impoundmt. Location **In Reach**
- 4.6 Up/Down strm flow reg **Down Stream**
  - (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: **865**
- 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: **Winooski - Montpelier to Cabot** **Phase 2 Reach Summary** November 13, 2009

Stream: **Winooski River** Reach # **R21** Segment: **A** Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **900** Segment Location: **Upstream from an old concrete dam (no longer in use) to the west of Route 2 in East**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam		8.00	5.00		

4.8 Channel Constrictions

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

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

Habitat Stream Condition

Project: **Winooski - Montpelier to Cabot** — **Phase 2 Segment Summary** November 13, 2009 SGAT Version: 3

Stream: **Winooski River** Reach # **R21** Segment: **B** Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Why Not assessed: Rain: **Yes**

Segment Length (ft): **3,737** Segment Location: **From 900 feet upstream from the old concrete dam on the north side of Route 2 to the reach**

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	3,390	0
height	30	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	Extremely	Hilly
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Always	Sometimes
Texture	Not Evalua	Mixed

1.5 Valley Features

Valley Width (ft)	315
Width Determination	Estimated
Confinement Type	Semi-confined
Rock Gorge?	No
Human-caused Change?	Yes

Step 2. Stream Channel

2.1 Bankfull Width	115
2.2 Max Depth (ft)	8.90
2.3 Mean Depth (ft)	6.56
2.4 Floodprone Width (ft)	148

Notes:

Reach is characterized by a fairly straight channel. Significant rip rap on left bank (concrete and quarried stone) that was likely put in place to protect the historic route 2 road bed. Large boulders in stream channel. Fairly narrow valley with agriculture on the

Step 2. (Contued)

2.5 Aband. Floodpln	17.80 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	17.53
2.7 Entrenchment Ratio	1.29
2.8 Incision Ratio	2.00
Human Elevated Inc Rat	0.00
2.9 Sinuosity	Low
2.10 Riffles Type	Not Applicable
2.11 Riffle/Step Spacing (ft)	0

2.12 Substrate Composition

Bedrock	0 %
Boulder	33 %
Cobble	22 %
Coarse Gravel	13 %
Fine Gravel	17 %
Sand	15 %
Silt and smaller	0 %

Silt/Clay Present?	Yes
Detritus	1 %
# Large Woody	44

2.13 Average Largest Particle on

Bed	12.0	inches
Bar	4.0	inches

2.14 Stream Type

Stream Type:	F
Bed Material:	Cobble
Subclass Slope:	c
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)	42	425
Erosion Height (ft)	5.00	5.69
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	2,452	0

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

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

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	26-50
Sub-dominant	26-50	>100
W less than 25	0	930

Buffer Veg. Type	Left	Right
Dominant	Invasives	Shrubs/Saplin
Sub-dominant	Shrubs/Saplin	Mixed Trees

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Shrubs/Saplin	Crop
Sub-dominant	Commercial	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	None
4.3 Flow Status	Moderate
4.4 # of Debris Jams	0
4.5 Flow Regulation Type	
Flow Regulation Use	
Impoundments	None
Impoundmt. Location	
4.6 Up/Down strm flow reg	Down Stream
(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	1	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	Yes

5.4 Stream Ford or Animal	No
5.5 Straightening	Straightening
Straightening Length:	3,182
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: **Winooski River** Reach # **R21** Segment: **B** Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **3,737** Segment Location: **From 900 feet upstream from the old concrete dam on the north side of Route 2 to the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions **None**

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

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Plane Bed**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**B to F**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**16**		**No**
Total Score	**49**		
Geomorphic Rating	**0.6125**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	11
6.2 Embeddedness	13
6.3 Velocity/Depth Patterns	10
6.4 Sediment Deposition	11
6.5 Channel Flow Status	11
6.6 Channel Alteration	9
6.7 Frequency of Riffles/Steps	10
6.8 Bank Stability	Left: 8 Right: 6
6.9 Bank Vegetation Protection	Left: 6 Right: 6
6.10 Riparian Vegetation Zone Width	Left: 6 Right: 4
Total Score	111
Habitat Rating	0.555
Habitat Stream Condition	**Fair**

Narrative:

Channel incised historically - dam at downstream end of reach may have affected this upper portion, but in general it appears that this a B type stream in a naturally semi-confined valley that has been confined by road and has incised and is widening

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: **Winooski River** Reach # **R22** Segment: **A** Completion Date: **September 8, 2006**

Organization: **Winooski Conservation District** Observers: **Dan Smith, Noelia Báez** Why Not assessed: Rain: **Yes**

Segment Length (ft): **4,753** Segment Location: **R22-A start where the river bends away from Route 2, ~ 1500ft downstream from the**

QC Status - Staff: Provisional Cons Passed

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	3,829	555
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	1,572	144

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) **400**
- Width Determination **Measured**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

2.1 Bankfull Width	92
2.2 Max Depth (ft)	3.60
2.3 Mean Depth (ft)	3.00
2.4 Floodprone Width (ft)	110

Notes:

Historic straightening mainly related with Route 2.
Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the segment as a Plane Bed.

Step 2. (Contued)

2.5 Aband. Floodpln	7.20 ft.
Human Elev Floodpln	0.00 ft.
2.6 Width/Depth Ratio	30.80
2.7 Entrenchment Ratio	1.19
2.8 Incision Ratio	2.00
Human Elevated Inc Rat	0.00
2.9 Sinuosity	Low
2.10 Riffles Type	Eroded
2.11 Riffle/Step Spacing (ft)	0

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	2 %
Fine Gravel	8 %
Sand	90 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**

Detritus **10** %

Large Woody **19**

2.13 Average Largest Particle on

- Bed **33.0** mm
- Bar **2.0** mm

2.14 Stream Type

- Stream Type: **F**
- 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	One	40.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

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

Bank Erosion	Left	Right
Erosion Length (ft)	1,010	1,343
Erosion Height (ft)	7.70	8.10
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,859	798

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

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	0-25
W less than 25	2,920	2,690

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	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	None
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	
(old) Upstrm Flow Reg	None

4.7 StormwaterInputs

Field Ditch	1	Road Ditch	0
Other	4	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	4	2
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: **1,875**

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: **Winooski River** Reach # **R22** Segment: **A** Completion Date: **September 8,**
Organization: **Winooski Conservation District** Observers: **Dan Smith, Noelia Báez Rodríguez** Rain: **Yes**
Segment Length (ft): **4,753** Segment Location: **R22-A start where the river bends away from Route 2, ~ 1500ft downstream from 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	108.	Yes	Yes	No	Yes
Problem	Deposition Above,Scour Above,Scour				
Bridge	135.	Yes	Yes	No	Yes
Problem	Scour Above,Scour Below				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**6**		**No**
7.4 Change in Planform	**10**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Poor**
Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	4
6.2 Embeddedness	3
6.3 Velocity/Depth Patterns	5
6.4 Sediment Deposition	6
6.5 Channel Flow Status	13
6.6 Channel Alteration	4
6.7 Frequency of Riffles/Steps	1
6.8 Bank Stability	Left: 3 Right: 3
6.9 Bank Vegetation Protection	Left: 2 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 1 Right: 3
Total Score	53
Habitat Rating	0.265

Habitat Stream Condition **Poor**

Narrative:
Active widening and degradation process evidently by steep and vertical banks of erosion and the developed of new terraces.

Project: **Winooski - Montpelier to Cabot** | **Phase 2 Segment Summary** | November 13, 2009 SGAT Version: 3

Stream: **Winooski River** | Reach # **R22** | Segment: **B** | Completion Date: **September 7, 2006**

Organization: **Winooski Conservation District** | Observers: **Dan Smith, Noelia Báez** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **5,495** | Segment Location: **R22-B starts ~ 300ft upstream of the concrete bridge along Route 2 and ends ~100ft**

QC Status - Staff: **Passed** Cons **Passed**

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	4,462	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,479	1

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

1.5 Valley Features

Valley Width (ft) **485**

Width Determination **Measured**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

2.1 Bankfull Width **85**

2.2 Max Depth (ft) **3.80**

2.3 Mean Depth (ft) **3.00**

2.4 Floodprone Width (ft) **101**

Notes:

The physical characteristic of the cross section indicated an F Stream Type. The entrenchments values calculated in the field have been modified using the adjusting factor of +/- 0.2. The Riffles have been partially eroded but you can still get some riffles

Step 2. (Contued)

2.5 Aband. Floodpln **7.80** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **28.40**

2.7 Entrenchment Ratio **1.19**

2.8 Incision Ratio **2.05**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **1,400**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	10 %
Coarse Gravel	42 %
Fine Gravel	16 %
Sand	32 %
Silt and smaller	0 %

Silt/Clay Present? **No**

Detritus **15** %

Large Woody **50**

2.13 Average Largest Particle on

Bed **136.0** mm

Bar **160.0** mm

2.14 Stream Type

Stream Type: **F**

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	One	25.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

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

Bank Erosion	Left	Right
Erosion Length (ft)	411	303
Erosion Height (ft)	9.03	7.20
Revetmt. Type	None	Rip-Rap
Revetmt. Length (ft)	0	2,196

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

Bank Canopy	Left	Right
Canopy %	26-50	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	0-25
Sub-dominant	51-100	None
W less than 25	982	4,375

Buffer Veg. Type	Left	Right
Dominant	Mixed Trees	Herbaceous
Sub-dominant	Coniferous	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Hay
Sub-dominant	Shrubs/Saplin	Commercial
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 **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

(old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	5	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	4
Diagonal	Delta	Island
1	3	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
3	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: **3,237**

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:	**Winooski - Montpelier to Cabot**		**Phase 2 Reach Summary**	page 2 of 2	November 13, 2009
Stream:	**Winooski River**	Reach #	**R22**	Segment: **B**	Completion Date: **September 7,**
Organization:	**Winooski Conservation District**	Observers:	**Dan Smith, Noelia Báez Rodríguez**		Rain: **Yes**
Segment Length (ft):	**5,495**	Segment Location:	**R22-B starts ~ 300ft upstream of the concrete bridge along Route 2 and ends ~100ft**		

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions **None**

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

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**10**	**None**	**No**
7.3 Widening Channel	**8**		**No**
7.4 Change in Planform	**13**		**No**
Total Score	**34**		
Geomorphic Rating	**0.425**		

Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	7
6.2 Embeddedness	5
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	6
6.5 Channel Flow Status	12
6.6 Channel Alteration	7
6.7 Frequency of Riffles/Steps	8
6.8 Bank Stability	Left: 5 Right: 6
6.9 Bank Vegetation Protection	Left: 9 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 9 Right: 3
Total Score	90
Habitat Rating	0.45

Habitat Stream Condition **Fair**

Narrative:
Active degradation and widening in some areas evidently by banks of erosion, some aggradations at the mouth of the tributary Mallory Brook.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R23 Segment: 0 Completion Date: July 24, 2009

Organization: Winooski Conservation District Observers: Michael Blazewicz Why Not assessed: Rain: Yes

Segment Length (ft): 14,945 Segment Location: From upstream of the Route 2 bridge in East Montpelier to just downstream of the Route 14

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	3,657	338
height	21	30
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,324	847

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

1.5 Valley Features

Valley Width (ft) **1,000**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **128**

2.2 Max Depth (ft) **5.90**

2.3 Mean Depth (ft) **4.37**

2.4 Floodprone Width (ft) **223**

Step 2. (Contued)

2.5 Aband. Floodpln **9.90** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **29.29**

2.7 Entrenchment Ratio **1.74**

2.8 Incision Ratio **1.68**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **5,800**

2.12 Substrate Composition

Bedrock	0 %
Boulder	15 %
Cobble	40 %
Coarse Gravel	25 %
Fine Gravel	10 %
Sand	10 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**

Detritus **5** %

Large Woody **123**

2.13 Average Largest Particle on

Bed **8.0** inches

Bar **4.0** inches

2.14 Stream Type

Stream Type: **B**

Bed Material: **Gravel**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	Multiple	43.00
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)	1,777	1,872
Erosion Height (ft)	9.28	9.80
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	439	1,676

Near Bank Veg. Type	Left	Right
Dominant	Invasives	Invasives
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	0-25	0-25
Sub-dominant	>100	26-50
W less than 25	7,316	9,227

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Commercial
Sub-dominant	Forest	Crop
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

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	2	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	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	Yes

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **7,954**

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.

Notes:

Pebble count was conducted in a riffle that had larger material than was typical throughout reach therefore I listed this as a B4c channel since gravel was the dominant substrate. In the long stretches between riffles there was plenty of sand in the channel

Stream: **Winooski River** Reach # **R23** Segment: **0** Completion Date: **July 24, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **14,945** Segment Location: **From upstream of the Route 2 bridge in East Montpelier to just downstream 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?
Bridge	121.	Yes	Yes	Yes	Yes
Problem	None				
Bridge	126.	Yes	Yes	Yes	Yes
Problem	Deposition Above,Deposition Below				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**E to B**	**Yes**
7.2 Channel Aggradation	**11**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**9**		**No**
Total Score	**30**		
Geomorphic Rating	**0.375**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

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	13
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	9
6.5 Channel Flow Status	13
6.6 Channel Alteration	8
6.7 Frequency of Riffles/Steps	5
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: 2
Total Score	100
Habitat Rating	0.5

Habitat Stream Condition **Fair**

Narrative:

E channel has incised and widened. Erosion on outside bends triggering major sloughing and mass failures indicates planform adjustment. Small juvenile benches on the inside of some bends, much of floodplain is unavailable during bankfull flows.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R24 Segment: 0 Completion Date: July 21, 2009

Organization: Winooski Conservation District Observers: Michael Blazewicz Why Not assessed: Rain: Yes

Segment Length (ft): 5,811 Segment Location: From the confluence of the Kingsbury branch near the Cate Farm downstream to several

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	862	0
height	10	0
Roads	1,366	0
height	12	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	364	0

1.4 Adjacent Side

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

1.5 Valley Features

Valley Width (ft) **378**

Width Determination **Estimated**

Confinement Type **Narrow**

Rock Gorge? **No**

Human-caused Change? **No**

Step 2. Stream Channel

2.1 Bankfull Width **75**

2.2 Max Depth (ft) **7.60**

2.3 Mean Depth (ft) **6.50**

2.4 Floodprone Width (ft) **600**

Notes:

Interesting very straight reach that is possibly in a narrow valley by reference but is also appears to be an E type channel by reference. Gravel mine on left bank may have been excavated from an existing hill, or may have been excavated in a wide

Step 2. (Contued)

2.5 Aband. Floodpln **9.10** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **11.54**

2.7 Entrenchment Ratio **8.00**

2.8 Incision Ratio **1.20**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Eroded**

2.11 Riffle/Step Spacing (ft) **3,000**

2.12 Substrate Composition

Bedrock	0%
Boulder	11%
Cobble	19%
Coarse Gravel	34%
Fine Gravel	20%
Sand	12%
Silt and smaller	4%

Silt/Clay Present? **No**

Detritus **2** %

Large Woody **65**

2.13 Average Largest Particle on

Bed	4.0	inches
Bar	N/A	inches

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	One	30.00
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	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	850	1,481
Erosion Height (ft)	6.71	7.22
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	309	547

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	26-50	>100
Sub-dominant	0-25	0-25
W less than 25	3,624	2,192

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

3.3 Riparian Corridor

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

4.3 Flow Status **Low**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

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	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	1
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: **2,140**

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: **Winooski River** Reach # **R24** Segment: **0** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **5,811** Segment Location: **From the confluence of the Kingsbury branch near the Cate Farm downstream 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	60.0	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	**11**	**None**	**Yes**
7.2 Channel Aggradation	**14**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planform	**14**		**No**
Total Score	**50**		
Geomorphic Rating	**0.625**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	9
6.2 Embeddedness	12
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	13
6.5 Channel Flow Status	13
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	1
6.8 Bank Stability	Left: 7 Right: 6
6.9 Bank Vegetation Protection	Left: 4 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 6
Total Score	93
Habitat Rating	0.465

Habitat Stream Condition **Fair**

Narrative:

Stream appears straightened from a naturally fairly straight channel. Some floodplain access on the right and left banks has been lost from road building and berming near the gravel mine. Sediment transport high naturally, storage now more limited.

Stream: Winooski River | Reach # R25 | Segment: 0 | Completion Date: August 31, 2006

Organization: Winooski Conservation District | Observers: Noelia Báez Rodríguez, Ann | Why Not assessed: | Rain: Yes

Segment Length (ft): 11,971 | Segment Location: 0.12 miles southeast of the Cate Farm/ Route 2 intersection

QC Status - Staff: Provisional Cons Passed

Step 1. Valley and Floodplain

1.1 Segmentation None

1.2 Alluvial Fan None

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	322	0
height	0	0
Roads	2,382	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	570	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) 810

Width Determination Estimated

Confinement Type Very Broad

Rock Gorge? No

Human-caused Change? no

Step 2. Stream Channel

2.1 Bankfull Width 60

2.2 Max Depth (ft) 3.90

2.3 Mean Depth (ft) 2.70

2.4 Floodprone Width (ft) 935

Notes:

Multiple mass failures and extensive bank erosion. The landuse is mostly agricultural.

Reach revisited by GGA and SNP 10/21/09. Reach is aggradational, especially in the viscinity of the large mass failures just

Step 2. (Contued)

2.5 Aband. Floodpln 5.20 ft.

Human Elev Floodpln 0.00 ft.

2.6 Width/Depth Ratio 22.15

2.7 Entrenchment Ratio 15.63

2.8 Incision Ratio 1.33

Human Elevated Inc Rat 0.00

2.9 Sinuosity High

2.10 Riffles Type Complete

2.11 Riffle/Step Spacing (ft) N/A

2.12 Substrate Composition

Bedrock	0%
Boulder	1%
Cobble	38%
Coarse Gravel	28%
Fine Gravel	8%
Sand	25%
Silt and smaller	0%

Silt/Clay Present? Yes

Detritus 5 %

Large Woody 75

2.13 Average Largest Particle on

Bed 160.0 mm

Bar 20.0 mm

2.14 Stream Type

Stream Type: C

Bed Material: Gravel

Subclass Slope: None

Bed Form: Riffle-Pool

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	Multiple	46.33
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	Mix	Mix
Consistency	Non-cohesive	Non-cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	3,703	2,423
Erosion Height (ft)	9.89	8.70
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,886	1,534

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

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	0-25	0-25
W less than 25	2,974	1,489

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Hay	Forest
Sub-dominant	Forest	Crop
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps Abundant

4.2 Adjacent Wetlands 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	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
8	18	6
Diagonal	Delta	Island
2	0	3

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
3	3	1	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	1	Yes

5.4 Stream Ford or Animal No

5.5 Straightening Straightening

Straightening Length: 4,388

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: **Winooski River** Reach # **R25** Segment: **0** Completion Date: **August 31, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Ann Smith** Rain: **Yes**

Segment Length (ft): **11,971** Segment Location: **0.12 miles southeast of the Cate Farm/ Route 2 intersection**

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	90.0	Yes	Yes	No	Yes
Problem	Deposition Below				
Old	51.0	Yes	Yes	Yes	No
Problem	Deposition Above,Deposition Below				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**9**	**Other**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**10**		**No**
7.4 Change in Planform	**4**		**No**
Total Score	**29**		
Geomorphic Rating	**0.3625**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	8
6.2 Embeddedness	10
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	6
6.5 Channel Flow Status	8
6.6 Channel Alteration	11
6.7 Frequency of Riffles/Steps	16
6.8 Bank Stability	Left: 1 Right: 2
6.9 Bank Vegetation Protection	Left: 1 Right: 2
6.10 Riparian Vegetation Zone Width	Left: 2 Right: 2
Total Score	82
Habitat Rating	0.41

Habitat Stream Condition **Fair**

Narrative:

Planform adjustment evidently by high sinousity and flood chutes. Reach revisited 10/21/09 by GGA and SNP. Previous comments regarding degradation as an active process were removed. Active processes appear to be widening and planform change.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River | Reach # R26 | Segment: 0 | Completion Date: July 27, 2009

Organization: Winooski Conservation District | Observers: Michael Blazewicz | Why Not assessed: | Rain: Yes

Segment Length (ft): 6,221 | Segment Location: Flows from just downstream of the dam in Plainfield Village to about 3500 feet upstream 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	3,556	23
height	22	20
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	1,642	39

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

1.5 Valley Features

Valley Width (ft) 880

Width Determination Measured

Confinement Type Broad

Rock Gorge? No

Human-caused Change? Yes

Step 2. Stream Channel

2.1 Bankfull Width 95

2.2 Max Depth (ft) 6.00

2.3 Mean Depth (ft) 4.84

2.4 Floodprone Width (ft) 224

Notes:

Trib rejuv checked for Great Brook. Fisherman described the channel undergoing major adjustment during a 1980 flood. Despite this, reach is still very popular for fishing due to habitat afforded by the high sinuosity. Pebble count indicated cobble

Step 2. (Contued)

2.5 Aband. Floodpln 9.10 ft.

Human Elev Floodpln 0.00 ft.

