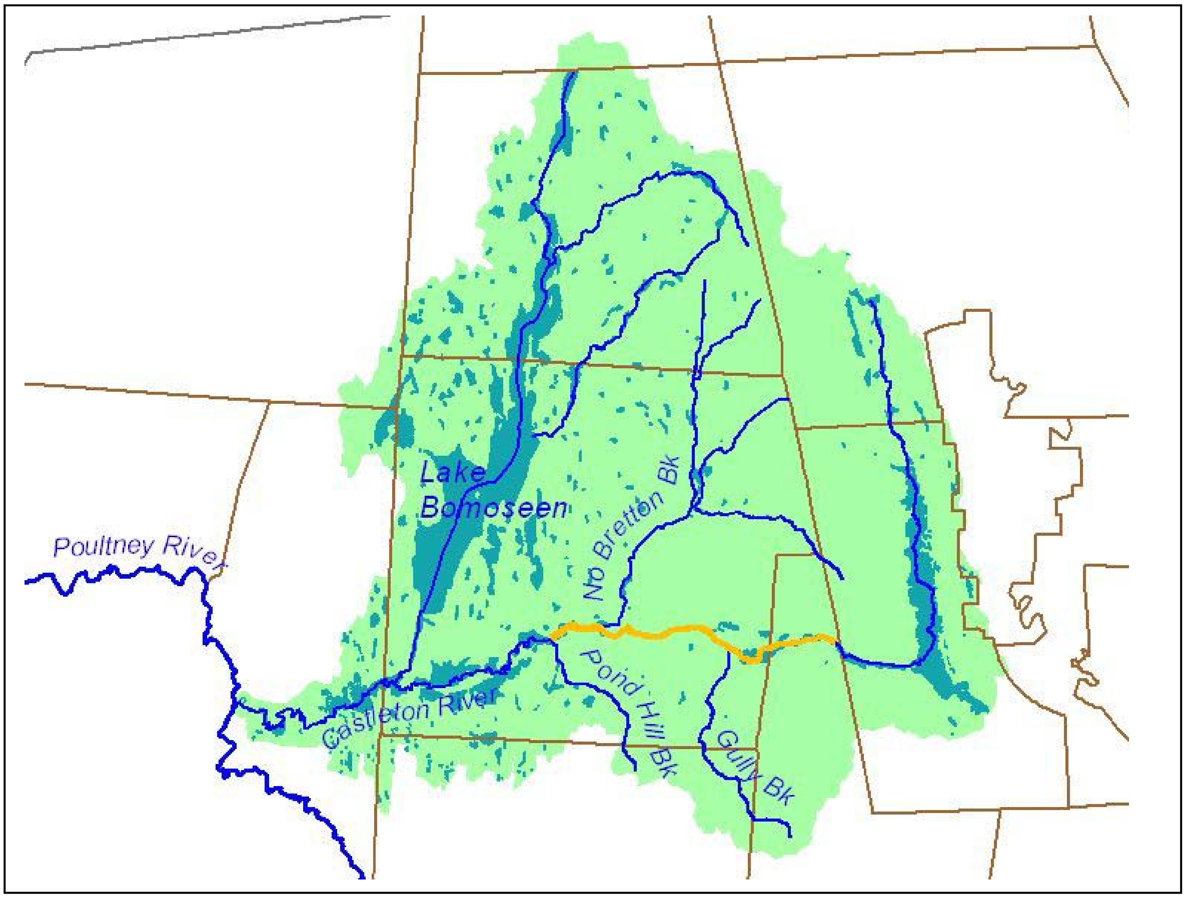
River Corridor Plan
Castleton River: Reaches T02.09 – T02.12

Town of Castleton
Rutland County, Vermont

March 2007 (Revised April 2008)



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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 project steering committee, Castleton town officials, State and regional agencies, interested community members, and open discussions with the many landowners who own property along the Castleton river reaches.

APRIL 2008 REVISIONS

April 2008 revisions to this Corridor Plan were completed to incorporate recently-updated, Quality-Assured Phase 2 stream geomorphic assessment data for the four corridor reaches (SMRC, 2008). Substantial changes to the corridor planning guidance from the VTANR River Management Section had also occurred in the years post-dating the original contract. While funding was not available to completely revise the Corridor Plan in accordance with the most up-to-date guidance, limited revisions were undertaken in this April 2008 version of the corridor plan (Appendices A and B) to bring the plan closer to current standards – namely, inclusion of sediment regime departure maps and tables, and text revisions to better address the connection between noted stressors and reach condition / sensitivity.

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. A grant appropriated through Governor Douglas' Clean & Clear Program 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 Steering Committee 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 Steering Committee 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 Steering Committee to these organizations is continuing, as needed.

A River Corridor Plan has been prepared for public review. The plan identifies and prioritizes 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 Steering Committee 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, 2008).

This 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, 2007) conducted by the Poultney-Mettowee Natural Resource Conservation District 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/)

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, 2007, 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 Steering Committee; (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 Steering Committee

A Steering Committee was established to steward the river corridor planning process. The Committee 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, 2008).

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 in 2005 and 2006 along the Castleton River main stem (SMRC, 2008) 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. Details of this analysis are summarized in Appendix A. The geomorphic conditions noted have informed the river corridor management strategies outlined in Section 5. The analysis followed 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 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 wetlands contiguous to the channel which may serve important sediment and nutrient attenuation functions in the watershed.

4.4 Attendance at Castleton Public Meetings

The Steering Committee 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 Steering Committee 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 steering committee 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 (Appendix D and Project CD).

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 Steering Committee 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

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.

Where landowner willingness is expressed, Poultney-Mettowee NRCD will seek additional funding 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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Analysis of Existing Geomorphic Data
to Support Identification of Corridor Management Strategies

APPENDIX A
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007 (Revised April 2008)

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Analysis of Existing Geomorphic Data
to Support Identification of 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 report for details of the methodology and results (SMRC, 2008). Geomorphic condition and reach sensitivities revealed from these assessments are summarized in this Appendix A to the River Corridor Plan for Castleton.

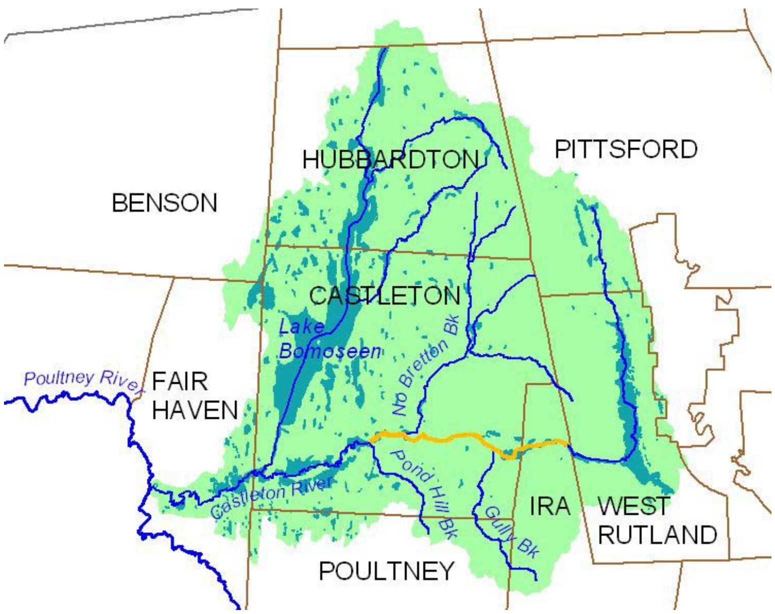


Figure 1. Location of Castleton River main stem reaches which are the focus of this corridor planning effort (highlighted in orange).

The 2005 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 toward equilibrium, thereby reducing erosion hazards and improving water quality over the long term. Analysis tasks 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; and

- 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.

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

Note: The original analysis followed utilized guidance from the VTDEC River Management Section:

- VT DEC River Management Section, 2005 (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.*

Substantial changes to the corridor planning guidance from the VTANR River Management Section have occurred in the years post-dating the original corridor planning scope of work for these Castleton River reaches. The updated guidance is titled:

- *VTANR River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects* (11 July 2007 draft).

While funding was not available to completely revise the Corridor Plan in accordance with the most up-to-date guidance, limited revisions were undertaken in this April 2008 version of the corridor plan (Appendices A and B) to bring the plan closer to current standards – namely, inclusion of sediment regime departure maps and tables, and re-ordering of text (in Appendix A) to better address the connection between noted stressors and reach condition / sensitivity.

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 four reaches comprising the river corridor in Castleton, Vermont (SMRC, 2008).

2.2 Channel and Watershed Disturbances

Various watershed-scale and channel-level disturbances have served as stressors to the Castleton River main stem 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.

Channel features are indicated on annotated reach maps in Attachment 1 to this Appendix.

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	Incision Ratio	RHA Condition	RGA Condition	Adjustment	Vertical Stream Type Departure?	Channel Evolution Stage	Sensitivity
T02.12	--	12,493	***0.1***	23.8	E4-R/D	Not Assessed - Wetland-Dominated						High
T02.11	B	5,876	***0.3***		C4-R/P	1.3 (RAF)	0.55 Fair	0.39 Fair	Aggr, PF & Wid	No	IV [F]	Very High
	A	5,145	***0.3***	32.9	C4-PB	1.0 (RAF)	0.47 Fair	0.71 Good	Aggradation	No	V [F]	High
T02.10	--	2,626	***0.3***	33.3	C4-R/P	1.3 (RAF)	0.81 Good	0.65 Good	Wid (slight) & Aggr	No	IV [F]	High
T02.09	B	2,045	***0.6***		F4-PB	NM	0.58 Fair	0.49 Fair	Aggr, PF & Wid	C to F	II [F]	Extreme
	A	3,190	***0.3***	47.9	C4-R/P	1.0 (RAF)	0.66 Good	0.48 Fair	PF, Aggr, Wid	No	IV [F]	Very High

Notes / Abbreviations:

Channel Slope: Values in italic bold have been updated since the Phase 1 SGA, due to field-truthing and/or segmentation.
Stream Type: S/P = Step/Pool; R/P = Riffle/Pool; R/D = Ripple/Dune; PB = Plane Bed; Casc = Cascade; Ref = Reference
Incision Ratio: RAF = Recently Abandoned Floodplain; HEF = Human-elevated Floodplain (following protocols, VTANR, 2007).
Condition: RHA = Rapid Habitat Assessment; RGA = Rapid Geomorphic Assessment (VTANR, 2006).
Adjustment: PF = Planform Adjustment; Aggr = Aggradation; Wid = Widening; Deg = Degradation; NM = Not Measured.
Channel Evolution Stage: F = F-stage model; D = D-stage model (see Appendix C of protocols, VTANR, 2006).

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

	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;

2.3 Sediment Transport Characteristics, Departure Analysis

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.

The sediment transport characteristics and departure analysis for Castleton River corridor reaches are summarized in the following *Sediment Regime Departure Maps* (Figures 2 and 3) and the *Departure Analysis Table* (Table 3). Preparation of these maps and table follows methods outlined in VTANR guidance (2007).

