

Fluvial Erosion Hazard Mapping and Phase 2 Assessment Report



For the Municipalities of
Georgia, Highgate and Saint Albans City

~Northwest Regional Planning Commission~
February 2008



Prepared for

Vermont Emergency Management
103 South Main Street
Waterbury, VT 05676

Prepared by

Northwest Regional Planning Commission
155 Lake Street
St. Albans, VT 05478

and

Ross Environmental Associates, Inc.
P.O. Box 1533
Stowe, VT 05672

Contributors to the report

Federal Granting Agency, Federal Emergency Management Agency
(grant#02140-31225-004-PDMC05)
VT Department of Environmental Conservation ~ River Management

Front and Inside Cover Photographs

Northwest Regional Planning Commission
James Gilhooly, Georgia
Ross Environmental Associates, Inc.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	I
A. PROJECT OVERVIEW (NRPC)	1
B. PHASE II GEOMORPHIC ASSESSMENT	1
1.0 BACKGROUND INFORMATION	1
1.1 <i>Geographic Setting</i>	1
1.2 <i>Geologic Setting</i>	3
1.3 <i>Geomorphic Setting</i>	4
1.4 <i>Hydrology</i>	5
1.5 <i>Ecological Setting</i>	5
2.0 METHODOLOGY	6
2.1 <i>Fluvial Geomorphic and Habitat Assessment Protocols</i>	6
2.2 <i>Quality Assurance and Quality Control</i>	6
3.0 RESULTS	6
3.1 <i>Watershed Scale Stressors</i>	7
3.1.1 <i>Hydrologic Regime Stressors</i>	7
3.1.2 <i>Sediment Regime Stressors</i>	11
3.1.3 <i>Reach-Scale Sediment Regime Stressors</i>	17
3.2 <i>Constraints to Sediment Transport and Attenuation</i>	21
3.2.1 <i>Sediment Regimes</i>	21
3.2.2 <i>Vertical and Lateral Constraints</i>	24
3.2.3 <i>Sensitivity Analysis</i>	26
4.0 CONCLUSIONS	28
C. FLUVIAL EROSION HAZARD MAPPING	29
1.0 METHODOLOGY	29
2.0 RESULTS AND APPLICATION	29
D. REFERENCES	32

LIST OF APPENDICES

Appendix A	Study Reaches
Appendix B	Stressor Maps
Appendix C	Tables
Appendix D	Photographs
Appendix E	Reach Summaries
Appendix F	QA Reports
Appendix G	Phase 2 DMS Reports
Appendix H	“Municipal Guide to Fluvial Erosion Hazards Mitigation” River Management Program, VT Agency of Natural Resources
Appendix I	Community Fluvial Erosion Hazard Maps and Tables

EXECUTIVE SUMMARY

During the summer of 2006, Phase 2 stream geomorphic assessments (SGA) were completed on approximately 26 miles of stream located throughout Franklin County, Vermont. These assessments were performed by the Northwest Regional Planning Commission (NRPC) and Ross Environmental Associates (*R.E.A.*) in accordance with the Vermont Department of Environmental Conservation River Management Program's Phase 2 Rapid Stream Assessment Field Protocols. The project was funded by FEMA with a Pre-Disaster Mitigation Grant (#EMB-2005-PC-003) and administered through the Vermont Department of Public Safety. The purpose of completing the Phase 2 assessments was to provide NRPC with field data to develop Fluvial Erosion Hazard (FEH) maps for participating municipalities. The results of the Phase 2 SGAs and the FEH maps can be used by the municipalities and NRPC to guide management decisions regarding future development and land use within the FEH corridor. Also, the NRPC will work with municipalities to implement stream corridor restoration projects.

A total of 45 stream segments (22.95 miles) were assessed within the Deer Brook, Mill River, Rugg Brook and Stonebridge Brook watersheds in Georgia, Vermont. An additional seven segments (3.22 miles) were assessed within the Missisquoi Black to Hungerford and Missisquoi Mouth watersheds in Highgate, Vermont. The assessed streams are located in rural residential, agricultural, and light commercial areas, where some of the streams have been altered to accommodate human land use activities, and continue to be threatened by possible future development and land use changes.

In general, the assessments demonstrated that most of the reaches are currently in regime with the Phase 1 reference stream types, though most reaches are experiencing some sort of adjustment process, including either degradation, or widening and aggradation, in response to several watershed and reach scale stressors. Geomorphic conditions were found to be mostly fair to good, though some poor conditions were noted, mostly in the Mill River watershed. Where conditions were poor, stream type departures were observed as a result of major stressors acting on the stream system. These stressors included lack of riparian buffer and/or extensive straightening in agricultural or development areas, increases in surface runoff in urban areas, and increases in sediment supply from unstable banks and valley walls. Overall, these stressors have caused the stream channels to deepen, causing the floodplain to become inaccessible. Consequently, during flooding events, the high flows are limited within the channel, which has caused significant bank erosion, channel widening, and other channel instabilities. Stream sensitivity ratings of all assessed reaches fell mostly within the high to extreme categories, indicating that even those reaches that have not experienced significant adjustment are inherently sensitive to future watershed changes.

While many of the streams have been historically altered to accommodate specific land use activities, very few large-scale human constructed bank stability projects, such as bank armoring, have been implemented within the study area. It is still possible; therefore, to regain equilibrium in these streams using alternative restoration projects and land preservation that allow lateral channel migration and creation of a new floodplain.

The NRPC used the results from this Phase 2 Assessment and earlier assessments by the Lake Champlain Committee and South Mountain Research to develop FEH maps for Georgia, Saint Albans City and Highgate. NRPC distributed FEH maps to all three communities and met with the Georgia and Saint Albans City planning commission. The information was well received and the NRPC will continue to work with these communities on implementing a FEH overlay in their zoning.

A. PROJECT OVERVIEW

This project was funded by FEMA with a Pre-Disaster Mitigation Grant (#EMB-2005-PC-003) and administered through the Vermont Department of Public Safety. The purpose of completing the Phase 2 assessments was to provide NRPC with field data to develop Fluvial Erosion Hazard (FEH) maps for participating municipalities. The results of the Phase 2 SGAs and the FEH maps can be used by the municipalities and NRPC to guide management decisions regarding future development and land use within the FEH corridor.

A total of 45 stream segments (22.95 miles) were assessed within the Deer Brook, Mill River, Rugg Brook and Stonebridge Brook watersheds in Georgia, Vermont. An additional seven segments (3.22 miles) were assessed within the Missisquoi Black to Hungerford and Missisquoi Mouth watersheds in Highgate, Vermont. The assessed streams are located in rural residential, agricultural, and light commercial areas, where some of the streams have been altered to accommodate human land use activities, and continue to be threatened by possible future development and land use changes. Ross Environmental Associates was the lead in collecting and analyzing the Phase 2 assessment data. The NRPC provided field and mapping assistance. The Vermont Agency of Natural Resources River Management Program provided training and completed quality assurance checks.

B. PHASE II GEOMORPHIC ASSESSMENT

1.0 Background Information

1.1 Geographic Setting

The six sub-watersheds are part of the Lake Champlain Basin of Vermont.

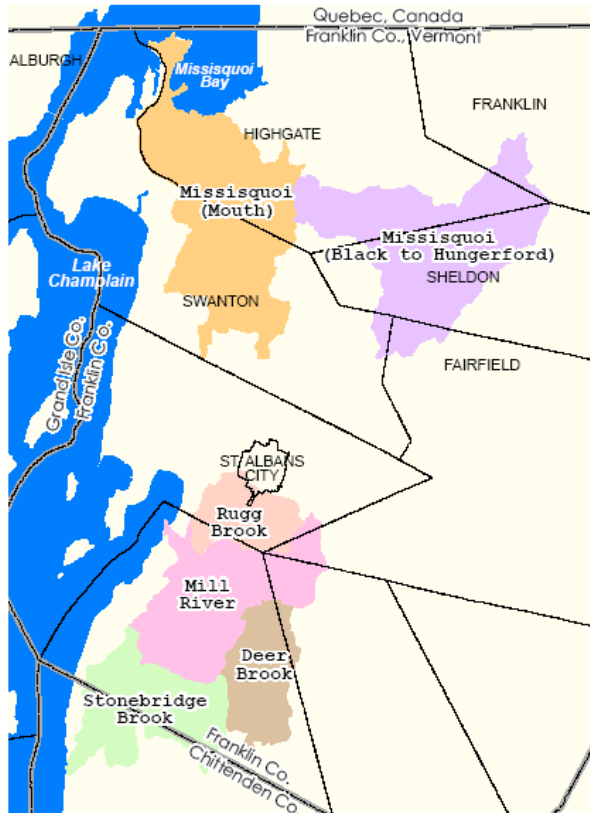


Figure 1: Watersheds included in Phase 2 Assessment

Deer Brook

The Deer Brook Watershed includes approximately 8.4 square miles in the towns of Georgia and Fairfax. This watershed flows into Arrowhead Mountain Lake, which is part of the Lamoille River, and ultimately flows into Lake Champlain. The elevation of the confluence with Arrowhead Mountain Lake is approximately 288 feet above sea level, and rises to approximately 793 feet above sea level at the uppermost Deer Brook tributaries.

Mill River

The Mill River Watershed includes approximately 16.67 square miles in the municipalities of Georgia, St. Albans Town, Fairfax, and Fairfield. The river flows directly into Lake Champlain, at an elevation of 96 feet above sea level from approximately 863 feet above sea level at its uppermost tributaries.

Rugg Brook

The Rugg Brook Watershed includes approximately 6.05 square miles in the municipalities of Georgia, Saint Albans City and Saint Albans Town. The brook flows into the Mill River at an elevation of 205 feet above sea level from approximately 657 feet above sea level at its uppermost tributaries.

Stonebridge Brook

The Stonebridge Brook watershed includes approximately 12.3 square miles and includes the towns of Georgia and Milton. The brook’s tributaries begin at approximately 551 feet above

sea level and flow into Stonebridge Brook, which drains directly into Lake Champlain at an elevation of approximately 95 feet above sea level.

Missisquoi River (Black Creek to Hungerford)

The Missisquoi River (Black Creek to Hungerford) watershed includes approximately 24.9 square miles and extends into the towns of Highgate, Sheldon, Fairfield, Franklin, and Swanton. The tributaries begin at approximately 615 feet above sea level and drop to approximately 109 feet above sea level.

Missisquoi River (Mouth)

The Missisquoi River (Mouth) watershed includes approximately 25.2 square miles and extends into the towns of Highgate and Swanton. The tributaries begin at approximately 358 feet above sea level and the Missisquoi flows directly into Lake Champlain, at approximately 96 feet above sea level.

1.2 Geologic Setting

Deer Brook

The Deer Brook watershed is located in the western foothills of Cushman Hill and other unnamed mountains in Georgia. The watershed area is dominated by the Dunham Dolomite formation (Doll, 1961). Surficial geology in the vicinity of the study area is dominated by pebbly marine sand, lake-bottom sediments, and till (Stewart and McClintock, 1970). Soils in the study area are mapped predominantly as Windsor loamy fine sand, Rumney variant silt loam, and Enosburg loamy fine sand.

Mill River

The Mill River watershed is located in a hilly area adjacent to the eastern shore of Lake Champlain. The area is dominated by the Sweetsburg formation, which is a combination of Skeels Corners Slate and the Mill River Conglomerate (limestone) (Doll, 1961). The surficial geology is mapped predominantly as marine clay with some till (Stewart and McClintock, 1970). Soils in the area are predominantly the Binghamville silt loam, the Scantic silt loam, and the Georgia stony loam.

Rugg Brook

The Rugg Brook watershed is located in the hilly area adjacent to the eastern shore of Lake Champlain. The area is dominated by the Sweetsburg formation, which is a combination of Skeels Corners Slate and the Mill River Conglomerate (limestone) (Doll, 1961). The surficial geology is mapped predominantly as marine clay, with some till (Stewart and McClintock, 1970). Soils in the area are predominantly the Massena stony loam, the Georgia stony loam, the Lordstown rock outcrop, and the Farmington Rock outcrop.

Stonebridge Brook

The Stonebridge Brook watershed is located in a hilly area adjacent to the eastern shore of Lake Champlain and is dominated by the Sweetsburg formation and the Rugg Brook formation, which is a sandy gray dolomite (Doll, 1961). The surficial deposits in the area are

mapped as marine clay, pebbly marine sand, and noted as having significant bedrock outcropping (Stewart and McClintock, 1970). Soils in the area are mapped predominantly as the Rumney variant silt loam and the Windsor loamy fine sand.

Missisquoi River Mouth and Black Creek to Hungerford

The Missisquoi River watershed is located in a relatively flat area adjacent to the eastern shore of Lake Champlain. Bedrock in the Missisquoi Mouth study area is dominated by the Morses Line formation, which is a slate (Doll, 1961). Surficial deposits are mapped predominantly as pebbly marine sand (Stewart and McClintock, 1970). Soils in the area are mapped as the Missisquoi loamy sand, the Windsor loamy fine sand, and the Limerick silt loam.

1.3 Geomorphic Setting

Deer Brook

The study area included the mainstem of Deer Brook (M01 to M06) with the exception of M04, which was not identified as a study reach due to known wetland impoundment. A tributary M5S3.01 was also part of the study area (See Study Reach Map, Appendix A). The channel slope for the assessed reaches ranged from 0.13 to 1.93. Very few natural grade controls were identified throughout the mainstem, with the exception of a few minor bedrock grade controls in the lower portion of the mainstem. Phase 1 data indicates that all of the study reaches have a reference stream type of either C or E, and the valley types range from broad to very broad, with the exception of M5S3.01, which is identified as being a narrowly confined valley.

Mill River

The study area included the mainstem of Mill River that fell within the Town of Georgia boundaries (Reaches M01 to M08), as well as many small tributaries (See Study Reach Map, Appendix A). The channel slope of the reaches ranges from 0.09 to 5.48. Several natural grade controls were observed throughout the study area, most notably in M04B, which was dominated by bedrock waterfall features. Phase 1 data indicates that the reference stream types are mostly C or E, and a few are B, and the natural valley types range from very broad to semi-confined.

Rugg Brook

The study area included the first three reaches (M01-M03) of the Rugg Brook mainstem (See Study Reach Map, Appendix A). Reaches M05 through M09 were assessed by the Lake Champlain Committee in 2005. Results from that assessment are included in this report and displayed on Phase 2 stressor maps (See Appendix B). Reaches M04, M10 and M11 were not assessed. The channel slopes of the assessed reaches range from 0.38 to 6.36. The Phase 1 data indicates that the reference stream types are either B or C with natural valley types of narrow, broad and very broad.

Stonebridge Brook

The study area included M02 to M06 on the mainstem, as well as a few small tributaries (See Study Reach Map, Appendix A). The channel slope of the reaches ranges from 0.32 to 3.13. Few natural grade controls were encountered in the assessed reaches, with M05 having the

most notable natural bedrock grade controls. Phase 1 data indicates that the reference stream types are either C or E, and the natural valley types range from very broad to broad.

Missisquoi River (Black Creek to Hungerford)

The study area included two tributaries of the mainstem, R4S1.1S1.01 and R4S3.01 (See Study Reach Map, Appendix A). The channel slope of the reaches ranges from 2.49 to 2.57. Few natural grade controls were encountered along the assessed reaches. Phase 1 data indicates that the reference stream types are C and E, and the natural valley type ranges between very broad and narrowly confined.

Missisquoi River (Mouth)

The study area included the four tributary reaches R3S4.01, R3S4.02, R3S4.03, and R3S4.04 (See Study Reach Map, Appendix A). The channel slope of the reaches ranges from 0.30 to 2.27. No natural grade controls were encountered within the assessed reaches. Phase 1 data indicates that the reference stream types are either C or E, and the natural valley type for each assessed reach is very broad.

1.4 Hydrology

The nearest United States Geological Survey (USGS) stream gages for Deer Brook, Mill River, and Stonebridge Brook are located in the Lamoille River at East Georgia, and in Stonebridge Brook near Georgia Plains. These gages indicate that there has been only one greater than 25 year discharge within the last twenty years, which occurred in 1996; however, there have been several greater than 10 year discharge events.

For the Highgate area, the nearest USGS gage is located in the Missisquoi River in Swanton. According to the stream gage, in the last 20 years, there has been one greater than 10-year discharge event, occurring in 1996; and no events greater than 25 years within the last 20 years.

1.5 Ecological Setting

Most of the study area in all six watersheds includes rural pasture and agricultural land, with some beaver ponds, and some rural residential and urban crossings. The majority of the study area consists of riffle-pool streams in agricultural or rural residential settings. In general, riparian buffers were moderately well intact except for in major agricultural and residential areas, where either stream crossings or removal of the riparian buffer was noted. This was most notable at the upstream end of the Deer Brook mainstem and throughout the majority of the Mill River and in the three assessed reaches of the Rugg Brook watershed. The Stonebridge Brook mainstem was relatively well protected by generally continuous wetlands and forest. Within the small study area of the Missisquoi watersheds, the riparian corridor was either very young woody and herbaceous plants, or was mostly replaced with development.

The majority of the streams had riffle-pool bedform features; however, there were several reaches in each watershed where ripple-dune bedforms were observed in areas of active agriculture. In these locations, where the stream had been straightened or ditched, or was being accessed by farm animals, the stream bed was observed to be very silty, which is not conducive

to a diverse aquatic environment. In addition, several waterfalls were observed on the Mill River mainstem, mostly in M01 and M04, which could act as barriers for fish migration.

2.0 METHODOLOGY

2.1 Fluvial Geomorphic and Habitat Assessment Protocols

The Phase 2 Stream Geomorphic Assessments were conducted exclusively in accordance with the 2006 Vermont Agency of Natural Resources Stream Geomorphic Rapid Stream Assessment Field Protocols steps 1 through 7 (VT ANR 2006). All field data was recorded on the VT ANR Phase 2 field forms and subsequently entered into the web-based VT ANR Stream Geomorphic Assessment Data Management System (DMS). All bridges and culverts were assessed using the latest Bridge and Culvert Assessment Protocol, recorded on Bridge and Culvert data sheets, and entered into the Bridge and Culvert database in the DMS.

Specifically, each reach was walked and segmented as needed. A detailed planform view of the reach was sketched as it was walked. Important reach features such as erosion, bank revetments, grade controls, migration points, debris jams, photo points, etc, were noted on the sketches. Bankfull elevations were measured along the length of each segment and a representative location within the segment was chosen to perform a cross section and pebble count.

2.2 Quality Assurance and Quality Control

A quality assurance review of the collected data was conducted by Ross Environmental Associates during November 2006 through February 2007. The VT ANR also performed a quality assurance review of the data during the Winter and Spring of 2007, and the database was updated accordingly. All data can be viewed in the DMS, and copies of all field forms and sketches are filed with Vermont ANR River Management Program. Copies of QA reports are included in Appendix I, and selected Phase 2 DMS reports are included in Appendix G.

3.0 RESULTS

In general, the Phase 2 Stream Geomorphic Assessments on the Deer Brook, Mill River, Rugg Brook, Stonebridge Brook, Missisquoi Black to Hungerford, and Missisquoi Mouth watersheds demonstrated that most of the assessed reaches are in regime with the Phase 1 reference stream types, though most reaches are experiencing some sort of adjustment process, whether it be degradation, widening, or aggradation. Geomorphic conditions were found to be mostly fair to good, though some poor conditions were noted, mostly in the Mill River watershed. Generally where conditions were poor, stream type departures were observed as a result of major stressors acting on the stream system. These stressors included lack of riparian buffer and/or extensive straightening in agricultural or development areas, increases in surface runoff in urban areas, and increases in sediment supply from unstable banks and valley walls. Habitat conditions were found to be poor to reference, and poor conditions were usually observed in streams with poor to fair geomorphic conditions.

Several maps were developed to illustrate different types of stressors acting on each stream/watershed, and were used to evaluate the watershed and reach scale stressors described below. These maps are Hydrologic Alterations, Land Use/Land Cover, Sediment Load Indicators, Channel Slope Modifiers, Channel Depth Modifiers, Boundary Conditions and Riparian Modifiers, Sediment Regime Departure, and Stream Sensitivity for each watershed. These maps are included in Appendix B.

Tables summarizing river stressors and sediment regime departure analyses for each assessed reach were also used to evaluate each watershed and are included in Appendix C. Photographs of each assessed reach are included in Appendix D, and individual reach summaries are included in Appendix E.

3.1 Watershed Scale Stressors (Departure Analysis)

3.1.1 Hydrologic Regime Stressors

The hydrologic regime of a stream is a result of the watershed inputs to the stream and connectivity with its riparian zone and floodplain. Hydrologic regime is naturally influenced by climate, soil type, geology, land cover, and riparian characteristics, but can be manipulated by human caused changes in the watershed, including loss of riparian areas due to urbanization, and the addition of stormwater inputs, dams, and road networks. Natural watershed inputs define the timing, volume, and duration of flow events, while human caused changes to the watershed can severely alter the hydrologic regime and cause channel adjustments to occur in the stream. The maps “Hydrologic Alterations” and “Land Use/Land Cover” in Appendix B, were used to assess the level at which stressors in the watershed are affecting the stream. Table 1 in Appendix C shows the level of increase/decrease or no change for hydrologic alterations.

Deer Brook

Currently, the land use in the Deer Brook Watershed is dominated by agriculture and light residential development, with a small commercial/industrial area in the southern portion of the watershed. It is likely that 19th century deforestation to accommodate agricultural activities originally contributed to the alteration of the hydrologic regime in the Deer Brook watershed. Currently, the upper portion of the stream (M05, M06, and M5S3.01) remains in agricultural use with very little riparian forest; while the lower portion of the stream (M01 and M02) was either never deforested, or it has restored much of its riparian forest, which provides a necessary buffer between the stream and a growing commercial/industrial area of Georgia.

Urbanization is most prevalent in the southern portion of Deer Brook, in the areas of M01, M02 and M03, and Phase 1 data indicates that a majority of the Deer Brook watershed is impacted by greater than 20% urban land use, which is likely a predominant stressor on the watershed (see Hydrologic Alterations Map for Deer Brook). While reaches M01 and M02 are located within the commercial district, the buffer is greater than 100 feet and the stream is somewhat protected from the encroachments by very steep valley walls. Most of M02 and some of M01 is adjacent to the Georgia Industrial Park (though it is outside the corridor). Overall, it appears that urbanization is indeed a dominant stressor to the Deer Brook Watershed. Stormwater impacts (increased flows and an increase of sediment input) resulting from this urbanization are most prevalent in the downstream reaches (See Figure 2).



Figure 2: Deer Brook M02- Stormwater Input

Dams or diversions, which alter the rate of water flow through the stream, were not encountered on Deer Brook.

Significant potential wetland loss, as demonstrated on the Land Use/Land Cover map, has occurred within the Deer Brook Watershed, predominantly in the agricultural and commercial areas; however, there are still large portions of impounded wetland along the mainstem (M03C, M04, M05A), which intercept flows from the agricultural area and likely act to store some of the increased flows resulting from loss of riparian habitat upstream. The downstream quarter of the mainstem is bound by commercial properties and major roadways, which has likely resulted in the filling of some wetlands, notably in M03, where Interstate-89 crosses the stream.

A relatively low density of road networks, drainage ditches, and skid trails exist in the watershed. The most significant road crossing is Interstate-89 in M03, where there are likely localized impacts from increased runoff from the road.

Overall, the initial deforestation of portions of the Deer Brook watershed, in addition to the current lack of riparian buffer in agricultural areas and the growing urbanization, is affecting the hydrologic regime by increasing watershed inputs. The presence of major wetland impoundments downstream of the agricultural area and at the confluence with Arrowhead Mountain Lake; however, is likely acting to somewhat offset this increase in watershed inputs.

Mill River

Overall, the land use in the Mill River Watershed is dominated by agricultural and light to heavy residential development. Original clearing of the riparian buffers and surrounding areas likely occurred at one time to accommodate agricultural activities; however, as agricultural tracts of land are divided into residential land plots, development is currently the dominant land use stressor on the watershed. Much of the mainstem, including reaches M02A, M02B, a portion of M03, M05, M06B, M07A and M07B are surrounded by active or fallow agricultural fields. Some of the tributaries also run through agricultural land, most notably on the western side of the watershed; however, the majority of the tributaries run through residential development. Overall, while there are some areas of relatively undisturbed riparian forest and wetlands, these areas are disconnected at best.

According to Phase 1 data, urbanization remains mostly between 5 and 10% of the watershed, which is considered a significant stressor on the hydrology. In a few select areas,

namely near Carpenter Hill Road and Oakland station road, urban land use exceeds 20% and is likely a dominant stressor in these areas.

Several stormwater inputs, as seen on the Mill River Hydrologic Alterations Map, were noted along the assessed reaches in Mill River. These inputs were observed mostly in small tributaries at road crossings, or in agricultural fields utilizing drainage ditches (M2T2.01). The stormwater inputs have had a significant impact on many of these small streams, such as M2T2.2S1.3S3.01, M2T2.2S1.2S2.01, M2T2.2S1.2S2.02, and M2T2.01, which have all experienced significant incision and in a few, stream type departures, to increase the cross section of the stream channel to accommodate the increased flows.

Dams, diversions, or impoundments were not encountered on the assessed reaches within the Mill River Watershed.

As illustrated on the Hydrologic Alterations map, significant wetland loss has occurred in the assessed area, as a result of land use changes. This watershed is experiencing increased flows resulting from this wetland loss in combination with the stormwater inputs, urbanization, and loss of riparian buffers.

Rugg Brook

The land use in the Mill River Watershed is dominated by agricultural and residential/commercial development. The residential/commercial development is concentrated around reaches M06 through M09. The downstream four reaches (M01-M04) are surrounded by agricultural fields. According to Phase 1 data, urbanization is greater than 20% in the subwatersheds of the assessed reaches; this is considered a significant stressor on the hydrology.

Several stormwater inputs were noted along the assessed reaches in Mill River. Many stormwater inputs that are noted in the online data management system (DMS) but are not included on the Hydrologic Alterations map (See Appendix B). Reach M07A has three stormwater inputs, M08A has six, M08B has eight and M09 has three inputs. These stormwater inputs may contribute to the significant erosion in reaches M07 through M09.

A diversion structure outlet is located in M07A. This structure diverts water from Stevens Brook to Rugg Brook during high flows. While this structure has contributed to increased flows, the municipalities of Saint Albans City and Town are working to mitigate these impacts.

Potential wetland loss was not assessed for the Rugg Brook watershed.

Stonebridge Brook

There are very few anthropogenic hydrologic alterations to the assessed reaches of Stonebridge Brook, as seen on the Hydrologic Alterations Map (Appendix B). Most of the mainstem is protected from development by natural wetlands and areas of heavy beaver activity. The map illustrates that very little wetland loss has occurred in the assessed area. Stormwater inputs were not observed within the assessed reaches, and urban land use remains mostly below 5%, but rises to 5-10% in a few localized areas, likely in small residential developments. Overall, no significant change in flows was observed on Stonebridge Brook.

Missisquoi River

No stormwater inputs or flow regulation structures were observed on the two assessed reaches (R4S1.1S1.01 and R4S3.01) of the Missisquoi Black to Hungerford watershed. The land use adjacent to R4S1.1S1.01A was mostly forested, though several ATV trails were observed

within the corridor and on the stream bed (See Figure 3). R4S3.01B had much of the riparian buffer removed and replaced with development, which has likely resulted in a moderate increase in runoff to the stream (See Figure 4). While some wetland loss has occurred within the watershed, very little has occurred in the vicinity of the two assessed reaches. Urban land use; however, remains fairly high, between 5 and 20% of the watershed, which is likely contributing increased flows to the streams. Overall, it appears that there is a small increase in hydrologic inputs based on the two assessed reaches and the surrounding land use.



Figure 3: Missisquoi River- R4S1.1S1.01- ATV trails on stream bed



Figure 4: Missisquoi River- R4S3.01B- Riparian Buffer

Three stormwater inputs were observed in R3S4.03 of the Missisquoi Mouth watershed. One of these inputs was from road runoff directly entering the stream through a swale, and the other two were from the adjacent rock quarry (located west of the stream). One input appeared to be a drainage tile and was not running during the assessment. The downstream-most input appeared to be an overflow from a settling pond in the quarry, and was periodically discharging major volumes of water and suspended silt into the stream (See Figure 5). An active beaver dam was observed within a few hundred feet downstream of this input, and is likely helping to attenuate some of the increased flows and sediment. Within the two downstream reaches, R3S4.01 and R3S4.02, a significant portion of the riparian buffer has been removed, and the

adjacent farm fields were being used as cropland. This agricultural area has also experienced significant wetland loss, and urban land use comprises approximately 5 to 20% of the watershed. This is a significant stressor on the streams and is contributing to increased flows within the streams. Overall, the urban land use, stormwater inputs, and loss of riparian buffer are contributing to increased flows within the stream, and ultimately to the Missisquoi River mainstem.



Figure 5: Missisquoi River- R3S4.03- Stormwater Input with Suspended Sediment

3.1.2 Sediment Regime Stressors

The sediment regime of a stream is governed by the quantity, size, transport, sorting, and distribution of its sediments. Changes in the amount and/or type of sediment, or to the capacity of a stream to carry that sediment can result in channel adjustments such as channel aggradation or degradation. The maps “Sediment Load Indicators” and “Land Use/Land Cover” in Appendix B, were used to assess the level at which stressors in the watershed are affecting the stream. Table 1 in Appendix C shows the level of increase/decrease or no change for sediment load.

Deer Brook

Overall each assessed reach had less than 30 percent erosion; however, concentrated areas of erosion were observed mostly in the downstream sinuous reaches (M01 and M02) of Deer Brook, where the area is already impacted by increased flows and sediment from stormwater inputs and the adjacent commercial/industrial area. This area also has a high concentration of mass failures supplying significant sediment to the reach (Photo 5). Very little erosion was noted throughout the middle of the mainstem, and somewhat significant erosion was again noted in M5S3.01, where the stream appears to be attempting to recover from historic straightening.



Figure 6: Deer Brook M02- Mass Failure

According to Phase 1 data, most of the subwatersheds of the Deer Brook Watershed are comprised of over 20% cropland, which is also a significant source of fine sediment, such as sand and silt, to each reach. Most of the agricultural land bordering the assessed reaches; however, was observed to be hay or pasture.

The presence of multiple steep riffles, mid-channel bars, and delta bars was noted most significantly in M02, and to a lesser extent in M03. In addition, these reaches include multiple migrations (flood chutes, avulsions, etc.). Multiple bars were also observed in M05B, and to a lesser extent in M05C and M5S3.01. The presence of multiple bars in combination with multiple migrations are further evidence that these downstream reaches are affected by an increased sediment load, and the transport capacity of the channel may be exceeded in these locations.

In general, the sediment supply has increased throughout the watershed, and is most prevalent in the two ends of the mainstem: M5S3.01, where erosion and mass wasting are occurring in response to historic straightening; M02, where the reach is adjusting to several sources of sediment input from the adjacent urban land use and includes several mass failure locations; and M01, where a large accumulation of very fine sediment was observed on the bed (See Figures 7 and 8).



Figure 7: Deer Brook M02- Silt Accumulation



Figure 8: Deer Brook M02- Silt Accumulation

Mill River

On the Mill River mainstem, some of the stream segments were observed to have significant erosion or mass failure including: M01C, M01D, M03, M04A, and M08. In addition, several of the small tributaries were observed to have significant erosion including M2T2.01, M2T2.02A, M2T2.02B, M2T2.2S1.2S2.01A and B, M2T2.2S1.2S2.02A and B, M2T2.2S1.03, and M2T2.06C (See Figure 9). The erosion observed in these segments is considered to be a response to several different stressors (including straightening, increased flows, agricultural inputs, etc). In addition, three gullies, which add a significant amount of sediment to the stream, were observed throughout the assessed area: M2T206C, M2T2.2S1.2S2.02A, and M2T2.02B (See Figure 10). Rejuvenating tributaries were also observed in segments M01E, M2T2.06C, M7S2.01A, and M2T2.2S1.2S2.01B. These rejuvenating tributaries add sediment to the segment as the elevated tributary stream bed degrades to meet the elevation of the receiving segment.



Figure 9: Mill River M2T2.2S1.2S2.01B- Severe Erosion



Figure 10: Mill River M2T2.2S1.2S2.02A- Gully

According to Phase 1 data, most of the Mill River subwatersheds are comprised of over 20% cropland, which indicates that this is a predominant stressor on the whole watershed, as fine-grained sediment from exposed soils can mobilize into the stream and contribute to a larger sediment load.

As a result of these sediment inputs, which have generally increased substantially from equilibrium conditions, most of the assessed reaches were observed to have a moderate to high number of depositional features (steep riffles, mid-channel bars, delta bars, flood chutes, avulsions, and braiding) per mile, which suggests that these segments are experiencing adjustment, and may be an indication that the transport capacity could be exceeded in a given segment.

Rugg Brook

On the Rugg Brook mainstem, five of the thirteen stream segments had significant erosion (erosion on greater than 20% of bank length) or mass failures including: M01, M02, M05B, M07B and M08A). Five stream segments had more moderate erosion of 5 to 20% bank erosion and only three segments had less than 5% erosion on both banks (See Figure 11). Mass failures were observed in M02 and M03 (See Figure 12). The erosion observed in these segments is considered to be a response to several different stressors including straightening, increased flows and stormwater inputs. Rejuvenating tributaries were also observed in segments M03, M05A, M06A, M06B, M07B and M08B. These rejuvenating tributaries add sediment to the stream as the elevated tributary stream bed degrades to meet the elevation of the receiving segment.



Figure 11: Rugg Brook M02- Severe Erosion



Figure 12: Rugg Brook M02- Mass Failure with Undercut Bank

The assessed reach had a moderate to high number of depositional features (steep riffles, mid-channel bars, delta bars, flood chutes, avulsions, and braiding) per mile, which suggests that these segments are experiencing adjustment. This could be an indication that the transport capacity is exceeded in a given segment.

Stonebridge Brook

Most of the assessed reaches in the Stonebridge Brook watershed did not have significant erosion and mass wasting, as illustrated in the Stonebridge Brook Sediment Load Indicators Map (Appendix B). The exceptions to this are segments M02A and M5S1.01A, and to a lesser extent M06B and M2S2.01B and C (See Figure 13). These segments are eroding in response to development encroachments and/or historic straightening. In addition, animal access was

observed in M06B and M5S1.01B, which has caused localized erosion and compaction (See Figure 14).



Figure 13: Stonebridge Brook M5S1.01- Erosion



Figure 14: Stonebridge Brook M5S1.01- Animal Access to Stream

According to Phase 1 data, crop land use generally remains below 5% for most of the watershed, though there are a few locations where it rises to 5-10%, and one hotspot, near M5S1.01, where crop land use comprises over 20% of the subwatershed. This localized area is likely experiencing increased sediment load from exposed cropland.

In general sediment supply has increased in a small portion of the watershed (based on assessed reaches), and as a result, these segments, as well as some downstream segments, were observed to have a moderate to high number of depositional features per mile.

Missisquoi River

Significant erosion and/or mass failure were observed in the two assessed reaches (R4S1.1S1.01 and R4S3.01) of the Missisquoi Black to Hungerford watershed, and as such, each reach was observed to contain greater than five depositional features per mile. Several ATV trails were observed in the corridor and on the stream bed of R4S1.1S1.01A, which has caused

significant erosion and compaction of the stream banks and bed. Moderate erosion and multiple mass failures observed in R4S3.01 is likely a result of development encroachments, which have increased the erosive power of the stream. In addition, the watershed is comprised of mostly between 10 and 20% cropland, which is likely adding a significant supply of sediment to the streams. These two reaches empty directly into the Missisquoi mainstem, and are likely inputting a significant amount of sediment based on the current ongoing processes and surrounding land use.

Little to moderate erosion and mass failure were observed in the four assessed reaches (R3S4.01, R3S4.02, R3S4.03, and R3S4.04A) of the Missisquoi Mouth watershed. The most significant erosion was observed in R3S4.02, where the stream appears to be eroding in response to historic straightening, and R3S4.03, where the stream may be responding to stormwater inputs. In addition, crop land use for the area is mostly between 10 and 20%, and in some locations greater than 20%, which is likely a significant stressor on the streams and contributing large amounts of fine sediment to the streams. Consequently, greater than five depositional features per mile was observed for each assessed reach except for R3S4.01, which did not have distinct features, but had a deep layer of silt and sand on the stream bed.

3.1.3 Reach-Scale Sediment Regime Stressors

Reach-scale sediment regime stressors affect the hydraulic geometry and change both the boundary resistance and the way sediment is transported, sorted, and distributed. Parameters that affect the overall sediment regime include changes in the energy grade (governed by slope and depth changes), and changes in boundary conditions (including resistance changes on the channel bed, and resistance changes on the banks and buffers). The maps “Channel Slope Modifiers,” “Channel Depth Modifiers,” and “Boundary Conditions and Riparian Modifiers” in Appendix B, were used to assess the level at which stressors in the watershed are affecting the stream. Table 1 in Appendix C shows the level of increase/decrease or no change for stream power and boundary resistance.

Deer Brook

The channel slope within the Deer Brook Watershed has mainly been affected by historic channel straightening, mostly through agricultural areas. The upstream portion of the Deer Brook mainstem includes many reaches that are over 20% straightened, which has resulted in increased stream power in segments M06A, M5S3.01, M05B, M05C. No current bank armoring techniques were observed in any of these segments. Hard bank armoring was noted extensively in segment M03A, where Interstate 89 and other roads cross or run adjacent to the channel. Stream power is certainly increased in this segment. No significant sediment deposition above bridges and culverts was observed throughout assessed reaches.

The channel depth has been increased moderately to significantly in segments that have incision ratios greater than 1.4, where degradation has deepened the channel. This includes segments M02A, M02C, M05B, M05C, M06, and M5S3.01. The degradation in these segments is likely a result of in-reach or upstream straightening, and flow increases below stormwater inputs in the lower portion of the mainstem have also likely locally increased channel depth. Localized decreases in channel depth (and stream energy) were identified in areas of backwater/delta deposits in segments M02A, M02B, M02C, M03A, M03B, M05A, M05B, M05C, and M5S3.01; however, overall, it appears the parameters causing an increase in stream

power in the upper reaches trump these localized decreases in channel depth, except in M02A, where aggradation from erosion and stormwater deposits is filling in the channel.

Resistance on the channel bed has not been significantly altered throughout the mainstem. A few natural bedrock grade controls were noted in M03A and B, which would locally increase bed resistance. Resistance on the stream bank and riparian buffer has been decreased in areas of little to no bank and riparian vegetation, which was most prevalent in segments M05B, M05C, M5S3.01, and M06A, where agricultural activities are occurring. The most significant increase in boundary resistance was observed in M03A, where a large portion of the segment is comprised of culverts beneath major roadways, which are flanked by substantial hard bank armoring. This increase in bed and bank resistance is likely contributing to the erosion and sediment deposition observed throughout M02.

Mill River

In general, stream power has increased throughout most of the Mill River watershed. Development and agricultural land use activities have resulted in an increased channel slope of most of the assessed reaches within Mill River watershed. The increased slope is an adjustment that is primarily in response to historic straightening, and/or road and development encroachments in-reach or upstream. The affects of channel straightening were most prevalent in the smaller tributaries in the southern portion of the watershed, mostly in agricultural areas, where several headcuts and some rejuvenating tributaries were observed (See Figure 15). Significant deposition above bridges and culverts was observed. Natural bedrock grade controls were observed throughout M01 as well as M04B, which are likely acting to hamper the effects of bed incision and bank instability resulting from the increased channel slope (See Figure 16). Human constructed grade controls, in the form of weirs, were observed in M04B and M05, in the vicinity of stream crossing structures. These weirs locally reduce channel slope; however, overall the watershed-wide stressors trump these two areas.



Figure 15: M07B- Straightening



Figure 16: Mill River M01B- Natural Grade Control

Channel depth in Mill River watershed has also been affected by channel straightening, stormwater inputs, and encroachments, which have increased channel depth (as indicated by the incision ratio) as the streambed lowers in response to these stressors. Berming in M01D is one example where the channel depth has increased, causing increased stream power to act on the downstream segments, where several mass failures have occurred as the increased energy makes contact with high banks. Depth decreases were generally only seen in areas of moderate to heavy beaver activity, or downstream of reaches with increased stream power, where transported sediment is depositing heavily.

Bank resistance in the form of armoring was very minor within the assessed reaches of Mill River. Some hard bank armoring was observed in areas abutting major bridges and culverts; however, it was not widespread throughout the watershed. Removal of the riparian buffer; however, was a dominant stressor within the watershed. Much of the original woody riparian buffer has been removed in the upper reaches of the mainstem (M05, M06, M07, M08). Several of the tributaries suffer from this stressor as well (as seen on the Boundary Conditions and Riparian Modifiers Map), as a result of agricultural activities and residential development. This removal of riparian buffer, in addition to channel straightening has caused significant erosion in reaches such as M2T2.01, M2T2.02, M2T2.2S1.2S2.01, M2T2.2S1.2S2.02, M2T2.2S1.03, and M2T2.2S1.3S3.01.

Rugg Brook

Stream power has increased throughout most of the Rugg Brook watershed. Development and agricultural land use activities have resulted in an increased channel slope of most of the assessed reaches within Rugg Brook watershed. The increased slope is an adjustment that is primarily in response to historic straightening, and/or road and development encroachments in-reach or upstream. The affects of channel straightening were most prevalent upstream portion of the watershed. Channel depth in Rugg Brook watershed has also been affected by channel straightening, stormwater inputs, and encroachments, which have increased channel depth (as indicated by the incision ratio) as the streambed lowers in response to these stressors.

Bank resistance in the form of armoring was moderate within the assessed reaches of Rugg Brook. Some hard bank armoring was observed in reaches M06-M09. M08B had the

most hard armoring which was present upstream and downstream from Fairfax road. The lack of riparian buffer was a dominant stressor within the watershed. Most reaches had 0-25 ft of woody buffer though M03, M08A and M08B appeared to have adequate buffer.

Stonebridge Brook

Stream power has been increased slightly throughout most of the assessed reaches of Stonebridge Brook watershed. The most significant stream power increase was observed in the upper portion of the mainstem (M06), as well as a few of the upper tributaries, including M2S2.01 and M5S1.01, which is where the most significant stress from straightening, encroachments, and land use was observed within the study area.