2.6 Width/Depth Ratio 19.63

2.7 Entrenchment Ratio 2.36

2.8 Incision Ratio 1.52

Human Elevated Inc Rat 0.00

2.9 Sinuosity High

2.10 Riffles Type Complete

2.11 Riffle/Step Spacing (ft) 700

2.12 Substrate Composition

Bedrock	0%
Boulder	19%
Cobble	40%
Coarse Gravel	27%
Fine Gravel	13%
Sand	1%
Silt and smaller	0%

Silt/Clay Present? No

Detritus 1 %

Large Woody 159

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	Multiple	70.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope Steep

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

Bank Erosion	Left	Right
Erosion Length (ft)	252	570
Erosion Height (ft)	5.29	5.28
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,353	698

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	26-50	>100
Sub-dominant	0-25	51-100
W less than 25	2,259	0

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Residential	Residential
Sub-dominant	Forest	Crop
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

Flow Regulation Use

Impoundments Small

Impoundmt. Location Upstream

4.6 Up/Down strm flow reg Up Stream

(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
2	4	2
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	Yes

5.4 Stream Ford or Animal No

5.5 Straightening Straightening

Straightening Length: 1,789

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: **Winooski - Montpelier to Cabot** | **Phase 2 Reach Summary** | November 13, 2009

Stream: **Winooski River** | Reach # **R26** | Segment: **0** | Completion Date: **July 27, 2009**

Organization: **Winooski Conservation District** | Observers: **Michael Blazewicz** | Rain: **Yes**

Segment Length (ft): **6,221** | Segment Location: **Flows from just downstream of the dam in Plainfield Village to about 3500 feet**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions **None**

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

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	**14**		**No**
7.4 Change in Planform	**8**		**No**
Total Score	**45**		
Geomorphic Rating	**0.5625**		

Channel Evolution Model **F**

Channel Evolution Stage **IV**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	16
6.2 Embeddedness	15
6.3 Velocity/Depth Patterns	18
6.4 Sediment Deposition	15
6.5 Channel Flow Status	13
6.6 Channel Alteration	9
6.7 Frequency of Riffles/Steps	15
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 5 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 7
Total Score	138
Habitat Rating	0.69
Habitat Stream Condition	**Good**

Narrative:

Historic degradation. Stream reacted to flood in 1980 and adjusted significantly in this reach. Current planform adjustment with aggradation and widening. Pebble count indicated cobble due to dam?, gravel dom. ref, sensitivity should be ranked VH

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R27 Segment: A Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Why Not assessed: **impounded** Rain: **No**

Segment Length (ft): **1,780** Segment Location: **From just downstream of the Plainfield Dam to 1500 feet upstream of the dam where the**

QC Status - Staff: Provisional Cons

Step 1. Valley and Floodplain

1.1 Segmentation **Other Reason**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	1,460
height	0	20
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	1,652

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

1.5 Valley Features

Valley Width (ft) **275**

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:

Partial assessment due to Plainfield Dam. Lower 280 feet of reach is a high gradient channel that should have been included as part of reach r26.

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:

Bed Material:

Subclass Slope:

Bed Form:

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	Sand	Sand
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	549	439

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Herbaceous
Sub-dominant	Herbaceous	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	0-25
Sub-dominant	None	None
W less than 25	1,011	1,524

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Residential	Residential
Sub-dominant	Commercial	Commercial
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

Flow Regulation Use

Impoundments **Small**

Impoundmt. Location **In Reach**

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

(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	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: **1,516**

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: **Winooski River** Reach # **R27** Segment: **A** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **No**

Segment Length (ft): **1,780** Segment Location: **From just downstream of the Plainfield Dam to 1500 feet upstream of the dam where**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken
Dam		17.00	14.00		

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	55.0	Yes	Yes	Yes	Yes

Problem Scour Below

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Narrative:

Project: Winooski - Montpelier to Cabot | **Phase 2 Segment Summary** | | November 13, 2009 | SGAT Version: 3

Stream: **Winooski River** | Reach # **R27** | Segment: **B** | Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** | Observers: **Michael Blazewicz** | Why Not assessed: | Rain: **No**

Segment Length (ft): **2,700** | Segment Location: **From the John Fowler Road Bridge in Marshfield downstream to 1500 feet above the**

QC Status - Staff: Provisional Cons Provisional

Step 1. Valley and Floodplain

1.1 Segmentation **Other Reason**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,809	0
height	20	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	917	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Never	Never
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 **80**

2.2 Max Depth (ft) **7.60**

2.3 Mean Depth (ft) **6.04**

2.4 Floodprone Width (ft) **600**

Notes:

Reach with very low slope. Meanders are almost non existent and it is likely that there was extensive straightening on this reach. Because slope is low and energy does not exist to create many new meanders (my estimation) the healthy and long term water

Step 2. (Contued)

2.5 Aband. Floodpln **7.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **13.25**

2.7 Entrenchment Ratio **7.50**

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) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	0%
Coarse Gravel	5%
Fine Gravel	30%
Sand	60%
Silt and smaller	5%

Silt/Clay Present? **No**

Detritus **5** %

Large Woody **15**

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	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	115	205
Erosion Height (ft)	4.00	4.59
Revetmt. Type	Multiple	Rip-Rap
Revetmt. Length (ft)	95	175

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
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	>100	0-25
Sub-dominant	0-25	26-50
W less than 25	0	2,219

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Residential
Sub-dominant	Hay	Commercial
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **Down Stream**

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

4.7 StormwaterInputs

Field Ditch	1	Road Ditch	0
Other	1	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: **2,507**

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: **Winooski River** Reach # **R27** Segment: **B** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **No**

Segment Length (ft): **2,700** Segment Location: **From the John Fowler Road Bridge in Marshfield downstream to 1500 feet above the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions **None**

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

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	**11**		**No**
7.4 Change in Planform	**17**		**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	10
6.2 Pool Substrate	10
6.3 Pool Variability	5
6.4 Sediment Deposition	13
6.5 Channel Flow Status	16
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: 2
6.10 Riparian Vegetation Zone Width	Left: 3 Right: 1
Total Score	92
Habitat Rating	0.46
Habitat Stream Condition	**Fair**

Narrative:

E channel that has been overwidened. Riparian buffer has been impacted by agriculture and channel has been extensively straightened historically. Some old riprap, some new, some recent erosion overall channel appears stable. Limited habitat.

APPENDIX C

STRESSOR IDENTIFICATION MAPS

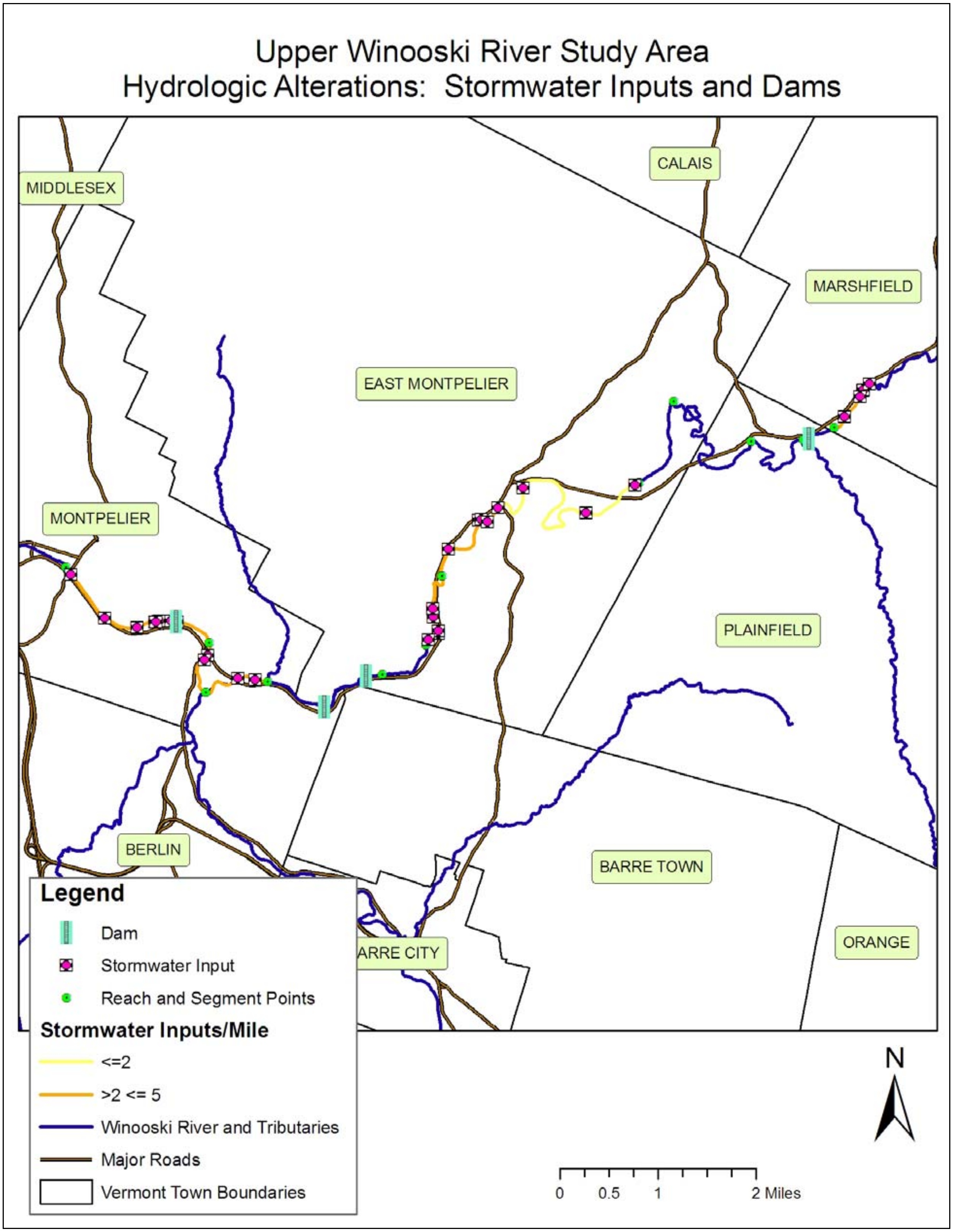


Figure 1: Stormwater Inputs and Dam Location: Upper Winooski River Study Area (M18-M27)

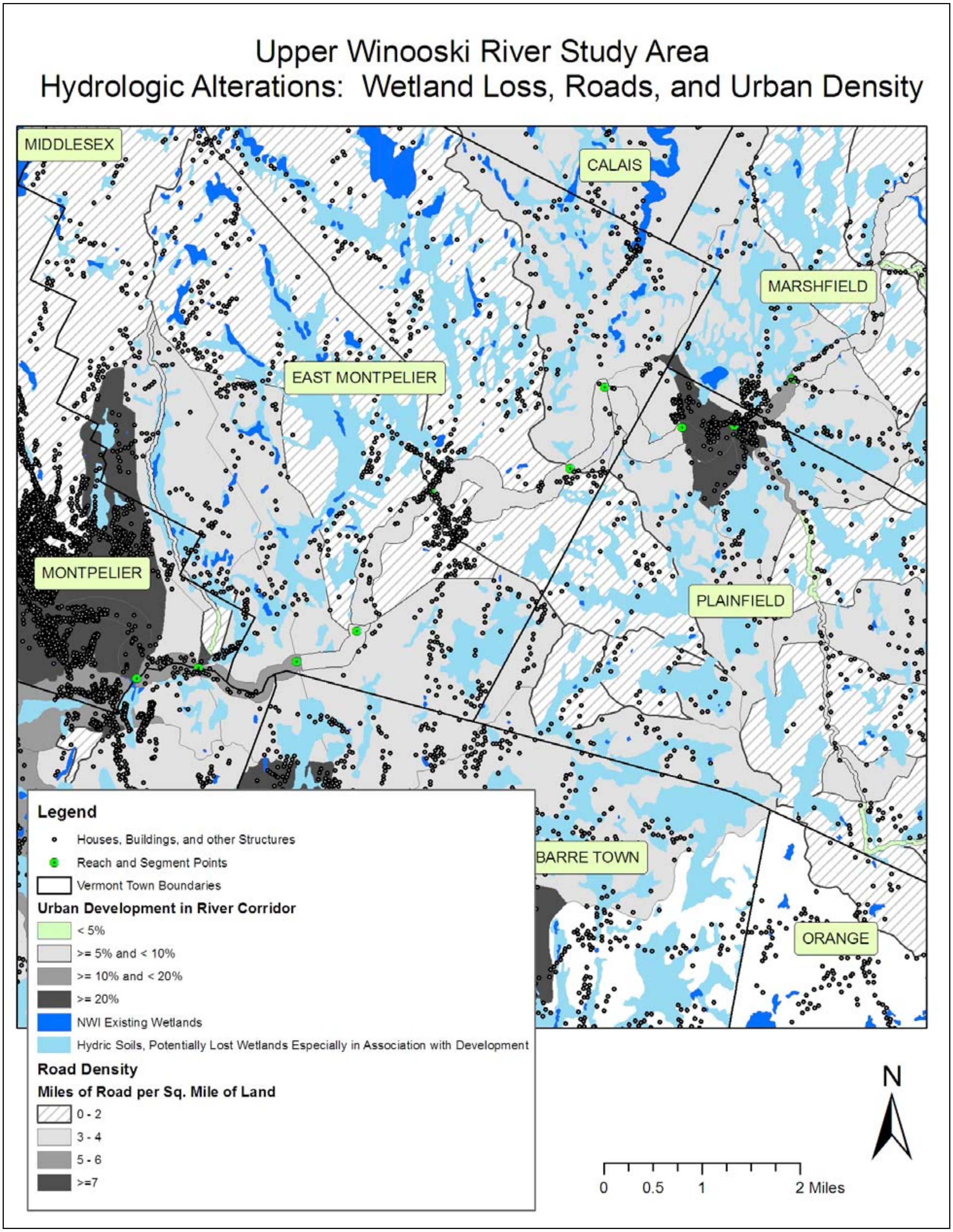


Figure 2: Potential Wetland Loss, Density of Roads and Urban Development: Upper Winooski River Study Area (M18-M27)

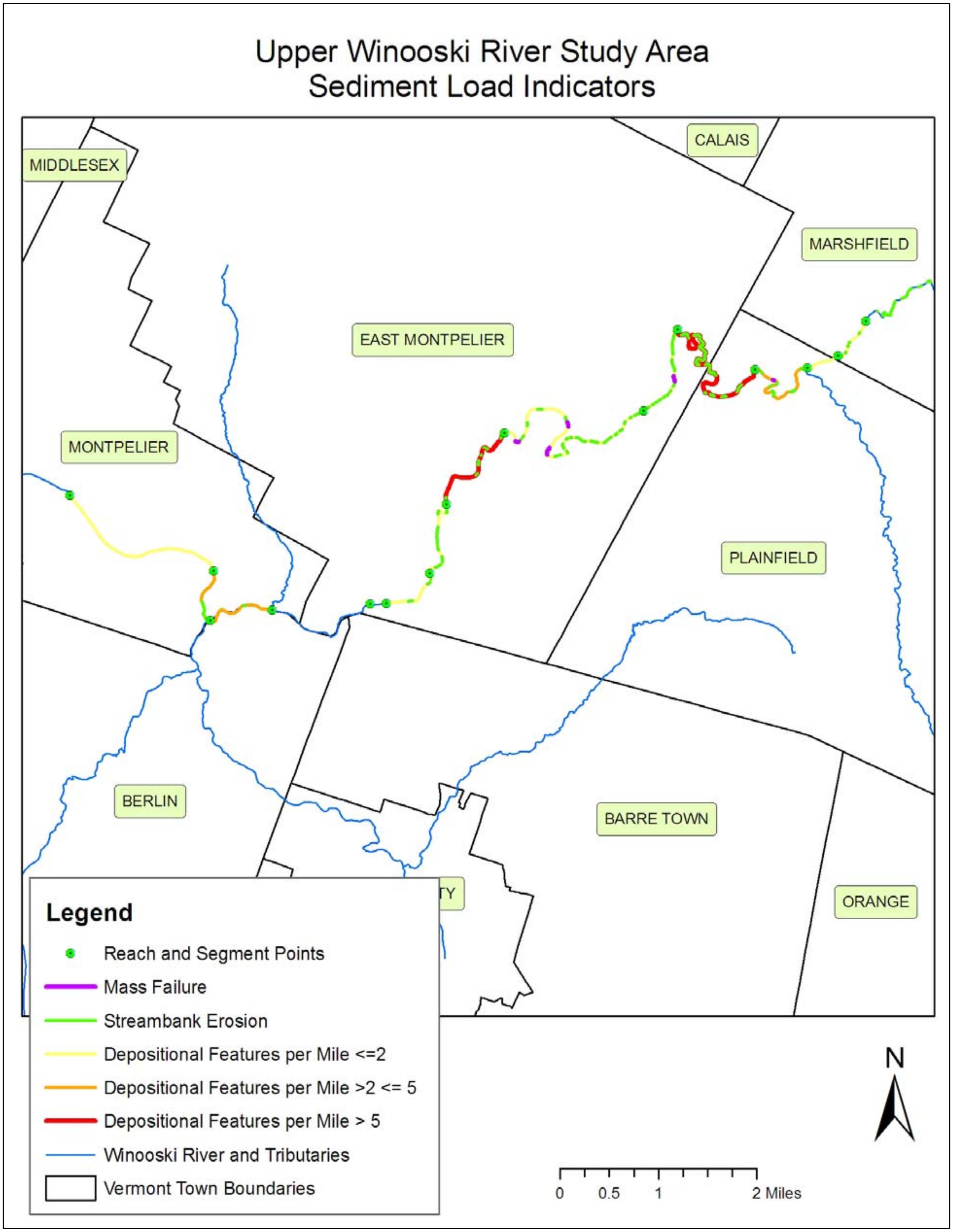


Figure 3: Sediment Inputs to the Upper Winooski River Study Area (M18-M27)

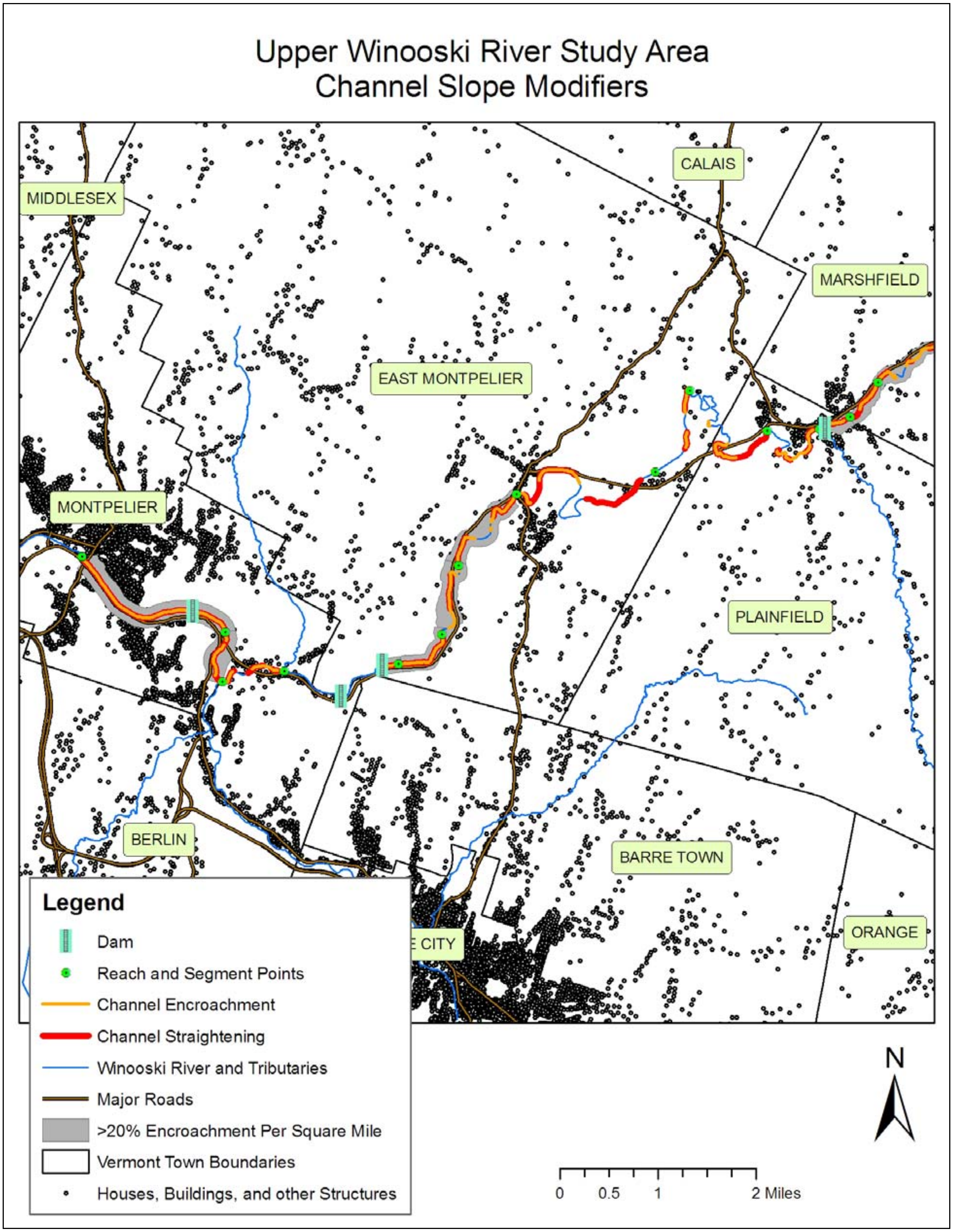


Figure 4: Channel Slope Modifiers of the Upper Winooski River Study Area (M18-M27)