Phase 1 (Reference) Sediment Regime

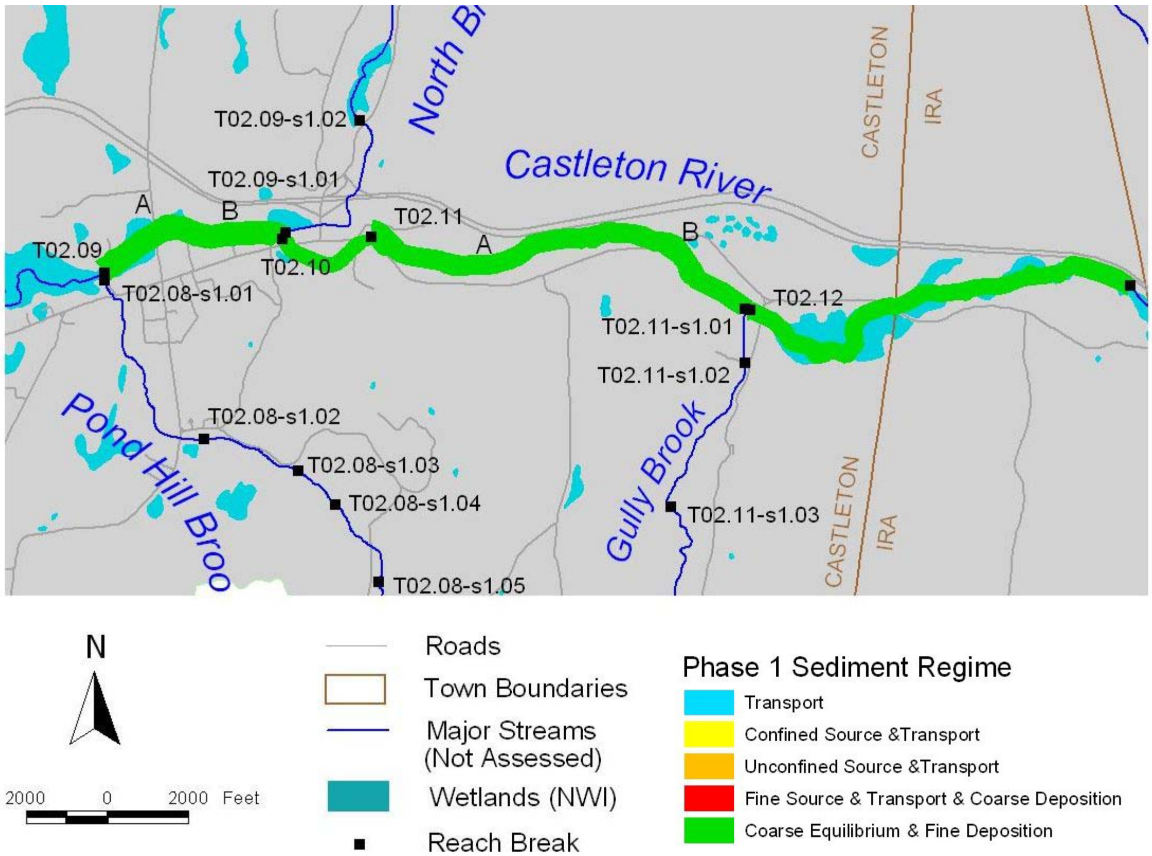
Figure 2 displays the inferred reference sediment regimes that would be characteristic of the river in a pre-developed state (say, 300 years before present). The four corridor reaches are in an unconfined, low-gradient (0.1 to 0.6%) valley setting. The reaches are largely unconstrained by bedrock, although point locations of channel-spanning bedrock do occur in reach T02.10 (south of the East Hubbardton Road intersection with Route 4) and in segment T02.09-B (just downstream of the North Bretton Brook confluence and low-head dam on the Castleton River). Bedrock also provides lateral grade control along the left bank of the Castleton River in reach T02.10 (see Table 3 and reach maps in Attachment 1).

The corridor reaches are bounded on the upstream end (reaches T02.12 and T02.13) and downstream end (reaches T02.08 through T02.04) by wetland hydrology. Based on the distribution of hydric soils (USDA, 1998), it is apparent that substantial portions of reach T02.11 were historically dominated by wetland conditions but have been converted to agricultural and residential land uses through ditching of tributaries, channelization and floodplain encroachments (fill).

In a pre-colonial era, prior to widespread development in the watershed, these corridor reaches would be expected to have good connection to the surrounding floodplain. The river would have had a natural meandering planform (altered locally by exposures of bedrock and variable sediment types in the stream bed and banks). Deposition and erosion cycles would have been balanced, such that there would be no net change in overall channel dimensions, gradient and planform (i.e., a channel in dynamic equilibrium). The channel would have moved within its floodplain in its reference (pre-disturbed) condition, but there would be no net change in average, reach-wide geometry such as slope and average meander width and amplitude. Theoretically, the pre-disturbed corridor reaches would have deposited fine sediments in their floodplains through periodic bankfull and flood-stage flows, and the transport of coarser sediments (bed load) would have been balanced, such that the bedload volumes entering the reach would be similar to bedload volumes leaving the reach averaged over a one- to two-year period. As such they are coded green in Figure 2, corresponding to a classification of *Coarse Equilibrium & Fine Deposition* (VTANR, 2007).

Sediment Regime Departure

The **Departure Analysis Table** (Table 3) summarizes the present status of each of the corridor reaches as either transport- or attenuation-dominated. Table 3 also indicates the natural constraints (e.g., bedrock) and human constraints (e.g., roads, development, land uses) to channel adjustment that are,



Reach / Seg	Phase 1 Reference Stream Type
T02.12 --	E4-R/D
T02.11 B	C4-R/P
T02.11 A	C4-R/P
T02.10 --	C4-R/P
T02.09 B	C4-R/P
T02.09 A	C4-R/P

Figure 2. Phase 1 (Reference) Sediment Regime Map, Castleton River corridor reaches, 2005 Stream Geomorphic Assessments

Table 3. Departure Analysis Table, Castleton River Corridor Reaches T02.09 through T02.12.

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
T02.12	None - no channel-spanning bedrock or dams.	H: RB Route 4 Highway (upstream end) H: LB trolley grade (berm) H: RB Farm/ Residential Development H: Bridge - railroad (FPW) H: Bridge - farm road (BKFL) H: Bridge - Route 4A (FPW) H: Culvert - former logging road (BKFL) H: Bridge - Birdseye Rd (FPW)			Wetlands contiguous to channel	**X** Local to short straightened sections of channel.		**X**
T02.11-B	None - no channel-spanning bedrock or dams.	H: RB trolley grade (berm) H: LB berms, few select locations H: RB railroad H: RB Route 4 Highway (downstream end) H: Residential Development H: agricultural fields (hay, pasture, crops) H: Bridge - Route 4A (FPW)		**X**	None - no alluvial fans or downstream, significant bedrock gorges.	**X** Historically, due to historic channelization and extensive floodplain encroachment (berms, railroad, road)	**X** Due to Gully Brook sediment sources, and recent segment avulsions to LB corridor, facilitated by lack of forested buffers and active breaching / undermining of abandoned trolley grade in the mid-segment upstream of Route 4A crossing.	**X**
T02.11-A	None - no channel-spanning bedrock or dams.	H: RB trolley grade (berm)- (upstream end) H: RB railroad (upstream & downstream ends) H: RB Route 4 Highway (upstream end) H: LB Route 4A (downstream end) H: Residential Development H: agricultural fields (hay, pasture, crops) H: Bridge - farm foot path (BKFL) H: Bridge - farm road (BKFL) H: Bridge - farm road (BKFL)		(X)	None - no alluvial fans or downstream, significant bedrock gorges.	**X** Due to historic channelization, armoring, and limited floodplain encroachment (berms, railroad, road)		

Abbreviations:
H = Human constraint; N = Natural constraint; BKFL = bankfull; FPW = Flood Prone Width; VB = Very Broad; SC = Semi-Confined.
LB = left bank; RB = right bank.

Table 3. Departure Analysis Table, Castleton River Corridor Reaches T02.09 through T02.12. – Continued

	Constraints		Transport		Attenuation (storage)			
Reach / Segment	Vertical	Lateral	Natural	Converted	Natural	Decreased	Increased	Asset
T02.10	Bedrock mid-reach	N: Bedrock along LB, mid-reach H: RB driveway H: LB Route 4A (upstream end) H: RB Commercial Development H: Bridge - Route 4A (FPW) H: Bridge - Route 4A (FPW)			None - no alluvial fans or downstream, significant bedrock gorges.			
T02.09-B	Low-head Dam (u/s end) Bedrock mid-segm	H: LB railroad H: LB trolley grade (berm) H: LB historic mill buildings H: LB residential development H: RB agricultural fields (hay) H: Bridge - railroad (FPW) H: Bridge - Mill Street (BKFL)		**X**			(X) - Local Historically, upstream of low-head dam at confluence of North Bretton Brook	
T02.09-A		H: LB railroad (very downstream end) H: LB recreation field H: RB agricultural fields (hay) H: Bridge - North Road (FPW)			Wetlands contiguous to channel - also in downstream reaches.			**X**

Abbreviations:
H = Human constraint; N = Natural constraint; BKFL = bankfull; FPW = Flood Prone Width; VB = Very Broad; SC = Semi-Confined.
LB = left bank; RB = right bank.

in part, influencing the current transport or attenuation status. Detailed locations of these natural and human constraints can be referenced on the annotated reach maps in Attachment 1.

Three segments of the unconfined reaches have been converted from equilibrium (fine depositional) conditions to transport-dominated conditions by virtue of various channel and watershed disturbances: T02.11-B, T02.11-A, and T02.09-B. Attenuation functions that might be expected in these unconfined valley settings have been decreased substantially as a result of:

- channelization, removal of meanders;
- encroachment (berms, trolley grade, railroad grade);
- residential development;
- commercial (and historic mill) development (T02.09-B);
- agricultural conversion, including tributary ditching; and
- historic incision / resultant decrease floodplain connection (T02.11-B, T02.09-B).

Also, woody vegetation along the streambanks and in the floodplain has been cleared for agriculture and residential use, which would have the effect of reducing the roughness of floodplain surfaces, further reducing potential for sediment attenuation in those floodplain areas. In fact, removal of woody buffers would also be expected to lead to increased streambank erosion, and these reaches could become a source of fine and coarse sediments to downstream reaches.

On the other hand, a couple of the corridor segments have experienced a minor to moderate degree of increased sediment attenuation in recent decades, as a consequence of channel and watershed disturbances.

- <u>T02.09-B – localized increase in sediment attenuation at low-head dam (minor)</u>
  Local to the upstream end of T02.09-B and the downstream end of T02.10, a low-head dam has persisted since at least the early 1800s (see Phase 2 Stream Geomorphic Assessment report; SMRC, 2008). Dams disrupt the flow dynamics (and sediment transport continuity) of rivers to varying degrees and extents, depending on their size, height, topographic setting, and operational status, and depending on the hydrologic, geomorphic and geologic characteristics of the river being impounded (Williams and Wolman, 1984; Kondolf, 1997). Sediments are trapped in the impoundment upstream of a dam; bed load and a portion of the suspended sediment load settle out in the still water environment of the reservoir. Water leaving the impoundment is essentially devoid of its sediment (bed) load, and possesses enhanced energy to erode the stream bed and banks. Depending on the nature of sediments in the channel margins and underlying surficial deposits, and vegetative boundary conditions, this increased erosional potential can lead to channel incision and/or widening downstream of the dam as the river seeks to restore its sediment load – a condition often termed "hungry water" (Kondolf, 1997). If scour is significant, the channel can incise below the surrounding floodplain.