Channel slope has been increased in areas of straightening and encroachments (M06B, M2S2.01B and C, and M5S1.01B). No significant deposition above constrictions, such as bridges and culverts, was noted throughout the assessed reaches. Moderate to significant beaver activity was observed in segments such as M02A, M02B, M03A, M03B, M04, and M05, where channel slope is locally decreased due to the aggradation of associated sediment deposits.

Channel depth has been increased in segments where degradation has occurred in response to several stressors. Channel depth has increased slightly in segments M02A, M04, and M05, and significantly in segments M06A, M06B, M2S2.01C, and M5S1.01B. While the incision ratio indicates some degradation, the most significant backwater deposits were observed in M02A, which is likely due to accumulated sediments from historic beaver activity. Here, the accumulation of these sediments is ultimately decreasing stream power.

In general, a fairly intact riparian buffer remains through most of the assessed area on Stonebridge Brook, which helps to prevent widespread erosion throughout the watershed. An exception to this was noted on M5S1.01B, where the stream runs through an agricultural area and active cow pasture. Significant erosion was observed in the downstream segment, M5S1.01A. Very little hard bank armoring was observed throughout the assessed areas, though minor armoring was noted in the vicinity of culverts.

Missisquoi River

Stream power on the two assessed reaches of the Missisquoi River Black to Hungerford watershed has increased. Channel slope for both reaches has increased primarily due to encroachments, such as development, roads, improved paths, etc. Channel depth has increased significantly in R4S1.1S1.01, as the stream has responded to the encroachments by degrading its stream bed. Despite the encroachments, channel depth has increased only slightly in R4S3.01 as a result of stream bed degradation. Little bank and bed armoring was observed within the two reaches. The only significant armoring/grade control is the lower portion of R4S3.01A, where a several hundred foot culvert conveys the stream beneath a power plant to the Missisquoi River, where it outlets into a bedrock gorge. Little riparian buffer remains in segment B of R4S3.01 due to residential development, and while R4S1.1S1.01A is mostly wooded, a network of ATV trails were observed along the banks and stream bed of the segment, and have caused significant erosion and compaction along this reach.

Stream power on the four assessed reaches of the Missisquoi River Mouth watershed has generally increased, with the exception of R3S4.03. R3S4.04 has increased in stream power due to an increase in channel depth, which may have occurred as a result of abandoned beaver dams blowing out. In R3S4.03, despite several stormwater inputs, the reach has not significantly degraded; however, several backwater deposits have accumulated, possibly in connection with

the sediment coming from the quarry pond stormwater outlet, which is adding a significant amount of fine sediment to the reach. As aforementioned, the active beaver dam may be acting to hamper some of the effects of this stormwater input. The lower two reaches, R3S4.02 and R3S4.01 have been significantly straightened, which has caused stream power to increase through this area (See Figure 17). R3S4.01 discharges directly into the Missisquoi River, which was unassessed. The lower two reaches did not have a continuous buffer, and were surrounded by cropland on at least one side, while the buffer around R3S4.03 and R3S4.04 was relatively well maintained. No bank armoring was identified during these assessments.



Figure 17: Missisquoi River R3S4.01- Straightening

3.2 Constraints to Sediment Transport and Attenuation

3.2.1 Sediment Regimes

To understand where a stream channel lies in the channel evolution process, and ultimately understand how quickly the channel may reach equilibrium conditions, an analysis of the departure from reference conditions and sensitivity of channel segments at the watershed scale is essential. This is complicated by the fact that several stressors in space and time are acting on the stream. Ultimately, changes in a stream's ability to transport and store sediment is the main factor affecting equilibrium; therefore, a simpler way to understand change in the stream is to observe departures in the sediment regime of a stream. The Vermont River Management Program has defined five different sediment regime types: transport reaches, confined source and transport reaches, unconfined source and transport reaches, fine source and transport reaches with coarse deposition, and coarse equilibrium with fine deposition. A comparison between predicted reference sediment regime types (determined by natural valley type, slope, and reference stream type) and the existing sediment regime type (determined by degree of incision, presence of bank armoring or straightening, stage of channel evolution and geomorphic condition, as well as existing stream types and natural valley types) helps us to understand the degree to which sediment transport properties have been altered throughout the system. The map "Sediment Regime Departures" in Appendix B, was used to assess the level at which stressors in the watershed were affecting the stream. Table 2 in Appendix C summarizes the constraints and

transport versus attenuation departures, and identifies potential attenuation assets to the watershed.

Deer Brook

Most of the assessed Deer Brook mainstem was likely once dominated by coarse equilibrium and fine deposition, in which the stream was able to balance coarse sediment transport and deposition, and had access to its floodplain to deposit fine sediment during flood events. The exception is M06, which based on its natural valley type and reference stream type, was likely a transport stream, in which the naturally higher gradient and natural entrenchment results in little storage of fine sediment.

Channel straightening in the upper segments of the mainstem have resulted in a shift from equilibrium conditions to unconfined source and transport conditions (M05B, M05C, and M06A), and fine source and transport and coarse deposition (M5S3.01). These segments are currently either in the incising or widening stages in response to the straightening and removal of woody riparian buffer. The segments that are beginning to widen are starting to supply coarse and fine sediment downstream. The middle portion of the mainstem (M03C, M04, and M05A) was not assessed due to wetland impoundment caused by extensive beaver activity. It is likely that this sediment attenuation area might be helping to offset the upstream departures, as the downstream segments M03A and M03B are unchanged from coarse equilibrium conditions. The extensive lateral and vertical constraints (large culverts beneath I-89) do not appear to be causing problems within M03A; however, downstream in M02C, equilibrium transport conditions have been replaced by confined source and transport conditions. This subreach is naturally more confined; however, it has also experienced major incision and some mass wasting, likely triggered by increased stream power caused by the upstream culverts. The lower portion of the Deer Brook mainstem has been unchanged from equilibrium conditions (M02B and M01B), with the exception of M02A, which has changed to a fine source and transport and coarse deposition channel. This change was likely influenced by major widening and mass wasting, as well as a cumulative effect of increased sediment input from the adjacent urban stormwater inputs, which extend between M02A and M03A. These sediment inputs are a result of stormwater being conveyed through ephemeral stream valleys with erodible soils, which have produced excess sediment to the stream as they adjust to the increased flows. This has caused sediment capacity in the mainstem to become too great to transport effectively in this area.

Overall, it appears that equilibrium conditions on the mainstem have been replaced by different types of transport conditions, which have been caused by a loss of floodplain due to incision caused by various stressors including straightening and loss of buffer in the upper portion of the watershed, and by extensive culverts and urban overland and stormwater runoff in the lower portion of the mainstem. The transport conditions in the upper portion of the watershed are likely somewhat attenuated by extensive wetlands in the middle of the mainstem; however transport conditions generated in the lower portion of the mainstem are resulting in massive aggradation in M02A. M01A was not assessed, as it was impounded by wetlands, but is likely a natural delta, and is helping to store some of the excess sediment.

Mill River

Depending on the valley type and slope, most of the assessed reaches within the Mill River watershed were once dominated by coarse equilibrium and fine deposition conditions, or by natural transport conditions.

Currently, most of the assessed reaches have been converted to some sort of transport reach, with the exception of M02A, M07A and B, M08, and M2T2.2S2.01A, which have remained in equilibrium (see Mill River Sediment Regime Departure Map). Overall, these changes have resulted in a loss of sediment storage for most of the Mill River watershed, as channels have deepened in response to several stressors, which has either partially or wholly cut the stream off from its floodplain. The channel deepening and widening has produced a significant amount of sediment that cannot deposit until equilibrium conditions are established.

Rugg Brook

It is likely that most of the assessed Rugg Brook reaches were once dominated by coarse equilibrium and fine deposition conditions. Exceptions to this are tributaries M09, T1.01 and T1.03, which based on their natural valley types and reference stream types, were likely transport streams, in which the naturally higher gradient and natural entrenchment results in little storage of fine sediment.

Many of the assessed reaches have been converted to some sort of transport reach (See Rugg Brook Sediment Regime Departure Map). Overall these changes have resulted in a loss of sediment storage for a portion of the watershed, as channels have deepened in response to several stressors, which has either partially or wholly cut the stream off from its floodplain.

Stonebridge Brook

All of the Stonebridge Brook mainstem was likely once dominated by coarse equilibrium and fine deposition conditions. Exceptions to this are tributaries M2S2.01 and M5S1.01, which based on their natural valley types and reference stream types, were likely transport streams, in which the naturally higher gradient and natural entrenchment results in little storage of fine sediment.

Currently, as a result of adjustments to several stressors, most of the reaches have been converted to fine source and transport and coarse deposition, with the exception of M03B and M04, where wetlands and a generous buffer have protected the stream from most stressors and the reaches are still in equilibrium. In most of the reaches, increased fine sediment supply is being generated by bed and bank degradation, and the bed degradation has also promoted transport conditions.

In general, Stonebridge Brook has lost much of its sediment storage capacity due to these changes; however, the wetland areas encountered in M02, M03, and M04 likely act to attenuate some of this sediment.

Missisquoi River

Of the assessed reaches within the Missisquoi River Black to Hungerford watershed, the reference sediment regime for R4S1.1S1.01 is considered transport, and the reference sediment regime for R4S3.01 is coarse equilibrium and fine deposition. The above mentioned stressors, such as straightening, encroachments, etc. have resulted in a sediment regime departure on R4S1.1S1.01 to fine source and transport and coarse deposition, which has resulted in increased sediment discharging directly into Missisquoi River. The sediment regime has converted from coarse equilibrium and fine deposition to fine source and transport and coarse deposition on R4S3.01B, generating more sediment and less storage in this segment. R4S3.01A, however, has not been converted, and is likely storing a portion of the sediment generated in the upstream segment.

Each of the assessed reaches within the Missisquoi Mouth watershed has a reference sediment regime of coarse equilibrium and fine deposition. Adjustments in response to stressors such as straightening have converted reaches R3S4.01 and R3S4.02 to unconfined source and transport reaches, due to the increase in transport capacity, and sediment generated by bed and/or bank degradation. R3S4.03 has been unchanged from reference conditions at this time. R3S4.04 has been converted to a fine source and transport and coarse deposition due to an increase in bed and bank degradation, which has increased transport capacity, and added a source of fine sediment. Overall, more sediment is being generated by widening and/or bed degradation throughout the assessed area. R3S4.03 is attenuating some of the sediment generated in R3S4.04; however, the sediment generated in R3S4.02 and R3S4.01, combined with transport conditions, suggests that fine sediment is likely making its way directly into the Missisquoi River.

3.2.2 Vertical and Lateral Constraints

Vertical and lateral constraints within the channel, both natural and human-caused, can influence how a channel that has experienced a sediment regime change can advance through each stage of channel evolution and return to reference conditions. Vertical and lateral constraints are mapped on the “Sediment Regime Departure Maps” for each watershed (Appendix B).

Deer Brook

There are generally very few natural constraints to vertical and lateral adjustment in Deer Brook. Natural bedrock grade controls were observed on the stream bed of M03A and M03B. Most other constraints consist of bridges and culverts, and associated revetments. There are few crossings located in the upper portion of the mainstem, and there is little riparian buffer, so meander development in these straightened segments is not likely significantly impacted. The culverts located in M03A are causing the most significant impact because not only are they constricting the channel, but the road approaches are built up above the floodplain, causing a disconnect when flooding occurs (See Figure 18). In addition, a series of human constructed weirs are located below a small foot bridge, and are acting as a vertical constraint; however, it does not appear to be affecting the segment at this time.



Figure 18: Deer Brook M03A- Major Culvert

The urbanization in the lower portion of the Deer Book mainstem appears to be the biggest hurdle for channel evolution, as the roads are permanent, and while there are no encroachments within the corridor of the downstream segments, this is one of the most highly urbanized areas of Georgia, which has resulted in several stormwater inputs. As long as the culverts exist, the resulting increase in stream power will not change. Certain projects, however, may be helpful to attenuate the transport capacity exceedance evident in M02A.

Mill River

There are several natural bedrock grade controls acting as vertical and lateral constraints to the Mill River streams. Most of these major grade controls, consisting of waterfalls and ledge outcrops, are located in M01 and M04. There are also a few human made grade controls, in the form of weirs, located in M04B and M05 in the vicinity of stream crossings. The watershed is significantly impacted by several bridges and culverts to accommodate road crossings. Some of these structures, namely those on Ethan Allen Highway and other major roads, are considered floodplain encroachments due to their elevation constructed above the stream – not sure this makes sense (See Figure 19). These structures and the associated urban development will have significant impacts on the Mill River and its tributaries as agricultural land is converted to residential development in this area.



Figure 19: Mill River M05- Ethan Allen Highway Box Culvert

Rugg Brook

There are generally very few natural constraints to vertical and lateral adjustment in the Rugg Brook watershed. Natural bedrock grade controls were observed on the stream bed of M01 and M06C. The most significant lateral constraints are located adjacent to M06C, M07A-C and M08, where residential development and road encroachments are barriers to stream adjustment.

Stonebridge Brook

There are several natural grade controls located in the upper portion of the Stonebridge Brook assessed area. Human constructed grade controls, such as weirs, were not observed. Natural grade controls, consisting of bedrock ledge, happen to be located upstream of headcuts, which should act to halt their upstream migration. Overall, road crossings have not significantly impacted the assessed area, and there is little bank armoring. The most significant lateral

constraints are located adjacent to M2S2.01 and M5S1.01, where residential development and road encroachments are permanent barriers to the stream.

Missisquoi River

There are few natural grade controls located within the assessed reaches of the Missisquoi Black to Hungerford Watershed. A major culvert, which conveys the downstream end of R4S3.01A to the Missisquoi, is a major vertical and lateral constraint. In addition, each assessed reach is experiencing lateral constraints caused by various encroachments including railroads, roads, development, etc. This appears to be the most significant constraint in conflict with each reach.

No natural or human made grade controls were observed within the assessed reaches of the Missisquoi Mouth watershed. Two major culverts, beneath Route 78, and the railroad, are vertical and lateral constraints to stream movement.

3.2.3 Sensitivity Analysis

Stream sensitivity helps to describe the likelihood, or rate, that vertical or lateral adjustments will occur in response to natural or human-caused stressors. The sensitivity rating is based on stream type and bed material characteristics, as well as the degree of adjustment that the stream is experiencing (reference or good condition, fair or poor condition, or poor condition resulting in a stream type departure). There are six classifications: very low, low, moderate, high, very high, and extreme. The map “Stream Sensitivity” in Appendix B was used to illustrate each segment’s sensitivity, as well as any current adjustment processes.

Geomorphic Stream Type Group	Existing Geomorphic Stream Type*	Sensitivity Ratings		
		Reference or Good Condition	Fair-Poor Condition in Major Adjustment	Poor Condition and represents a Stream Type Departure
1	A1, A2, B1, B2,	Very Low	Very Low	Low
2	C1, C2	Very Low	Low	Moderate
3	G1, G2	Low	Moderate	High
4	F1, F2	Low	Moderate	High
5	B3, B4, B5	Moderate	High	High
6	B3c, C3, E3	Moderate	High	High
7	C4, C5, B4c, B5c, E4, E5	High	Very High	Very High
8	A3, A4, A5, G3, F3	High	Very High	Extreme
9	G4, G5, F4, F5	Very High	Very High	Extreme
10	D3, D4, D5	Extreme	Extreme	Extreme

* Geomorphic stream types from the Rosgen (1994) Classification System

Figure 20: Sensitivity Ratings Vermont ANR, "The Municipal Guide to Fluvial Erosion Hazard Mitigation" (Appendix H)

Deer Brook

Sensitivity ratings on Deer Brook ranged from moderate to very high. No stream type departures were observed in connection with stressors. One segment, M02C, was identified as moderate sensitivity due to the stream type (B) and the bed material (cobble), despite adjustments occurring in response to the upstream culverts. M01B, M02B, M03A, M03B, and M05A were assigned a high sensitivity because though the segments were in good or reference

condition, the bed material (sand) results in an inherent increased sensitivity to changes in the system. Segments M02B, M05C, M06A, and M5S3.01 were assigned a very high sensitivity due to the bed material (sand) and low condition rating resulting from either significant active aggradation (M02B and M5S3.01) or incision (M05C and M06A) currently occurring within the segment.

Mill River

Sensitivity ratings in Mill River watershed ranged from very low to extreme. Stream type departures were observed in some of the segments where degradation and loss of floodplain access were very severe (M02B, M2T2.01, M2T2.02A, M2T2.02B, M2T2.06C, M2T2.1S1.1S1.01, M2T2.2S1.2S2.01A, and M2T2.2S1.2S2.01B - see Mill River Stream Sensitivity Map). Most of the assessed reaches ranged from high to extreme due to active ongoing adjustments (aggradation or degradation). Those segments that were rated moderate due to little to no change from equilibrium conditions are still considered somewhat sensitive due to non-cohesive bank material, which makes the segments susceptible to future changes. One rating of very low was given to M01B, which is a naturally occurring bedrock gorge and is very unlikely to experience change.

Rugg Brook

Sensitivity ratings in the Rugg Brook watershed ranged from moderate to extreme. Four segments had an extreme sensitivity, four segments had a very high sensitivity, four segments had a high sensitivity and only one reach (M09) had a moderate sensitivity (See Rugg Brook Sensitivity Map). M09 was the only reach assessed in the watershed that was rated “good” for geomorphic condition. Stream type departures were observed in six segments where degradation and loss of floodplain access were very severe: M01, M02, M06A, M06B, M07B and M07C.

Stonebridge Brook

The sensitivity ratings on the assessed reaches of Stonebridge Brook watershed ranged from high to very high. One stream type departure was observed in M06A, due to major degradation, which has caused widening and plane bed features (See Figure 21). The remaining segments remain highly sensitive due to the active adjustments processes (M02, M05, M06B, M5S1.01A, M5S1.01B) in response to stressors, and segments that are generally in equilibrium (M03B and M04) remain sensitive due to inherent stream bed properties, such as fine grain size, which causes them to respond readily to any lateral and/or vertical adjustments.



Figure 21: Stonebridge Brook M06A- Plane Bed Features

Missisquoi River

The sensitivity ratings on the two assessed reaches of Missisquoi Black to Hungerford Watershed range from high to very high due to active adjustments occurring. The sensitivity ratings on the assessed reaches of Missisquoi Mouth Watershed range from high to extreme. A stream type departure was observed in R3S4.02 due to extreme degradation resulting from historic straightening.

4.0 CONCLUSIONS

Historic and current land use practices have impacted the assessed streams greatly. The stressors have generally caused downcutting of the stream bed, which has cut the stream off from its floodplain, and caused high energy floodwaters to be contained within the channel, instead of dissipating flow energy onto the floodplain. This increased energy has caused significant erosion and channel instability in many of the reaches. Some of the assessed reaches were stable; however, most of the assessed reaches were found to be somewhere within this evolution process in response to changes in the watershed. The current channel instabilities are causing problems such as flooding, erosion and sediment load problems as more sediment, generated from erosion, is getting transported through the system.

In an area where increased development continues to threaten the already sensitive streams, it would be prudent to implement corridor preservation/restoration projects to ultimately allow the streams to regain equilibrium. The Phase 2 assessments have demonstrated that in general, an adequate buffer can help attenuate some of the stream's instabilities. Municipalities can use the FEH data to make good management decisions regarding current and future land use within the FEH corridor. Ultimately, implementing FEH management and regaining system-wide equilibrium will not only benefit the streams, but will help alleviate potential damage to property and infrastructure during flood events.

C. FLUVIAL EROSION HAZARD MAPPING

1.0 Methodology

The NRPC used the Stream Geomorphic Assessment Tool (SGAT) to generate two types of Fluvial Erosion Hazard (FEH) zones: Option 1 and Option 2. Option 1 draws a buffer that is a default six reference channel widths. A stream's reference channel width is calculated in the Phase 1 Stream Geomorphic Assessment (SGA) and is derived from the stream type and upstream drainage area. An Option 1 FEH corridor can be drawn on any stream reach that has Phase 1 data. An Option 2 FEH corridor can only be drawn for a stream reach with a Phase 2 SGA. Option 2 draws a corridor based on a stream's reference channel width and stream sensitivity. Stream sensitivity is derived from stream type and existing geomorphic condition. Sensitivity can range from very low to extreme and the corresponding corridors can range from equal to the reference channel width to six times the reference channel width (See Figure 22).

Sensitivity	Belt Widths based on reference channel widths
Very Low (VL)	Equal to the reference channel width
Low (LW)	Equal to the reference channel width
Moderate (MD)	Four (4) channel widths
High (HI)	Six (6) channel widths
Very High (VH)	Six (6) channel widths
Extreme (EX)	Six (6) channel widths

Figure 22: FEH Corridor Widths from "Municipal Guide to Fluvial Erosion Hazard Mitigation" Appendix H

Refer to the "Stream Geomorphic Assessment Tools User Guide" for complete methodology for developing FEH Zones.

For the Town of Georgia, a build-out analysis was conducted using the "Community Build-Out Analysis" Version 2.0 software. The FEH zones were overlaid on the current Georgia Zoning map and defined as an area where development could not occur and the software calculated the potential impact of the FEH zones on the build-out potential of the community.

2.0 Results and Application

FEH maps were created for the communities of Georgia, Highgate and Saint Albans City (Appendix I). These communities were selected because of their expressed interest in utilizing

the information for planning and zoning purposes. NRPC planning staff met with the planning commissions in Georgia and St. Albans City to present the draft maps and discuss their potential application in each community. Planning Commissioners were provided with copies of the “Municipal Guide,” Appendix H. In each case, Planning Commissioners provided valuable feedback on the draft maps, noting areas of local flooding and potential hazard.

Both Georgia and St. Albans City are now interested in incorporating the FEH zones into their municipal zoning regulations, however there were concerns brought up by each community. These concerns fall into three broad categories:

- 1. *Ability to Maintain Maps.*** There is concern that without ongoing technical support, FEH maps could become outdated and inaccurate. While the FEH corridor is intended to represent the area in which the stream will move, there is always the potential that a stream could experience a major adjustment and no longer be within the defined corridor. When adopting regulations, towns may need to account for this possibility. Given that small, rural towns generally have very limited GIS capabilities, on-going technical support will be needed to ensure that maps are kept up-to-date.
- 2. *Interpretation and Enforcement of FEH Zones.*** In developing regulations for FEH zones, it is imperative that towns consider how they will interpret and enforce those regulations. Developing FEH zoning maps that are easy to interpret is particularly important given the limited GIS capabilities at the local level. Towns have expressed concern that how they will make a determination on the exact location of the FEH zone boundary. Whereas measuring a buffer from a streambank is a relatively easy task, using an aerial photo to identify an FEH boundary on the ground may prove more challenging, particularly for towns that do not have high resolution aerial photography. This task, and the task of enforcing those boundaries, will largely fall to town Zoning Administrators. In many small towns, this is a part-time position, despite their full-time workload. Thus, in establishing the restrictions within the FEH zones, it is important to set realistic expectations for what can be regulated and enforced given the capacity of the town.
- 3. *Potential Impact on Landowners.*** There is concern that designating an area as a “hazard district” may place an unfair burden on those who own land within that district. Land values may be reduced within this zone and the potential to develop such lots will be restricted. Furthermore, there is concern that these landowners may be faced with higher insurance premiums because of their location in a hazardous area. However, by designating these areas, towns do have the opportunity to alert potential buyers and developers to the fact that certain areas may not be suitable to development and may pose a risk to public health and safety. In order to balance the costs and benefits, Towns may be able to adequately compensate landowners and restrict development in the FEH corridor by enabling landowners to relocate density on other areas of a parcel.

In an effort to quantify the impact that FEH zoning will have on local development potential, the NRPC conducted a built-out analysis for residential development in the Town of Georgia. In the hypothetical analysis, development was not allowed on land within the FEH zone, but when possible was transferred to another portion of the lot outside of the FEH zone. In other words, if a portion of a subdivision was within the FEH zone, the analysis still allowed the subdivision, but placed the potential units on the area outside of the FEH zone.

The build-out analysis for Georgia showed that implementing an FEH zone would have little impact on the overall build-out potential for the community (see below). The new zone may create one additional grandfathered lot and would require the relocation of a couple potential housing units. This application of the build-out tool to analyze FEH zoning is considered to be a “work in progress” and will continue to be revised with additional input from town officials.

Summary of Build-Out Analysis for Town of Georgia showing potential impact of FEH zoning.

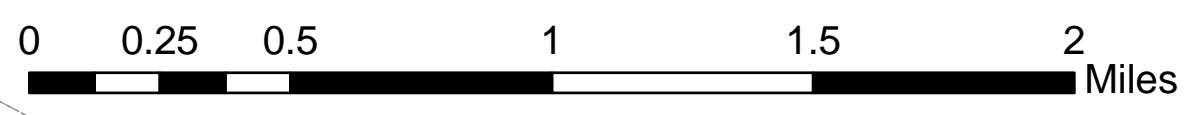
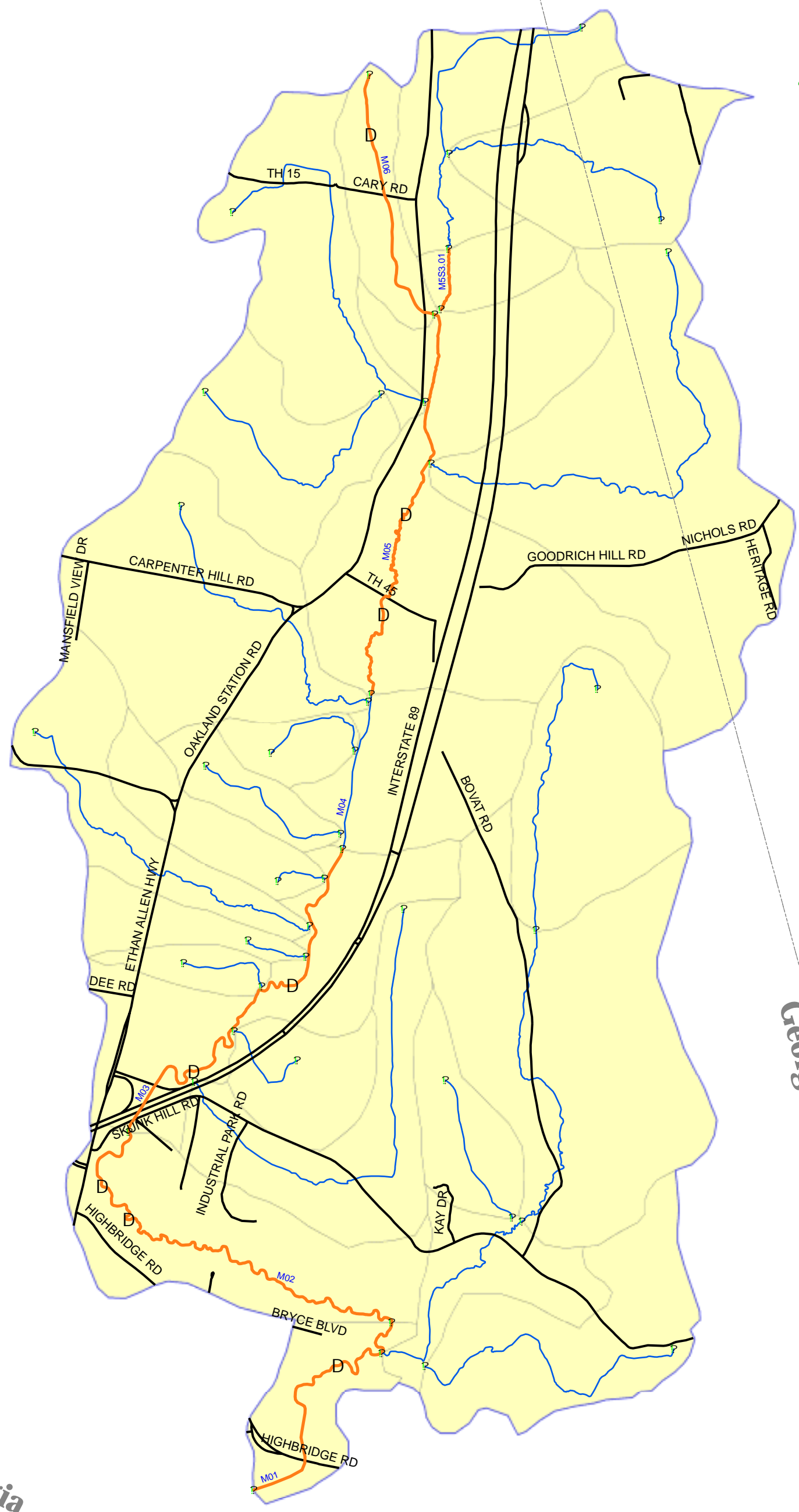
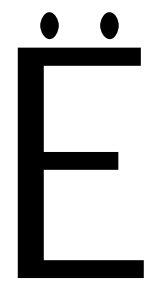
District	# Current Units	# of Total Potential Units		# of Grandfathered Units		# of Units Relocated due to constraints	
		current	w/ FEH	current	w/ FEH	current	w/ FEH
Total Town	1,688	1,369	1369	250	251	6	8
Agricultural/Residential (AR-1)	387	403	404	85	86	0	0
Residential Med Density (AR-2)	341	348	348	19	19	0	0
Residential Hi Density (AR-3)	564	557	556	42	42	6	8
Business High (B-1)	0	0	0	0	0	0	0
Business Medium (B-2)	18	20	20	1	1	0	0
Recreational (R-1)	73	2	2	17	17	0	0
Lakeshore (L-1)	237	2	2	66	66	0	0
Lake Residential (L-2)	59	37	37	11	11	0	0
Natural (N-1)	9	0	0	9	9	0	0
Commercial (I-2)	0	0	0	0	0	0	0
Industrial (I-1)	0	0	0	0	0	0	0

The NRPC, with assistance from VT DEC River Management, will continue to work with these communities to address these concerns and develop an appropriate and effective way

to regulate development within the FEH corridors. Through these regulations, communities will be able to reduce future conflicts and reduce the potential for flooding and erosion hazards.

D. REFERENCES

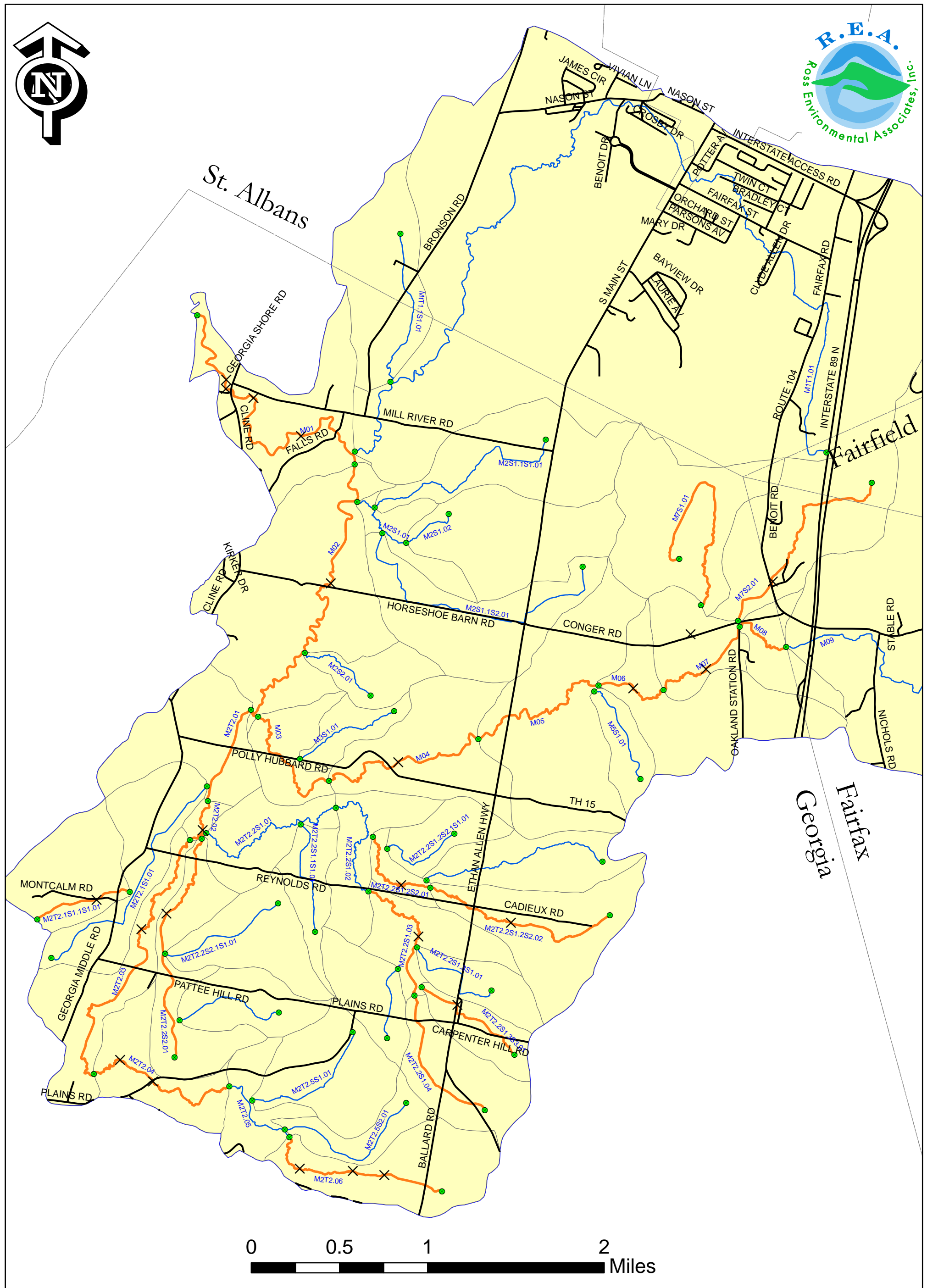
- Doll, Charles, Centennial Geologic map of Vermont, State of Vermont Geologists Office, 1961.
- Stewart, D.P. and McClintock, P., Surficial Geologic Map of Vermont; State of Vermont, 1970.
- <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>
- Vermont Agency of Natural Resources, Vermont Stream Geomorphic Assessment Phase 2 Handbook and Appendices, March 2006



Legend

- D Segment Breaks
- Stream
- Subwatershed Boundaries
- P Reach Breaks
- Roads
- Town Boundary
- Study Reach
- Watershed Boundary

**Deer Brook
Study Reaches
Georgia, Vermont**



Legend

- ✕ Segment Breaks
- Reach Breaks
- Study Reach
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary

Mill River
Study Reaches
Georgia, Vermont
Appendix A

Rugg Brook

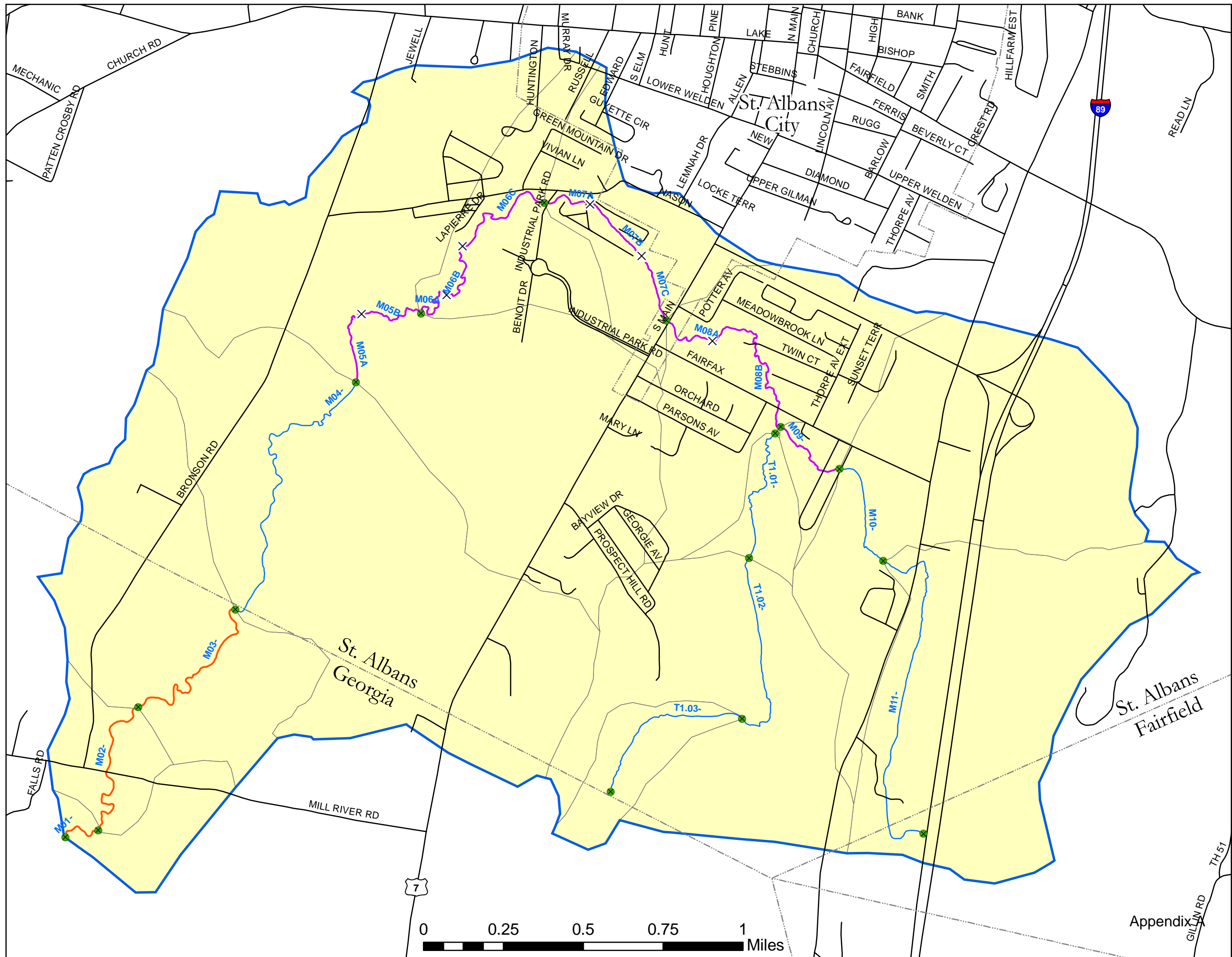
Study Reaches

St. Albans, Vermont

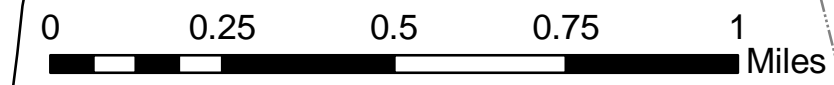


LEGEND

- Reach Breaks
- × Segment Breaks
- Brook
- Roads
- Study Reach completed by NRPC & REA in 2006.
- Study Reach completed by Lake Champlain Committee in 2005.
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary



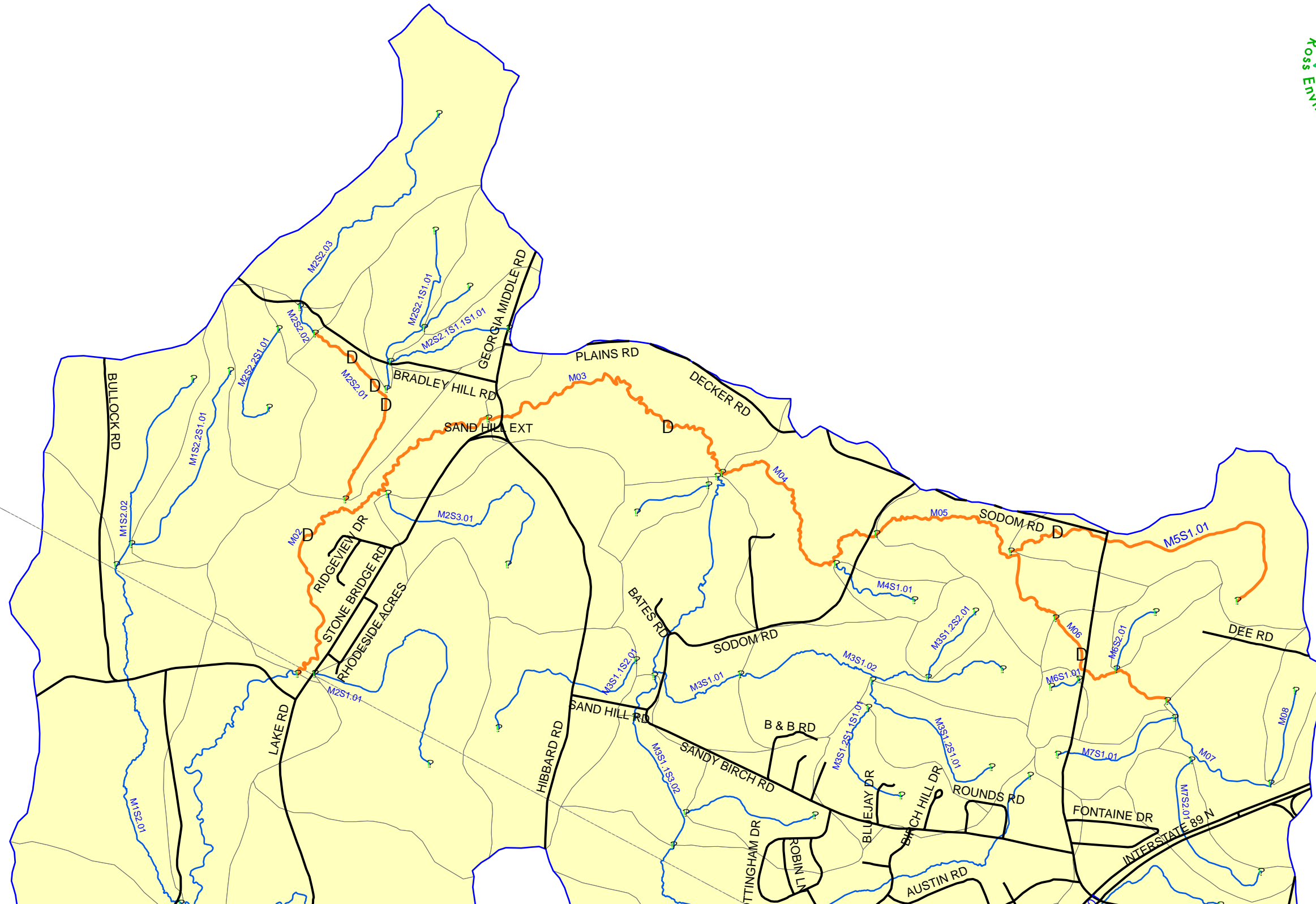
Vermont Coordinate System
 Transverse Mercator, NAD 83.
 For planning purposes only.
 Prepared by:
 Northwest Regional
 Planning Commission
 155 Lake Street
 St. Albans, VT 05478
 802.524.5958
 www.nrpvt.com