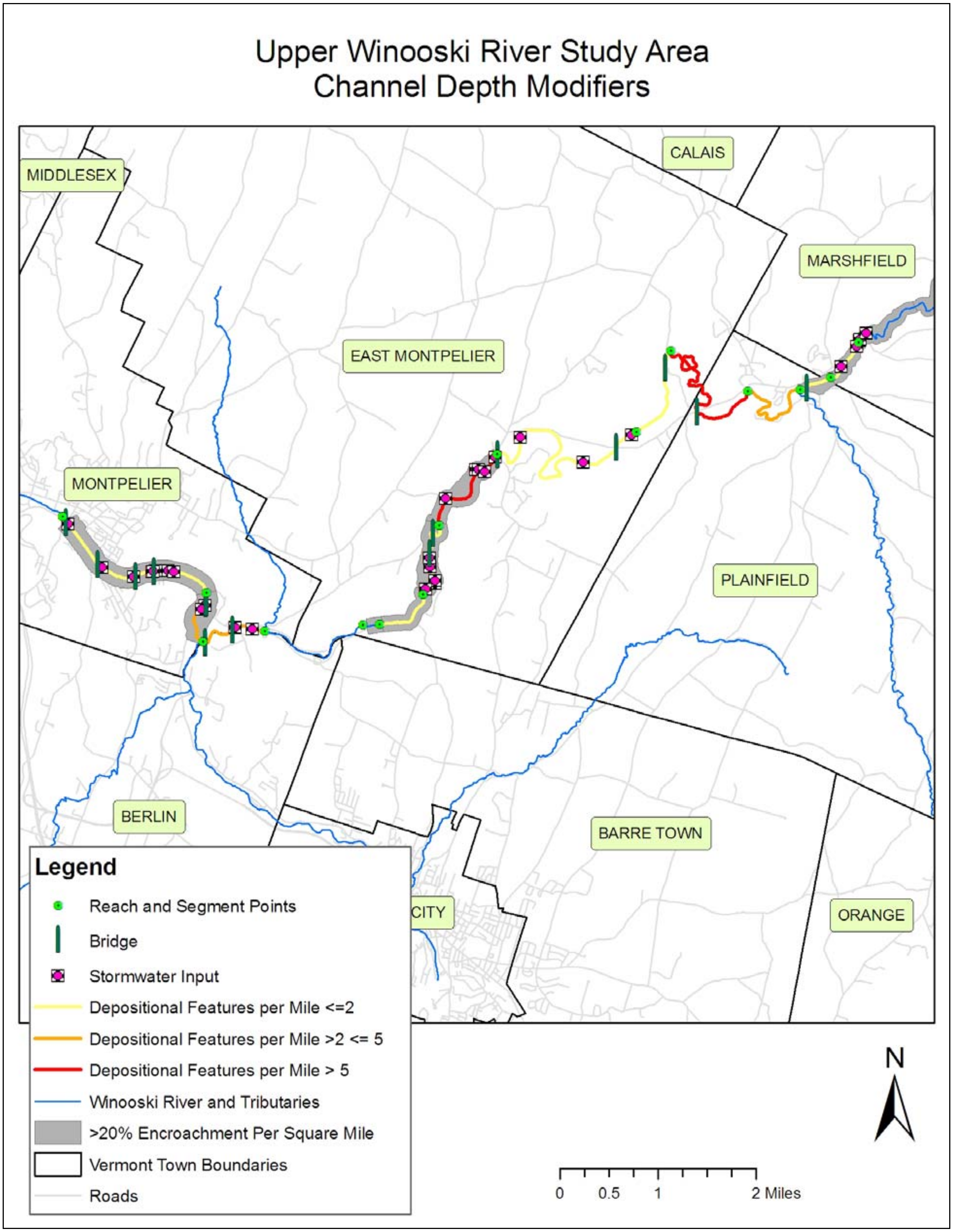


Figure 5: Channel Depth Modifiers of the Upper Winooski River Study Area (M18-M27)

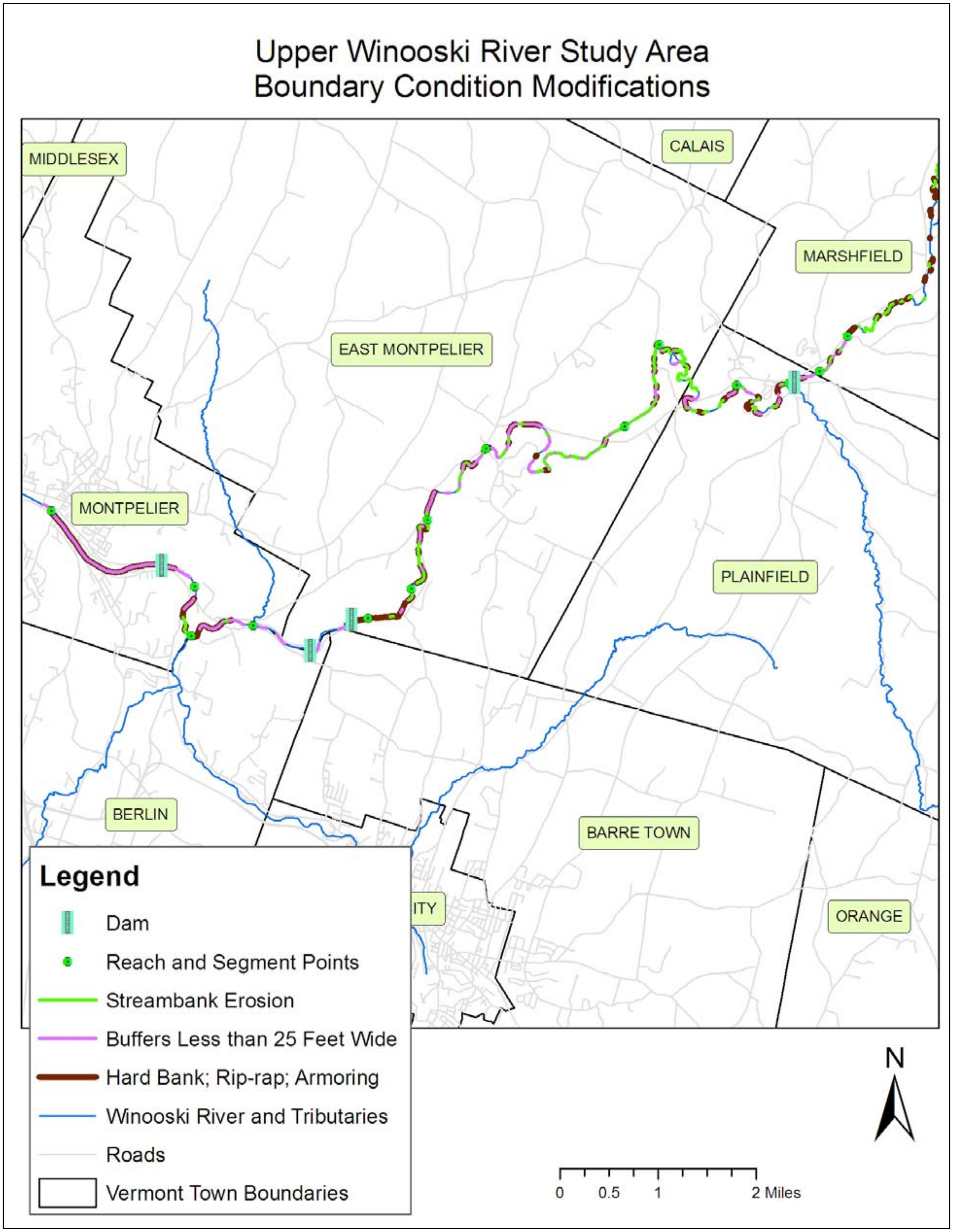


Figure 6: Boundary Condition Modifiers of the Upper Winooski River Study Area (M18-M27)

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.

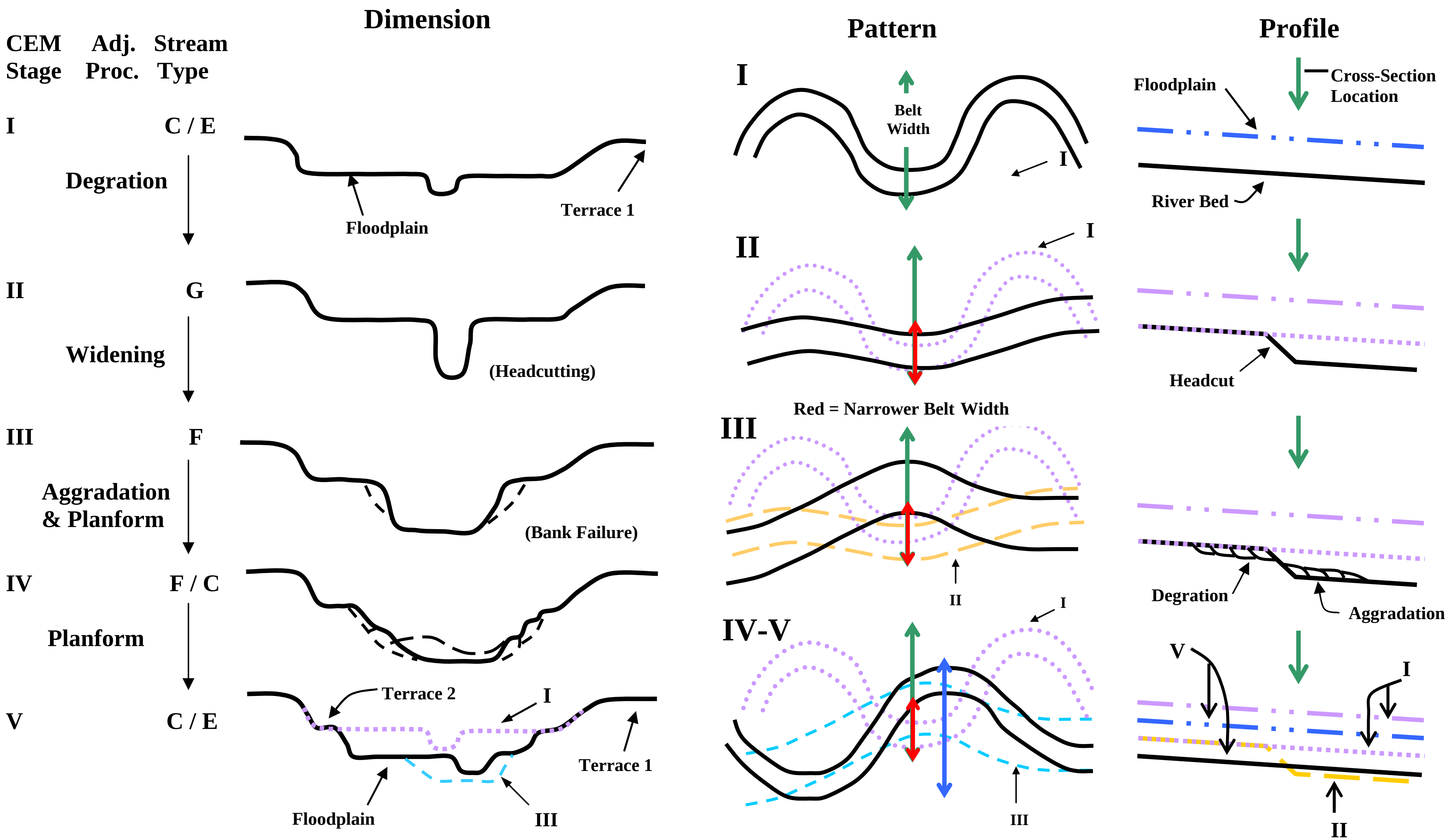
Stage III - Channel is still entrenched, widening and migrating laterally through bank erosion caused by the increased stream power (B or G or F Stream Type). The system regains balance between the power produced and the boundary materials as sinuosity increases and slope decreases. There are profound 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:**

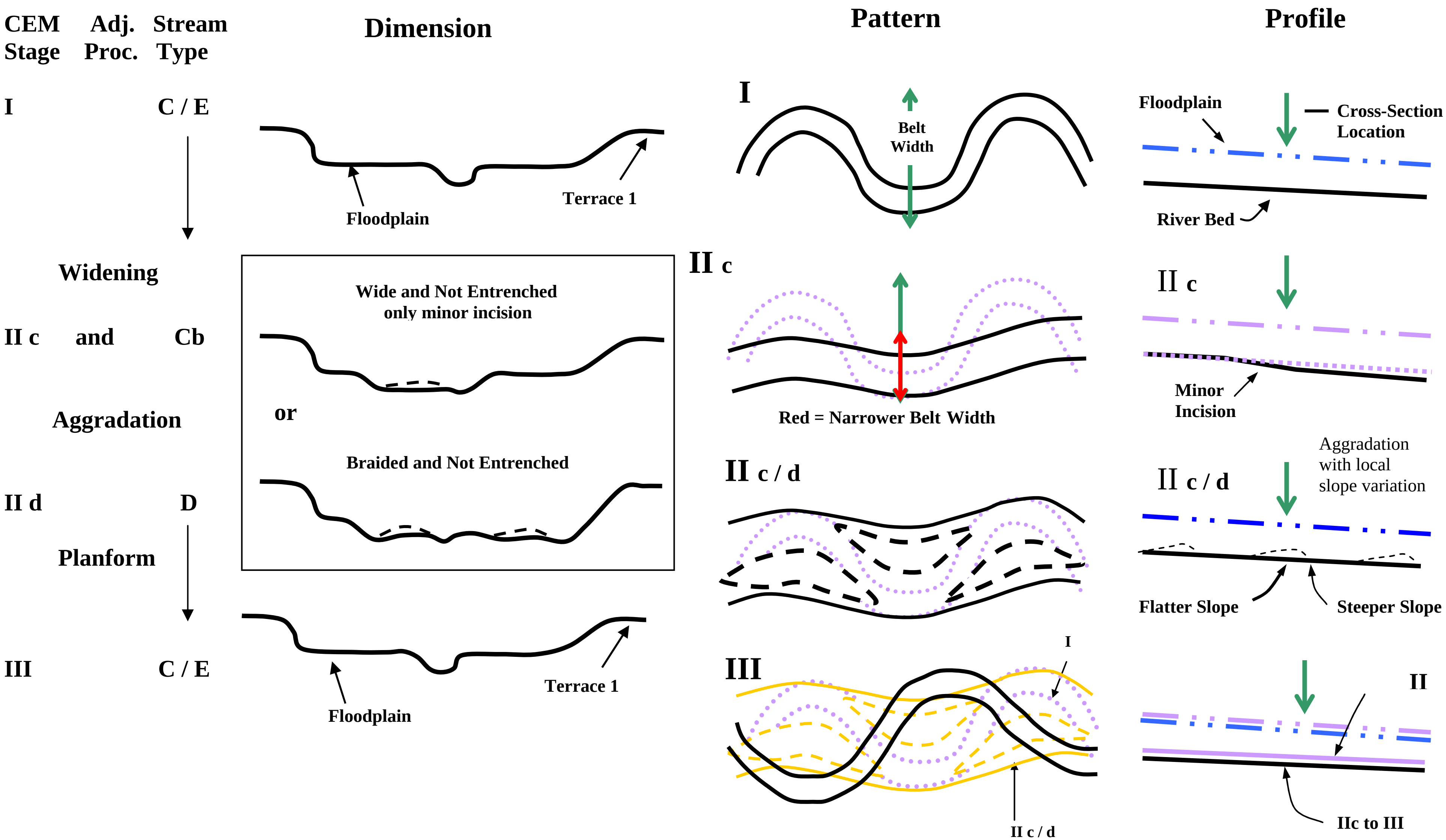
Stage IIc Steeper gradient may be imposed through activities such as channelization, but due to the resistance of the bed material, the stream has not incised significantly or lost access to its floodplain (remaining a "C" Stream Type). Channel is widening and migrating laterally through bank erosion 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)



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. Planform change refers to the shifting of a channel laterally across a valley bottom. Planform adjustment 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 on the main stem of the Upper Winooski River are widening and planform migration as a result of historic channel straightening and floodplain encroachment which caused degradation and reduced floodplain access within the channel.

The results of the Phase 2 geomorphic assessment are discussed below by reach number from upstream to downstream. Reaches that were assessed in a previous study were included here (descriptions quoted from the original author) in order to document a complete description of the Upper Winooski River from reach R27 to R18 (the length of which is documented in this River Corridor Management Plan). Six overview maps (Figures 1, 5, 8, 10, 13, and 16) have been included to provide a reference for location as well as to display riparian buffer impacts and channel straightening both of which have greatly affected the condition of the Upper Winooski River.

RIVER REACHES R27 AND R26: MARSHFIELD TO PLAINFIELD VILLAGE

The first section of river (illustrated in Figure1) begins in Marshfield and flows westerly towards Plainfield Village. The valley alternates between broad and narrow and land use changes from predominately agricultural and forested to commercial and residential in Plainfield. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, a dam, and floodplain encroachment.

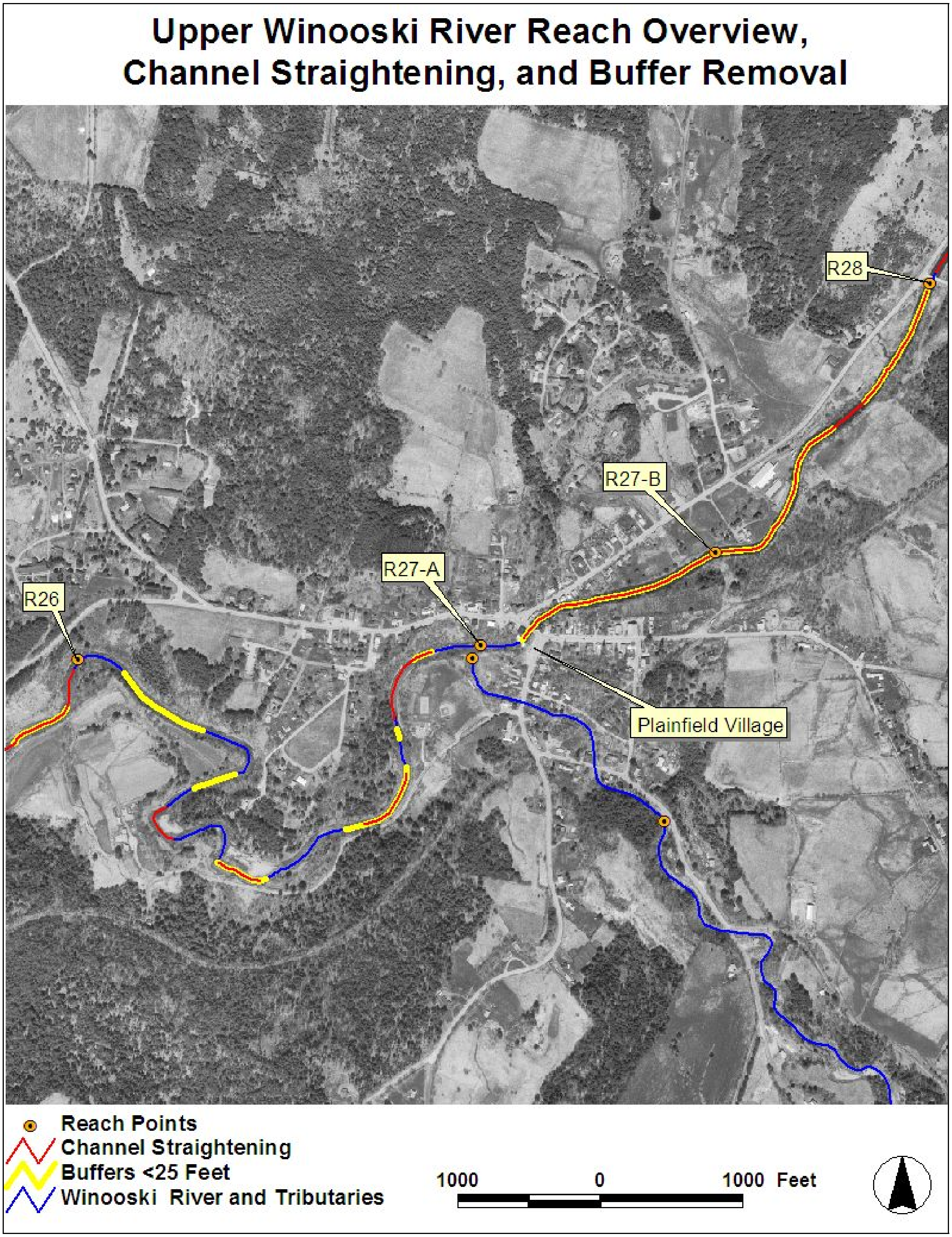


Figure 1: Reaches R27 through R26 with channel straightening and riparian buffers <25 feet wide.

Reach R27

Upper Winooski River reach R27 begins in the town of Marshfield, close to the Plainfield town line. It is the uppermost reach of this study area (upstream reaches are included in separate reports). The reach begins at the John Fowler Road bridge and continues downstream into the Village of Plainfield where it ends near the mouth of Great Brook, just below the dam in Plainfield. The dam affects the river by reducing the slope of the channel, thereby disrupting sediment transport and geomorphic processes. R27 was segmented into two study sections, A and B, in order to account for the dams influence on the channel. R27-B is the upstream segment and represents a free-flowing stream. R27-A is the downstream segment and represents the area impeded by the dam as well as a very small area of cobble bottomed fast moving water (that closely resembles reach R26) just below the dam.

R27-B

Upper Winooski segment R27-B begins at the John Fowler Bridge and flows downstream to approximately 1500 feet upstream of the Plainfield dam. The reach is characterized by a very straight E-type stream channel dominated by a ripple-dune sand bottom. The channel appears straight due to historic manipulation. This straightened channel has widened and there is evidence of some minor planform adjustment as the river attempts to erode an outside bank. Lack of significant adjustment may be attributed to the low slope and excellent floodplain access and a moderately healthy riparian buffer (see Figure 2). The straightening and widening have, however, greatly reduced instream habitat quality. Forest clearing for residential and recreational use has significantly impacted the right bank as well as a portion of the left riparian area which has been cleared for agriculture. Route 2, several residences, and a commercial operation impede on the right corridor while the left corridor has no significant development.