  The low-head dam on segment T02.09-B of the Castleton River appears small enough in size and/or low enough in profile that sediment (and water) impounding effects in the river channel are considered minor under the current configuration. Also, sediment contributions from the North Bretton Brook are thought to be minor due to the impounding effects of Pelletier Dam approximately 4,500 feet upstream of the confluence with the Castleton River main stem (SMRC, 2008). The exposures of channel-spanning bedrock within 1,700 feet upstream and 400 feet downstream of the low-head dam on T02.09-B, would serve to limit the extent of potential incision related to impounding effects of this dam, or historic base level changes associated with dam construction or maintenance.

- T02.11-B – increase in sediment attenuation downstream of Gully Brook (moderate)
  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. A major channel avulsion occurred just downstream of the Gully Brook confluence in 2007, and the main channel now flows in the avulsed planform (Rupe, 2007). Deposition of sediments from upstream Gully Brook and associated channel avulsions have become superimposed on the historically incised conditions in this segment that resulted from channelization and encroachment of the former electric trolley grade.

  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. 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 (VTDEC WQD, 2004; VTDEC WQD, 2006).

  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. 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 (VTDEC WQD, 2004; Swift, 2006; PMWP, 2006).

  Ongoing passive geomorphic elements of the project include allowing the Gully Brook to re-establish meanders on a natural timeline. During field assessments of the Castleton River watershed in 2005 and 2006, multiple active flood chutes (incipient meanders) were observed along the right bank extending out onto the constructed floodplain (SMRC, 2008). Sediments are actively being deposited in the floodplain. Passive geomorphic elements have also included wildlife habitat enhancements, including tree plantings in the new floodplain (PMWP, 2006).

Reach T02.12 and segment T02.09-A have channel-contiguous wetlands and appear to be functioning as locations of flow, sediment (and possibly nutrient) attenuation in the watershed. Both segments are reasonably free of encroachments, and protection of these channel segments and their surrounding river corridor could preserve their attenuation functions. T02.09-A is particularly noteworthy as an attenuation asset downstream of modified, channelized segment T02.09-B.

If floodplain and channel functions of segment T02.11-A can be protected and restored (through a passive geomorphic approach), sediment and flow attenuation functions of this segment may also be enhanced at this strategic location downstream of modified and channelized segment T02.11-B.

Phase 2 (Existing) Sediment Regime

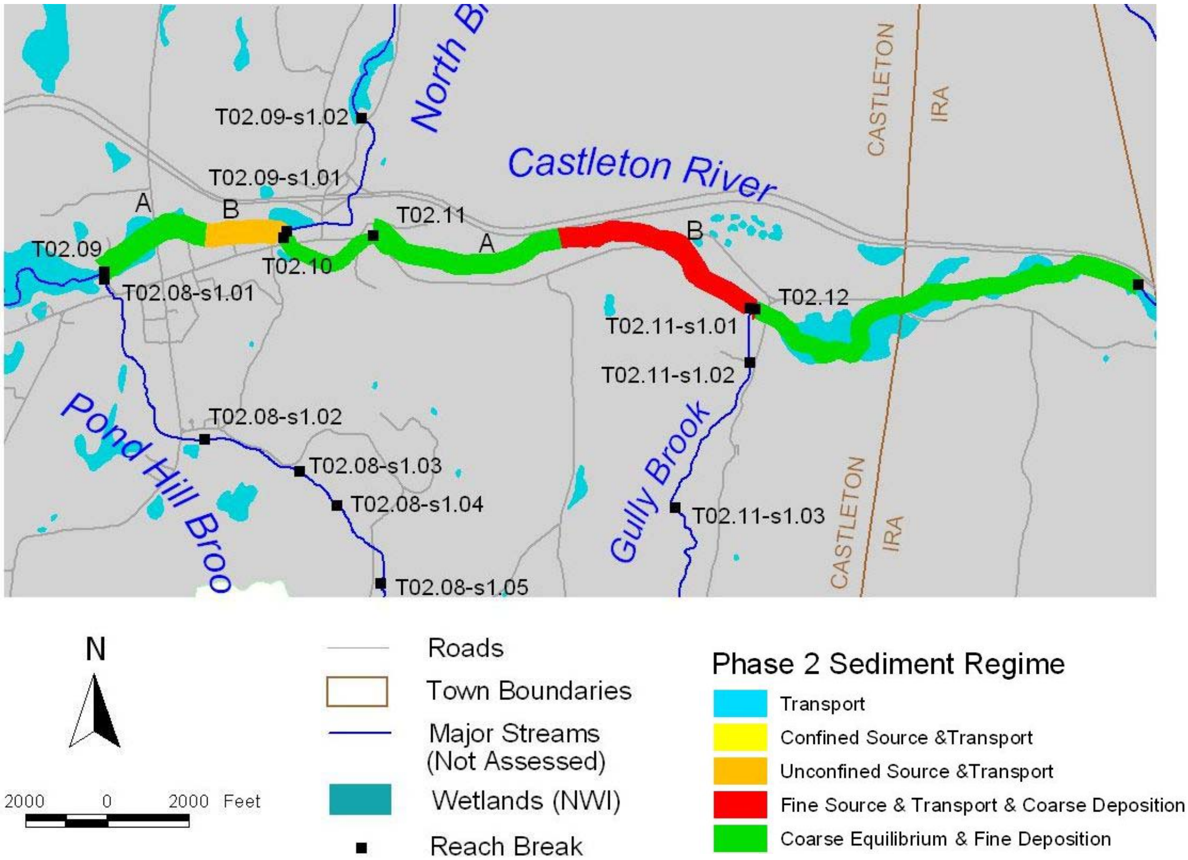
Figure 3 displays the existing sediment regimes, theorized based on Phase 2 assessment results and the departure analysis previously described. The contrast in coding of the reaches in the two figures illustrates the degree of departure from reference sediment regime that is inferred.

As a consequence of the various channel and watershed disturbances outlined above, segments T02.11-B and T02.09-B have undergone an apparent sediment regime departure (VTANR, 2007).

- T02.11-B
  This segment has been converted from a *Coarse Equilibrium & Fine Deposition* category to a *Fine Source & Transport and Coarse Deposition* category (see Figure 3). Floodplain access (and the associated sediment attenuation function) was historically compromised by channelization (removal of meanders) and encroachment of the electric trolley grade (berm) along the right bank. It is inferred that such channelization would have led to incision, followed by widening and lateral adjustment. Increased sediment loading from Gully Brook has contributed to an overall reduction in sediment transport capacity. Localized incision at the upstream end of the segment following periodic dredging near the Gully Brook confluence has likely contributed to localized instability at the head of the segment. A recent avulsion (in 2007) has diverted flows to an altogether different channel to the south of the former channel. Overall, the segment is in the later stages of channel evolution (IV [F]) and appears to be building a floodplain at a slightly lower elevation through channel widening and significant planform adjustments. A moderate degree of incision (IR_{RAF} = 1.3) has probably reduced the frequency of overbank fine deposition. Thus, rather than supporting net deposition of fine-grained sediments through regular overbank flooding, segment T02.11-B has been converted to a *Fine Source & Transport* segment. In-segment and upstream erosion is, in turn, contributing to coarse sediment deposition within the segment, locally enhanced by debris jams, entrained large woody debris, and reduced channel depths. The channel is locally overwidened in vicinity of these features. Thus, the segment has been converted from a *Coarse Equilibrium* condition to *Coarse Deposition*

- T02.09-B
  This segment has been converted from a *Coarse Equilibrium & Fine Deposition* category to an *Unconfined Source & Transport* category (see Figure 3). The loss of floodplain connection in Segment T02.09-B is substantial enough to have resulted in a stream type departure (from C to F). As a consequence of the moderately incised status, the enhanced scour energy of bankfull and low-magnitude flood flows would tend to be trapped within the banks of the channel, rather than dissipated out in the floodplain. Such increased scour energy is likely contributing to streambank erosion and local widening within the segment. Minimal-width, but mature, tree buffers are present along both banks, moderating the potential for widening or avulsions of the channel. Storage of fine and coarse sediment fractions has been reduced by the reduction in floodplain access and enhanced transport capacity resulting from channelization / encroachment.

While segment T02.11-A is also inferred to have been converted to a more transport-dominated channel by virtue of historic channelization and armoring (Table 3), this channel segment still maintains connection to the surrounding floodplain (IR_{RAF} = 1.0). The tendency for channel incision in response to



Reach / Seg	Phase 1 Reference Stream Type	Measured Stream Type	Incision Ratio (RAF)	Width/ Depth Ratio	Condition Score (RGA)	Channel Evolution Stage
T02.12 --	E4-R/D	E4-R/D	1.00	NM *	NM *	I (F)
T02.11 B	C4-R/P	C4-R/P	1.30	23	0.39 Fair	IV (F)
T02.11 A	C4-R/P	C4-PB	1.00	10	0.71 Good	V (F)
T02.10 --	C4-R/P	C4-R/P	1.30	18	0.65 Good	IV (F)
T02.09 B	C4-R/P	F4-PB	NM	NM	0.49 Fair	II (F)
T02.09 A	C4-R/P	C4-R/P	1.00	23	0.58 Fair	IV (F)

Stream Type Departure, Administrative Judgment

** Not Measured. Reach dominated by wetlands.*

Figure 3. Phase 2 (Existing) Sediment Regime Map, Castleton River corridor reaches, 2005 Stream Geomorphic Assessments

channel manipulations appears to have been offset by the cohesive nature of soils in the bed and banks, the relatively low channel gradient, and maintenance of channel armoring along the banks. While this segment does not have equilibrium planform (less-than-regime meander belt width [RRPC, 2005]), it is still expected to function as a *Coarse Equilibrium & Fine Deposition* channel.

The remaining reaches / segments have maintained a *Coarse Equilibrium & Fine Deposition* classification, since they have exhibited only minimal to moderate lateral or vertical adjustments in response to channel and watershed disturbances. The tendency for channel incision in response to channel manipulations appears to have been offset by the cohesive nature of soils in the bed and banks, maintenance of channel armoring along the banks, the occasional presence of bedrock grade controls (T02.10), and possibly the presence of the historic dam (upstream end of T02.09-B) offering vertical grade control and localized sediment impounding effects (though minor in degree). Reaches / segments T02.12, T02.11-A, and T02.09-A have good floodplain connection (IR_{RAF} = 1.0). Reach T02.10 has a minor degree of disconnection to the surrounding floodplain resulting from inferred historic incision (IR_{RAF} = 1.3). Fine deposition in the floodplain has likely been somewhat reduced in frequency as compared to the reference state of this reach.