E



Georgia
Milton

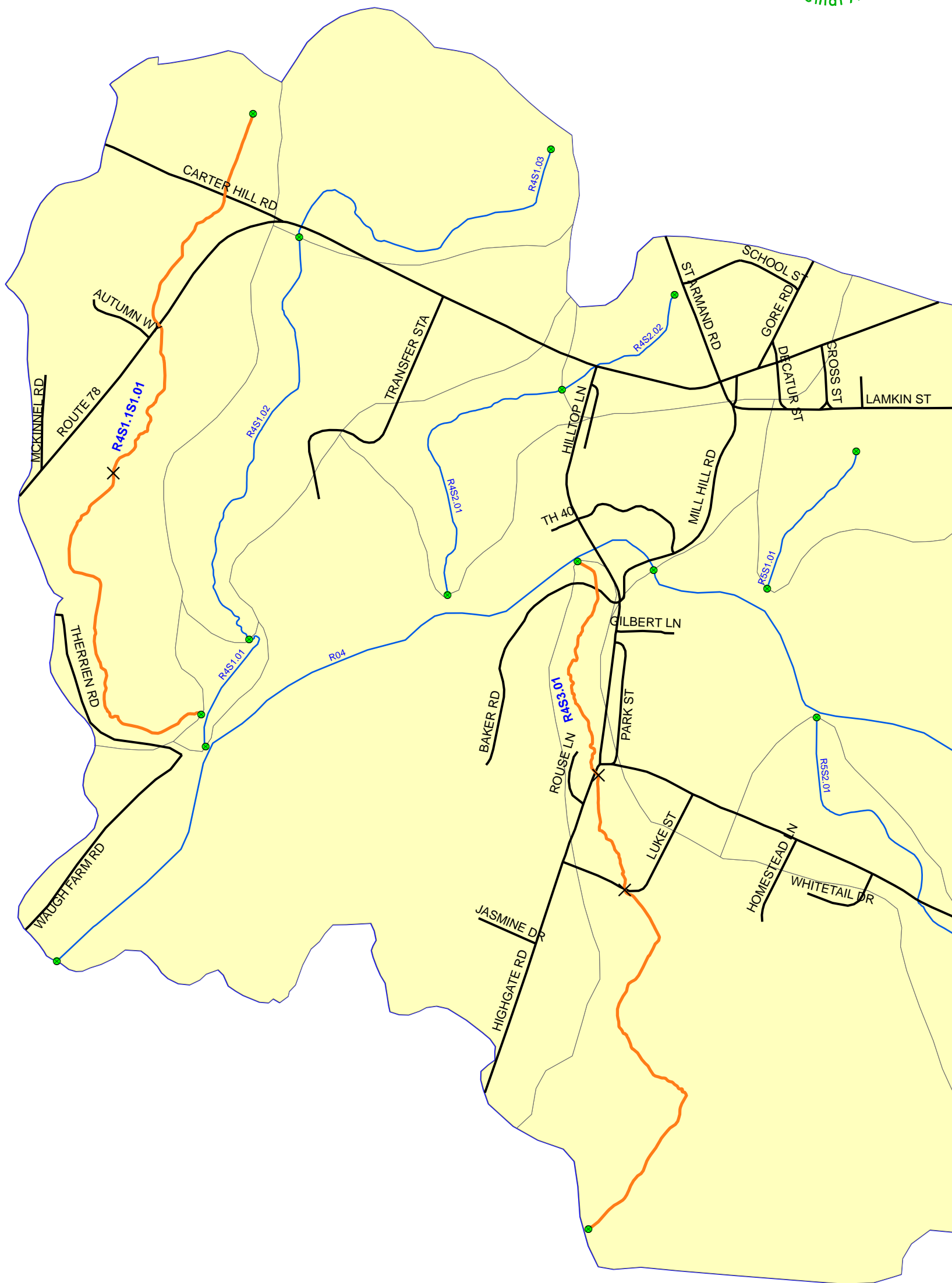


Legend

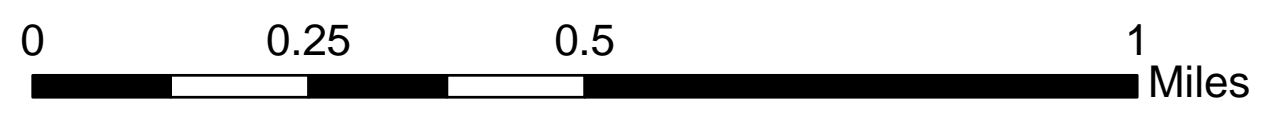
- D Segment Breaks
- Reach Breaks
- Study Reach
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary



Stonebridge Brook
Study Reaches
Georgia, Vermont



Highgate
Swanton

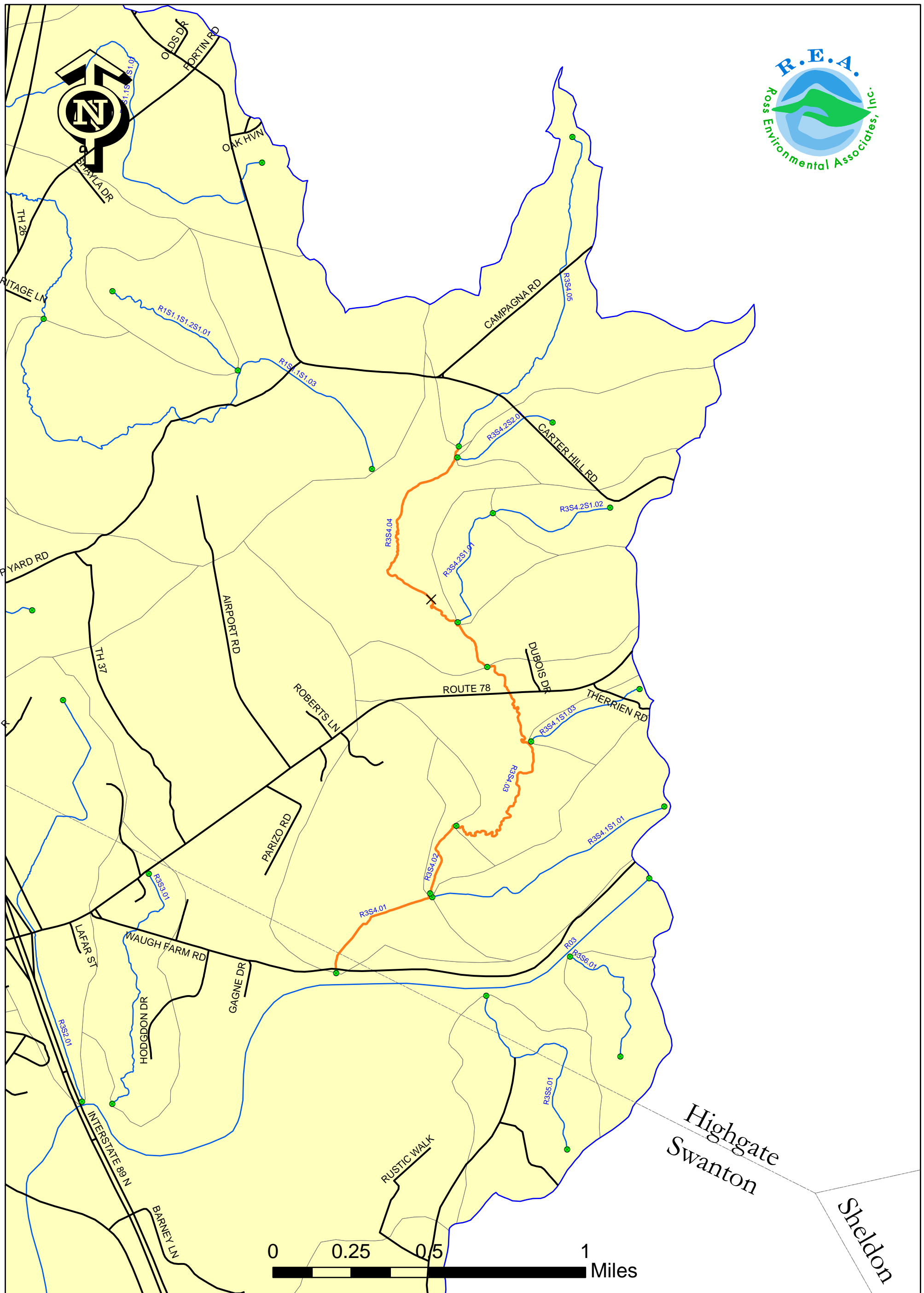


Legend

- ✕ Segment Breaks
- Reach Breaks
- Study Reach
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary

**Missisquoi
Black to Hungerford**

**Study Reaches
Highgate, Vermont Appendix A**

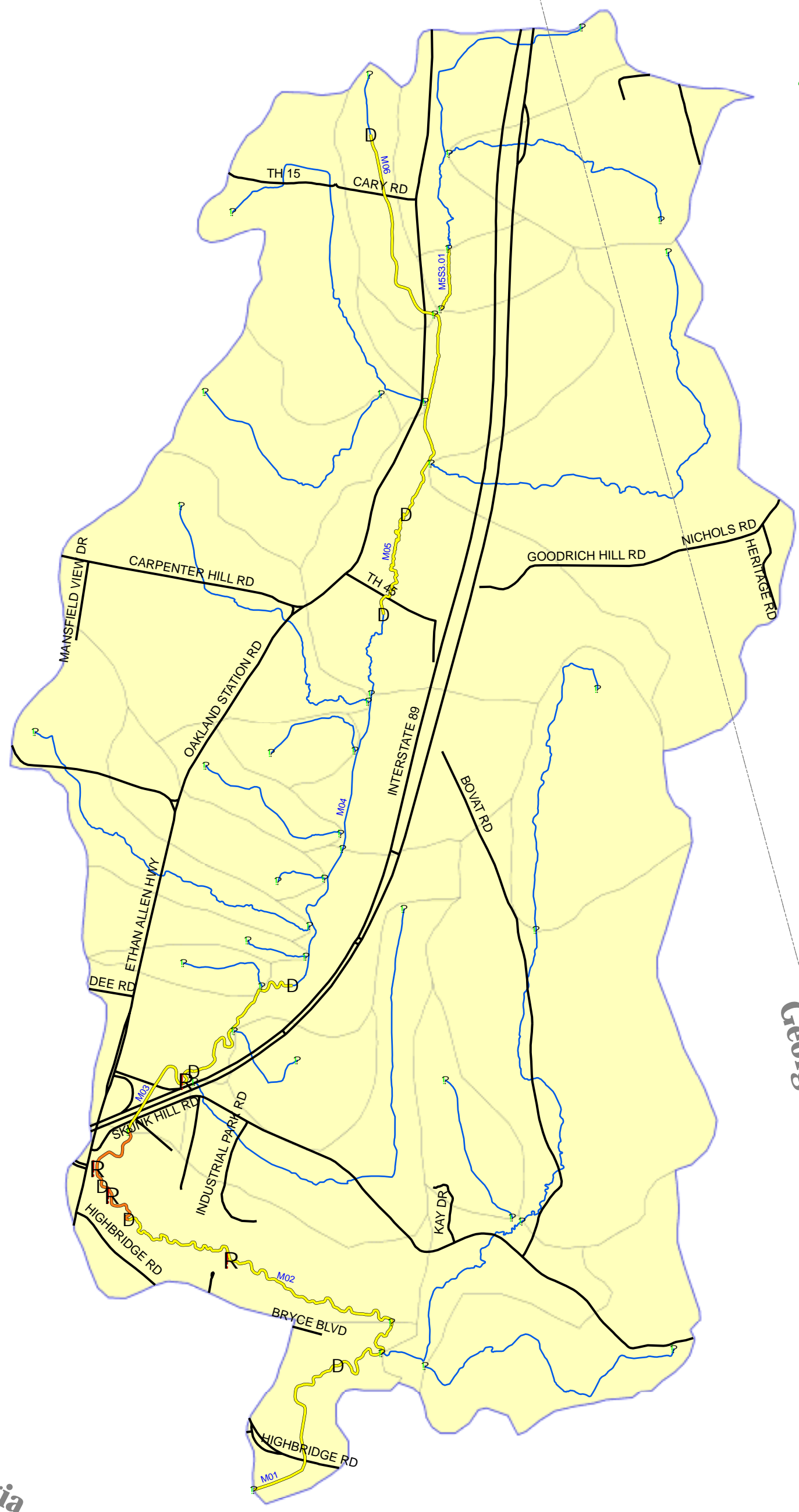
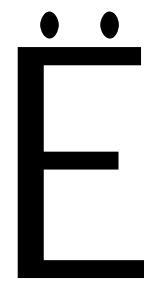


Legend

- ✕ Segment Breaks
- Reach Breaks
- Study Reach
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- - - Town Boundary

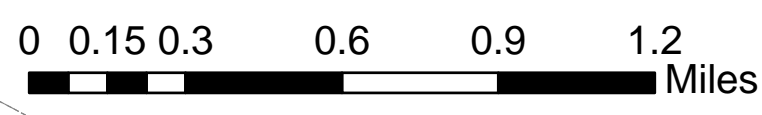
Missisquoi River Mouth

Study Reaches
Highgate, Vermont Appendix A



Georgia
Milton

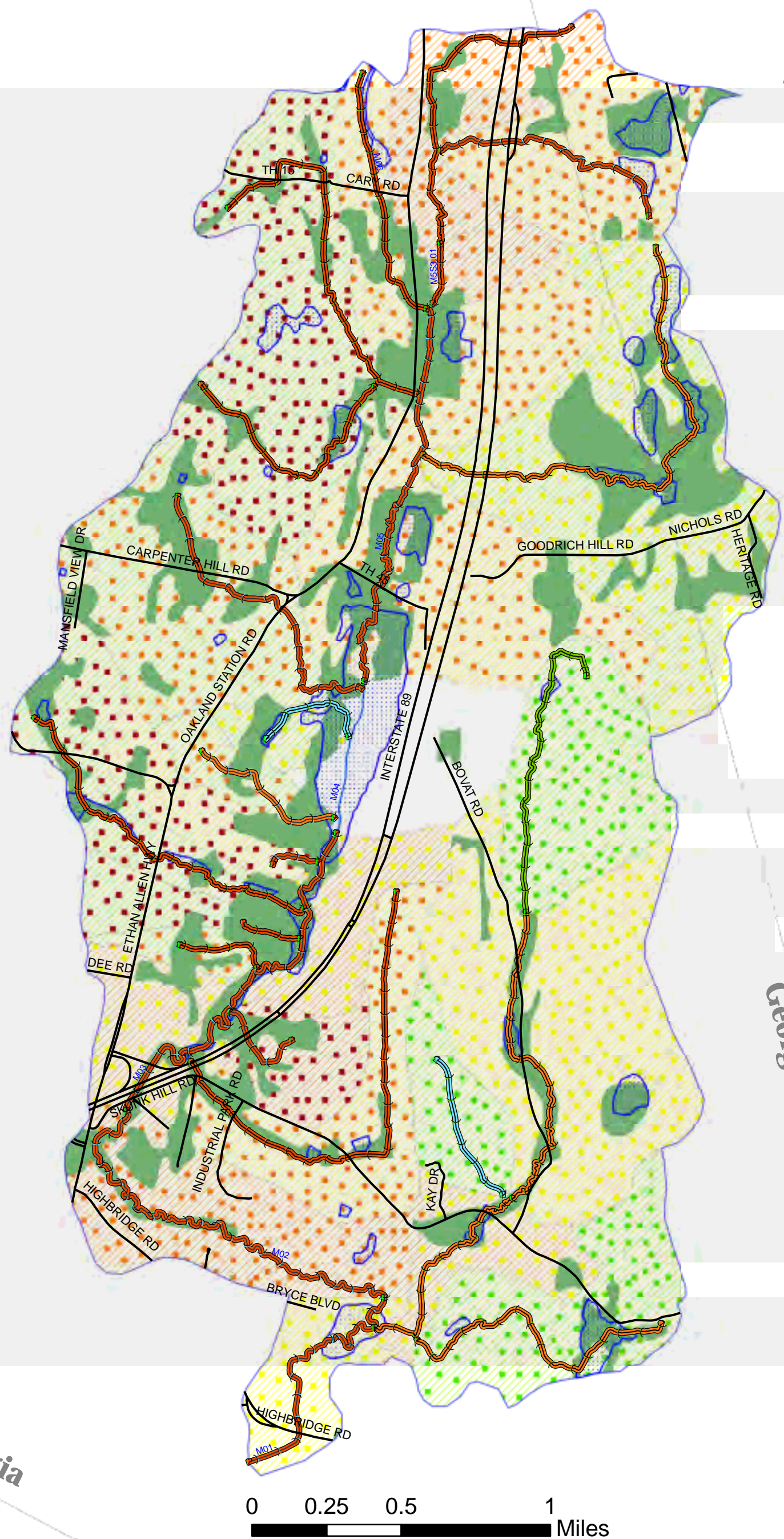
Georgia
Fairfax



Legend

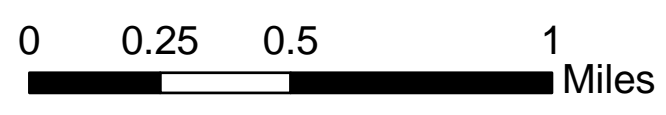
- | | | |
|----------------|--------------------------------|-----------------------|
| Reach Breaks | Stormwater Input Range <=2 | Watershed Boundary |
| Segment Breaks | Stormwater Input Range >2 <= 5 | Subwatershed Boundary |
| Stream | Stormwater Input Range > 5 | Town Boundary |
| Roads | Stormwater Inputs | |

**Deer Brook
Hydrologic Alterations Map
Georgia, Vermont**



Georgia
Fairfax

Georgia
Milton



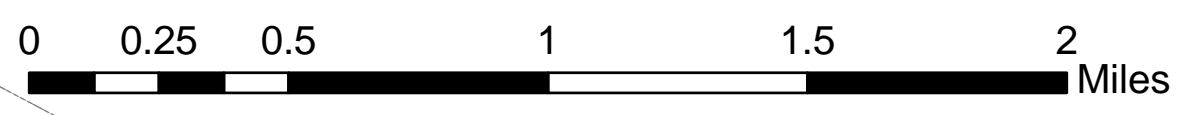
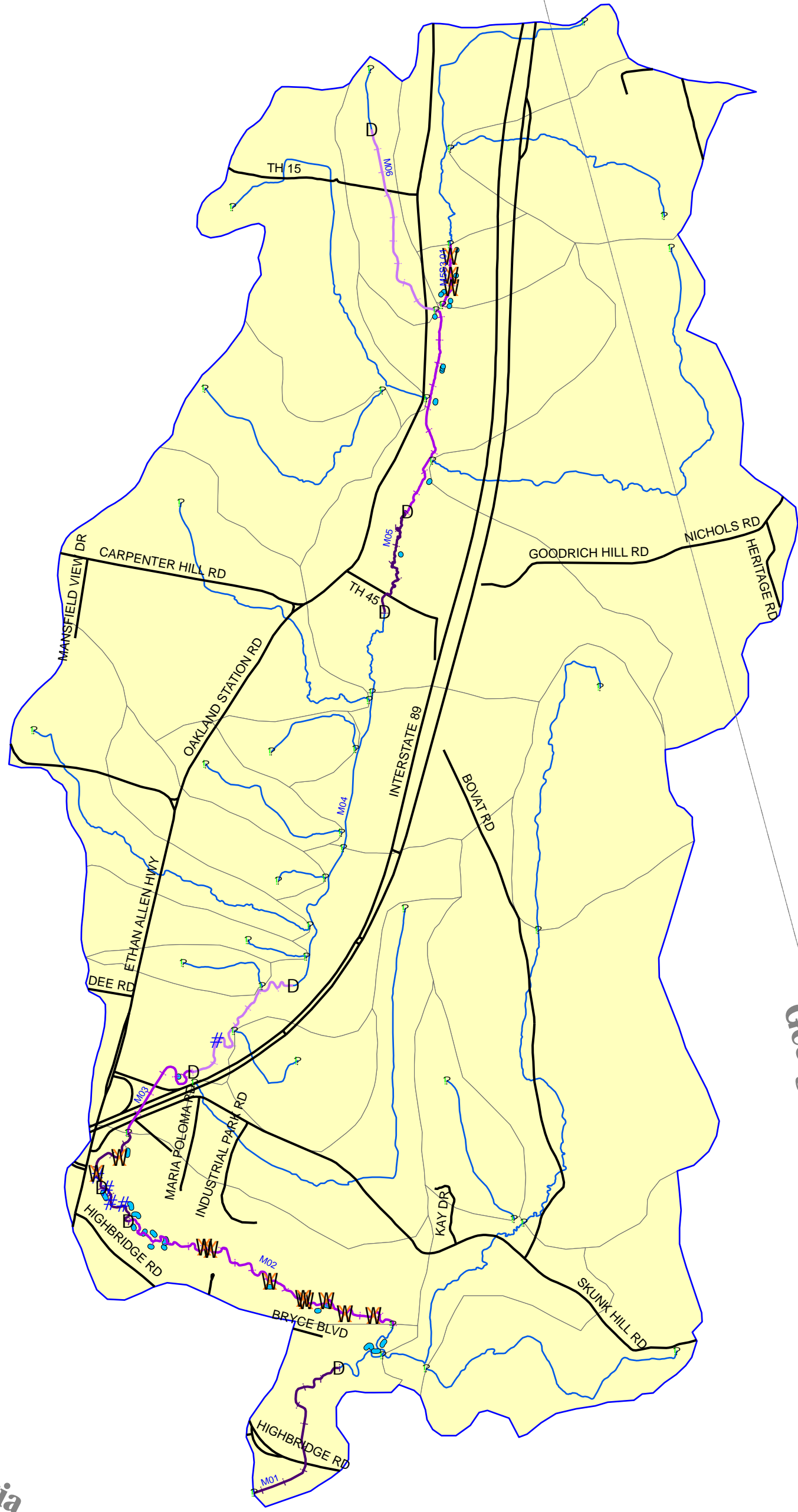
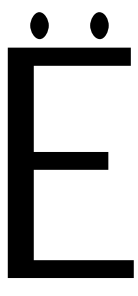
Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Wetland Loss
- Existing Wetlands
- Town Boundary
- Watershed Boundary

- Cumulative Upstream Urban Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Cumulative Crop Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

- Urban Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Crop Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

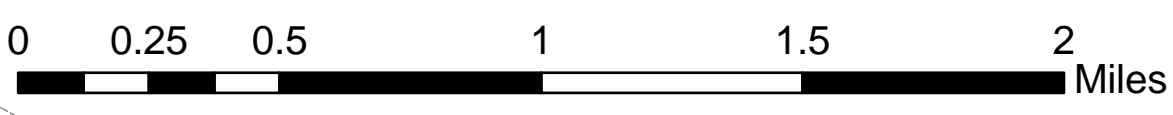
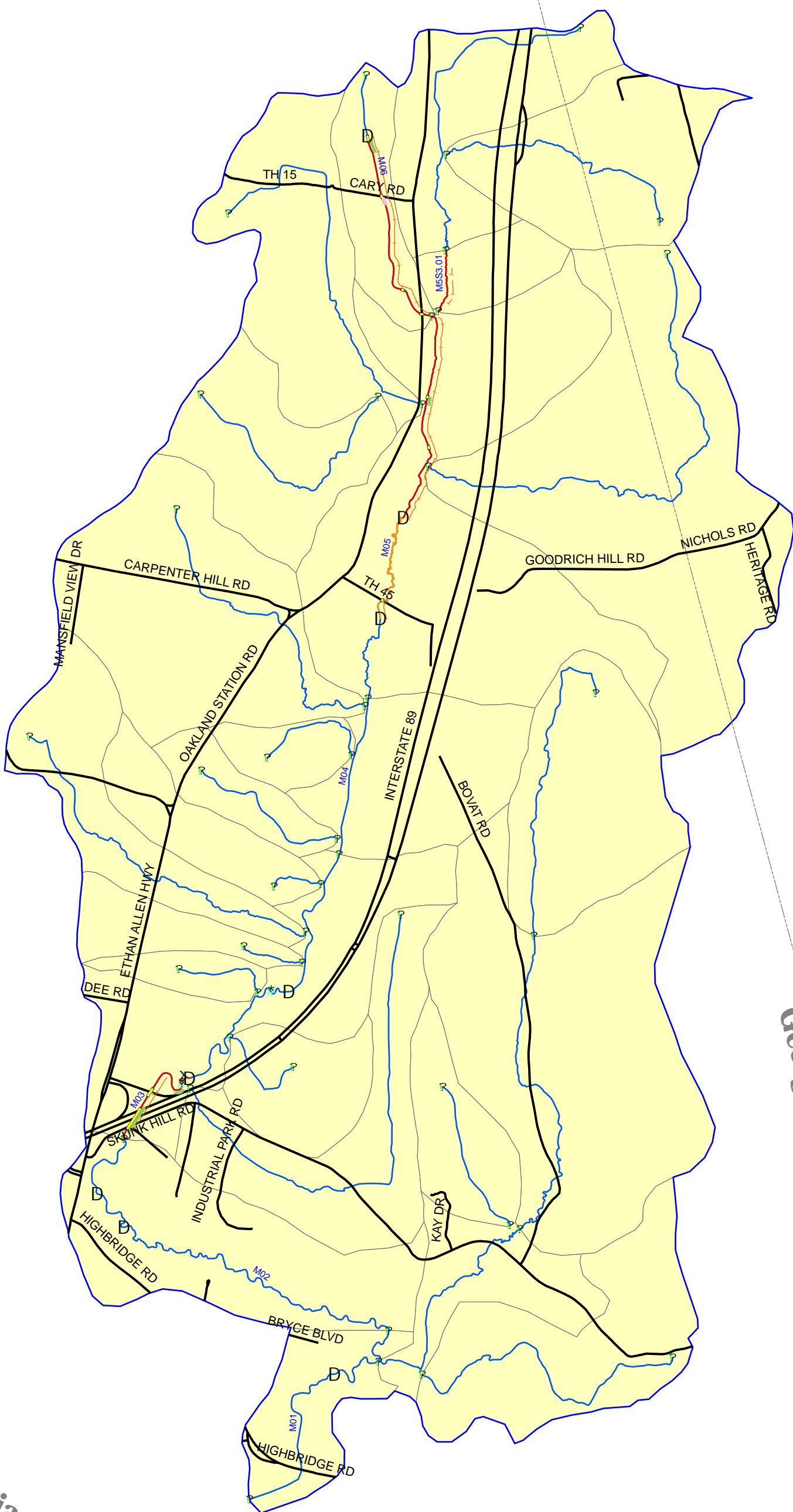
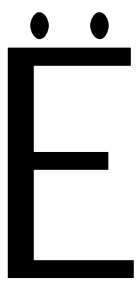
**Deer Brook
Land Use Land Cover
Georgia, Vermont**



Legend

- | | | |
|----------------|--------------------------------|-----------------------|
| Reach Breaks | Flood Chute | Watershed Boundary |
| Segment Breaks | Depositional Features Per Mile | Subwatershed Boundary |
| Stream | <=2 | Town Boundary |
| Roads | >2 <= 5 | |
| Erosion | > 5 | |
| Mass Failure | | |

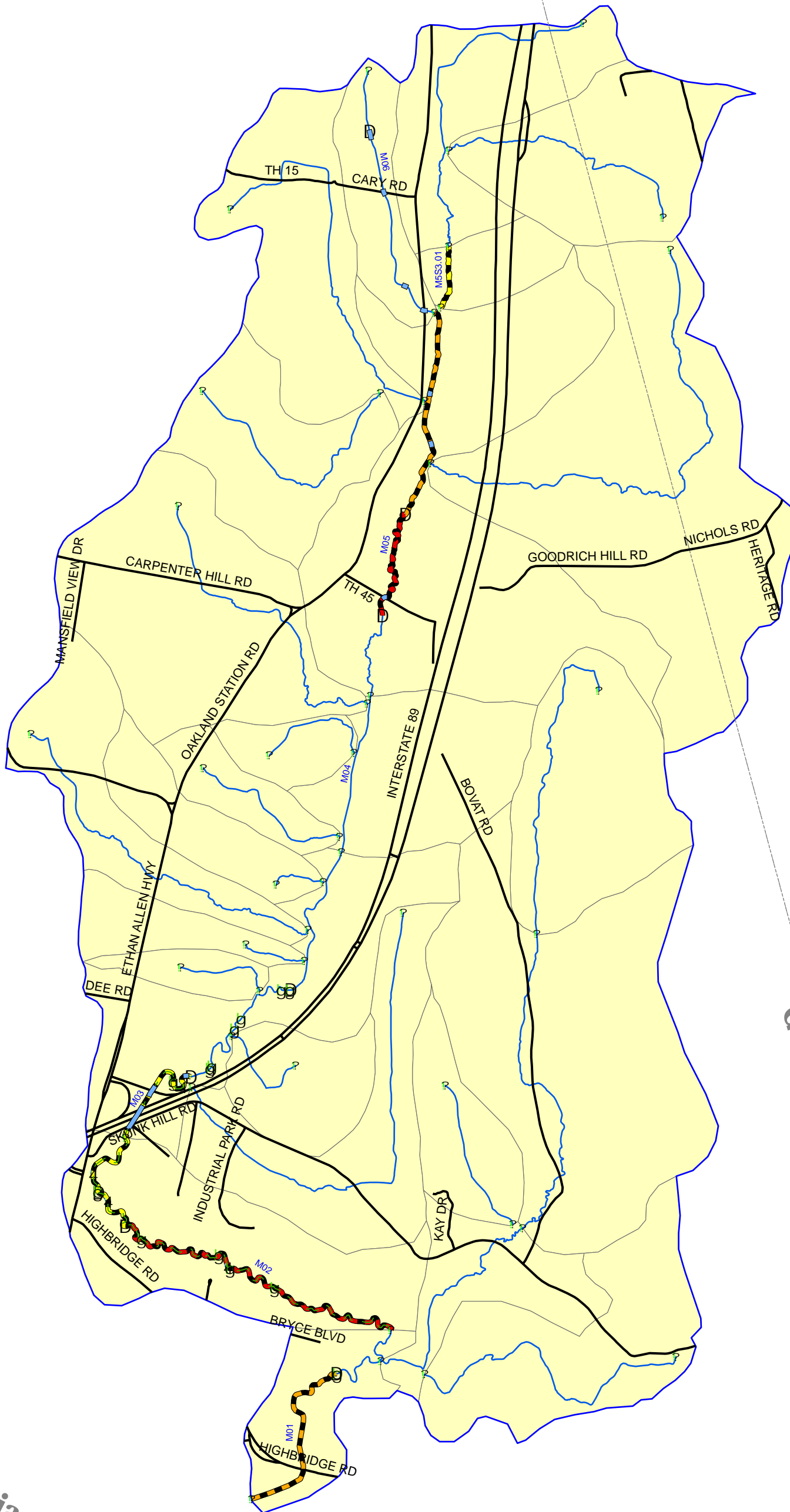
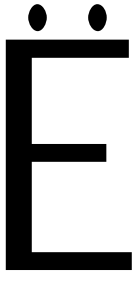
Deer Brook
Sediment Load Indicators Map
Georgia, Vermont



Legend

- | | | | | | |
|---|-------------------|---|---------------------------------|-------|-----------------------|
| ? | Reach Breaks | — | Development | - - - | Town Boundary |
| D | Segment Breaks | * | Natural Grade Control | ▭ | Watershed Boundary |
| — | Roads |) | Human Constructed Grade Control | ▭ | Subwatershed Boundary |
| — | Stream | | Percent Straightening | | |
| — | Straightening | | None | | |
| — | Bridge or Culvert | | <20% | | |
| — | Road Encroachment | | >20% | | |

Deer Brook
Channel Slope Modifiers Map
Georgia, Vermont



Georgia
Fairfax

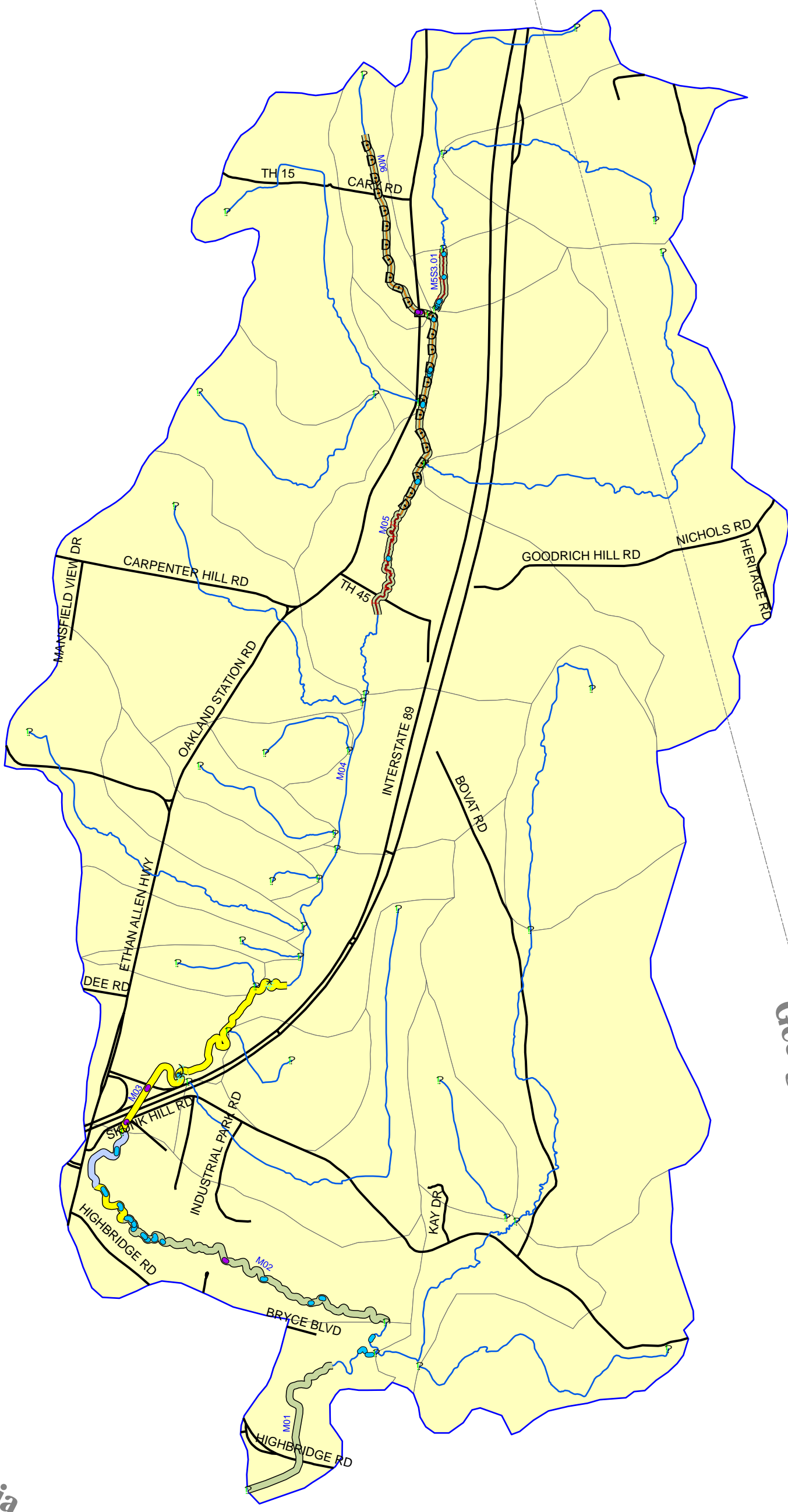
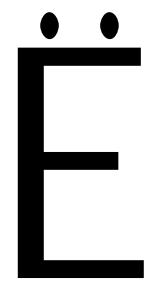
Georgia
Milton



Legend

- | | | |
|-------------------|-------------------------------------|-----------------------|
| Reach Breaks | Number of Stormwater Inputs 1-2 | Town Boundary |
| Segment Breaks | Number of Migration Features 1 or 2 | Watershed Boundary |
| Roads | 3 or 4 | Subwatershed Boundary |
| Stream | >4 | |
| Bridge or Culvert | | |
| Beaver Dam | | |
| Stormwater Input | | |

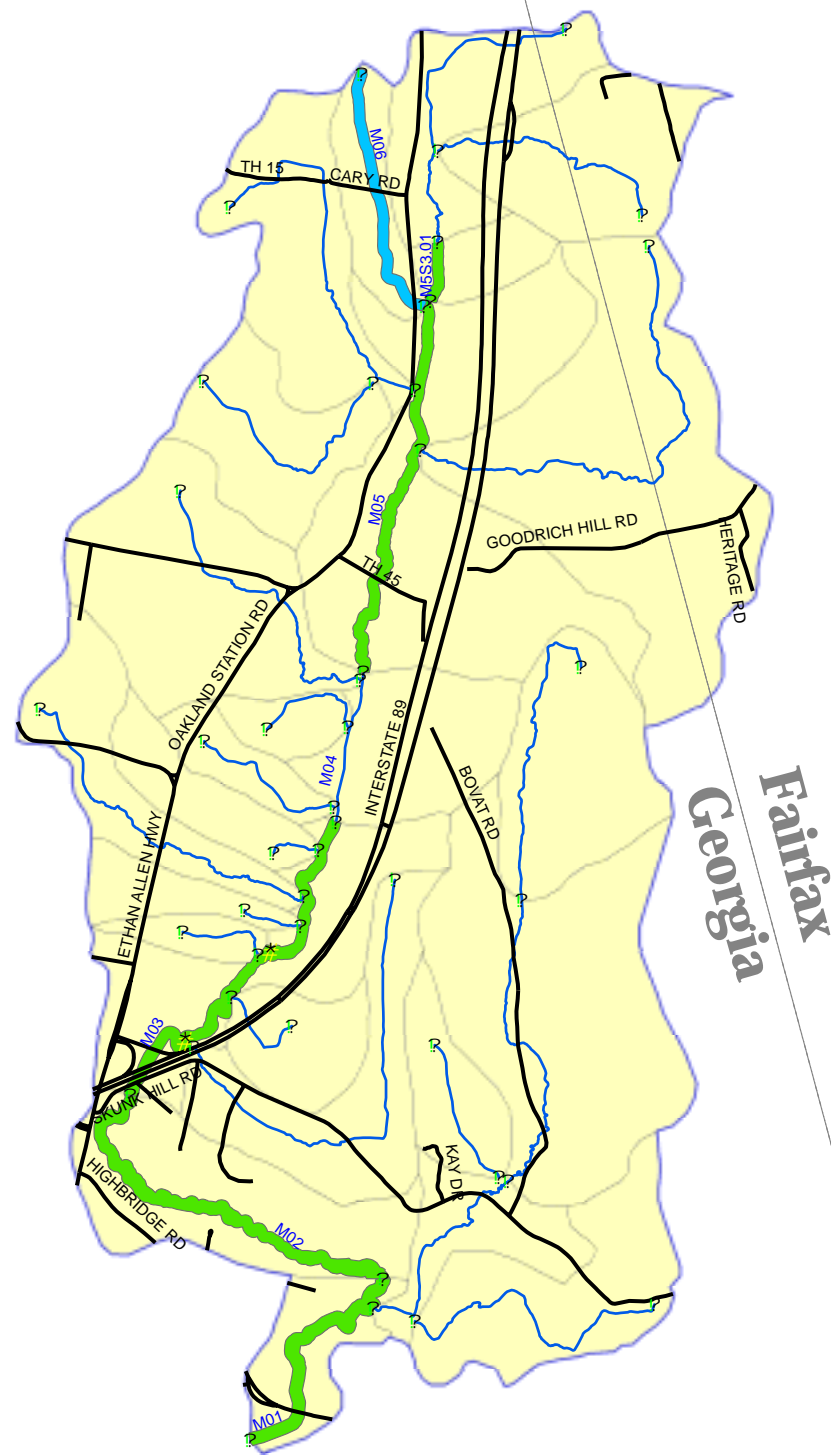
Deer Brook Channel Depth Modifiers Map Georgia, Vermont