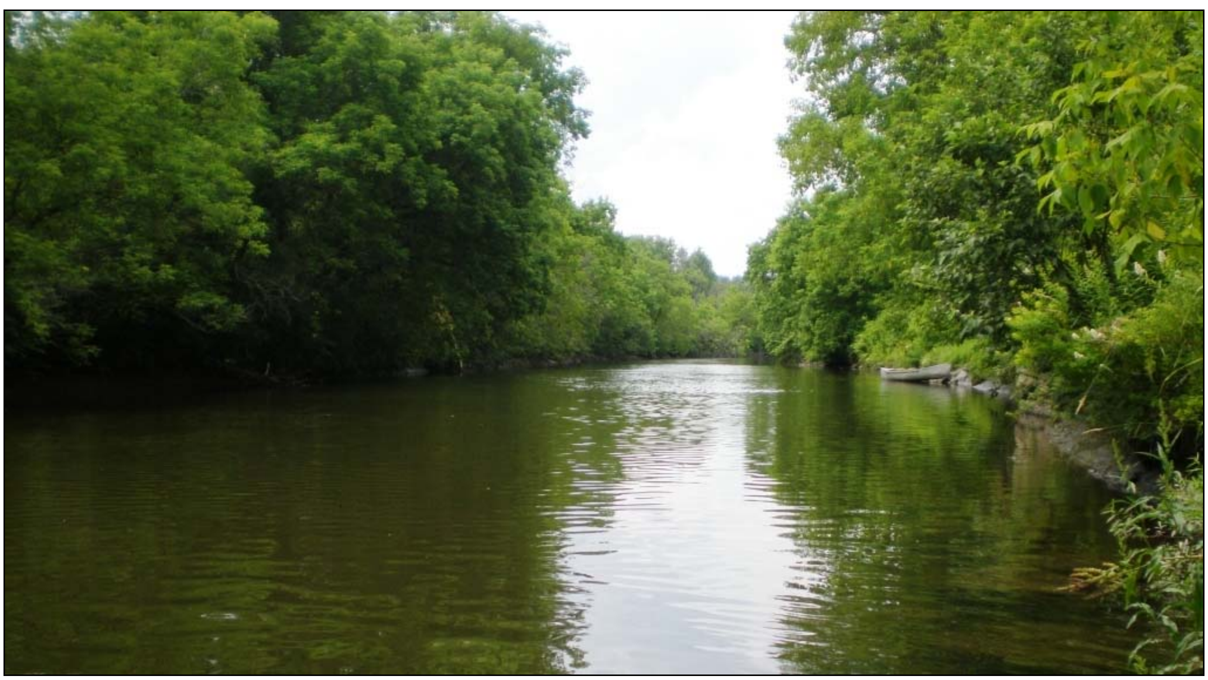


Figure 2: Typical perspective of segment R27-B, a ripple-dune channel with a very low slope.

R27-A

Upper Winooski River segment R27-A begins ~1500 feet upstream of the Plainfield Dam and ends at the confluence with the Great Brook. Only a partial Phase 2 Assessment was conducted for this segment due to the disruptive influence of the dam on the sediment transport of the river. Because velocity and water surface slopes are reduced, pooling of water occurs during a high flow event leading to settling of gravels, sands, and silts on the river bottom. As the river goes through the Village impacts associated with urbanization affect the river including significant disturbance to the riparian buffer, excessive riprap and concrete walls (which offer little habitat value), and stormwater runoff sources (from rooftops, driveways, and lawns).

The Plainfield Dam is owned by the Town of Plainfield and has recently been considered for hydropower development (Figure 3).

Figure 3: Dam in Plainfield Village on Reach R27-A.

Reach R26

Winooski River reach R26 begins at the confluence with the Great Brook next to the recreation fields in Plainfield Village. The reach continues downstream for over a mile in a broad valley with a greater slope (valley slope = 1.04%) than both the upstream and downstream reaches. This steeper slope influences the stream type, bedform, and dominant bottom substrates found in R26. The reach is a C-type channel with a riffle-pool form dominated by cobble and gravel material. It is evident from terraces in the floodplain and the mouth of Great Brook that historic channel incision has occurred in this reach (current incision ratio is 1.5). Presently it appears that planform migration is the most significant adjustment occurring within this reach (see Figure 4). This was especially evident in 1980 when according to a local fisherman the stream underwent a major adjustment in location. As a result of this channel movement, and perhaps influenced by material moving in from the Great Brook, channel aggradation and widening are also occurring in minor amounts.

A road on the left bank has severed some potential floodplain access for the river. Riparian buffer removal on the left bank has also occurred in significant amounts. On the right bank some minor encroachment by residential development has occurred, however, overall the buffer is in better condition. The Plainfield Water Treatment facility, located within the river channel corridor is on the left bank next to the recreation fields. Future continued planform adjustment can be expected in this reach as the river works to develop accessible floodplain and to transport sediments arriving from Great Brook.

Figure 4: Dynamic channel movement in reach R26. New floodplain development and sediment deposition on inside bend (right), erosion and prevention (rip-rap) on left bank.

RIVER REACHES R25 TO R24: PLAINFIELD / EAST MONTPELIER TOWN LINE

The second section of river (illustrated in Figure5) begins in Plainfield at R25 and flows westerly crossing into East Montpelier near Coburn Road, the start of R24. The valley alternates between very broad and narrow and land use is dominated by forest, agriculture and residences. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

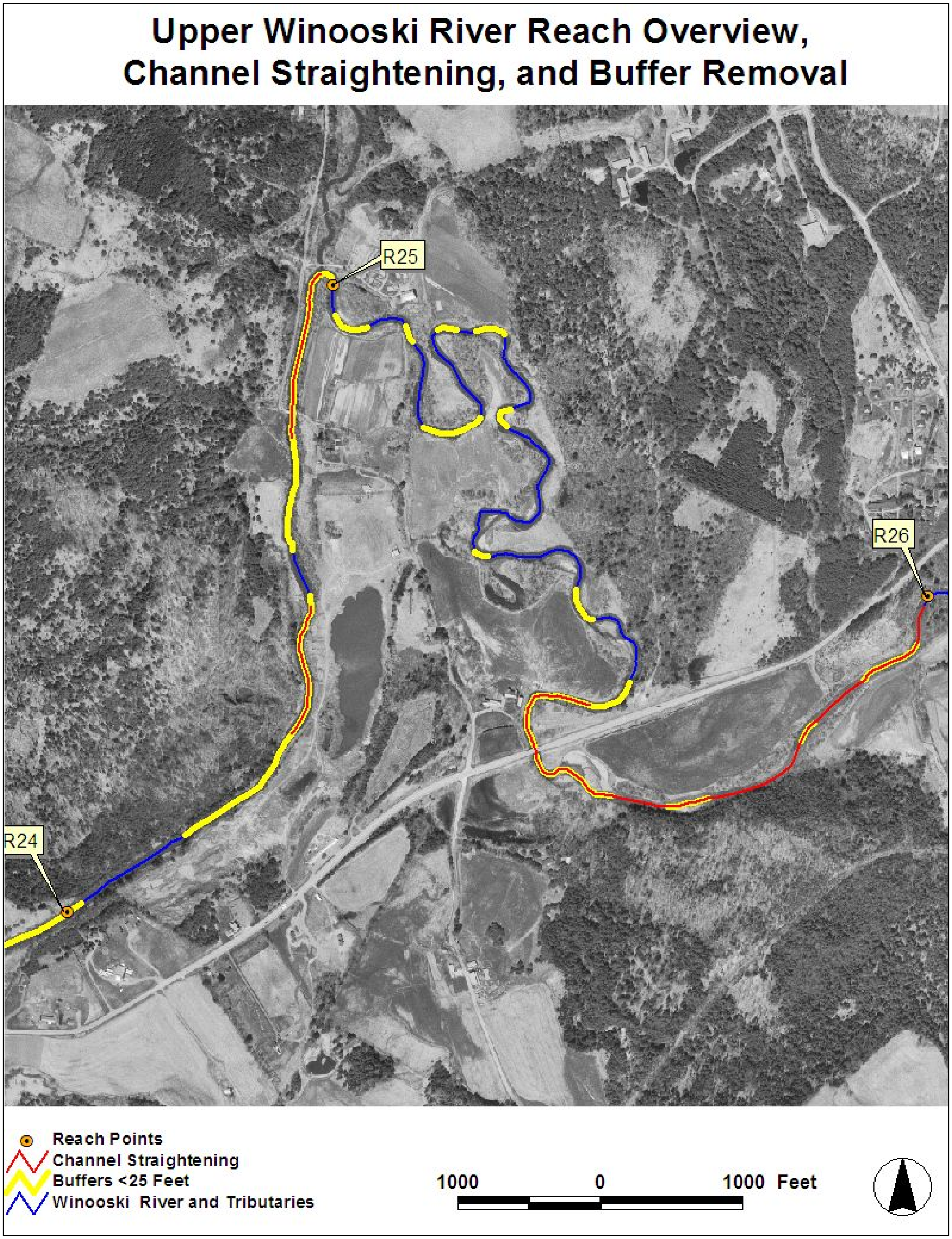


Figure 5: Reaches R25 through R24 with channel straightening and riparian buffers <25 feet wide.

Reach R25 (As reported by the Johnson Company)

R25 is located from 600 feet upstream from the upper corner of a corn field along Route 2 in Plainfield to the confluence with Kingsbury Branch in East Montpelier near Coburn Road (Figure 6).

"R25 has undergone a stream type departure from its reference E type stream to the current C type channel. The reach is not highly entrenched and is moderately incised, which means that it still has access to the flood plain during high flow events. The reach was found to be in Stage III of evolution. The major adjustment processes are planform and widening evidenced by the bank erosion, and flood chutes. Evidence of channel avulsion was found on the mid-portion of the reach. There is also some aggradation occurring as shown by the enlargement of depositional features such as point, mid, side, and diagonal bars, and islands. Multiple eroding banks on both sides (approximately 9 feet high and 250 feet long) and mass failures with an average failure height of 40 feet are present mainly on the right bank at the valley wall. Some of the factors increasing the sediment input to this reach are glacial geology, highly erodable soils, lack of riparian buffer, and the relocation of the channel to accommodate Route 2, which has moved the channel close to the valley wall. This reach contributes a significant sediment and nutrient load to the downstream reaches. The right riparian corridor was dominated by forest, but this vegetation did not extend to the river bank. The buffer width was generally less than 5 feet. The left riparian corridor consisted of hay fields with a narrow wooded buffer of <5 feet. Rip-rap is present for approximately 500 feet upstream and downstream from the bridge on Route 2. The downstream stretch is primarily farm land."

Figure 6: Widening and planform adjustment in Reach R25. Photo credit: Johnson Company

Reach R24

Winooski River reach R24 begins at the confluence with the Kingsbury Branch where the valley narrows and flows downstream to where the valley naturally reopens just upstream of a new Route 2 bridge in East Montpelier. The reach is just over a mile long with a channel slope of under 1%. Mining of gravel along an adjacent hillside (now floodplain) has changed the entrenchment in the middle of the reach. Despite its location in a narrow valley this reach appears to be an "E" type channel based on the width to depth ratio of 11.5.

Current conditions in the channel include some encroachment in the floodplain by the Coburn Road. The covered Coburn Bridge rests on narrow abutments that are causing streambank scour both upstream and downstream of the structure (this despite the bridge itself having been elevated several years ago in order to improve flood flow capacity under the structure). Streambank erosion and rip-rapping are common along much of the reach (less riprap in the more remote downstream area). The riparian buffer has been disturbed along much of the river (particularly upstream) due to agricultural activities, the road, and the mining operation. Some berming along the left bank exists at the mining operation and reduces access to a potential floodplain area.

R24 is slightly incised. Excessive energy in the channel may have caused a large mass failure on the right bank as well as other intermittent erosion patches that exist commonly on both the right and left banks. It also may have reduced the habitat complexity which is dominated by a plane bed bottom and only two riffles over the course of the mile long reach (sediment contributions from R25 and the Kingsbury branch may also have filled in some of the bottom topography) (see Figure 7).

Figure 7: Measuring channel incision along reach R24.

RIVER REACH R23 : EAST MONTPELIER VILLAGE AND UPSTREAM

The third section of river (illustrated in Figure 8) begins in East Montpelier downstream of the Coburn covered bridge and flows westerly into East Montpelier Center ending at the Route 14 South Bridge. The valley is predominately broad and land use is dominated by forest, agriculture and residences. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

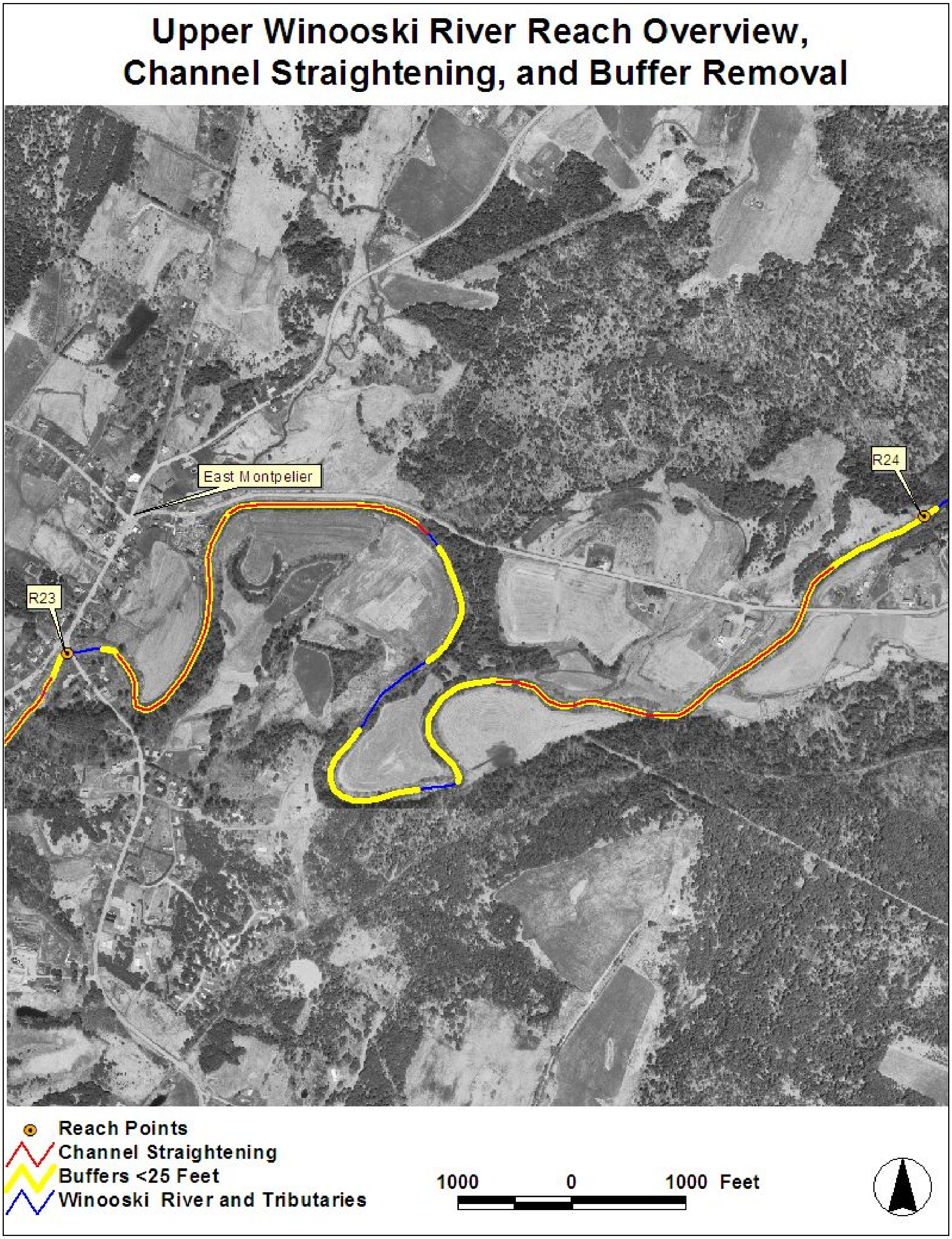


Figure 8: Reach R23 with channel straightening and riparian buffers <25 feet wide.

Reach R23

Upper Winooski River reach R23 starts just upstream of the new Route 2 Bridge in East Montpelier and flows downstream to just below the Route 14 south bridge in East Montpelier. This is a long meandering reach with a total length of 2.8 miles. The reach flows through predominately farm fields and forests before reaching the more developed residential lands near the East Montpelier Village. Significant impacts have occurred in this reach historically. First, channel straightening has occurred in several areas where the stream was channeled in order to maximize cultivated land and for the placement of Route 2. Secondly, the channel has been significantly affected by the removal of forested riparian buffers (see Figure 9). A number of stormwater inputs and two channel constricting bridges were also recorded in this reach.

R23 is an "E" type channel by reference and should by nature be sinuous, narrow, and deep with excellent floodplain access. The reach is, however, severely incised. Excess erosive energy is widening the stream channel and exacerbating planform adjustment. These processes may have contributed to triggering several mass failures which are found in the lower part of the reach. Incision is so excessive that the entrenchment of the channel has been reduced and the channel is now best described as a "B" type channel having departed from reference channel conditions. As the stream widens and adjusts laterally it is already building new floodplain benches on the inside of some meander bends. These floodplain benches will colonize with vegetation and may, over time, become part of the functioning floodplain for the Winooski. The geomorphic adjustment processes are, however, causing excessive streambank erosion along much of the reach and sending these sediments downstream into other reaches reducing stream bottom habitat and transporting nutrients towards Lake Champlain.

Figure 9: Significant streambank erosion through alluvial soils in reach R23.

RIVER REACH R22: EAST MONTPELIER VILLAGE TOWARDS MONTPELIER

The fourth section of river (illustrated in Figure 10) begins from the Route 14 South Bridge in East Montpelier and continues downstream towards Montpelier. The valley is predominately broad and land use is dominated by forest, agriculture, residences and some commercial use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, and floodplain encroachment.

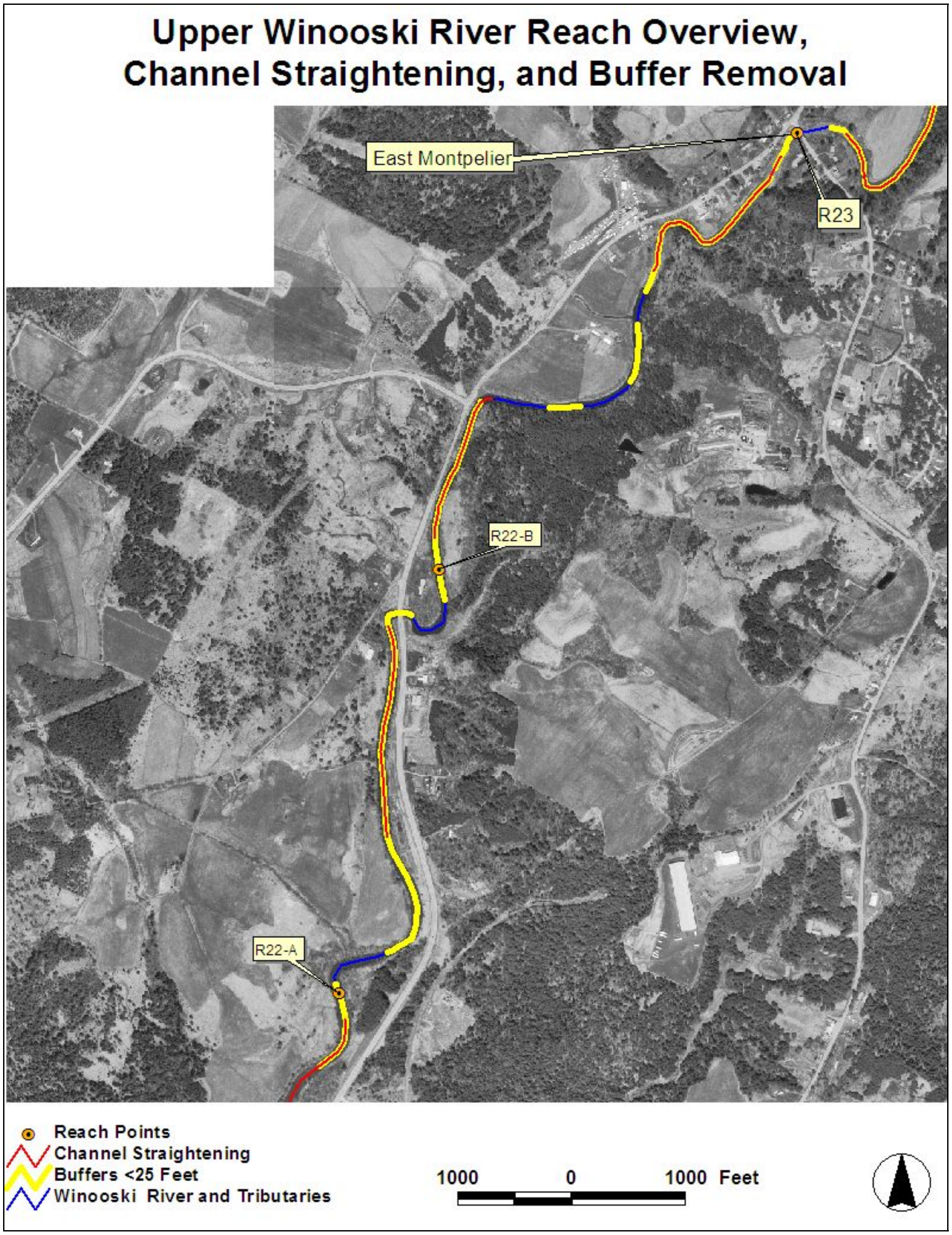


Figure 10: Reach R22 with channel straightening and riparian buffers <25 feet wide.

