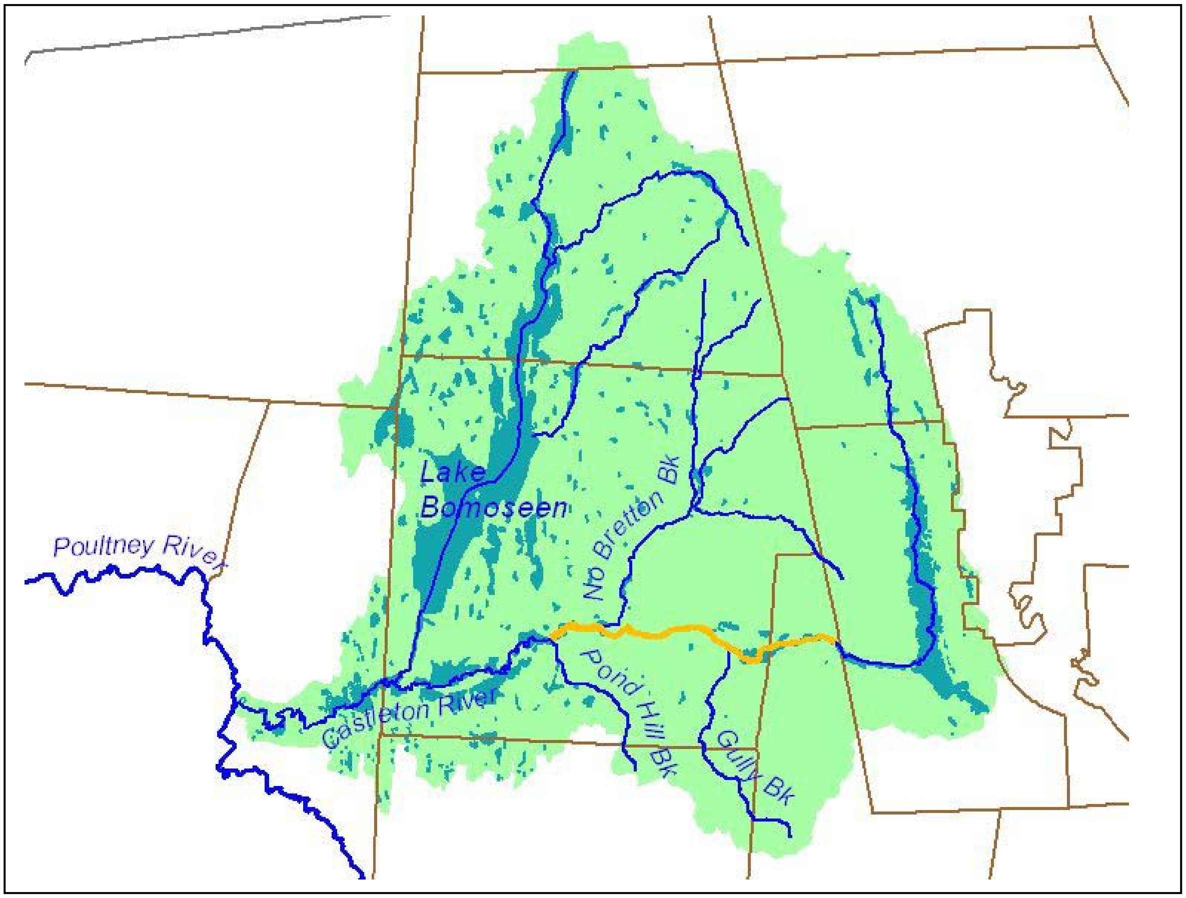
DRAFT River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007



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ACKNOWLEDGEMENTS

This corridor planning project has been supported by a Vermont Agency of Natural Resources Water Quality Division, Category 2 River Corridor Grant (FY2006).

Recommendations in the plan are based upon the geomorphic condition of the river corridor revealed from assessment work previously completed by South Mountain Research & Consulting of Bristol, Vermont. Previous assessment work was funded under a Section 319 Grant from VT Water Quality Division administered by the Poultney-Mettowee Natural Resource Conservation District and a 604B Grant from the VT Water Quality Division administered by the Rutland Regional Planning Commission.

The work presented in this document is the result of a collaborative effort by members of the technical working group, Castleton town officials, State and regional agencies, conservation organizations, interested community members, and open discussions with the many landowners who own property along the Castleton river reaches.

EXECUTIVE SUMMARY

The Poultney-Mettowee Natural Resources Conservation District (Poultney, VT) received a grant from the Vermont Department of Environmental Conservation (VTDEC) to develop a River Corridor Plan for a 6-mile length of the Castleton River in the town of Castleton from the eastern town boundary with Ira downstream to the Castleton village. Funding has been appropriated through Governor Douglas' Clean & Clear Action Plan. This grant has funded a 12-month outreach and planning process with the long-term objectives of reducing streambank erosion, sediment, and nutrient loading, by managing for the equilibrium channel. This planning project builds upon results of a geomorphic study of the river and select major tributaries that was completed in 2005 and 2006 by the PMNRCD under separate funding.

A Technical Working Group for the project was convened, consisting of Marli Rupe (Poultney-Mettowee NRCD), Hilary Solomon (Poultney-Mettowee Watershed Partnership), Shannon Pytlik (VTDEC River Management Section), Ethan Swift (VTDEC Planning Section), and Kristen Underwood (South Mountain Research & Consulting).

In May of 2006, a direct mailing was sent to landowners along this section of the Castleton River. From May 2006 to April 2007, the Poultney-Mettowee NRCD conducted outreach with several landowners to discuss the project, assisted on occasion by South Mountain R&C. Landowner interviews provided an opportunity to discuss the goals of this project, to gather information from landowners about river corridor constraints, land uses, concerns, and to identify river management alternatives acceptable to the landowners.

In May 2006 and January 2007, various members of the Technical Working Group for this project attended meetings of the Castleton Planning Commission. Fluvial Erosion Hazard Corridor Maps were introduced displaying a proposed fluvial erosion hazard corridor designed to assist landowners and the town of Castleton in avoiding future erosion losses during floods. An overlay district based on the Fluvial Erosion Hazard mapping was discussed as a potential tool along with various other planning and zoning strategies. The Planning Commission has requested additional feedback as they work to revise the Castleton Town Plan and Zoning Regulations. Assistance from the Technical Working Group to these organizations is continuing, as needed.

A draft River Corridor Plan has been prepared for public review. The plan identifies and ranks short-term and long-term actions for implementation, including potential river restoration and conservation projects.

CASTLETON RIVER
CORRIDOR MANAGEMENT PLAN:
TOWN OF CASTLETON

1.0 INTRODUCTION

The Poultney-Mettowee Natural Resources Conservation District has completed a river corridor planning process funded by a Category 2 - Project Development grant through the VTDEC Water Quality Division, River Management Section. This 12-month process has explored potential site-level, town-level, and watershed-level strategies for reducing streambank erosion and sediment and nutrient loading in the Castleton River, by managing toward the equilibrium channel.

Through outreach to individual landowners and through a series of working meetings, a Technical Working Group has identified river corridor management strategies. The study area has focused on the Castleton River main stem reaches from the eastern town border with Ira downstream to the Castleton village (reaches T02.12 through T2.09 – highlighted on the cover sheet of this report).

While focusing on the four reaches east of Castleton village, the process has considered consequences of channel and watershed management choices farther upstream and downstream (and in contributing tributaries), as informed by results of geomorphic assessments previously completed in the watershed (SMRC, 2005).

This draft plan is offered for public review and comment. It is anticipated that a final, publicly-approved plan could be incorporated by reference in the next update to the Castleton Town Plan. This corridor plan could also be considered in the context of future updates to the Rutland County Region-wide All Hazards Mitigation Plan and its Castleton section. Acknowledgement of the science of fluvial geomorphology, the current geomorphic condition of the river, and the continuity of river networks, will help to ensure compatibility of this Castleton River Corridor Plan with other corridor plans that may be developed by adjoining communities (e.g., Fair Haven).

The Plan is intended to facilitate action, and contains a prioritization of various planning, restoration and conservation projects. General methods and resources are provided so that community members and landowners can follow-through on recommended implementation strategies, and secure funding and resources.

This Plan is intended to support an adaptive management approach to the river corridor, as conditions change and the community's understanding of river dynamics evolves.

2.0 BACKGROUND and PREVIOUS STUDIES

The main impetus for development of this River Corridor Management Plan has been the repeated flood losses experienced by Castleton residents in recent years, including the floods of 1981, 1998, and 2000.

Additional focus on these particular reaches is warranted to ensure the long-term sustainability of the Gully Brook restoration project recently completed by the VT Agency of Natural Resources and collaborating regional, state and federal agencies. The Gully Brook flows into the Castleton River main stem at mid-point of this section of river corridor, and adjustment processes in the two channels are inextricably linked.

2.1 Fluvial Erosion Hazards and Flood Losses

The Town of Castleton is a participant in the National Flood Insurance Program, and the Federal Emergency Management Agency (FEMA) has delineated areas along the Castleton River main stem which are at risk from flooding by inundation (rising water). However, there is increasing recognition within Castleton, Vermont, and the nation, that flood damages in recent years have occurred not entirely as a result of rising waters, but also from sudden erosion of streambanks and channel avulsions during flood events (VTDEC Water Quality Division, 1999; VT Dept of Housing & Community Affairs, 1998; FEMA, 2003).

The risks of these fluvial erosion hazards are not adequately captured by the FEMA Flood Insurance Rating Maps (FEMA-FIRM). Often, properties and infrastructure located outside the boundary of the FEMA-FIRM floodway, or elevated above the predicted flood stage, are incurring losses as a result of streambank erosion. Often these are locations of repeated losses over the years.

2.2 Water Quality

Summer-time water quality sampling (2006) conducted by the Poultney-Mettowee Watershed Partnership has identified phosphorus and *E. coli* impacts in the Castleton River. Results are available at the Poultney-Mettowee Watershed Partnership web site (http://www.poultneymettowee.org/water_quality.html)

E.coli has been detected above the State water quality standard (77 colony-forming-units per 100 mL) (PMWP, 2006). Total phosphorus concentrations were at levels that would suggest nutrient enrichment. No in-stream Vermont water quality standard exists for Total Phosphorus, at present. However, elevated phosphorus levels lead to algae production in the river and in the receiving waters, Poultney River and Lake Champlain. The algae decomposition process consumes oxygen from the water, leading to reduced oxygen levels that may impair populations of fish and other aquatic organisms. In recent years, phosphorus has been linked to the production of toxic blue-green algae along the shores of Lake Champlain (LCBP, 2005).

In addition to agricultural and developed land use practices, eroding streambanks have been identified as a contributing nonpoint source of phosphorus in rivers and streams of Vermont (VTANR, 2001; DeWolfe *et al.*, 2004).

3.0 PLAN OBJECTIVES

River corridor management planning, which acknowledges the dynamic nature of rivers and manages toward the equilibrium (or balanced) condition of our rivers, has been identified in the State of Vermont and elsewhere in the nation as an ecologically and economically sustainable means of addressing the above concerns for fluvial erosion hazards, and degraded water quality and riparian habitats (VTDEC River Management Section, 2005a, 2005b, 2003; VTDEC Water Quality Division, 1999; USEPA, 1995). Managing toward dynamic equilibrium of river channels, can reduce erosion hazards and improve channel stability in the long term, thereby reducing sedimentation and nutrient loading to our rivers. Reduced sedimentation and nutrients, in turn, will improve in-stream and Lake Champlain habitats.

A community-based river corridor planning process recognizes the public value of riparian areas and the need for public resources to support and facilitate stewardship of these lands in private and public ownership.

The following objectives have been identified for this Castleton River Corridor Plan:

a) Improve water quality, restore habitats, and reduce erosion hazards by managing toward the equilibrium channel.

b) Analyze previous geomorphic assessment work, identify the causes of channel instability, and evaluate options for restoring long-term stability to the river.

c) Identify sustainable river corridor management strategies through continued outreach to individual landowners and through a series of public forums.

d) Review potential channel management choices for their effectiveness and potential consequences to downstream and upstream properties and infrastructure.

e) Prepare a River Corridor Plan for public review by March 2007. The plan will identify and rank short-term and long-term actions and approaches for implementation, including potential river restoration projects.

4.0 CORRIDOR PLANNING TASKS

The river corridor planning process for the Castleton River reaches (T02.12 – T02.09) has included the following tasks: (1) establishment of a Technical Working Group; (2) delineation of a river corridor to define the spatial context for discussion of various management strategies; (3) analysis of existing geomorphic data to identify restoration and conservation strategies which will facilitate the river's ability to laterally adjust; (4) attendance at Castleton public meetings; and (5) individualized landowner outreach.

Identification of various site-level and watershed-level corridor management strategies followed from the consideration of the geomorphic condition at various locations along the river corridor and from the feedback received during individual landowner outreach meetings and public meetings. The site-level and watershed-level strategies are outlined in Section 5.0. Select strategies and projects were prioritized, and short-term and long-term implementation plans are outlined in Section 6.0.

4.1 Technical Working Group

A Technical Working Group (TWG) was established to steward the river corridor planning process. The TWG convened several meetings from April 2006 through March 2007.

