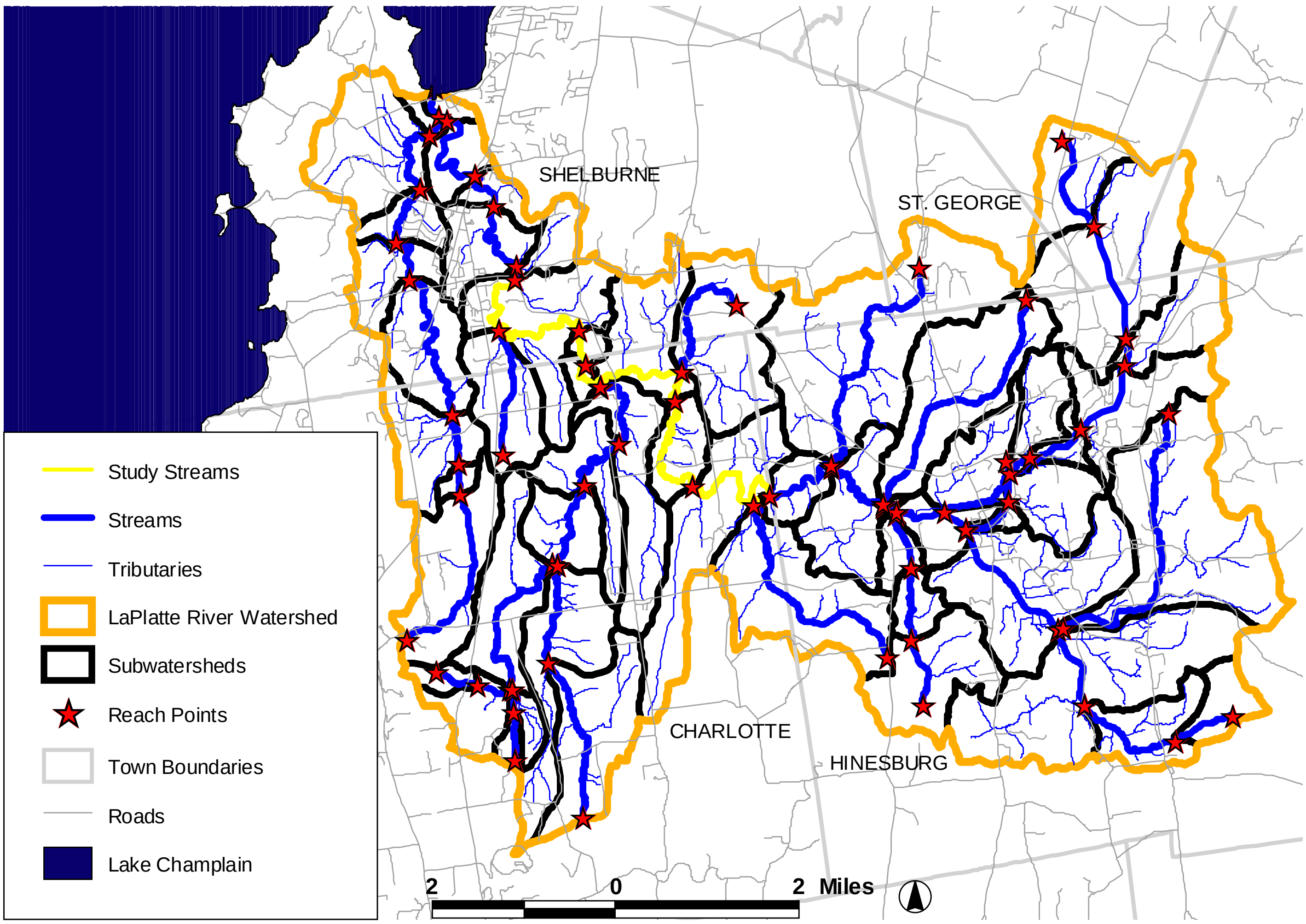
LaPlatte River Corridor Plan
Reaches M6 – M11
Towns of Charlotte and Shelburne, Vermont



Prepared by the LaPlatte Watershed Partnership
April, 2008

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1.0 Executive Summary

The LaPlatte Watershed Partnership (LWP) and Lewis Creek Association (LCA) received a grant from the Vermont Department of Environmental Conservation to develop a River Corridor Plan (RCP) for an 8.14-mile section of the LaPlatte River from Shelburne Falls in Shelburne to just east of the Dorset Street crossing at the Charlotte/Hinesburg boundary (Reaches M06-M11). Please refer to Appendix A for study area maps.

The RCP combines data collected in Phase 1 and 2 studies and provides a framework for management decisions for road maintenance, development, habitat improvement, and stormwater management. The RCP also utilizes Fluvial Erosion Hazard (FEH) mapping to highlight the importance of land management planning, flood hazard planning, stream equilibrium planning and restoration strategies. Please see Appendix B for FEH information and mapping. The RCP aims to identify attenuation sites to reduce sediment and phosphorus from flowing to Shelburne Bay. The RCP also identifies opportunities for improving geomorphic function and habitat value. This plan and data results should be used to inform WQ monitoring and interpretation being undertaken by LWP and Champlain Water District (CWD). Discussions with landowners attempted to identify concerns, timescales, and level of interest for such activities.

Most reaches in the LaPlatte River assessed are undergoing channel adjustments related to historical land use and channel management practices as well as current alterations to hydrology and sediment loads. Proper planning now could reduce future disturbances in order to limit costly damage to land and infrastructure in future flood events.

Potential restoration and protection projects were analyzed following the RMP Corridor Planning Guide (VT ANR, 11 July 2007) (“the Guide”) and step-wise procedure to identify projects that would be compatible with geomorphic adjustments and managing the stream toward equilibrium conditions. Types of projects include: Protecting River Corridors, Planting Stream Buffers, Stabilizing Stream Banks, Arresting Head Cuts and Nick Points, Removing Berms, Removing or Replacing Structures, Restoring Incised Reaches, and Restoring Aggraded Reaches.

Current stressors to geomorphic equilibrium were identified using previous assessment data and protocols in the River Corridor Planning Guide (VT ANR, 11 July 2007). Impervious surface coverage in many study subwatersheds was nearing the threshold of 5% identified by Fitzgerald (2007) as the level of impervious surface where there are impacts to stream geomorphology. Stormwater outfalls were a factor affecting reach M06 and the extent of stormwater inputs to the system should be studied. Bank erosion, mass failures, and lateral channel migration add significant sediment inputs to the system. Channel straightening appeared to be a stressor in reaches M06, M08, and M10. Sediment regime types were analyzed and revealed a shift from a balanced sediment regime toward fine sediment source and transport with coarse sediment deposition, except for reaches M07 and M11 remained in their reference sediment regimes as transport reaches. This implies an increase in fine sediments produced and transported downstream toward Shelburne Bay.

Potential Projects identified for each reach include:

- M06 – Protect the River Corridor, Plant Buffer Vegetation, Replace Bridge, and Restore (possibly with active measures) the reach.
- M07 – Protect the River Corridor.
- M08 – Protect the River Corridor, Plant Buffer Vegetation.
- M09A – Protect the River Corridor, Replace Bridge.
- M09B – Protect the River Corridor.
- M10 – Protect the River Corridor, Plant Buffer Vegetation.
- M11 – Protect the River Corridor.

2.0 Introduction

The LaPlatte Watershed Partnership (LWP) and Lewis Creek Association (LCA) received a grant from the Vermont Department of Environmental Conservation to develop a River Corridor Management Plan for an 8.14-mile section of the LaPlatte River from Shelburne Falls in Shelburne to just east of the Dorset Street crossing at the Charlotte/Hinesburg boundary. Please refer to Appendix A for study area maps. The LWP has undertaken the river corridor planning process by exploring potential stream corridor restoration and protection projects that are geomorphically compatible with the current channel condition and adjustments. The goal of the River Corridor Plan (RCP) is to develop projects with the goal of increasing the capacity for stream corridor capture and storage of sediment and nutrients in the watershed in order to reduce sediment and nutrient loading of Lake Champlain.

Funding for the development of the Corridor Plan was through a Category 2 Clean and Clear Grant from the VT Department of Environmental Conservation (DEC) River Management Program (RMP). The RMP aims to reduce long-term costs, damage, and risks associated with flooding and river dynamics, and increase safety by identifying streams in adjustment and working to address stressors in order to move streams toward equilibrium conditions. The RMP has promoted the Corridor Planning Process to help achieve these goals.

Previous studies including Phase 1 and Phase 2 Stream Geomorphic Assessments (SGA) provided an information basis for the identification of corridor planning activities.

LWP previously completed a Corridor Plan for the Town of Hinesburg and aims to continue corridor planning efforts throughout the watershed.

2.1 Goals and Objectives

Stream restoration and protection projects and efforts are most successful when they are planned with consideration for the reach and watershed stressors and physical processes causing the channel instability and adjustments (VT DEC, September 2005; April 2003).

The goal of the RCP is to develop projects with the goal of increasing the capacity for stream corridor capture and storage of sediment and nutrients in the watershed in order to reduce sediment and nutrient loading of Lake Champlain.

Overall River Management Program goals for stream corridor planning are:

- To define and achieve water resource goals and objectives
- To assess the degree of stream departure from equilibrium and the condition of instream and riparian habitat,
- To identify potential restoration and protection projects that would support stream dynamic equilibrium conditions and reduce potential future conflicts between human investments and stream channels and their associated expenses.

LWP Goals

- To allow for resources to be protected and private and public investments to be made that are economically and ecologically sustainable as individual parcels are subdivided and developed within the growth center area.
- To engage decision makers, landowners and other citizens who can be guided by a better understanding of riparian systems before additional public and private investment are made within the designated village growth area.
- To provide officials and landowners the information and a framework to implement strategies that can result when the community understands and values the river as a system and recognizes the importance and opportunity in avoiding future conflicts between human investments and river dynamics and in resolving current conflicts in the most economical and ecologically sustainable manner.
- To utilize Fluvial Erosion Hazard (FEH) mapping to highlight the importance of land management planning, flood hazard planning, stream equilibrium planning and restoration strategies.
- To use this plan and data results to inform WQ monitoring and interpretation being undertaken by LWP and Champlain Water District (CWD).

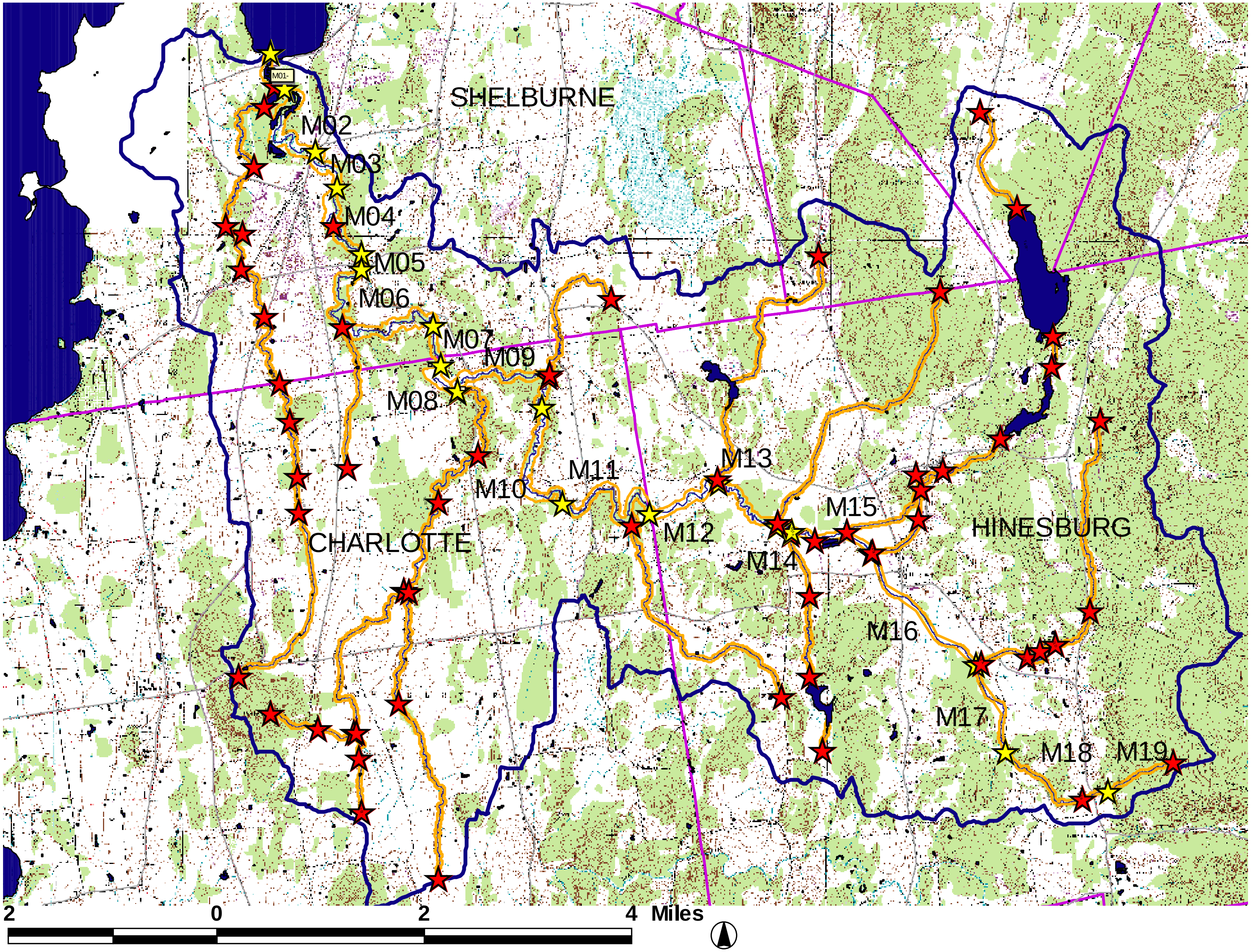


Figure 3.1: LaPlatte River Watershed with reach breaks.

3.0 Background

3.1 Setting

The LaPlatte River Watershed (Figure 3.1) encompasses 53 square miles, in the towns of Shelburne, Charlotte, and Hinesburg, with small sections in Williston, Richmond, and St. George. The LaPlatte is the largest watershed feeding Shelburne Bay, a drinking water source for much of Chittenden County, therefore sediment and nutrient loading through erosion are of major concern. Steeper hill reaches have signs and remains of old milldams and foundations. Lower valley reaches have largely been straightened, ditched, and managed to increase tillable land. Much of the LaPlatte River and its tributaries have been managed for mill power and agriculture. These past practices and now incremental development resulted in channel degradation and adjustment and extreme loss of instream and riparian habitat. Given the extensive channel management history and changing runoff characteristics related to increased development in the watershed, there is a high likelihood of continued and increased channel adjustment. The reduction in use of land for agriculture has lead to development of these riparian areas within the watershed. Future channel adjustments combined with increased development in the watershed can lead to increased sediment and nutrient loads in the LaPlatte and therefore in Shelburne Bay and Lake Champlain.

Regional Geological Setting

The LaPlatte watershed from the headwaters of the mainstem in Hinesburg and Williston to the mouth at Shelburne Bay is contained within the geologic province of the Champlain Valley. In recent geologic time (from 20,000 to 13,000 years before present) this landscape was occupied by advancing and retreating glaciers, with ice up to a mile or more in thickness above the present land surface in the Champlain Valley. As the global climate warmed and the glaciers receded, a large fresh water lake inundated the Champlain Valley. At it highest stage, Lake Vermont's shoreline was located at the foot of the Green Mountains. As Lake Vermont waters receded in stages from about 12,800 to 10,200 years before present, marine waters inundated the valley from the St Lawrence Seaway. These Champlain Sea waters receded from the region by 10,000 years before the present as the land rise began to outpace the rate of sea level rise. River systems then went to work moving sediments left in the wake of the glaciers. "The LaPlatte River is distinct from these other rivers in that it follows the course of a deep, pre-glacial valley that is now filled with glacial, glacial-fluvial and/or lacustrine sediments. In the Hinesburg and Shelburne sections of the valley the fill is gravel, probably outwash, but in between lake silts and clays fill the valley."[1]

Study Reaches

The study area for the LaPlatte River included roughly from east of the Dorset Street crossing in Charlotte, northwest to Spear Street, then to Shelburne Falls. The upstream extent of this study was Reach M11 in Charlotte, in a semi-confined valley downstream of the wide, flat Hinesburg Valley. The upper study reaches, M09B-M11, were in the area of silt/clay soils. M09A had a steeper slope and began the area of mixed fine and coarse bank material. The valley widened at

[1] Stewart, David P., 1973 Geology For Environmental Planning in the Burlington-Middlebury Region, Vermont

M08, promoting agricultural uses, but then narrowed again in M07. Overall, the study reaches appeared to be undergoing channel adjustments related to past channel management practices and effects from agriculture and recent development. Key stressors appeared to be stormwater effects, excess erosion, agricultural practices, and stream crossings. Upstream of the study area, many of the valley reaches in Hinesburg have been extensively straightened. Downstream of the study area, the river is wide with a very shallow slope as it meanders toward Shelburne Bay. The Nature Conservancy currently protects this area.