Reach R22 (As reported by the Johnson Company)

R-22 is located 100 feet downstream from the bridge on Route 14 South to approximately 1500 feet downstream of the hanging bridge. The reach was segmented into R22B (Figure 11) and R22A (Figure 12).

"Both reaches are highly entrenched and incised related to the development of East Montpelier and straightening along Route 2. R22B was segmented from due to its grade control and the proximity to the valley wall. Segment B was found to be an F gravel stream. R22A consists of the lower 1/3 of the reach and was found to be an F sandy stream."

R22B

"R22B also may have also been straightened in the past because of development in East Montpelier. The geomorphic and habitat assessment scores were 0.45 and 0.43 respectively, both "fair" conditions. The segment was found to be in Stage III of evolution and has lost access to its historic floodplain. The dominant adjustment processes are widening and historic degradation. Active channel migration evidenced by flute chutes was observed. There is aggradation at the mouth of the tributary, Mallory Brook, as is evident by depositional features such as delta, side, point and mid-channel bars. The right riparian corridor was dominated by a hay field on the right, and had a narrow buffer of less than 5 feet. The left riparian corridor consisted of forest with a buffer of more than 100 feet."

Figure 11: Cross section on reach R22-B. Photo credit: Johnson Company

R22A

"R22A had undergone a stream type departure from its reference C type stream to the current F type channel due to historic degradation, which has lowered the entrenchment to 1.2 and increased the incision ratio to 2.1. The segment no longer has access to its original floodplain and was found to be in Stage III of evolution. The dominant adjustment process was found to be widening as evident by steep to vertical eroding banks (approximately 7 feet high and 150 feet long) and the development of new terraces. One mass failure, approximately 40 feet high, is located on the left bank, approximately 350 feet upstream from the bridge on Route 2. The habitat and geomorphic assessment scores were 0.27 and 0.34 respectively, both “poor” conditions. The riparian corridor was dominated by commercial development on the left side and crops on the right side with a very narrow buffer of < 5 feet on both sides. The bridge on Route 2 is located in a meandering river area, which could potentially cause some stress to the structure in the future (Figure 12). Route 2 presents an encroachment to the historic river corridor along a significant portion of the reach.”

Figure 12: Route 2 Bridge with difficult alignment, R22-A. Photo credit: Johnson Company

RIVER REACHES R21 AND R20: EAST MONTPELIER TO MONTPELIER, BERLIN, BARRE CORNER

The fifth section of river (illustrated in Figure 13) begins from below the hanging bridge in East Montpelier and continues downstream towards Montpelier flowing over three dams including the near 100 year old Winooski #4 dam operated by Winooski Hydroelectric Company. The valley is predominately semi-confined and use is dominated by forest, agriculture, and commercial use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, two dams, and floodplain encroachment.

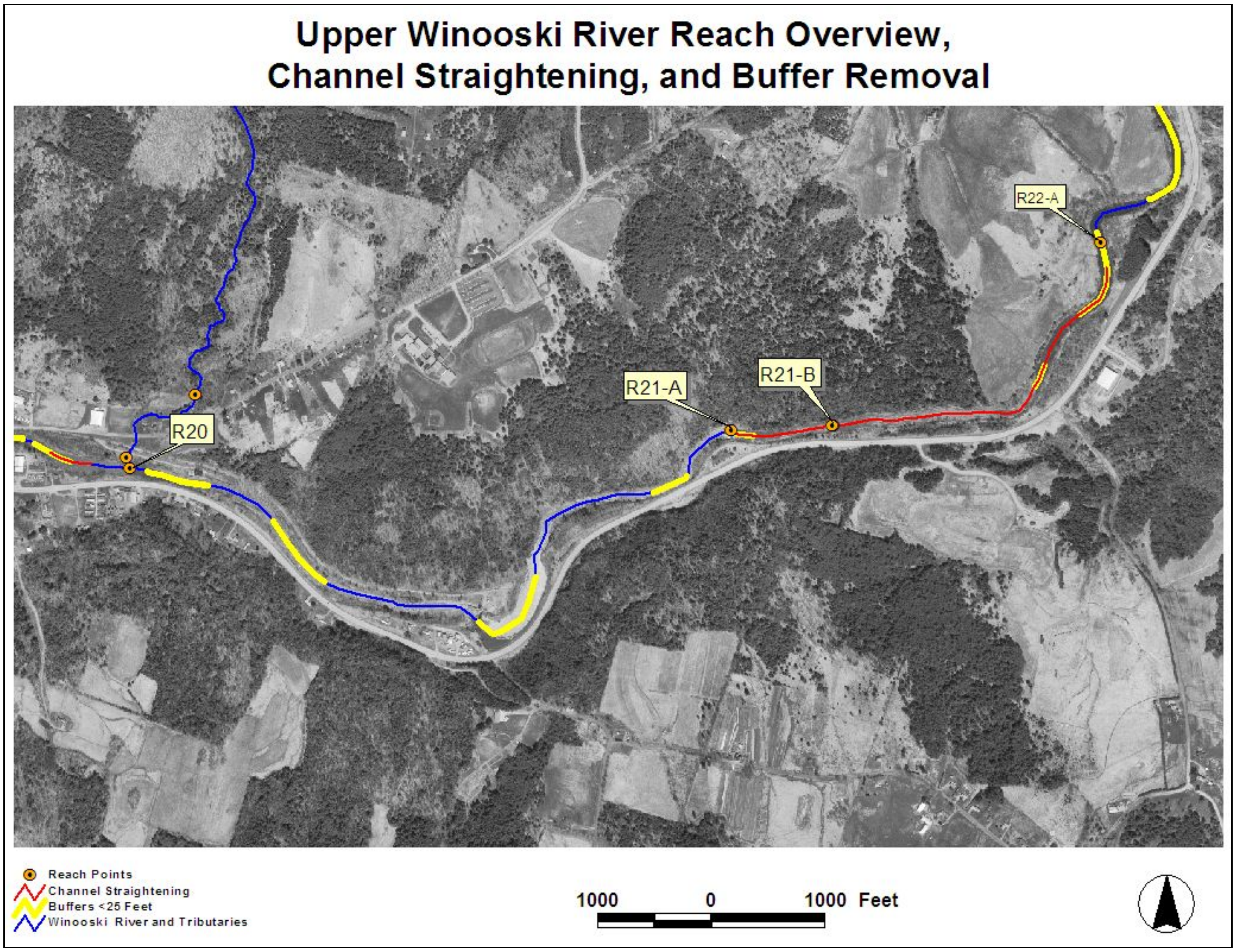


Figure 13: Reaches R21 and R20 with channel straightening and riparian buffers <25 feet wide.

Reach R21

Upper Winooski River reach R21 begins approximately 1500 feet downstream of the hanging bridge in East Montpelier and continues to an old concrete dam several hundred feet upstream of the Montpelier #4 hydro dam. The reach was segmented due to the influence of the concrete dam on the flow and sediment transport capacity of the lower end of this reach.

R21-B

Winooski River segment R21-B begins just upstream from Packard Road in East Montpelier where the channel bends away from Route 2. The valley and channel slope of the Winooski become steeper as the valley becomes semi-confined and dominated by agriculture on the right bank and the old Route 2 corridor on the left bank. The reach is characterized by a fairly straight channel with little room to adjust laterally. There exists significant rip rap on left bank (concrete and quarried stone) that was likely put in place to protect the historic route 2 road bed. Large boulders exist in stream channel indicating the rivers greater ability to transport fine materials in this narrow, steeper reach (Figure 14). Because of this natural and enhanced (due to the old Route 2 roadbed) condition, very little sediment storage potential exists in this reach. The dominant channel adjustment processes are historic channel incision and current channel widening.

Figure 14: R21-B flows over boulders and cobbles alongside the old route 2 roadbed which flanks the left bank (right side of photo).

R21-A

Winooski River segment R21-A was only partially assessed due to the impact of the concrete dam that exists at its lower end (Figure 15). The dam reduces water surface slope and changes the channel bottom from cobble/gravel to sand/silt. The dam is no longer in use but still impacts the channel. Just on the downstream side of the old dam a large alluvial fan has developed where a tributary affected from upstream disturbance is carrying a significant amount of sediment towards the river.

Figure 15: An old concrete dam disrupts water and sediment transport at reach R21-A (looking upstream).

Reach R20

Reach R20 drains from below the small concrete dam described in Segment R21-B downstream through the Winooski #4 hydro dam to a point 1500 feet downstream of the Montpelier/East Montpelier town line where an unnamed tributary enters from the north (right) bank. Due to the influence of the dam on the condition of this reach a Phase 2 assessment was not conducted here.

RIVER REACHES R19 AND R18: MONTPELIER, BERLIN, BARRE TO DOWNTOWN MONTPELIER

The sixth section of river (illustrated in Figure 16) begins from the confluence with an unnamed tributary downstream of the Winooski #4 dam to the confluence with the North Branch in downtown Montpelier. The valley alternates from semi-confined to broad and is dominated commercial land use. Major significant impacts in this section include: removal of riparian vegetation, channel straightening, channel armoring, two dams, and floodplain encroachment due to urban development.

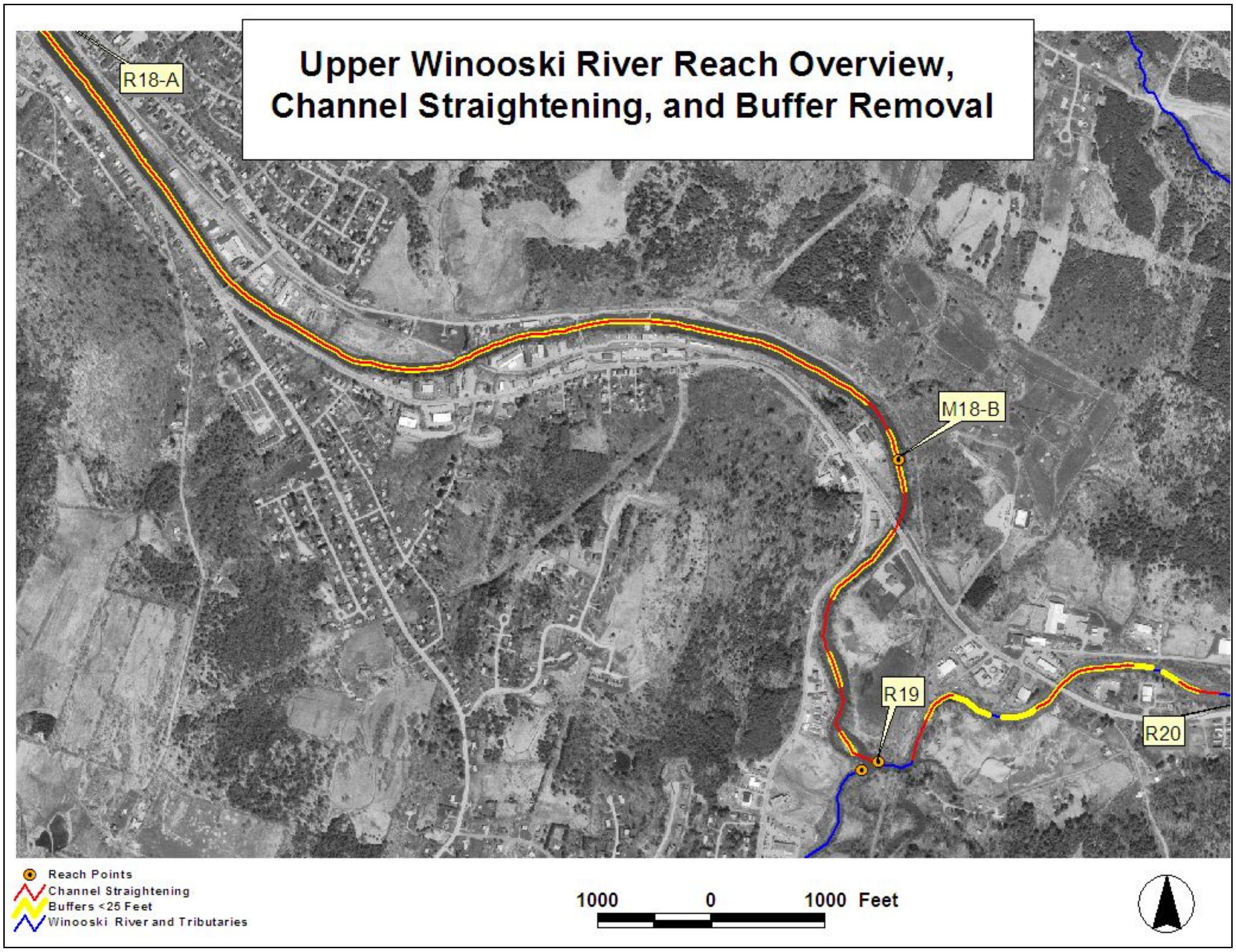


Figure 16 Reaches R20, R19, and R18 with channel straightening and riparian buffers <25 feet wide.

Reach R19 (As reported by the Johnson Company)

R-19 (Figure 17 is located from the unnamed tributary on the right approximately 50 feet north of Route 2 and approximately 1800 feet upstream of the Route 2 bridge to R-18B, approximately 125 feet downstream of a railroad bridge.

"It was found to be an F boulder stream, which was a stream type departure from the Phase 1 reference C stream type. The stream type departure is due to historic degradation and the commercial and industrial development along Route 2. These stressors have lowered the entrenchment to 1.5 and increased the incision ratio to 1.4. The major active adjustment process is widening, as evidenced by rip-rap failure of approximately 160 feet long located upstream from the railroad bridge on the left bank. The two bridges are channel constrictions. Although bank instability was clear near the two bridges, no active head cuts were documented. The reach was found to be in Stage III of evolution. Historically, the reach has been straightened. The habitat score was 0.48, or "fair," and geomorphic score 0.34 or in "poor" condition. Relatively minor bank erosion was noted along both the right and left bank with a total length of 185 feet and an average height of 10 feet. The right bank erosion is located upstream from the bridge on Route 2 and adjacent to a parking lot. The left bank erosion is located downstream and adjacent to the railroad bridge. The erosion is related to constriction by the bridge. The riparian corridor was dominated by development. Buffers ranged from <5 to 25 feet along the left and <5 feet along the right. This reach may be affected by the water release coming from the Levesque Station-Montpelier Hydroelectric Dam #4. The lower portion of the reach is connected to the mouth of the Steven Branch and the Food Works site described above."

Figure 17: Typical channel conditions along reach R19. Photo credit: Johnson Company

Reach R18 (As reported by the Johnson Company)

R18 is the most downstream reach in the Upper Winooski assessment area and extends from the confluence with the Stevens Branch downstream to the confluence with the North Branch at the Main Street Bridge in Montpelier.

"The reach was segmented into R18-A and R18-B. R18-B was segmented due to its channel dimensions and historic stream channel management and encroachment through the City of Montpelier. R18-A and R18-B were highly incised due to historic degradation caused by historic channel management activities. R18-A consists of the lower 2/3 of the reach and was found to be an F gravel stream. Segment B was found to be a B sandy stream with a sub-slope of <2%."

R18-B

"R18-B may have also been straightened in the past. The geomorphic and habitat assessment scores were 0.33 and 0.34 respectively, both "poor" conditions. The dominant adjustment process was [historic] degradation and widening (see Figure 18), with an incision ratio of 1.9 and enrichment ration of 1.6. The segment was found to be in Stage III of evolution and has lost access to its historic floodplain. Evidence of channel avulsion was found on the upper portion of the segment near the confluence with the Stevens Branch. The right riparian corridor was dominated by agricultural crops managed by the Food Works project, and had a buffer from 5-25 feet. An eroding bank approximately 10 feet high and 320 feet long exists on this property. The left riparian corridor consisted of a narrow wooded buffer of <5 to 25 feet. A mobile home sales business is located on the top of the left bank. A river meander is cutting the bottom of the left bank creating some serious instability on the steep slope of the bank."

Figure 18: Typical channel conditions along reach R18-B. Photo credit: Johnson Company

R18-A

"R18-A had undergone a stream type departure from its reference C type stream to the current F type due to historic degradation and the development of Montpelier within the historic river corridor, which has lowered the entrenchment to 1.2 and increased the incision ratio to 1.5. The actual conditions show a highly entrenched stream with a moderate incision ratio (Figure 19). The segment no longer has access to its original floodplain and was found to be in evolution stage II. Historically, it has been channelized as a flood control measure for the City of Montpelier. R18A had a habitat score of 0.44 "fair" and a geomorphic assessment score of 0.30 "poor". Despite the incision, there was relatively no erosion noted in the segment due to the significant amount of rip-rap. The riparian corridor was dominated by commercial development on both sides with a very narrow buffer of < 5 feet on both sides. An old dam located at the upper portion of the segment on a bedrock constriction serves as a grade control. The dam was found to be partially breached and does not impound much more water than the naturally occurring bedrock grade control upon which it is constructed."

Figure 19: Typical channel conditions along reach R18-A. Photo credit: Johnson Company

APPENDIX B

PHASE 2 DATA

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R18 Segment: A Completion Date: **September 22, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez,Sonja** Why Not assessed: Rain: **Yes**

Segment Length (ft): **9,525** Segment Location: **R18-A begins at the bridge on Main Street to ~ 500ft downstream from the Railroad Bridge,**

QC Status - Staff: Provisional Cons Passed

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	2,039	7,101
height	0	0
Railroads	7,277	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,617	4,850

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) **190**
- Width Determination **Measured**
- Confinement Type **Narrowly**
- Rock Gorge? **No**
- Human-caused Change? **yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **126**
- 2.2 Max Depth (ft) **3.90**
- 2.3 Mean Depth (ft) **3.10**
- 2.4 Floodprone Width (ft) **155**

Notes:

Historic straightening related with development of downtown Montpelier. Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the segment as a Plane Bed.

Step 2. (Contued)

- 2.5 Aband. Floodpln **5.90** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **40.55**
- 2.7 Entrenchment Ratio **1.23**
- 2.8 Incision Ratio **1.51**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Eroded**
- 2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0 %
Boulder	4 %
Cobble	43 %
Coarse Gravel	17 %
Fine Gravel	13 %
Sand	23 %
Silt and smaller	0 %

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

2.13 Average Largest Particle on

Bed	200.0	mm
Bar	60.0	mm

2.14 Stream Type

- Stream Type: **F**
- 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)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	7,776	6,758

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

Bank Canopy	Left	Right
Canopy %	26-50	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	26-50	0-25
W less than 25	8,197	7,275

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	Commercial
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 **None**
- 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	9	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	1
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: **9,522**
- 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: **Winooski River** Reach # **R18** Segment: **A** Completion Date: **September 22,**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez,Sonja** Rain: **Yes**

Segment Length (ft): **9,525** Segment Location: **R18-A begins at the bridge on Main Street to ~ 500ft downstream from the Railroad**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken
Dam	Mid-Segment	10.00	5.00		

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Other	155.	Yes	Yes	Yes	Yes
Problem	Deposition Above,Scour Below				
Bridge	153.	Yes	Yes	Yes	Yes
Problem	None				
Bridge	170.	Yes	Yes	No	Yes
Problem	None				
Bridge	170.	Yes	Yes	No	Yes
Problem	None				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**4**	**C to F**	**No**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**7**		**No**
Total Score	**24**		
Geomorphic Rating	**0.3**		

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

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	6
6.2 Embeddedness	11
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	16
6.5 Channel Flow Status	15
6.6 Channel Alteration	3
6.7 Frequency of Riffles/Steps	3
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 3 Right: 4
6.10 Riparian Vegetation Zone Width	Left: 2 Right: 1
Total Score	88
Habitat Rating	0.44

Habitat Stream Condition **Fair**

Narrative:
In terms of channel evolution remains in Stage II because of the encroachment.

Project: Winooski - Montpelier to Cabot | **Phase 2 Segment Summary** | | November 13, 2009 | SGAT Version: 3

Stream: **Winooski River** | Reach # **R18** | Segment: **B** | Completion Date: **July 24, 2006**

Organization: **Winooski Conservation District** | Observers: **Noelia Báez Rodríguez, Abbey** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **3,131** | Segment Location: **R18-B begins ~ 500ft downstream from the Railroad Bridge, which runs parallels to Route 2**

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

Step 1. Valley and Floodplain

1.1 Segmentation **Channel Dimensions**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,883	407
height	0	0
Railroads	444	0
height	0	0
Improved Paths	0	0
height	0	0
Development	995	327

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

1.5 Valley Features

Valley Width (ft) **500**

Width Determination **Measured**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

2.1 Bankfull Width **130**

2.2 Max Depth (ft) **7.40**

2.3 Mean Depth (ft) **5.84**

2.4 Floodprone Width (ft) **220**

Notes:

Segmentation due to Channel Dimension and Corridor Management options. Food Works segment and irrigation water withdrawal. Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the

Step 2. (Contued)

2.5 Aband. Floodpln **14.24** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **22.29**

2.7 Entrenchment Ratio **1.69**

2.8 Incision Ratio **1.92**

Human Elevated Inc Rat **0.00**

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	0 %
Coarse Gravel	15 %
Fine Gravel	15 %
Sand	70 %
Silt and smaller	0 %

Silt/Clay Present? **No**

Detritus **1** %

\# Large Woody **8**

2.13 Average Largest Particle on

Bed **200.0** mm

Bar **160.0** mm

2.14 Stream Type

Stream Type: **B**

Bed Material: **Sand**

Subclass Slope: **c**

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	Clay
Consistency	Non-cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	241	958
Erosion Height (ft)	25.00	10.42
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,463	1,264

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

Bank Canopy	Left	Right
Canopy %	1-25	26-50

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	0-25	0-25
Sub-dominant	0-25	26-50
W less than 25	1,487	812

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Crop
Sub-dominant	Commercial	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 **None**

4.3 Flow Status **Moderate**

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	2	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	1
Diagonal	**Delta**	**Island**
0	0	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
0	0	1	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: **3,126**

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: **Winooski River** Reach # **R18** Segment: **B** Completion Date: **July 24, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Abbey Willard** Rain: **Yes**

Segment Length (ft): **3,131** Segment Location: **R18-B begins ~ 500ft downstream from the Railroad Bridge, which runs parallels 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	144.	Yes	Yes	No	Yes
Problem	None				
Bridge	124.	Yes	Yes	Yes	Yes
Problem	None				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**4**	**C to B**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**6**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Poor**
Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	6
6.2 Embeddedness	5
6.3 Velocity/Depth Patterns	7
6.4 Sediment Deposition	6
6.5 Channel Flow Status	11
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	5
6.8 Bank Stability	Left: 5 Right: 3
6.9 Bank Vegetation Protection	Left: 4 Right: 3
6.10 Riparian Vegetation Zone Width	Left: 5 Right: 3
Total Score	68
Habitat Rating	0.34

Habitat Stream Condition **Poor**

Narrative:

A midchannel island is enlarging, and its elevation is above bankfull; the island is deflecting flow into the right bank; the stream is overwidening.