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4.2 Corridor Delineation Based on Geomorphic Condition

To define the area within which management options would be considered, a riparian corridor was delineated. Corridor delineation is based, in part, on geomorphic condition and sensitivity as defined by results of the geomorphic assessment work previously completed in the watershed (SMRC, 2005).

Results of the geomorphic assessment of the four reaches are briefly summarized in Appendix A. Specifics of the process for delineating the river corridor are summarized in Appendix B.

The river corridor has been introduced to the Castleton Planning Commission (22 January 2007 meeting) as a means for the Castleton community to meet the objectives of reducing fluvial erosion hazards, reducing sediment and nutrient loading to the river, and improving water quality and riparian habitats. Proposed Castleton zoning regulations (October 2006) call for a 100-foot no-build set-back "*from the mean high water mark of rivers and streams …except for uses and structures that do not have the potential to threaten the stability of the streambank*." This limitation would appear to be subject to interpretation of the reviewer. Moreover, given the dynamic nature of rivers, the mean high water mark can migrate over time, which can complicate implementation of this zoning limitation. A river corridor management area that acknowledges the dynamic nature of rivers and which is based on the geomorphic condition of the channel has advantages over a simple, no-build setback from the river.

River channels vary in width along their length, depending on the size and nature of the upstream watershed draining to a given location, and the valley setting of the channel. Rivers are also continuously adjusting their position in the landscape, both vertically and laterally, in an attempt to optimize their slope and channel dimensions to efficiently carry the water and sediment loads supplied from the upstream watershed. A default setback is often inadequate and difficult to administer where a river is adjusting laterally at a rate of several feet per year.

A river corridor is a footprint in the landscape, which encompasses the dynamically-adjusting river channel. The corridor varies in width along its length, accounting for the actual width of the river channel at various locations, the size and nature of the watershed draining to that particular reach, knowledge of historic migration patterns of the river, and the position of the steep valley walls adjacent to the channel.

Definitions

Setback – a specified distance perpendicular to a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. For example, setbacks could be established to prevent new structures adjacent to waterways. While new structures would not be allowed, the area of land within the setback could be considered to count toward density requirements under zoning.

Overlay District – an area of variable size and width surrounding a channel or waterbody, in which specific standards are established concerning structures, land use activities, and/or vegetative conditions. Overlay Districts are informed by geomorphic assessments and developed to meet specific functions, such as reducing streambank erosion losses and reducing sediment and nutrient loading to receiving waters by managing toward the equilibrium channel.

Buffer – zone of undisturbed natural vegetation alongside a channel or waterbody, in which no new structures are permitted, and disturbance of the natural land surface is minimized. The vegetated buffer represents a transition zone which functions to protect the waterway from disturbances and adjacent land uses. Buffers can be established at a default distance perpendicular to the channel or waterbody. Ideally, for rivers and streams, buffer distances should be informed by geomorphic assessments, and will be wider for adjusting reaches, narrower for stable reaches (e.g., following VTANR Riparian Buffer Guidance).

4.3 Analyze Existing Geomorphic Data to Identify Management Strategies

The Phase 1 and 2 Geomorphic Assessment data collected along the Castleton River main stem (SMRC, 2005) were analyzed during the corridor planning process to identify corridor management strategies that could support the river's return to a more balanced condition, thereby reducing erosion hazards and improving water quality over the long term. The analysis follows recent guidance from the VTDEC River Management Section (VTDEC, 2005) and included:

- Classifying corridor reaches into general management categories based on their geomorphic condition. This step involves identifying, qualitatively, the sediment transport characteristics of the corridor reaches, to identify the major sediment deposition and transport modifiers.
- Acknowledging natural constraints (bedrock) and human constraints (roads, buildings, bridges, dams) along the river corridor that limit the river channels' ability to laterally and vertically adjust in response to changing water and sediment conditions.
- Identifying sediment sources which may be impacting the sediment transport capacities in the watershed.
- Locating areas of active lateral adjustment and wetland areas contiguous to the channel which may serve important sediment and nutrient attenuation functions in the watershed.

Details of this geomorphic data analysis are summarized in Appendix A. The geomorphic conditions noted have informed the river corridor management strategies outlined in Section 5.

4.4 Attendance at Castleton Public Meetings

The Technical Working Group attended two Castleton Planning Commission meetings over the past year – 18 May 2006 and 23 January 2007. A handout distributed at these meetings is reproduced in Appendix C. Additional background documents published by the VTANR Water Quality Division were also distributed – including select documents noted under *Publications* in Appendix E.

The Vermont River Management Section (Shannon Pytlik and Ethan Swift) have been in communication with the Castleton Planning Commission (Shelley Rogers, Scott Lobdell). The Planning Commission has requested review of the Natural Resources section of their Town Plan and proposed Zoning Regulations to incorporate elements of fluvial erosion hazard protection and water quality protection. Continuing assistance to the Castleton Planning Commission from members of the Technical Working Group is anticipated.

4.5 Individualized Outreach

Outreach was conducted on an individualized basis to several riparian landowners within the four reaches of the Castleton River main stem that are the subject of this corridor plan.

May 2006 – A direct mailing was sent to ## riverside landowners, introducing the project, identifying the technical working group and inviting participation from landowners. A copy of the landowner letter is provided in Appendix C.

May 2006 – March 2007 – Meetings and communications with individual landowners were carried out by the Poultney-Mettowee NRCD, with occasional assistance from South Mountain Research & Consulting. Feedback from landowners and outcomes of these meetings were summarized in a project database (reprints from which are documented in Appendix D).

5.0 OPPORTUNITIES & RESOURCES: Selection & Prioritization of Management Strategies

Geomorphic studies (Appendix A) and landowner outreach efforts conducted to date have identified several opportunities for working toward the objectives of erosion mitigation, water quality improvement, and habitat restoration along the Castleton River main stem (east of Castleton village).

Potential opportunities are categorized into site and reach-level management options (Section 5.1) and watershed-level management options (Section 5.2). Many resources at the private, municipal, state and federal levels are available to convert these opportunities into action. Appendix E provides a listing of some of these resources.

5.1 Site/Reach – Level Management Alternatives

Based upon the stream conditions summarized in Appendix A, and feedback obtained from landowners, the TWG has identified discrete site-level and reach-level projects which could be most effective at reducing sediment and nutrient loading to the Castleton River watershed. These are summarized in Appendix D. Geomorphically-informed restoration and conservation projects were identified, and classified into "passive" or "active" approaches based on geomorphic condition. Technically-feasible projects were then prioritized based on landowner approval, gross measures of cost (low, medium, high), and the extent to which each project addressed the primary objective of sediment and nutrient reduction in the watershed.

5.2 Watershed-Level Management Strategies

Several watershed-level management strategies were identified that should be undertaken to achieve nutrient / sediment reductions, reduce potential for future fluvial erosion hazards, and restore and conserve riparian habitats.

5.2.1 Town Planning

The TWG has recently introduced the concept of fluvial erosion hazard (FEH) corridors to the Castleton Planning Commission. A preliminary FEH corridor has been developed by the VTDEC River Management Section for four reaches of the Castleton River main stem during this Corridor Planning project (Appendix B). The Planning Commission has expressed an interest in learning more and considering the potential benefits and consequences of incorporating FEH corridors in town planning.

The Castleton community is presented with an opportunity to engage in a proactive planning process that supports the river's ability to move toward an equilibrium condition. Planning strategies can ensure that new development does not further encroach on the river corridor, reduce the sediment and flow attenuation functions of the floodplain area, and place infrastructure at risk of fluvial erosion losses.

Currently, funding and technical resources are available to the town to support a public planning process to review the possible role of a corridor overlay district in town planning and to develop a viable draft ordinance for public review.

5.2.2 Crossing Structures

Undersized or improperly sited bridge and culvert crossing structures were identified as contributors to localized channel instabilities in the Castleton River watershed. When these crossing structures are scheduled for rehabilitation or replacement, the geomorphic context should be considered. For future development, the town of Castleton could establish ordinances or identify zoning requirements which would ensure adherence to proper siting and design practices for future development. The geomorphic context should be considered when designing new and rehabilitated structures.

- New or replacement bridges and culverts should ideally have openings which pass the bankfull width without constriction. Bankfull widths and flood-prone widths have been measured for the assessed reaches during the Phase 2 assessment and are available to the Town for future crossing structure designs.

- Bridges and culverts should be designed to cross the river without creating channel approaches at an angle to structures. Such sharp angles can lead to undermining of fill materials and structural components.

- The historic channel migration pattern of the river should be considered when installing new or replacement crossing structures, and when constructing new roads, driveways, and buildings. Corridor protection strategies that prevent or limit placement of infrastructure within the corridor will protect structures from future erosion and flood losses.

- Planned build-out for watershed communities and resultant channel enlargement (from increased percent imperviousness) should be considered when designing new or replacement bridges and crossing structures.

Potential funding sources to support public planning and development of such ordinances for crossing structures include: Better Back Roads grants, Municipal Planning Grants (VT Department of Housing and Community Affairs), or Vermont Watershed Grants (see Appendix E).

6.0 PLAN IMPLEMENTATION

Implementation of this River Corridor Plan will be achieved through both short-term and long-term approaches.

6.1 Short-term

6.1.1 Review of the draft plan by riverside landowners and Castleton officials

In the Summer of 2007, this draft plan will be shared with riverside landowners as well as Castleton officials, including the Planning Commission and Selectboard. Feedback will be incorporated in a subsequent draft of the plan. Respective roles and tasks for continued stewardship of the plan will be determined through discussions with Castleton officials.

6.1.2 Proceed with further education / outreach concerning a possible River Corridor Overlay District.

As requested, the Poultney-Mettowee NRCD and the River Management Section will continue to make themselves available to Castleton town officials to discuss the possible role of a River Corridor Overlay District in town planning.

6.1.3 Seek funding for high-priority, landowner-approved projects.

As of Spring 2007, the Poultney-Mettowee NRCD has made an application to the VTDEC River Management Section for a Category 2/3 River Corridor Grant to fund project development activities concerning: (a) possible conservation and buffer enhancements along the Castleton main stem upstream of the Fort Warren mobile home park; and (b) alternatives analysis of a possible stream restoration project for the Castleton main stem downstream of the Gully Brook confluence (see Appendix D). Where landowner willingness is expressed, additional funding will be sought from appropriate partner agencies to proceed with other projects identified in Appendix D.

6.2 Long-term

6.2.1 Vermont Basin Planning

The VTDEC Water Quality Division will seek to incorporate the finalized Castleton River Corridor Plan for the Town of Castleton within the larger Poultney-Mettowee Basin Plan. The intent of the basin plan is to be able to leverage resources that are needed for implementation of strategies outlined in the River Corridor Plan.

6.2.2 Periodic Plan Updates

Pending available funding, updates to the Castleton River Corridor Plan will be performed periodically by the Poultney-Mettowee Natural Resources Conservation District or other local stewardship organization to:

- Identify additional site-level and watershed-level management options.
- Report on ongoing needs of riparian landowners for financial and technical support to achieve plan objectives.
- Report on the ways in which the plan is supporting Castleton officials and staff.

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APPENDIX A

Analysis of Existing Geomorphic Data to Identify Management Strategies

Analysis of Existing Geomorphic Data
to Identify Corridor Management Strategies

APPENDIX A
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007

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**Analysis of Existing Geomorphic Data
to Identify Management Strategies**

1.0 INTRODUCTION

Geomorphic assessments were conducted in 2005 on the four reaches comprising the 5.9-mile length of the Castleton River main stem which are the subject of the Castleton River Corridor Plan. Study objectives were to: (1) assess the present geomorphic condition of the river network; (2) identify local and regional stressors impacting the channel and watershed; and (3) characterize the sensitivity of river reaches to future lateral and vertical adjustments.

The reader is referred to the Phase 2 geomorphic summary reports for details of the methodology and results (SMRC, 2005, 2007). Geomorphic condition and reach sensitivities revealed from these assessments are summarized in this Appendix A to the River Corridor Plan for Castleton.

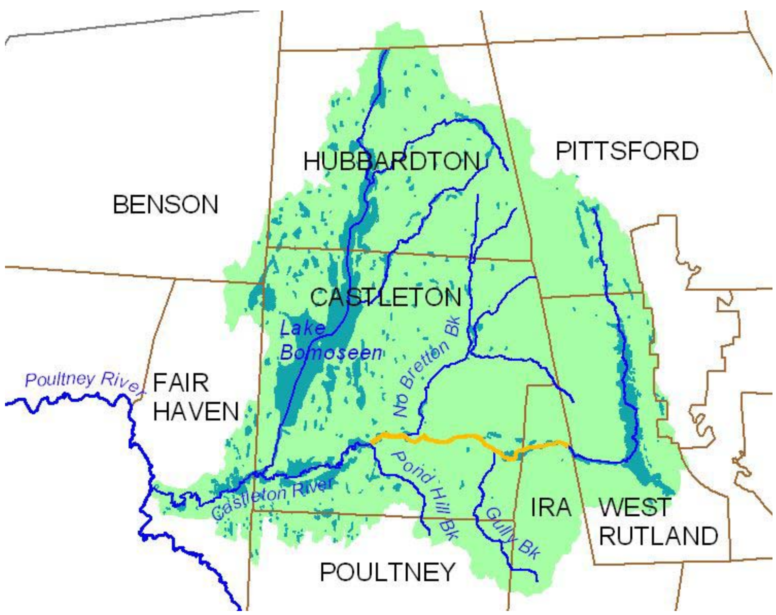


Figure 1. Location of Castleton River main stem reaches which are the focus of this corridor planning effort (highlighted in orange).