2.4 Sensitivity Analysis

The ***Stream Sensitivity Map*** (Figure 4) identifies the sensitivity classification for each of the corridor reaches assigned based on the Phase 2 stream geomorphic assessment data (SMRC, 2008). Inherent in the stream sensitivity rating are:

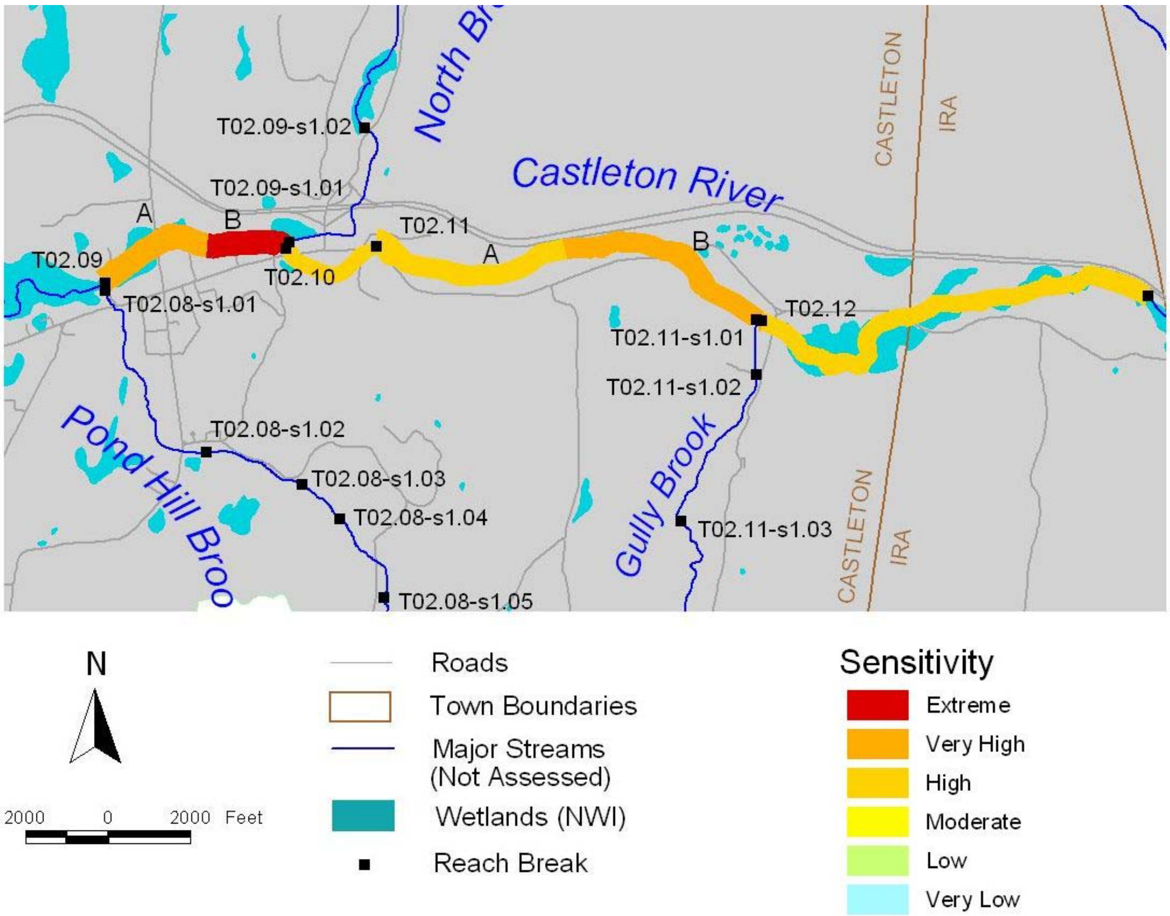
- the natural sensitivity of the reach given the topographic setting (confinement, gradient) and geologic boundary conditions (sediment sizes) – as reflected in the reference stream type classification (after Rosgen, 1996 and Montgomery & Buffington, 1997); and

- the enhanced sensitivity of the reach given by the degree of departure from reference (or dynamic equilibrium) condition – as reflected in the existing stream type classification and the condition (Reference, Good, Fair to Poor ratings in the Rapid Geomorphic Assessment).

The sensitivity classification is intended to identify "the degree or likelihood that vertical and lateral adjustments (erosion) will occur, as driven by natural and/or human-induced fluvial processes" (VTANR 2007).

Sensitivities of the study area reaches/segments as defined in VTANR protocols (2005) range from High to Extreme (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.

One of the corridor segments (T02.09-A) was assigned an **Extreme** sensitivity due to a stream type departure from C to F, and is depicted in red on Figure 4. This segment has lost access to the surrounding floodplain as a result of historic channelization, historic encroachments associated with mill operations, and streambank armoring. Dominant adjustment processes observed in this segment was planform adjustment (flood chutes) with localized aggradation and widening.



Reach / Seg	Condition Score (RGA)	Channel Evolution Stage	Sensitivity
T02.12 --	NM *	I (F)	High
T02.11 B	0.39 Fair	IV (F)	Very High
T02.11 A	0.71 Good	V (F)	High
T02.10 --	0.65 Good	IV (F)	High
T02.09 B	0.49 Fair	II (F)	Extreme
T02.09 A	0.58 Fair	IV (F)	Very High

** Not Measured. Reach dominated by wetlands.*

Figure 4. Reach / Segment Sensitivity, Castleton River corridor reaches, 2005 Stream Geomorphic Assessments

The remaining corridor reaches / segments were assigned a **High** or **Very High** sensitivity, as prescribed in VTANR protocols, and are depicted in light orange or dark orange (respectively) on Figure 4. They exhibited moderate to minor adjustments, and consequently were rated in Fair or Good condition. Some indicated a minor to moderate degree of historic incision, but none had lost access to their floodplain.

These stream sensitivity data were utilized during subsequent planning steps to inform the identification and prioritization of corridor restoration and protection projects and practices (Appendix D) (see also Phase 2 Stream Geomorphic Assessment report, Section 6).

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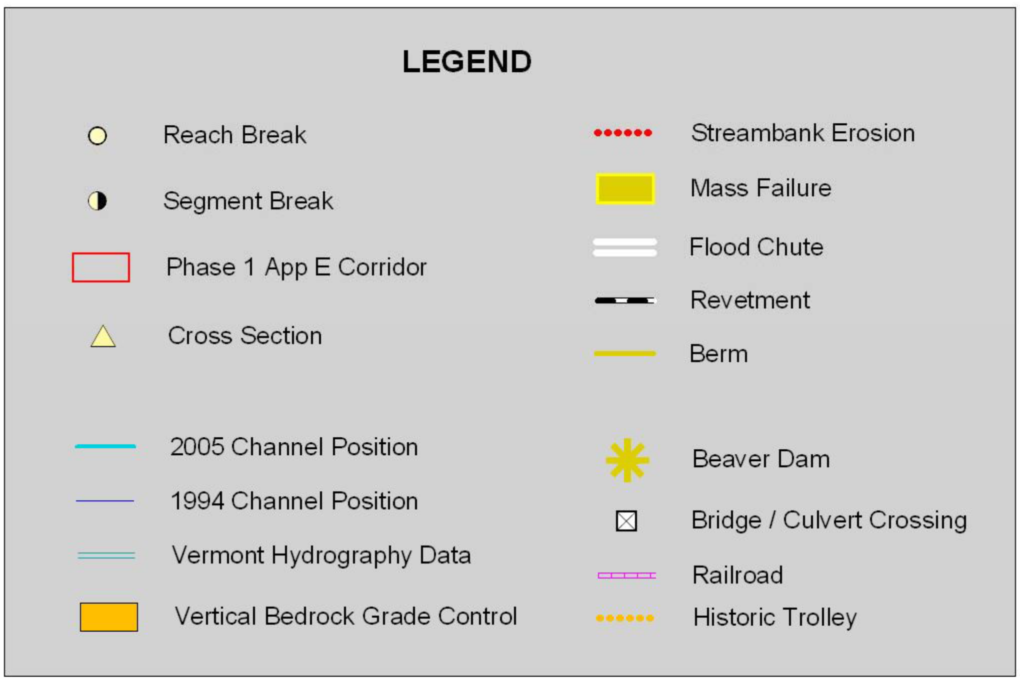
Attachment 1.

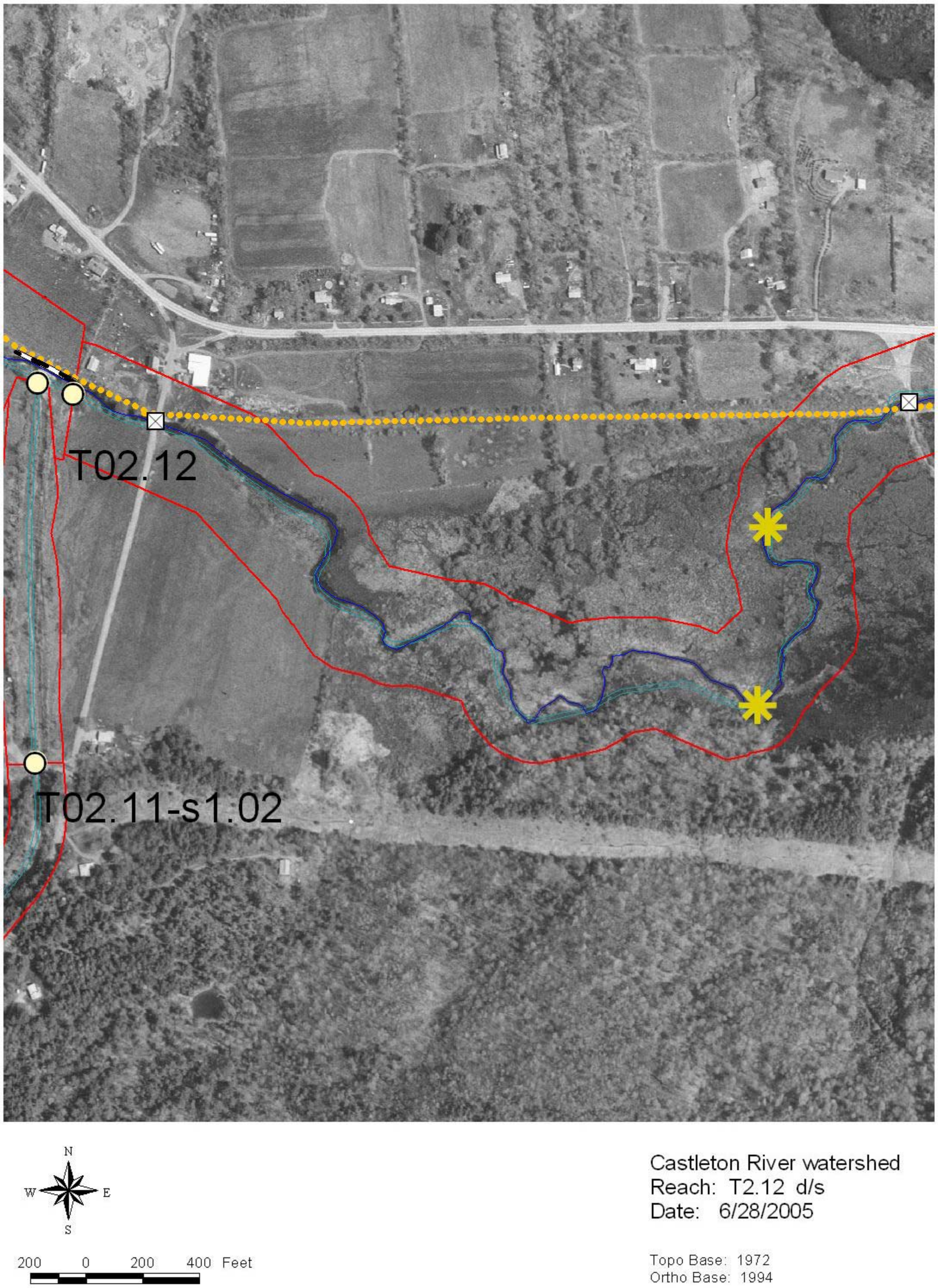
Annotated Reach Maps from 2005 Assessments