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Project: **Winooski - Montpelier to Cabot**
Stream: **Winooski River** Reach # **R19** Segment: **0** Completion Date: **August 8, 2006**
Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Kelsey** Why Not assessed: Rain: **Yes**
Segment Length (ft): **4,057** Segment Location: **R19 starts at the confluences of the Stevens with the Winooski ~100ft downstream from the**

QC Status - Staff: Provisional Cons Passed

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	628	1,485
height	0	0
Railroads	815	0
height	0	0
Improved Paths	0	0
height	0	0
Development	990	2,121

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

1.5 Valley Features
- Valley Width (ft) **416**
- Width Determination **Measured**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**

Human-caused Change? **yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **112**
- 2.2 Max Depth (ft) **3.40**
- 2.3 Mean Depth (ft) **2.50**
- 2.4 Floodprone Width (ft) **169**

Notes:

The physical characteristic of the cross section indicated an F Stream Type. The entrenchments values calculated in the field have been modified using the adjusting factor of +/- 0.2. This is Semi-confine section characterize by high revetment bank on both

Step 2. (Contued)

- 2.5 Aband. Floodpln **4.70** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **44.80**
- 2.7 Entrenchment Ratio **1.51**
- 2.8 Incision Ratio **1.38**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Moderate**
- 2.10 Riffles Type **Eroded**
- 2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	39%
Cobble	37%
Coarse Gravel	7%
Fine Gravel	6%
Sand	11%
Silt and smaller	0%

- Silt/Clay Present? **Yes**
- Detritus **1** %
- # Large Woody **12**

2.13 Average Largest Particle on
- Bed **300.0** mm
- Bar **160.0** mm

2.14 Stream Type
- Stream Type: **F**
- Bed Material: **Cobble**
- 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	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)	75	109
Erosion Height (ft)	8.00	10.00
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,440	2,297
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	0-25
Sub-dominant	0-25	0-25
W less than 25	683	1,954
Buffer Veg. Type	**Left**	**Right**
Dominant	Shrubs/Saplin	Shrubs/Saplin
Sub-dominant	Herbaceous	Herbaceous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Industrial	Industrial
Sub-dominant	Pasture	Commercial
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 **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
- (old) Upstrm Flow Reg **Store-release**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	2	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	2
Diagonal	**Delta**	**Island**
2	0	2

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: **2,076**
- 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: **Winooski River** Reach # **R19** Segment: **0** Completion Date: **August 8, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Kelsey** Rain: **Yes**

Segment Length (ft): **4,057** Segment Location: **R19 starts at the confluences of the Stevens with the Winooski ~100ft downstream**

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	110.	Yes	Yes	Yes	No
Problem	Deposition Below,Scour Below				
Bridge	108.	Yes	Yes	No	Yes
Problem	Deposition Above				
Bridge	114.	Yes	Yes	No	Yes
Problem	Deposition Above,Deposition Below,Scour				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**C to F**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**11**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Poor**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	12
6.2 Embeddedness	11
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	11
6.5 Channel Flow Status	13
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	5
6.8 Bank Stability	Left: 7 Right: 6
6.9 Bank Vegetation Protection	Left: 4 Right: 2
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 2
Total Score	95
Habitat Rating	0.475

Habitat Stream Condition **Fair**

Narrative:

Active widening evidently by failure rip-rap and bank of erosion. Some degradation on the lower section evidently by bar with steep faces and deep pool.

Project:	Winooski - Montpelier to Cabot		**Phase 2 Segment Summary**	page 1 of 2	November 13, 2009	SGAT Version: 3
Stream:	**Winooski River**	Reach #	**R21**	Segment: **A**	Completion Date:	**July 29, 2009**
Organization:	**Winooski Conservation District**	Observers:	**Michael Blazewicz**	Why Not assessed: **impounded**		Rain: **Yes**
Segment Length (ft):	**900**	Segment Location:	**Upstream from an old concrete dam (no longer in use) to the west of Route 2 in East**			

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	**867**	**0**
height	**30**	**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	**Extremely**	**Very Steep**
Continuous w/	**Always**	**Sometimes**
W/in 1 Bankfill	**Always**	**Always**
Texture	**Not Evalua**	**Not Evalua**

1.5 Valley Features

Valley Width (ft)	**240**
Width Determination	**Estimated**
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:

Segment only partially assessed due to the impact of the concrete dam on the sediment transport of the Winooski. The dam reduces water surface slope and changes the channel bottom from cobble/gravel to sand/silt. Dam is no longer in use. Tributary on right bank

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?	**No**
Detritus	**50** %
# Large Woody	**12**

2.13 Average Largest Particle on

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

2.14 Stream Type

Stream Type:

Bed Material:

Subclass Slope:

Bed Form:

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)	**0**	**0**
Erosion Height (ft)	**0.00**	**0.00**
Revetmt. Type	**Rip-Rap**	**None**
Revetmt. Length (ft)	**896**	**0**
Near Bank Veg. Type	Left	Right
Dominant	**Invasives**	**Herbaceous**
Sub-dominant	**Shrubs/Saplin**	**Coniferous**
Bank Canopy	Left	Right
Canopy %	**1-25**	**26-50**
Mid-Channel Canopy	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-dominant	**26-50**	**None**
W less than 25	**162**	**0**
Buffer Veg. Type	Left	Right
Dominant	**Invasives**	**Coniferous**
Sub-dominant	**Shrubs/Saplin**	**Deciduous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Commercial**	**Forest**
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	**Moderate**
4.4 # of Debris Jams	**0**
4.5 Flow Regulation Type	
Flow Regulation Use	
Impoundments	**Small**
Impoundmt. Location	**In Reach**
4.6 Up/Down strm flow reg	**Down Stream**
(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:	**865**
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: **Winooski River** Reach # **R21** Segment: **A** Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **900** Segment Location: **Upstream from an old concrete dam (no longer in use) to the west of Route 2 in East**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam		8.00	5.00		

4.8 Channel Constrictions

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

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

Habitat Stream Condition

Project: Winooski - Montpelier to Cabot | **Phase 2 Segment Summary** | | November 13, 2009 | SGAT Version: 3

Stream: **Winooski River** | Reach # **R21** | Segment: **B** | Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** | Observers: **Michael Blazewicz** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **3,737** | Segment Location: **From 900 feet upstream from the old concrete dam on the north side of Route 2 to the reach**

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	3,390	0
height	30	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	Extremely	Hilly
Continuous w/	Sometimes	Never
W/in 1 Bankfill	Always	Sometimes
Texture	Not Evalua	Mixed

1.5 Valley Features

Valley Width (ft) **315**

Width Determination **Estimated**

Confinement Type **Semi-confined**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **115**

2.2 Max Depth (ft) **8.90**

2.3 Mean Depth (ft) **6.56**

2.4 Floodprone Width (ft) **148**

Notes:

Reach is characterized by a fairly straight channel. Significant rip rap on left bank (concrete and quarried stone) that was likely put in place to protect the historic route 2 road bed. Large boulders in stream channel. Fairly narrow valley with agriculture on the

Step 2. (Contued)

2.5 Aband. Floodpln **17.80** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **17.53**

2.7 Entrenchment Ratio **1.29**

2.8 Incision Ratio **2.00**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Low**

2.10 Riffles Type **Not Applicable**

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

2.12 Substrate Composition

Bedrock	0 %
Boulder	33 %
Cobble	22 %
Coarse Gravel	13 %
Fine Gravel	17 %
Sand	15 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**

Detritus **1** %

Large Woody **44**

2.13 Average Largest Particle on

Bed **12.0** inches

Bar **4.0** inches

2.14 Stream Type

Stream Type: **F**

Bed Material: **Cobble**

Subclass Slope: **c**

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)	42	425
Erosion Height (ft)	5.00	5.69
Revetmt. Type	Rip-Rap	None
Revetmt. Length (ft)	2,452	0

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

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

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	26-50
Sub-dominant	26-50	>100
W less than 25	0	930

Buffer Veg. Type	Left	Right
Dominant	Invasives	Shrubs/Saplin
Sub-dominant	Shrubs/Saplin	Mixed Trees

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Shrubs/Saplin	Crop
Sub-dominant	Commercial	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 **None**

4.3 Flow Status **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **Down Stream**

(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	1	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	Yes

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **3,182**

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: **Winooski River** Reach # **R21** Segment: **B** Completion Date: **July 29, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **3,737** Segment Location: **From 900 feet upstream from the old concrete dam on the north side of Route 2 to the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions **None**

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

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Plane Bed**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**B to F**	**Yes**
7.2 Channel Aggradation	**15**	**None**	**No**
7.3 Widening Channel	**13**		**No**
7.4 Change in Planform	**16**		**No**
Total Score	**49**		
Geomorphic Rating	**0.6125**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	11
6.2 Embeddedness	13
6.3 Velocity/Depth Patterns	10
6.4 Sediment Deposition	11
6.5 Channel Flow Status	11
6.6 Channel Alteration	9
6.7 Frequency of Riffles/Steps	10
6.8 Bank Stability	Left: 8 Right: 6
6.9 Bank Vegetation Protection	Left: 6 Right: 6
6.10 Riparian Vegetation Zone Width	Left: 6 Right: 4
Total Score	111
Habitat Rating	0.555
Habitat Stream Condition	**Fair**

Narrative:

Channel incised historically - dam at downstream end of reach may have affected this upper portion, but in general it appears that this a B type stream in a naturally semi-confined valley that has been confined by road and has incised and is widening

Stream: **Winooski River** Reach # **R22** Segment: **A** Completion Date: **September 8, 2006**

Organization: **Winooski Conservation District** Observers: **Dan Smith, Noelia Báez** Why Not assessed: Rain: **Yes**

Segment Length (ft): **4,753** Segment Location: **R22-A start where the river bends away from Route 2, ~ 1500ft downstream from the**

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

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	3,829	555
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	1,572	144

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) **400**
- Width Determination **Measured**
- Confinement Type **Semi-confined**
- Rock Gorge? **No**
- Human-caused Change? **yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **92**
- 2.2 Max Depth (ft) **3.60**
- 2.3 Mean Depth (ft) **3.00**
- 2.4 Floodprone Width (ft) **110**

Notes:

Historic straightening mainly related with Route 2.
Runs are predominant thought out the entire segment. Riffles have been eroded. These are the reasons why we categorized the segment as a Plane Bed.

Step 2. (Contued)

- 2.5 Aband. Floodpln **7.20** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **30.80**
- 2.7 Entrenchment Ratio **1.19**
- 2.8 Incision Ratio **2.00**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Eroded**
- 2.11 Riffle/Step Spacing (ft) **0**

2.12 Substrate Composition

Bedrock	0%
Boulder	0%
Cobble	0%
Coarse Gravel	2%
Fine Gravel	8%
Sand	90%
Silt and smaller	0%

- Silt/Clay Present? **Yes**
- Detritus **10** %
- # Large Woody **19**

2.13 Average Largest Particle on

- Bed **33.0** mm
- Bar **2.0** mm

2.14 Stream Type

- Stream Type: **F**
- 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	One	40.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

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

Bank Erosion	Left	Right
Erosion Length (ft)	1,010	1,343
Erosion Height (ft)	7.70	8.10
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,859	798

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

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	0-25
W less than 25	2,920	2,690

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Commercial	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 **None**
- 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
- (old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	1	Road Ditch	0
Other	4	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	4	2
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: **1,875**
- 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: **Winooski River** Reach # **R22** Segment: **A** Completion Date: **September 8,**

Organization: **Winooski Conservation District** Observers: **Dan Smith, Noelia Báez Rodríguez** Rain: **Yes**

Segment Length (ft): **4,753** Segment Location: **R22-A start where the river bends away from Route 2, ~ 1500ft downstream from 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	108.	Yes	Yes	No	Yes
Problem	Deposition Above,Scour Above,Scour				
Bridge	135.	Yes	Yes	No	Yes
Problem	Scour Above,Scour Below				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**6**		**No**
7.4 Change in Planform	**10**		**No**
Total Score	**27**		
Geomorphic Rating	**0.3375**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Poor**

Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	4
6.2 Embeddedness	3
6.3 Velocity/Depth Patterns	5
6.4 Sediment Deposition	6
6.5 Channel Flow Status	13
6.6 Channel Alteration	4
6.7 Frequency of Riffles/Steps	1
6.8 Bank Stability	Left: 3 Right: 3
6.9 Bank Vegetation Protection	Left: 2 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 1 Right: 3
Total Score	53
Habitat Rating	0.265

Habitat Stream Condition **Poor**

Narrative:

Active widening and degradation process evidently by steep and vertical banks of erosion and the developed of new terraces.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River | Reach # R22 | Segment: B | Completion Date: **September 7, 2006**

Organization: **Winooski Conservation District** | Observers: **Dan Smith, Noelia Báez** | Why Not assessed: | Rain: **Yes**

Segment Length (ft): **5,495** | Segment Location: **R22-B starts ~ 300ft upstream of the concrete bridge along Route 2 and ends ~100ft**

QC Status - Staff: Passed Cons Passed

Step 1. Valley and Floodplain

1.1 Segmentation **Grade Controls**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	4,462	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,479	1

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

1.5 Valley Features

- Valley Width (ft) **485**
- Width Determination **Measured**
- Confinement Type **Narrow**
- Rock Gorge? **No**
- Human-caused Change? **yes**

Step 2. Stream Channel

- 2.1 Bankfull Width **85**
- 2.2 Max Depth (ft) **3.80**
- 2.3 Mean Depth (ft) **3.00**
- 2.4 Floodprone Width (ft) **101**

Notes:

The physical characteristic of the cross section indicated an F Stream Type. The entrenchments values calculated in the field have been modified using the adjusting factor of +/- 0.2. The Riffles have been partially eroded but you can still get some riffles

Step 2. (Contued)

- 2.5 Aband. Floodpln **7.80** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **28.40**
- 2.7 Entrenchment Ratio **1.19**
- 2.8 Incision Ratio **2.05**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Moderate**
- 2.10 Riffles Type **Eroded**
- 2.11 Riffle/Step Spacing (ft) **1,400**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	10 %
Coarse Gravel	42 %
Fine Gravel	16 %
Sand	32 %
Silt and smaller	0 %

- Silt/Clay Present? **No**
- Detritus **15** %
- # Large Woody **50**

2.13 Average Largest Particle on

Bed	136.0	mm
Bar	160.0	mm

2.14 Stream Type

- Stream Type: **F**
- 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	One	25.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Undercut**

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

Bank Erosion	Left	Right
Erosion Length (ft)	411	303
Erosion Height (ft)	9.03	7.20
Revetmt. Type	None	Rip-Rap
Revetmt. Length (ft)	0	2,196

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

Bank Canopy	Left	Right
Canopy %	26-50	1-25

Mid-Channel Canopy **Open**

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	>100	0-25
Sub-dominant	51-100	None
W less than 25	982	4,375

Buffer Veg. Type	Left	Right
Dominant	Mixed Trees	Herbaceous
Sub-dominant	Coniferous	Shrubs/Saplin

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Hay
Sub-dominant	Shrubs/Saplin	Commercial
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 **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
- (old) Upstrm Flow Reg **None**

4.7 StormwaterInputs

Field Ditch	0	Road Ditch	0
Other	5	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	4
Diagonal	**Delta**	**Island**
1	3	1

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
3	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: **3,237**
- 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: **Winooski River** Reach # **R22** Segment: **B** Completion Date: **September 7,**

Organization: **Winooski Conservation District** Observers: **Dan Smith, Noelia Báez Rodríguez** Rain: **Yes**

Segment Length (ft): **5,495** Segment Location: **R22-B starts ~ 300ft upstream of the concrete bridge along Route 2 and ends ~100ft**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Take	GPSTaken

4.8 Channel Constrictions **None**

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

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**3**	**C to F**	**Yes**
7.2 Channel Aggradation	**10**	**None**	**No**
7.3 Widening Channel	**8**		**No**
7.4 Change in Planform	**13**		**No**
Total Score	**34**		
Geomorphic Rating	**0.425**		

Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	7
6.2 Embeddedness	5
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	6
6.5 Channel Flow Status	12
6.6 Channel Alteration	7
6.7 Frequency of Riffles/Steps	8
6.8 Bank Stability	Left: 5 Right: 6
6.9 Bank Vegetation Protection	Left: 9 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 9 Right: 3
Total Score	90
Habitat Rating	0.45

Habitat Stream Condition **Fair**

Narrative:

Active degradation and widening in some areas evidently by banks of erosion, some aggradations at the mouth of the tributary Mallory Brook.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

 November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R23 Segment: 0 Completion Date: July 24, 2009

Organization: Winooski Conservation District Observers: Michael Blazewicz Why Not assessed: Rain: Yes

Segment Length (ft): 14,945 Segment Location: From upstream of the Route 2 bridge in East Montpelier to just downstream of the Route 14

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	3,657	338
height	21	30
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	2,324	847

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

1.5 Valley Features

Valley Width (ft) **1,000**

Width Determination **Estimated**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **128**

2.2 Max Depth (ft) **5.90**

2.3 Mean Depth (ft) **4.37**

2.4 Floodprone Width (ft) **223**

Notes:

Pebble count was conducted in a riffle that had larger material than was typical throughout reach therefore I listed this as a B4c channel since gravel was the dominant substrate. In the long stretches between riffles there was plenty of sand in the channel

Step 2. (Contued)

2.5 Aband. Floodpln **9.90** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **29.29**

2.7 Entrenchment Ratio **1.74**

2.8 Incision Ratio **1.68**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **Moderate**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **5,800**

2.12 Substrate Composition

Bedrock	0 %
Boulder	15 %
Cobble	40 %
Coarse Gravel	25 %
Fine Gravel	10 %
Sand	10 %
Silt and smaller	0 %

Silt/Clay Present? **Yes**

Detritus **5** %

Large Woody **123**

2.13 Average Largest Particle on

Bed	8.0	inches
Bar	4.0	inches

2.14 Stream Type

Stream Type: **B**

Bed Material: **Gravel**

Subclass Slope: **c**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	Multiple	43.00
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)	1,777	1,872
Erosion Height (ft)	9.28	9.80
Revetmt. Type	Rip-Rap	Multiple
Revetmt. Length (ft)	439	1,676

Near Bank Veg. Type	Left	Right
Dominant	Invasives	Invasives
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	0-25	0-25
Sub-dominant	>100	26-50
W less than 25	7,316	9,227

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Crop	Commercial
Sub-dominant	Forest	Crop
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

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	2	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	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	Yes

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **7,954**

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: **Winooski River** Reach # **R23** Segment: **0** Completion Date: **July 24, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **14,945** Segment Location: **From upstream of the Route 2 bridge in East Montpelier to just downstream 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?
Bridge	121.	Yes	Yes	Yes	Yes
Problem	None				
Bridge	126.	Yes	Yes	Yes	Yes
Problem	Deposition Above,Deposition Below				

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**5**	**E to B**	**Yes**
7.2 Channel Aggradation	**11**	**None**	**No**
7.3 Widening Channel	**5**		**No**
7.4 Change in Planform	**9**		**No**
Total Score	**30**		
Geomorphic Rating	**0.375**		

Channel Evolution Model **F**

Channel Evolution Stage **III**

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	13
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	9
6.5 Channel Flow Status	13
6.6 Channel Alteration	8
6.7 Frequency of Riffles/Steps	5
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: 2
Total Score	100
Habitat Rating	0.5

Habitat Stream Condition **Fair**

Narrative:

E channel has incised and widened. Erosion on outside bends triggering major sloughing and mass failures indicates planform adjustment. Small juvenile benches on the inside of some bends, much of floodplain is unavailable during bankfull flows.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R24 Segment: 0 Completion Date: July 21, 2009

Organization: Winooski Conservation District Observers: Michael Blazewicz Why Not assessed: Rain: Yes

Segment Length (ft): 5,811 Segment Location: From the confluence of the Kingsbury branch near the Cate Farm downstream to several

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	862	0
height	10	0
Roads	1,366	0
height	12	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	364	0

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

1.5 Valley Features

- Valley Width (ft) **378**
- Width Determination **Estimated**
- Confinement Type **Narrow**
- Rock Gorge? **No**
- Human-caused Change? **No**

Step 2. Stream Channel

- 2.1 Bankfull Width **75**
- 2.2 Max Depth (ft) **7.60**
- 2.3 Mean Depth (ft) **6.50**
- 2.4 Floodprone Width (ft) **600**

Notes:

Interesting very straight reach that is possibly in a narrow valley by reference but is also appears to be an E type channel by reference. Gravel mine on left bank may have been excavated from an existing hill, or may have been excavated in a wide

Step 2. (Contued)

- 2.5 Aband. Floodpln **9.10** ft.
- Human Elev Floodpln **0.00** ft.
- 2.6 Width/Depth Ratio **11.54**
- 2.7 Entrenchment Ratio **8.00**
- 2.8 Incision Ratio **1.20**
- Human Elevated Inc Rat **0.00**
- 2.9 Sinuosity **Low**
- 2.10 Riffles Type **Eroded**
- 2.11 Riffle/Step Spacing (ft) **3,000**

2.12 Substrate Composition

Bedrock	0%
Boulder	11%
Cobble	19%
Coarse Gravel	34%
Fine Gravel	20%
Sand	12%
Silt and smaller	4%

- Silt/Clay Present? **No**
- Detritus **2** %
- # Large Woody **65**

2.13 Average Largest Particle on

Bed	4.0	inches
Bar	N/A	inches

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	One	30.00
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	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	850	1,481
Erosion Height (ft)	6.71	7.22
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	309	547

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	26-50	>100
Sub-dominant	0-25	0-25
W less than 25	3,624	2,192

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Shrubs/Saplin	Forest
Sub-dominant	Crop	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 **Minimal**
- 4.3 Flow Status **Low**
- 4.4 # of Debris Jams **0**
- 4.5 Flow Regulation Type
  - 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	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	1
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: **2,140**
- 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: **Winooski River** Reach # **R24** Segment: **0** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**

Segment Length (ft): **5,811** Segment Location: **From the confluence of the Kingsbury branch near the Cate Farm downstream to**

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	60.0	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	**11**	**None**	**Yes**
7.2 Channel Aggradation	**14**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planform	**14**		**No**
Total Score	**50**		
Geomorphic Rating	**0.625**		

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

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	9
6.2 Embeddedness	12
6.3 Velocity/Depth Patterns	8
6.4 Sediment Deposition	13
6.5 Channel Flow Status	13
6.6 Channel Alteration	5
6.7 Frequency of Riffles/Steps	1
6.8 Bank Stability	Left: 7 Right: 6
6.9 Bank Vegetation Protection	Left: 4 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 6
Total Score	93
Habitat Rating	0.465

Habitat Stream Condition **Fair**

Narrative:

Stream appears straightened from a naturally fairly straight channel. Some floodplain access on the right and left banks has been lost from road building and berming near the gravel mine. Sediment transport high naturally, storage now more limited.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: **Winooski River** Reach # **R25** Segment: **0** Completion Date: **August 31, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Ann** Why Not assessed: Rain: **Yes**

Segment Length (ft): **11,971** Segment Location: **0.12 miles southeast of the Cate Farm/ Route 2 intersection**

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

Step 1. Valley and Floodplain

1.1 Segmentation **None**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	322	0
height	0	0
Roads	2,382	0
height	0	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	570	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) **810**

Width Determination **Estimated**

Confinement Type **Very Broad**

Rock Gorge? **No**

Human-caused Change? **no**

Step 2. Stream Channel

2.1 Bankfull Width **60**

2.2 Max Depth (ft) **3.90**

2.3 Mean Depth (ft) **2.70**

2.4 Floodprone Width (ft) **935**

Notes:

Multiple mass failures and extensive bank erosion. The landuse is mostly agricultural.