The 2005 and 2006 Phase 1 and 2 Geomorphic Assessment data were analyzed during the corridor planning process to identify corridor management strategies that could support the river's return to a more balanced condition, thereby reducing erosion hazards and improving water quality over the long term. The analysis followed recent guidance from the VTDEC River Management Section (VTDEC, 2005c) and included:

- Classifying corridor reaches into general management categories based on their geomorphic condition. This step involves characterizing, qualitatively, the sediment transport characteristics of the corridor reaches, to identify the major sediment deposition and transport modifiers.

- Acknowledging natural constraints (bedrock) and human constraints (roads, buildings, bridges) along the river corridor that limit the river channels' ability to laterally and vertically adjust in response to changing water and sediment conditions;

- Identifying sediment sources which may be impacting the sediment transport capacities in the watershed.

- Locating areas of active lateral adjustment and wetland areas contiguous to the channel which may serve important sediment and nutrient attenuation functions in the watershed; and

This analysis has informed the specific management strategies and opportunities outlined for implementation in sections of the River Corridor Plan for Castleton.

2.0 SUMMARY OF GEOMORPHIC CONDITION – CORRIDOR REACHES

2.1 Geomorphic Assessment Results

Table 1 summarizes the results of geomorphic assessment data collected in 2005 for the reaches comprising the delineated river corridor in Castleton, Vermont (SMRC, 2005).

Table 1. Geomorphic Assessment Results for Corridor Reaches, Castleton River main stem.

Reach	Seg-ment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)	Stream Type	RHA Condition	RGA Condition	Adjustment	Stream Type Departure?	Sensitivity
T2.12	--	12,493	0.04	23.8	E4-R/D	0.84 Good	0.80 Good	None	No	High
T2.11	B	5,951	***0.32***		C4-RP	0.55 Fair	0.39 Poor	Aggr, PF & Wid	No	Very High
	A	5,070	***0.26***	32.9	C4-PB	0.47 Fair	0.71 Good	Aggradation	No	High
T2.10	--	2,626	0.46	33.3	C4-R/P	0.81 Good	0.65 Good	Wid (slight) & Aggr	No	High
T2.09	--	5,234	***0.30***	47.9	C4-R/P	0.73 Good	0.58 Fair	PF, w/ aggr, wid (localized)	No	Very High

Abbreviations:
S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Casc = Cascade; Ref = Reference
RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTDEC, 2005).
PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; NM = Not Measured.
Note: Channel slope values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.

2.2 Channel and Watershed Disturbances

Various watershed-scale and channel-level disturbances have served as stressors to the New Haven River main stem and Beaver Meadow tributary reaches (Table 2). These stressors have been identified through direct observation, limited historical research, anecdotal accounts from landowners and local citizens, as well as remote sensing. This is not a comprehensive list, but it begins to characterize the degree of natural and human disturbance to the watershed, that has caused variable and overlapping adjustment responses in the channel.

	T02.09		T02.10	T02.11		T02.12
	A	B		A	B	
Stressors	Castleton River Main Stem					
Watershed						
deforestation in 1800s						
Road, Railroad Networks (1700s, 1800s)						
Flood events (1927, 1938, 1945, 2000)						
Channel - Reach Scale						
Channelization / Straightening	√	√	√	√	√	√
Dredging					√	
Berming				√	√	
Bank Armoring	√	√	√	√	√	√
Floodplain Encroachment	√	√	√	√	√	√
Loss of Forested Buffers		√		√	√	√
Impoundment (dam)		√ (H)				
Channel - Site Scale						
Gravel extraction				√	√	
Undersized Crossing Structure	√	√	√	√	√	√
Ford				√	√	

Notes: √ (H) = historic stressor;

Table 2. Channel and Watershed Stressors in corridor reaches, Castleton River main stem.

2.3 Summary of Geomorphic Sensitivity

The Castleton River is responding to the above stressors through adjustment of its dimension, planform, and profile (where not constrained by floodplain and channel encroachments or bedrock). Adjustments have occurred to varying degrees, as dependent on multiple factors (including channel sediment types, vegetative cover type and density, presence of grade controls, etc.). The relative magnitude of these channel adjustment processes, together with the topographic, geologic, and vegetative setting define the sensitivity of each reach /segment to continuing and future stresses.

Sensitivities of the study area reaches/segments as defined in VTANR protocols (2005) range from High to Very High (Table 1). Phase 2 field-based assessments purposely targeted lower-gradient, (reference C-stream-type) reaches that would be expected to exhibit higher sensitivity, and which have current constraints within the river corridor. Therefore, it is not unexpected that study area reaches were defined as having sensitivities at the high end of the scale.

3.0 CORRIDOR CONSTRAINTS

Natural boundary conditions (i.e., bedrock) as well as human boundary conditions (i.e., dam, roads, railroad, development) exist within the Castleton corridor and constrain the river's ability to laterally and vertically adjust in response to changing water and sediment conditions.

3.1 Bedrock

Channel-spanning exposures of bedrock constraining vertical adjustments and serving as a local base-level control are present at the mid-point of reach T02.10 and in the upstream half of reach T02.09. Bedrock also constrains a portion of the left valley wall in reach T02.10, limiting the lateral adjustment potential of the channel:

3.2 Infrastructure

Roads and active rail lines reduce the valley width available to the channel along the corridor reaches and constrain lateral adjustments in many sections.

Table 3. Infrastructure located within the corridor along the New Haven River main stem and Beaver Meadow tributary.

Reach	Roads	Active Railroad	Abandoned Trolley Grade
T02.12	RB (Rt 4)		LB
T02.11	RB (Rt 4) LB (Rt 4A)	RB	RB
T02.10	LB (Rt 4A)		
T02.09		LB	

Note: RB = Right Bank; LB = Left Bank

Thirteen bridges and one culvert crossing were identified within the 4 reaches considered under this corridor planning process (Table 3). Phase 2 assessments determined that the in-stream culvert and five of the bridges are bankfull constrictors, meaning that they have a narrower span than the width of the bankfull channel measured at the closest upstream or downstream crossing (SMRC, 2005). Flow velocities are reduced on the upstream end of these crossings resulting in localized reductions in sediment transport capacity.

Table 4. Crossing structures located within the Castleton River corridor reaches

Reach	Type	Road	Constriction Status
T02.12	Bridge	railroad	FPW
T02.12	Bridge	farm road	BKFL
T02.12	Bridge	Route 4A	FPW
T02.12	Culvert	Former logging road	BKFL
T02.12	Bridge	Birdseye Road	FPW
T02.11	Bridge	Route 4A	FPW
T02.11	Bridge	farm foot path	BKFL
T02.11	Bridge	farm road	BKFL
T02.11	Bridge	farm road	BKFL
T02.10	Bridge	Route 4A	FPW
T02.10	Bridge	Route 4A	FPW
T02.09	Bridge	railroad	FPW
T02.09	Bridge	Mill Street	BKFL
T02.09	Bridge	North Road	FPW

Note: FPW = Flood-prone-width constrictor; BKFL = Bankfull-width constrictor

Several residential, commercial and agricultural buildings are located within the corridor along reaches T02.12 through T02.09. Highest densities are within reach T02.09 along the north side of the Castleton village.

Table 5. Development within the Castleton River corridor reaches

Reach	**Buildings / Development**
T02.12	RB shed (1)
T02.11	LB shed (1); RB house (1)
T02.10	RB commercial building
T02.09	LB houses (4); LB mill buildings; RB supply well pump house; LB supply well pump house; LB tennis courts and other rec fields; LB house.

Note: RB = Right Bank; LB = Left Bank

4.0 Sediment Transport Characteristics

Geomorphic assessment results from 2005 were reviewed during this river corridor planning project to identify how the channel and watershed disturbances catalogued in these reaches may have modified (either increased or decreased) sediment transport capacities of the river channel within the known geologic and infrastructure constraints and vegetative boundary conditions.

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

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

Sediment transport capacity of the channel can be inferred from the geomorphic features observed during field work and from the stressors catalogued in Table 2. Even a qualitative understanding of these processes can help to identify and prioritize appropriate management strategies for the river that will facilitate a return toward a more balanced (dynamic equilibrium) condition.

In general, past channelization, berming, and armoring have converted a naturally meandering channel into a linear, transport-dominated channel with enhanced sediment transport capacity in reaches T02.11 through T02.09, downstream of the wetland-dominated reach T02.12. A tendency for channel incision in response to these channel manipulations appears to have been offset by the cohesive nature of soils in the bed and banks, the occasional presence of bedrock grade controls (T02.10, T02.09), the presence of a historic dam offering vertical grade control (upstream end of T02.09), and maintenance of channel armoring along the banks. The River is slightly incised, with incision ratios ranging from 1.0 to 1.3, but generally has access to its floodplain in a major flood event.

There are two major areas of very active lateral and vertical channel adjustments outside of this historically channelized, transport-dominated portion of the corridor: (1) at the downstream end of the corridor in reach T02.09; and (2) within T02.11 downstream of the Gully Brook confluence.

> (1) At the downstream end of the corridor in an area of channel-contiguous wetlands north of the recreational fields off North Street in Castleton village, the channel has avulsed and has a multi-thread planform. This is one of the first locations along the corridor where the river is relatively unconstrained. This is an area of active sediment

and flow attenuation, where the river appears to be attempting to lengthen and build sinuosity.

(2) Gully Brook tributary has historically contributed significant quantities of sediment to the Castleton River, locally reducing the sediment transport capacity in the Castleton main stem, and leading to aggradation, widening and flood-related channel avulsions. The Gully Brook itself is prone to very dynamic lateral and vertical adjustments upstream of the Castleton River confluence due to the natural reduction in sediment transport capacity at this alluvial fan setting near the base of Bird Mountain. In an attempt to protect the investments of the Woodbury Road bridge crossing, Birdseye Road, residential development, and agricultural lands along this highly dynamic section of the river, there has been a history of channelization, windrowing, and berming of the Gully Brook as well as repeated gravel extraction from the Gully Brook and from the Castleton River in the vicinity of the confluence. In the mid-1900s, intensive channel management (channelization, dredging and berming) on this tributary disconnected the Gully Brook from its floodplain, and stripped the channel of its meanders and the function of associated point bar areas for sediment deposition. Consequently, the straightened and bermed channel has been an efficient conveyor of sediments directly to the area of its confluence with the Castleton River. Following Gully Brook channelization, sediments were reported to accumulate at the confluence and downstream of the confluence within the Castleton River. This caused backwater effects in the Castleton River, leading to occasional flooding of upstream pasture and barnyard areas near the Birdseye Road crossing of the Castleton River (VTDEC WQD, 2004 – 305b rpt). Repeated gravel extraction in the area of the confluence was required to mitigate upstream flooding; dredging spoils were placed along the stream banks of the Gully Brook, further entrenching the channel.

In 2004, a restoration project was implemented by the VTDEC Water Quality Division (WQD) in partnership with the US Department of Agriculture – Natural Resources Conservation Service, US Fish and Wildlife, the Poultney-Mettowee Natural Resources Conservation District, the Poultney-Mettowee Watershed Partnership (PMWP), and landowners (VTDEC, 2004 draft PMbas plan). The restoration project involved both passive and active geomorphic elements to re-connect the Gully Brook channel with its floodplain. Active measures involved excavations to remove the right-bank berm and lower the floodplain elevation along the right-bank corridor. Approximately 7,000 cubic yards of sediments were excavated (and trucked to a permitted off-site location). The left-bank berm remains in place, since residential homes occupy the left-bank corridor, and floodplain lowering in this area was deemed incompatible with these current investments (Swift, 2006; PMWP, 2006).

VTDEC WQD and PMWP will continue to monitor the restoration site over the next few years. It will take some time for the channel to create the more sinuous planform and fully utilize the new floodplain with roughness offered by deposited sediments and maturing vegetation. In the next few years, the channel and floodplain may not function as effectively as expected over the long term, and sediments accumulating at the confluence may need to be removed on occasion. One such "maintenance" event occurred on 25 August 2006 under direction of the VTDEC WQD. It is expected that such maintenance events will not be required in future.