Geomorphic Setting

Table 3.1 briefly summarizes Phase 2 data for each study segment. Included in the table are the reach number, existing stream type, habitat condition category from the RHA, geomorphic condition category from the RGA, stream sensitivity rating, channel evolution stage, and overall stream condition.

Table 3.1: Summary of results of Phase 2 Stream Geomorphic Assessment

Segment & Town	Stream Type	Geomorphic Condition	Evolution Stage	Sensitivity	Habitat Condition
M06 Shelburne	B4c Plane Bed*	Poor	IV (Planform)	High	Fair
M07 Shelburne	B5 Plane Bed	Good	III (Aggradation)	Moderate	Good
M08 Charlotte	C4 Riffle-Pool	Fair	IV (Planform)	Very High	Fair
M09A Charlotte	B4 Plane Bed	Fair	IV (Planform)	High	Fair
M09B Charlotte	C5 Riffle-Pool	Fair	IV (Planform)	Very High	Good
M10 Charlotte	C5 Riffle-Pool	Fair	IV (Planform)	Very High	Fair
M11 Charlotte	B4c Dune-Ripple	Good	I (Minor aggradation)	Moderate	Good

* Indicates a Stream Type Departure

Reach M06 appeared to have undergone a stream type departure, resulting in significant channel adjustment and a loss of geomorphic functionality.

Reach M11 appeared "In Regime," meaning not undergoing adjustment, and in good condition. Downstream of the project area, reaches M03 and M04 also appeared "in regime." These "In Regime" reaches bracketed a group of reaches (M06-M10) undergoing channel adjustments. Having these "In Regime" reaches upstream and downstream of adjusting reaches helps moderate effects of channel adjustment and helps reduce pressures upstream and downstream. Having floodplain access, they also help store sediments and nutrients headed for Lake Champlain. Therefore, protection of these "In Regime" reaches, M11, M03, and M04, and their stream corridors would be important to preserve their valuable functions. A further step could be to plant woody vegetation or allow it to regenerate in areas where it is lacking.

4.0 Stream Corridor Planning Tasks

The LWP undertook the following tasks in the process of developing the LaPlatte River Watershed Corridor Plan in Charlotte and Shelburne: 1) Analyze Geomorphic Assessment Data; 2) Define the stream corridor; 3) Identify potential restoration and protection projects that meet the above goals; and 4) contact and meet with landowners to discuss goals and opportunities.

4.1 Analysis of Geomorphic Data

Data collected during Phase 1 and Phase 2 Stream Geomorphic Assessments were analyzed according to the Protocols (VT DEC, March 2006). The Phase 1 study delineated the 53 square mile watershed, identified 52 distinct reaches, and collected remote sensing data such as slopes, stream type, land use, riparian buffers, soils, and channel modifications. The Phase 2 SGA was completed in 2006-2007 through a Special Environmental Project grant from the Town of Shelburne.

4.2 Outreach

Landowner Contact

Landowners along the study area were identified using the parcel information from the towns of Shelburne and Charlotte overlaid on orthophoto maps with the stream corridor. Riparian landowners along study streams were mailed an informative letter describing the corridor planning process. Outreach volunteers followed-up with telephone calls to allow for interested landowners to schedule a meeting with members of LWP. Meetings were held with interested landowners where information was shared about the project and stream assessment data. At these meetings, landowners were asked to share their knowledge of the stream over time. Packets of information including a map, reach condition details, and ANR publications were prepared for each landowner and discussed at the meetings. Information about the river gained from these meetings was included in this Plan.

4.3 Corridor Delineations

Two corridors have been identified for the LaPlatte River and tributaries through the SGA process:

1. Phase 1 Stream Corridor (S09 from SGAT);
2. Fluvial Erosion Hazard (FEH) corridor.

Phase 1 Stream Corridor

Mapping included in this plan depicts the Phase 1 corridor. The Phase 1 Stream Corridor is the minimum width the channel needs to migrate laterally and achieve equilibrium plus one channel width as a buffer. The Phase 1 Stream Corridor, as described by the Protocols:

> "…attempts to define a width of land on either side of the river, together called the river corridor, that will capture:

- Factors influencing runoff and erosion;
- Factors influencing flood plain function; and
- A minimum width of land within the overall valley width that may be occupied by the active stream channel, as slope and dimension remain in balance with the watershed inputs." (VT DEC Stream Geomorphic Assessment Handbook, Phase 1, Appendix E, p. E1.)

Please refer to the Protocols for more on stream corridor delineation.
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm

Fluvial Erosion Hazard Corridor

Fluvial Erosion Hazard (FEH) corridors identify approximate boundaries and intensities of erosion hazard risk for each stream segment. The FEH tools developed by the RMP use Phase 2 SGA data to assign a belt width and sensitivity rating for each segment. FEH analysis for the Charlotte and Shelburne study area is presented in Appendix B. Please refer to http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_floodhazard.htm for more on FEH corridors and application.

4.4 Project Identification

The River Corridor Planning Guide (VT ANR, 11 July 2007) has been developed by RMP to identify projects that would be compatible with geomorphic adjustments and managing the stream toward equilibrium conditions. This step-wise procedure and the Planning Guide was used to identify potential stream restoration projects compatible with RMP goals.
Please refer to the RMP Corridor Planning Guide at:
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_restoration.htm for more detailed information.

Types of projects include:

- Protecting river corridors from channel management and future encroachment,
- Planting stream buffers with woody vegetation,
- Stabilizing stream banks if it will achieve the stated goals,
- Arresting channel erosion such as head cuts and nick points,
- Removing berms and other barriers to geomorphic processes,
- Removing or replacing structures following RMP and F&W recommendations,
- Restoring incised reaches through "passive" or "active" measures,
- Restoring aggraded reaches.

Corridor protection and conservation is an effective tool for stream restoration. Protecting stream corridors helps avoid future conflicts between streams and human investments while allowing streams room to establish their desired dynamic equilibrium. Vegetated buffers, whether planted or allowed to reestablish, protect water quality, stabilize banks, and provide riparian habitat. Protecting the river corridor and allowing the stream to recreate its own equilibrium geometry can be more cost effective long-term than attempting to impose a calculated stream geometry in the short-term.

Planting stream buffers helps protect water quality, stabilize banks, and provide riparian habitat. Riparian or stream bank vegetation is important to stream stability because of its ability to slow flood flows and its quality as a binder of stream bank soils. While thick bushy riparian vegetation slows flood flows above ground its root systems help bind the soil below ground making it more resistant to the erosive energy of the flood flows.

Another approach is stabilizing eroding stream channels with hard armoring such as rock riprap or log revetments to provide temporary bank stability while woody vegetation is established. The extent to which this approach is successful depends on the natural characteristics of the channel and the degree of channel instability. This method can have negative upstream and downstream effects, mainly increased erosion rates, which should be considered.

Undersized crossing structures (bridges and culverts) can aggravate channel instability by preventing the steady, uninterrupted passage of both channel flow (water) and bed material (sands and gravels). An interruption of flow and bed materials causes changes in the erosive energy of the flow leading to channel erosion and possibly crossing structure instability. Replacing undersized crossing structures with structures that allow for flow and sediment passage is highly successful in restoring channel stability.

Encouraging land uses that are compatible with healthy well functioning riparian and floodplain areas can be an effective tool for restoring streams. Floodplains perform the critical function of storing floodwaters during times of extreme flow events. By providing a storage area for floodwaters floodplains provide for the dispersion of the tremendous erosive energy of flood flows, energy that is otherwise spent eroding the bed and banks of the river channel. Any development within the floodplain inherently diminishes its ability to store flood flows and is therefore ideally avoided.

Avoiding development in floodplains also reduces the need to “lock the river in place”. The meandering nature of rivers is driven by the ever-present erosive energy of the flow. Healthy rivers, with vigorous riparian vegetation and well functioning floodplain display low rates of erosion and this erosion is a necessary natural process which allows the river to distribute energy evenly throughout the channel over time. Maintaining land uses along the river corridor that do not bring about the need to “lock the river in place” allows natural processes to minimize erosion rates.

Analyzing the desired time frame for results can help determine if a “passive” or “hands-off” approach to channel restoration is feasible, or if a more “active” approach for more immediate results is desired. Examples of “active” restoration projects include constructed meander bends, constructed or lowered floodplain areas, bank stabilization measures, constructed grade controls, or constructed habitat structures. The chosen approaches for restoring a given stretch of river will depend on the characteristics of the river and the nature of the instability demonstrated.

5.0 Stressor, Departure, and Sensitivity Analysis

The maps presented in this section highlight watershed stressors and stream departure from equilibrium conditions. The maps were developed using criteria outlined in the River Corridor Planning Guide (VT ANR, 11 July 2007) ("the Guide"). The maps help visualize the types of stressors acting on the stream channel over a watershed scale, allowing upstream and downstream effects to be seen across the watershed. The maps were used along with Table 5.1 to identify potential restoration and protection projects included in Table 6.2.

In the Guide, Fluvial Geomorphic Equilibrium is defined as:

> "…the condition in which a persistent stream and floodplain morphology is created by the dynamic fluvial processes associated with the inputs of water, sediment, and woody debris from the watershed. The stream and floodplain morphology is derived within a consistent climate; and influenced by topographic and geologic boundary conditions. When achieved at a watershed scale, equilibrium conditions are associated with minimal erosion, watershed storage of organic material and nutrients, and aquatic and riparian habitat diversity." (p. 2)

A stream can undergo a departure from such equilibrium conditions in the presence, or as the result, of stressors either at the watershed scale or a more local scale. Stressors can include changes in inputs to the system such as increases or decreases in water or sediment. An example is an increase in sediment after historical deforestation left exposed soil prone to erosion. Stressors can also include changes in the timing of these inputs such as increased peak runoff from stormwater systems. These stressors can be ongoing or a one-time event, such as a flood. Climate change can also be considered a stressor, in that it is human-induced and changes are expected to occur more rapidly than historical swings in climate. When the stressors build, a stream can become altered or undergo a departure from its equilibrium conditions.

If a stream has departed from its equilibrium conditions, it works through a set of adjustment processes until it finds a new equilibrium condition. These adjustments have been described in channel evolution models as described by Schumm (1977) (Figure 5.1) and others. Types of adjustment processes include channel incision (degradation), channel widening, sediment deposition (aggradation), and lateral migration (planform). These processes can take decades to complete, and if stressors continue to increase or change, a channel will continue to adjust. A section of stream in adjustment can also affect stream sections upstream and downstream. Addressing stressors and allowing the stream room to complete these adjustments can be most effective in achieving long-term stream balance and avoiding conflicts with human interests.

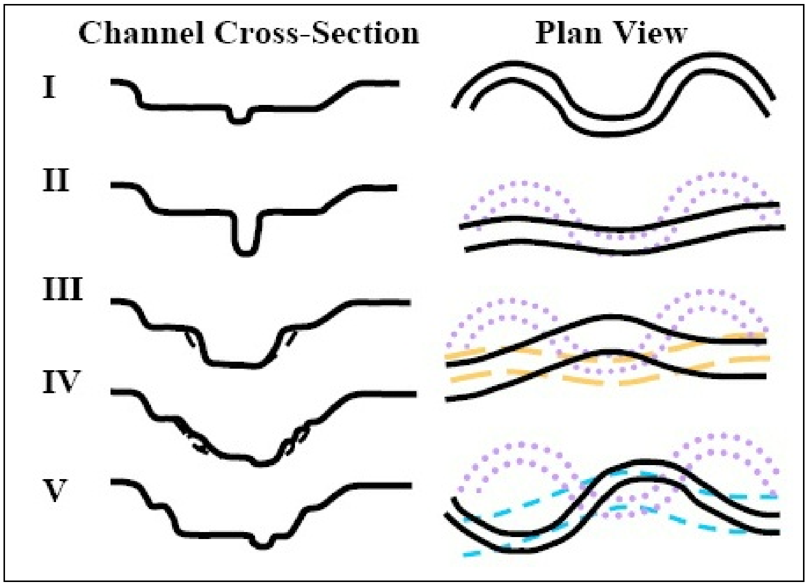


Figure 5.1. Diagram of Channel Evolution from VT ANR 11 July 2007 as adapted from Schumm 1977. Stage I indicates reference equilibrium conditions, Stage II shows incision, Stage III shows widening through bank erosion, Stage IV shows aggradation and lateral channel migration, followed by Stage V, a return to equilibrium conditions, but typically at a lower elevation.

Stressors in the LaPlatte River study area were mapped and are presented in the following sections.

5.2 Hydrologic Regime Stressors

Figure 5.2 depicts stressors to the hydrologic regime in the study reaches. From the Guide,

"The hydrologic regime may be defined as the timing, volume, and duration of flow events throughout the year and over time. Hydrologic regime may be influenced by climate, soils, geology, groundwater, watershed land cover, connectivity of the stream, riparian, and floodplain network, and valley and stream morphology." (VT ANR, 11 July 2007 p.16).

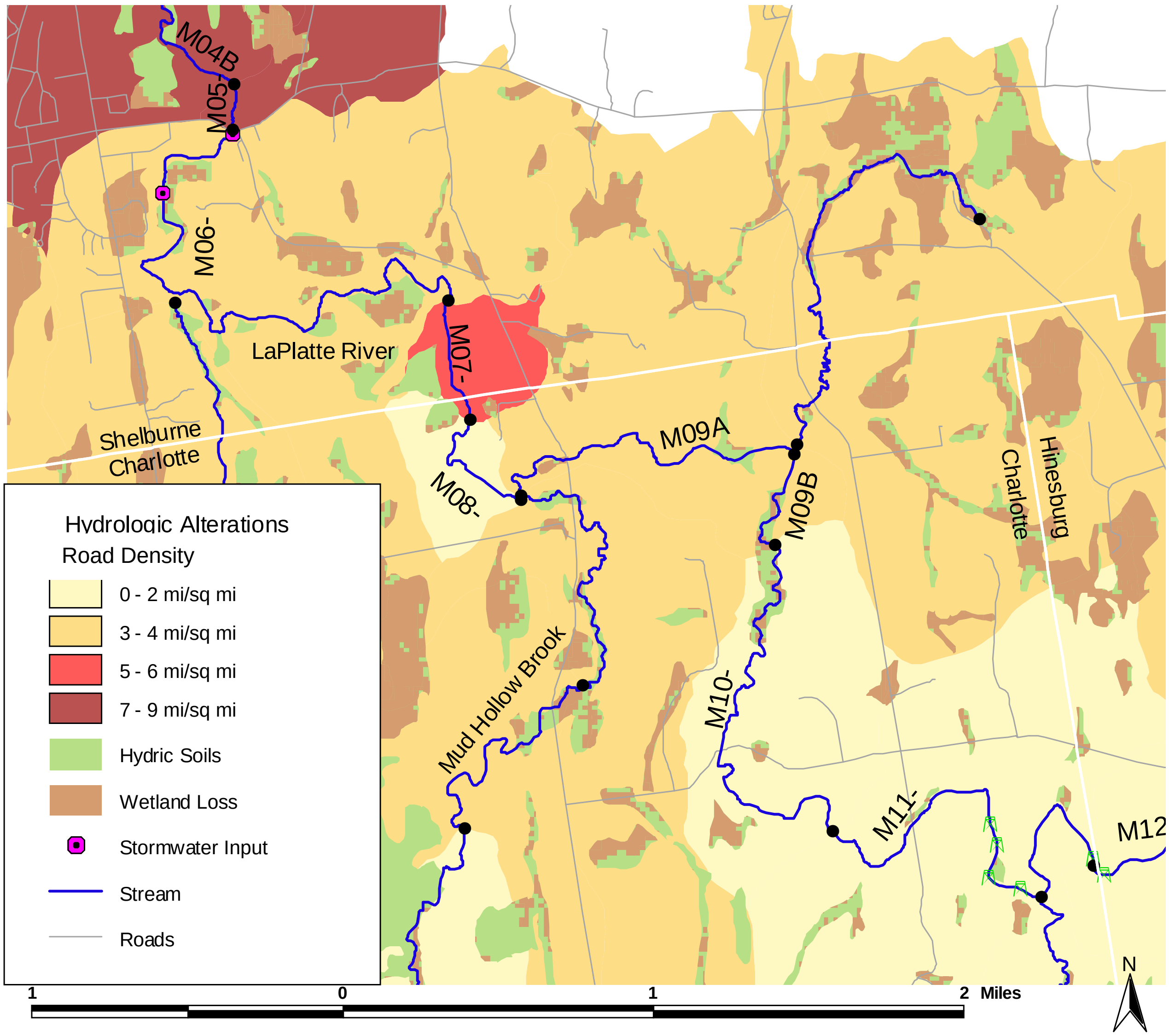


Figure 5.2. Hydrologic Regime Map. Note that no dams were present on the reaches examined in this plan.