Reach revisited by GGA and SNP 10/21/09. Reach is aggradational, especially in the viscinity of the large mass failures just

Step 2. (Contued)

2.5 Aband. Floodpln **5.20** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **22.15**

2.7 Entrenchment Ratio **15.63**

2.8 Incision Ratio **1.33**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **High**

2.10 Riffles Type **Complete**

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

2.12 Substrate Composition

Bedrock	0%
Boulder	1%
Cobble	38%
Coarse Gravel	28%
Fine Gravel	8%
Sand	25%
Silt and smaller	0%

Silt/Clay Present? **Yes**

Detritus **5** %

Large Woody **75**

2.13 Average Largest Particle on

Bed **160.0** mm

Bar **20.0** mm

2.14 Stream Type

Stream Type: **C**

Bed Material: **Gravel**

Subclass Slope: **None**

Bed Form: **Riffle-Pool**

Field Measured Slope:

2.15 Reference Stream Type

(if different from Phase 1)

3.3 old	Amount	Mean Height
Failures	Multiple	46.33
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	Mix	Mix
Consistency	Non-cohesive	Non-cohesive
Bank Erosion	Left	Right
Erosion Length (ft)	3,703	2,423
Erosion Height (ft)	9.89	8.70
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,886	1,534
Near Bank Veg. Type	Left	Right
Dominant	Herbaceous	Herbaceous
Sub-dominant	Bare	Bare
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	0-25	0-25
W less than 25	2,974	1,489
Buffer Veg. Type	Left	Right
Dominant	Herbaceous	Herbaceous
Sub-dominant	Deciduous	Deciduous

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Hay	Forest
Sub-dominant	Forest	Crop
Mass Failures	0	0
Height	0	0
Gullies	0	0
Height	0	0

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps **Abundant**

4.2 Adjacent Wetlands **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	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
8	18	6
Diagonal	**Delta**	**Island**
2	0	3

5.2 Other Features

Flood	Neck Cutoff	Avulsion	Braiding
3	3	1	0

5.3 Steep Riffles and Head Cuts

Steep Riffles	Head Cuts	Trib Rejuv.
0	1	Yes

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **4,388**

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: **Winooski River** Reach # **R25** Segment: **0** Completion Date: **August 31, 2006**

Organization: **Winooski Conservation District** Observers: **Noelia Báez Rodríguez, Ann Smith** Rain: **Yes**

Segment Length (ft): **11,971** Segment Location: **0.12 miles southeast of the Cate Farm/ Route 2 intersection**

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	90.0	Yes	Yes	No	Yes
	Problem	Deposition Below			
Old	51.0	Yes	Yes	Yes	No
	Problem	Deposition Above,Deposition Below			

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**

	Score	STD	Historic
7.1 Channel Degradation	**9**	**Other**	**Yes**
7.2 Channel Aggradation	**6**	**None**	**No**
7.3 Widening Channel	**10**		**No**
7.4 Change in Planform	**4**		**No**
Total Score	**29**		
Geomorphic Rating	**0.3625**		

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

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	8
6.2 Embeddedness	10
6.3 Velocity/Depth Patterns	13
6.4 Sediment Deposition	6
6.5 Channel Flow Status	8
6.6 Channel Alteration	11
6.7 Frequency of Riffles/Steps	16
6.8 Bank Stability	Left: 1 Right: 2
6.9 Bank Vegetation Protection	Left: 1 Right: 2
6.10 Riparian Vegetation Zone Width	Left: 2 Right: 2
Total Score	82
Habitat Rating	0.41

Habitat Stream Condition **Fair**

Narrative:

Planform adjustment evidently by high sinousity and flood chutes. Reach revisited 10/21/09 by GGA and SNP. Previous comments regarding degradation as an active process were removed. Active processes appear to be widening and planform change.

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: Winooski River Reach # R26 Segment: 0 Completion Date: July 27, 2009

Organization: Winooski Conservation District Observers: Michael Blazewicz Why Not assessed: Rain: Yes

Segment Length (ft): 6,221 Segment Location: Flows from just downstream of the dam in Plainfield Village to about 3500 feet upstream 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	3,556	23
height	22	20
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	1,642	39

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

1.5 Valley Features

Valley Width (ft) **880**

Width Determination **Measured**

Confinement Type **Broad**

Rock Gorge? **No**

Human-caused Change? **Yes**

Step 2. Stream Channel

2.1 Bankfull Width **95**

2.2 Max Depth (ft) **6.00**

2.3 Mean Depth (ft) **4.84**

2.4 Floodprone Width (ft) **224**

Notes:

Trib rejuv checked for Great Brook. Fisherman described the channel undergoing major adjustment during a 1980 flood. Despite this, reach is still very popular for fishing due to habitat afforded by the high sinuosity. Pebble count indicated cobble

Step 2. (Contued)

2.5 Aband. Floodpln **9.10** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **19.63**

2.7 Entrenchment Ratio **2.36**

2.8 Incision Ratio **1.52**

Human Elevated Inc Rat **0.00**

2.9 Sinuosity **High**

2.10 Riffles Type **Complete**

2.11 Riffle/Step Spacing (ft) **700**

2.12 Substrate Composition

Bedrock	0 %
Boulder	19 %
Cobble	40 %
Coarse Gravel	27 %
Fine Gravel	13 %
Sand	1 %
Silt and smaller	0 %

Silt/Clay Present? **No**

Detritus **1** %

Large Woody **159**

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	Multiple	70.00
Gullies	None	0.00

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope **Steep**

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

Bank Erosion	Left	Right
Erosion Length (ft)	252	570
Erosion Height (ft)	5.29	5.28
Revetmt. Type	Rip-Rap	Rip-Rap
Revetmt. Length (ft)	1,353	698

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	26-50	>100
Sub-dominant	0-25	51-100
W less than 25	2,259	0

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Residential	Residential
Sub-dominant	Forest	Crop
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

Flow Regulation Use

Impoundments **Small**

Impoundmt. Location **Upstream**

4.6 Up/Down strm flow reg **Up Stream**

(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
2	4	2
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	Yes

5.4 Stream Ford or Animal **No**

5.5 Straightening **Straightening**

Straightening Length: **1,789**

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: **Winooski River** Reach # **R26** Segment: **0** Completion Date: **July 27, 2009**
Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **Yes**
Segment Length (ft): **6,221** Segment Location: **Flows from just downstream of the dam in Plainfield Village to about 3500 feet**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions **None**

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

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	**14**		**No**
7.4 Change in Planform	**8**		**No**
Total Score	**45**		
Geomorphic Rating	**0.5625**		

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

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type **High**

	Score
6.1 Epifaunal Substrate - Available Cover	16
6.2 Embeddedness	15
6.3 Velocity/Depth Patterns	18
6.4 Sediment Deposition	15
6.5 Channel Flow Status	13
6.6 Channel Alteration	9
6.7 Frequency of Riffles/Steps	15
6.8 Bank Stability	Left: 8 Right: 8
6.9 Bank Vegetation Protection	Left: 5 Right: 5
6.10 Riparian Vegetation Zone Width	Left: 4 Right: 7
Total Score	138
Habitat Rating	0.69
Habitat Stream Condition	**Good**

Narrative:

Historic degradation. Stream reacted to flood in 1980 and adjusted significantly in this reach. Current planform adjustment with aggradation and widening. Pebble count indicated cobble due to dam?, gravel dom. ref, sensitivity should be ranked VH

Project: Winooski - Montpelier to Cabot — **Phase 2 Segment Summary** — November 13, 2009 — SGAT Version: 3

Stream: **Winooski River** Reach # **R27** Segment: **A** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Why Not assessed: **impounded** Rain: **No**

Segment Length (ft): **1,780** Segment Location: **From just downstream of the Plainfield Dam to 1500 feet upstream of the dam where the**

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

Step 1. Valley and Floodplain

1.1 Segmentation **Other Reason**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	0	1,460
height	0	20
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	0	1,652

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

1.5 Valley Features

Valley Width (ft) **275**

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:

Partial assessment due to Plainfield Dam. Lower 280 feet of reach is a high gradient channel that should have been included as part of reach r26.

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:

Bed Material:

Subclass Slope:

Bed Form:

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	Sand	Sand
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	0	0
Erosion Height (ft)	0.00	0.00
Revetmt. Type	Multiple	Multiple
Revetmt. Length (ft)	549	439

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Herbaceous
Sub-dominant	Herbaceous	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	0-25
Sub-dominant	None	None
W less than 25	1,011	1,524

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Residential	Residential
Sub-dominant	Commercial	Commercial
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

Flow Regulation Use

Impoundments **Small**

Impoundmt. Location **In Reach**

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

(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	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: **1,516**

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: **Winooski River** Reach # **R27** Segment: **A** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **No**

Segment Length (ft): **1,780** Segment Location: **From just downstream of the Plainfield Dam to 1500 feet upstream of the dam where**

1.6 Grade Controls

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken
Dam		17.00	14.00		

4.8 Channel Constrictions

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?
Bridge	55.0	Yes	Yes	Yes	Yes

Problem Scour Below

Narrative:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type

Channel Evolution Model

Channel Evolution Stage

Geomorphic Condition

Stream Sensitivity

Step 6. Rapid Habitat Assessment Data

Stream Gradient Type

Habitat Stream Condition

Project: Winooski - Montpelier to Cabot

Phase 2 Segment Summary

November 13, 2009 SGAT Version: 3

Stream: **Winooski River** Reach # **R27** Segment: **B** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Why Not assessed: Rain: **No**

Segment Length (ft): **2,700** Segment Location: **From the John Fowler Road Bridge in Marshfield downstream to 1500 feet above the**

QC Status - Staff: **Provisional Cons**

Step 1. Valley and Floodplain

1.1 Segmentation **Other Reason**

1.2 Alluvial Fan **None**

1.3 Corridor Encroachments

Length (ft)	One	Both
Berms	0	0
height	0	0
Roads	1,809	0
height	20	0
Railroads	0	0
height	0	0
Improved Paths	0	0
height	0	0
Development	917	0

1.4 Adjacent Side	Left	Right
Hillside Slope	Steep	Steep
Continuous w/	Never	Never
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 **80**

2.2 Max Depth (ft) **7.60**

2.3 Mean Depth (ft) **6.04**

2.4 Floodprone Width (ft) **600**

Notes:

Reach with very low slope. Meanders are almost non existent and it is likely that there was extensive straightening on this reach. Because slope is low and energy does not exist to create many new meanders (my estimation) the healthy and long term water

Provisional *Step 2. (Contued)*

2.5 Aband. Floodpln **7.60** ft.

Human Elev Floodpln **0.00** ft.

2.6 Width/Depth Ratio **13.25**

2.7 Entrenchment Ratio **7.50**

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) **0**

2.12 Substrate Composition

Bedrock	0 %
Boulder	0 %
Cobble	0 %
Coarse Gravel	5 %
Fine Gravel	30 %
Sand	60 %
Silt and smaller	5 %

Silt/Clay Present? **No**

Detritus **5** %

Large Woody **15**

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	Sand	Sand
Consistency	Non-cohesive	Non-cohesive
Lower		
Material Type	Silt	Silt
Consistency	Cohesive	Cohesive

Bank Erosion	Left	Right
Erosion Length (ft)	115	205
Erosion Height (ft)	4.00	4.59
Revetmt. Type	Multiple	Rip-Rap
Revetmt. Length (ft)	95	175

Near Bank Veg. Type	Left	Right
Dominant	Shrubs/Saplin	Shrubs/Saplin
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	>100	0-25
Sub-dominant	0-25	26-50
W less than 25	0	2,219

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

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	Forest	Residential
Sub-dominant	Hay	Commercial
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 **Moderate**

4.4 # of Debris Jams **0**

4.5 Flow Regulation Type

Flow Regulation Use

Impoundments **None**

Impoundmt. Location

4.6 Up/Down strm flow reg **Down Stream**

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

4.7 StormwaterInputs

Field Ditch	1	Road Ditch	0
Other	1	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: **2,507**

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: **Winooski River** Reach # **R27** Segment: **B** Completion Date: **July 21, 2009**

Organization: **Winooski Conservation District** Observers: **Michael Blazewicz** Rain: **No**

Segment Length (ft): **2,700** Segment Location: **From the John Fowler Road Bridge in Marshfield downstream to 1500 feet above the**

1.6 Grade Controls **None**

Type	Location	Total	Total Height Above Water	Photo Taken	GPSTaken

4.8 Channel Constrictions **None**

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

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	**11**		**No**
7.4 Change in Planform	**17**		**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	10
6.2 Pool Substrate	10
6.3 Pool Variability	5
6.4 Sediment Deposition	13
6.5 Channel Flow Status	16
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: 2
6.10 Riparian Vegetation Zone Width	Left: 3 Right: 1
Total Score	92
Habitat Rating	0.46
Habitat Stream Condition	**Fair**

Narrative:

E channel that has been overwidened. Riparian buffer has been impacted by agriculture and channel has been extensively straightened historically. Some old riprap, some new, some recent erosion overall channel appears stable. Limited habitat.

APPENDIX C

STRESSOR IDENTIFICATION MAPS

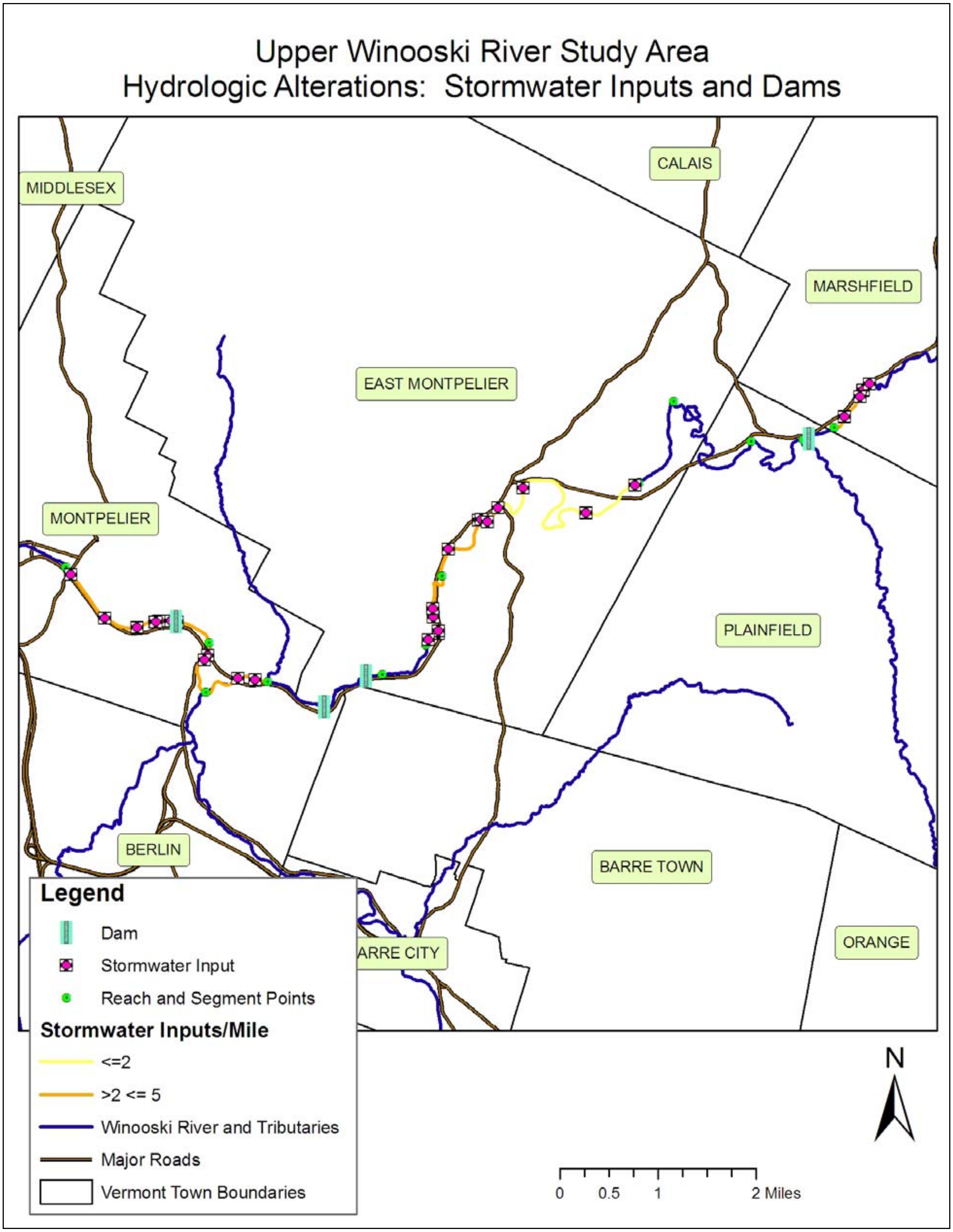


Figure 1: Stormwater Inputs and Dam Location: Upper Winooski River Study Area (M18-M27)