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

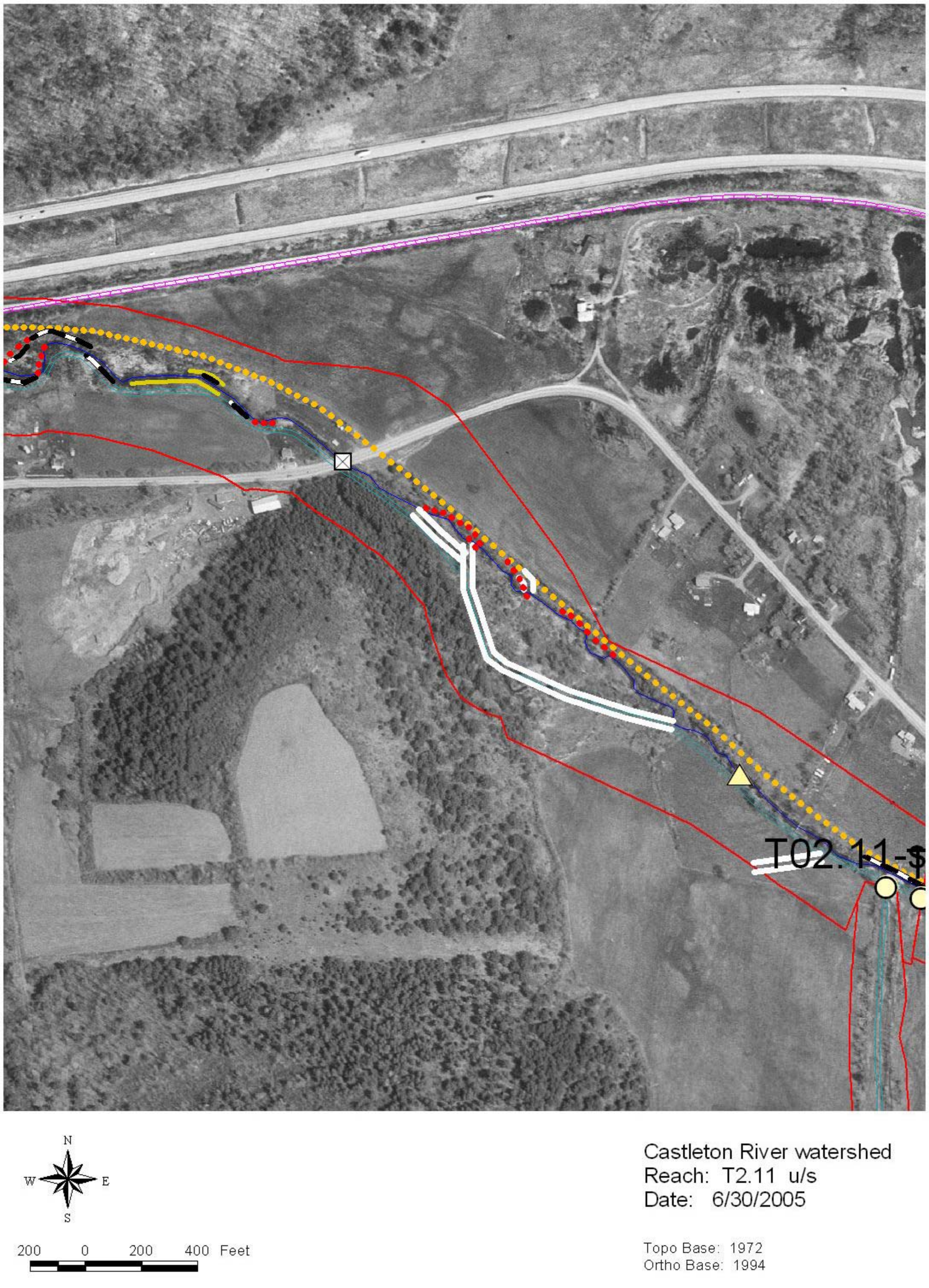
Topo Base: 1972
Ortho Base: 1994


N
W
E
S
200 0 200 400 Feet
Castleton River watershed
Reach: T2.12 m/s
Date: 6/28/2005
Topo Base: 1972
Ortho Base: 1994



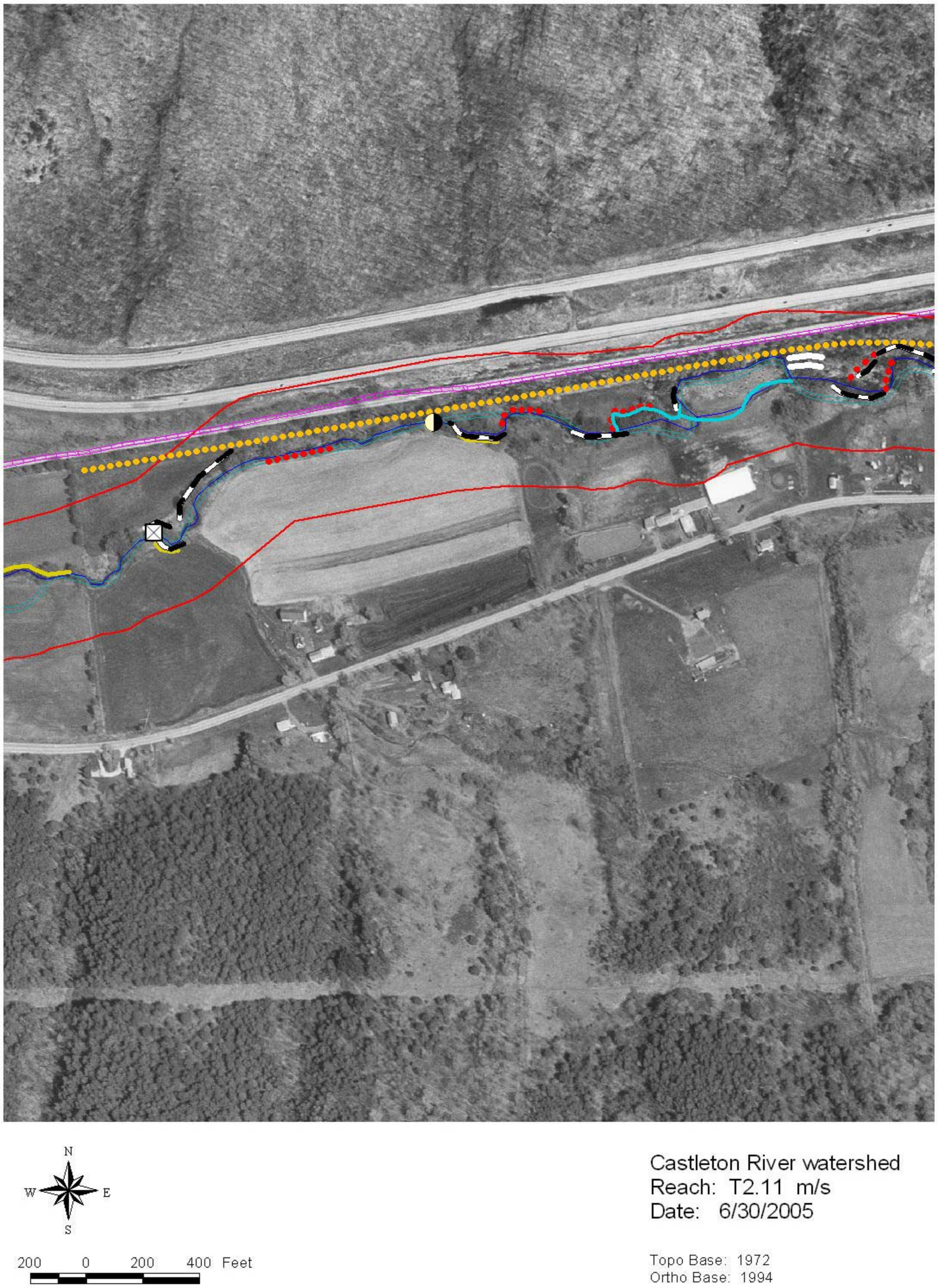
Castleton River watershed
Reach: T2.12 d/s
Date: 6/28/2005