The subwatersheds are shaded according to the density of roads. Road density is listed in 4 categories, related to effects on streams. Road density has been correlated to percent impervious cover following work by Fitzgerald (2007). In Fitzgerald's research, a road density of 4% correlated to 5% impervious cover, which was the threshold for impacts to stream geomorphology described by Fitzgerald (2007).

This study area was part of a larger study of impervious surface cover by South Mountain Research and Consulting (2005). The impervious surface study had larger subwatersheds than depicted here; so all subwatersheds in this study were grouped into one area found to have 4% impervious surface cover. That research as well as the mapping shown here indicates that these subwatersheds are close to the 5% impervious cover threshold described by Fitzgerald (2007).

High road density around the town of Shelburne that well exceeds the 4% threshold correlated with 5% impervious cover. A small watershed around M07 also exceeded the threshold due to some subdivisions in that area. The area around northern Charlotte and Hinesburg has road densities nearing the threshold.

Wetland loss is shown by shading hydric soils (green) and then using brown shading to depict where agricultural land use and urban land use overlap with hydric soils, indicating conversion of wetland function to agriculture or urban land use. The hydric soils dataset likely overestimates the historical wetland area, however other wetland layers focus on significant wetlands and leave out Class III and sometimes Class II wetlands. Agricultural land uses and increasingly residential areas are now occupying hydric soil area.

Stormwater inputs were only seen in reach M06, however more stormwater inputs are likely, as they may enter tributaries before entering the mainstem and therefore were not identified during the assessment. An inventory of stormwater infrastructure and outfalls would be useful to determine the extent of stormwater impacts in the watershed.

Figure 5.2a shows Emergency 911 buildings in the context of the stream subwatersheds. Note the high density of buildings in Shelburne Village.

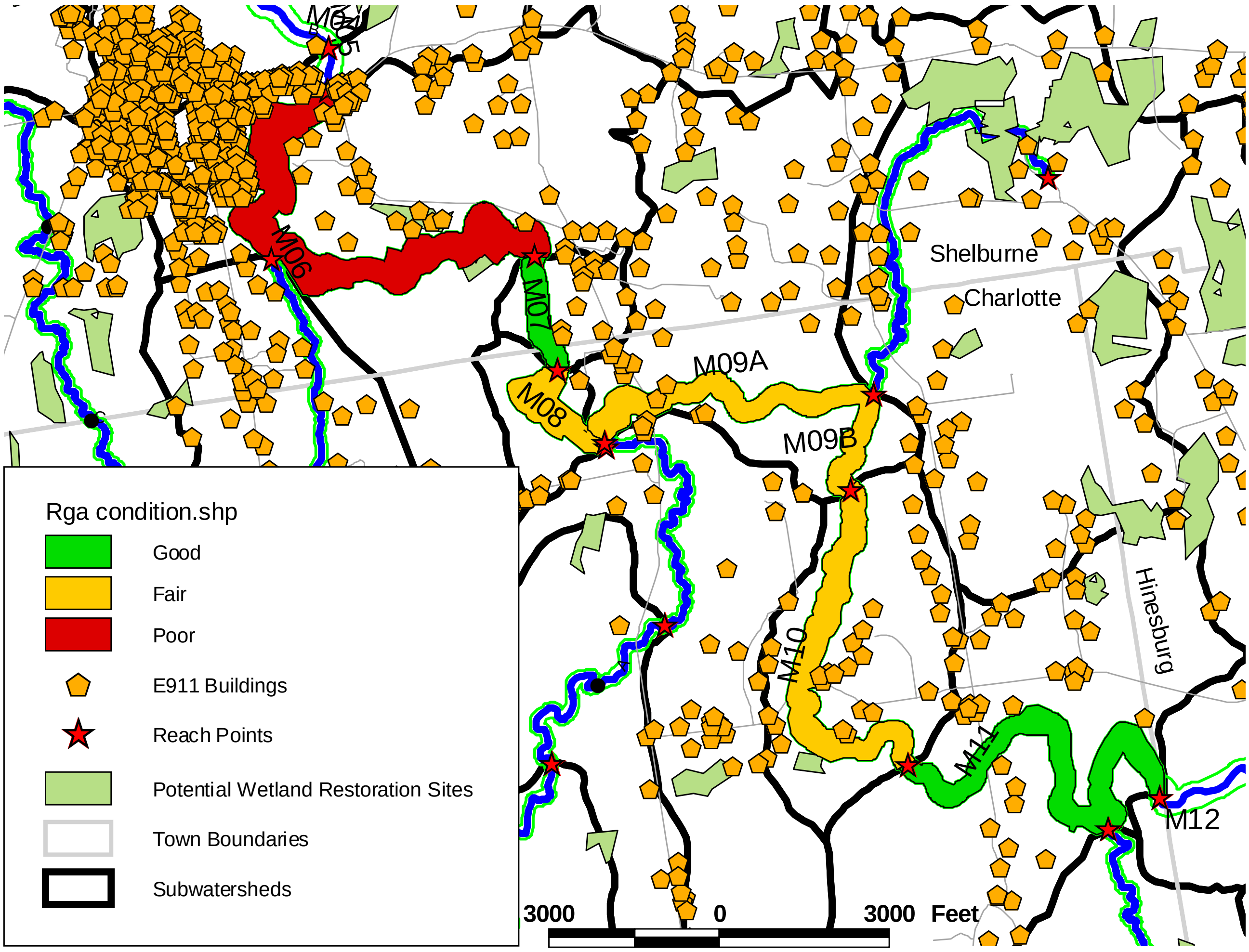


Figure 5.2a. Stream RGA Condition, E911 sites (buildings), and Potential Wetland Restoration Sites in the context of the reach subwatersheds.

5.2 Sediment Regime Stressors

Figure 5.3 depicts stressors to the hydrologic regime in the study reaches. From the Guide,

"The sediment regime may be defined as the quantity, size, transport, sorting, and distribution of sediments. The sediment regime may be influenced by the proximity of sediment sources, the hydrologic regime, and valley, floodplain and stream morphology." (VT ANR, 11 July 2007 p. 20).

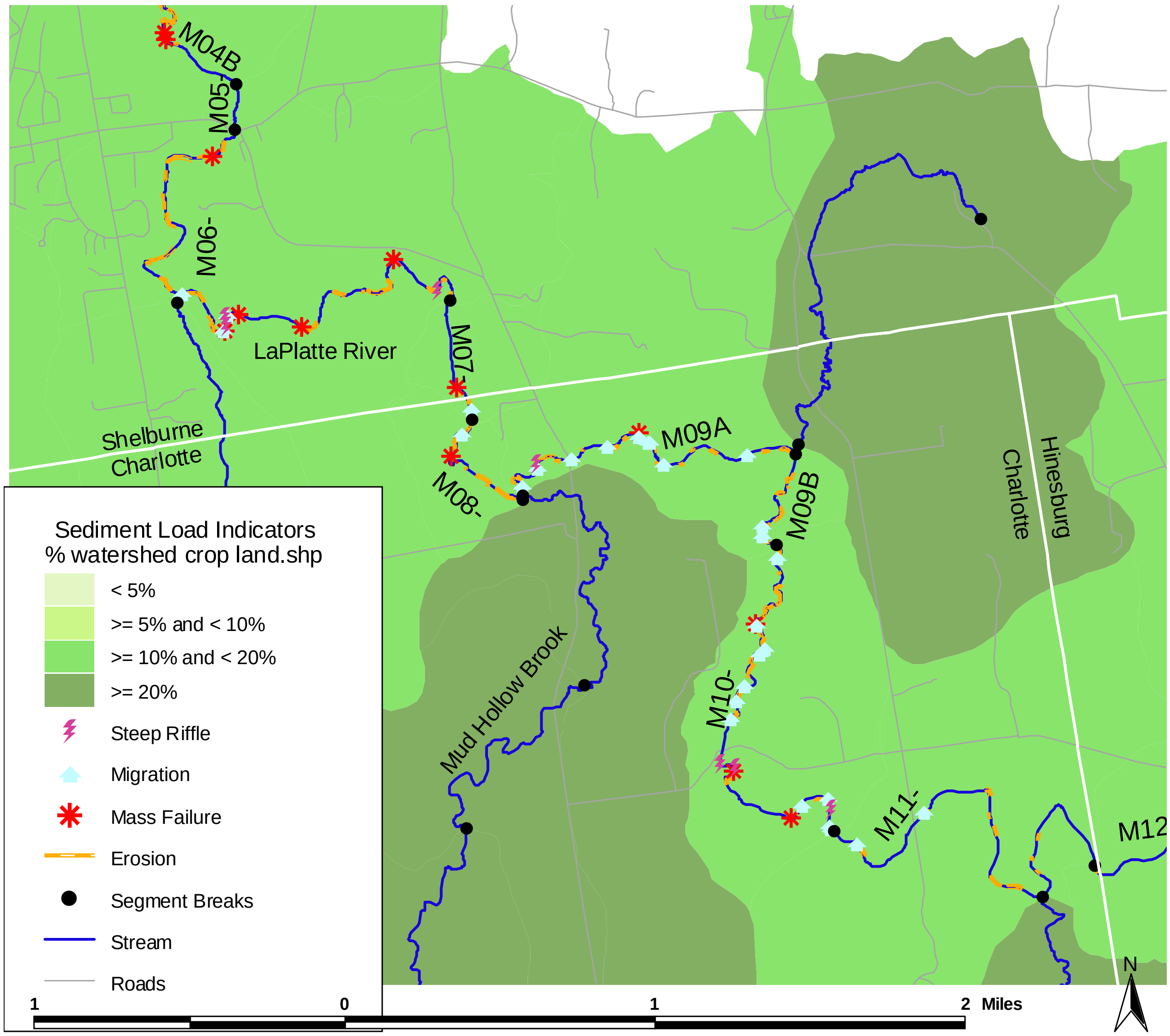


Figure 5.3. Sediment Load Indicators Map. All subwatershed cropland coverages were over 10% with some over 20%. Tributary rejuvenation was observed in reaches M06 and M09A.

Subwatersheds in Figure 5.3 are shaded according to the percent cropland in each. Cropping tends to result in exposed soils, prone to erosion. Other sources of sediment such as bank erosion, channel migration, and mass failures are also highlighted.

The subwatersheds in the study area had over 10% cropland use with tributary streams (including Mud Hollow Brook) having over 20% cropland use. Such high percentages of cropland can contribute significantly to the sediment load. Additionally, many areas of bank erosion, channel migration, and mass failures were present, contributing sediment to the stream.

Watershed cropland can be addressed by establishing woody buffers to filter runoff from fields. Additionally, wooded buffers can help provide bank stability to reduce bank erosion. Protecting stream corridors to allow for the reestablishment of equilibrium conditions can reduce instream production of sediment in the long-term.

5.3 Channel Slope Modifiers

Figure 5.4 shows reach-scale modifications to channel slope.

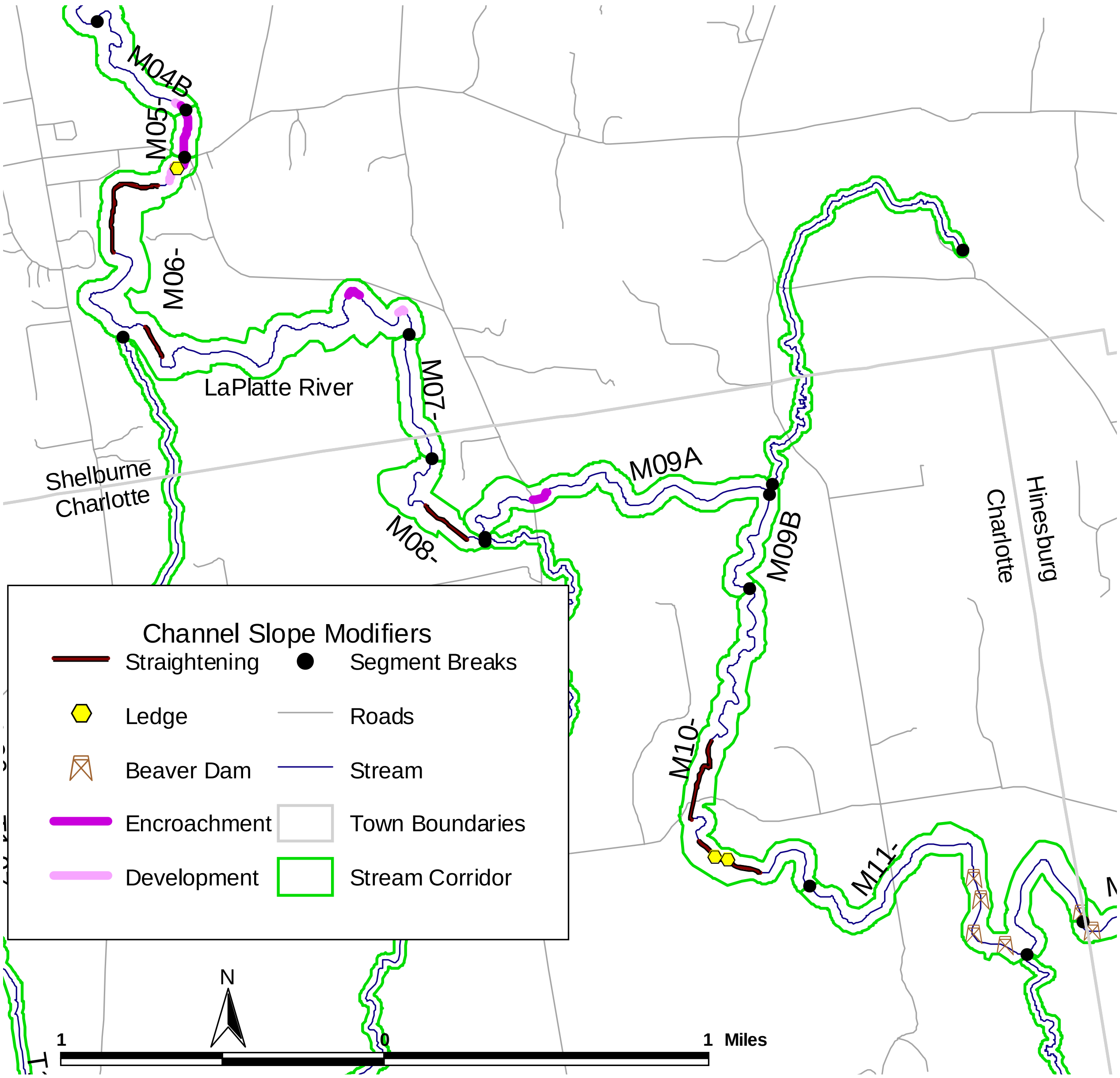


Figure 5.4. Channel Slope Modifiers Map. No dams were in the study area, although beaver dams were seen in reach M11.

Historical channel straightening affects sections of reaches M06, M08, and M10, resulting in increased channel slope. Bedrock ledges provide grade control, limiting channel incision, at the downstream end of reach M06 and in reach M10. Overall, relatively little development, roads or berms have encroached into the stream corridor.