5.0 River Corridor Management Strategies

Preliminary identification of corridor management strategies was conducted by the TWG following guidance contained in two recent documents published by the VTDEC River Corridor Management Section:

- *Alternatives for River Corridor Management* (VTDEC, 2003)

- *Using geomorphic assessment data to guide the development of River Corridor Management Plans to achieve: Fluvial Erosion Hazard (FEH) Mitigation, Sediment and Nutrient Load Reduction, and Ecological-based River Corridor Conservation* (VTDEC, draft Oct 2005c)

Landowners, community members, and resource agencies, including the Poultney-Mettowee NRCD, Rutland County Regional Planning Commission, the USDA Natural Resources Conservation Service, US Fish & Wildlife, Vermont Agency of Agriculture, and Vermont Agency of Natural Resources, can use geomorphic data to inform future management strategies within the river corridor. For a given reach or segment, the active adjustment processes, degree of departure from reference, and sensitivity ranking will define the short-term compatibility and long-term sustainability of various restoration or conservation options and future land use or channel management activities. VTDEC River Management Section has developed guidelines for classifying reaches / segments into potential management approaches based on geomorphic characteristics (VTDEC, 2005c):

- Equilibrium – Stable Reference (Conservation Reach)
- Equilibrium – Minor Adjustment (Eroding Banks, High Recovery Reach)
- Unstable – Moderate Departure (Moderately Unstable Reach)
- Unstable – Downcutting (Incising Reach)
- Unstable – Severe Departure (Highly Unstable Reach)

The Castleton corridor reaches have been classified into the above management categories in the sections below. Based on these categorizations, various opportunities for geomorphically-compatible river corridor management strategies have been outlined in Appendix D of this corridor plan. These opportunities for corridor management can be broadly categorized into active versus passive approaches, with respect to the geomorphic condition.

Active vs. Passive Management Strategies

Active geomorphic approaches are typically appropriate for unstable reaches exhibiting active bed degradation and/or a severe departure from reference condition. Certain moderately unstable reaches can also be candidates for active geomorphic solutions, particularly where infrastructure may be at risk or where such active approaches are strategic in the protection of upstream stable or reference reaches. Active approaches are also relevant when there is a desire among stakeholders to accelerate the river's return to a more balanced condition. Cost of active approaches and their risk of failure are typically much higher than other alternatives.

A passive geomorphic approach involves long-term management and preservation of the belt-width derived river corridor (see Appendix C). Under this approach, the river channel is allowed to freely meander within the area defined as the belt-width-derived river corridor. For a reach that is already close to reference condition or exhibiting only minor adjustments, preserving a river corridor will ensure the river's ability to continue to meander through the valley unconstrained by human infrastructure. In turn, human investments in the landscape will be protected from future channel adjustments. For a reach that has seen significant channel management in the past, and has lost some measure of its sinuosity and balanced planform and profile, the channel is allowed to adjust unimpeded to a more sinuous, meandering planform closer to regime conditions. During ongoing adjustments, the river will re-establish greater floodplain access (where access has been lost) and adjust channel dimensions for optimum conveyance of its water and sediment loads.

Generally speaking, the river can achieve a sustainable and balanced planform, profile and channel geometry more successfully and much more cheaply than humans engaged in a series of active channel restoration projects. Floodplain access for the river can be maintained and enhanced by protecting the corridors from development and floodplain filling, and refraining from channel management activities that tend to cause the channel to become disconnected with its floodplain (e.g., channelization, dredging, berming).

Generally, passive approaches to channel and floodplain restoration and conservation are most appropriate for reaches / segments in the following stream condition categories:

- Equilibrium – Stable Reference - where conservation of the corridor can serve to protect stream equilibrium conditions and ecological processes within the riparian corridor.
- Equilibrium – Eroding Banks – High Recovery Reach where restoring channel boundary conditions (vegetation, to increase roughness elements
- Unstable – Moderate Departure.

5.1 Equilibrium – Stable / Reference

None of the corridor reaches were categorized as Equilibrium – Stable / Reference.

5.2 Equilibrium – Minor Adjustment

One of the corridor reaches – T02.12 – was classified in this category. This reach has abundant channel-contiguous wetlands and is offering significant flow (and nutrient) attenuation functions at a strategic location downstream of pasture and cultivated fields, as well as adjacent highway and railroad corridors.

Equilibrium-Minor adjustment reaches are undergoing relatively minor widening, aggradation, and planform adjustment. Channel stressors are minor in extent and degree. Equilibrium-Minor Adjustment reaches have high recovery potential.

Channel and corridor management strategies appropriate to Equilibrium-Minor Adjustment reaches include the following (all are appropriate for T02.12):

- Conservation to maintain ecological functioning of riparian corridor areas;
- Conservation to maintain floodplain access, and flow and sediment attenuation functions of floodplains and contiguous wetlands;
- Private and municipal planning strategies to prevent placement of infrastructure within the corridor;
- Enhancement and maintenance of forested buffers to improve streambank and corridor erosion resistance, provide for sediment and nutrient buffering and filtration;

- Maintenance of appropriate buffers and exclusion zones for cultivation and pasture uses of adjacent lands to reduce sediment and nutrient inputs to the channel and contiguous wetlands;
- Proper road maintenance to prevent stormwaters and road sediment from washing directly to the stream channel;
- Replacement of undersized crossing structures at the next opportunity.

Specific recommendations for reach T02.12 are provided in Appendix D of the corridor plan.

5.3 Unstable (Dis-equilibrium) – Moderate Departure

The remaining three corridor reaches – T02.11, T02.10 and T02.09 - were classified in this category.

Unstable-Moderate Departure reaches exhibit a moderate degree of channel adjustment in response to current and past channel management and watershed-level stressors. Channel and corridor management strategies appropriate to Unstable-Moderate Departure reaches generally include passive geomorphic measures to restore channel dimensions and boundary resistance (VTDEC, 2005c). Active geomorphic measures at limited sites can be appropriate: (1) to accelerate a return to dynamic equilibrium; (2) where such active approaches are strategic in the protection of upstream or downstream stable or reference reaches; or (3) to protect infrastructure that may be at risk.

Channel and corridor management strategies appropriate to Unstable-Moderate Departure reaches include the following:

- Conservation or other planning strategies to maintain floodplain access, permit lateral adjustments of the channel to return to a more balanced planform, profile, and channel dimensions, which will enhance flow and sediment attenuation functions in the reach and contiguous wetlands;
- Private and municipal planning strategies to prevent placement of infrastructure within the corridor;
- Enhancement and maintenance of forested buffers to improve streambank and corridor erosion resistance, reduce width/depth ratios, and provide for sediment and nutrient buffering and filtration;
- Proper road maintenance to prevent stormwaters and road sediment from washing directly to the stream channel;
- Replacement of undersized crossing structures with wider-span structures to reduce localized instabilities.

Specific recommendations for reaches T02.11, T02.10, and T02.09 are provided in Appendix D of the corridor plan.

5.4 Unstable (Dis-equilibrium) – Downcutting (Incising Reach)

None of the corridor reaches were categorized as Equilibrium – Stable / Reference.

5.5 Unstable (Dis-equilibrium) – Severe Departure

None of the corridor reaches were categorized as Equilibrium – Stable / Reference.

6.0 REFERENCES

VT DEC River Management Section, 2005a, *River Corridor Protection and Management: Fact Sheet #1* http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf

VT DEC River Management Section, 2005b, *Defining River Corridors: Fact Sheet #2*. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf

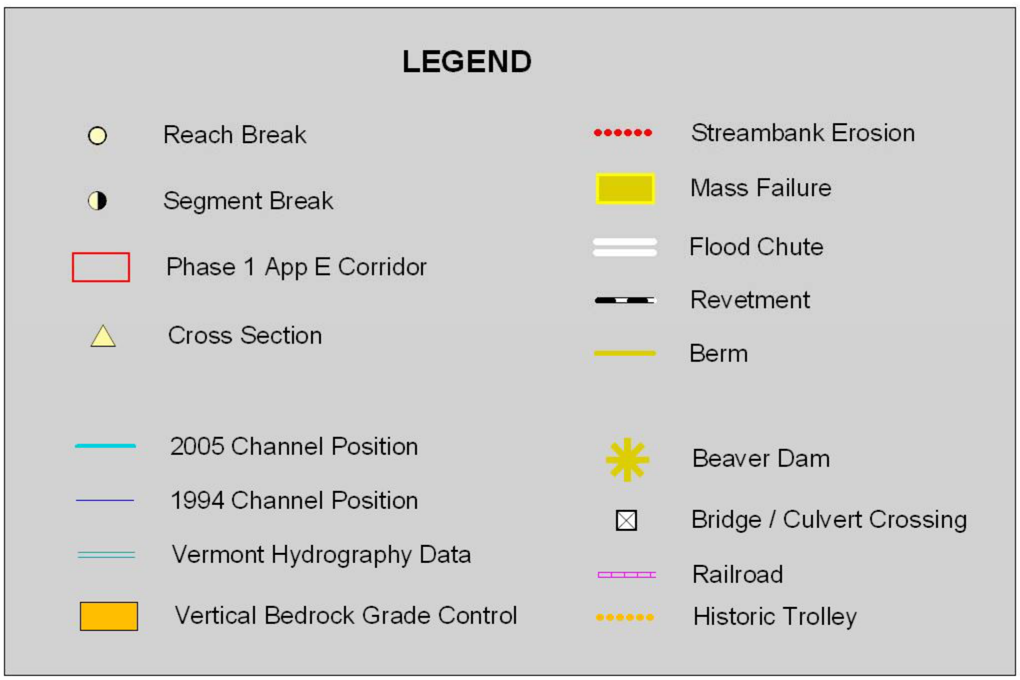
VT DEC River Management Section, 2005c (26 October draft), *Using geomorphic assessment data to guide the development of River Corridor Management Plans to achieve: Fluvial Erosion Hazard (FEH) Mitigation, Sediment and Nutrient Load Reduction, and Ecological-based River Corridor Conservation.*

VT DEC River Management Program, 2005d (14 February draft), *Vermont Fluvial Erosion Hazard Mitigation Program.*

VT DEC River Management Program, 18 April 2003, *Alternatives for River Corridor Management*: Vermont DEC River Management Program Position Paper. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf

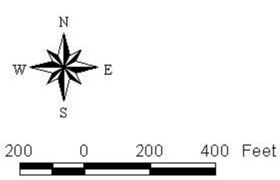
Attachment 1.

Annotated Reach Maps from 2005 Assessments



Castleton River watershed
Reach: T2.12 u/s
Date: 6/28/2005

Topo Base: 1972
Ortho Base: 1994



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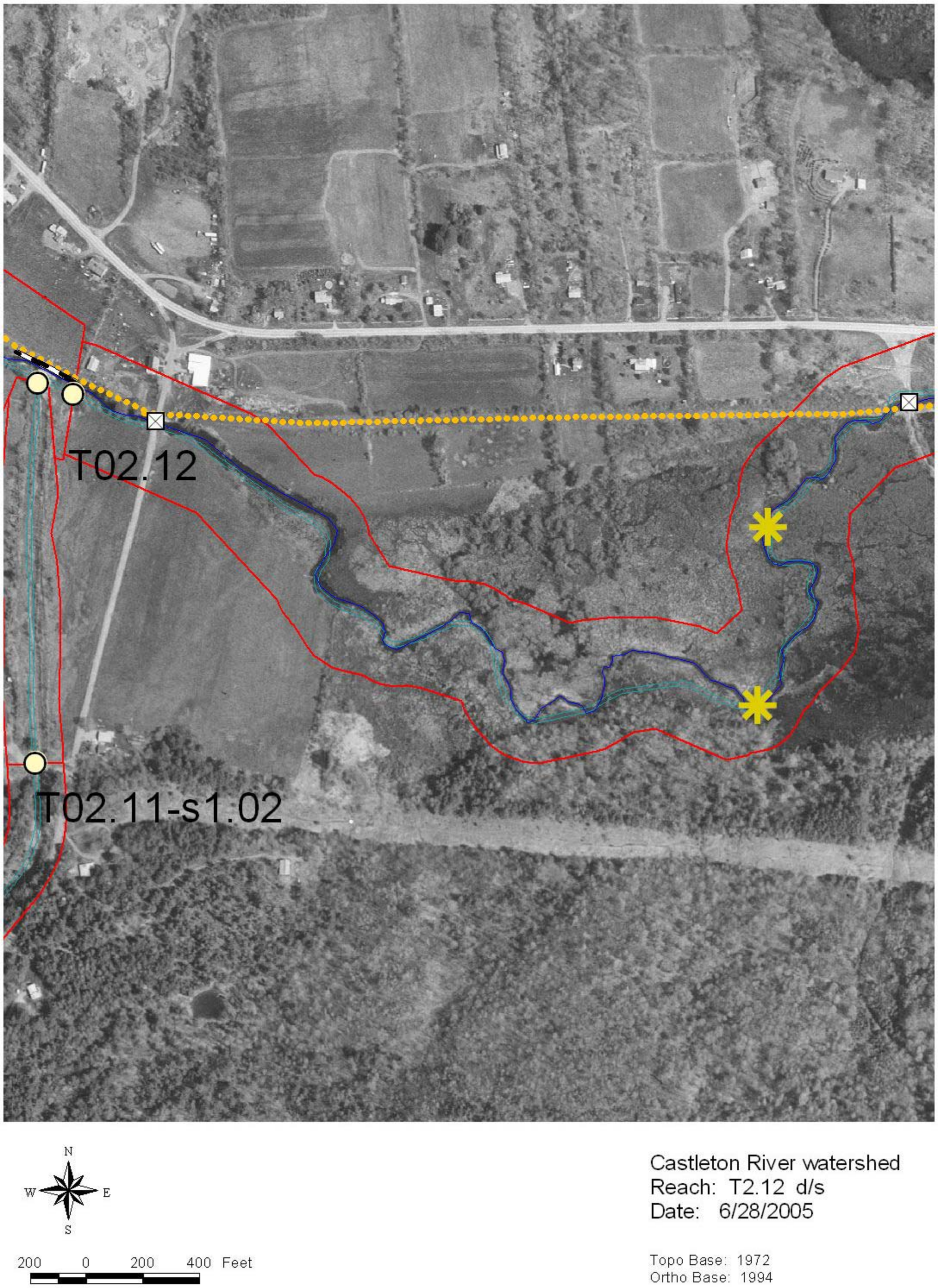
Date: 6/28/2005