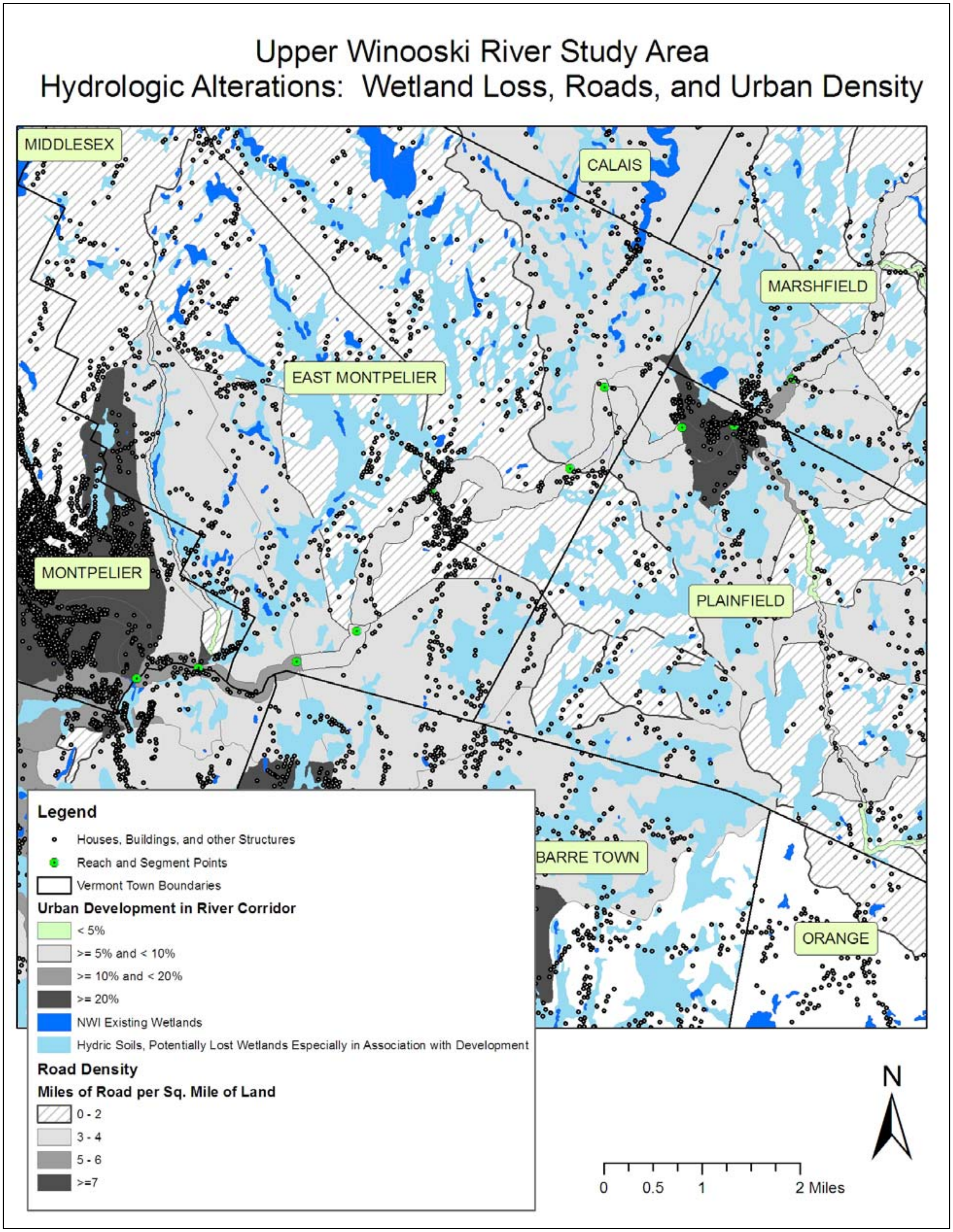


Figure 2: Potential Wetland Loss, Density of Roads and Urban Development: Upper Winooski River Study Area (M18-M27)

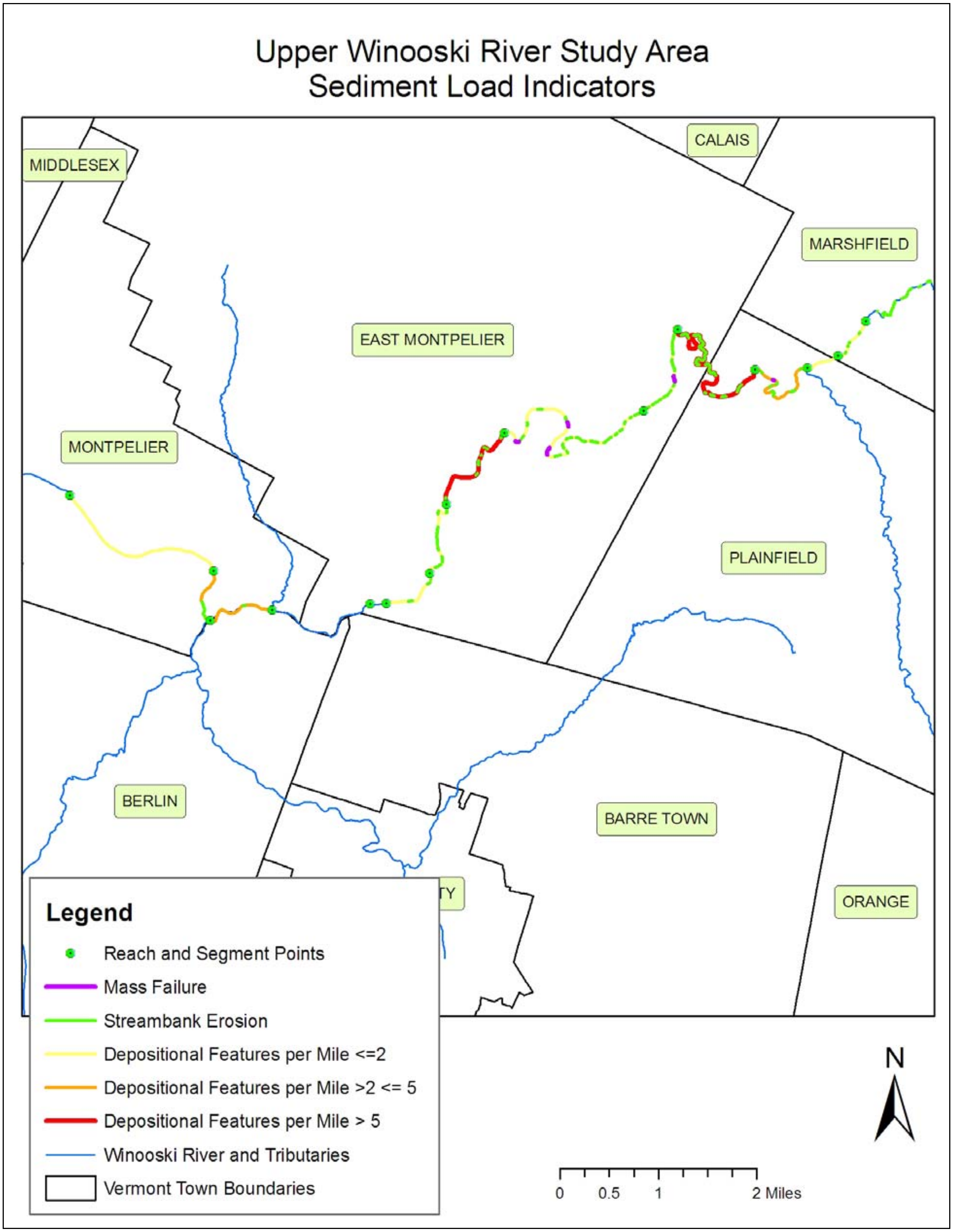


Figure 3: Sediment Inputs to the Upper Winooski River Study Area (M18-M27)

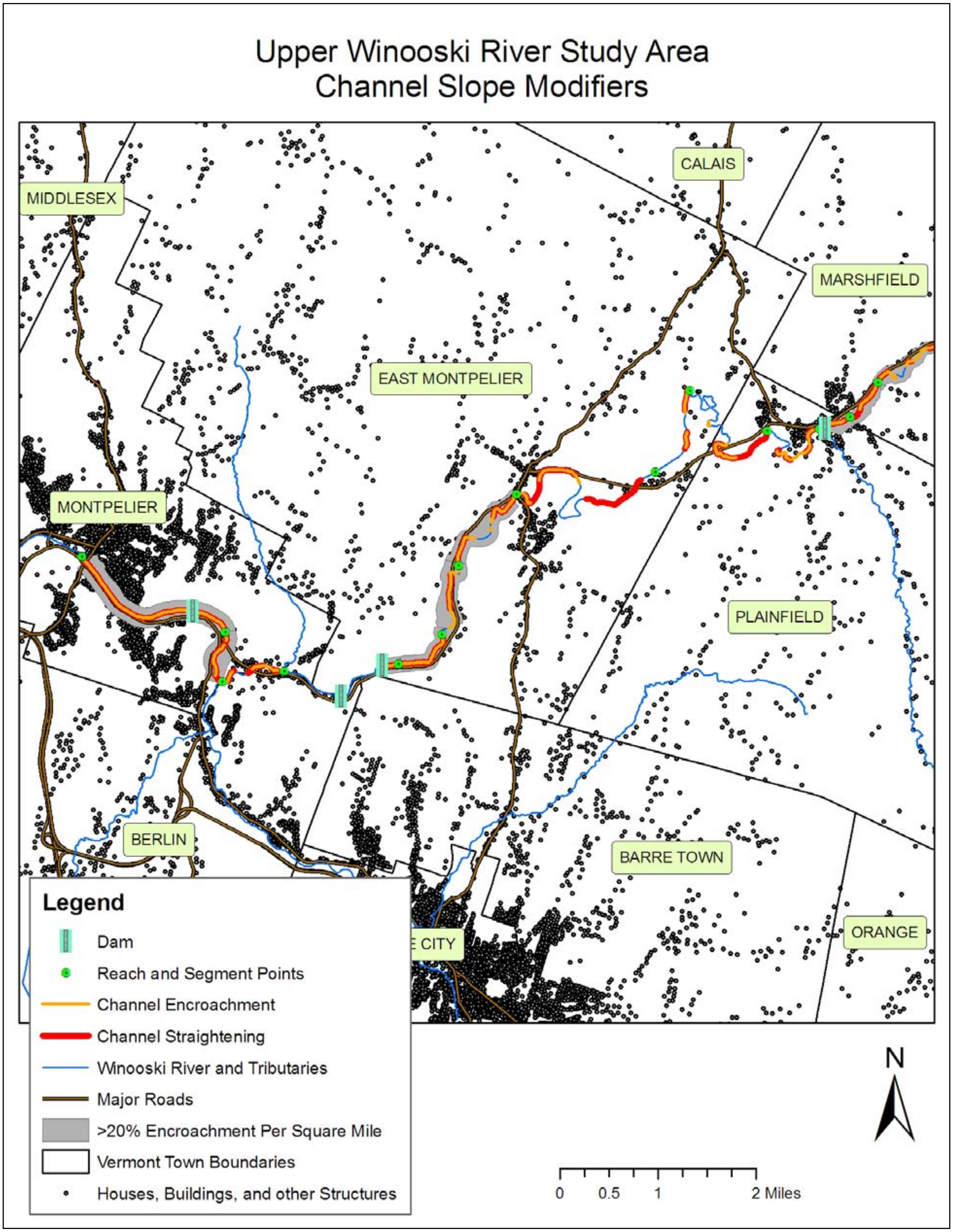


Figure 4: Channel Slope Modifiers of the Upper Winooski River Study Area (M18-M27)

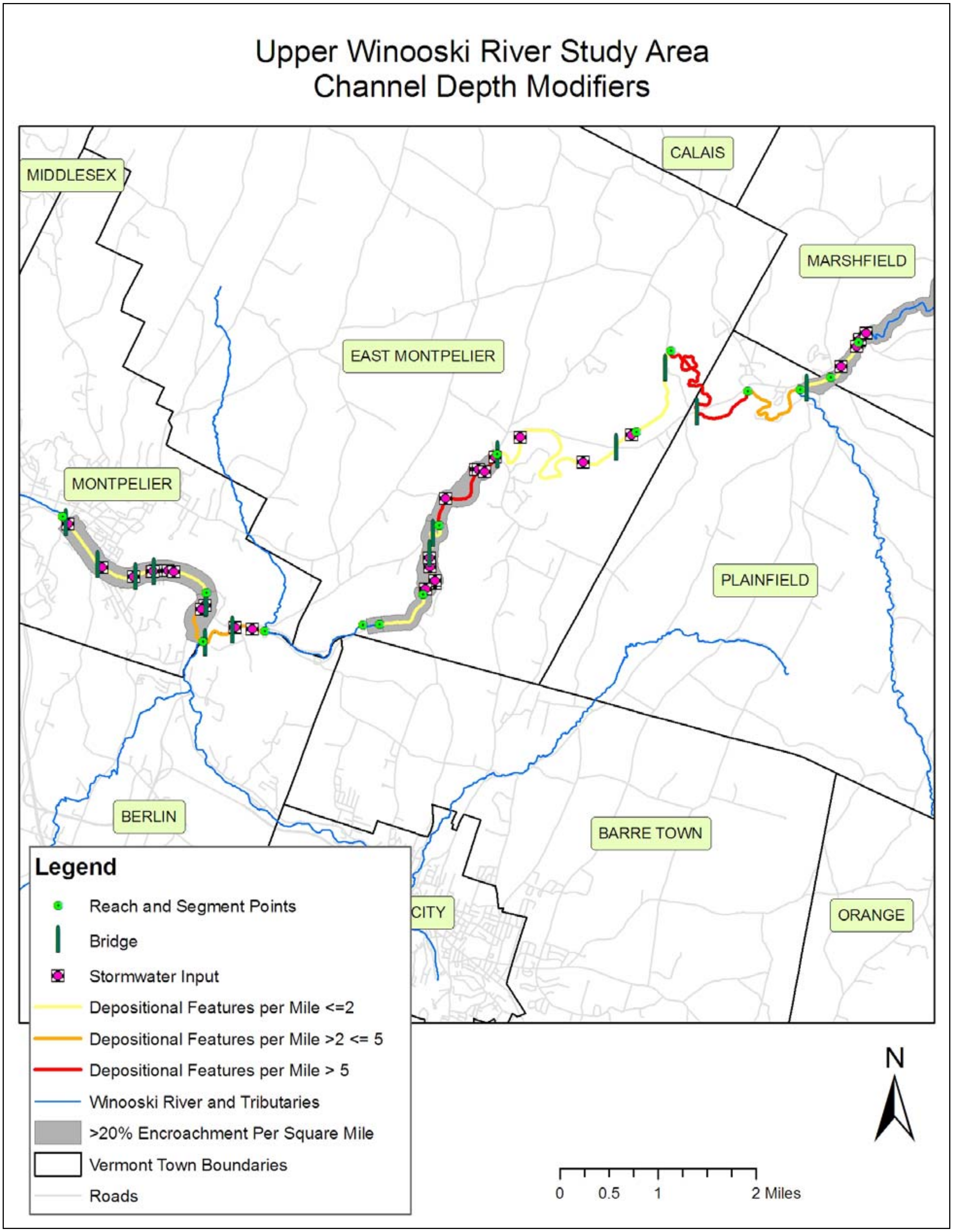


Figure 5: Channel Depth Modifiers of the Upper Winooski River Study Area (M18-M27)

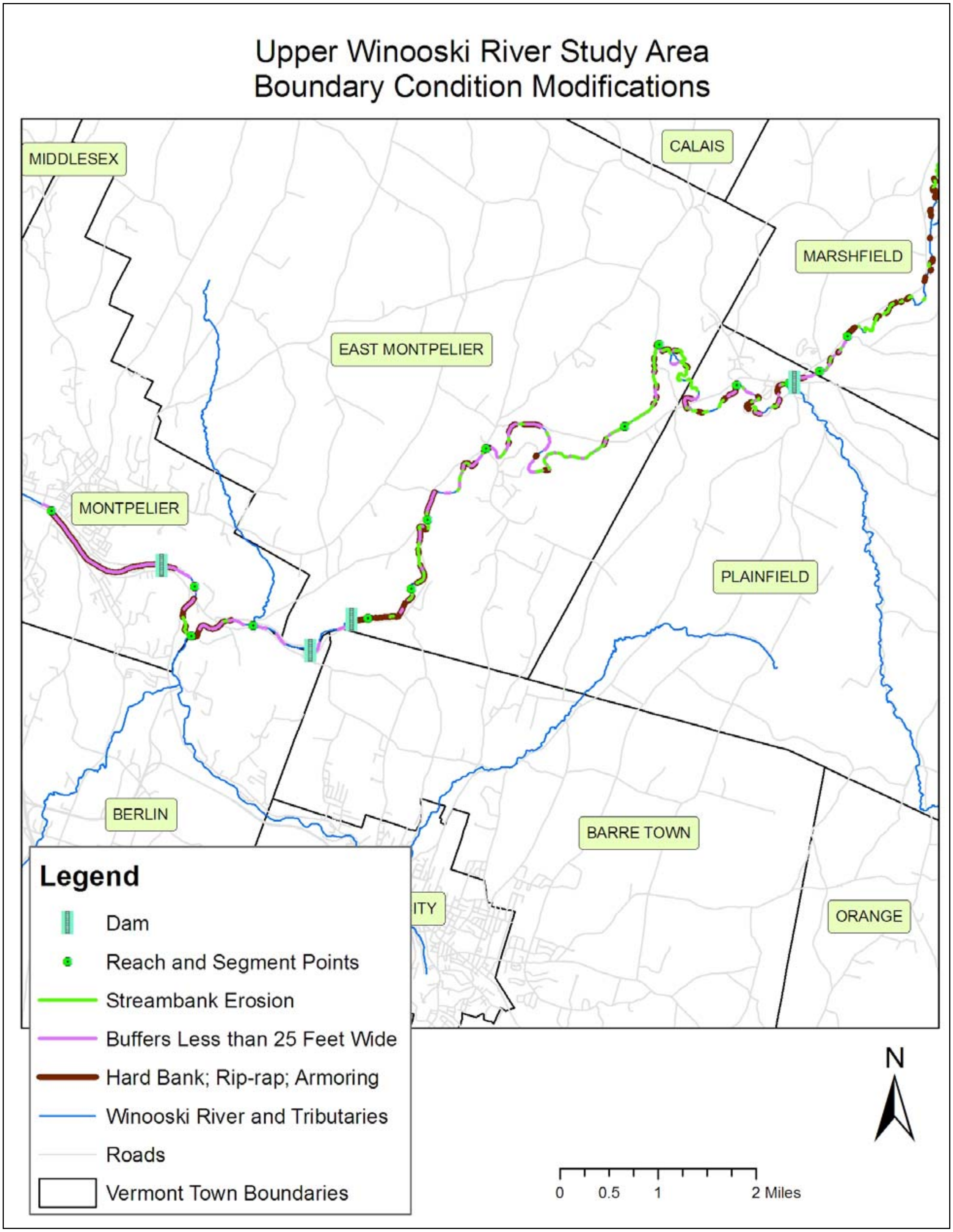


Figure 6: Boundary Condition Modifiers of the Upper Winooski River Study Area (M18-M27)

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.

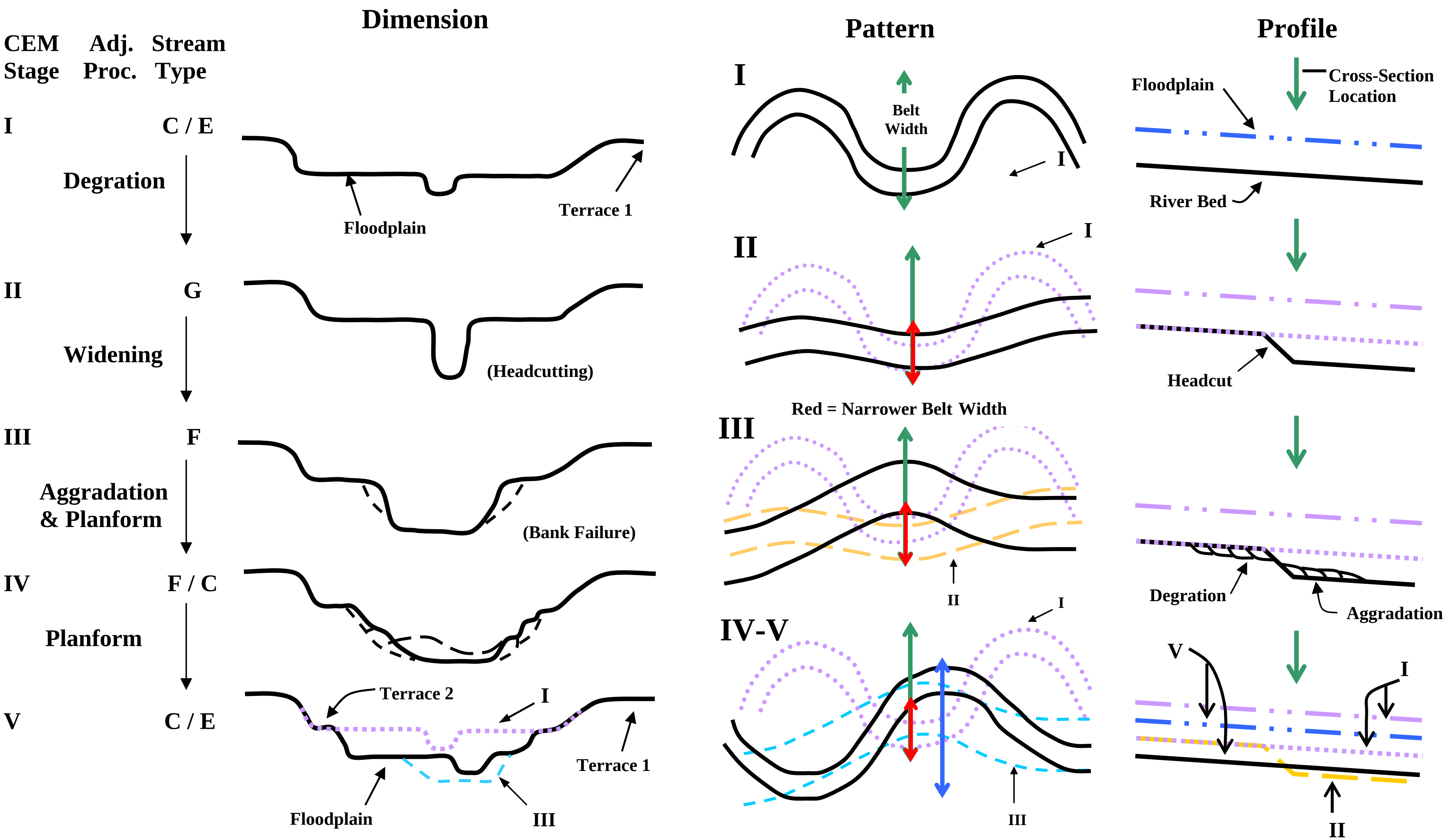
Stage III - Channel is still entrenched, widening and migrating laterally through bank erosion caused by the increased stream power (B or G or F Stream Type). The system regains balance between the power produced and the boundary materials as sinuosity increases and slope decreases. There are profound 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)