5.4 Channel Depth Modifiers

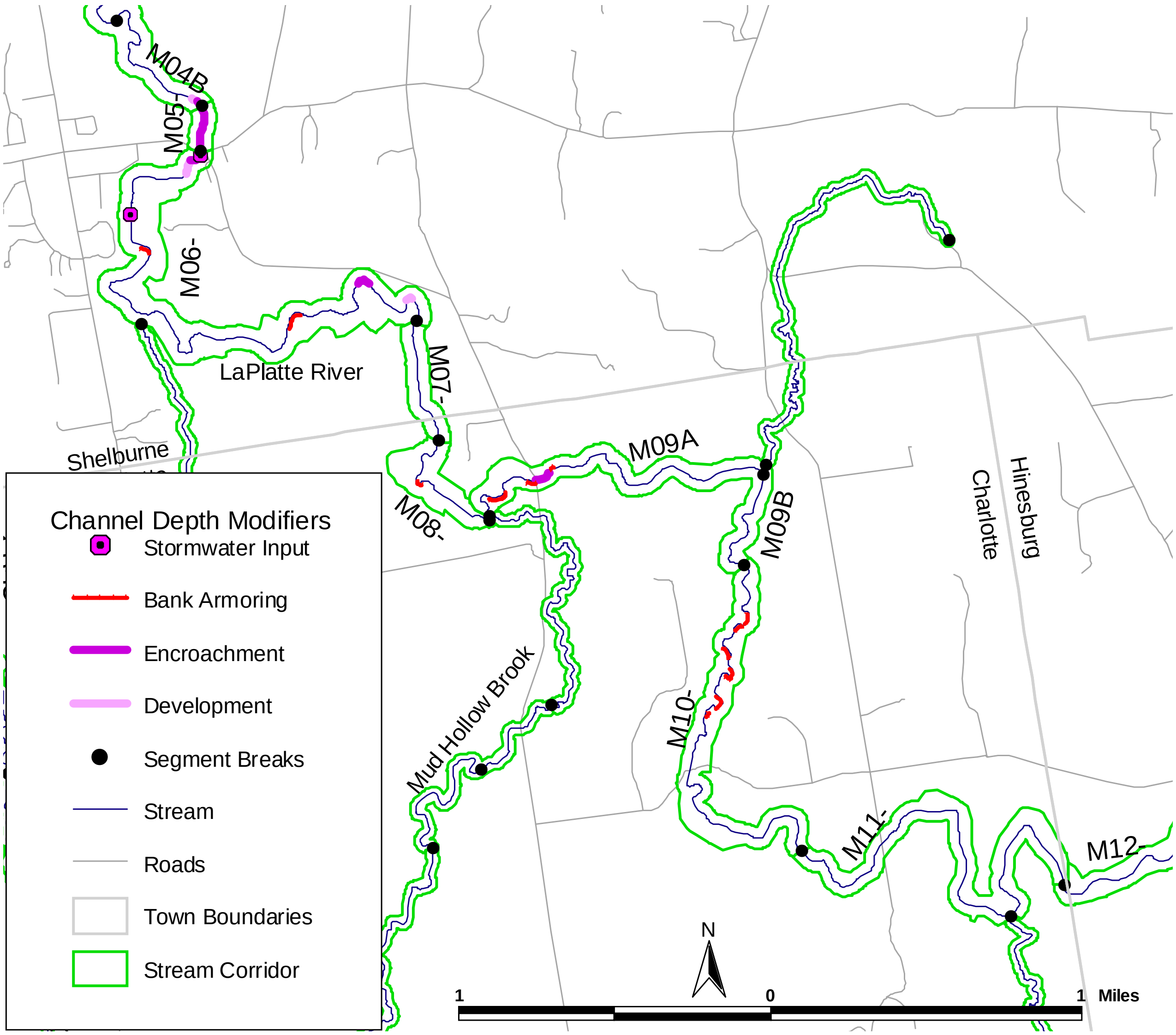


Figure 5.5. Channel Depth Modifiers Map. No documentation or signs of dredging were found, although past dredging activities may have occurred, especially in straightened sections.

Figure 5.5 depicts impacts to channel depth. Channel depth can increase as a response to increased runoff, decreased sediment, armoring of banks, dredging, berm or road construction, etc. Depth can decrease from significant sediment deposition or channel alterations.

Stormwater inputs, especially in reach M06, can be a significant contributor to channel depth increases. As mentioned earlier, more information would be helpful in identifying the extent of stormwater inputs.

Some areas of bank armoring (riprap) were identified and could impact channel depth. Additionally, straightening, as shown in figure 5.4, can also lead to channel incision. Channel incision was noted in all study reaches except for reach M11.

5.5 Boundary Conditions

The condition and characteristics of the channel bed and banks influences the ability of the channel to withstand erosion. For example, woody vegetation increases the resistance of the banks by holding soil with roots and providing some roughness to slow velocities. Bedrock in the bed or banks also provides stability by limiting channel incision or migration. Figure 5.6 shows alterations to boundary conditions in the study reaches.

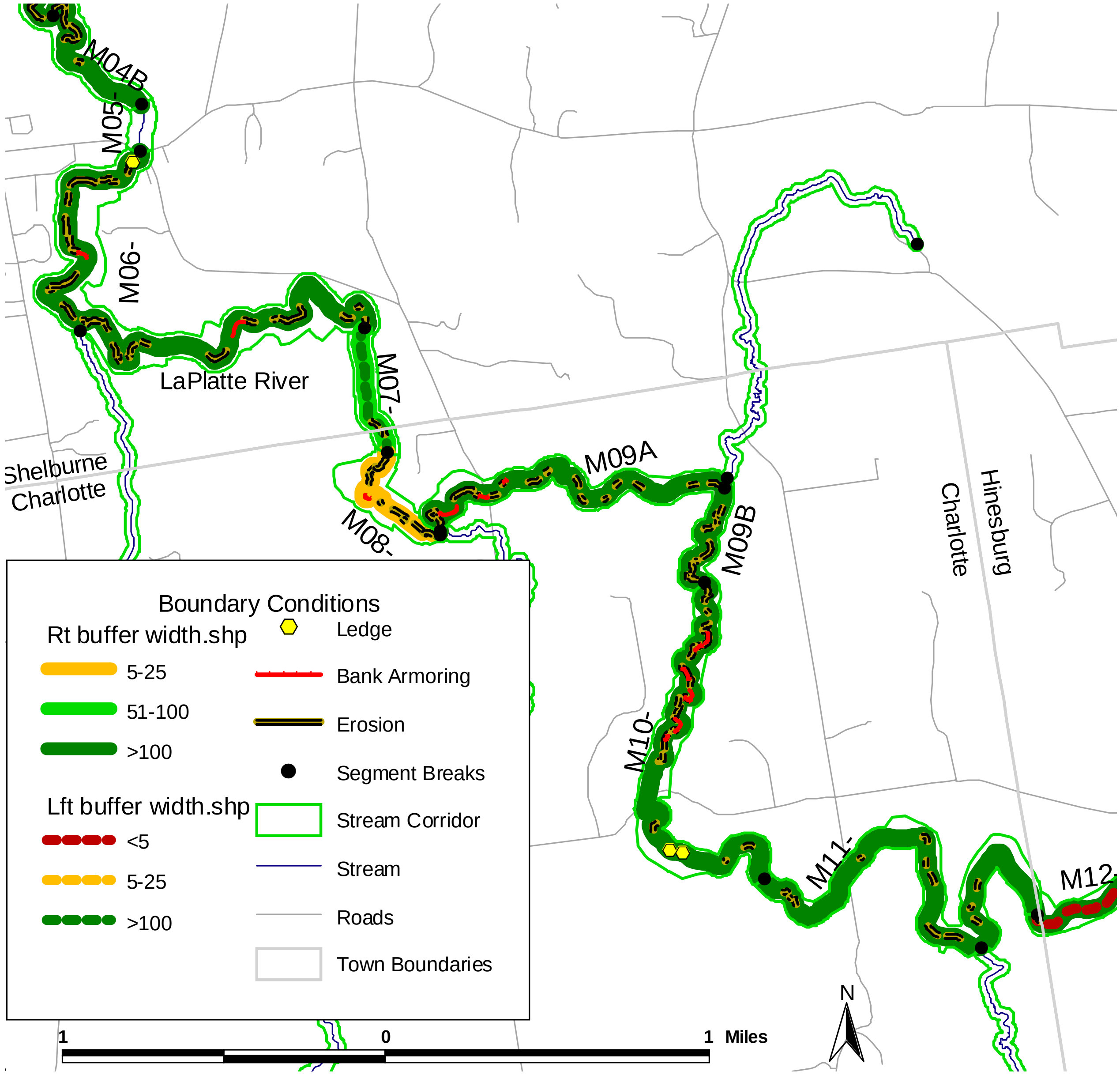


Figure 5.6. Boundary Conditions Map. No dams were present in the study reaches.

Removal of woody bank vegetation can decrease boundary resistance, leading to bank erosion and channel migration. Reach M08 had reduced buffer width (5-25 feet) and significant bank erosion. Other reaches had adequate woody buffer widths, although some areas within the reaches had low buffer widths, such as in M06, M09A, and M10.

Bank armoring is often installed to prevent bank erosion, if only temporarily. Reach M10 had brush revetments installed in an attempt to provide bank stability. Many of the revetments had failed at the time of assessment. Rock riprap armoring was present in M06 and M09A, increasing the resistance to bank erosion at these sites, but transferring the erosive power downstream.

Ledges provided bed resistance at the downstream end of M06 and in M10. Otherwise bed and bank materials were comprised mostly of non-cohesive sands and gravels, with the exception of cohesive clay banks present in reach M10. Table 5.1 summarizes by reach stressors contributing to departure from equilibrium conditions at the watershed and reach scales.

Table 5.1 River Stressor Identification Table

Reach Number	**Hydrologic (Watershed)**	**Sediment Load (Watershed)**	**Stream Power (Reach)**	**Boundary Resistance (Reach)**
M06	*Increase:* Moderate Impervious Surface; Stormwater Inputs; Wetland Loss	*Increase:* High Watershed and Upstream Crop Land; Bank Erosion; Multiple Mass Failures; Lateral Channel Migration	*Increase:* Straightening; Stormwater Inputs; Some Corridor Encroachment *Decrease:* Deposition Features; Migration Features	*Increase:* Ledge Grade Control (downstream end); Some Bank Armoring *Decrease:* Bank Erosion
M07	*Increase:* High Impervious Surface	*Increase:* High Watershed and Upstream Crop Land; One Mass Failure	*Decrease:* Deposition Features	
M08	*Increase:* Some Wetland Loss	*Increase:* High Watershed and Upstream Crop Land; Bank Erosion; One Mass Failure; Lateral Channel Migration	*Increase:* Straightening *Decrease:* Deposition Features; Migration Features	*Decrease:* Low Buffer Vegetation; Bank Erosion
M09A	*Increase:* Moderate Impervious Surface	*Increase:* High Watershed and Upstream Crop Land; Bank Erosion; Lateral Channel Migration	*Increase:* Some Corridor Encroachment *Decrease:* Migration Features	*Increase:* Some bank Armoring *Decrease:* Bank Erosion
M09B	*Increase:* Moderate Impervious Surface	*Increase:* High Watershed and Upstream Crop Land; Bank Erosion; Lateral Channel Migration	*Decrease:* Migration Features	*Decrease:* Bank Erosion
M10	*Increase:* Some Wetland Loss	*Increase:* High Watershed and Upstream Crop Land; Bank Erosion; Lateral Channel Migration	*Increase:* Straightening *Decrease:* Deposition Features; Migration Features	*Increase:* Ledge Grade Controls; Some Bank Armoring (tree revetments) *Decrease:* Bank Erosion
M11	*Increase:* Some Wetland Loss	*Increase:* High Watershed and Upstream Crop Land; Low Bank Erosion; Low Lateral Channel Migration	*Decrease:* Some Migration Features	*Decrease:* Bank Erosion

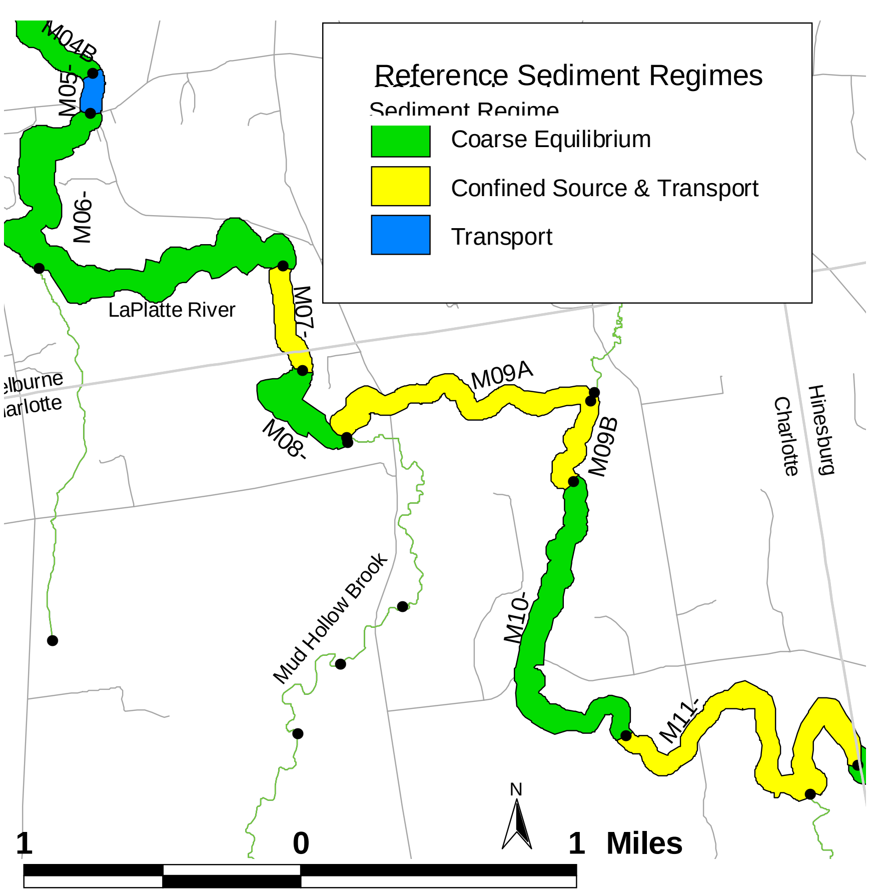
5.6 Sediment Regime Analysis

Comparing reference and existing sediment regimes is useful in understanding gains or losses in sediment storage capacity in the system. This can help in identifying restoration and protections project priorities aimed at increasing sediment storage in streams, thereby reducing sediment transport downstream and eventually to Lake Champlain. RMP has developed sediment regime descriptions (Table 5.2) and mapping protocols to classify reference and existing sediment regimes using the Phase 1 and Phase 2 data.

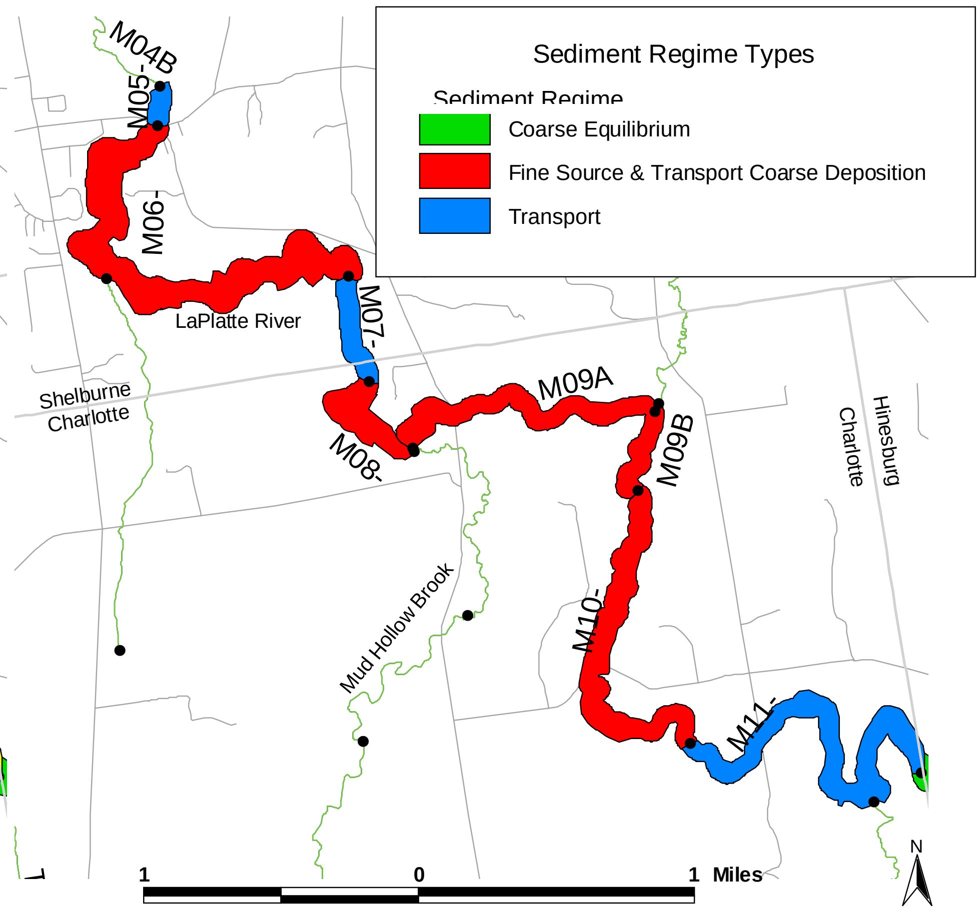
Table 5.2. Sediment Regimes and descriptions from VT ANR July 11, 2007.