Topo Base: 1972
Ortho Base: 1994



Castleton River watershed
Reach: T2.11 u/s
Date: 6/30/2005

Topo Base: 1972
Ortho Base: 1994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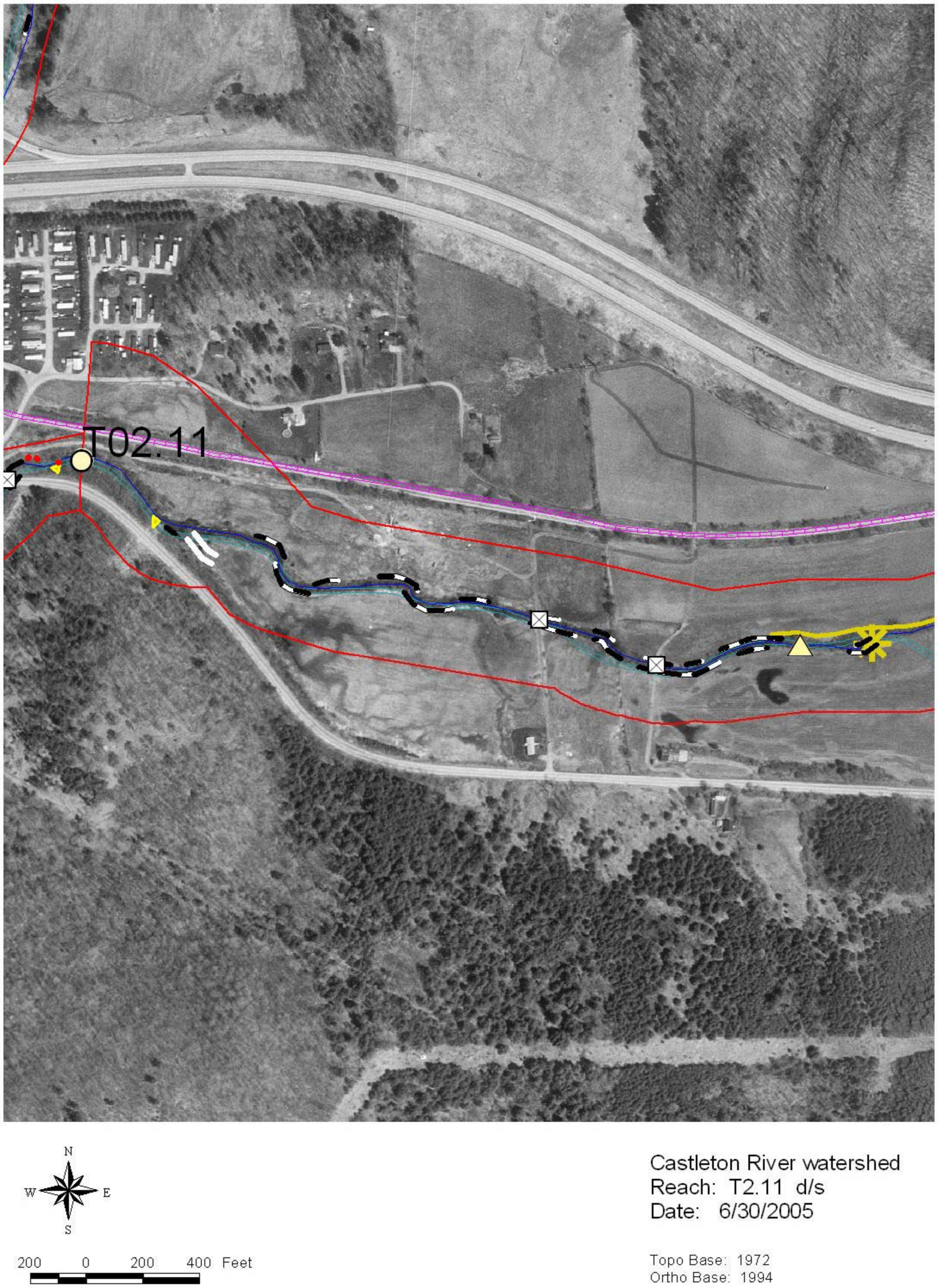
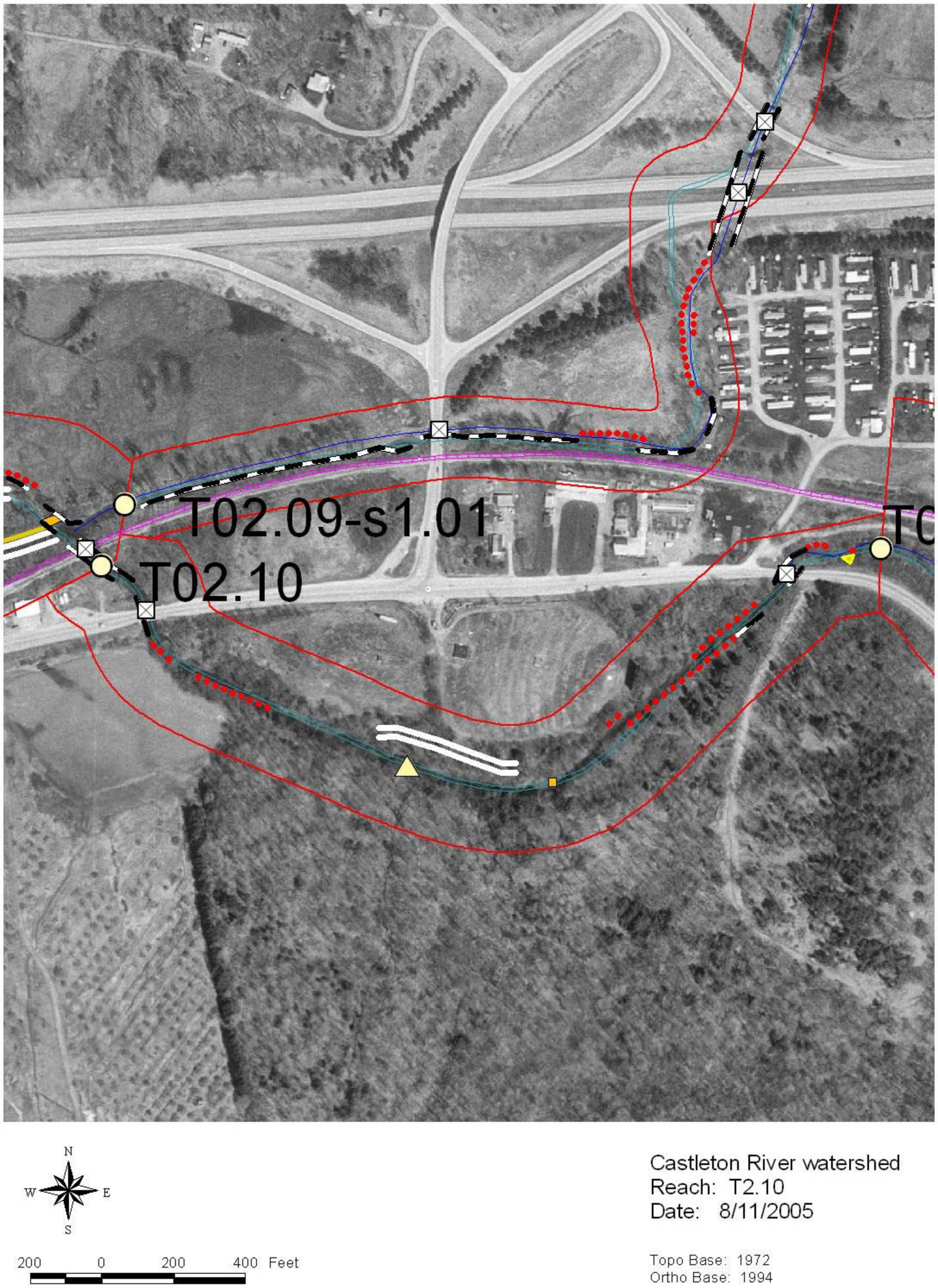
Feet
Castleton River watershed
Reach: T2.11 m/s
Date: 6/30/2005
Topo Base: 1972
Ortho Base: 1994



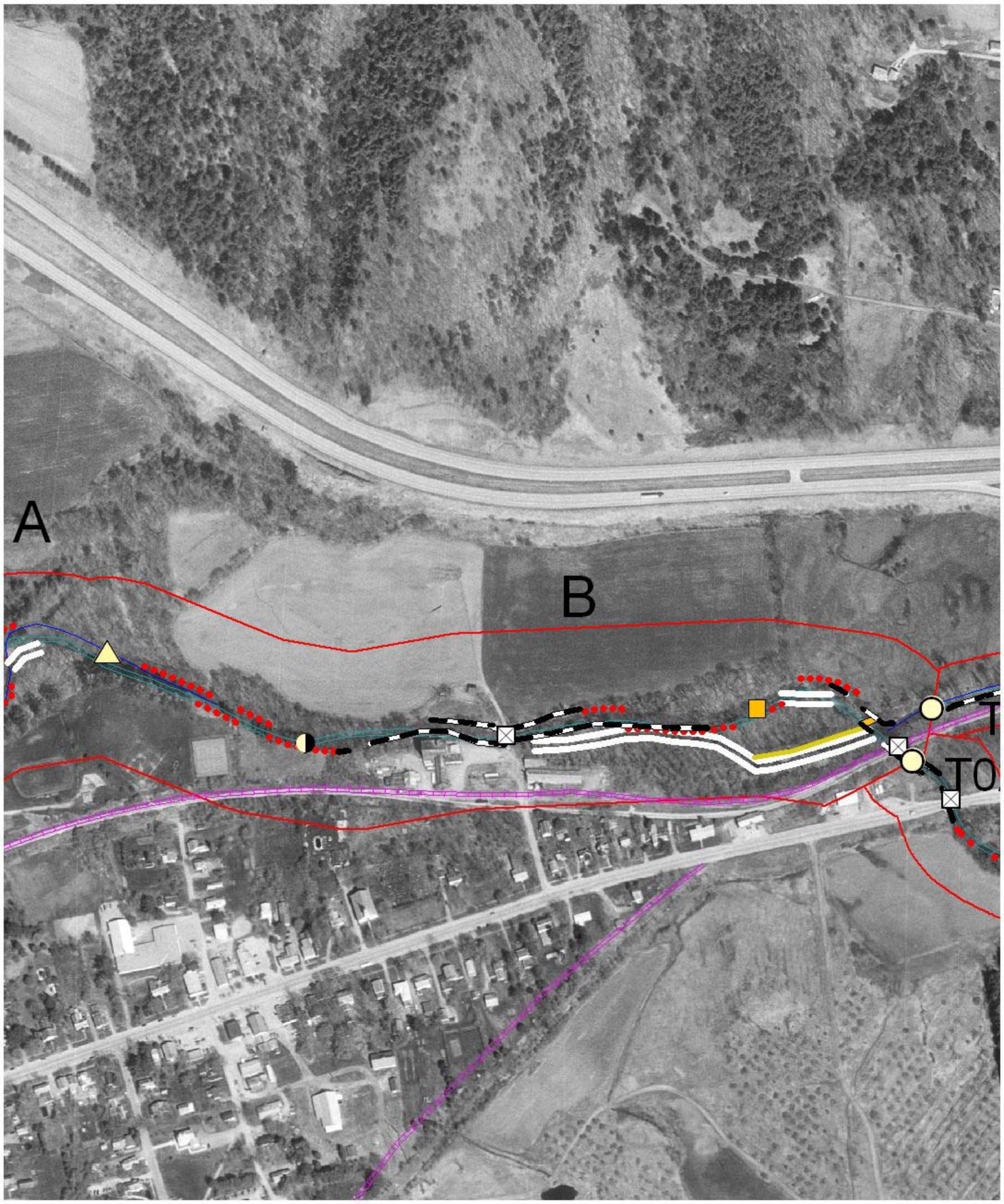
Castleton River watershed
Reach: T2.11 d/s
Date: 6/30/2005