Topo Base: 1972
Ortho Base: 1994



Castleton River watershed
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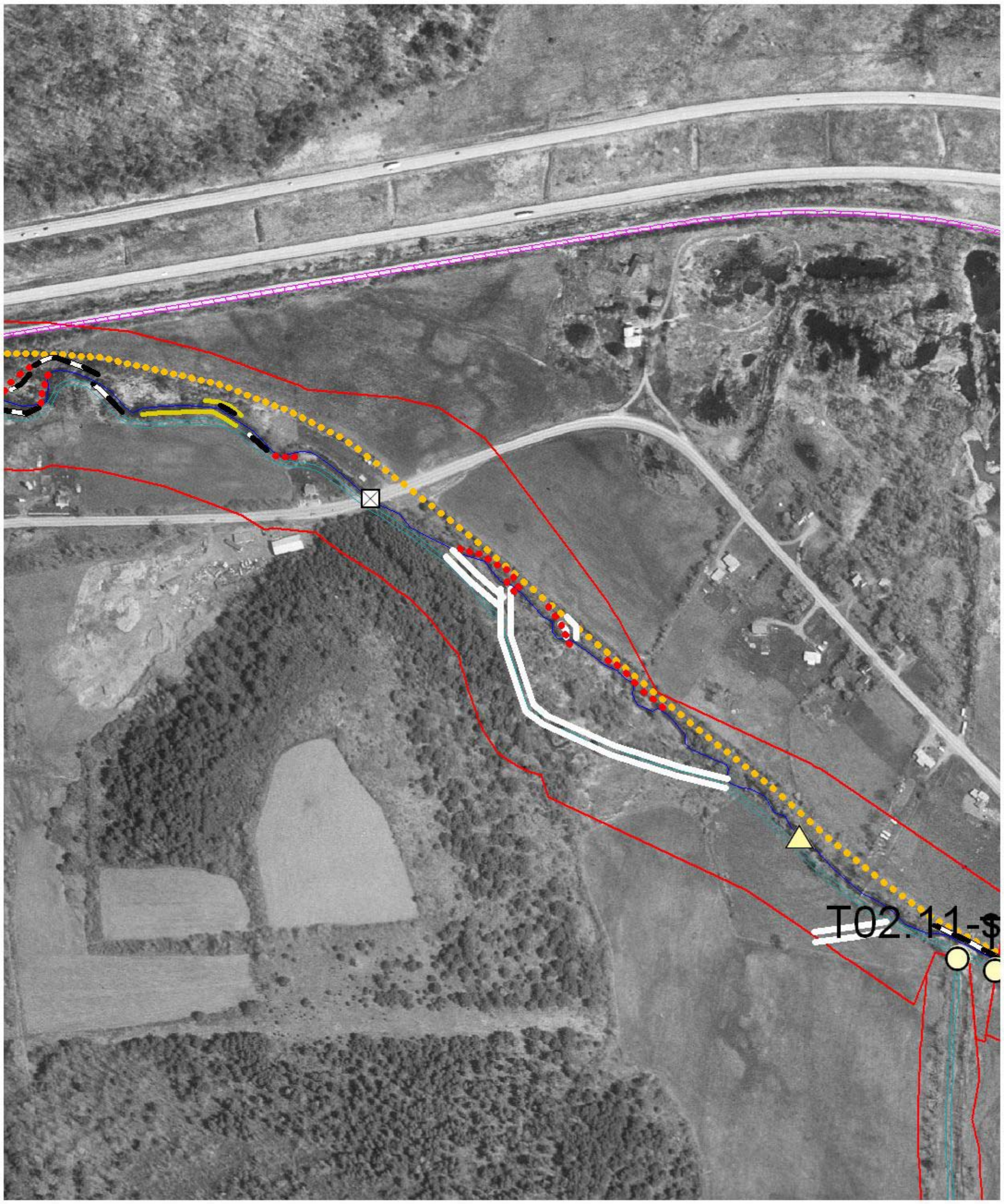
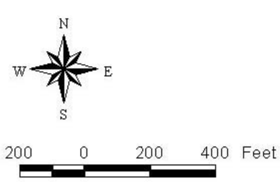
Date: 6/28/2005

Topo Base: 1972
Ortho Base: 1994





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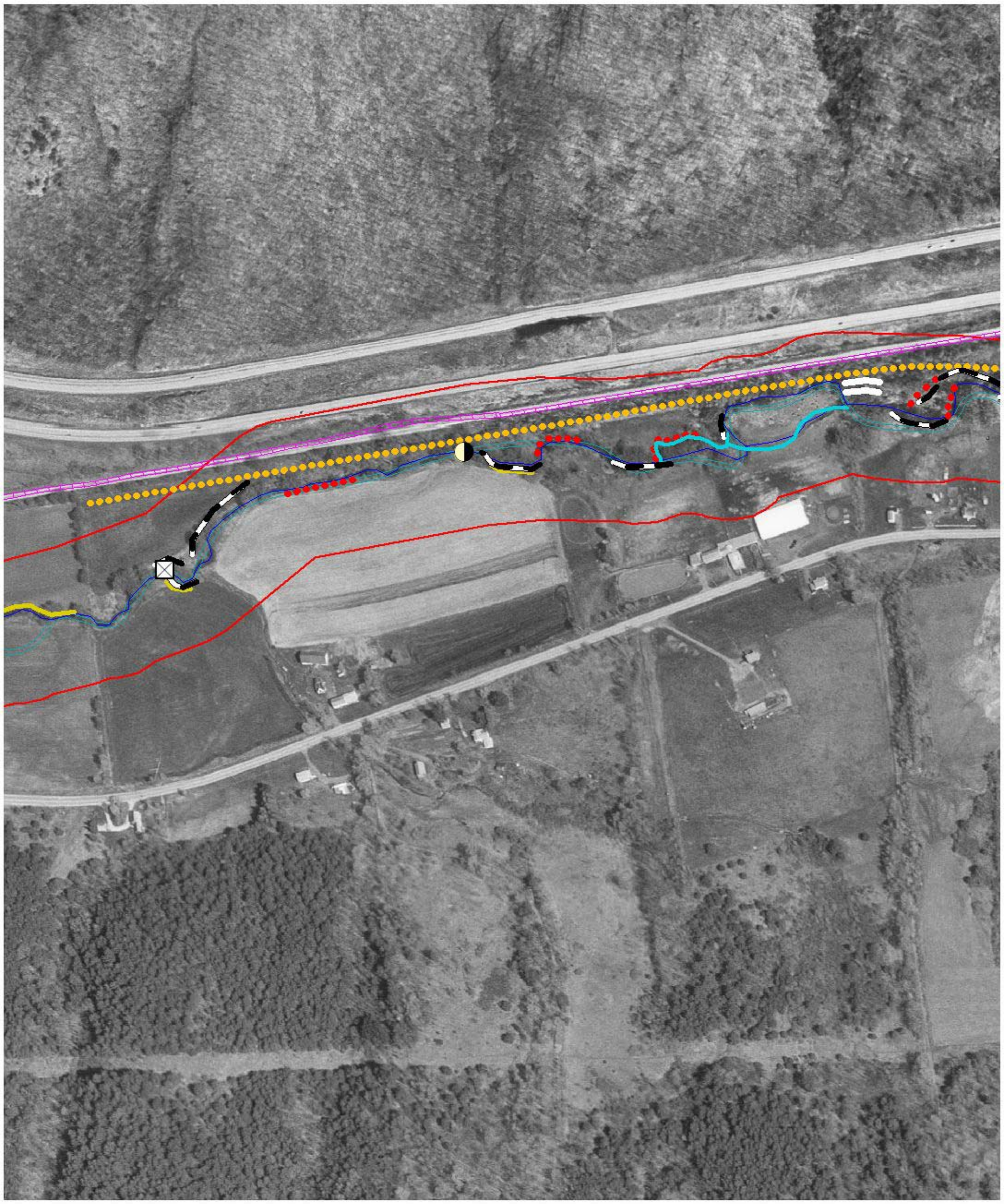

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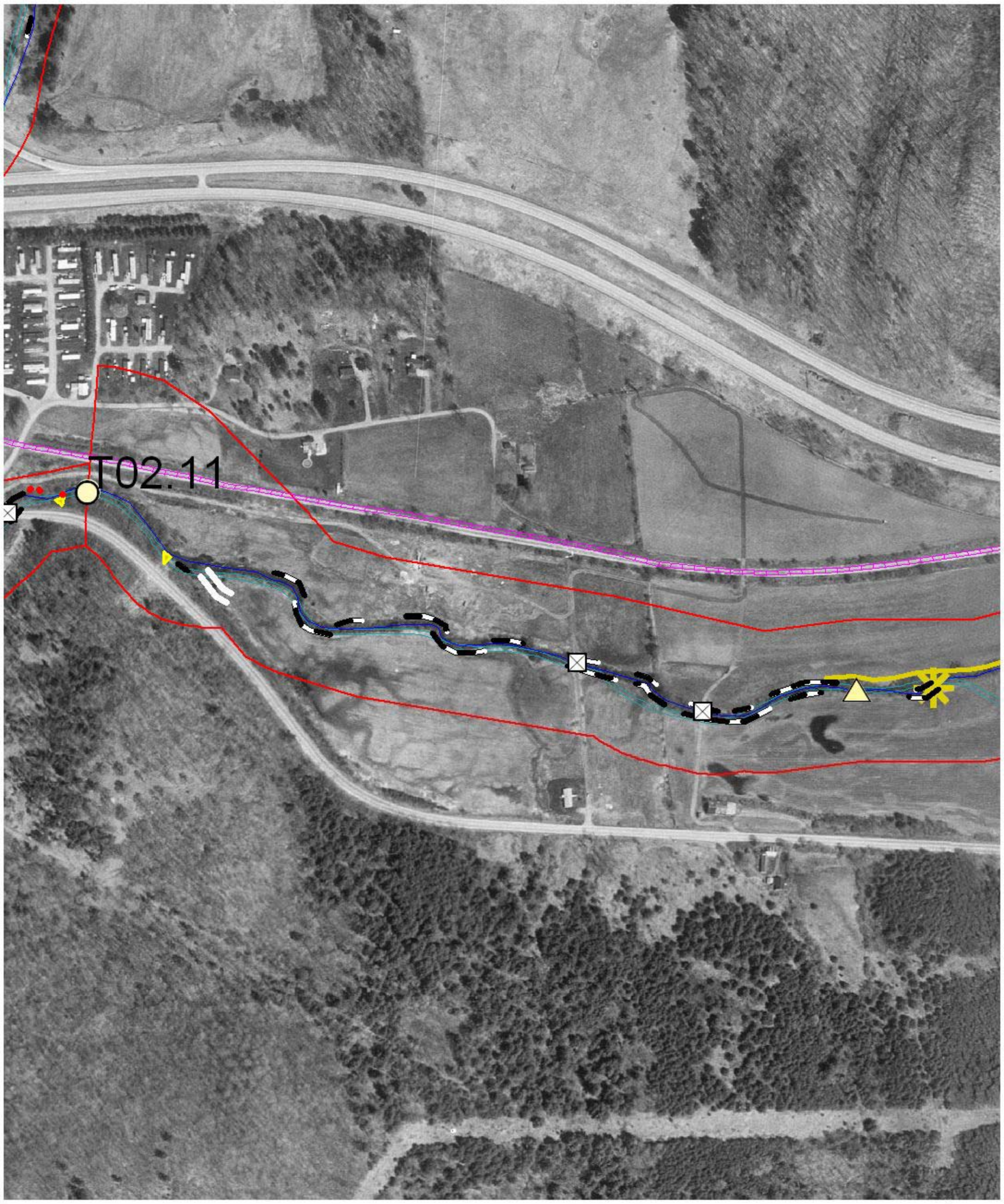
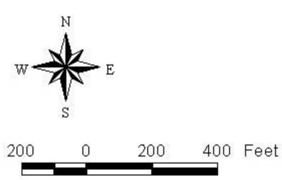
Ortho Base: 1994





Castleton River watershed
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Date: 6/30/2005