Sediment Regime	Narrative Description
Transport	Steeper bedrock and boulder/cobble cascade and step-pool stream types; typically in more confined valleys, do not supply appreciable quantities of sediments to downstream reaches on an annual basis; little or no mass wasting; storage of fine sediment is negligible due to high transport capacity derived from both the high gradient and/or natural entrenchment of the channel.
Confined Source and Transport	Cobble step pool and steep plane bed streams; confining valley walls, comprised of erodible tills, glacial lacustrine, glacial fluvial, or alluvial materials; mass wasting and landslides common and may be triggered by valley rejuvenation processes; storage of coarse or fine sediment is limited due to high transport capacity derived from both the gradient and entrenchment of the channel. Look for streams in narrow valleys where dams, culverts, encroachment (roads, houses, etc.), and subsequent channel management may trigger incision, rejuvenation, and mass wasting processes.
Unconfined Source and Transport	Sand, gravel, or cobble plane bed streams; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to entrenchment or incision and associated bed form changes; these streams are not a significant sediment supply due to boundary resistance such as bank armoring, but may begin to experience erosion and supply both coarse and fine sediment when bank failure leads to channel widening; storage of coarse or fine sediment is negligible due to high transport capacity derived from the deep incision and little or no floodplain access. Look for straightened, incised or entrenched streams in unconfined valleys, which may have been bermed and extensively armored and are in Stage II or early Stage III of channel evolution.
Fine Source and Transport & Coarse Deposition	Sand, gravel, or cobble streams with variable bed forms; at least one side of the channel is unconfined by valley walls; may represent a stream type departure due to vertical profile and associated bed form changes; these streams supply both coarse and fine sediments due to little or no boundary resistance; storage of fine sediment is lost or severely limited as a result of channel incision and little or no floodplain access; an increase in coarse sediment storage occurs due to a high coarse sediment load coupled with the lower transport capacity that results from a lower gradient and/or channel depth. Look for historically straightened, incised, or entrenched streams in unconfined valleys, having little or no boundary resistance, increased bank erosion, and large unvegetated bars. These streams are typically in late Stage III and Stage IV of channel evolution.
Coarse Equilibrium (in = out) & Fine Deposition	Sand, gravel, or cobble streams with equilibrium bed forms; at least one side of the channel is unconfined by valley walls; these streams transport and deposit coarse sediment in equilibrium (stream power—produce as a result of channel gradient and hydraulic radius—is balanced by the sediment load, sediment size, and channel boundary resistance); storage of fine sediment as a result of floodplain access for high frequency (annual) floods. Look for unconfined streams, which are not incised or entrenched, have boundary resistance (woody buffers), minimal bank erosion, and vegetated bars. These streams are Stage I, late Stage IV, and Stage V of channel evolution.

The reference sediment regimes in the study area (Figure 5.7) were alternating sections of Transport (M05, M07, M09, M11) and Coarse Equilibrium areas (M06, M08, M10). Existing sediment regime types, based on Phase 2 data, show departures in regime in all but the most confined transport areas, M07 and M11. Reaches M06, M08, and M10 have changed from Coarse Equilibrium regimes to Fine Source and Transport, Coarse Deposition regimes. This indicates an increase in fine sediments produced in these reaches and transported downstream, as also illustrated in figure 5.3. Segments M09A and M09B experienced a departure in sediment regime from Transport to Fine Source and Transport, Coarse Deposition. This indicates that while these segments may be storing more coarse sediment than they were under reference conditions, they are now considered sources of fine sediments. Deposition of coarse sediments can lead to large bar features that induce channel migration and can lead to channel avulsions and flood damage.



Reference Sediment Regimes



Existing Sediment Regimes

Figure 5.7. Reference and existing sediment regimes for the LaPlatte study area. Reaches M07, M09, and M11 have valley slopes less than 2% so have reference sediment regimes of Confined Source and Transport rather than Transport.

5.7 Stream Sensitivity and Adjustment Process

Stream sensitivity ratings are assigned to each reach or segment based on the stream channel characteristics and adjustment processes or departure from equilibrium conditions. The stream sensitivity rating refers to the sensitivity of the reach to ongoing or future stressors. The sensitivity map (Figure 5.8) also depicts the dominant adjustment process underway in each segment.

All reaches in the study area except for M07 and M11 show high to very high sensitivity with lateral channel migration (planform) being the dominant adjustment process. This implies that continued and future stressors to these reaches are likely to result in further channel migration, avulsion, and/or flood damage.

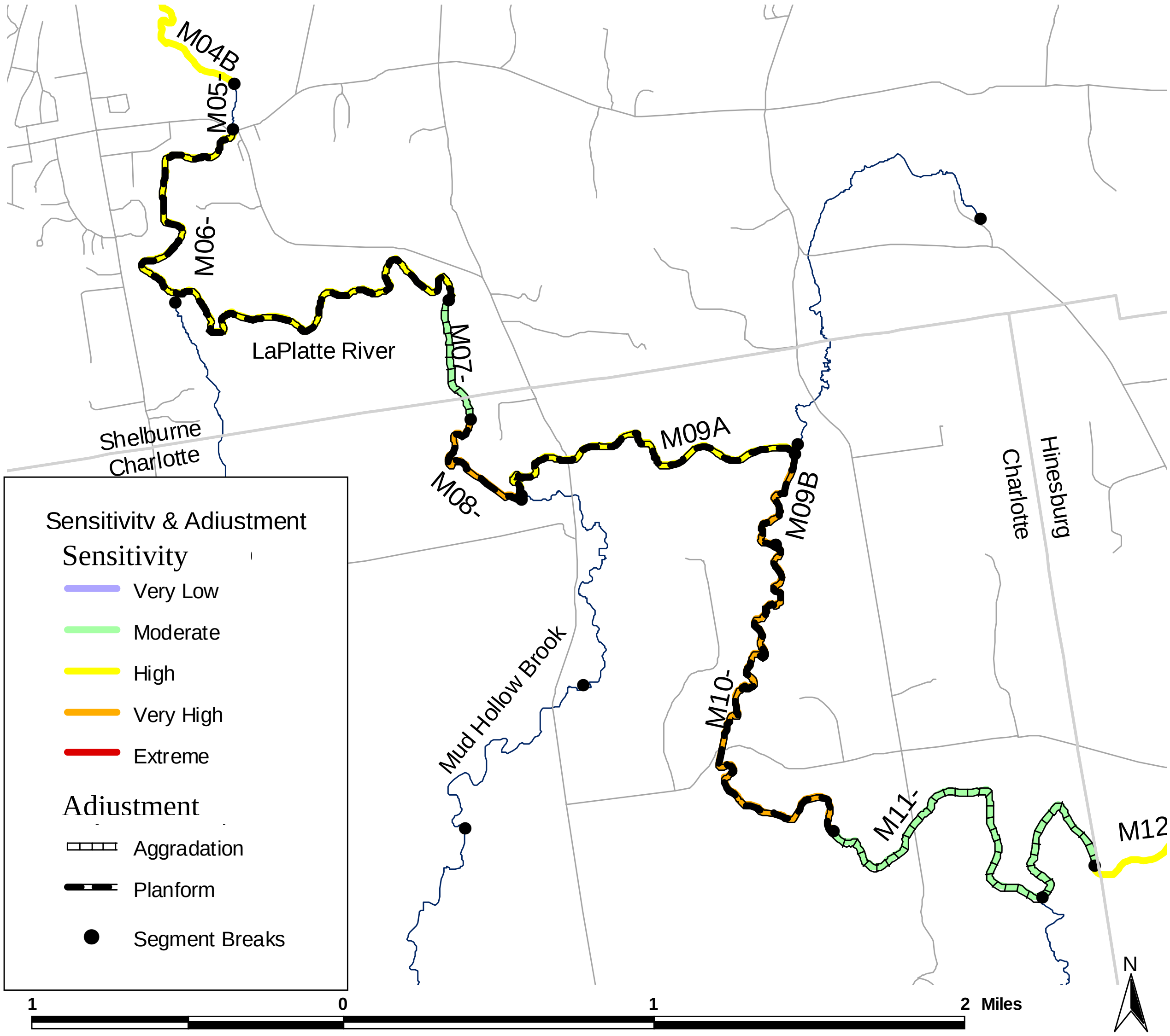


Figure 5.8. Stream Sensitivity and channel adjustment process.

6.0 Potential Project Identification

Results from the River Corridor Planning Guide Preliminary Project Identification process (VT ANR, 11 July 2007) are presented in the following sections and have been divided into two sections: 1) broader, watershed level opportunities and 2) more localized, reach or site level opportunities.

6.1 Watershed Level Opportunities

Impervious Surfaces

Stormwater runoff from impervious surfaces can lead to increased peak flows, increased erosion, and decreased water quality. The Hydrologic Alterations Map (Figure 5.2) highlights changes to the natural hydrology of the area. Note that many of the study segments were at or nearing the 5% threshold for effects of impervious surface cover on stream geomorphology described by Fitzgerald (2007). Stormwater inputs were noted in reach M06. More stormwater inlets likely exist and may enter small tributaries before entering the main channels. Other possible signs of stormwater inputs include gullies, noted in segments M09A, M10, M11, and tributary rejuvenation or erosion, noted in segments M06, M09A, and M11. Gullies and rejuvenating tributaries are also sources of sediment and nutrients.

Increasing impervious surfaces in the watershed, especially the riparian corridor could increase storm runoff and peak stream flows (Dunne and Leopold, 1978). This could result in further stream adjustments such as bank erosion, widening, and channel migration, all contributing to sediment and nutrient loading of the LaPlatte and eventually Shelburne Bay. In planning for developments, increases in percentage of impervious surfaces created by the developments should be considered as this can greatly affect runoff amounts and therefore erosion, sedimentation, and changes in channel dimensions (widening, incision, migration). Facilities to reduce increased runoff such as detention ponds should be recommended. Sediment from roads and driveways can be addressed with improved ditches, limiting future driveway lengths in sensitive areas, and other methods.

Erosion

Excessive erosion, as seen in segments M06, M08, M09A and B, M10, leads to sediment and nutrient loading of the system and deposition in downstream reaches. Mass failures, where large segments of high banks fall or slump into the channel, also contribute sediment to the system. This sediment carries nutrients and also can form deposits downstream, which can instigate or exacerbate channel adjustment. The Sediment Load Indicators Map (Figure 5.3) highlights bank erosion and mass failures seen during this assessment. Implementing measures to reduce stormwater runoff combined with site level projects to increase bank stability (planting) can help reduce excessive erosion over the long term.

Agriculture

Agriculture can be a stressor in terms of addition of nutrients to the system and in reduction of woody buffer areas. Some sections of stream had reduced woody buffer widths due to current or past agricultural practices. This can reduce channel resistance and lead to excessive erosion. Stream segments with areas of reduced woody buffer were M06, a small portion of M07, most of M08, M09A, M10, and areas of M11.

Some sections of stream ran through pasture areas, especially in M11. Allowing animals free access to the channel causes problems for stream stability and water quality. Animal waste and therefore nutrients are added directly to the water when livestock is near or in stream channels and negatively affects water quality of streams and Lake Champlain. Additionally, bank and bed trampling by livestock contributes sediment and nutrients to waterways. Programs such as CREP work with landowners to fence pasture areas away from waterways and look for alternate drinking arrangements. Tree planting can be a component of such buffer projects as well, providing filtration and additional water quality and habitat benefits.

Planning and Zoning

Protecting the corridor to prevent future investments from being placed in potential erosion hazard areas is very important, even if additional restoration activities are needed. If those restoration activities are not feasible, at least protecting the corridor can prevent erosion related losses and the need for future channel management activities.

Towns can reduce future costs and increase public safety by limiting stream corridor encroachment. Using the Phase 1 stream corridor or the FEH corridor, towns can create zoning overlay districts or setbacks. These districts or setbacks can help protect the stream corridors and help move streams toward equilibrium conditions by limiting future encroachment into the corridors. By keeping future development out of areas with high erosion potential, towns can reduce future costs associated with protecting these developments from erosion. This can help protect the streams and riparian areas and allow for the continued adjustment and eventual establishment of equilibrium conditions. Avoiding future conflicts between the streams and investments by utilizing zoning to prevent encroachment will reduce future costs and risks and increase safety for local residents as well as those downstream. A Water Resources Overlay District can be developed using the FEH map to accomplish these goals. Please refer to Appendix B for the FEH analysis and mapping.

The FEH zone was created by Stream Geomorphic Assessment Tool (SGAT), a GIS application, using data collected during Phase 1 and 2 SGAs. FEH zones identify the location and intensity of fluvial erosion hazards, as well as the area needed by a river to maintain a state of dynamic equilibrium (a condition where the sediment load and water load of a river are in balance, and erosion is minimized). The FEH zone is not a definitive outline of all areas at risk of erosion. Risks of erosion and flood hazards do exist outside the FEH zone. The FEH zone is not the same as the FEMA flood inundation area. The RMP considers this the minimum planning area for streams. It is intended as a planning tool to guide development in order to reduce potential future losses and risks and associated costs to society.

Stream Crossings

Table 6.1 shows structures assessed during Bridge and Culvert Assessments for study reaches. Individual structures and significant problems are discussed below. Appendix C presents results from the RMP Bridge and Culvert Screening Tool.

Table 6.1. Structure Summary Table

Reach Town	Road	Road Type	Stream	Location	Struct Type	Struct Height	Struct Span	Stream Width	% Span/ Stream Width	Floodplain Filled	Stream Approach	Comments
M05 Shelburne	Shelburne Falls Rd	Paved	LaPlatte	SE of the village over the Falls	Bridge	20	50	50	100	Entirely	Mild Bend	Over the falls and gorge, bedrock controlled area with a natural constriction.
M06 Shelburne	Farm Access/ Trail	Trail	LaPlatte River	In the upstream half of the reach	Bridge	7.5	41.5	72.5	**57**	Not Significant	Mild Bend	A snowmobile/farm access bridge. Floodplain not filled for bridge. Minor scour downstream.
M09 Charlotte	Spear St	Paved	LaPlatte River	At the Spear St crossing.	Bridge	12.7	53.4	60.7	**88**	Entirely	Mild Bend	Sediment deposition upstream, bank erosion.
M10 Charlotte	Carpenter Rd	Paved	LaPlatte River	On Carpenter Rd, west of Dorset St.	Bridge	16.0	63.0	43.0	147	Entirely	Channelized Straight	Stream appeared straightened in this area. Bedrock present upstream.
M11 Charlotte	Dorset St	Paved at bridge only.	LaPlatte River	Dorset St just south of Carpenter Rd.	Bridge	15.0	82.0	57.0	**144**	Entirely	Mild Bend	Deer carcasses, trash dumped at bridge. Scour downstream. Failing riprap and bank erosion.

Recent recommendations from VT River Management encourage sizing structures to 1 -1.5 stream width (100-150%). The % Span/Stream Width column in Table 6.1 shows the existing structures' width as a percent of stream width. Numbers in bold type indicate structures whose span and other problems pose threats to structure failure or stream equilibrium. More detail of these structures is presented below.

Figure 6.1. Shelburne Falls Road Bridge in M05.

The Shelburne Falls Road Bridge is equal to the channel width for reach M06 so was smaller than the recommended width. However, it is located just upstream of Shelburne Falls, a naturally constricted and bedrock controlled area. So although the bridge constricts and fills the floodplain in this area, the concern is less because of the natural constriction of the falls. Higher pressures would be exerted on the bridge abutments during floods, as it constricts the floodplain, so widening it could increase the lifespan of the structure.

Figure 6.2. Farm access bridge in M06.

In reach M06, a farm access bridge constricts the channel width. Minor scouring of the channel bed was present downstream of the structure. Reach M06 did appear to be incised, so additional pressure would be placed on the banks in higher than bankfull flows that are not high enough to reach the floodplain. This structure could be at risk of failure from erosion due to it constricting the channel, however, the floodplain did not appear to have been filled for the roadway or the approaches to the structure. Therefore flood flows that reach the floodplain could pass over the road and around the structure.


Figure 6.3. Spear Street Bridge in M09A.

The Spear Street Bridge in segment M09A did slightly constrict the channel width (88%) and had sediment deposition upstream and bank erosion present. Again, the floodplain was entirely filled by the road approaches, forcing all flood flows through this structure. Bank armoring was present as well, but resizing this structure could alleviate bank pressure and reduce erosion.


Figure 6.4. M10 Bridge at Carpenter Rd.

The Bridge at Carpenter Road in reach M10 meets the recommended width at 147% of stream width. Bedrock upstream of the structure helps control channel location in this area.

Figure 6.5. M11 Bridge at Dorset Street

The Dorset Street Bridge in M11 also meets the recommended structure width at 144% of stream width. An animal crossing at the bridge has led to bank trampling and erosion. Additional erosion and failing riprap are present. At the time of assessment, several deer carcasses had been dumped onto the bank from the bridge above as well as other trash. This dumping, as well as the animal crossing, compromise water quality. While the overall span of the bridge is large enough to meet RMP guidelines, the riprap at the base of the structure acts to constrict the channel. Widening this area by moving the riprap is recommended.