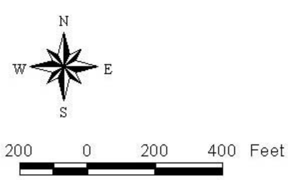
Topo Base: 1972
Ortho Base: 1994



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

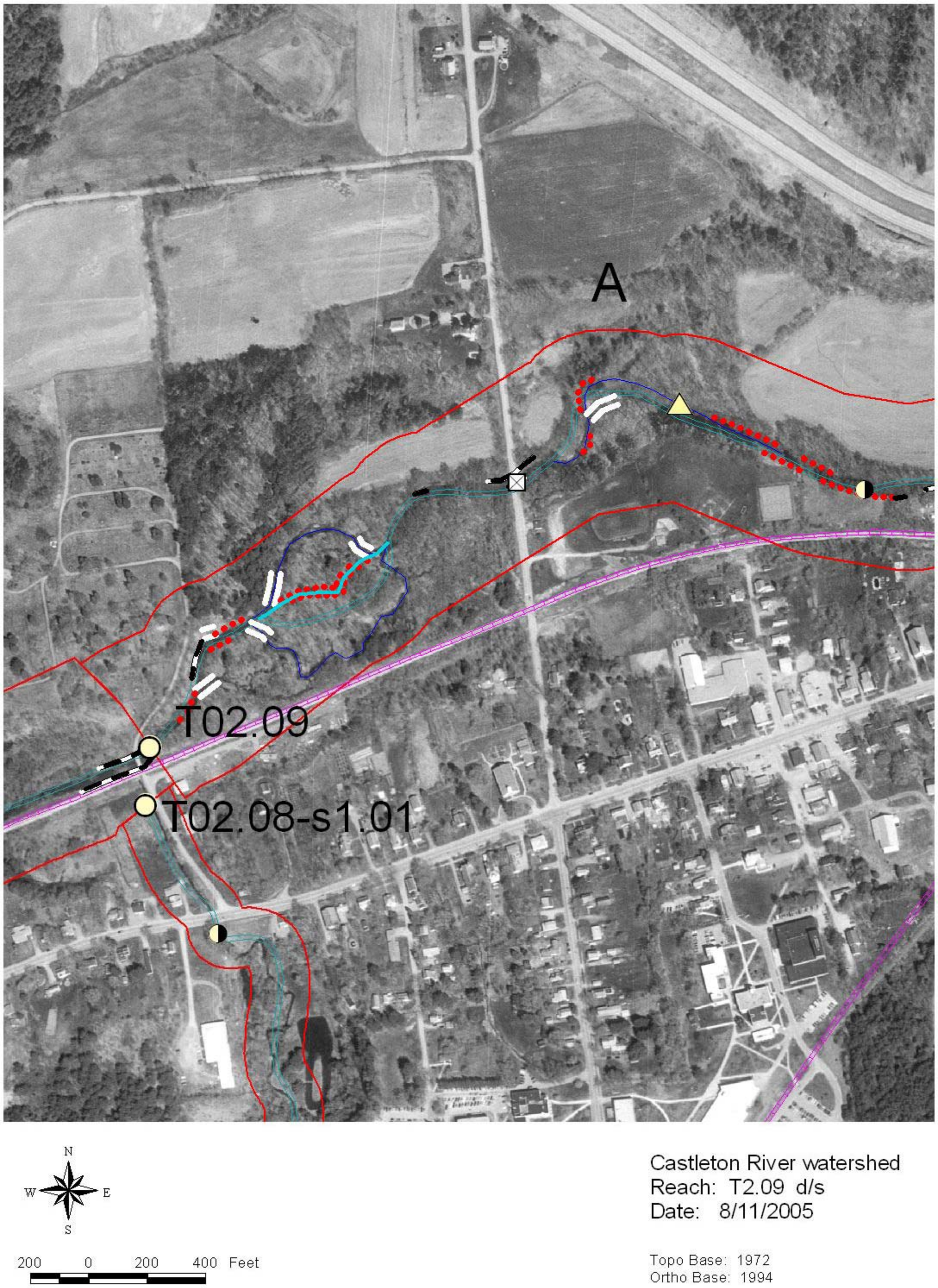
Topo Base: 1972
Ortho Base: 1994





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

Topo Base: 1972
Ortho Base: 1994



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

Topo Base: 1972
Ortho Base: 1994

Delineation of Draft Fluvial Erosion Hazard Corridor

APPENDIX B
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007 (Revised April 2008)

TABLE OF CONTENTS

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, 2008).

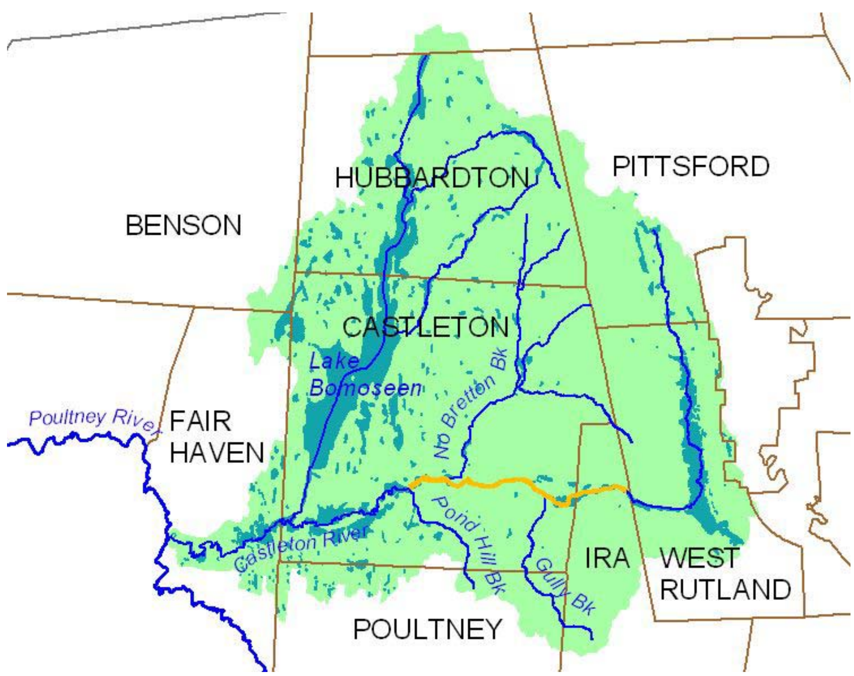


Figure 1. Location of corridor planning reaches in Castleton River watershed, Castleton and Ira, Rutland County, VT. (highlighted in orange).

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 A 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: Municipal Guide to Fluvial Erosion Hazard Mitigation
VT DEC River Management Program, 2007 (1 August 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, 2007).

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, 2008), 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	--	NM (c)	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	0.49 Fair	Extreme	6x
	A	0.48 Fair	Very High	6x

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

(b) - as per 1 August 2007 *Municipal Guide to Fluvial Erosion Hazard Mitigation*
(c) - reach not assessed, wetland-dominated.

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, 2008. *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.

VT Agency of Natural Resources, May 2003, *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 DEC River Management Program, 2007 (1 August draft), *Municipal Guide to Fluvial Erosion Hazard Mitigation.*

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, 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

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

Phase 1 & 2 Geomorphic Assessment
of Castleton River main stem and select tributary reaches
2005 - 2006

Objectives

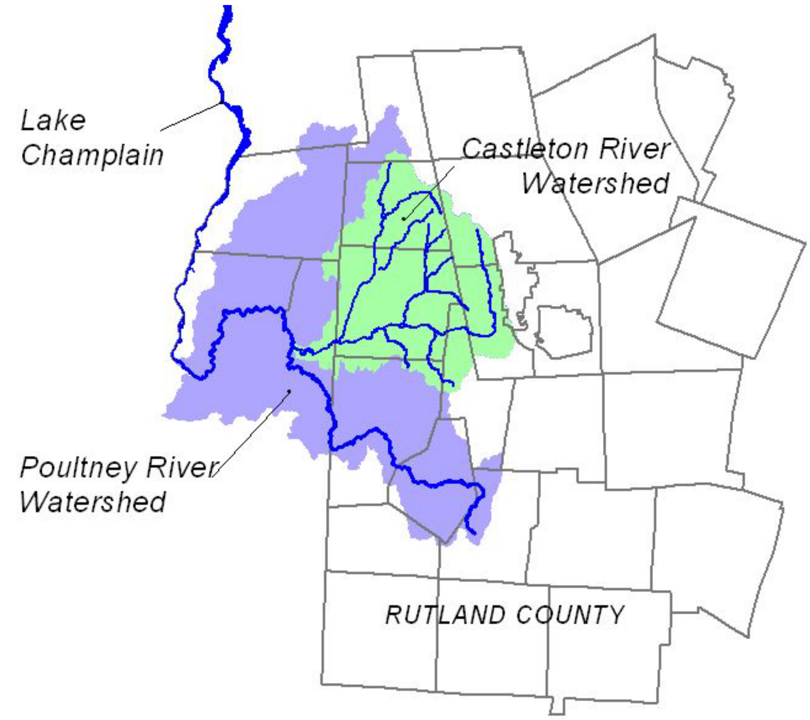
- What are the physical processes and features that characterize the Castleton River, its tributaries, and its watershed?
- How have human activities affected these processes and features over time?
- Which of these physical processes and features are more sensitive to change, and how are they likely to change in the future?
- Which of these processes and features are important for creating and sustaining quality habitat for fish and other aquatic biota?
- Which of these processes and features present high erosion and flood hazard risks to human investments?

Methods

Phase 1 & 2 Stream Geomorphic Assessment protocols
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Data Uses

- Understand where the river is actively scouring its bed, building up sediment, widening, or shifting its position in the landscape.
- Provide a watershed and river-network context for landowner-approved restoration and conservation projects.
- Support design and planning of landowner-approved channel restoration or conservation projects.
- Support citizens and town officials in planning for future development which is compatible with adjusting river channels.
- Minimize future flood erosion losses.
- Improve water quality and riparian habitats.



(a)

(b)

(c)

Location of Castleton River watershed,
(a) within the Poultney River watershed and Rutland County;
(b) within Rutland County towns; and
(c) within Vermont.

2005 Phase 1 Stream Geomorphic Assessment

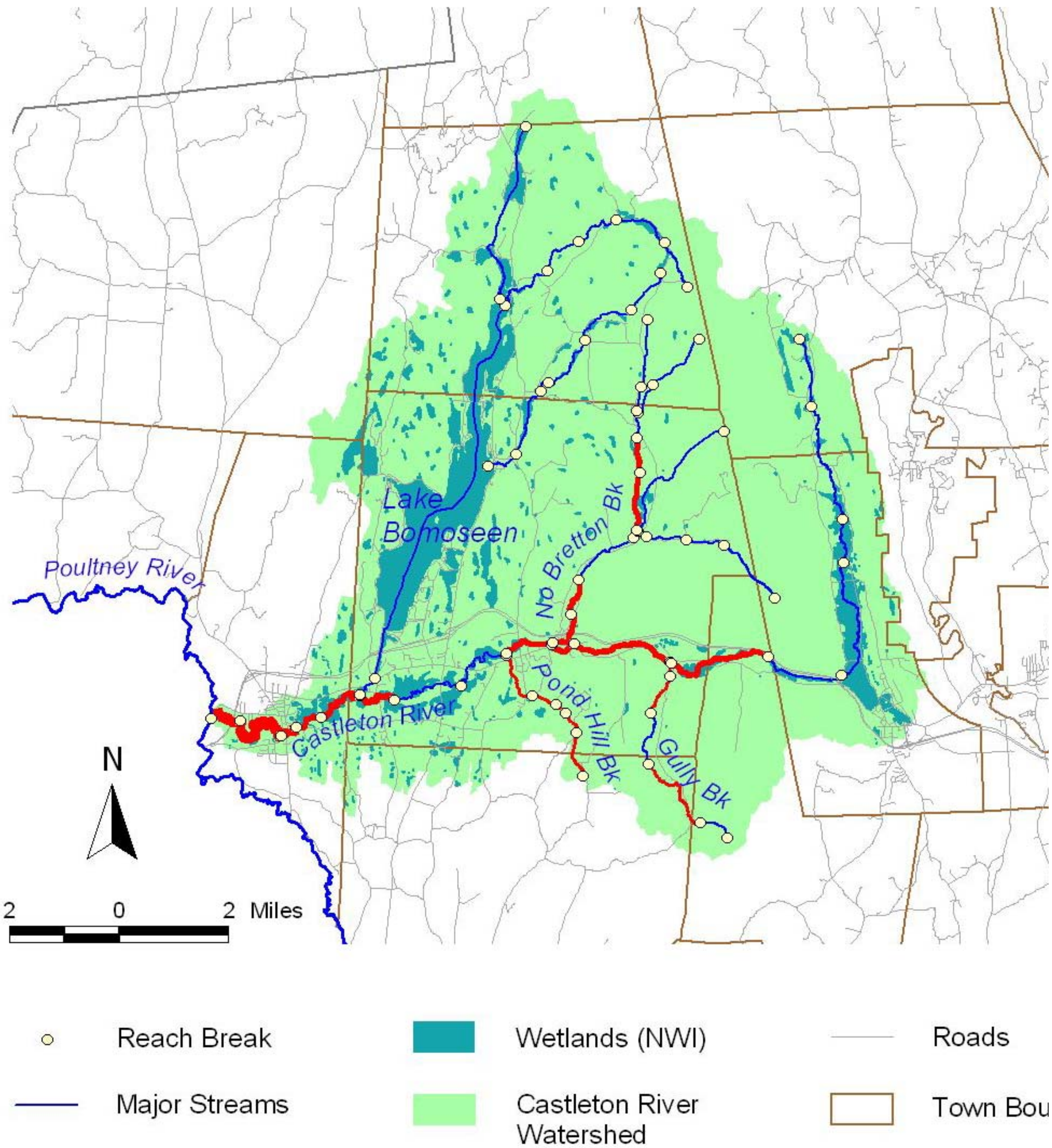
During a Phase 1 Stream Geomorphic Assessment completed in 2005 by the Rutland Regional Planning Commission, the Castleton River and its major tributaries were delineated into geomorphic reaches using remote sensing methods supported by windshield surveys. Geomorphic reaches were defined based on variation in valley confinement, slope, and sinuosity. The Castleton River watershed was delineated into a total of 56 reaches, ranging in length from 0.2 mile to 7.8 miles, with an average length of 1.3 miles (RRPC, 2005).