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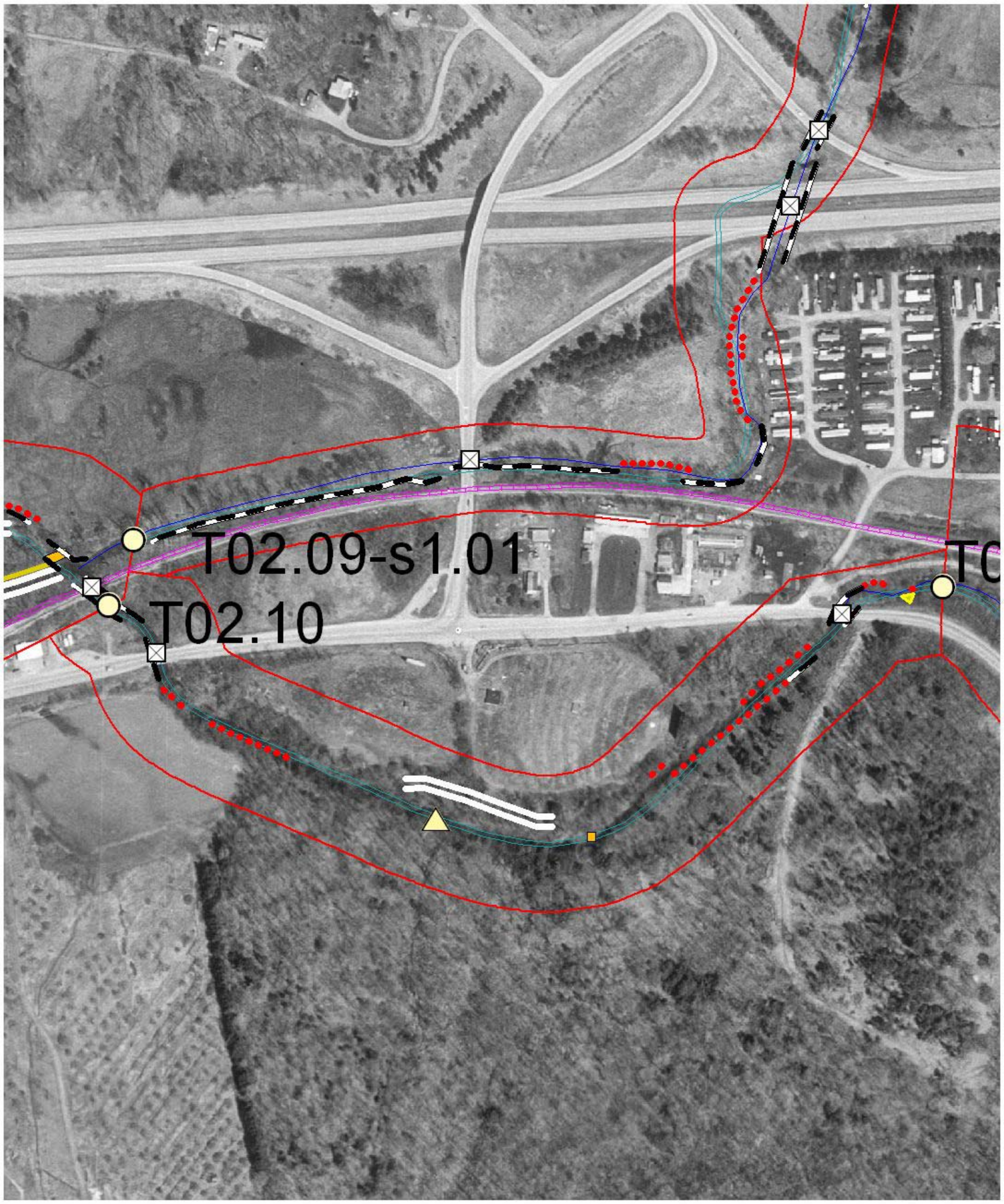
Ortho Base: 1994



Castleton River watershed
Reach: T2.10
Date: 8/11/2005

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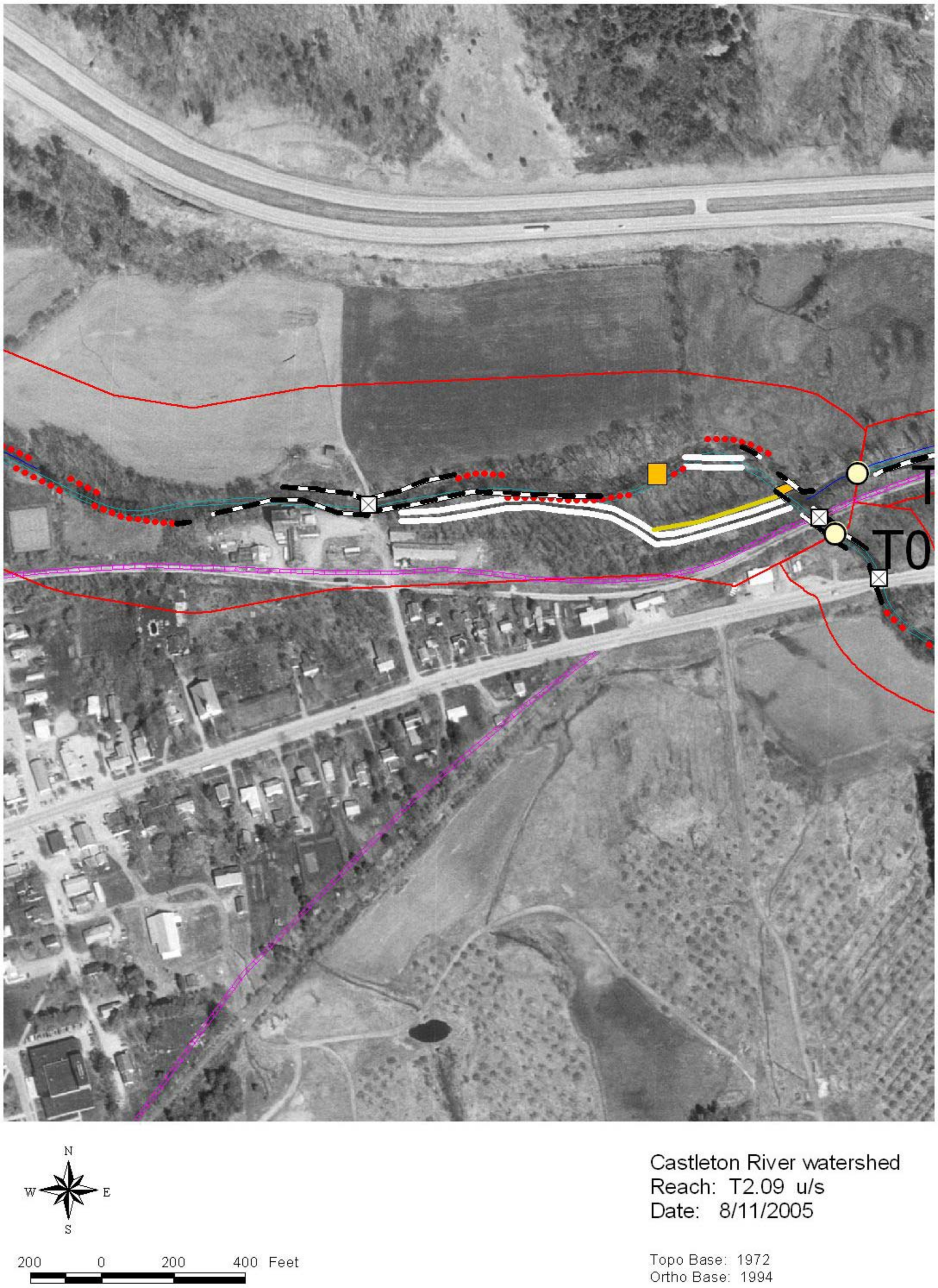
Ortho Base: 1994



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Date: 8/11/2005

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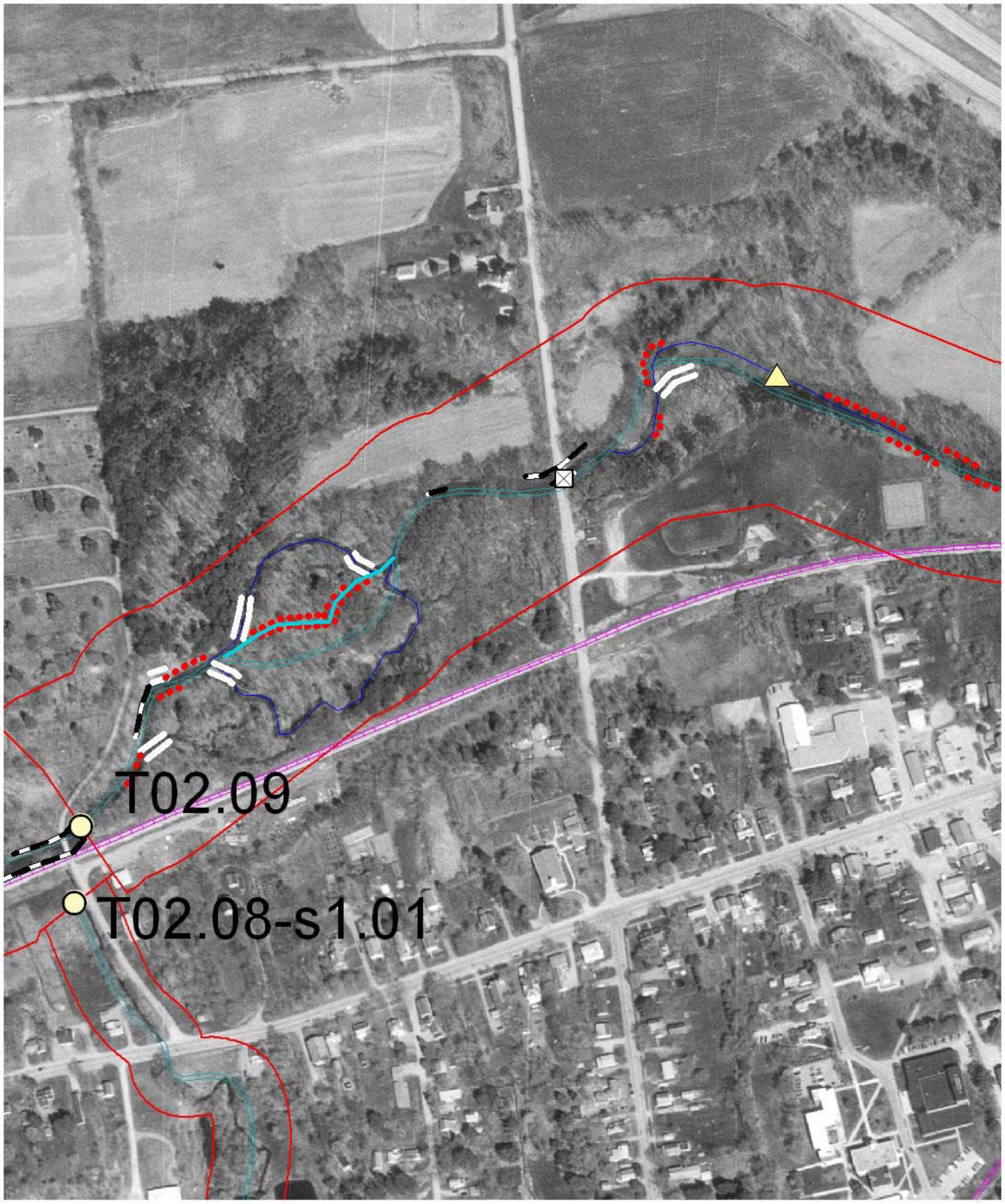

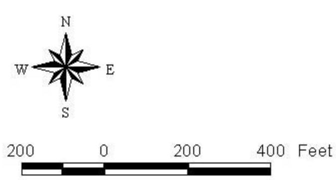

Castleton River watershed
Reach: T2.09 d/s
Date: 8/11/2005

Topo Base: 1972
Ortho Base: 1994

APPENDIX B

Delineation of Draft River Corridor

Delineation of Draft Fluvial Erosion Hazard Corridor

APPENDIX B
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007

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Delineation of Draft Fluvial Erosion Hazard Corridor

1.0 INTRODUCTION

A draft fluvial erosion hazard corridor has been generated for four reaches of the Castleton River main stem and in the town of Castleton, Rutland County, Vermont (Figure 1). This draft corridor has been delineated to define a management area, within which planning strategies and restoration and conservation projects are being pursued with willing landowners to improve water quality and riparian habitats and reduce hazards to the community from streambank erosion.

Development of this draft of the corridor for these four reaches has relied, in part, on results of previously-completed Phase 1 and Phase 2 Stream Geomorphic Assessments (RRPC, 2005; SMRC, 2005).