6.2 Site-Level Opportunities

The projects outlined in Table 6.2 meet the criteria for geomorphically compatible projects as outlined in Step 6: Preliminary Project Identification (VT ANR, 11 July 2007) as potential projects that could lead the channel to a dynamic geomorphic equilibrium.

Table 6.2 LaPlatte River Corridor Planning Project and Strategy Summary Table, Reaches M6-M11

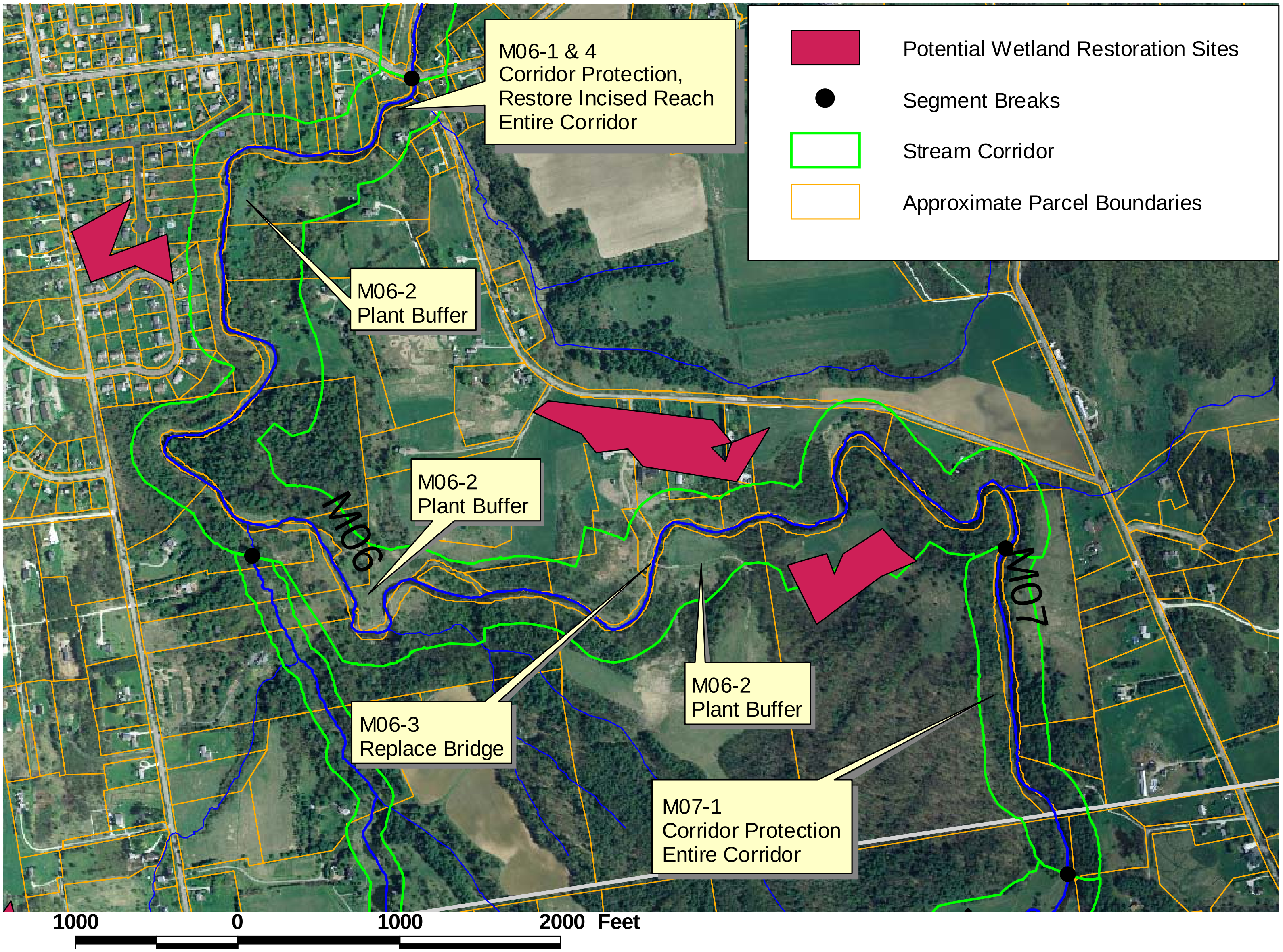
Project #, Condition, Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners with LWP
M06-1 Poor IV	Stream type departure from meandering Riffle-Pool to an incised Plane Bed type, incision ratio 1.95. Floodplain access was limited. Incision appeared to be historical, as did channel widening. Current channel adjustments aggradation and major planform.	Protect the river corridor to allow for adjustment to equilibrium conditions, to allow for flow and sediment attenuation, and to improve water and habitat quality. Also to avoid encroachment into the corridor and future expense of protecting those investments.	High priority due to stream sensitivity and development pressures in the area. Technically very feasible. An entity needed to hold easement.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest and hay fields.	RMP, VLT, Town of Shelburne
M06-2	Many areas have only 5-25 feet of buffer vegetation.	Plant buffer vegetation as part of the overall restoration plan, ideally with more expensive plantings away from the adjusting channel and migrating banks (toward the outer part of the corridor).	Lower priority due to fairly wooded corridor and continuing channel adjustment.	Improved habitat diversity, improved water quality, increased bank stability.	Varied depending on the type of planting program.	Corridor land use was forest and hay fields.	RMP, schools.
M06-3	One bridge for farm access constricted the channel.	Replace structure (bridge) with appropriately sized structure (see structures table).	Medium priority as this constricts the channel and can lead to higher flood and erosion risks, but few problems noted.	Reduced flood and erosion risks, improved habitat and water quality.	Fairly high.		Better Back Roads, Town of Shelburne

Project #, Condition, Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners with LWP
M06-4	Reach is incised (1.95) and has some signs of past straightening. Some incision could also be due to higher peak flows from stormwater runoff.	Restore incised reach: (Recommend analyzing stormwater in the area and pursuing watershed strategies to reduce impacts (i.e. grassy swales, rain gardens, etc). Investigate the possibility of active restoration of meanders and floodplain to restore the incised reach if more near-term results are desired. Work with 2 landowners with riprap to investigate possible removal. Riprap does not appear to be protecting structures, only preventing adjustment.	High priority as there is little encroachment so active or passive restoration of floodplain and/or meanders at a lower elevation is feasible with landowner cooperation.	Reduced flood and erosion risks, improved habitat and water quality.	High costs if an active approach is necessary.	Corridor land use was forest and hay fields.	RMP, Town of Shelburne
M07-1 Good III	The reach was in a narrowly confined, somewhat deep valley setting; historical channel widening with the current adjustment process being sediment deposition. Major sediment deposition filled the pools, leaving the stream with a Plane Bed stream type and more sand and fine gravel bed material	Protect the river corridor to allow passive restoration and adjustment to equilibrium condition.	This project is considered a low priority due to wooded corridor and “moderate” stream sensitivity.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest and some hay fields.	RMP, VLT, Town of Shelburne

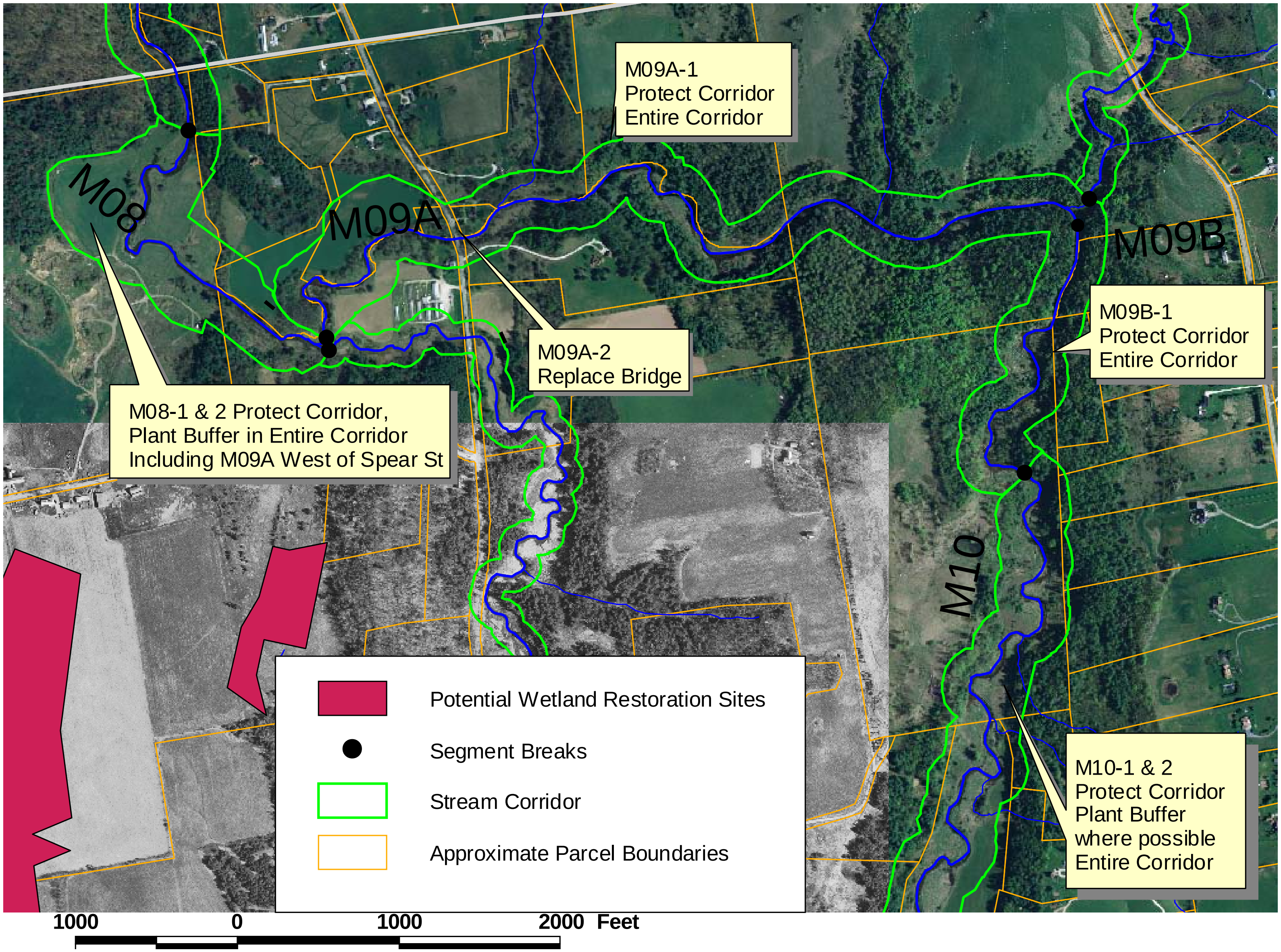
Project #, Condition, Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners with LWP
M08-1 **Fair** **IV**	The major adjustment process was lateral channel migration with minor aggradation. Herbaceous bank and buffer vegetation.	Protect the river corridor to allow for passive restoration of equilibrium conditions. The corridor is undeveloped, currently hay and shrub/sapling with some forest.	High priority as this is a sensitive reach and an attenuation area.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was mostly hay fields.	RMP, VLT, Town of Charlotte
M08-2	Limited buffer vegetation.	Plant stream buffer away from migrating banks. Use low cost plantings near the channel.	High priority as the reach appeared to be vertically stable at this point and migrating laterally.	Improved habitat diversity, improved water quality, increased bank stability, and filtration for adjacent land uses (farming and firing range).	Relatively low, depending on the type of plantings.	Corridor land use was mostly hay fields.	RMP, schools.

Project #, Condition, Evolution Stage	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners with LWP
M09A-1 **Fair** **IV**	Historical incision, with evidence of an older, higher floodplain terrace adjacent to the stream. Current adjustments were minor sediment deposition, channel widening, and lateral channel migration. Projects identified for M08 should also apply to the portion of M09A downstream of Spear St as that area is similar to M08 and not as similar to M09A.	Protect the river corridor to allow passive restoration and adjustment to equilibrium condition.	Low priority in the upstream portion of the segment due to the wooded corridor and low development pressure on the steep slopes. Higher priority in the downstream portion of the segment due to some loss of woody vegetation, and potential for development.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest with some hay and crop fields.	RMP, VLT, Town of Charlotte
M09A-2	One bridge constricted the channel. Riprap and rock placed at the base of the structure were significantly narrower than overall structure width.	Replace structure with one of appropriate size and widen riprap/rock base.	Requires coordination with transportation authorities, fairly high priority to alleviate pressure.	Reduced flood and erosion risks, improved habitat and water quality.	Fairly high.	Corridor land use was forest with some hay and crop fields.	RMP, AOT, Town of Charlotte
M09B-1 **Fair** **IV**	This segment also appeared to have incised from an older terrace in the past, with current adjustment processes being planform with minor aggradation.	Protect river corridor to allow for passive restoration through continued adjustment to equilibrium conditions.	Moderate priority: low due to the wooded corridor and likely lack of development pressure, higher due to the “very high” stream sensitivity.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest.	RMP, VLT, Town of Charlotte

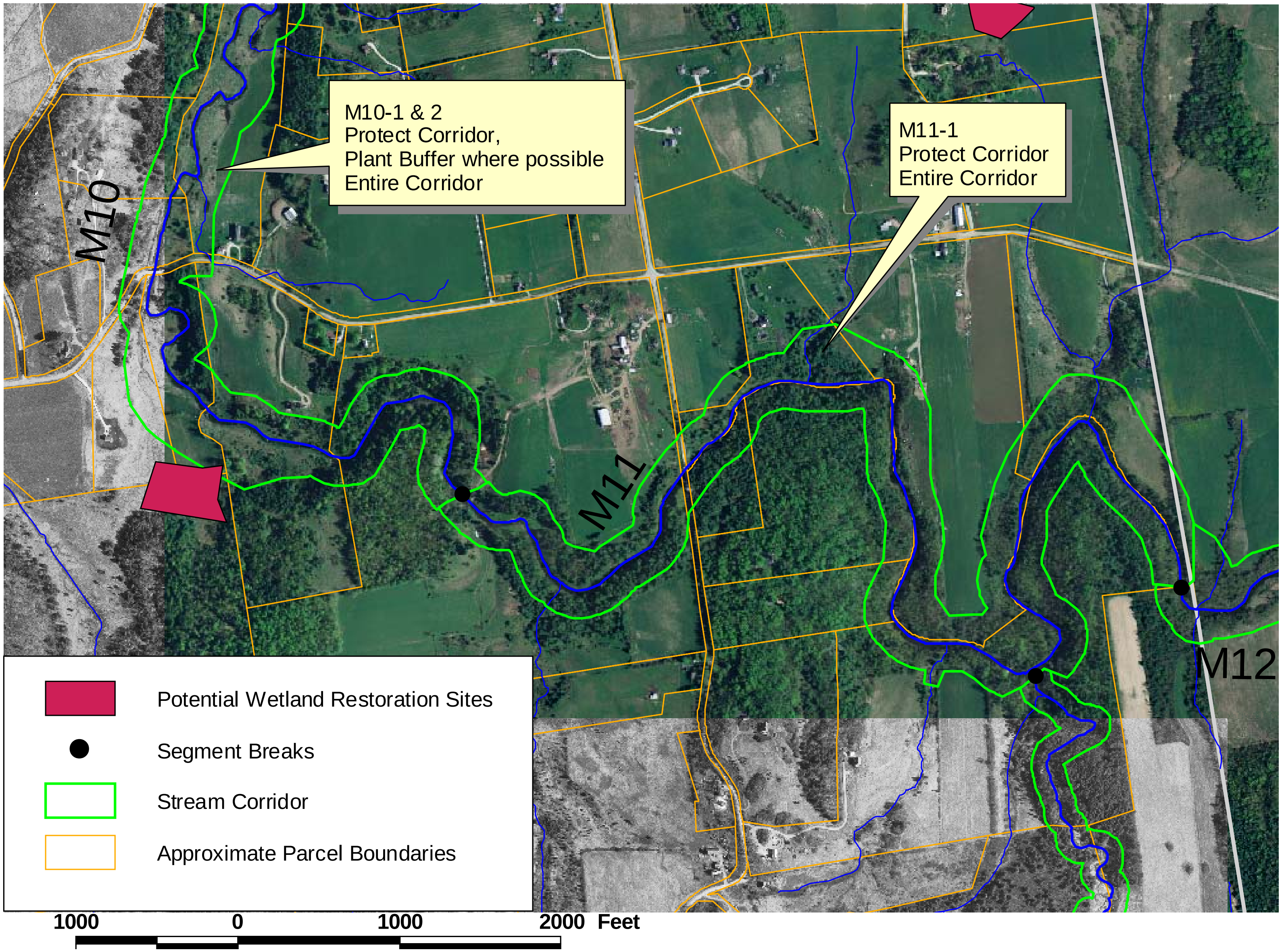
Project #, Condition, Evolution Stage	**Site Description Including Stressors and Constraints**	**Project or Strategy Description**	**Technical Feasibility and Priority**	**Other Social Benefits**	**Costs**	**Land Use Conversion**	**Potential Partners with LWP**
M10-1 **Fair** **IV**	Much bank erosion and several mass failures were present in the reach, contributing sediment. Current adjustments were major planform and minor aggradation and widening. The channel did not appear incised.	Protect the river corridor to allow for passive restoration of equilibrium conditions. Corridor is undeveloped and the channel is likely to adjust to equilibrium in a passive setting.	High priority due to stream sensitivity and the value of this area for attenuation.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest and hay fields.	RMP, VLT, Town of Charlotte
M10-2	Bank vegetation was herbaceous, as was the majority of the corridor vegetation with some saplings and forested areas. Many wetland areas were near the channel, which could account for some of the herbaceous vegetation.	Plant stream buffers with woody vegetation or allow vegetation to reestablish if planting has been attempted in the past and failed.	High priority as this reach is vertically stable and to improve habitat and water quality.	Improved habitat diversity, improved water quality, increased bank stability.	Relatively low, depending on the type of plantings.	Corridor land use was forest and hay fields.	RMP, schools.
M11 **Good** **I**	No incision and only minor aggradation observed. The reach was considered “in regime.”	Protect river corridor to prevent encroachment, as this is one of the few reaches “in regime.”	Moderate priority: low due to “moderate” stream sensitivity and the mostly wooded corridor. Higher due to the potential for encroachment pressure.	Habitat benefits, recreation, hunting, clean water, reduced erosion/flood risks.	Cost of corridor or easement acquisition, or purchase of development & management rights.	Corridor land use was forest and pasture with some hay fields.	RMP, VLT, Town of Charlotte



M06 and M07 Potential Project Sites.