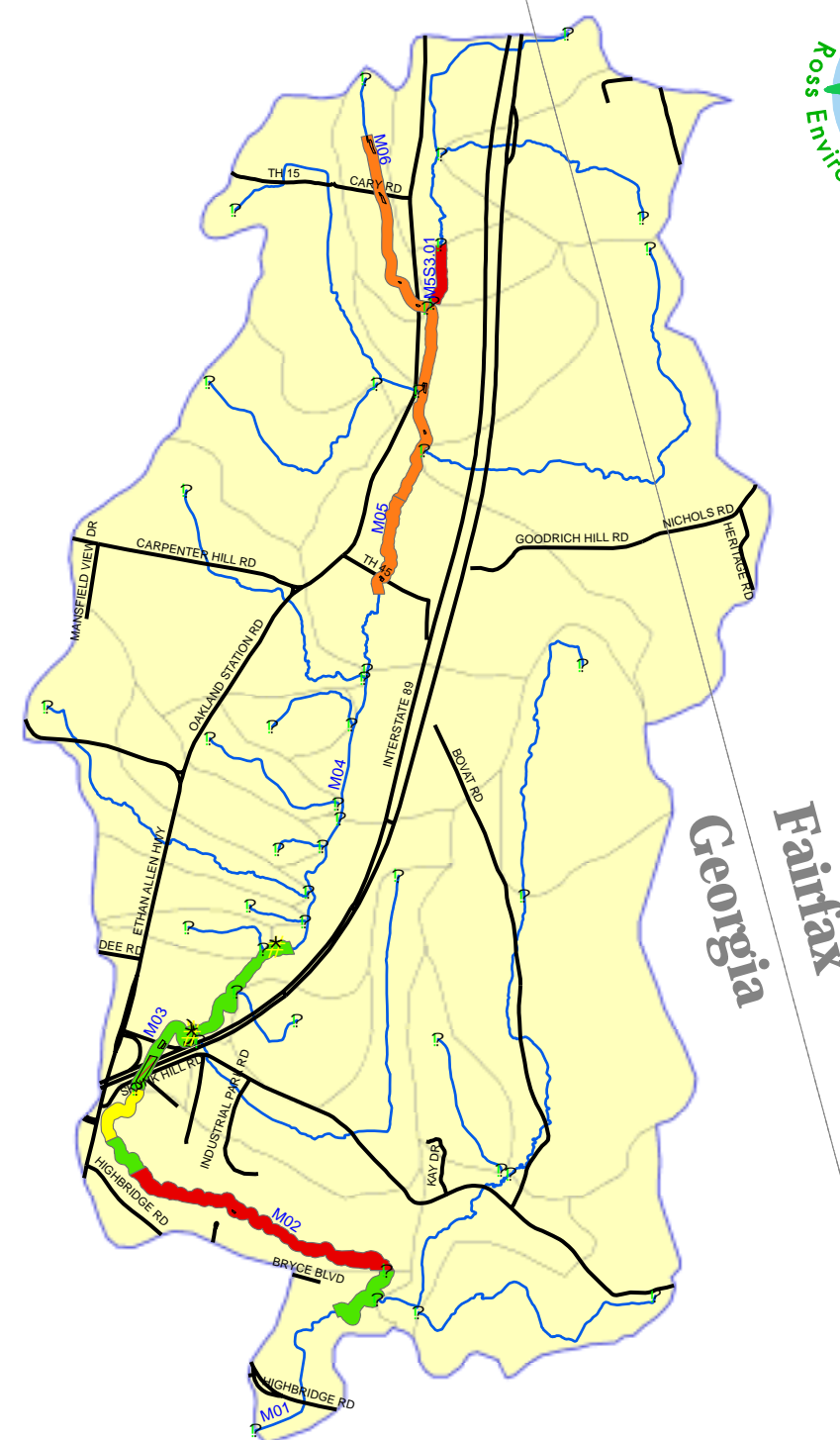
Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Erosion
- Bank Armoring
- Natural Grade Control
- Human Constructed Grade Control
- Bed Material**
 - Cobble
 - Gravel
 - Sand
- Right Bank Buffer Width**
 - <5
 - 5-25
- Left Bank Buffer Width**
 - <5
 - 5-25
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

**Deer Brook
Boundary Conditions and
Riparian Modifiers Map
Georgia, Vermont**



Phase 1 Reference Sediment Regimes



Phase 2 Existing Sediment Regimes

Legend

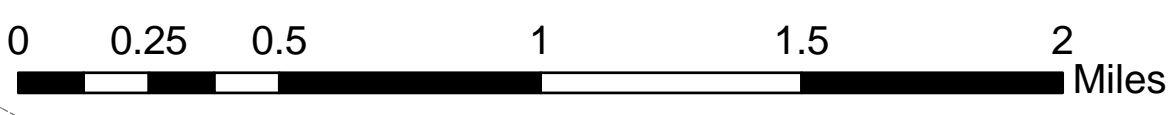
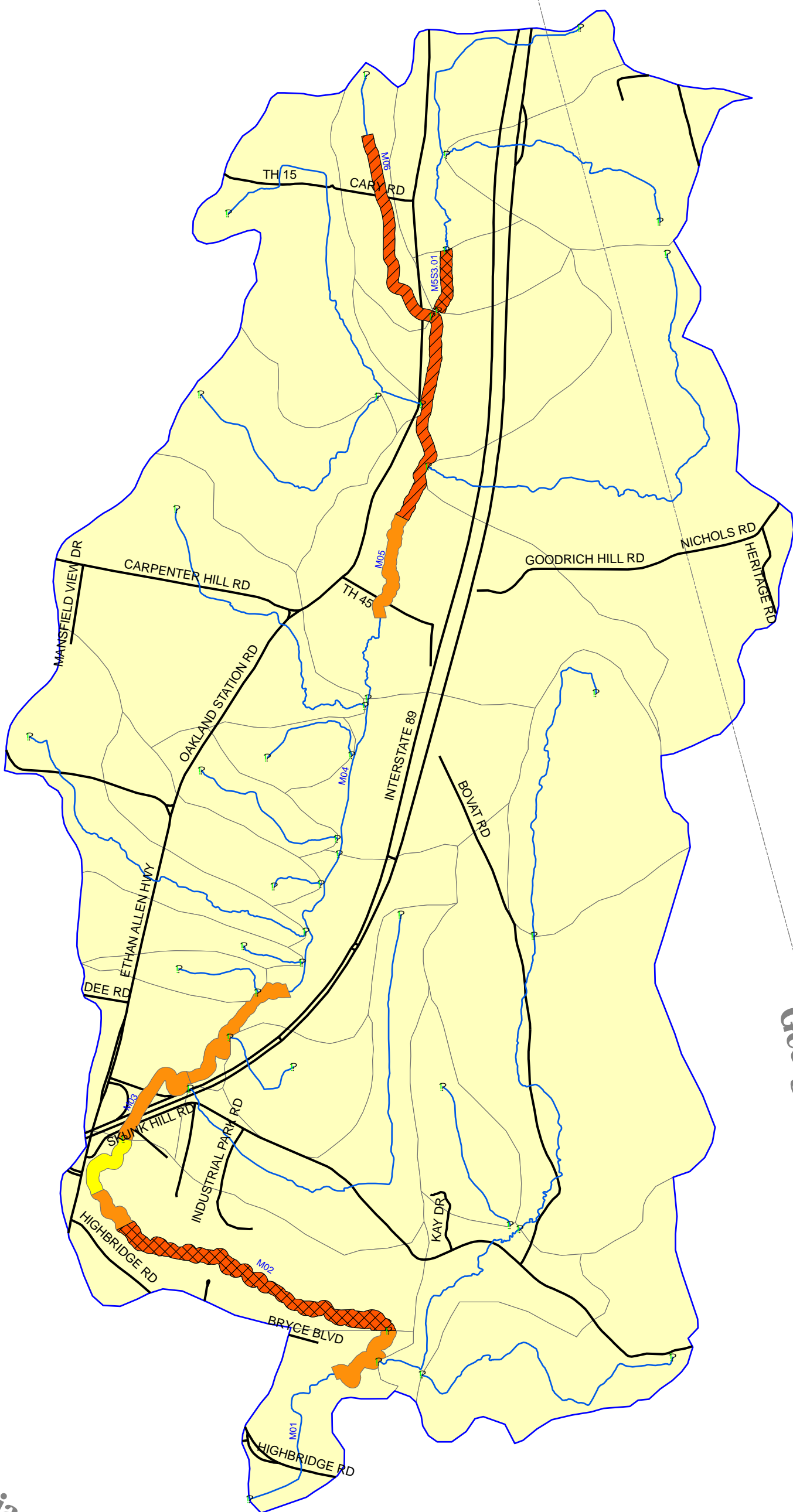
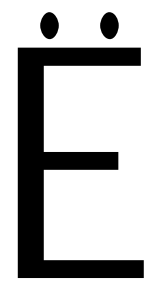
- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Natural Grade Control
- Reference Sediment Regime
- Coarse Equilibrium & Fine Deposition
- Transport
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

**Deer Brook
Sediment Regime Departure Maps
Georgia, Vermont**



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Natural Grade Control
- Human Constructed Grade Controls
- Lateral Constraints
- Phase 2 Existing Sediment Regimes
- Confined Source & Transport
- Unconfined Source & Transport
- Fine Source & Transport and Coarse Deposition
- Coarse Equilibrium & Fine Deposition
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary



Legend

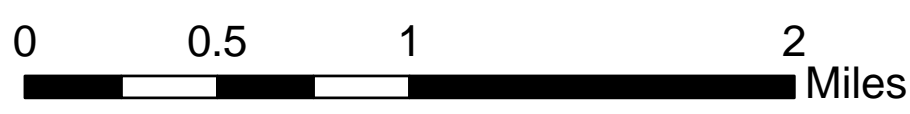
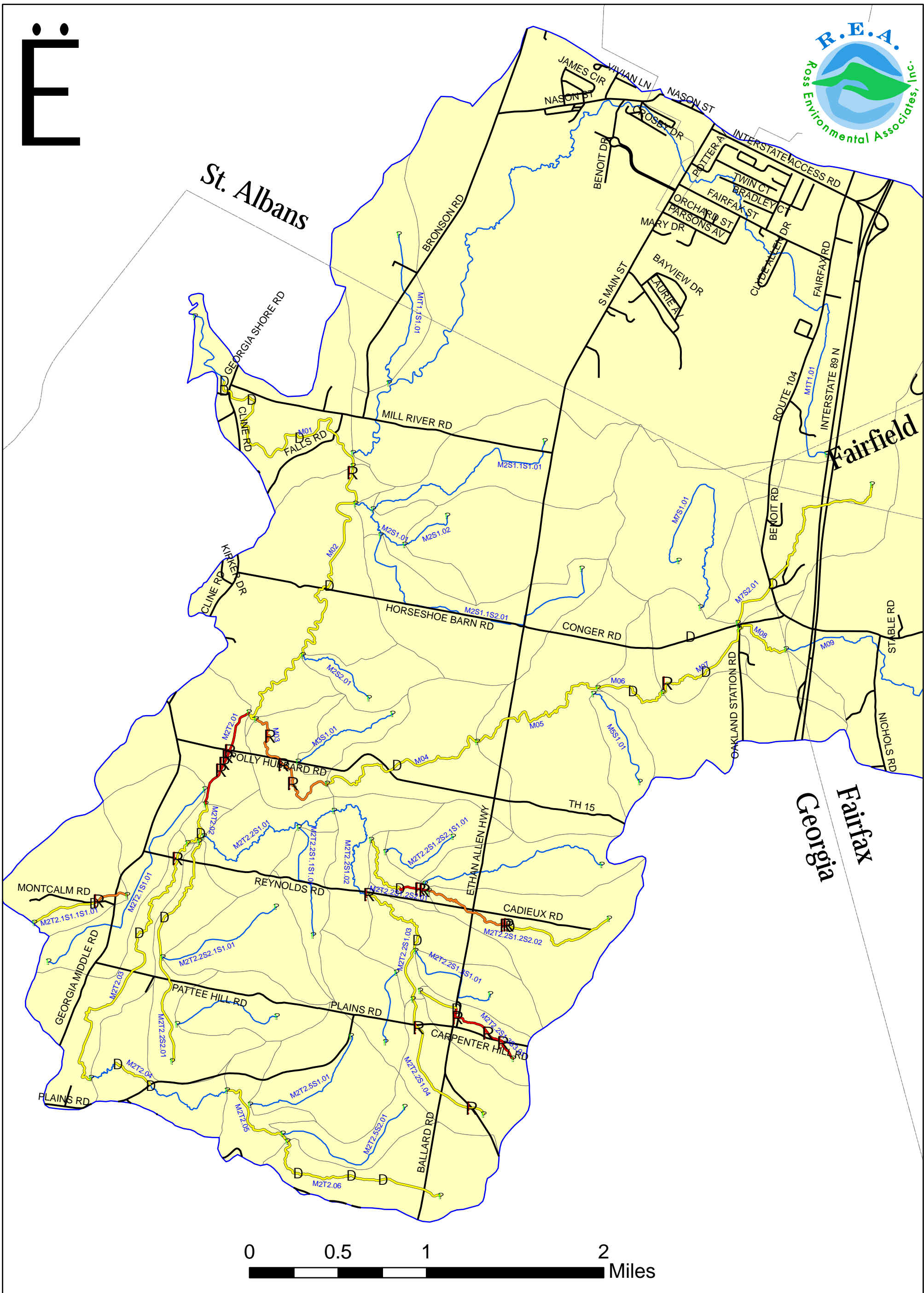
- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Current Adjustment Process
- Aggradation
- Degradation

- Stream Sensitivity
- Very Low
 - Moderate
 - High
 - Very High
 - Extreme

- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

**Deer Brook
Stream Sensitivity
Georgia, Vermont**

E



Legend

Reach Breaks	Stormwater Input Range	Watershed Boundary
Segment Breaks	<=2	Subwatershed Boundary
Stream	>2 <=5	Town Boundary
Roads	>5	
Stormwater Inputs		

Mill River
Hydrologic Alterations
Georgia, Vermont

E



St. Albans

Fairfield

Georgia
Fairfax



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Wetland Loss
- Existing Wetlands
- Town Boundary
- Watershed Boundary

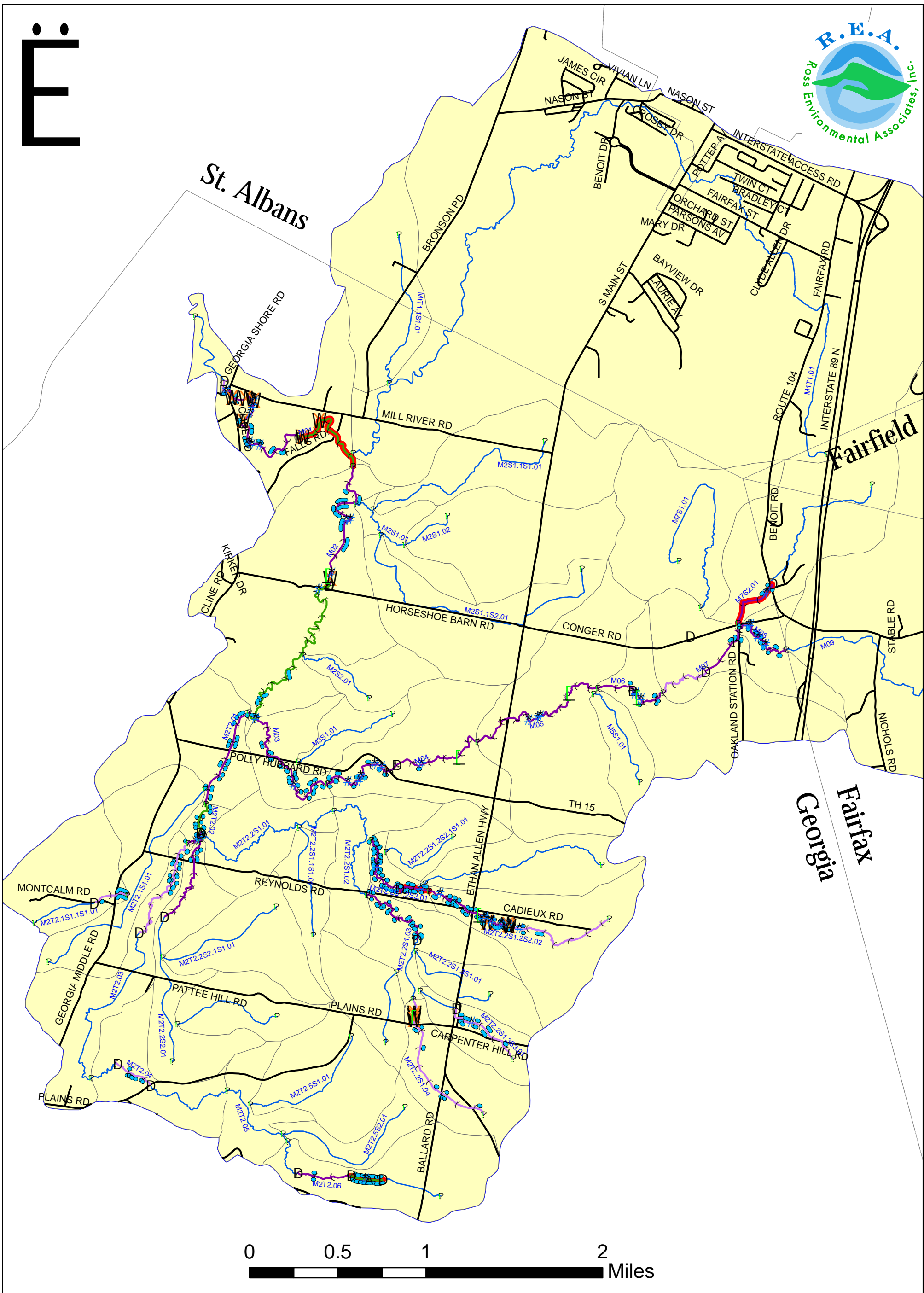
- Cumulative Upstream Land Use Percentage
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Cumulative Crop Land Use Percentage
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

- Urban Land Use
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Crop Land Use
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

Mill River Land Use Land Cover Georgia, Vermont

Appendix B

E



<ul style="list-style-type: none"> Reach Breaks Segment Breaks Stream Roads Gullies Steep Riffles Avulsions 	<ul style="list-style-type: none"> Flood Chute Mass Failure Erosion Rejuvenating Tributaries <p>Depositional Features Per Mile</p> <ul style="list-style-type: none"> <= 2 > 2 <= 5 > 5 	<ul style="list-style-type: none"> Subwatershed Boundary Watershed Boundary Town Boundary
---	---	---

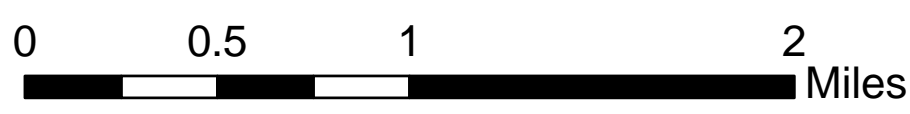
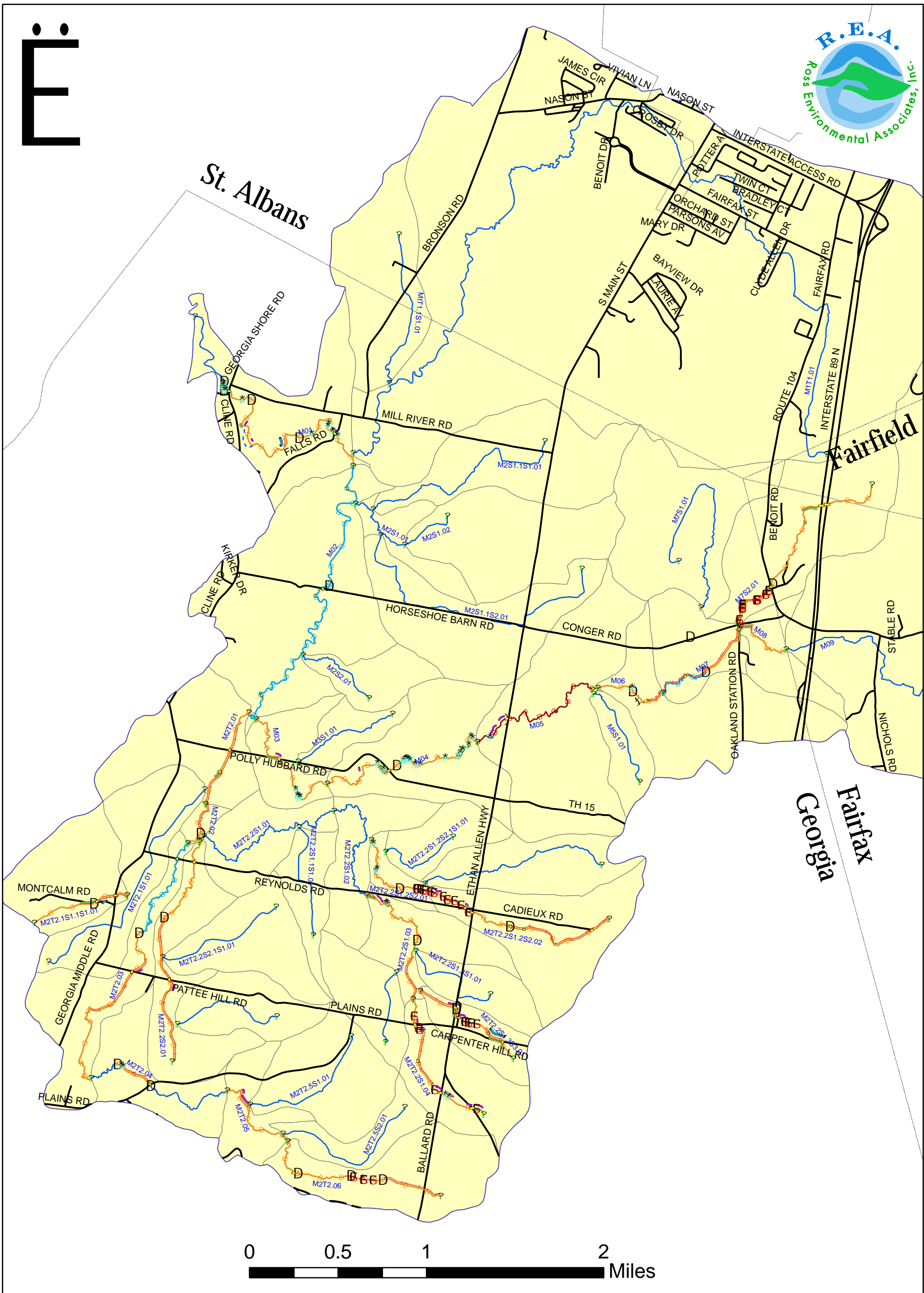
Mill River

Sediment Load Indicators

Georgia, Vermont

Appendix B

E



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Straightening
- Bridge or Culvert
- Road Encroachment
- Development
- Berm
- Railroad
- Improved Path
- Natural Grade Control
- Human Constructed Grade Control
- Headcut
- Beaver Dams per Mile <= 2
- Beaver Dams per Mile > 2 <= 5
- Beaver Dams per Mile > 5
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

Mill River
Channel Slope Modifiers
Georgia, Vermont

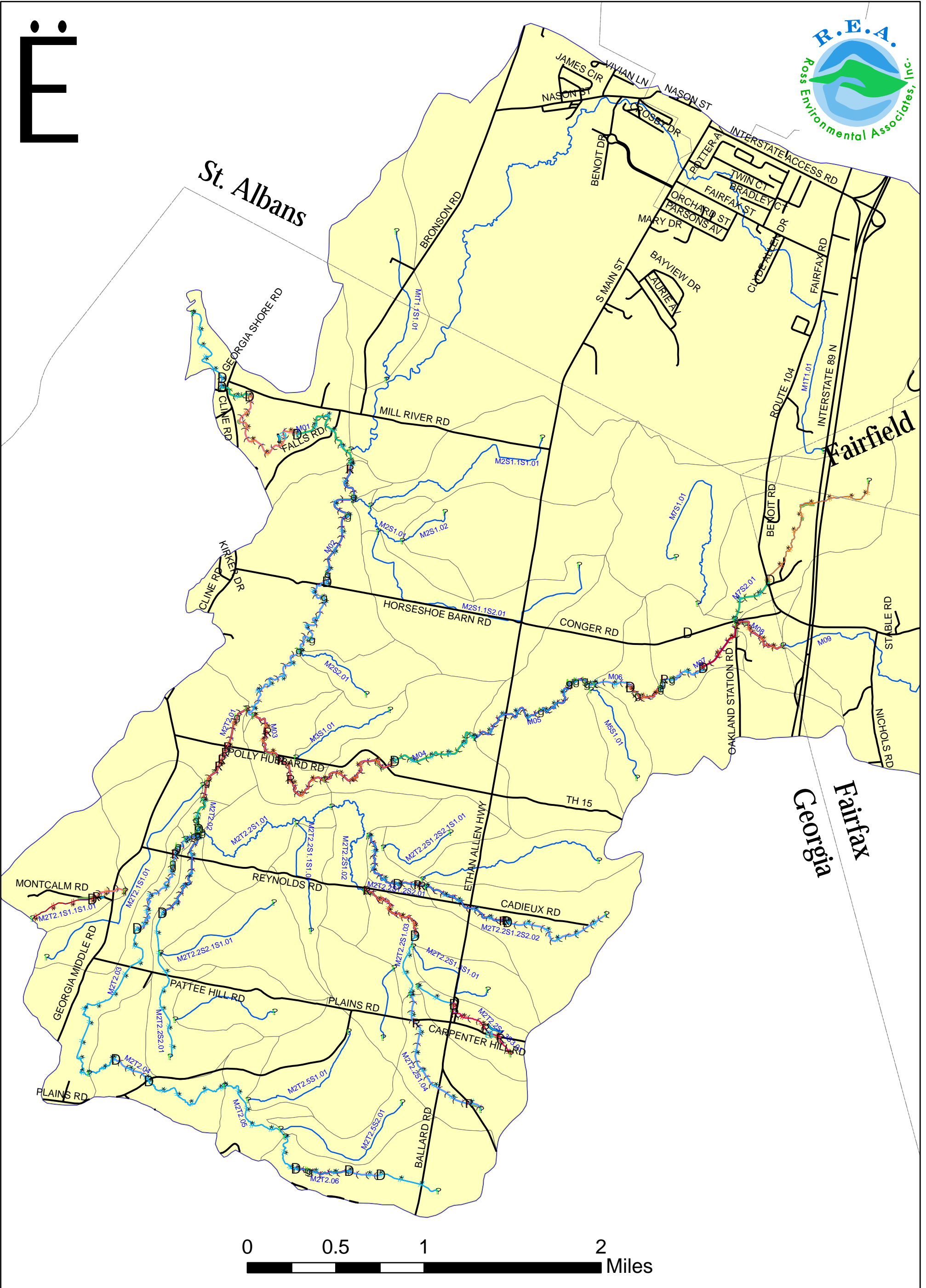
E



St. Albans

Fairfield

Georgia
Fairfax



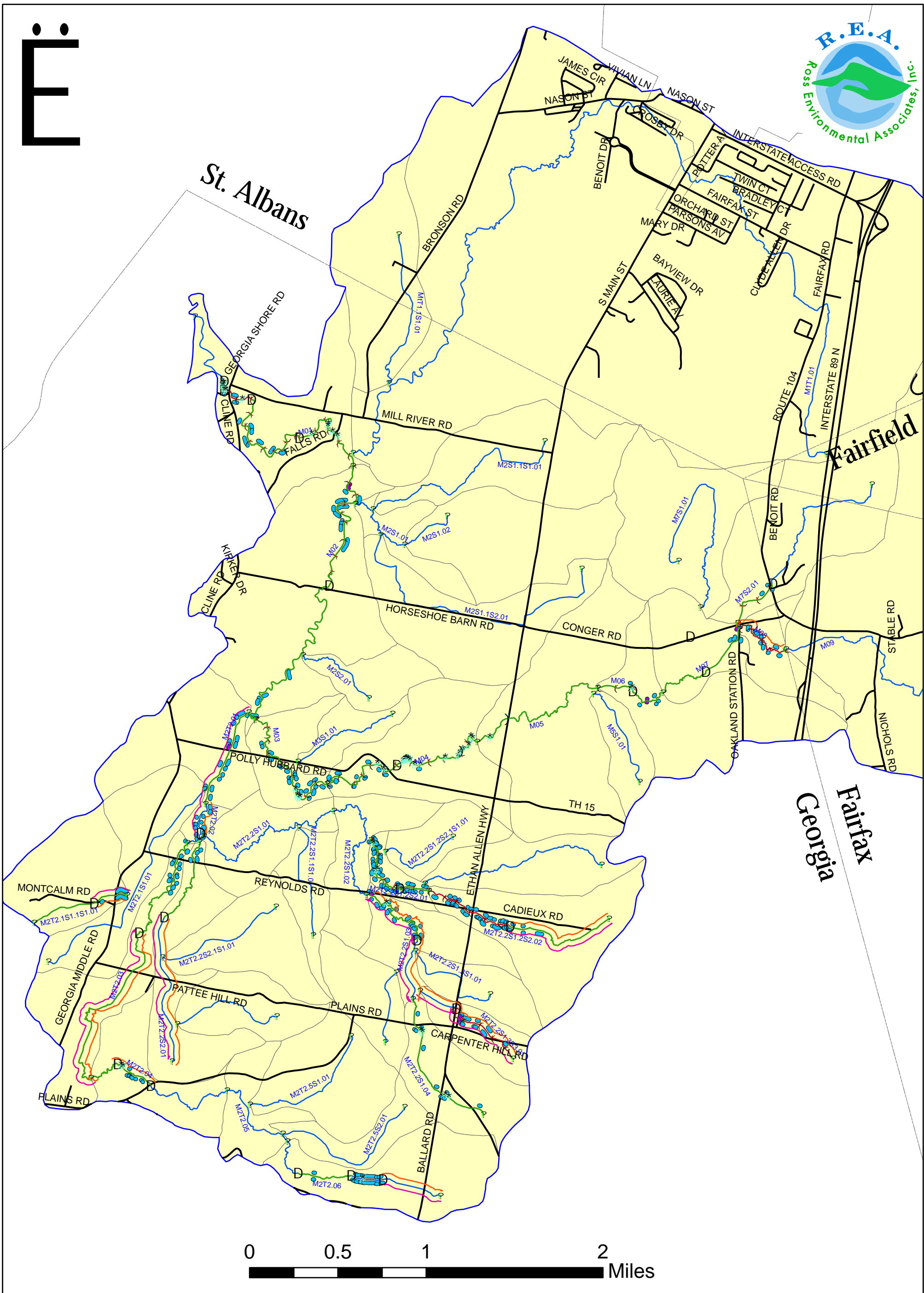
Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Dredging
- Beaver Dam
- Stormwater Input
- Road Encroachment
- Railroad
- Berm
- Percentage of Encroachments**
- <5%
- >5% <=20%
- >20%
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary
- Sum of Depositional Features per Mile**
- <=2
- >2 <=5
- >5

Mill River
Channel Depth Modifiers
Georgia, Vermont

Appendix B

E

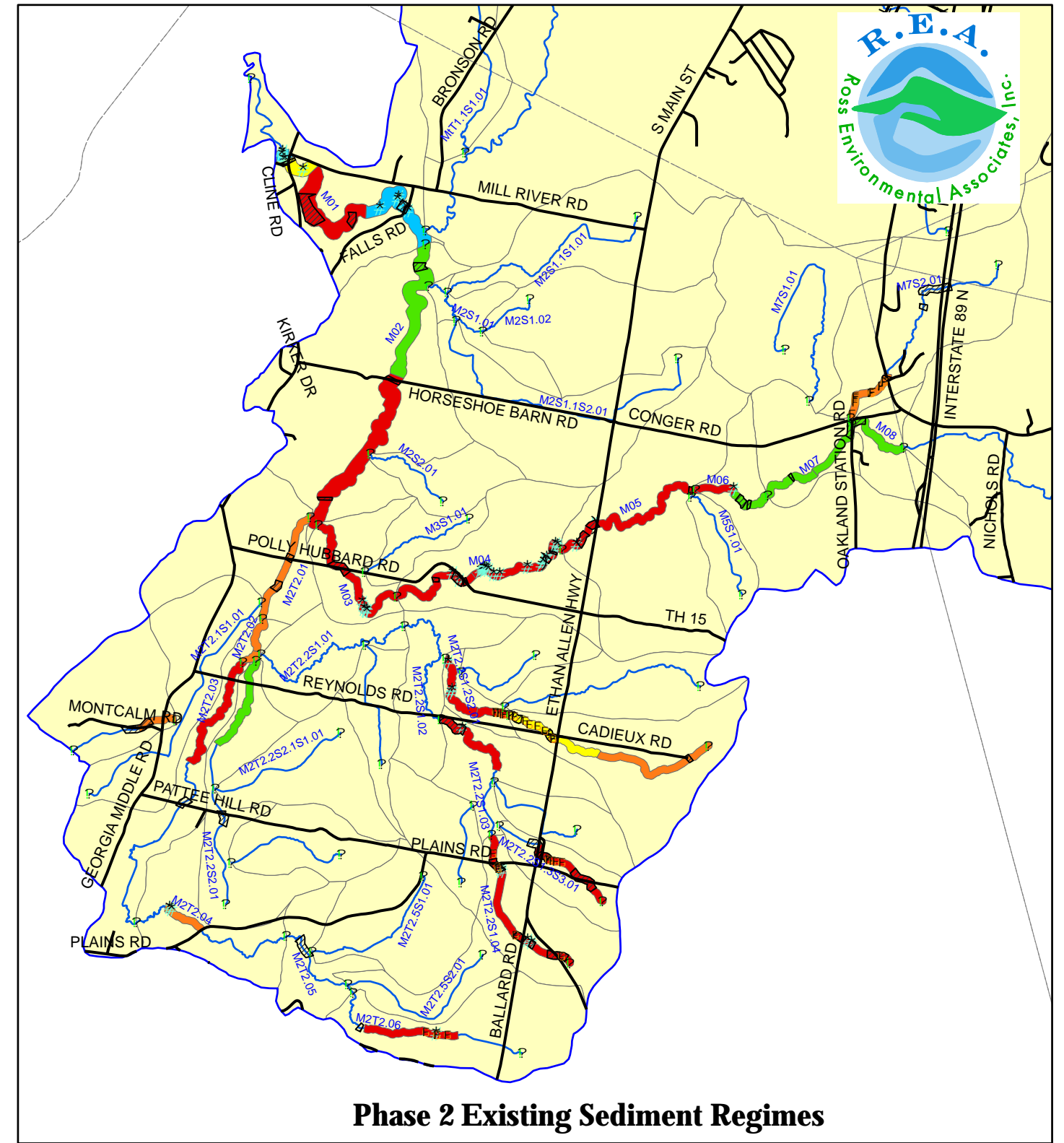
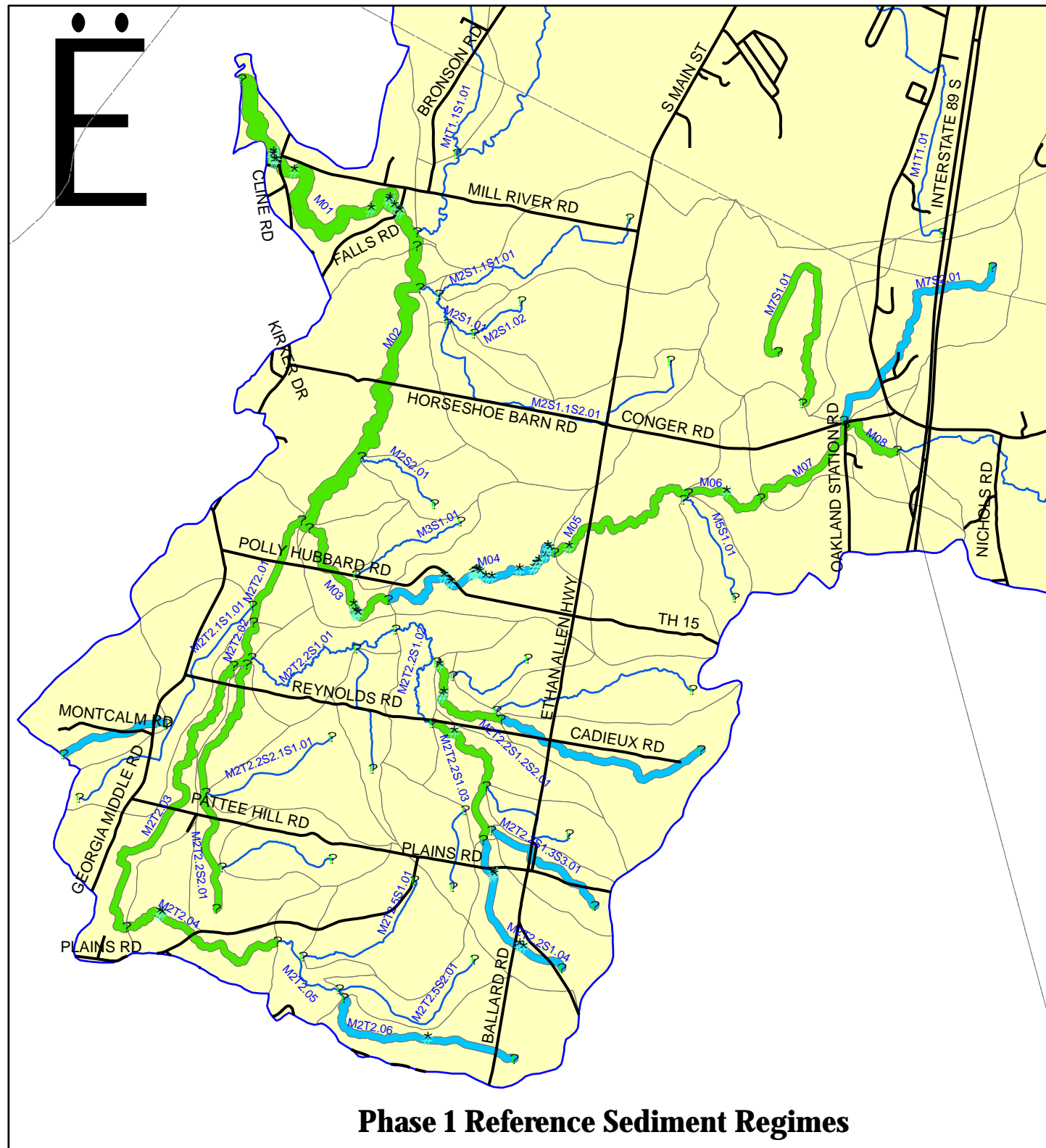


Reach Breaks	Human Constructed Grade Control	Town Boundary
Segment Breaks	Right Buffer <25 ft	Watershed Boundary
Roads	Left Buffer <25 ft	Subwatershed Boundary
Stream	Cohesive Bank Soils	
Erosion	Coarse Bed Material	
Bank Armoring		
Natural Grade Control		

Mill River

Boundary Conditions and Riparian Modifiers

Georgia, Vermont



Mill River Sediment Regime Departure Maps Georgia, Vermont

Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Natural Grade Control

Legend

- Reference Sediment Regime
- Coarse Equilibrium & Fine Deposition
- Transport

Legend

- Town Boundary
- Watershed Boundary
- Subwatershed Boundary
- Lateral Constraints
- Headcut
- Phase 2 Existing Sediment Regimes**
- Transport
- Confined Source & Transport
- Unconfined Source & Transport
- Fine Source & Transport and Coarse Deposition
- Coarse Equilibrium & Fine Deposition

0 0.5 1 2
Miles

Appendix B



St. Albans

Fairfield

Georgia
Fairfax



Legend

✕ segment_breaksall	p2_currentadjustment	STR_SENSIT	Very High	s01watershed
● s06rpts	CURRENT_AD	Very Low	Extreme	
— roadsclip	Aggradation	Moderate	Extreme	towns polygon
	Degradation	High		s05swfinaldsv
	p2_sensitivity			exp01s00subwshed

Mill River
Stream Sensitivity
Georgia, Vermont
 Appendix B

Rugg Brook

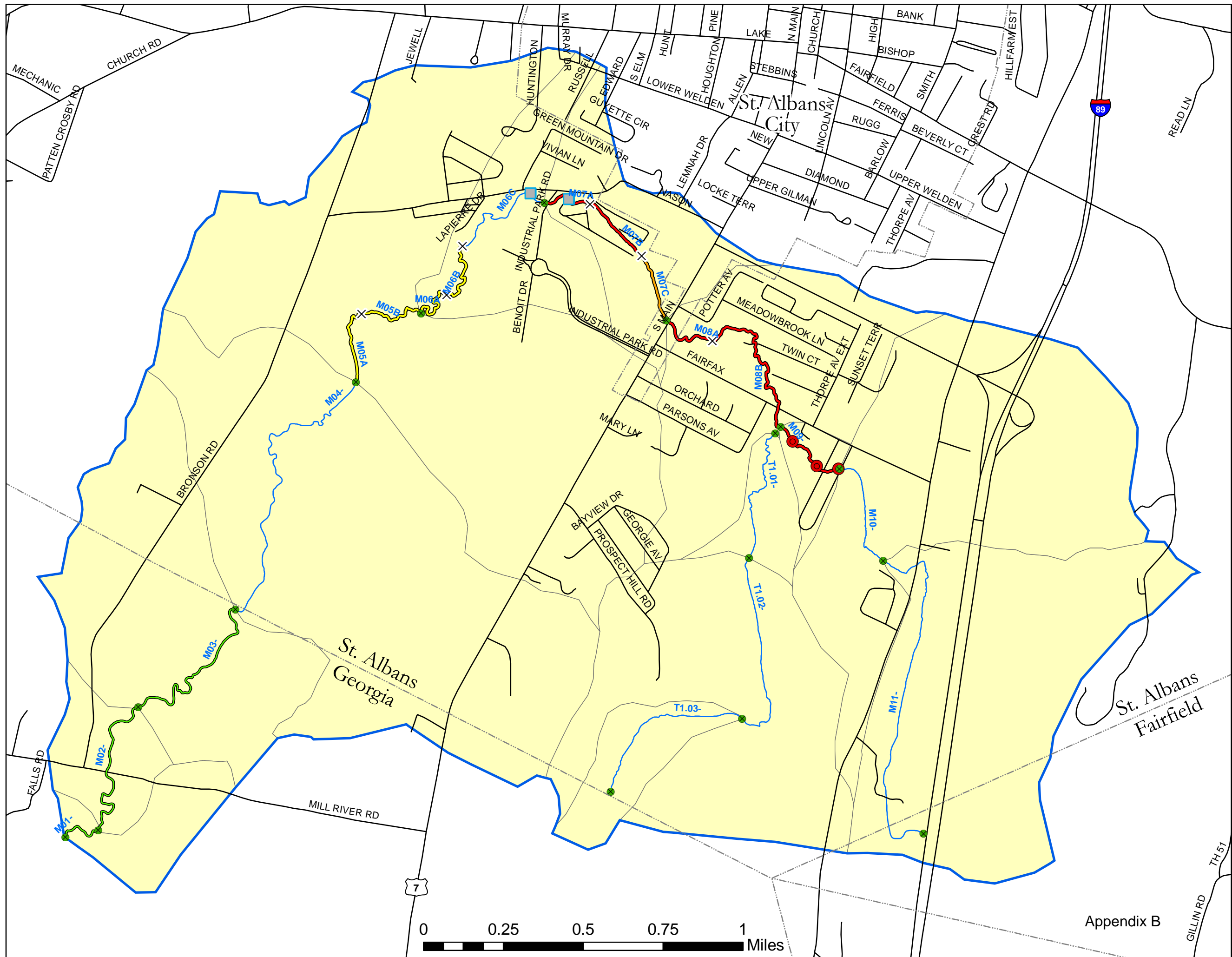
Hydrologic Alterations

St. Albans, Vermont

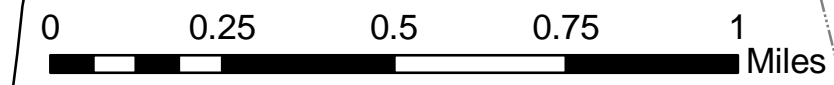


LEGEND

- Reach Breaks
 - × Segment Breaks
 - Dam/Diversion Structure
 - Brook
 - Roads
 - Watershed Boundary
 - Subwatershed Boundary
 - Town Boundary
- Stormwater Input Range**
- Stormwater Inputs
 - ≤ 2
 - $> 2 \leq 5$
 - > 5
 - Unknown