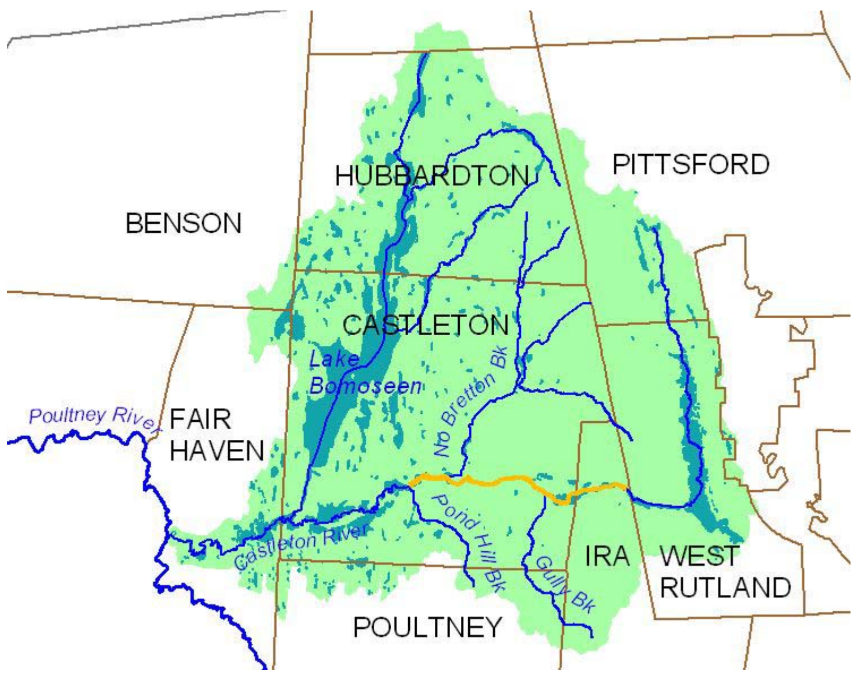

Figure 1. Location of corridor planning reaches in Castleton River watershed, Castleton and Ira, Rutland County, VT. (highlighted in orange).

2.0 IDENTIFICATION OF REACHES

Previous studies have assembled geomorphic data for several reaches of the Castleton River main stem and tributaries, including the four Castleton River main stem reaches that are the subject of this corridor planning effort.

Reach	Seg-ment	Channel Length (ft)	Channel Slope (%)	Drainage Area (sq mi)
T02.12	--	12,493	***0.1***	23.8
T02.11	B	5,876	***0.3***	
	A	5,145	***0.3***	32.9
T02.10	--	2,626	***0.3***	33.3
T02.09	B	2,045	***0.6***	
	A	3,190	***0.3***	47.9

These four reaches comprise a 5.9-mile length of river - the extent of the corridor being considered at present in this corridor planning project. For more details of the geomorphic condition of these reaches, refer to Appendix X of the *Castleton River Corridor Management Plan*.

3.0 DELINEATION OF CORRIDOR

To define a river corridor overlay district for the town of Castleton with the objective of reducing fluvial erosion hazards, the VTDEC River Management Section ran the Fluvial Erosion Hazard module of Stream Geomorphic Assessment Tool (SGAT), an ArcView© 3.x extension (Geographic Information Systems mapping software). Various input data are required to run the SGAT software as detailed in Section 3.1.

Derivation of the corridor within SGAT follows guidance contained in:

> *Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D).*
> http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwaytechguidance.pdf
> (VT Agency of Natural Resources, May 2003)

While this specific guidance pertains to the Agency's review of floodways under Act 250, the same science-based procedure is applied by the Agency when collaborating with towns who are voluntarily pursuing the preparation of a corridor for the purpose of reducing fluvial erosion hazard risks (or also reducing nutrient and sediment loading to their surface waters).

Generally, speaking this corridor delineation method relies on the meander belt-width concept as outlined in the following fact sheets:

> *River Corridor Protection and Management: Fact Sheet #1*
> http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf
> (VTDEC River Management Program, 2005a)

> *Defining River Corridors: Fact Sheet #2*.
> http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf
> (VTDEC River Management Program, 2005b)

A meander belt is defined by connecting the outside point of meander bends along the left and right banks of a channel. In a balanced river system that has not been subjected to intensive floodplain encroachment and channel management, the meanders will theoretically have full expression, and connecting the outside points of each meander will approximate an area which is subject to erosion hazards as the river channel migrates laterally and longitudinally through time.

Since many of Vermont's streams have been channelized and straightened with the meanders removed or significantly reduced in amplitude, connecting the points at the outside edge of these straightened meanders would result in a narrow "meander belt" that was insufficient in width to describe the area at risk of future lateral adjustments. Therefore, Vermont guidance calls for the meander belt width to be buffered at a specified distance off the meander center line. The meander center line is a line connecting each successive meander cross-over point, proceeding down-valley (see the above fact sheets for more detailed explanation).

The distance buffered off the meander center line is determined by the (1) approximate channel width in the reach and (2) by the present geomorphic condition and sensitivity of that reach to further adjustments. Channel widths and sensitivity ratings are determined during Phase 1 and Phase 2 Stream Geomorphic Assessments. The Sensitivity ranking (from Very Low to Extreme) is dependent on the stream type (e.g., steep, narrow channels in mountainous settings versus shallow, meandering channels in broader valley settings) and the geomorphic condition of the reach (Reference, Minor Adjustment, Major Adjustment, Stream Type Departure). Further details of the Phase 1 and 2 Stream Geomorphic Assessment protocols are available at:
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Following VTDEC guidance documents, the reach Sensitivity is used to define a Fluvial Erosion Hazard rating from Very Low to Extreme. Depending on the Sensitivity (FEH) Rating, the channel is buffered to varying widths, which increase with increasing sensitivity.

Table 1. Belt Width Dimensions based on Geomorphic Sensitivity

FEH Rating (Sensitivity)	Belt Widths based on reference channel widths
Very Low	Equal to the reference channel width
Low	Equal to the reference channel width
Moderate	Four (4) channel widths
High	Six (6) channel widths
Very High	Six (6) channel widths
Extreme	Six (6) channel widths

Reference: Vermont Fluvial Erosion Hazard Mitigation Program
VT DEC River Management Program, 2005d (14 February draft)

The process of corridor delineation in GIS, as outlined in VTANR guidance (2003) and automated in SGAT, will identify where the above meander belt width impinges on a valley wall. In those cases, the meander belt width is clipped to the valley wall and the clipped area is re-distributed to the opposite side of the channel. In some cases (not typical of the four Castleton reaches) the valley walls are so narrowly-confining, that the full dimension of the meander belt width is not expressed, and the corridor width becomes defined by the left and right valley walls.

The meander belt width is a close ***approximation*** of the area surrounding an alluvial channel which is at risk of fluvial erosion hazards in the short term. To comprehensively map fluvial erosion hazard risk with greatest confidence and accuracy would require detailed survey work along the entire river section of interest; field-based evaluation of soil types, geotechnical properties and erodibilities; analysis of historic channel positions; as well as hydrologic and hydraulic modeling (FEMA, 2003; Rapp & Abbe, 2003). Such an intensive study would be cost-prohibitive for most towns, and such an endeavor statewide would require resources beyond what is reasonably available at the present time.

The meander belt width provides a first approximation that can be quickly derived with reasonably limited resources. As suggested in *Defining River Corridors: Fact Sheet #2*, the belt-width derived corridors "provide an area within which channel adjustments may occur, in order to re-establish an equilibrium condition, and there can be a reasonable expectation that fluvial erosion hazards will be minimized" (VTDEC RMS, 2005b).

3.1 Input Data

Reach-based channel widths

Since the corridor is defined based on a multiplier of the channel width, a channel width value is identified for each stream reach in SGAT. The regime-based channel widths from Phase 1 geomorphic assessment were used (RRPC, 2005). These are approximate channel widths estimated in relation to drainage area, based on Vermont Hydraulic Geometry Curve data (VTDEC WQD, 2001, 2006).

Hazard Indices based on Geomorphic Condition and Sensitivity

Hazard Ratings were assigned to each of the four Castleton River reaches based on geomorphic condition and sensitivity determined by the Phase 2 Stream Geomorphic Assessment (SMRC, 2005), as follows:

Table 2. Recommended Belt-width Dimensions for Select Castleton River main stem reaches based on Geomorphic Condition and Sensitivity.

Reach	Segment	RGA Condition	FEH Rating (Sensitivity) (a)	Belt Width (b)
T02.12	--	0.80 Good	High	6x
T02.11	B	0.39 Poor	Very High	6x
	A	0.71 Good	High	6x
T02.10	--	0.65 Good	High	6x
T02.09	B	0.39 Poor	Very High	6x
	A	0.71 Good	High	6x

(a) - as per VTANR Stream Geomorphic Assessment protocols (2006) and Phase 2 Stream Geomorphic Assessment: Castleton River (SMRC, 2005)

(b) - as per 14 February 2005 *Vermont Fluvial Erosion Hazard Mitigation Program*

Meander Center Line

A meander center line was delineated along the Castleton River main stem during the completion of the Phase 1 Stream Geomorphic Assessment (RRPC, 2005). This shape file is available for review through the web-based Data Management System maintained by the VTDEC Water Quality Division.

As an interim step in the delineation of the FEH corridor in SGAT, the multipliers of channel width defined in Table 2 were then buffered off this meander center line to define the belt-width-derived corridor.

Valley Wall

Within the SGAT software, where the meander belt width impinges on either the left or right valley wall, the belt width area is "clipped" to the valley wall and the clipped area is re-distributed to the opposite side of the channel in GIS. A delineation of the valley wall was originally generated during completion of the Phase 1 Stream Geomorphic Assessment (RRPC, 2005). Valley walls were subsequently field-truthed by the VTDEC River Management Section. An updated valley wall delineation was utilized to prepare the draft FEH corridor for use in this corridor planning project. A copy of the updated valley wall delineation is available from the VT River Management Section (Contact Shannon M. Hill Pytlik).

In this provisional draft of the corridor it should be noted that the valley wall in some main stem reaches was delineated along the Route 4 highway and the Clarendon & Pittsford Railroad, rather than the natural toe of the valley wall beyond the road.

4.0 REFERENCES

Federal Emergency Management Agency, 2003. *Riverine Erosion Hazard Areas: Mapping Feasibility Study*. Washington, D.C.: FEMA. http://www.fema.gov/fhm/dl_river.shtm

Rapp, Cygnia & Timothy Abbe, 2004. A Framework for Delineating Channel Migration Zones.Washington State Department of Ecology, Washington State Department of Transportation, Ecology Publication #03-06-027. http://www.ecy.wa.gov/biblio/0306027.html

South Mountain Research & Consulting, 2005. *Phase 2 Stream Geomorphic Assessment: Castleton River Watershed, Rutland County, Vermont.*. Prepared for Poultney-Mettowee Natural Resources Conservation District and Rutland County Regional Planning Commission.

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VT DEC River Management Program, 2005a, *River Corridor Protection and Management: Fact Sheet #1* http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf

VT DEC River Management Program, 2005b, *Defining River Corridors: Fact Sheet #2*. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf

VT DEC River Management Program, 2005c (26 October draft), *Using geomorphic assessment data to guide the development of River Corridor Management Plans to achieve: Fluvial Erosion Hazard (FEH) Mitigation, Sediment and Nutrient Load Reduction, and Ecological-based River Corridor Conservation.*

VT DEC River Management Program, 2005d (14 February draft), *Vermont Fluvial Erosion Hazard Mitigation Program.*

VT DEC River Management Program, 18 April 2003, *Alternatives for River Corridor Management*: Vermont DEC River Management Program Position Paper. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf

VT DEC Water Quality Division, 2001, *Vermont Regional Hydraulic Geometry Curves: 2001 Provisional* http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_hydraulicgeocurves.pdf

APPENDIX C

Outreach Materials

Outreach Materials

APPENDIX C
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007

Landowner Letter

conserving
natural resources
for our future

Poultney-Mettowee Natural Resources Conservation District
PO Box 209, Poultney, VT 05764 – (802) 287-8339 – pmnrcd@sover.net
www.poultneymettowee.org

May 30, 2006

Dear Landowner:

The Poultney Mettowee Conservation District has received a grant from the Vermont Department of Environmental Conservation to continue its assessment and analysis of the Castleton River this summer. The long-term objectives are to reduce streambank erosion, as well as sediment and nutrient levels, and thereby improve water quality. We intend for this information to assist landowners and the town government in voluntary streambank area planning.

This summer, with the help of consultant Kristen Underwood, we are hoping to complete the data assessment begun last year to include the Pond Hill and Gully Brooks. Using this information, as well as previous data, the District will also be conducting a Corridor Protection Planning process. This will begin with personal discussions with landowners on the mainstem of the Castleton River to determine interest in participating in the process. We will then, with landowner support, begin identifying opportunities for projects that might result in water quality improvements in the future. The goal is to develop a prioritized list of alternatives that we can then work towards implementing in the future as funding permits.

As with our previous assessments, this planning process is completely non-regulatory and intended only to evaluate options for individual and community projects that have the local and community support. We would welcome any questions and comments about this project, and are happy to explain the project further. One of us will be contacting you in the near future, but please feel free to call or email us at any time.

Thank you.