M08, M09, and M10 Potential Project Sites.



M10 and M11 Potential Project Sites.

Potential Project Summaries

The following list of potential projects details those outlined in Table 6.2 and are in order of reach and project number. Please see Appendix A for orthophoto reach maps with Phase 1 stream corridor overlay.

M06

Figure 6.6. View of Reach M06.

The reference stream type for this reach appeared to be a meandering, gravel bed stream with Riffle-Pool features. However, due to channel incision (ratio 1.95), the reach experienced a stream type departure to a more incised, less meandering, Plane Bed type. Floodplain access was limited, although old channels and/or flood chutes on the upper terrace could provide additional floodplain access and relief from high flows. Incision appeared to be historical, as did channel widening. Current channel adjustments appeared to be aggradation and major planform. Bank erosion, islands, and multiple mass failures were indicators of these adjustments with significant contributions to sediment loads. Also contributing sediment were rejuvenating tributaries in the reach and gullies from stormwater inputs. Shelburne Falls at the downstream end of the reach provided grade control. The river corridor was largely undeveloped except for some short sections of road and some houses on the fringes.

Figure 6.7. Bank erosion on an outside bend, contributing sediment (L) and one of many mass failures in M06 (R).

M06-1
Protect the river corridor to allow for adjustment to equilibrium conditions. This may take longer than the 30-year “near-term” goal of RMP, so additional efforts could be employed to enhance the process (see M06-4). This project is considered a high priority due to stream sensitivity and development pressures in the area.

M06-2
Plant buffer vegetation as part of the overall restoration plan, ideally with more expensive plantings away from the adjusting channel and migrating banks (toward the outer part of the corridor). This project is considered a lower priority due to the fairly wooded stream corridor and the continuing channel adjustments that could erode plantings if too close to migrating banks.

M06-3
Replace structure (bridge) with appropriately sized structures (see structures table 6.1 and summaries for bridge details).

M06-4
Restore incised reach: reach is incised (1.95) and has some signs of past straightening. Some incision could also be due to higher peak flows from stormwater runoff. (Analyzing stormwater in the area and pursuing watershed strategies to reduce impacts i.e. grassy swales, rain gardens, etc is recommended). Investigate the possibility of active restoration of meanders and floodplain to restore the incised reach if more near-term results are desired. Work with 2 landowners with riprap to investigate possible removal. Riprap does not appear to be protecting structures (homes, barns, etc), only preventing adjustment. This project is considered a high priority as there is little encroachment so active or passive restoration of floodplain and/or meanders at a lower elevation is feasible with landowner cooperation.

M07

Figure 6.8. View of reach M7, appearing overwidened and with a plane bed form.

Reach M07 was fairly short, 2158 feet long, and appeared naturally straight. This section of the LaPlatte was in a narrowly confined, somewhat deep valley setting. Due to this narrow valley, there was very little floodplain adjacent to the channel. The “reference” stream would likely have been a step-pool type stream with cobble bed material. However, major sediment deposition filled the pools, leaving the stream with a Plane Bed stream type (no defined steps or pools) and more sand and fine gravel bed material. Overall, the stream geomorphic condition appeared “Good” with the channel widening historically and the current adjustment process being sediment deposition. Habitat condition in this section was “Good” but had a low mix of habitat types, no pools, incomplete riffles, and sediment deposition. Some hay fields on the right bank encroached into the otherwise forested corridor.

M07-1

Protect the river corridor to allow passive restoration and adjustment to equilibrium condition. This project is considered a low priority due to wooded corridor and “moderate” stream sensitivity.

M08

Figure 6.9. Right bank erosion and diagonal bar.

Reach M08 flowed through a broad valley dominated by herbaceous and shrub/sapling vegetation. The stream type appeared to be a meandering, riffle-pool type stream with mostly gravel bed material. Multiple sediment deposits (mid, point, side, and diagonal bars) were present. Many areas of bank erosion were observed as well as flood chutes (where high flows access chutes across the inside of a bend), signaling lateral channel migration.

The reach appeared to be in "Fair" geomorphic condition, meaning that it was in the process of adjusting to past and present watershed stressors and was no longer it its "reference" condition. The major adjustment process was lateral channel migration with minor aggradation (channel evolution stage IV). Habitat condition was also "Fair," being affected by the sediment deposition and lack of woody bank vegetation. A shooting range was in the corridor on the left bank and a hay field on the right bank.

Figure 6.10. Channel meandering and varying terrace levels in reach M8, signaling lateral channel migration and slight incision with new bars forming.

Figure 6.11. Trash close to the channel at the shooting range. Photo taken from the top of the left bank.

M08-1
Protect the river corridor to allow for passive restoration of equilibrium conditions. The corridor is undeveloped, currently hay and shrub/sapling with some forest. High priority as this is a sensitive reach and an attenuation area.

M08-2
Plant stream buffer away from migrating banks. Use low cost plantings near the channel. High priority as the reach appeared to be vertically stable at this point and migrating laterally and also to improve habitat and water quality and provide filtration from adjacent land uses (farming and firing range).

Projects identified for M08 should also apply to the portion of M09A downstream of Spear St as that area is similar to M08 and not as similar to the portion of M09A upstream of Spear Street.

M09A

Figure 6.12. View of reach M9A upstream of Spear Street with small floodplain terrace developing.

Reach M09 was segmented into two segments due to varying planform and slope characteristics. Segment M09A (downstream segment) had a steeper slope and appeared to be a straighter stream with large gravel bed material and Plane Bed features by reference. Adjacent side slopes in the narrow valley were steep to very steep. The channel appeared to have eroded downward in the past, with evidence of an older, higher floodplain terrace adjacent to the stream. Current adjustment processes were minor sediment deposition, channel widening, and lateral channel migration. Overall stream condition appeared “Fair” and the channel in stage IV of evolution, no longer in reference condition but moving toward a new stage of balance.

Habitat condition appeared “Fair,” affected by bank instability, infrequent riffles, sediment deposition, and lack of cover. Some crop areas encroached into the corridor on both banks with forest in the majority of the corridor. Bank vegetation was dominated by herbaceous species. Multiple sediment deposits (bars) were present. A bridge at Spear Street constricted the channel width, with signs of sediment deposition upstream.

Figure 6.13. Mass Failure in M09A, a source of sediment to the system. Several flood chutes were seen in M09A, signaling planform adjustment.

M09A-1

Protect the river corridor to allow passive restoration and adjustment to equilibrium condition. This project is considered a low priority in the upstream portion of the segment due to the wooded stream corridor and presumably low development pressure on the steep slopes. This project is a higher priority in the downstream portion of the segment due to some loss of woody vegetation and a higher potential for development.

M09A-2

Replace structure (bridge) with one of appropriate size and widen the riprap/rock base. Riprap and rock placed at the base of the structure were significantly narrower than overall structure width (see structures table 6.1 and summaries for bridge details).

M09B

Figure 6.14. Migration in M09B.

Segment M09B appeared to be in a slightly shallower valley, although also narrow, with a meandering, mostly sandy, Riffle-Pool type. The riparian corridor was forested, with the same herbaceous bank vegetation as in M09A. This segment also appeared to have incised from an older terrace in the past, with current adjustment processes being planform with minor aggradation (stage IV of evolution). Overall stream condition appeared “Fair.” RHA condition appeared ‘Good” with bank instability and sediment deposition being the main factors affecting habitat. Some signs of beaver activity were observed in the segment.

M09B-1

Protect the river corridor to allow for passive restoration through continued adjustment to equilibrium conditions. This project is considered a moderate priority: low due to the wooded corridor and likely lack of development pressure, but higher due to the “very high” stream sensitivity.

M10

Figure 6.15. Tree Revetments in M10.

Reach M10 appeared to be a meandering, sandy bed, Riffle-Pool stream type in a broad valley setting with steep adjacent hill slopes. Bank vegetation was herbaceous, as was the majority of the corridor vegetation with some saplings and forested areas. Many wetland areas were near the channel, which could account for some of the herbaceous vegetation. Many sediment deposition types (mid, point, side, diagonal bars) were noted in the reach along with two islands. Much bank erosion and several mass failures were present in the reach, contributing sediment. Current adjustments were major planform and minor aggradation and widening. The channel did not appear incised. Overall RGA condition was "Fair" and the channel appeared to be in stage IV of channel evolution. RHA condition appeared "Fair" with sediment deposition, embeddedness, and bank instability the main factors affecting habitat scores. Some ledges provide grade control in the reach, and one bridge constricts the flood prone width.

Figure 6.16. Ledge grade control and herbaceous bank vegetation (L), and one of several mass failures in the reach (R).

M10-1
Protect the river corridor to allow for passive restoration of equilibrium conditions. The corridor is currently undeveloped and the channel is likely to adjust to equilibrium in a passive setting. This project is considered a high priority due to stream sensitivity and the value of this area for attenuation.

M10-2
Plant stream buffers with woody vegetation or allow vegetation to reestablish if planting has been attempted in the past and failed. This project is considered a high priority as this reach is vertically stable and this would improve habitat and water quality. This would be a lower priority if previous plantings had been attempted and failed.

M11

Figure 6.17. Cross section view of M11.

Reach M11 had a fairly shallow slope for its confined valley setting. The stream type appeared to be an somewhat incised, Dune-Ripple type having a fairly shallow slope. Beaver activity increased toward the upstream end of the reach, with a large dam and pond on a tributary. The riparian corridor was forested, however downstream of the bridge, cows had free access to the channel and many crossing areas and areas where banks were trampled noted. The channel did not appear incised, however tributary erosion was noted, possibly due to beaver activity in the upstream areas, and land use at the downstream end as well as possible channel adjustment in the tributary itself. One bridge constricted the floodprone width and had scour downstream. Trash and deer carcasses were seen dumped on the banks at the bridge. Trash and old farm equipment were dumped on the right bank roughly in the middle of the reach. RGA condition appeared “Good” with only minor aggradation observed. The reach was considered “in regime.” RHA condition was also “Good.” Few substrates for food and cover were present. Riffles and diversity of velocity/depth patterns were infrequent.

Figure 6.19. Animal access to channel and bank trampling (L) and cows with full access to the channel (R) in M11.

M11-1

Protect river corridor to eliminate livestock access and to prevent encroachment, as this is one of the few reaches "in regime." This project is considered a moderate priority: low due to "moderate" stream sensitivity and the mostly wooded corridor; higher due to the current livestock access and potential for encroachment pressure.

7.0 Next Steps

The following list summarizes projects recommended for immediate action or requiring further study to help determine appropriate actions. The list is separated into short-term actions and longer-term actions to aid planning efforts.

Short-Term Actions

- A high priority recommendation for further information is to study stormwater infrastructure and inputs to the stream and especially inputs to tributaries that may be affected. Looking at stormwater GIS coverages for points where stormwater enters the system and more details of impervious surfaces could help in this analysis. This is important to begin to understand and address the watershed wide stormwater impacts.

- Discuss corridor conservation with large landowners in M06 in conjunction with farm bridge replacement and wetland restoration possibilities.

- Protect the river corridor and plant buffer vegetation in M08 and M09A as this area is actively migrating and would be an important attenuation asset under equilibrium conditions.

- Protect the corridor in M10 due to the value of this area for attenuation.

- Protect the river corridor and fence out livestock (if the area is to be used for pasture in the future) in M11 to improve water quality. Clean up dump site on right bank toward the upstream end of the reach.

Long-Term Actions

- A high priority recommendation is to restore floodplain access in M06 passively through high priority corridor protection, or through town planning and zoning by pursuing FEH zoning. This should be combined with stormwater remediation (following stormwater study described above), as the increased runoff could limit the channels ability to regain equilibrium. Helping M06 achieve equilibrium conditions is important not only from a water quality standpoint (reducing sediment to Shelburne Bay) but also to reduce erosion and flood damage downstream.

- Pursue stormwater remediation following the stormwater study described above.

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Acronym List

CCRPC – Chittenden County Regional Planning Commission
DMS – Data Management System (Developed by the DEC)
GIS – Geographic Information System
GPS – Global Positioning System
LCA – Lewis Creek Association
LWD – Large Woody Debris
LWP – LaPlatte Watershed Partnership
RGA – Rapid Geomorphic Assessment
RHA – Rapid Habitat Assessment
RMP – River Management Program
SCP – Stream Corridor Plan
SGA - Stream Geomorphic Assessment
SGAT – Stream Geomorphic Assessment Tool
VT ANR DEC – Vermont Agency of Natural Resources Department of Environmental Conservation

Glossary of Terms

Aggradation - The build up of sediment in a streambed.

Avulsion – A change in a river's course; a section of channel that has moved laterally from its bed to create another segment of channel some distance from the previous bed location.

Bankfull width - The width of the channel at a height corresponding to the level of stream flow that would overtop the natural banks in a reference stream system, occurring on average 1.5 to 2 years.

Bankfull maximum depth – The depth of the channel from the bankfull elevation to the thalweg (see below).

Confinement – Referring to the ratio of valley width to channel width. Unconfined channels (confinement of 4 or greater) flow through broader valleys and typically have higher sinuosity and area for floodplain. Confined channels (confinement of less than 4) typically flow through narrower valleys.

Debris jam - A collection of large woody debris that has lodged in a stream channel and spans the channel from bank to bank.

Degradation or incision - Down cutting of the streambed by erosion of bed material.

Embedded – Larger bed substrate particles (gravels, cobbles, boulders) surrounded by fine sediment, reducing the oxygen in the substrata and the ability of organisms to retreat into the substrata for cover.

Entrenched - A state where a channel has lowered significantly and floodwaters can no longer overtop the banks and access the floodplain.

Flood chute - A small side channel crossing the inside of a meander bend where flood waters will bypass the main channel, taking a shorter route through the chute.

Floodprone width - The area outward from the channel that is at an elevation that could be inundated by a flood, measured in Phase 2 SGA as at an elevation of 2 times the bankfull maximum depth.

Grade control – A fixed surface on the streambed that controls the bed elevation at that point, effectively fixing the bed elevation from potential incision, typically bedrock or culverts.

Head-cut – A sharp change in slope, almost vertical, where the streambed is being eroded from downstream to upstream.

High gradient streams - Typically found in steep, narrow valleys, these streams have steep slopes and are usually fast moving with many riffles or steps and low sinuosity.

Impervious surface – A hard surface, such as concrete or a rooftop, which prevents water from infiltrating the soil.

In Regime – Referring to a stream that is in an equilibrium state, one that would be expected given the stream setting.

Large woody debris - Pieces of wood in the active channel (within the bankfull width) usually from trees falling into the channel and with minimum dimensions of 12 inches in diameter (at one end) by 6 feet long.

Low gradient streams – Typically found in wide valleys, these streams have shallow slopes and are usually slow and meandering.