Vermont Coordinate System
 Transverse Mercator, NAD 83.
 For planning purposes only.
 Prepared by:
 Northwest Regional
 Planning Commission
 155 Lake Street
 St. Albans, VT 05478
 802.524.5958
 www.nrpvt.com



Rugg Brook

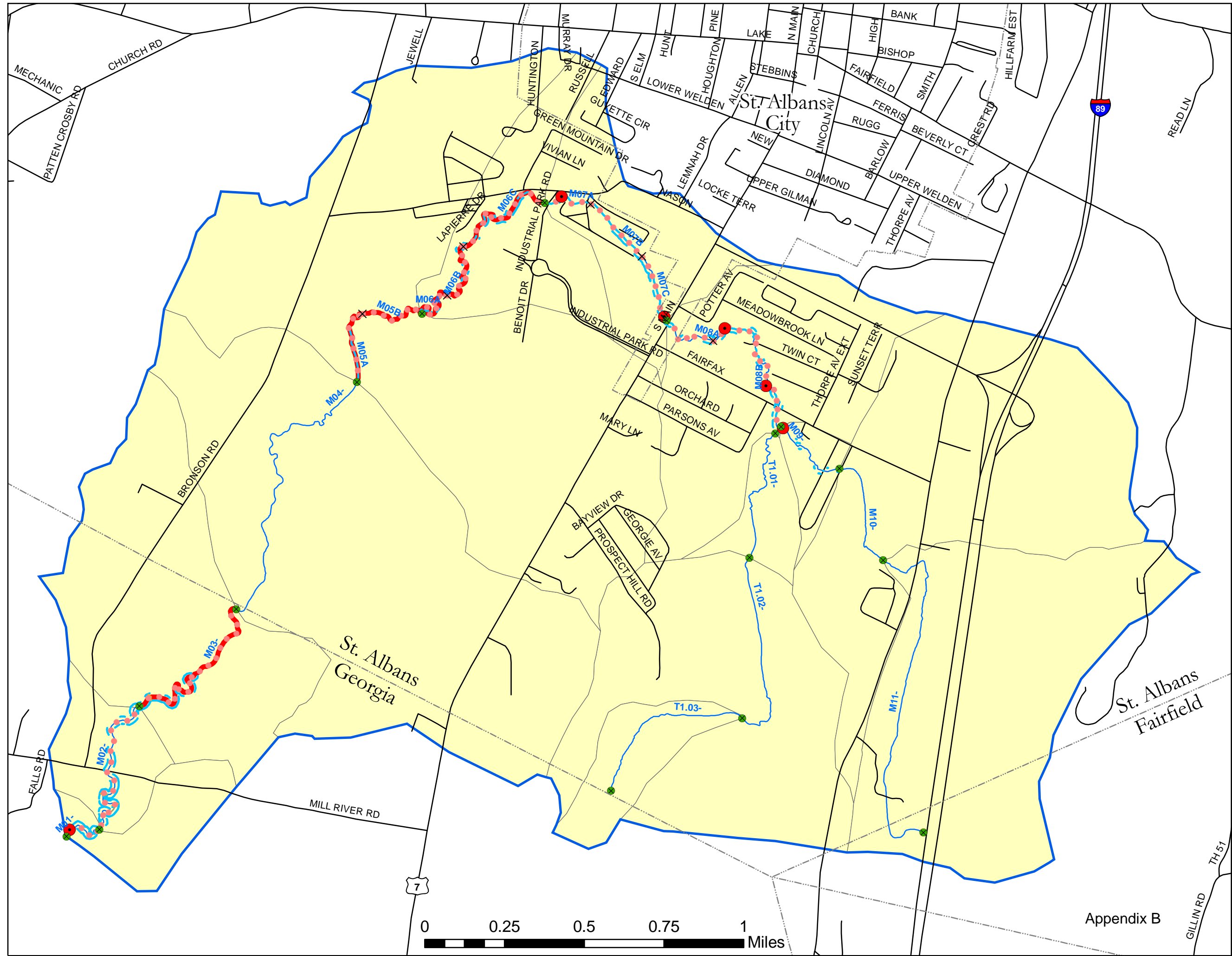
Sediment Load Indicators

St. Albans, Vermont

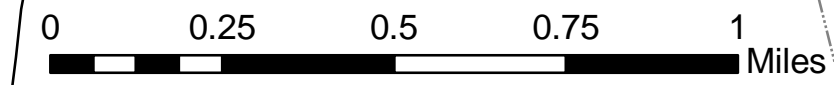


LEGEND

- Reach Breaks
- × Segment Breaks
- Steep Riffle
- Brook
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary
- ◆◆◆◆ Mass Failure
- Erosion
- Rejuvenating Tributaries
- Depositional Features Per Mile**
- >5



Vermont Coordinate System
 Transverse Mercator, NAD 83.
 For planning purposes only.
 Prepared by:
 Northwest Regional
 Planning Commission
 155 Lake Street
 St. Albans, VT 05478
 802.524.5958
 www.nrpvt.com



GILLIN RD
 TH 51

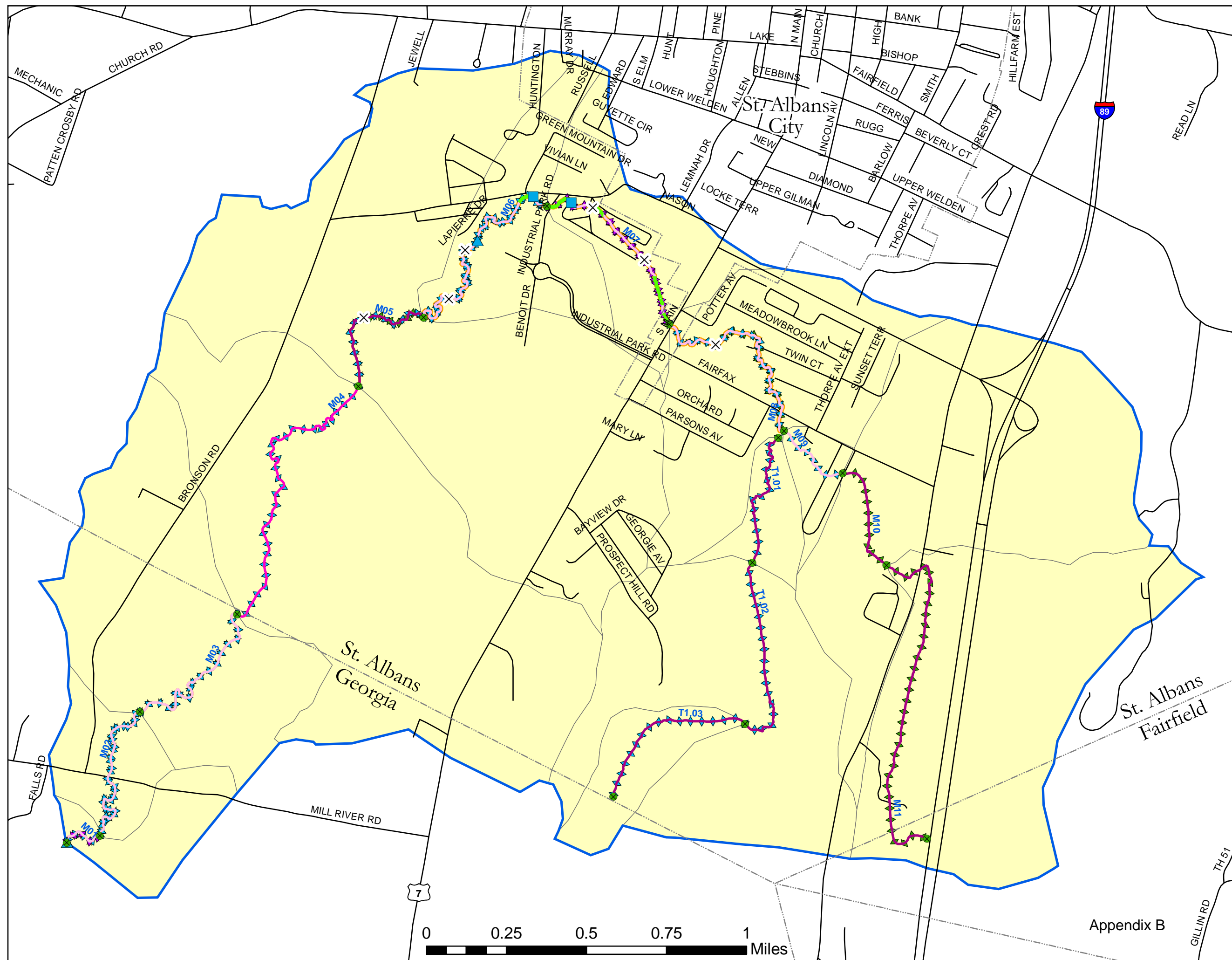
Rugg Brook

Channel Slope Modifiers

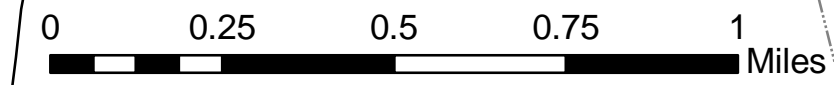
St. Albans, Vermont



- LEGEND**
- Reach Breaks
 - × Segment Breaks
 - Dam
 - ▲ Ledge
 - ★ Beaver Dams at ≤ 2 per mile
 - Road Encroachment
 - Stream
 - Roads
 - ▭ Watershed Boundary
 - ▭ Subwatershed Boundary
 - ▭ Town Boundary
- Grade Control Per Mile**
- ◆ ≤ 2
 - ◆ > 5
- % Straightening**
- <math>< 5\%</math>
 - >= 10% and <math>< 20\%</math>
 - >= 20%



Vermont Coordinate System
 Transverse Mercator, NAD 83.
 For planning purposes only.
 Prepared by:
 Northwest Regional
 Planning Commission
 155 Lake Street
 St. Albans, VT 05478
 802.524.5958
 www.nrpvt.com



GILLIN RD
 TH 51

Rugg Brook

Channel Depth Modifiers

St. Albans, Vermont



LEGEND

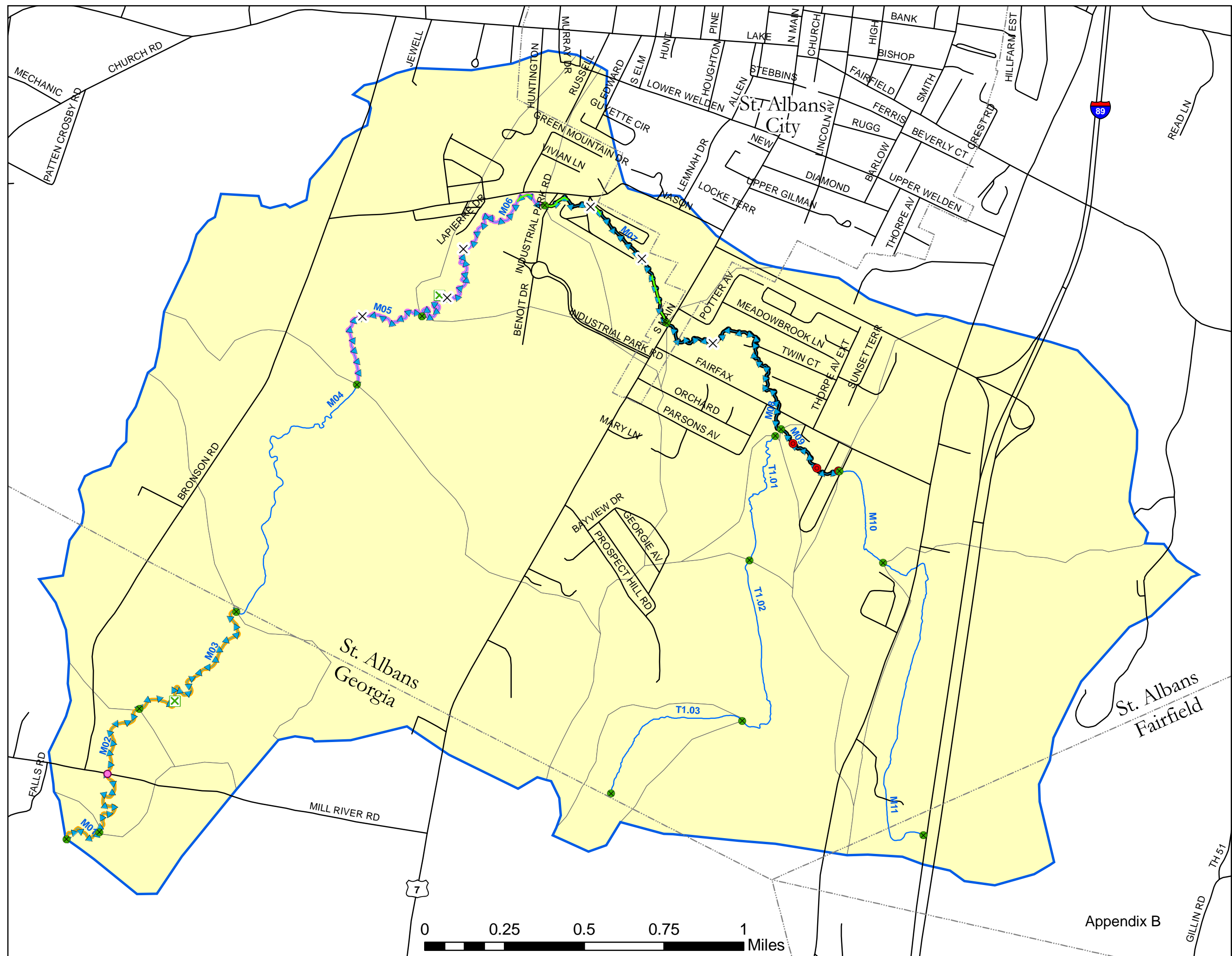
- Reach Breaks
- × Segment Breaks
- Bridge or Culvert
- ⊠ Beaver Dam
- Stormwater Inputs
- Road Encroachment
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary

Deposition Features Per Mile

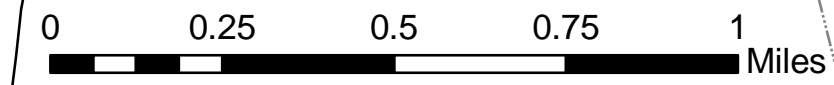
—▲▲▲▲▲ > 5 Deposition

% of Encroachments Per Mile

▲▲▲▲▲ <5%



Vermont Coordinate System
Transverse Mercator, NAD 83.
For planning purposes only.
Prepared by:
Northwest Regional
Planning Commission
155 Lake Street
St. Albans, VT 05478
802.524.5958
www.nrpvt.com



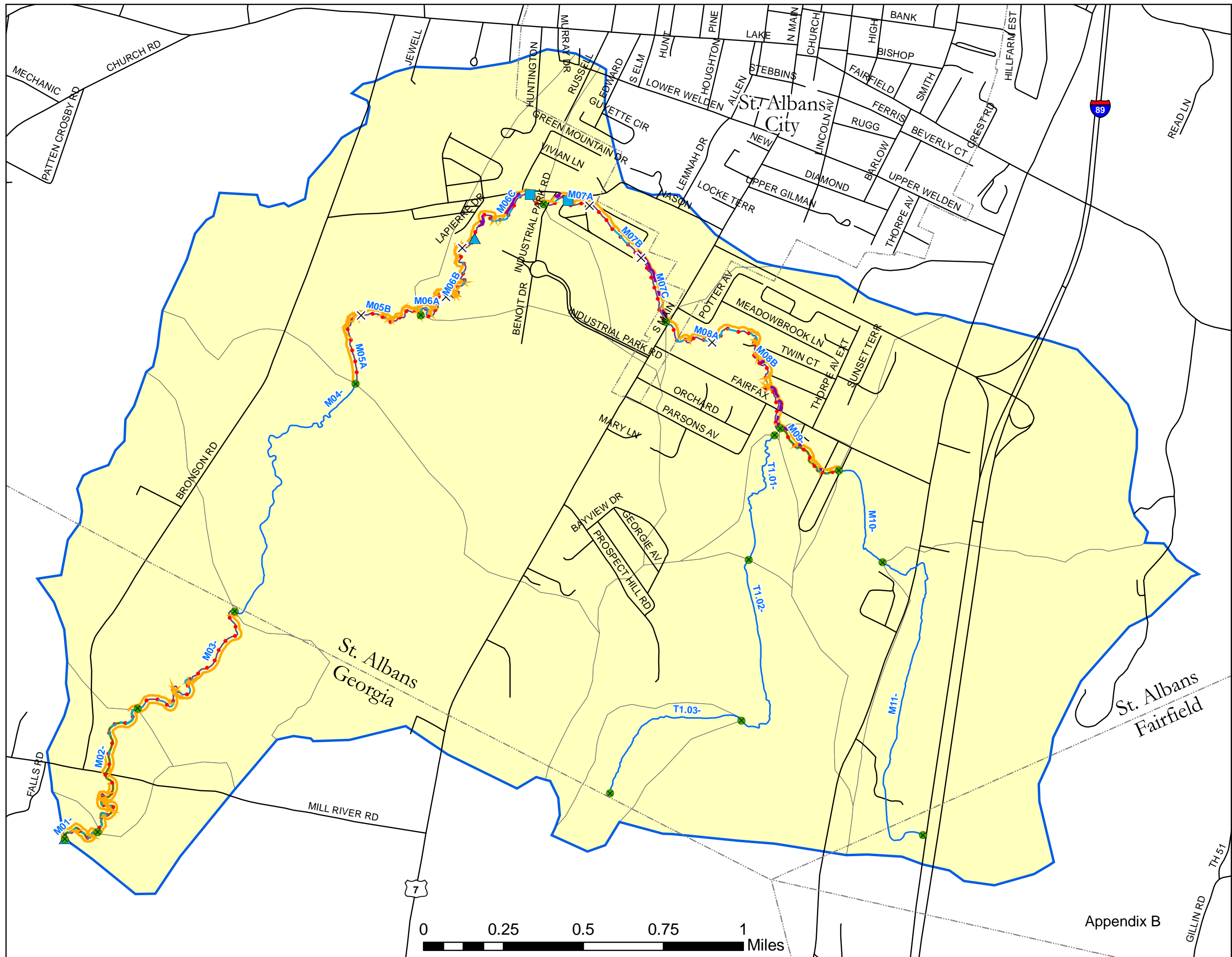
Rugg Brook

Boundary Conditions
& Riparian Modifiers
St. Albans, Vermont

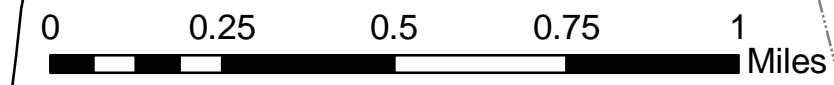


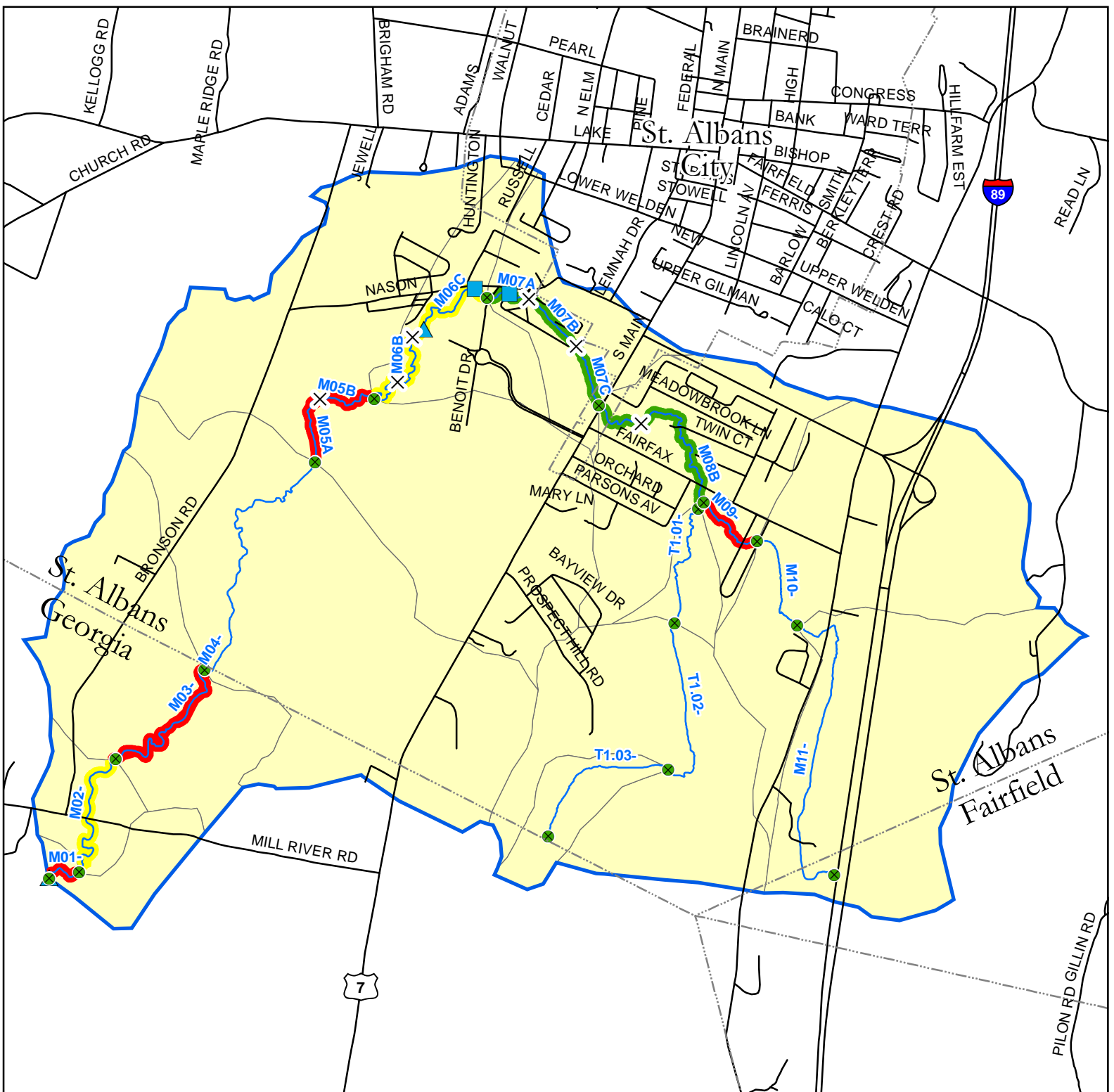
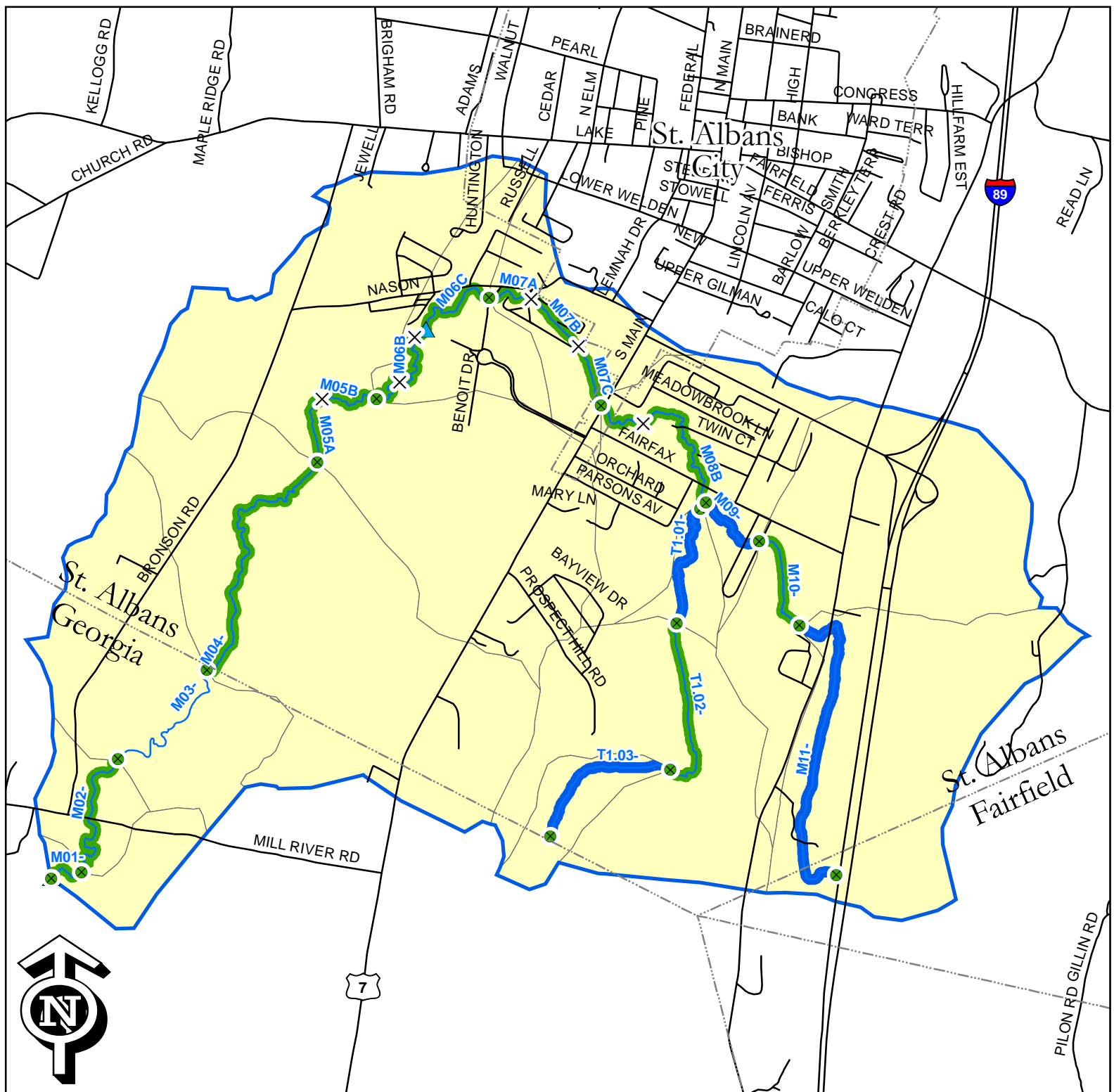
LEGEND

- Reach Breaks
- × Segment Breaks
- Dam
- ▲ Ledge
- Stream
- Roads
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary
- Buffer <25 ft
- Cohesive Bank Soils
- Coarse Bed Materials



Vermont Coordinate System
Transverse Mercator, NAD 83.
For planning purposes only.
Prepared by:
Northwest Regional
Planning Commission
155 Lake Street
St. Albans, VT 05478
802.524.5958
www.nrpvt.com





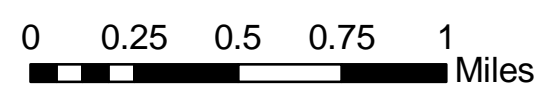
Rugg Brook

Sediment Regime Departure

St. Albans, Vermont



Vermont Coordinate System
Transverse Mercator, NAD 83.
For planning purposes only.
Prepared by:
Northwest Regional
Planning Commission
155 Lake Street
St. Albans, VT 05478
802.524.5958
www.nrpcvt.com



LEGEND

- Reach Breaks
- × Segment Breaks
- ▲ Ledge
- Brook
- Roads

LEGEND

- Watershed Boundary
- Subwatershed Boundary
- Town Boundary
- Reference Sediment Regime**
- Coarse Equilibrium & Fine Deposition
- Transport

LEGEND

- Reach Breaks
- × Segment Breaks
- Dam
- ▲ Ledge
- Brook
- Roads

LEGEND

- Watershed Boundary
- Subwatershed Boundary
- Town Boundary
- Phase 2 Existing Sediment Regimes**
- Confinement
- Fine Source Source & Transport and Course Deposition
- Coarse Equilibrium & Fine Deposition

Rugg Brook

Stream Sensitivity

St. Albans, Vermont

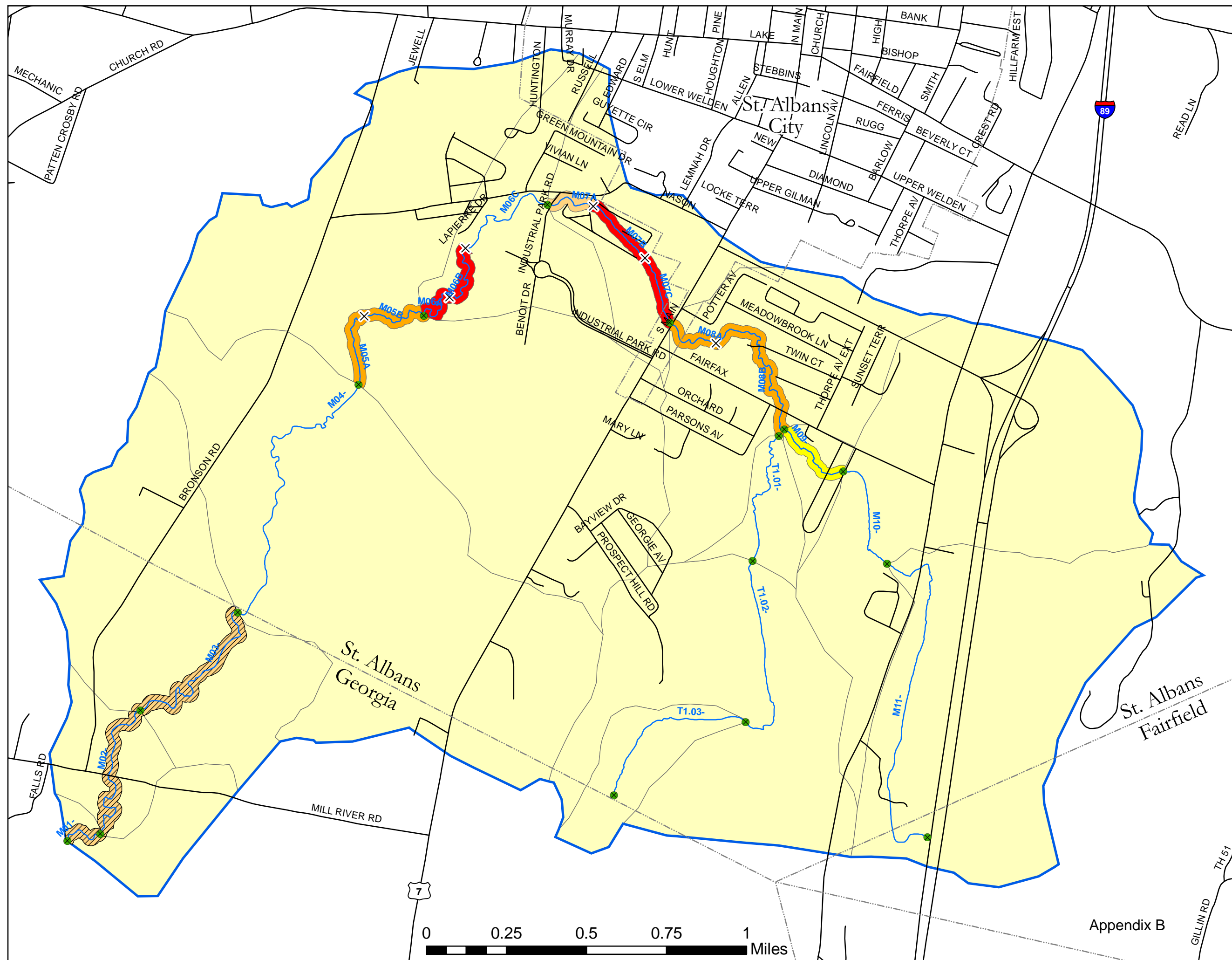


LEGEND

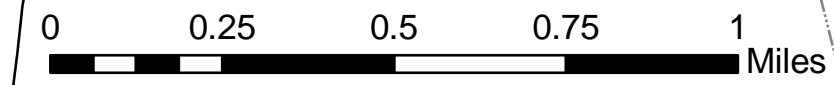
- Reach Breaks
- × Segment Breaks
- Brook
- Roads
- Degradation
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary

Stream Sensitivity

- Extreme
- Very High
- High
- Moderate



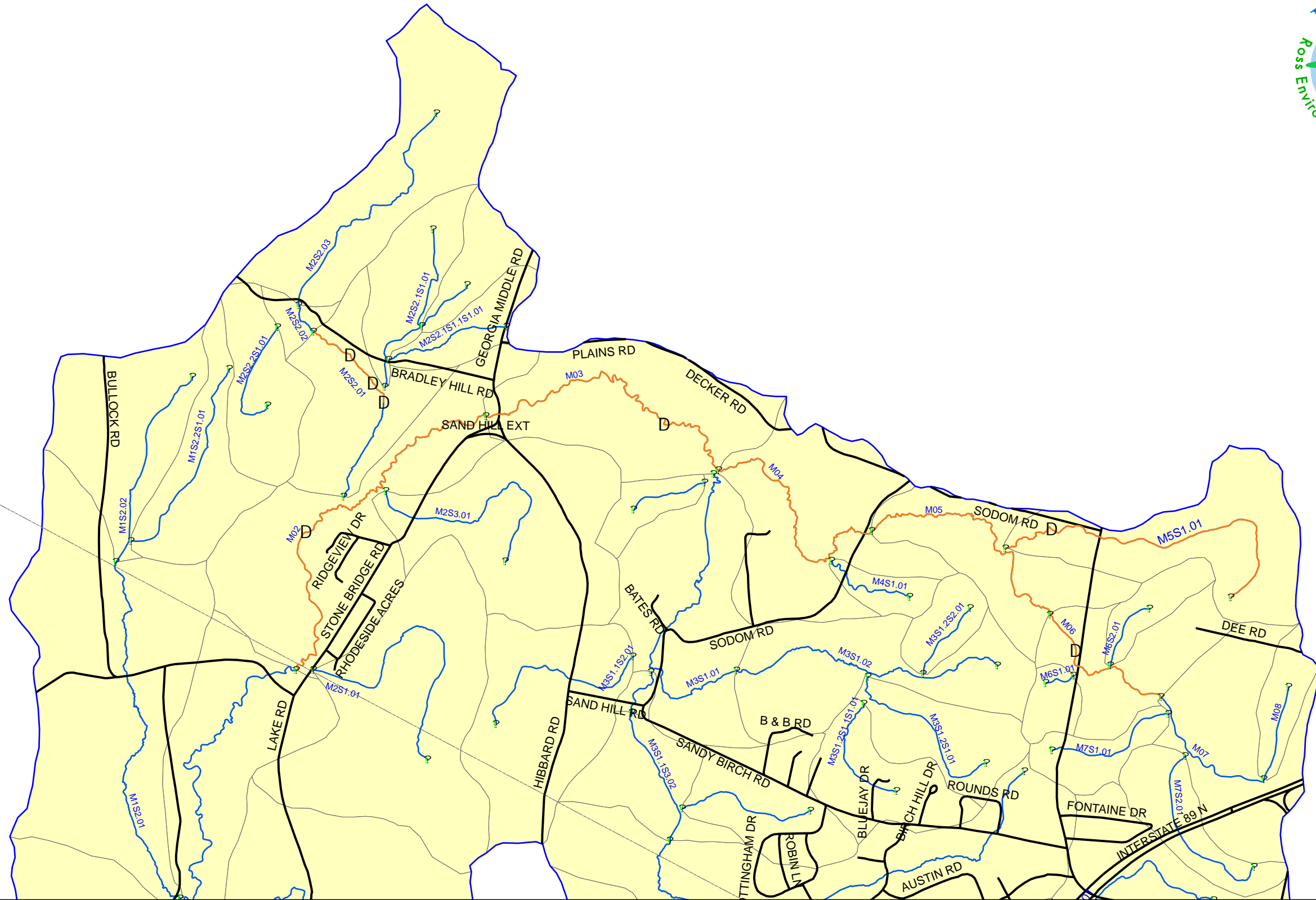
Vermont Coordinate System
 Transverse Mercator, NAD 83.
 For planning purposes only.
 Prepared by:
 Northwest Regional
 Planning Commission
 155 Lake Street
 St. Albans, VT 05478
 802.524.5958
 www.nrpvt.com



E

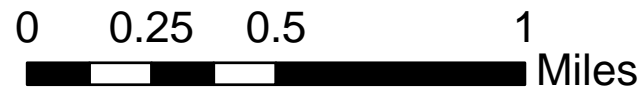


Georgia
Milton



Legend

- Reach Breaks
- Segment Breaks
- Stream
- Roads
- Stormwater Input Range**
- <=2
- >2 <= 5
- > 5
- Stormwater Inputs
- Watershed Boundary
- Subwatershed Boundary
- Town Boundary



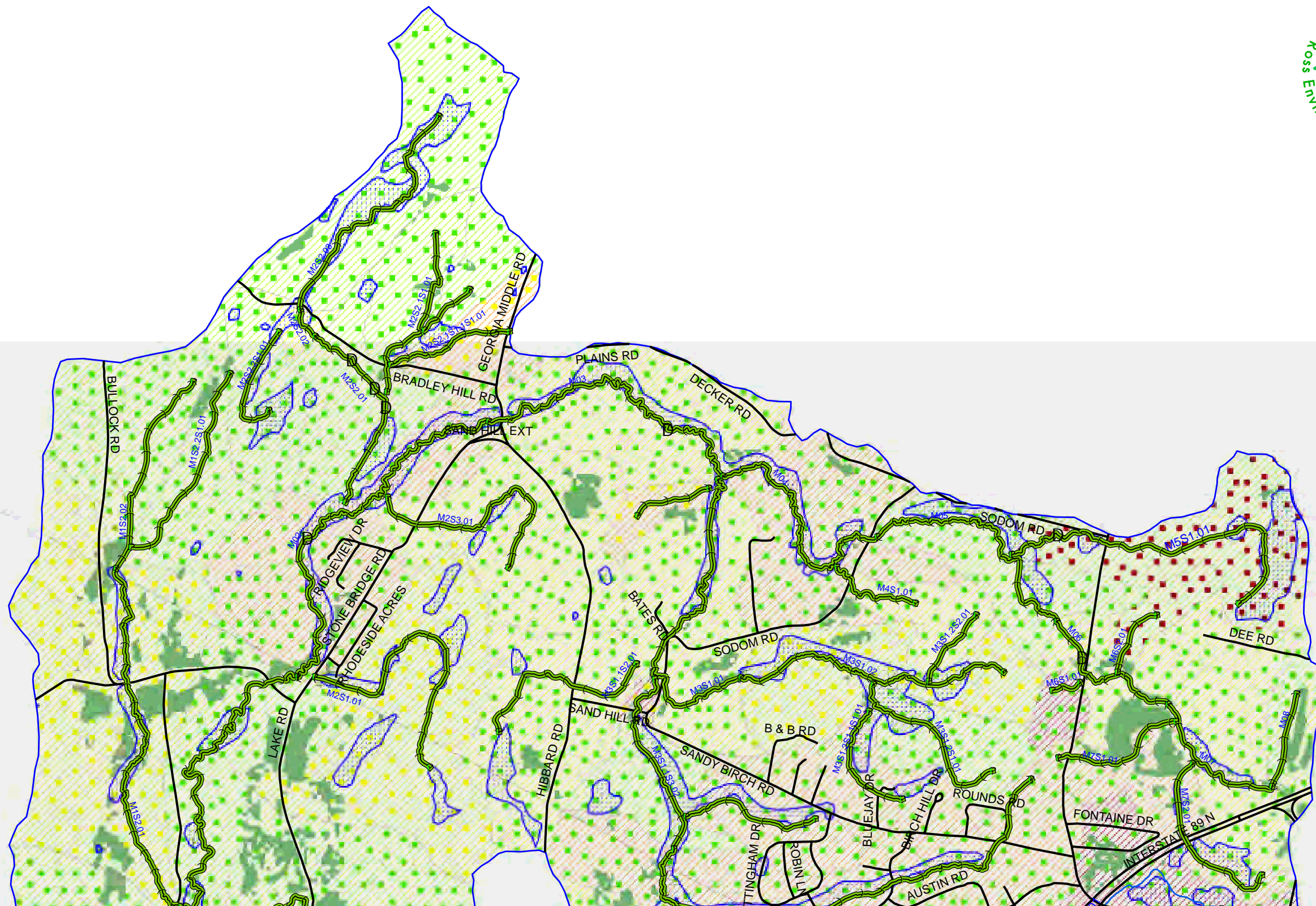
Stonebridge Brook

Hydrologic Alterations Georgia, Vermont

E



Georgia
Milton



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Wetland Loss
- Existing Wetlands
- Town Boundary
- Watershed Boundary

- Cumulative Upstream Land Use Percentage
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Cumulative Crop Land Use Percentage
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

- Urban Land Use
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Crop Land Use
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%