Marli Rupe, District Manager
pmnrcd@sover.net
287-8339

Kristen Underwood
South Mountain Research & Consulting
southmountain@gmavt.net
453-3076

Meeting Handout

APPENDIX D

Potential Site- and Reach-level Projects

Project #	Reach/ Segment	Potential Project Type	Description	Opportunities / Issues	Action	Considerations
T2.12-1	T2.12	Restoration	Ira Birdseye tributary - remove berm/ restore floodplain (similar to Gully Brook project)	Need for repeated channel dredging leading to berms (of dredged material) and channel incision, blockage of railroad crossing, sediment accumulation at confluence and upstream flooding at Grabowski Farm.	Obtain Ira parcels and landowner info; Meet w/ Grabowski; Contact Railroad	Need for Phase 1 and Phase 2 assessment of tributary. Offsite removal of sediments.
T2.12-2	T2.12	Cattle Exclusion	Collapsed crossing at steep riffle and DS pool - direct cattle access (small herd)	trampling erosion of streambanks; direct fecal matter contact with Castleton River.	Obtain Ira parcels and landowner info; Contact farmer.	Ag of Ag program; or CREP
T2.12-3	T2.12	Wetland Conservation	Conserve functioning wetland and remove former Ski Area access road	Functioning wetland offering wildlife and instream habitat, sediment and flow attenuation, and possible nutrient attenuation.	Continue discussions w/ Ed Davis; Obtain Ira parcel data (rel to alternate road access to high ground south of wetland). Bring up in discussions with Brian Traverse. Investigate possible dam.	Habitat and wetland hydrologic function would be best enhanced by removal of former ski area access road. Need alternate road access for owner if take out former ski area road. Determine interest of additional landowners downstream to Birdseye Rd. VCGI coverage indicates dam located at main culvert crossing (?).
T2.11-4	T2.11-B	Active Channel Restoration	Restore channel access to flood chutes and floodplain southwest of current channel.	Approximately 1600 feet of channel from the Gully Brook confluence downstream to the Route 4A crossing is channelized along the historic trolley grade and has lost connection to its floodplain. At higher flows, the river has breached the trolley grade in a few locations along left bank on Savage property and along right bank at the Ruby property, creating conflicts with adjacent agricultural lands. Significant sediment volumes will continue to be transported from Gully Brook headwaters. While the Gully Brook floodplain restoration project has provided some opportunity for sediment attenuation, more opportunities are needed along the Castleton River, to relieve pressures on downstream reaches.	Contact Jerry Savage; continue dialogue with Brian Traverse. Discussions will need to consider impacts to Grabowski who currently leases the Savage and Ruby lands to grow corn / hay, respectively. Contact Ruby (Pete Sr.); consider impacts to Grabowski lot. FEH should be revised (Shannon) near Savage / Ruby prop line to reflect that actual channel position is along the trolley grade and not where the surface water coverage shows it to be. Short-term (one-time) gravel removal from main stem just downstream of Gully Bk confluence (PMNRCD).	Phase 3 assessment would be required along with HEC-RAS or appropriate hydraulic assessements to support restoration design. Possible wier constructed downstream of the Gully Brook confluence to keep sediment from accumulating at that location. Possible need for grade controls in Gully Brook to prevent headcuts from migrating upstream. Seek potential sources of compensation for landowners, particularly Savage and Ruby (and Grabowski ?) . Probable maintenance of trolley grade on Savage lands and possible berm removal on Ruby lands (depending on analysis of consequences).
T2.11-5	T2.11-B	Passive Channel Restoration and Berm Removal	Restore channel access to floodplain north and northeast of current channel.	Downstream of Route 4A crossing, the Castleton River is confined between berms along LB and the historic trolley grade along RB. A plane-bed, transport-dominated channel directs sediments to the vicinity of the Ward and O'Rourke properties where sediment is locally aggrading and apparent avulsions are active. Channel management activities attempted in the Ward / O'Rourke vicinity have not been sustainable, and there are ongoing land use conflicts with the river channel. A recent channel avulsion has resulted in the River flowing through active horse pasture close to a manure storage area. With LO willingness and appropriate compensation, it may be possible to provide for increased floodplain access, and sediment /flow attenuation through berm (trolley grade) removal along RB on the Ruby parcels. This action may reduce conflicts through the Ward / O'Rourke parcels - especially if in combination with floodplain / channel restoration upstream of the Route 4A crossing.	Contact Ruby (Pete Sr.); consider impacts to farmer who hays Ruby lot. Possible recent conveyance of lot to another party? Contact Ward & Davis - understand goals / recent conflicts with river. Continue discussions with O'Rourke.	Pending LO meetings. Care not to create / exacerbate potential conflicts with Railroad, Route 4A. If channel / floodplain restorations upstream and downstream of Route 4A crossing are implemented, consider pros/cons of restoring channel to pre-avulsed condition on O'Rourke property to reduce water quality impacts of horse pasture and manure storage areas.

Project #	Reach/ Segment	Potential Project Type	Description	Opportunities / Issues	Action	Considerations
T2.11-6	T2.11-A	Buffer Enhancements; possible corridor conservation.	Passive geomorphic approach, including restore woody vegetation and boundary conditions, reduce agricultural encroachments, prevent future residential/commercial encroachments.	Historically channelized segment is partly incised, spanned by a couple constricting bridges, armored along much of its length. Buffer enhancement projects to restore woody vegetation to greater widths, and reduce agricultural encroachments, would support a passive geomorphic approach to restoring channel sinuosity, and manage toward an equilibrium channel. Buffer enhancements would also improve habitats and reduce water quality impacts.	Contact Landowners to understand future goals / past conflicts with river. Discuss river management goals and determine if there might be voluntary cooperation by landowners involving appropriate compensation.	Pending LO meetings.
T2.10-7	T2.10	Streambank stabilization	Streambank stabilization along private driveway and Route 4A just upstream of Route 4A crossing at upstream end of reach.	Old abutments from former alignment of Route 4 are contributing to channel avulsions; mass failures along LB have the potential to impact Route 4A; erosion and inundation along RB have potential to impact driveway access to Dumas property.	Contact Dumas to understand conflict with river. Re-examine area with focus on potential abutment removal and/or streambank stabilization.	Streambank stabilization should only occur in combination with other reach-wide opportunities to enhance sediment attenuation and improve woody riparian buffers.
T2.09-8	T2.09	Dam Removal	Possible removal of historic dam just downstream of North Bretton Brook confluence.	Run-of-river low-head dam is serving to interupt sediment transport and may block fish passage; on the other hand it serves as a vertical grade control (though channel spanning bedrock also exists 1650 feet upstream and 380 feet downstream in the Castleton main stem). This dam is apparently not on the Dam Inventory of the Dam Safety Section.	Notify Dam Safety Section of existence / location of the dam so that it can be inspected and a hazard rating assigned. Complete a Dam and Impoundment Assessment per VTANR SGA protocols. Conduct limited historical research to determine dam ownership / historic use. Contact dam owner (if able to be determined).	Dam owner may be difficult to ascertain. If in public ownership (e.g., Town), potential removal would involve a public process and historic/cultural research, environmental assessment, hydrologic and hydraulic assessment, etc. Impacts on North Bretton Brook stability and sediment / flow regimes would need to be considered along with Castleton main stem.
T2.09-9	T2.09	Corridor Conservation	Passive geomorphic approach to conserve ample woody vegetation prevent future encroachments where the Castleton River is undergoing active lateral adjustments and attenuating sediments.	Presently, there are ample woody buffers and limited development in this actively adjusting segment of the Castleton River. And only 2 major landowners: Proctor Trust, and the Town of Castleton. This area is also coincident with the Source Water Protection Area surrounding one of the town's gravel pack wells. Town parcel (Dewey Field) provides an opportunity for education / outreach activities. Two major stormwater inputs from Castleton village and Castleton State College are directed to the vicinity of this section of the Castleton. Town has concerns for water quality impacts so close to their Source Protection Area.	Contact the owner representative for the Proctor Trust parcels to understand their future goals for the property. Locate technical and financial resources to assist the town in completing an assessment of the stormwater issues and feasibility of alternate treatments.	Pending LO discussions.

APPENDIX E

Resources

Resources

APPENDIX E
River Corridor Plan
Castleton River: Town of Castleton
Reaches T2.09 through T2.12

Rutland County, Vermont

March 2007

GRANTS / RESOURCES

Northern Vermont Resource Conservation and Development Council
617 Comstock Road, Suite 2
Berlin VT 05602-8498
http://www.anr.state.vt.us/cleanandclear/bbroads.htm
Vermont Better Back Roads Grants
Up to $7,000 with 25% local match

VT Department of Housing & Community Affairs
National Life Building, 6th Floor, Drawer 20
Montpelier, VT 05620
http://www.dhca.state.vt.us/Planning/MPG.htm
Vermont Municipal Planning Grants
Single town: $15,000
Consortium (Multiple towns): $25,000

VT Department of Environmental Conservation
River Corridor Management Section
103 South Main St./ West Bldg.
Waterbury, VT 05761-0403

Vermont River Corridor Restoration & Protection Grants
http://www.anr.state.vt.us/dec/waterq/rivers.htm
Clean and Clear Water Action Plan
Available FY2006. to Lake Champlain Basin watersheds

Category I:	Project Identification:	$100,000
Category II:	Project Development:	$300,000
Category III:	Project Implementation:	$850,000

Vermont Watershed Grants
http://www.anr.state.vt.us/dec/waterq/lakes/htm/lp_watershedgrants.htm
Mini-grants: $200 to $1000
Grants: $1,000 and higher

Nonpoint Source Management Grants
EPA - Clean Water Act Section 319
Rick Hopkins rick.hopkins@state.vt.us
802-241-3769

PUBLICATIONS

Geomorphic Assessment and Corridor Delineation

Managing Toward Stream Equilibrium. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_ManagingTowardStreamEquilibrium.pdf

River Corridor Protection as a Restoration Tool. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_CorridorProtectionasRestoration.pdf

Conservation of River Corridor Lands. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_MunicipalIncentives%20.pdf

Municipal Guide to Fluvial Erosion Hazard Mitigation. VT DEC River Management Program, 2006.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_municipalguide.pdf

River Corridor Protection and Management: Fact Sheet #1. VT DEC River Management Program, 2005. http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagefactsheet.pdf

Defining River Corridors: Fact Sheet #2. VT DEC River Management Program, 2005.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_definingrcfactsheet.pdf

Alternatives for River Corridor Management: Vermont DEC River Management Program Position Paper. VT DEC River Management Program, 18 April 2003.
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf

Procedure on ANR Floodway Determinations in Act 250 Proceedings
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwayprocedure.pdf

Vermont Agency of Natural Resources Technical Guidance for Determining Floodway Limits Pursuant to Act 250 Criterion 1(D) 2/21/03
http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_floodwaytechguidance.pdf

Buffers

VTANR Riparian Buffer Guidance – Adopted 20 January 2005
http://www.anr.state.vt.us/site/html/buff/buffer-final-2005.pdf

VTANR Riparian Buffers and Corridors Technical Papers, 2005
http://www.anr.state.vt.us/site/html/buff/buffer-tech-final.pdf

Sources of Native Plant Materials in Vermont. Compiled by Erin Hanley. VT DEC Water Quality. Report #209. 2005.
http://www.anr.state.vt.us/dec/waterq/wetlands/docs/wl_nativeplants.pdf

Water Quality

Poultney-Mettowee Watershed Partnership, 2006 Water Quality Monitoring Project: Final Report. Prepared by Hilary Solomon, PMWP. Available from Poultney-Mettowee Natural Resources Conservation District, PO Box 209, Poultney, Vermont 05764. (802) 287-8339.
See also current water quality monitoring program overview at.
http://www.poultneymettowee.org/water_quality.html

State of the Lake: Lake Champlain in 2005--A Snapshot for Citizens. Lake Champlain Basin Program, 2005. Available at: http://www.lcbp.org/PDFs/sol_web.pdf

Lake Champlain Long-term Monitoring – Tributary Station Summary Statistics. VT DEC Water Quality Division, 2006.
http://www.anr.state.vt.us/dec/waterq/cfm/champlain/tribstats_results.cfm

Beavers

Best Management Practices for Resolving Human-Beaver Conflicts in Vermont. Vermont Fish and Wildlife Department. Vermont DEC. Revised 2004.
http://www.anr.state.vt.us/FW/FWHOME/library/factsheets/Fish_and_Wildlife/Best_Management_Practices_for_Human-Beaver_Conflicts.pdf

CONTACTS

Conservation

Vermont Land Trust - http://www.vlt.org/

Leslie Ratley-Beach: (866) 457-2369

Lake Champlain Land Trust – http://www.lclt.org/ (802) 862-4150

Vermont River Conservancy - http://www.vermontriverconservancy.org/

Steve Libby: (802) 434-2592

The Nature Conservancy of Vermont - (802) 229-4425
http://nature.org/wherewework/northamerica/states/vermont/

Stream Permits

To find out about stream-crossing structures or gravel extraction permits, see the VT DEC website, under River Management and Permits. http://www.vtwaterquality.org/rivers.htm.

Contact Chris Brunelle, Stream Alteration Engineer with questions. (802) 879-5631 or chris.brunelle@state.vt.us

Restoration

USDA Natural Resources Conservation Service – http://www.vt.nrcs.usda.gov/

Bill Forbes, District Conservationist, NRCS Rutland County
William.Forbes@vt.usda.gov
(802) 775-8034 x14

US Fish and Wildlife Service /Partners for Wildlife - http://www.fws.gov

Chris Smith
Chris_E_Smith@fws.gov
(802)-872-0629 x 20