Meander – A bend in a stream, or referring to the way a stream winds down its valley.

Sinuosity - The level of bends or turns in a stream, calculated by dividing the stream length by the valley length.

Thalweg – Deepest point along the length of the stream, as if the deepest point of all cross sections were connected. The thalweg of a meandering channel typically alternates from right to left bank connecting pools.

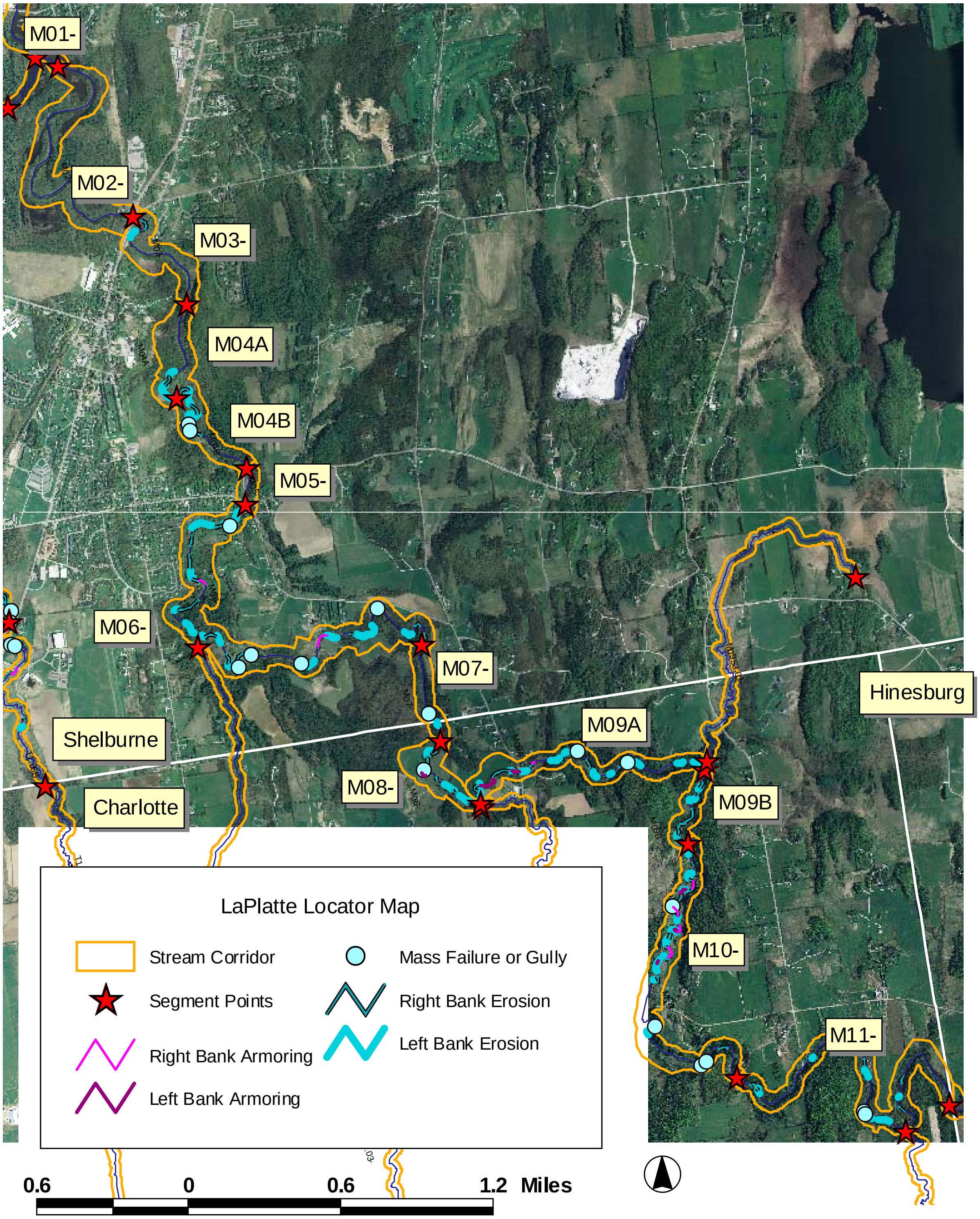
Width/depth Ratio – The ratio of channel bankfull width to the average bankfull depth. An indicator of channel widening or aggradation.

Windrowing - Digging material from the channel bed and piling it on the bank, creating berms.

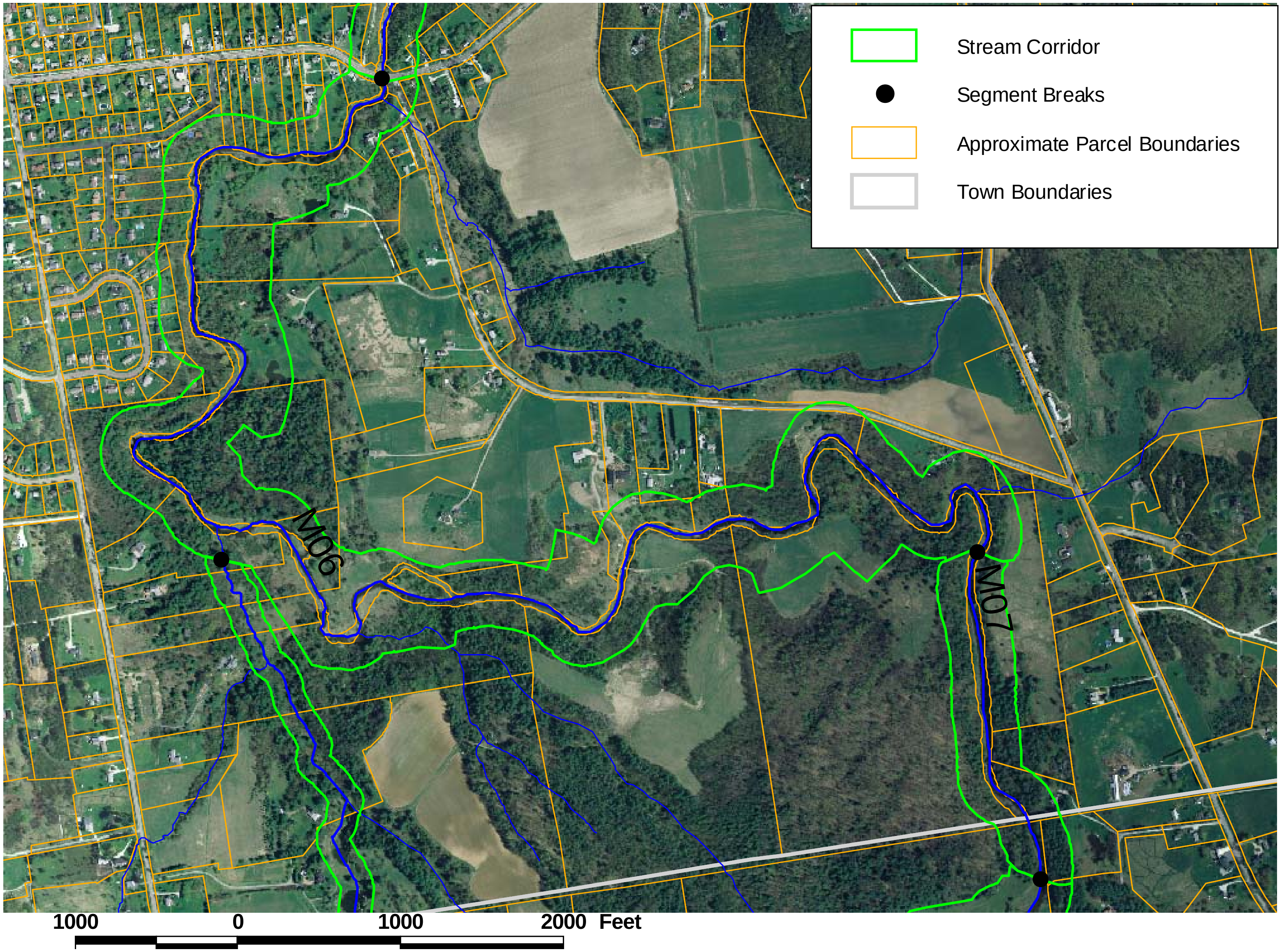
List of Resources/Links:

- River Corridor Planning Guide from ANR River Management Program - http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rivercorridorguide.pdf
- Flood hazard management information from ANR River Management Program - http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_floodhazard.htm
- Alternatives for River Corridor Management (RMP paper) - http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_managementAlternatives.pdf
- Municipal Guide to Fluvial Erosion Hazard (from RMP) – http://www.anr.state.vt.us/dec/waterq/rivers/docs/rv_municipalguide.pdf
- ANR Buffer Guidance – http://www.anr.state.vt.us/site/html/buff/BufferGuidanceFINAL-120905.pdf

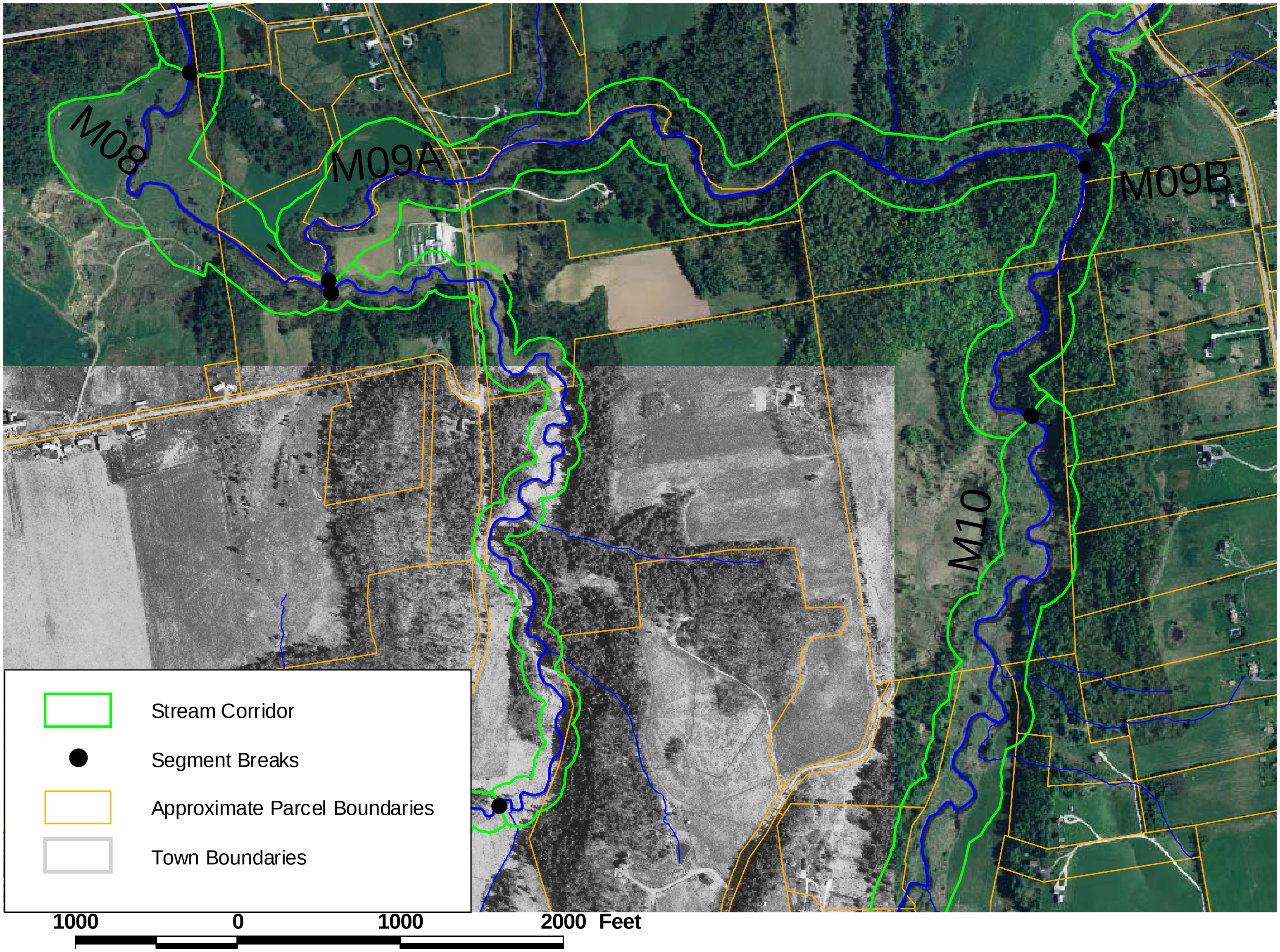
Appendix A: Study Area Maps



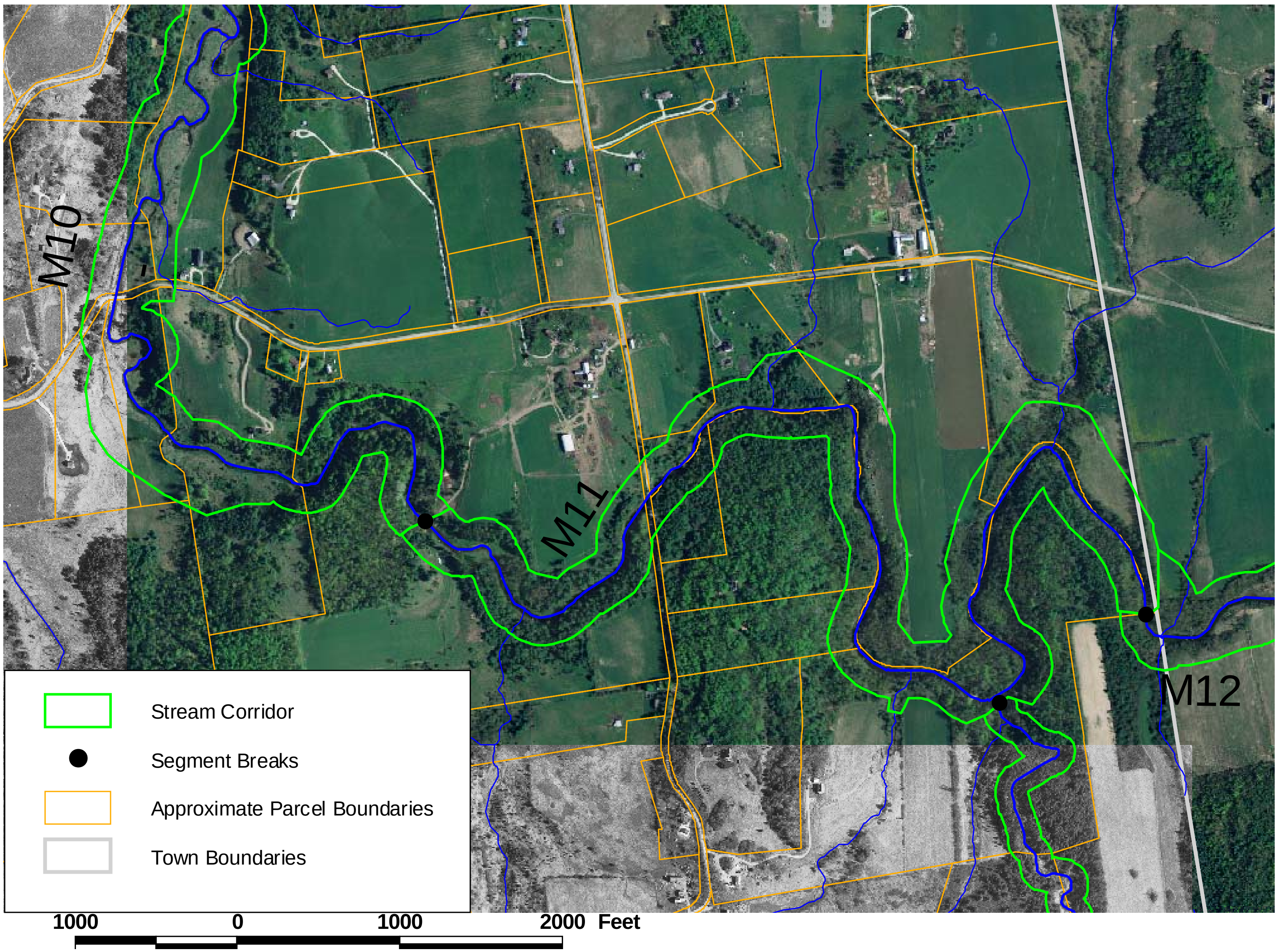
Study Area Locator Map



M06 and M07 Site Map



M08, M09 and M10 (downstream portion) Site Map



M10 (upstream portion) and M11 Site Map

Appendix B: Fluvial Erosion Hazard (FEH) Analysis

Appendix C: Bridge and Culvert Screening Tool Results