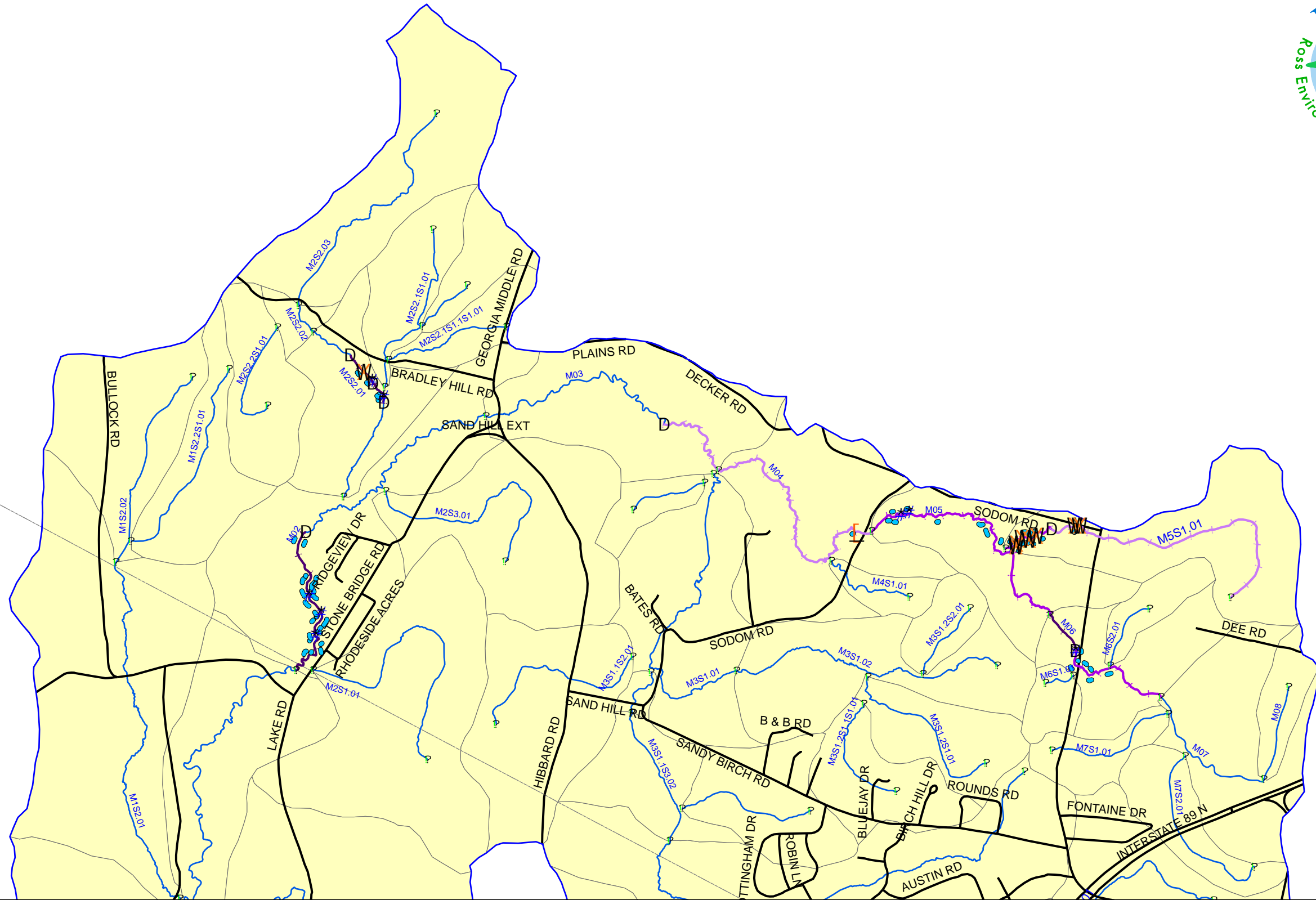
Stonebridge Brook

Land Use/Land Cover
Georgia, Vermont

E



Georgia
Milton



Legend

- Reach Breaks
- Segment Breaks
- Stream
- Roads
- Avulsions
- Flood Chute
- Mass Failure
- Erosion
- Depositional Features Per Mile
 - ≤2
 - >2 ≤5
 - >5
- Subwatershed Boundary
- Watershed Boundary
- Town Boundary

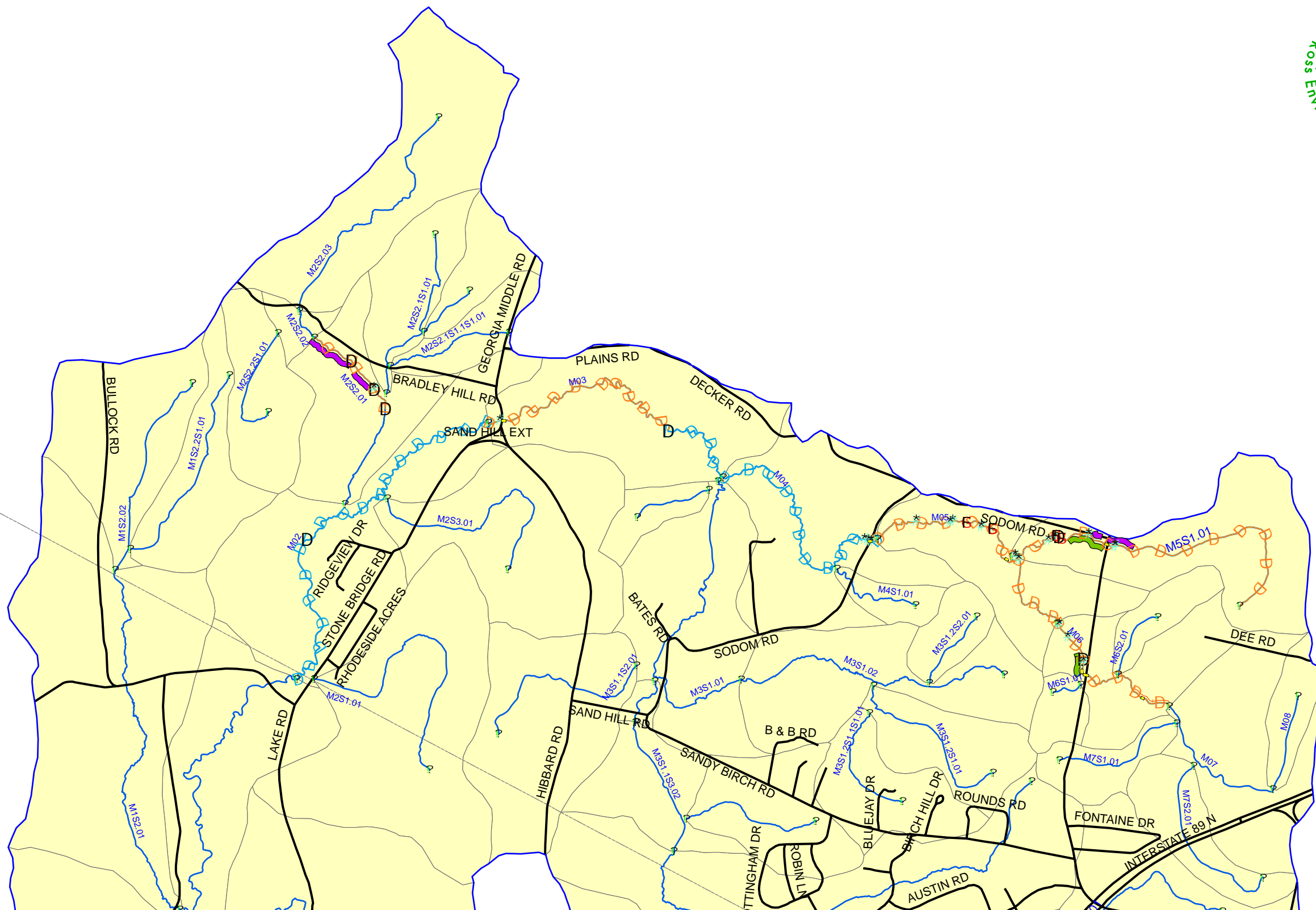


Stonebridge Brook
Sediment Load Indicators
Georgia, Vermont

E

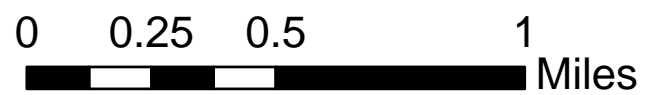


Georgia
Milton



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Straightening
- Bridge or Culvert
- Road Encroachment
- Development
- Natural Grade Control
- Headcut
- Beaver Dams per Mile
 - <=2
 - >2 <= 5
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary



Stonebridge Brook

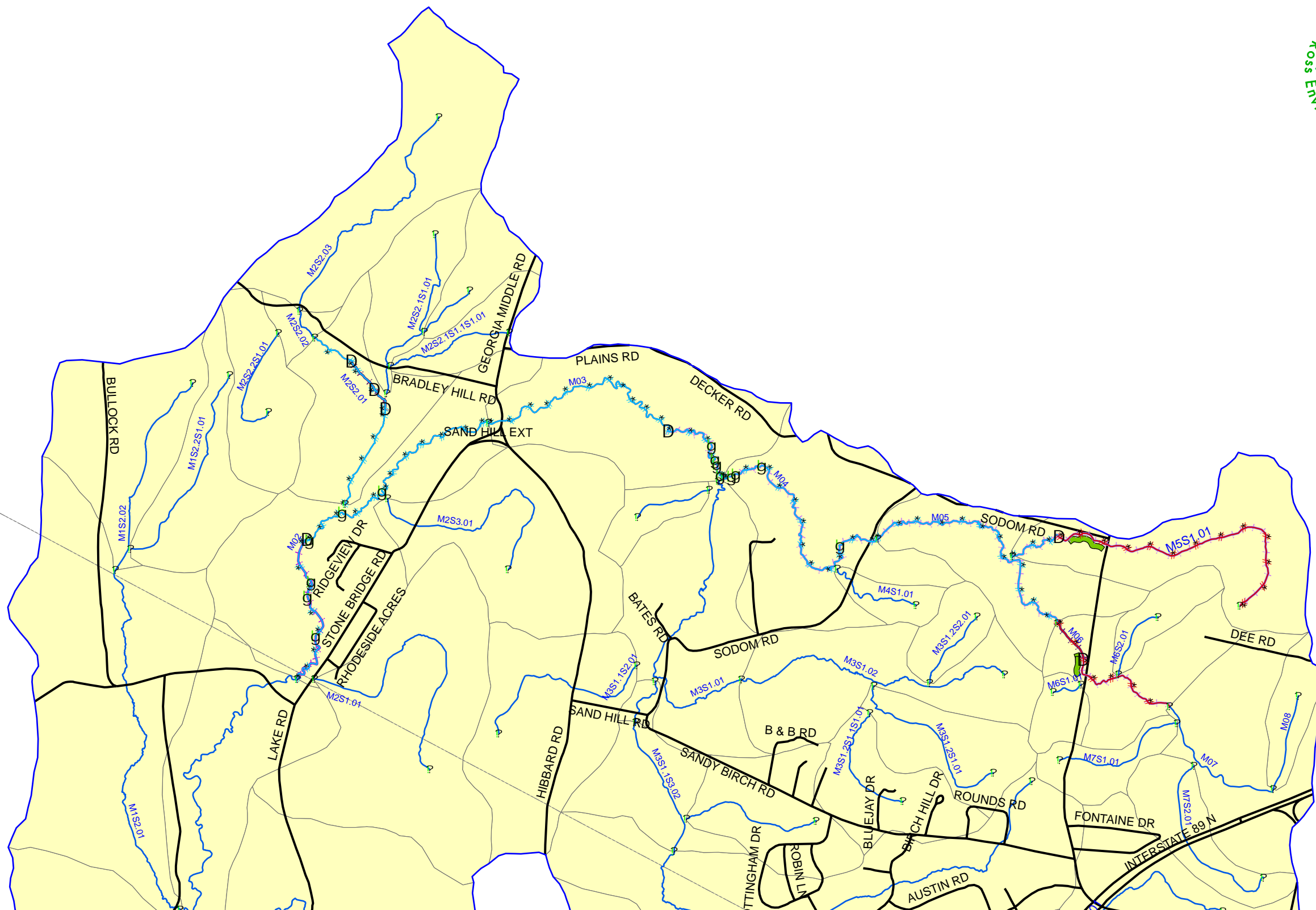
Channel Slope Modifiers

Georgia, Vermont

E

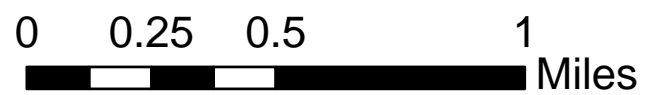


Georgia
Milton



Legend

- | | | |
|-------------------|------------------------------------|--|
| Reach Breaks | Stormwater Inputs Range | Sum of Depositional Features per Mile |
| Segment Breaks | <=2 | <=2 |
| Roads | Percentage of Encroachments | >2 <= 5 |
| Stream | <5% | > 5 |
| Road Encroachment | >5% <=20% | Town Boundary |
| Beaver Dam | | Watershed Boundary |
| | | Subwatershed Boundary |



Stonebridge Brook

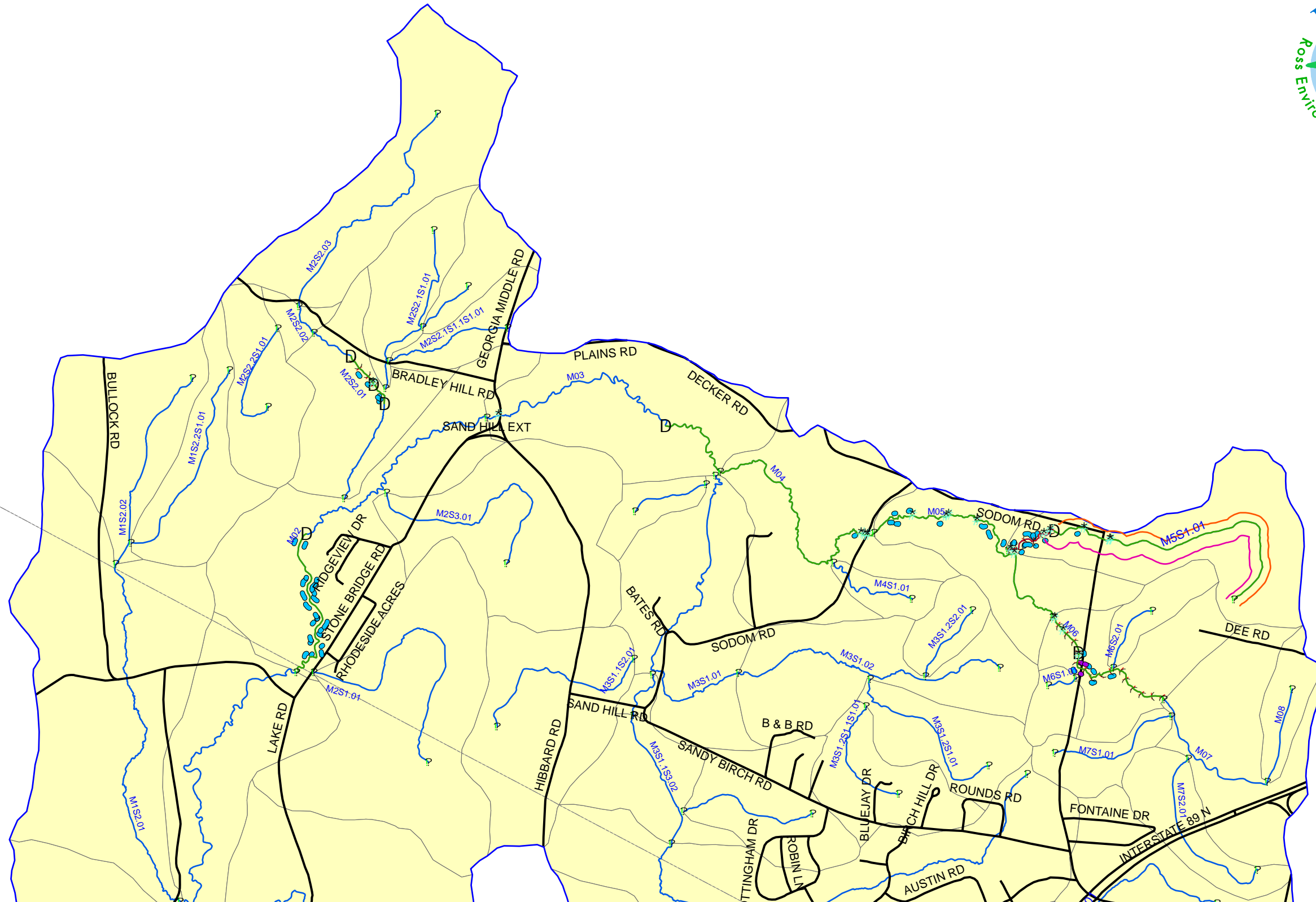
Channel Depth Modifiers

Georgia, Vermont

E



Georgia
Milton



Legend

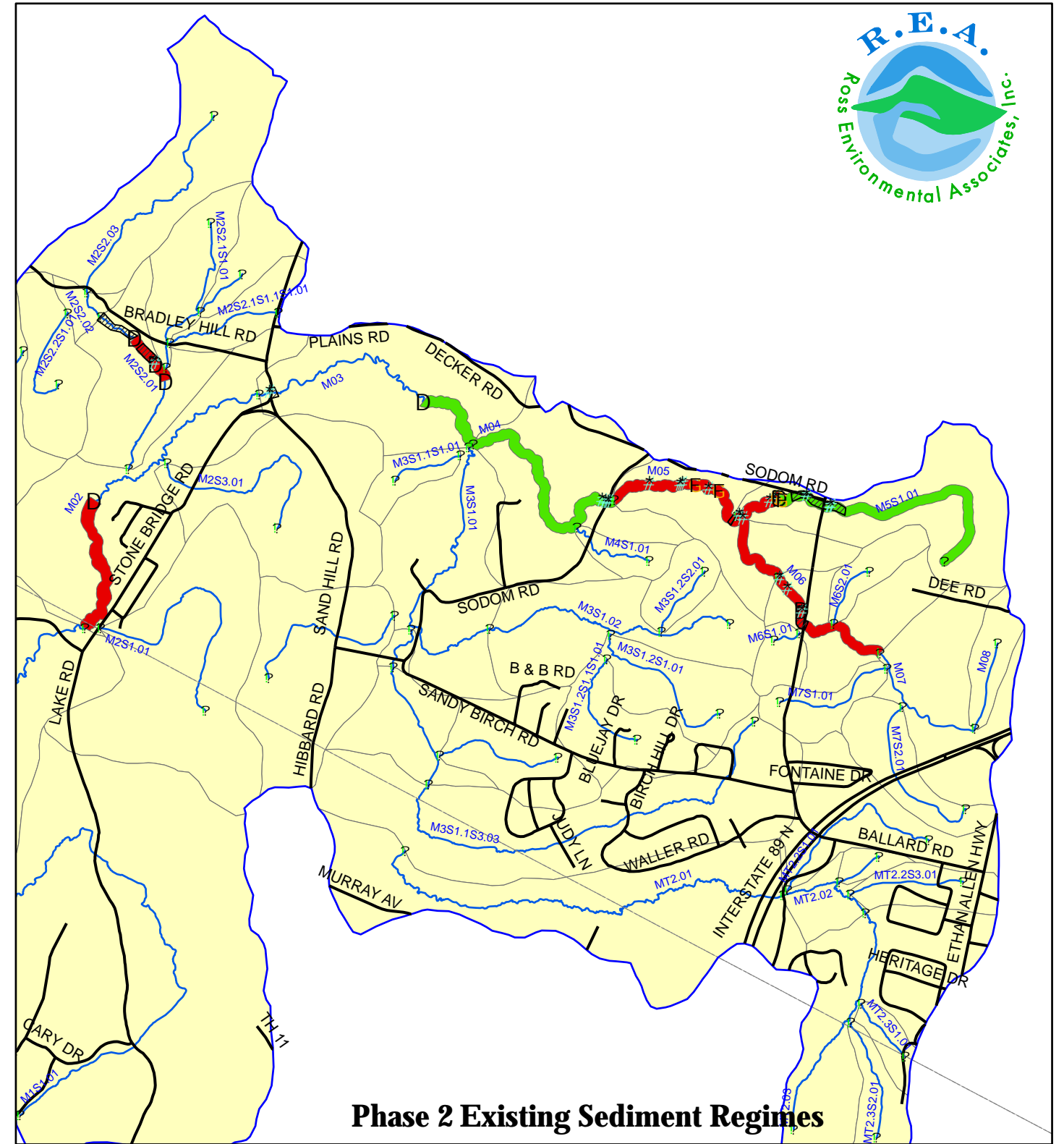
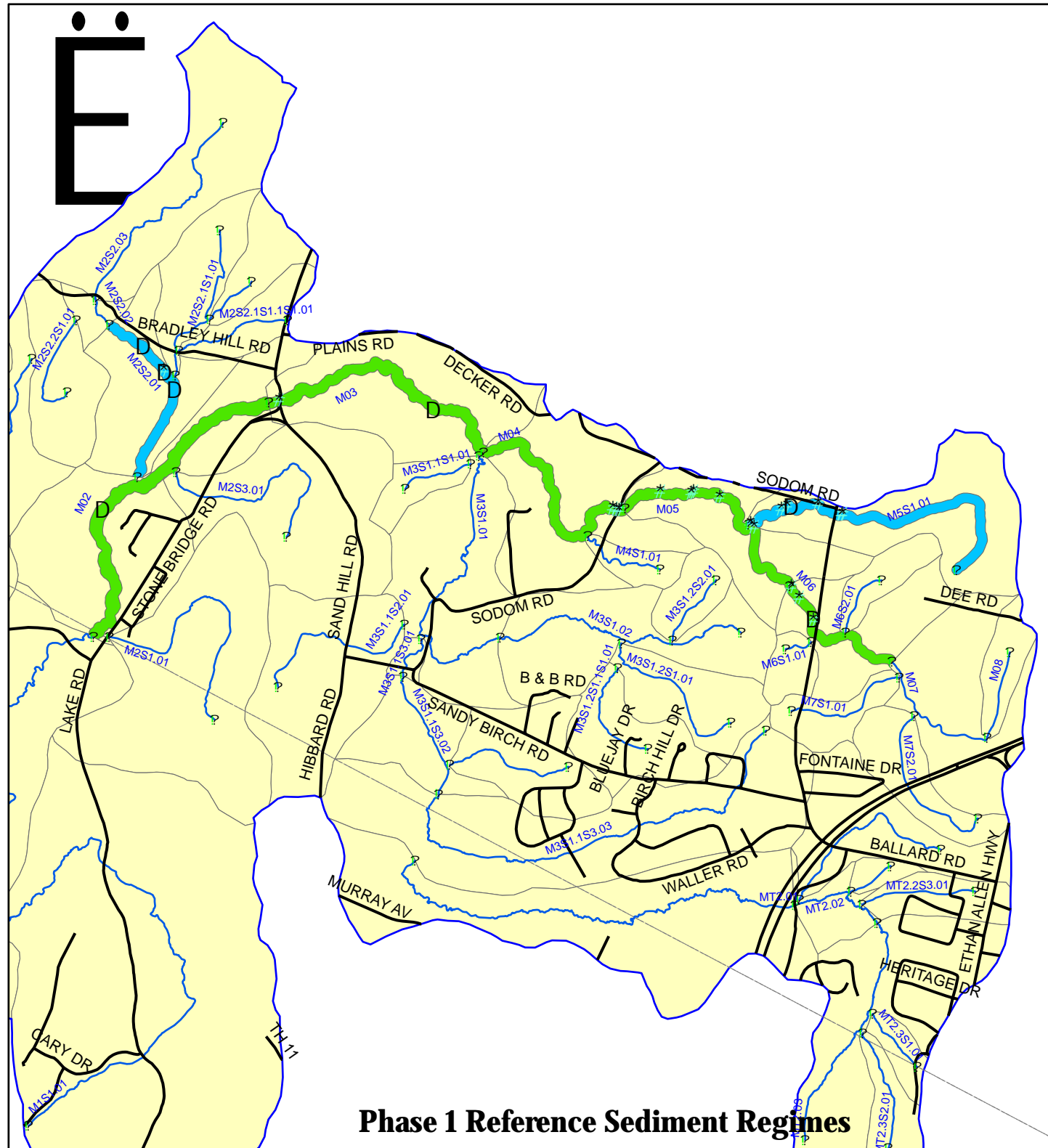
- | | | |
|-----------------------|---------------------------------|-----------------------|
| Reach Breaks | Human Constructed Grade Control | Town Boundary |
| Segment Breaks | Right Buffer <25 ft | Watershed Boundary |
| Roads | Left Buffer <25 ft | Subwatershed Boundary |
| Stream | Cohesive Bank Soils | |
| Erosion | Coarse Bed Material | |
| Bank Armoring | | |
| Natural Grade Control | | |



Stonebridge Brook

Boundary Conditions and Riparian Modifiers

Georgia, Vermont



Stonebridge Brook Sediment Regime Departure Maps Georgia, Vermont

Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Natural Grade Control

Reference Sediment Regime

- Coarse Equilibrium & Fine Deposition
- Transport

Town Boundary

- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Natural Grade Control
- Human Constructed Grade Controls

Phase 2 Existing Sediment Regimes

- Transport
- Confined Source & Transport
- Unconfined Source & Transport
- Fine Source & Transport and Coarse Deposition
- Coarse Equilibrium & Fine Deposition

Town Boundary

- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

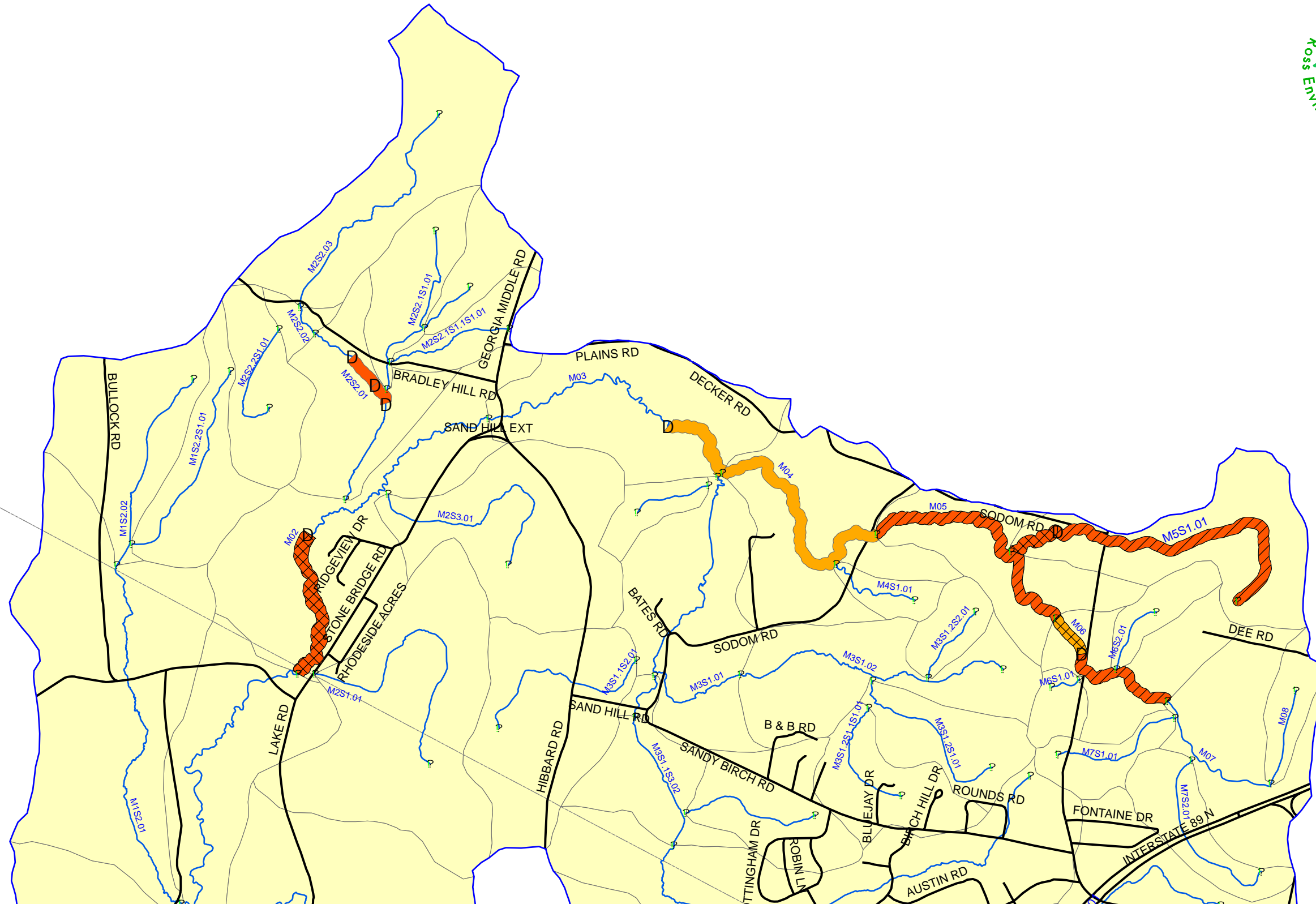
0 0.25 0.5 1 Miles

Appendix B

E



Georgia
Milton



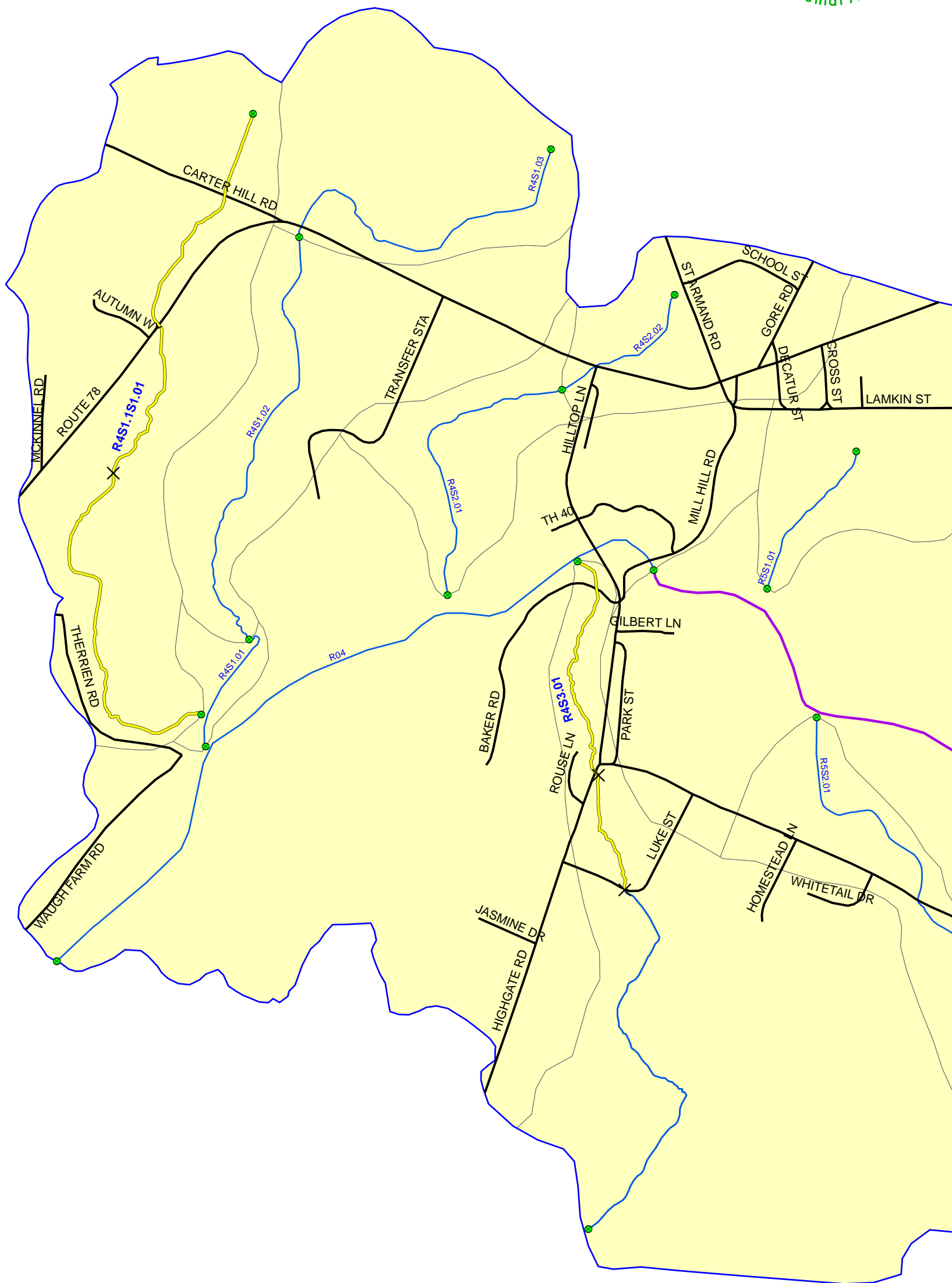
Legend

- Reach Breaks (green square with 'P')
- Segment Breaks (black square with 'D')
- Roads (black line)
- Stream (blue line)
- Current Adjustment Process
 - Aggradation (cross-hatched box)
 - Degradation (diagonal-hatched box)
- Stream Sensitivity
 - Very Low (green box)
 - Moderate (yellow box)
 - High (orange box)
 - Very High (red-orange box)
 - Extreme (red box)
- Town Boundary (dashed line)
- Watershed Boundary (blue outline)
- Subwatershed Boundary (yellow outline)

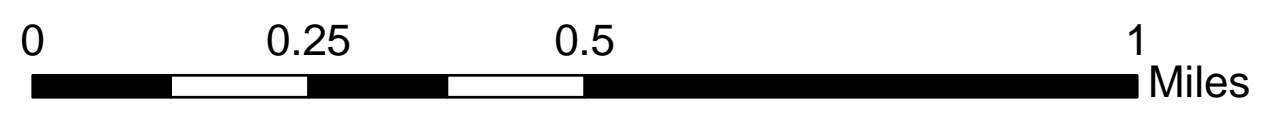


Stonebridge Brook

**Stream Sensitivity
Georgia, Vermont**



Highgate
Swanton



Legend

- Reach Breaks
 - X Segment Breaks
 - Stream
 - Roads
 - Phase 1 Significant Flow Regulation
 - Watershed Boundary
 - Subwatershed Boundary
 - Town Boundary
- Stormwater Input Range
- <=2
 - >2 <= 5
 - > 5
- Stormwater Inputs

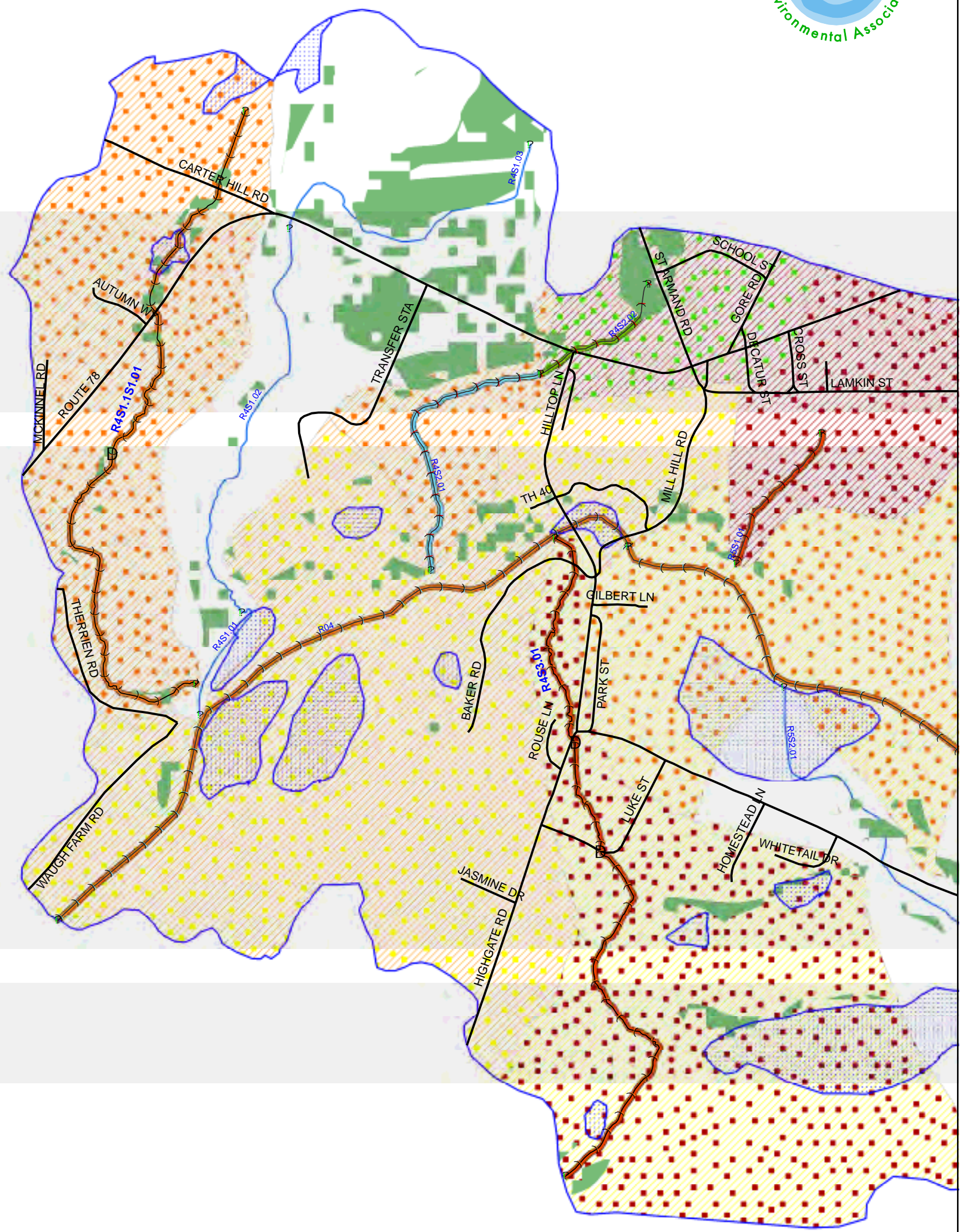
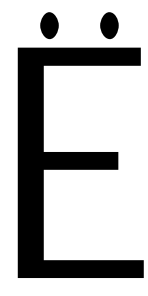
Missisquoi

Black to Hungerford

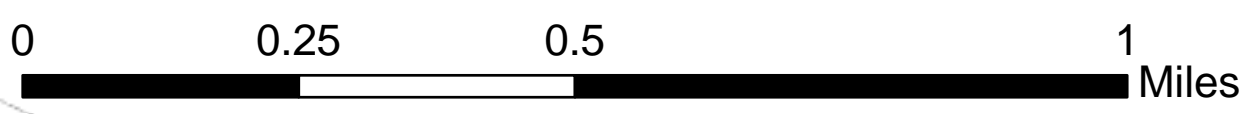
Hydrologic Alterations Map

Highgate, Vermont

Appendix B



Highgate
Swanton



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Wetland Loss
- Existing Wetlands
- Town Boundary
- Watershed Boundary

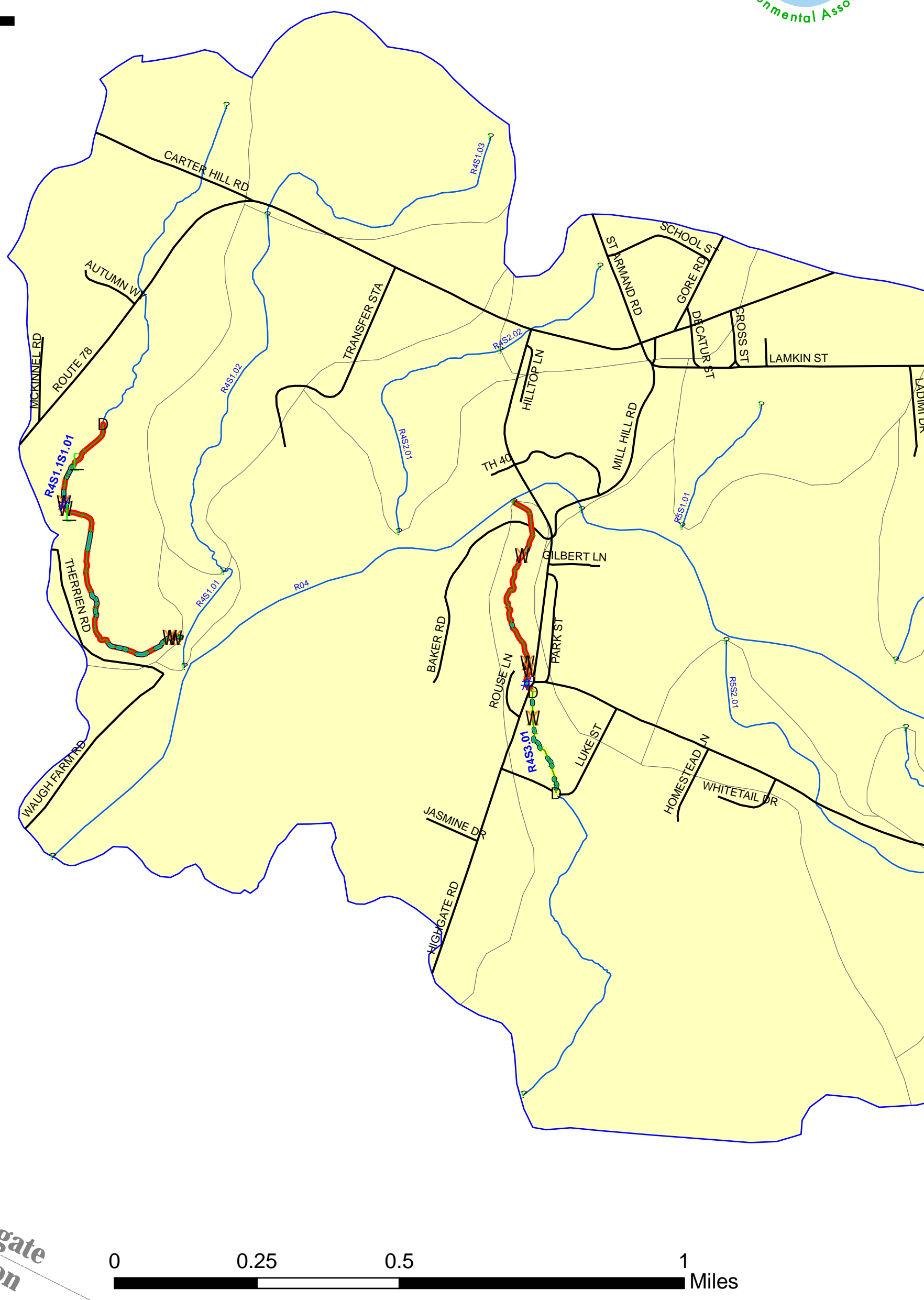
- Cumulative Upstream Urban Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Cumulative Crop Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