Based on the channel and watershed stressors identified through remote sensing, windshield surveys and limited historical research during the Phase 1 Geomorphic Assessment, certain reaches were targeted for field-based Phase 2 assessment. Selected reaches were those expected to demonstrate higher degrees of channel adjustment and sensitivity based on their geologic setting and the identification of past and current watershed and channel disturbances.

2005-2006 Phase 2 Assessment

Twenty-two reaches (21.9 river miles) were prioritized for Phase 2 Stream Geomorphic Assessment in 2005 and 2006: ten main stem reaches in the towns of Fair Haven and Castleton; five reaches along Pond Hill Brook in the towns of Poultney and Castleton; four reaches along the North Bretton Brook in Castleton; and three reaches along Gully Brook in the towns of Ira, Poultney, and Castleton.

Tributary Identification	Reach Number	Channel Length (ft)	Year Assessed
Castleton River Main Stem	T02.01	3,626	2006
	T02.02	12,230	2006
	T02.03	1,996	2006
	T02.04	3,389	2005
	T02.05	7,849	2005
	T02.06	5,302	2005
	T02.09	5,234	2005
	T02.10	2,626	2005
	T02.11	11,021	2005
	T02.12	12,493	2005
Pond Hill Brook	T02.08-s1.01	5,451	2006
	T02.08-s1.02	2,537	2006
	T02.08-s1.03	1,256	2006
	T02.08-s1.04	2,425	2006
	T02.08-s1.05	4,802	2006
North Bretton Brook	T02.09-s1.01	4,507	2005
	T02.09-s1.02	3,964	2005
	T02.09-s1.04	6,709	2005
	T02.09-s1.05	3,458	2005
Gully Brook	T02.11-s1.01	1,346	2006
	T02.11-s1.02	4,275	2006
	T02.11-s1.04	9,130	2006


Lake
Bomoseen
Poultney River
No Bretton Bk
Castleton River
Pond Hill Bk
Gully Bk
N
2 0 2 Miles
Reach Break
Major Streams
Wetlands (NWI)
Castleton River Watershed
Roads
Town Bou

Funding

2005 – Phase 1 and limited Phase 2 assessment

Section 319 Grant from VT Water Quality Division
Administered by the Poultney-Mettowee Natural Resource Conservation District

604B Grant from the VT Water Quality Division
Administered by the Rutland Regional Planning Commission.

2006 – limited Phase 2 assessment

River Corridor Grant from the VT Water Quality Division
(Governor Douglas Clean & Clear Action Program)
Administered by the Poultney-Mettowee Natural Resource Conservation District

Watershed stakeholders

Landowners along the river
Citizens of Castleton, Fair Haven, and Ira townships
Poultney-Mettowee Watershed Partnership (PMWP),
Rutland Regional Planning Commission
Poultney-Mettowee Natural Resources Conservation District
VT Department of Environmental Conservation Water Quality Division (VTDEC WQD),
Vermont Agency of Agriculture
USDA Natural Resource Conservation Service / Farm Service Agencies
US Fish & Wildlife Service
Others identified in future outreach efforts

Contacts

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Potential Site- and Reach-level Projects

APPENDIX D
River Corridor Plan
Castleton River: Town of Castleton

Rutland County, Vermont

March 2007

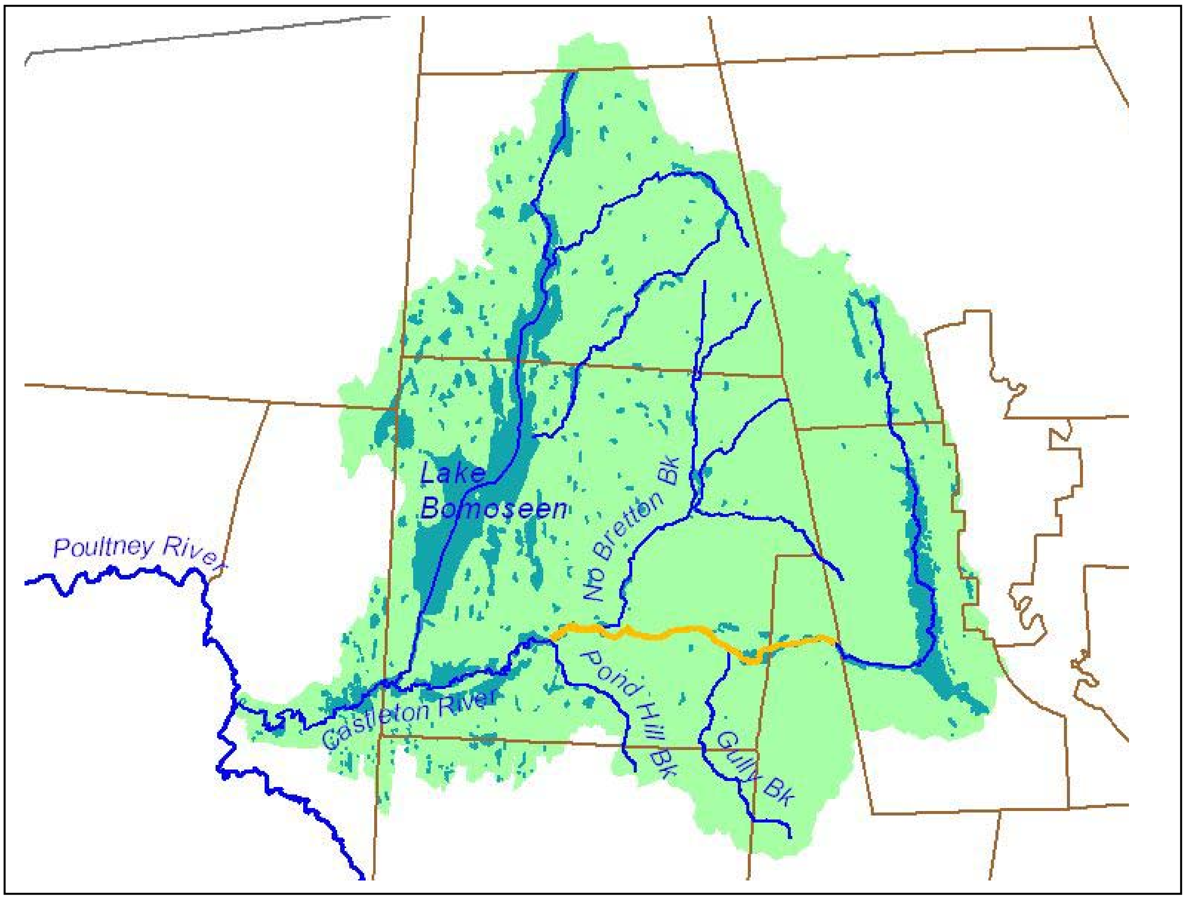
Project #	Reach/ Segment	Potential Project Type	Description	Opportunities / Issues	Action	Considerations
T2.12-1	T2.12	Restoration	Ira Birdseye tributary - remove berm/ restore floodplain (similar to Gully Brook project)	Need for repeated channel dredging leading to berms (of dredged material) and channel 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 assesements 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.

River Corridor Plan
Castleton River: Reaches T02.09 – T02.12

Town of Castleton
Rutland County, Vermont

March 2007 (Revised April 2008)



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APPENDICES

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 project steering committee, Castleton town officials, State and regional agencies, interested community members, and open discussions with the many landowners who own property along the Castleton river reaches.

APRIL 2008 REVISIONS

April 2008 revisions to this Corridor Plan were completed to incorporate recently-updated, Quality-Assured Phase 2 stream geomorphic assessment data for the four corridor reaches (SMRC, 2008). Substantial changes to the corridor planning guidance from the VTANR River Management Section had also occurred in the years post-dating the original contract. While funding was not available to completely revise the Corridor Plan in accordance with the most up-to-date guidance, limited revisions were undertaken in this April 2008 version of the corridor plan (Appendices A and B) to bring the plan closer to current standards – namely, inclusion of sediment regime departure maps and tables, and text revisions to better address the connection between noted stressors and reach condition / sensitivity.

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. A grant appropriated through Governor Douglas' Clean & Clear Program 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 Steering Committee 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 Steering Committee 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 Steering Committee to these organizations is continuing, as needed.

A River Corridor Plan has been prepared for public review. The plan identifies and prioritizes 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 Steering Committee 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, 2008).

This 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, 2007) conducted by the Poultney-Mettowee Natural Resource Conservation District 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/)

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, 2007, 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 Steering Committee; (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 Steering Committee

A Steering Committee was established to steward the river corridor planning process. The Committee 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, 2008).

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 in 2005 and 2006 along the Castleton River main stem (SMRC, 2008) 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. Details of this analysis are summarized in Appendix A. The geomorphic conditions noted have informed the river corridor management strategies outlined in Section 5. The analysis followed 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 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 wetlands contiguous to the channel which may serve important sediment and nutrient attenuation functions in the watershed.

4.4 Attendance at Castleton Public Meetings

The Steering Committee 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 Steering Committee 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 steering committee 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 (Appendix D and Project CD).

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 Steering Committee 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

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.

Where landowner willingness is expressed, Poultney-Mettowee NRCD will seek additional funding 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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Resources

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

Rutland County, Vermont

March 2007 (Revised April 2008)

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.
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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 Fred Nicholson, Stream Alteration Engineer with questions. (802) 786-5906 or frederick.nicholson@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