- Urban Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Crop Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

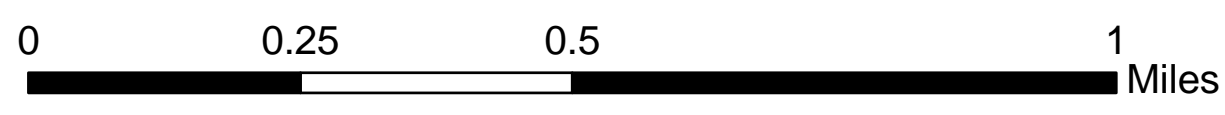
**Missisquoi
Black to Hungerford
Land Use/Land Cover Map
Highgate, Vermont** Appendix B



E



Highgate
Swanton

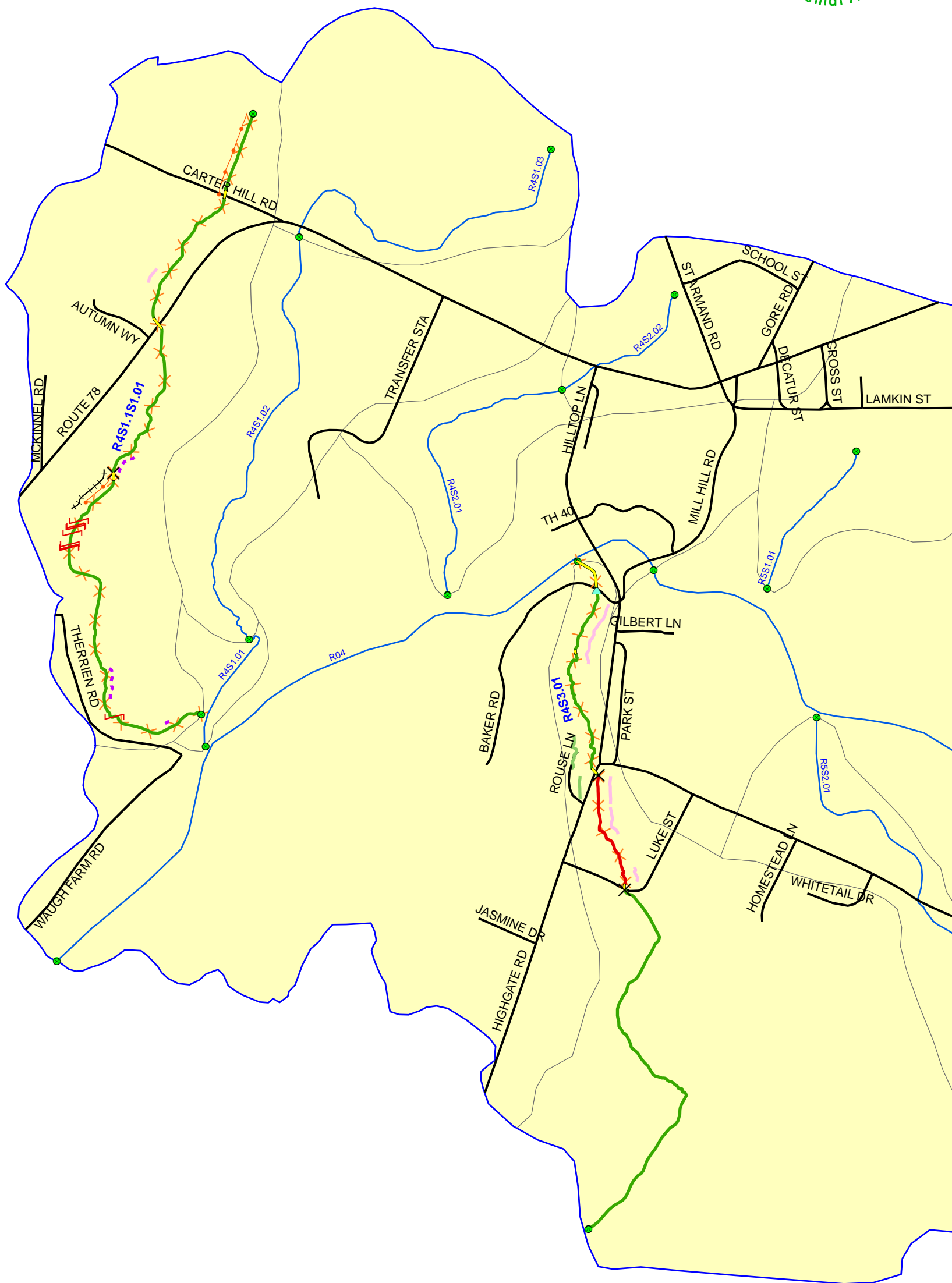


Legend

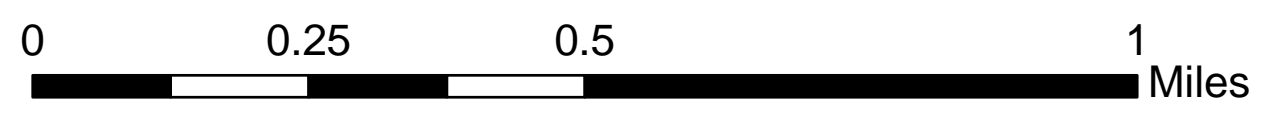
- | | | |
|----------------|-----------------------------------|-----------------------|
| Reach Breaks | Flood Chute | Watershed Boundary |
| Segment Breaks | Avulsions | Subwatershed Boundary |
| Stream | Depositional Features Per Mile | Town Boundary |
| Roads | > 5 | |
| Erosion | Gullies or Mass Failures Per Mile | |
| Mass Failure | >2 <= 5 | |
| | > 5 | |

**Missisquoi
Black to Hungerford
Sediment Load Indicators Map
Highgate, Vermont**

Appendix B



Highgate
Swanton



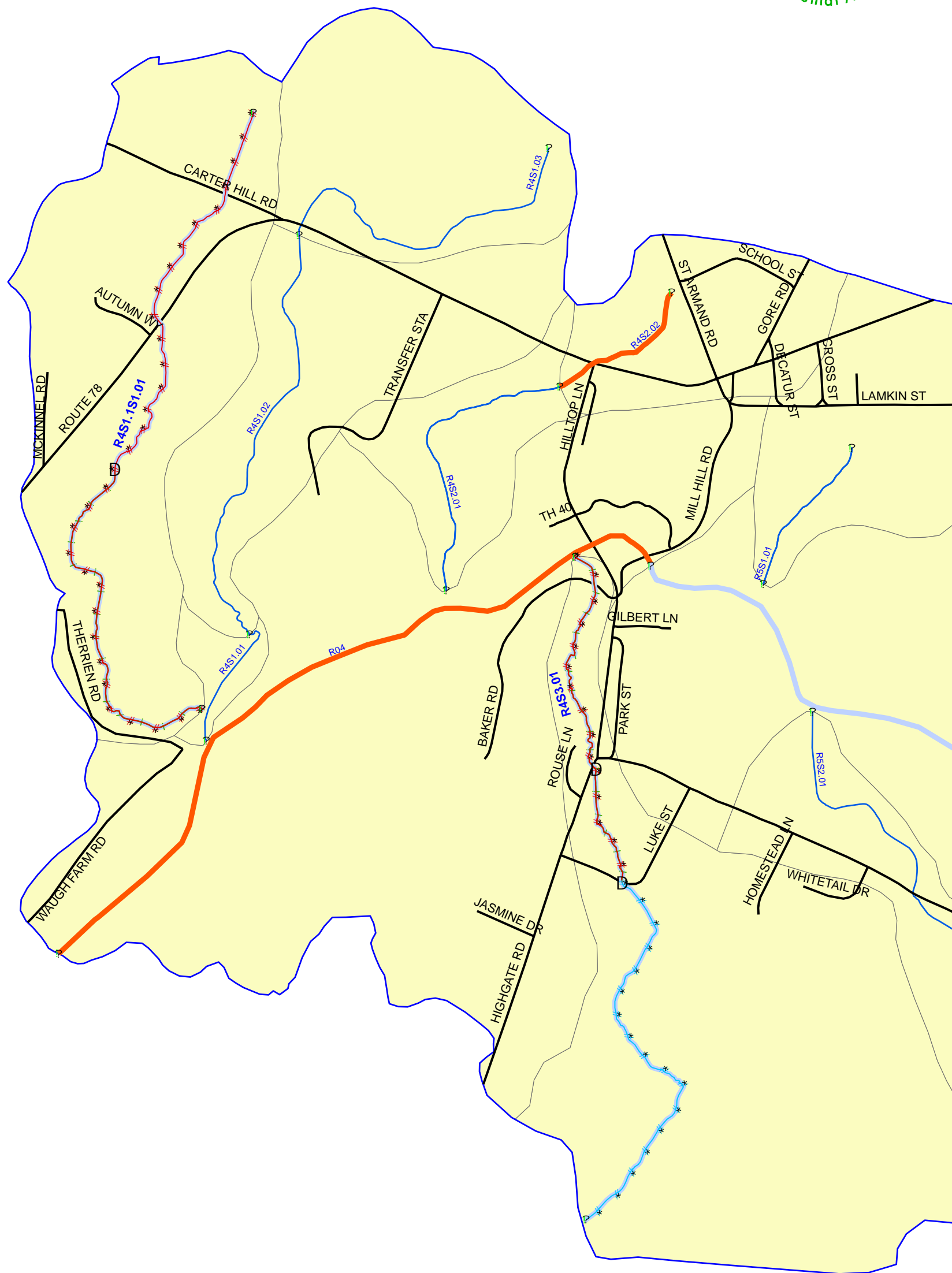
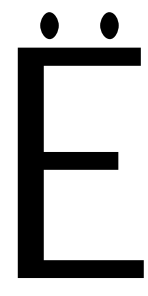
Legend		
● Reach Breaks	Development	Constrictions and Controls per Mile
× Segment Breaks	++++ Railroad	— ≤2
— Roads	◆ Improved Path	— >2 ≤5
— Stream	▲ Natural Grade Control	□ Town Boundary
— Straightening	∟ Headcut	□ Watershed Boundary
— Bridge or Culvert	Beaver Dams per Mile	□ Subwatershed Boundary
— Road Encroachment	× ≤2	

Missisquoi

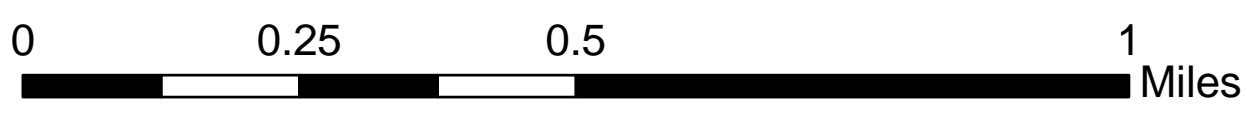
Black to Hungerford

Channel Slope Modifiers Map

Highgate, Vermont Appendix B



Highgate
Swanton

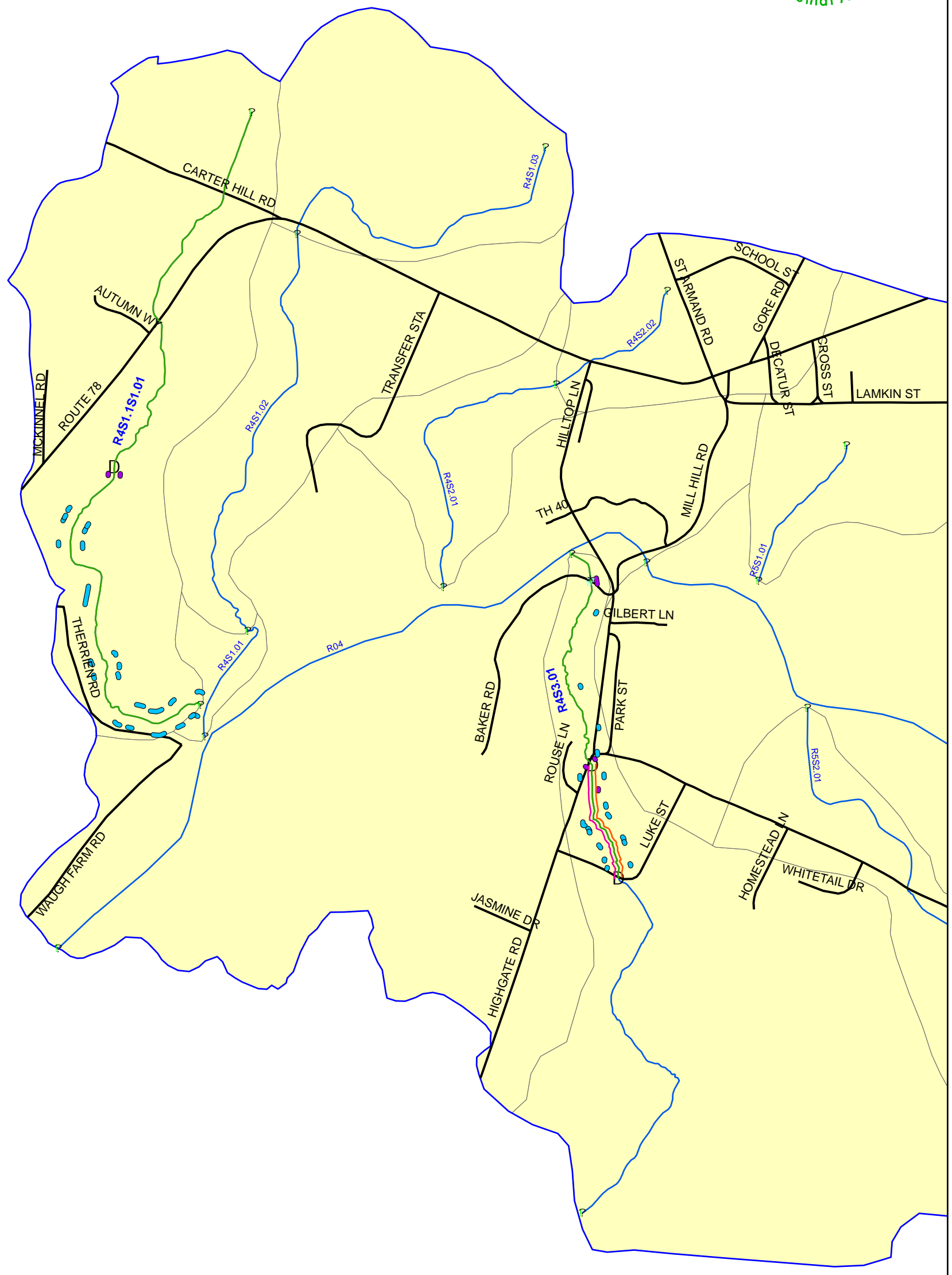
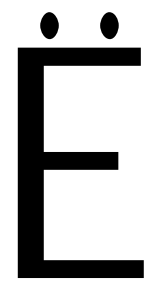


Legend

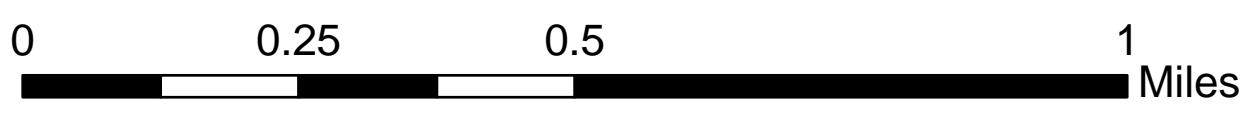
- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Phase 1 Encroachment Impacts - Low
- Phase 1 Encroachment Impacts - High
- Percentage of Encroachments < 5%
- Percentage of Encroachments > 5% <= 20%
- Sum of Depositional Features per Mile > 5
- Town Boundary
- Watershed Boundary
- Subwatershed Boundary

Missisquoi
Black to Hungerford
Channel Depth Modifiers Map
Highgate, Vermont

Appendix B



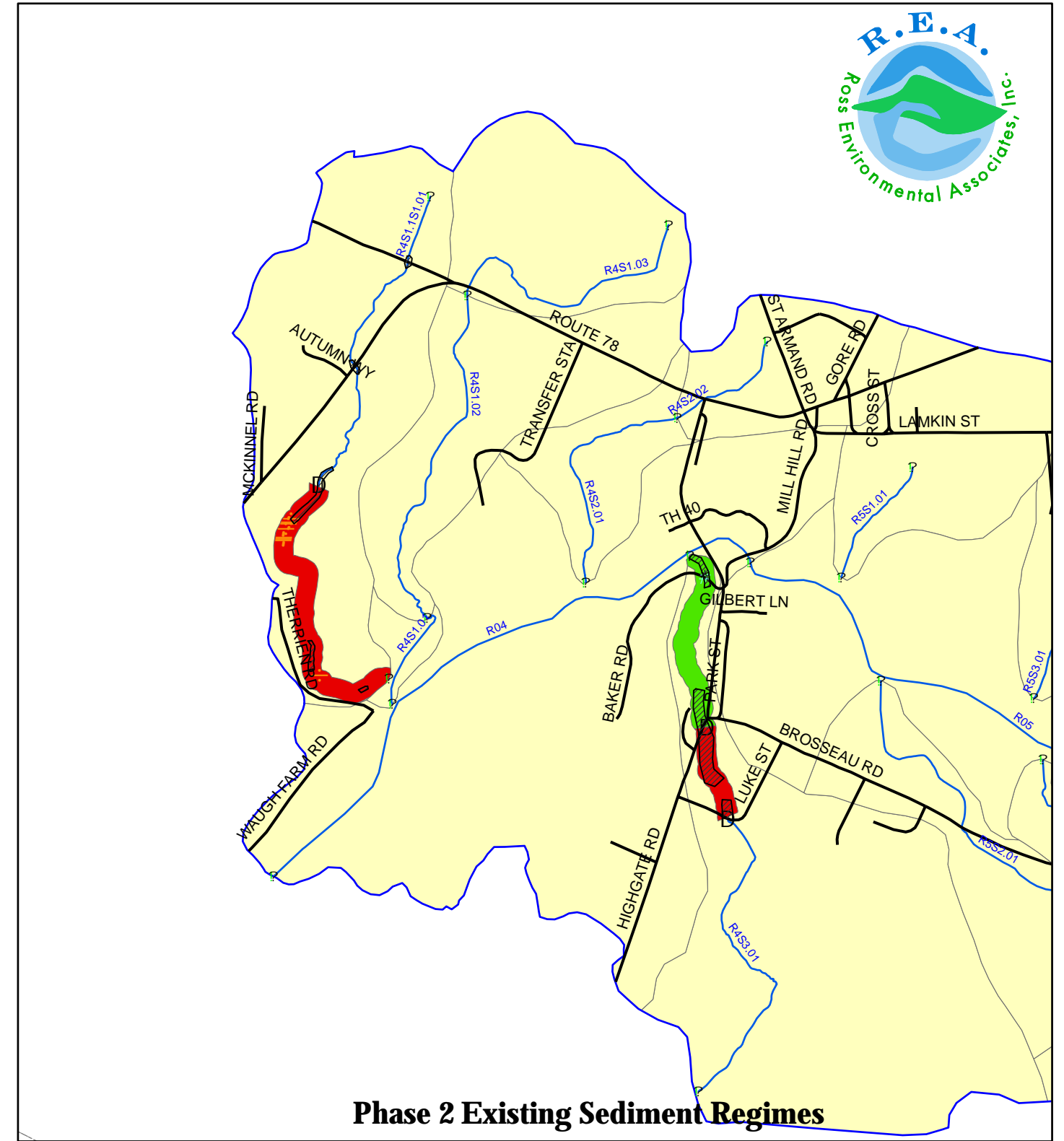
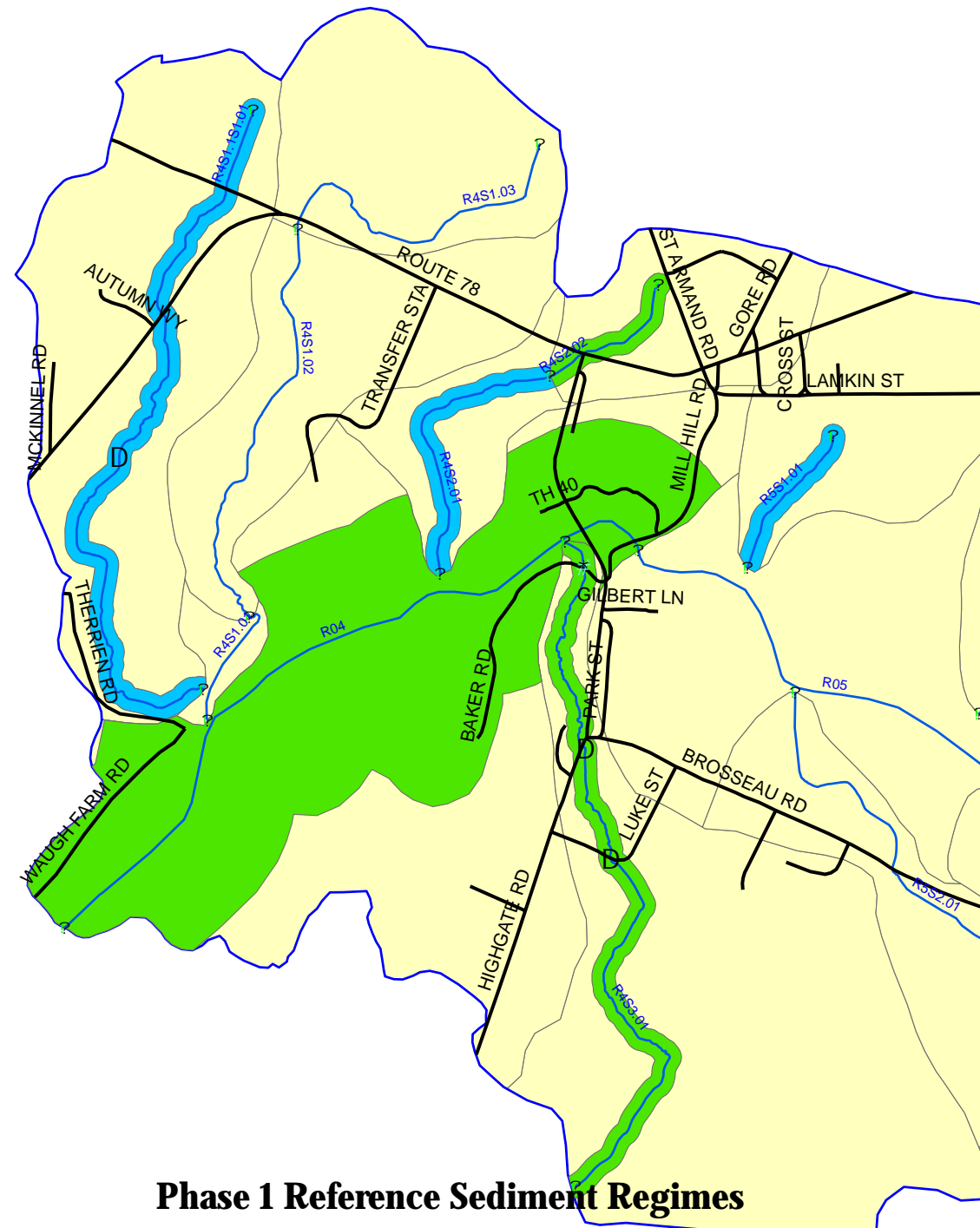
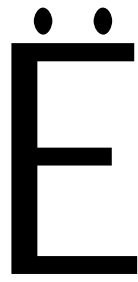
Highgate
Swanton



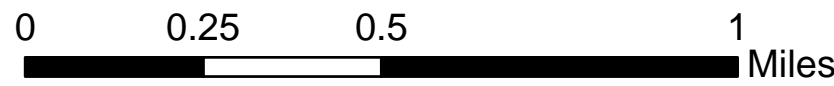
Legend

Reach Breaks	Human Constructed Grade Control	Town Boundary
Segment Breaks	Right Buffer <25 ft	Watershed Boundary
Roads	Left Buffer <25 ft	Subwatershed Boundary
Stream	Cohesive Bank Soils	
Erosion	Coarse Bed Material	
Bank Armoring		
Natural Grade Control		

Missisquoi
Black to Hungerford
Boundary Conditions and Riparian Modifiers
Highgate, Vermont
 Appendix B

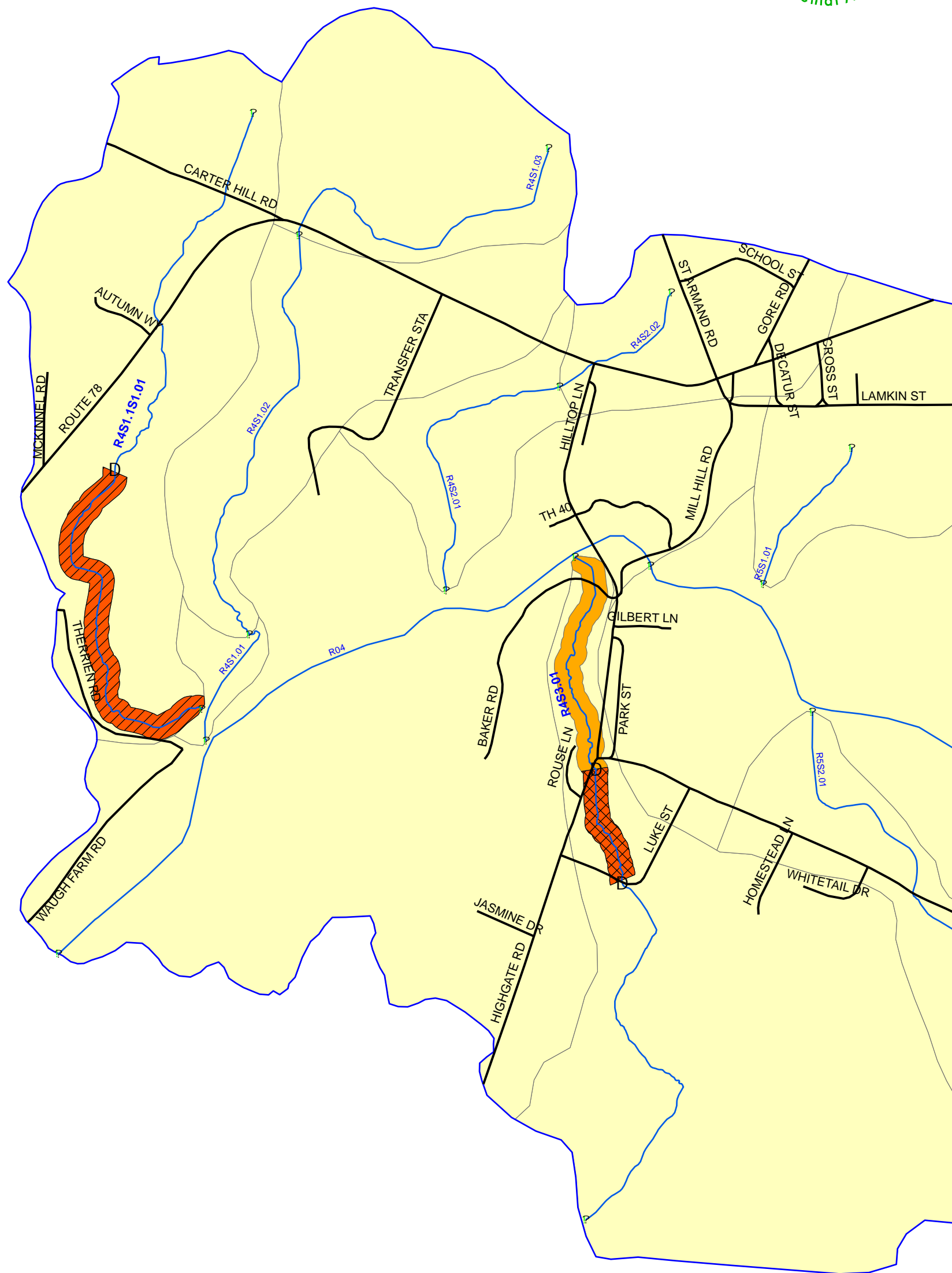
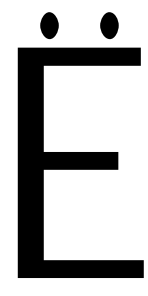


Missisquoi - Black to Hungerford Sediment Regime Departure Maps Highgate, Vermont

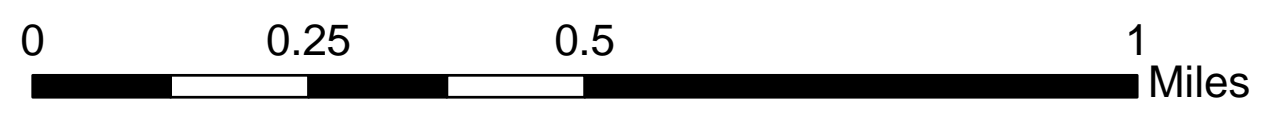


- Legend**
- Reach Breaks
 - Segment Breaks
 - Roads
 - Stream
 - Natural Grade Control
 - Reference Sediment Regime
 - Coarse Equilibrium & Fine Deposition
 - Transport
 - Town Boundary
 - Watershed Boundary
 - Subwatershed Boundary

- Legend**
- Reach Breaks
 - Segment Breaks
 - Roads
 - Stream
 - Natural Grade Control
 - Human Constructed Grade Controls
 - Lateral Constraints
 - Headcut
 - Phase 2 Existing Sediment Regimes
 - Transport
 - Confined Source & Transport
 - Unconfined Source & Transport
 - Fine Source & Transport and Coarse Deposition
 - Coarse Equilibrium & Fine Deposition
 - Town Boundary
 - Watershed Boundary
 - Subwatershed Boundary



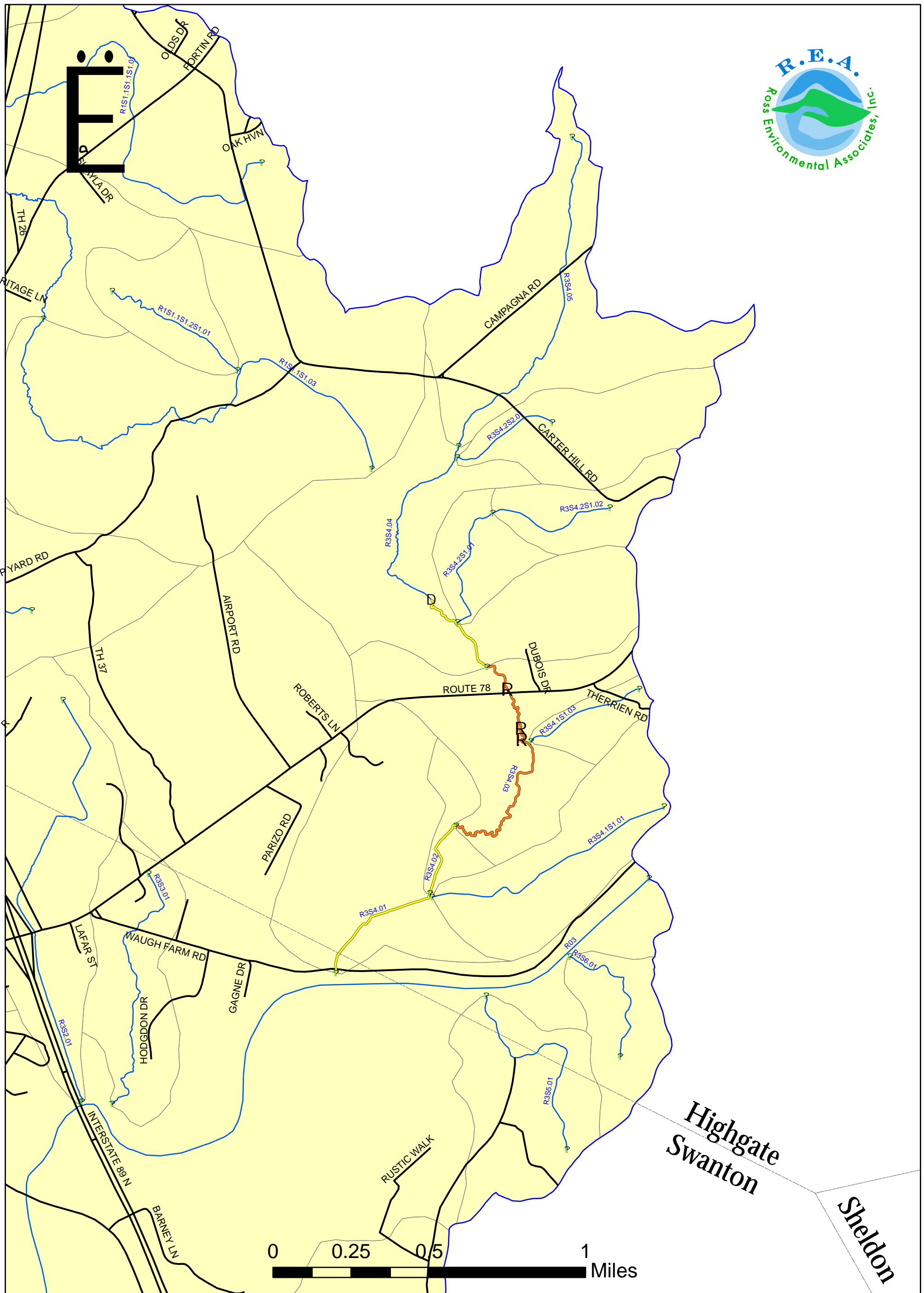
Highgate
Swanton



Legend

- | | | |
|----------------------------|-----------|-----------------------|
| Reach Breaks | Very Low | Town Boundary |
| Segment Breaks | Moderate | Watershed Boundary |
| Roads | High | Subwatershed Boundary |
| Stream | Very High | |
| Current Adjustment Process | Extreme | |
| Aggradation | | |
| Degradation | | |

**Missisquoi
Black to Hungerford
Stream Sensitivity
Highgate, Vermont** Appendix B

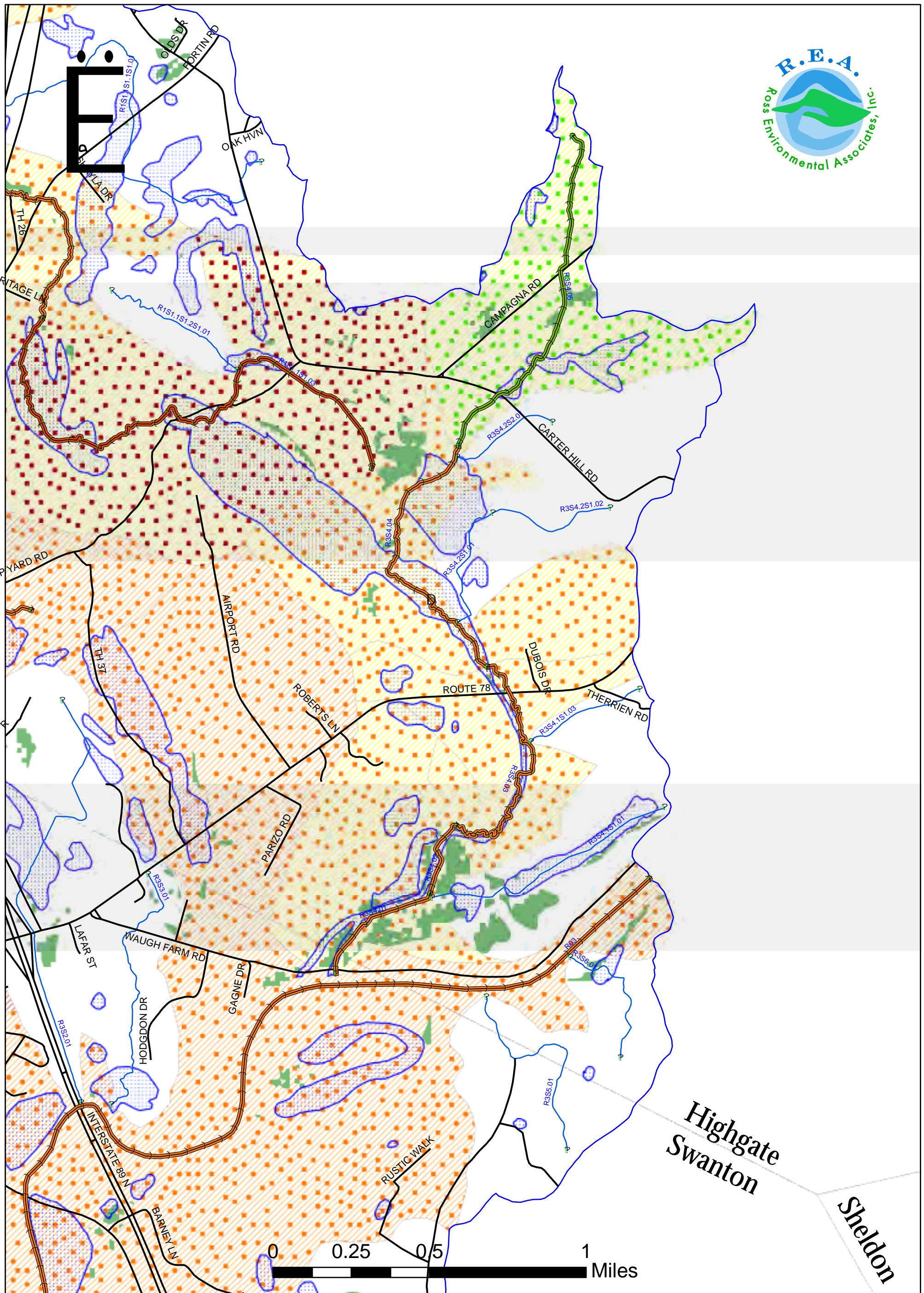


Legend

- | | | | |
|----------------|------------------------|-----------------------|-----------------------|
| Reach Breaks | Stormwater Input Range | Watershed Boundary | Watershed Boundary |
| Segment Breaks | ≤ 2 | Subwatershed Boundary | Subwatershed Boundary |
| Stream | $> 2 \leq 5$ | Town Boundary | Town Boundary |
| Roads | > 5 | | |
| | Stormwater Inputs | | |

Missisquoi River Mouth

Hydrologic Alterations
Highgate, Vermont Appendix B



Legend

- Reach Breaks
- Segment Breaks
- Roads
- Stream
- Wetland Loss
- Existing Wetlands
- Town Boundary
- Watershed Boundary

- Cumulative Upstream Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Cumulative Crop Land Use Percentage**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

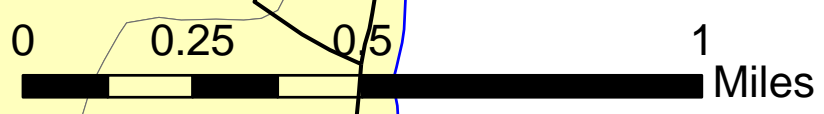
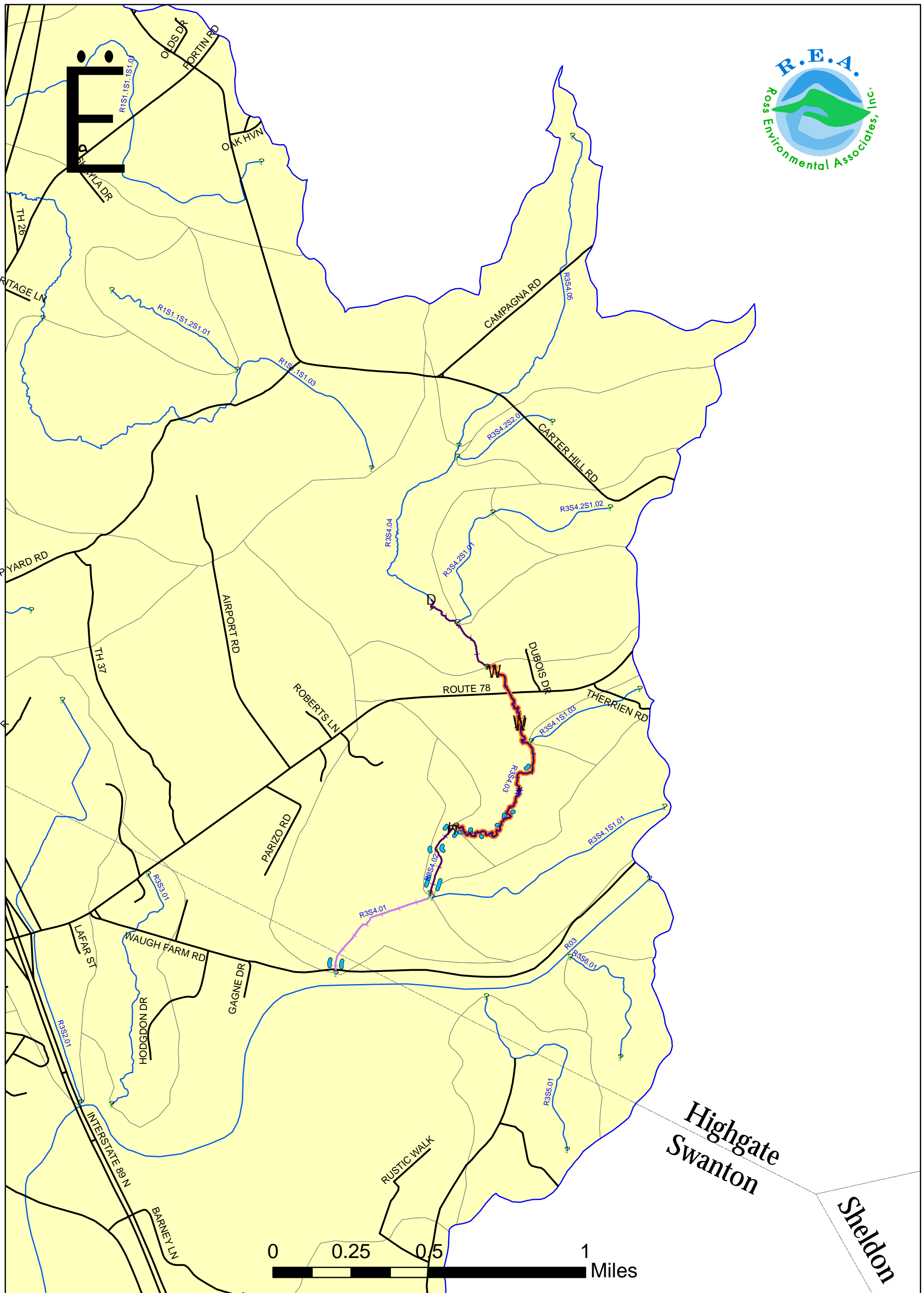
- Urban Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%
- Crop Land Use**
- < 5%
 - >= 5% and < 10%
 - >= 10% and < 20%
 - >= 20%

Missisquoi River Mouth

Land Use Land Cover

Appendix B

Highgate
Swanton
Sheldon



Highgate
Swanton
Sheldon

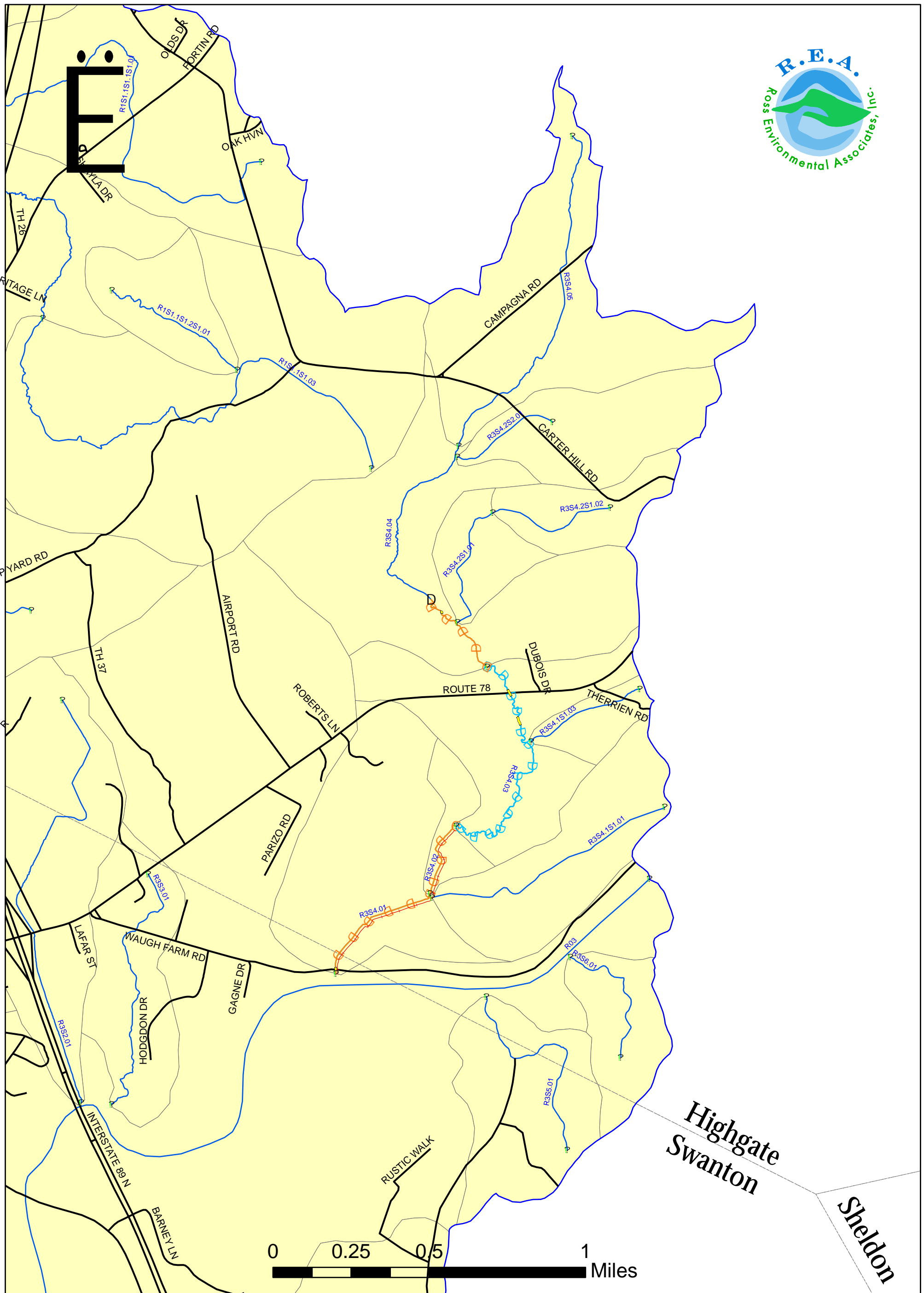
Legend

- Reach Breaks
- Segment Breaks
- Stream
- Roads
- Steep Riffles
- Flood Chute
- Mass Failure
- Erosion
- Depositional Features Per Mile
 - <=2
 - > 5
- Gullies and Mass Failures per Mile
 - >2 <= 5
- Subwatershed Boundary
- Watershed Boundary
- Town Boundary

Missisquoi River Mouth

Sediment Load Indicators

Highgate, Vermont Appendix B



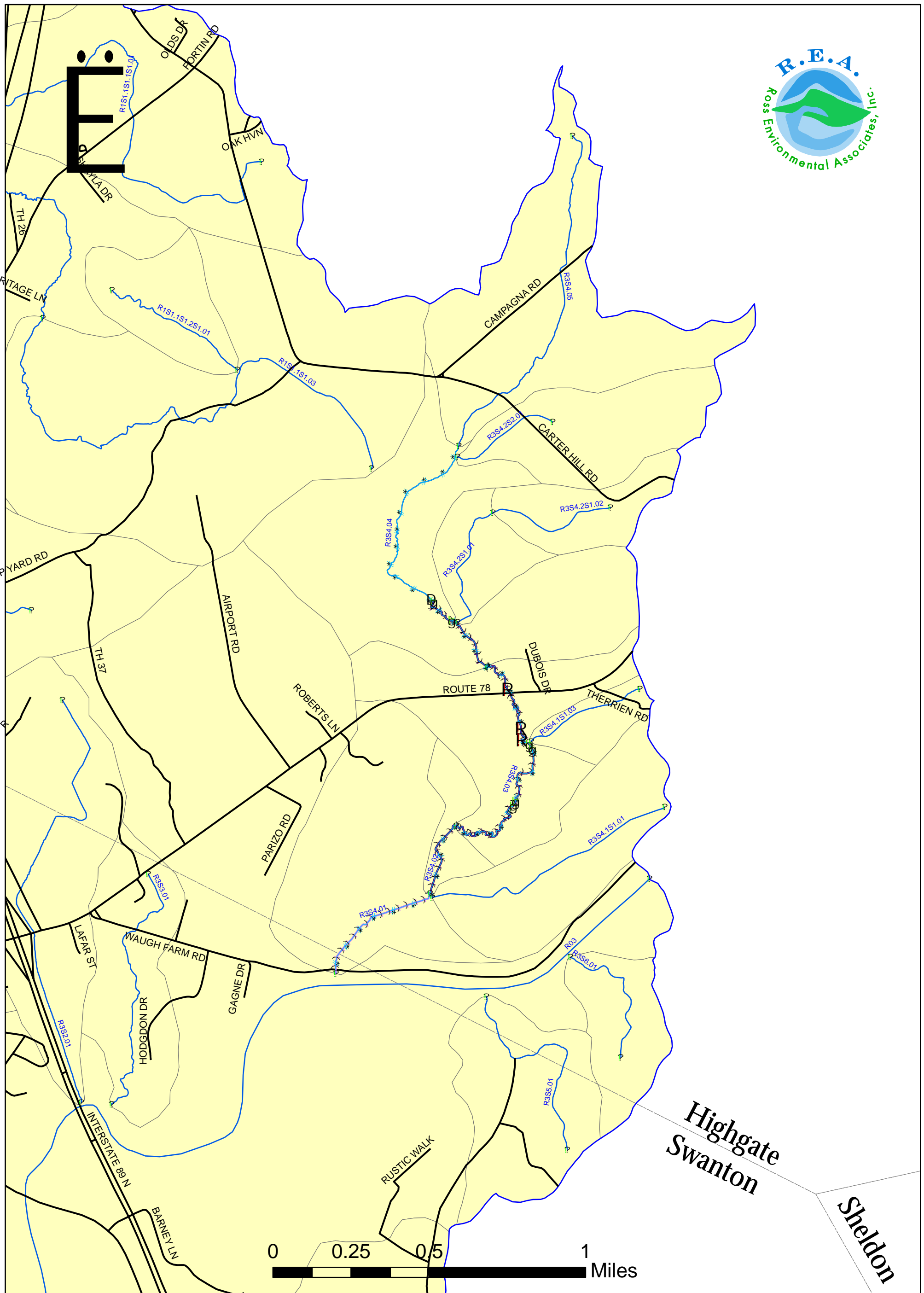
Legend

- | | | | | | |
|--|-------------------|--|--|--|-----------------------|
| | Reach Breaks | | Beaver Dams per Mile ≤ 2 | | Town Boundary |
| | Segment Breaks | | Beaver Dams per Mile $> 2 \leq 5$ | | Watershed Boundary |
| | Roads | | | | Subwatershed Boundary |
| | Stream | | | | |
| | Straightening | | | | |
| | Bridge or Culvert | | | | |

Missisquoi River Mouth

Channel Slope Modifiers

Highgate, Vermont Appendix B

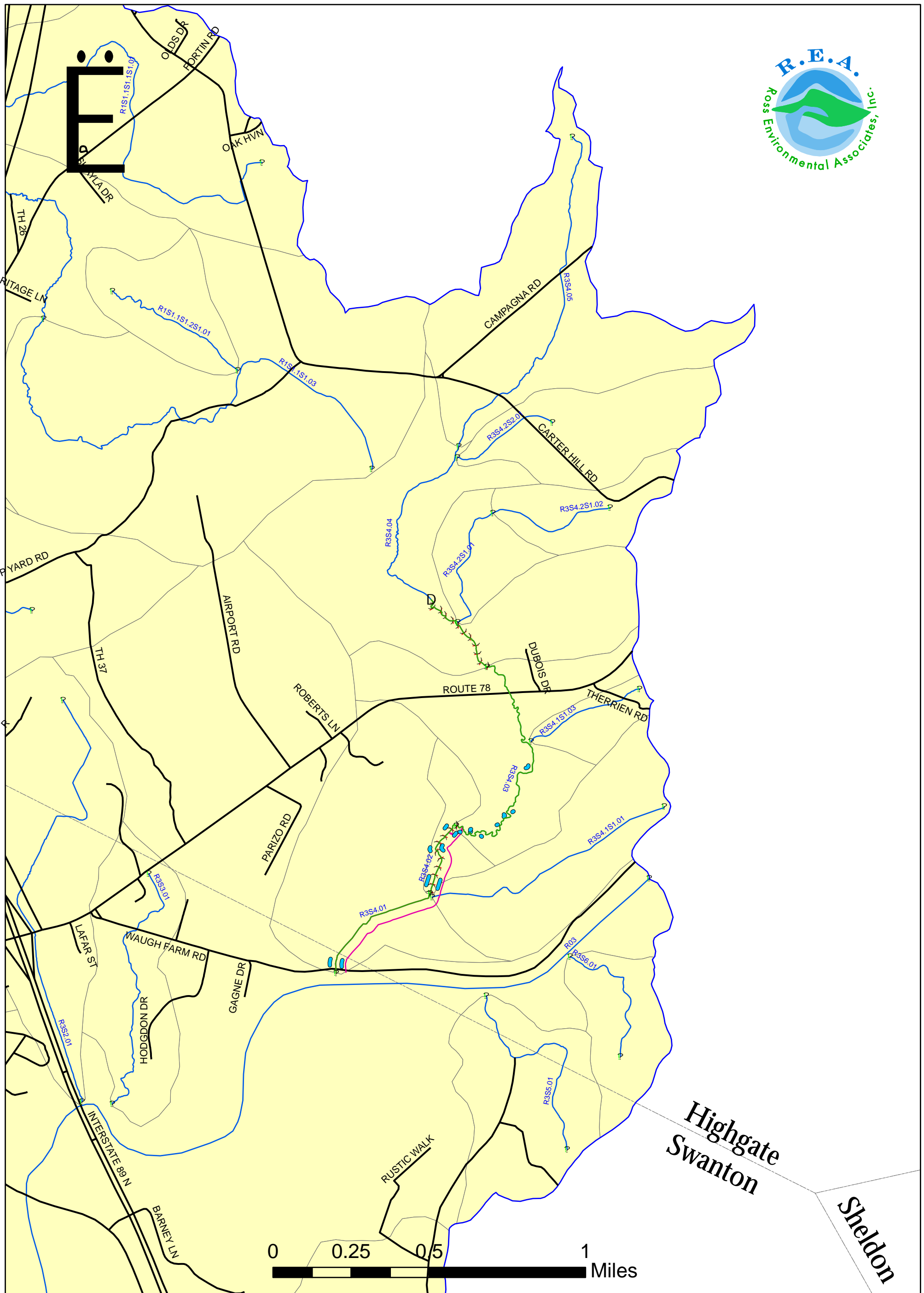


Legend

- | | | |
|------------------|---------------------------------------|-----------------------|
| Reach Breaks | Percentage of Encroachments | Town Boundary |
| Segment Breaks | < 5% | Watershed Boundary |
| Roads | Sum of Depositional Features per Mile | Subwatershed Boundary |
| Stream | <= 2 | |
| Stormwater Input | > 5 | |
| Beaver Dam | | |

Missisquoi River Mouth

Channel Depth Modifiers
Highgate, Vermont



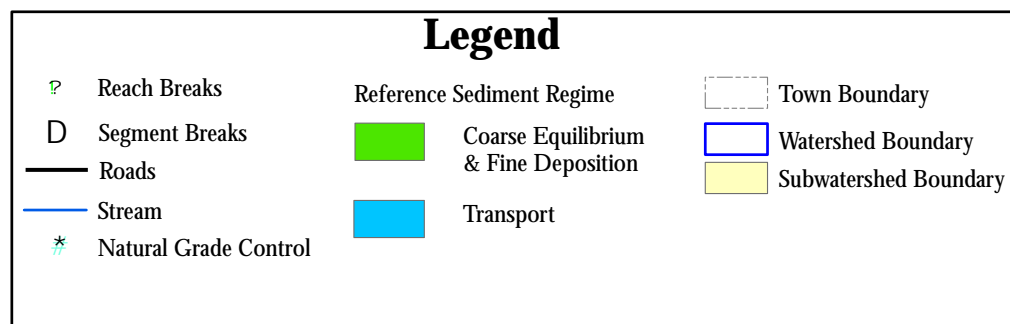
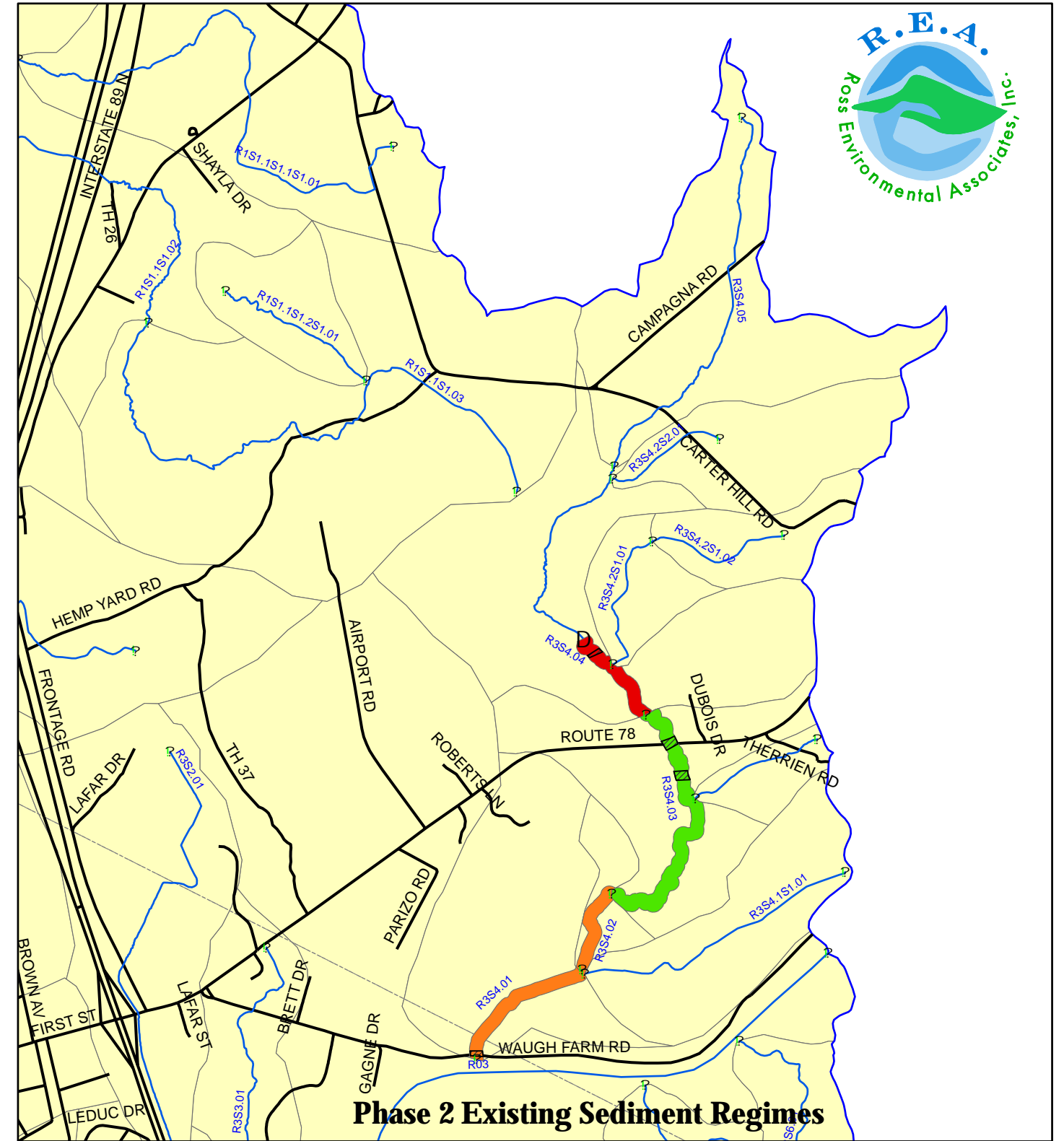
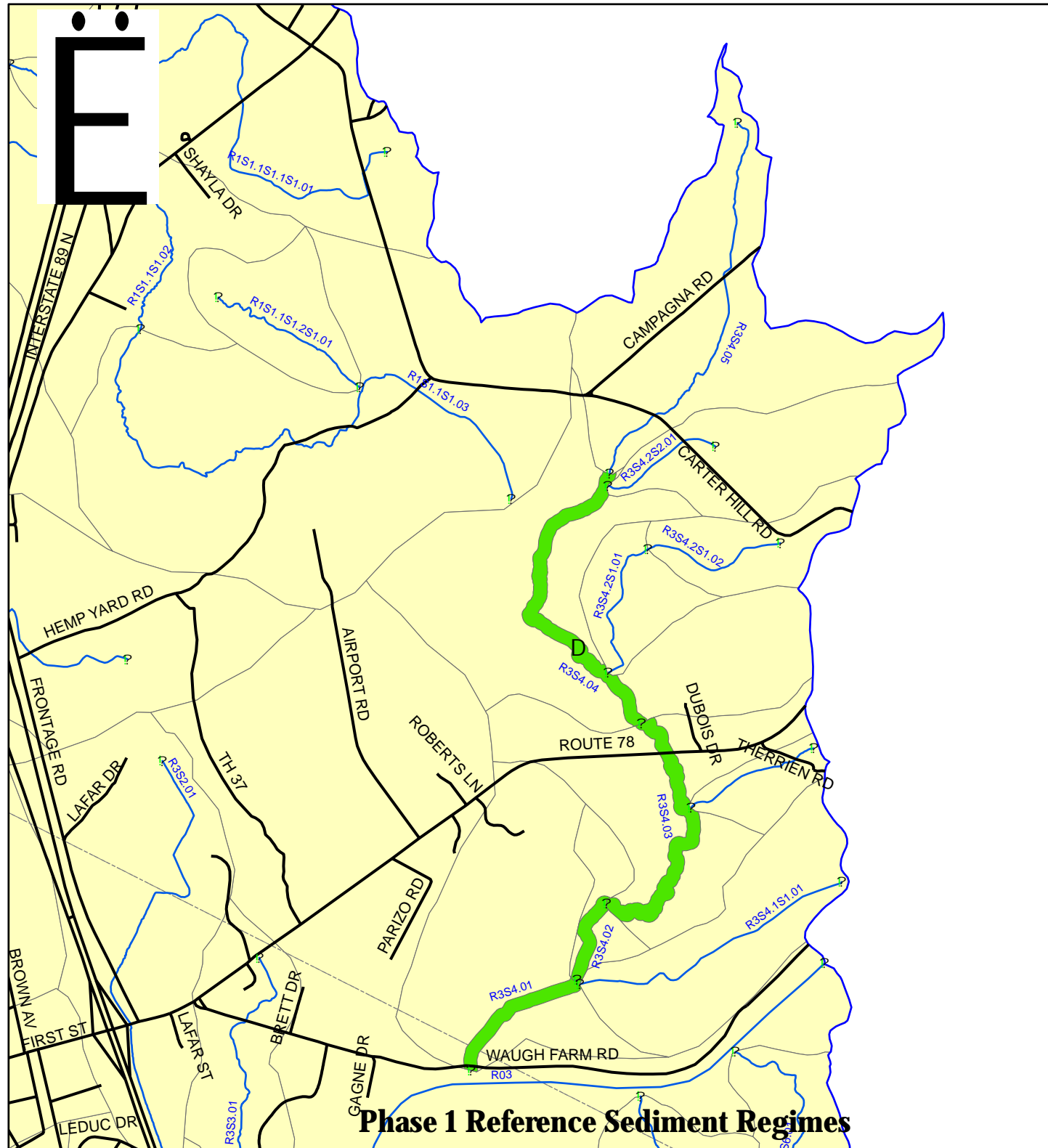
<ul style="list-style-type: none"> Reach Breaks Segment Breaks Roads Stream Erosion Bank Armoring Natural Grade Control 	<p>Legend</p> <ul style="list-style-type: none"> Human Constructed Grade Control Right Buffer <25 ft Left Buffer <25 ft Cohesive Bank Soils Coarse Bed Material 	<ul style="list-style-type: none"> Town Boundary Watershed Boundary Subwatershed Boundary
---	--	---

Missisquoi River Mouth

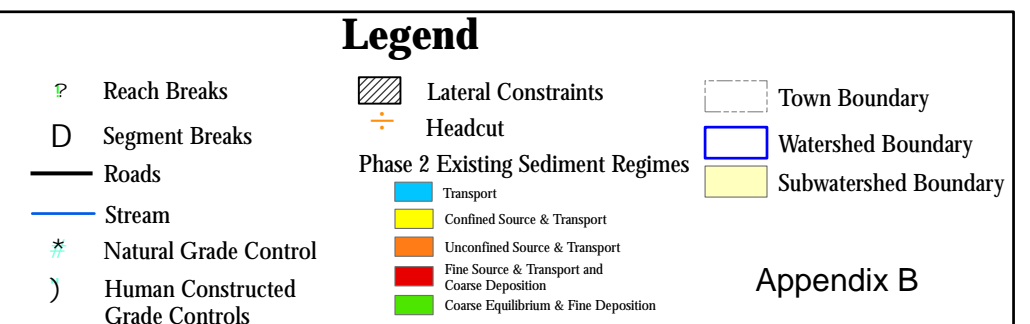
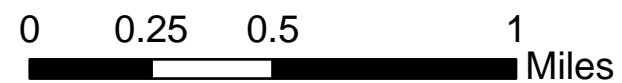
Boundary Conditions and Riparian Modifiers

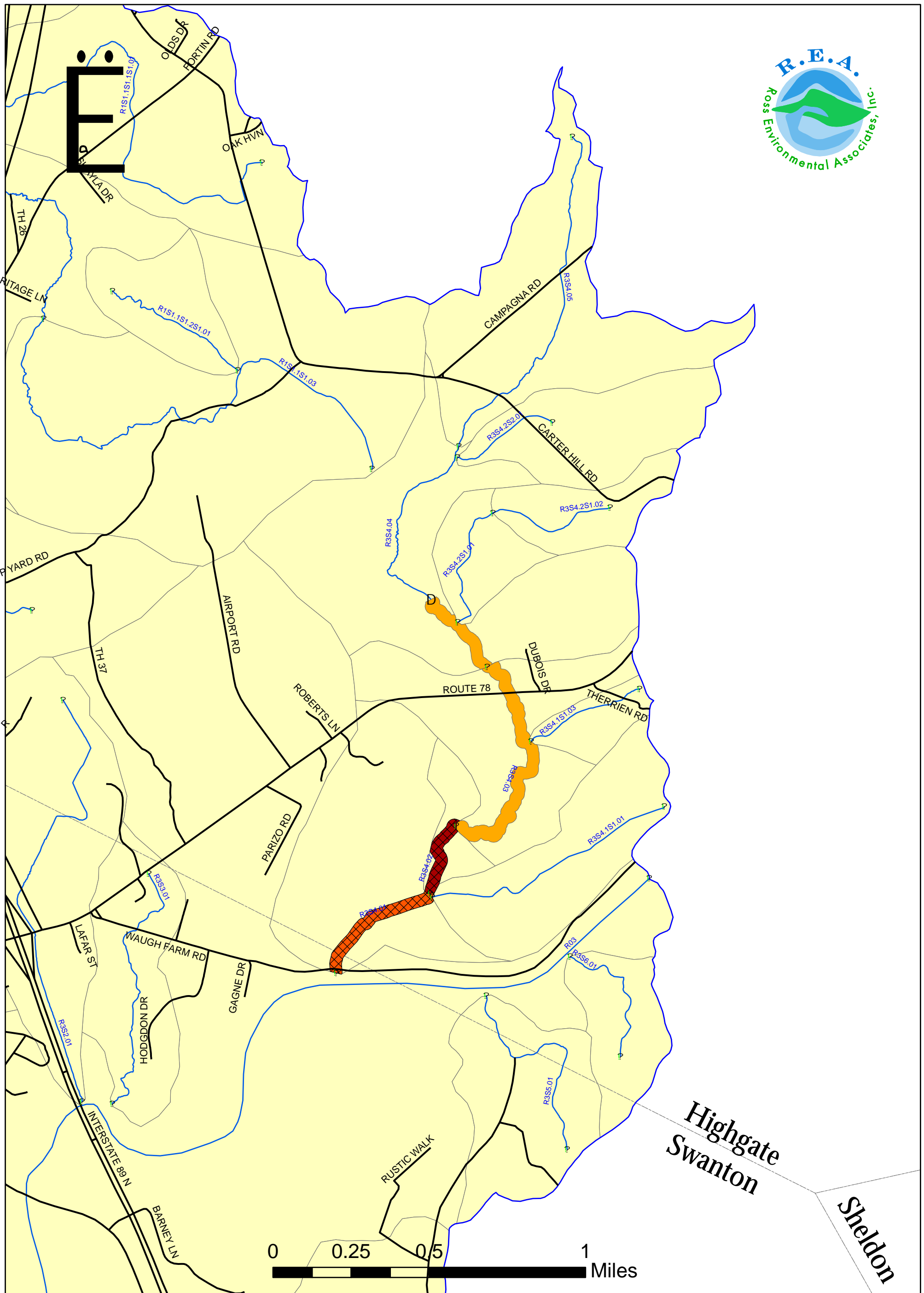
Highgate, Vermont

Appendix B



Missisquoi Mouth Sediment Regime Departure Maps Highgate, Vermont





<ul style="list-style-type: none"> Reach Breaks Segment Breaks Roads Stream Current Adjustment Process Aggradation Degradation 	<p>Legend</p> <p>Stream Sensitivity</p> <ul style="list-style-type: none"> Very Low Moderate High Very High Extreme 	<ul style="list-style-type: none"> Town Boundary Watershed Boundary Subwatershed Boundary 	<h2>Missisquoi River</h2> <h3>Mouth</h3> <h4>Stream Sensitivity</h4> <p>Highgate, Vermont Appendix B</p>
--	--	---	--

**A
T
T
A
C
H
M
E
N
T
C**

TABLES

Table 2
Departure Analysis Table

Deer Brook
Mill River
Stonebridge Brook
Missisquoi - Mouth
Missisquoi - Black_Hungerford
Franklin County, Vermont

River Segment	Constraints		Transport		Attenuation (storage)				
	Vertical	Lateral	Natural	Converted	Natural	Increased	Asset		
Deer Brook	M01A	Not Assessed							
	M01B					X	X	X	
	M02A		Human		X		X	X	
	M02B						X	X	
	M02C								
	M03A	Human & Natural	Human			X		X	
	M03B					X		X	
	M03C	Not Assessed							
	M05A	Not Assessed							
	M05B		Human		X				
	M05C		Human		X				
	M06A		Human	X					
	M06B	Not Assessed							
	M5S3.01				X				
	Mill River	M01A	Not Assessed						
		M01B	Natural	Natural		X			
M01C		Human & Natural	Human		X	X		X	
M01D					X				
M01E		Natural	Human		X				
M02A			Human					X	
M02B		Human	Human		X		X	X	
M03		Human & Natural	Human		X		X	X	
M04A		Human & Natural	Human & Natural		X		X	X	
M04B		Human & Natural	Human & Natural	X					
M05		Human & Natural	Human & Natural		X				
M06A		Natural	Natural		X				
M06B		Human	Human						
M07A		Human	Human						
M07B		Human	Human				X		
M08		Human	Human				X		
M2T2.01		Human	Human		X		X		
M2T2.02A					X		X		
M2T2.02B					X		X		

Table 2
Departure Analysis Table

Deer Brook
Mill River
Stonebridge Brook
Missisquoi - Mouth
Missisquoi - Black_Hungerford
Franklin County, Vermont

River Segment	Constraints		Transport		Attenuation (storage)			
	Vertical	Lateral	Natural	Converted	Natural	Increased	Asset	
M2T2.03A				X		X		
M2T2.03B	Not Assessed							
M2T2.04A	Not Assessed							
M2T2.04B	Human & Natural	Human & Natural		X				
M2T2.04C	Not Assessed							
M2T2.06A	Not Assessed							
M2T2.06B				X		X	X	
M2T2.06C				X				
M2T2.06D	Not Assessed							
M2T2.1S1.1S1.01A	Human	Human		X				
M2T2.1S1.1S1.01B	Not Assessed							
M2T2.2S1.03A	Human	Human		X		X	X	
M2T2.2S1.03B	Not Assessed							
M2T2.2S1.04	Human & Natural	Human & Natural		X				
M2T2.2S1.2S2.01A	Natural	Natural		X		X	X	
M2T2.2S1.2S2.01B				X				
M2T2.2S1.2S2.02A	Human	Human		X				
M2T2.2S1.2S2.02B	Human	Human		X				
M2T2.2S2.01A	Human	Human						
M2T2.2S2.01B	Not Assessed							
M2T2.2S1.3S3.01A	Not Assessed							
M2T2.2S1.3S3.01B	Human	Human		X				
Stonebridge Brook	M01	Not Assessed						
	M02A			X	X	X	X	
	M02B	Not Assessed						
	M03A	Not Assessed						
	M03B					X		X
	M04	Human & Natural	Human			X		X
	M05	Natural			X			
	M06A	Natural			X			
	M06B	Human & Natural	Human		X		X	
	M2S2.01A	Not Assessed						
	M2S2.01B			X				

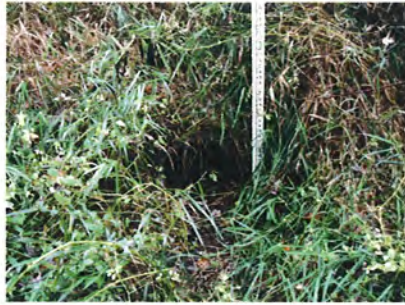
Table 2
Departure Analysis Table
 Deer Brook
 Mill River
 Stonebridge Brook
 Missisquoi - Mouth
 Missisquoi - Black_Hungerford
 Franklin County, Vermont

River Segment	Constraints		Transport		Attenuation (storage)			
	Vertical	Lateral	Natural	Converted	Natural	Increased	Asset	
M2S2.01C	Natural		X					
M2S2.01D	Not Assessed							
M5S1.01A	Natural		X					
M5S1.01B	Human & Natural	Human	X			X	X	
Missisquoi Black to Hungerford	R4S1.1S1.01A		Human	X		X	X	
	R4S1.1S1.01B	Not Assessed						
	R4S3.01A	Natural	Human		X	X	X	
	R4S3.01B		Human		X	X	X	
	R4S3.01C	Not Assessed						
Missisquoi Mouth	R3S4.01	Human	Human		X	X	X	
	R3S4.02				X			
	R3S4.03	Human	Human					
	R3S4.04A	Human	Human		X			
	R3S4.04B	Not Assessed						

Deer Brook Photos - Bridges and Culverts 100206



File Name : Deer M1S1.02 016.jpg



File Name : Deer M1S1.02 017.jpg



File Name : Deer M1S1.02 018.jpg



File Name : Deer M1S1.02 019.jpg



File Name : Deer M1S1.02 020.jpg



File Name : Deer M1S1.02 021.jpg



File Name : Deer M3S1.01 010.jpg



File Name : Deer M3S1.01 011.jpg



File Name : Deer M3S1.01 012.jpg

Deer Brook Photos - Bridges and Culverts 100206



File Name : Deer M3S1.01 013.jpg



File Name : Deer M3S1.01 014.jpg



File Name : Deer M3S1.01 015.jpg



File Name : Deer M3S5.01 004.jpg



File Name : Deer M3S5.01 005.jpg



File Name : Deer M3S5.01 006.jpg



File Name : Deer M3S5.01 007.jpg



File Name : Deer M3S5.01 008.jpg



File Name : Deer M3S5.01 009.jpg

Deer Brook Photos - Bridges and Culverts 100206



File Name : Deer M4S3.01 001.jpg



File Name : Deer M4S3.01 002.jpg



File Name : Deer M4S3.01 003.jpg

Deer Brook Photos - M01



File Name : M01B 034.jpg



File Name : M01B 035.jpg



File Name : M01B 036.jpg



File Name : M01B 037.jpg



File Name : M01B 038.jpg



File Name : M01B 039.jpg



File Name : M01B 040.jpg



File Name : M01B 041.jpg

Deer Brook Photos - M02



File Name : M02A 012.jpg



File Name : M02A 013.jpg



File Name : M02A 014.jpg



File Name : M02A 015.jpg



File Name : M02A 016.jpg



File Name : M02A 017.jpg



File Name : M02A 022.jpg



File Name : M02B 004.jpg



File Name : M02B 005.jpg

Deer Brook Photos - M02



File Name : M02B 006.jpg



File Name : M02B 007.jpg



File Name : M02B 008.jpg



File Name : M02B 009.jpg



File Name : M02B 010.jpg



File Name : M02B 011.jpg



File Name : M02C 001.jpg



File Name : M02C 002.jpg



File Name : M02C 003.jpg

Deer Brook Photos - M02



File Name : M02subC 018.jpg



File Name : M02subC 019.jpg



File Name : M02subC 020.jpg



File Name : M02subC 021.jpg

Deer Brook Photos - M03



File Name : M03A 001.jpg



File Name : M03A 002.jpg



File Name : M03A 003.jpg



File Name : M03A 004.jpg



File Name : M03A 005.jpg



File Name : M03A 006.jpg



File Name : M03A 007.jpg



File Name : M03A 008.jpg



File Name : M03A 009.jpg

Deer Brook Photos - M03



File Name : M03A 010.jpg



File Name : M03A 011.jpg



File Name : M03A 012.jpg



File Name : M03A 014.jpg



File Name : M03A 015.jpg



File Name : M03A 016.jpg



File Name : M03A 017.jpg



File Name : M03B 013.jpg



File Name : M03B 018.jpg

Deer Brook Photos - M03



File Name : M03B 019.jpg



File Name : M03B 020.jpg



File Name : M03B 021.jpg



File Name : M03B 022.jpg



File Name : M03B 023.jpg



File Name : M03B 024.jpg



File Name : M03B 025.jpg



File Name : M03B 026.jpg



File Name : M03B 027.jpg

Deer Brook Photos - M03



File Name : M03B 028.jpg



File Name : M03B 029.jpg



File Name : M03B 030.jpg



File Name : M03B 031.jpg



File Name : M03B 032.jpg



File Name : M03B 033.jpg

Deer Brook Photos - M05



File Name : M05B 040.jpg



File Name : M05B 041.jpg



File Name : M05B 042.jpg



File Name : M05B 043.jpg



File Name : M05B 044.jpg



File Name : M05B 045.jpg



File Name : M05B 046.jpg



File Name : M05B 047.jpg



File Name : M05C 048.jpg

Deer Brook Photos - M05



File Name : M05C 049.jpg



File Name : M05C 050.jpg



File Name : M05C 051.jpg



File Name : M05C 052.jpg



File Name : M05C 053.jpg



File Name : M05C 054.jpg



File Name : M05C 055.jpg



File Name : M05C 056.jpg



File Name : M05C 057.jpg

Deer Brook Photos - M05



File Name : M05C 058.jpg



File Name : M05C 059.jpg

Deer Brook Photos - M5S03.01



File Name : M5S3.01 001.jpg



File Name : M5S3.01 002.jpg



File Name : M5S3.01 003.jpg



File Name : M5S3.01 004.jpg

Deer Brook Photos - M06



File Name : M06 027.jpg



File Name : M06 033.jpg



File Name : M06 23.jpg



File Name : M06 24.jpg



File Name : M06 25.jpg



File Name : M06 26.jpg



File Name : M06 28.jpg



File Name : M06 29.jpg



File Name : M06 30.jpg

Deer Brook Photos - M06



File Name : M06 31.jpg



File Name : M06 32.jpg



File Name : M06 34.jpg



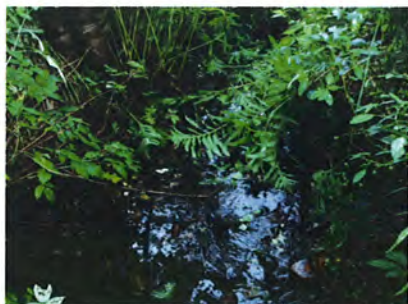
File Name : M06 35.jpg



File Name : M06 36.jpg



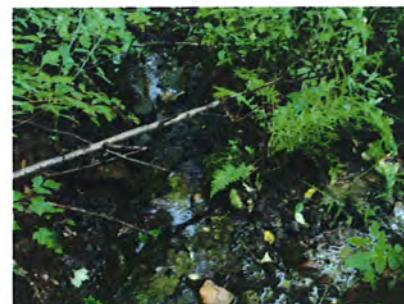
File Name : M06A railroad culvert 001.jpg



File Name : M06A railroad culvert 002.jpg



File Name : M06A railroad culvert 003.jpg



File Name : M06A railroad culvert 004.jpg

Mill River Photos - M01



File Name : M01 027.jpg



File Name : M01 028.jpg



File Name : M01 029.jpg



File Name : M01 030.jpg



File Name : M01B 001.jpg



File Name : M01B 002.jpg



File Name : M01B 003.jpg



File Name : M01B 004.jpg



File Name : M01B 005.jpg

Mill River Photos - M01



File Name : M01B 006.jpg



File Name : M01B 007.jpg



File Name : M01B 031.jpg



File Name : M01B 032.jpg



File Name : M01C 008.jpg



File Name : M01C 009.jpg



File Name : M01C 010.jpg



File Name : M01C 011.jpg



File Name : M01C 012.jpg

Mill River Photos - M01



File Name : M01D 013.jpg



File Name : M01D 014.jpg



File Name : M01D 015.jpg



File Name : M01D 016.jpg



File Name : M01D 017.jpg



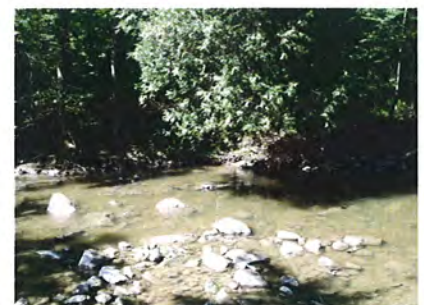
File Name : M01E 018.jpg



File Name : M01E 019.jpg



File Name : M01E 020.jpg



File Name : M01E 021.jpg

Mill River Photos - M01



File Name : M01E 022.jpg



File Name : M01E 023.jpg



File Name : M01E 024.jpg



File Name : M01E 025.jpg



File Name : M01E 026.jpg

Mill River Photos - M02



File Name : M02A 001.jpg



File Name : M02A 002.jpg



File Name : M02A 003.jpg



File Name : M02A 004.jpg



File Name : M02A 005.jpg



File Name : M02A 006.jpg



File Name : M02B 007.jpg



File Name : M02B 008.jpg



File Name : M02B 009.jpg

Mill River Photos - M02



File Name : M02B 010.jpg



File Name : M02B 011.jpg



File Name : M02B 012.jpg

Mill River Photos - M2T2.01



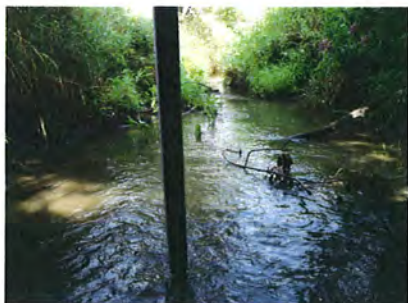
File Name : M2T2.01 001.jpg



File Name : M2T2.01 002.jpg



File Name : M2T2.01 003.jpg



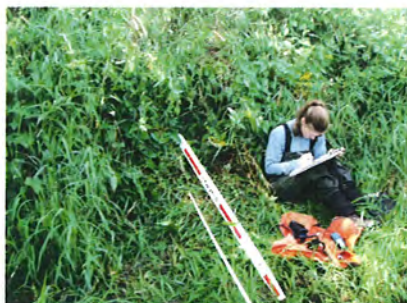
File Name : M2T2.01 004.jpg



File Name : M2T2.01 005.jpg



File Name : M2T2.01 006.jpg



File Name : M2T2.01 007.jpg



File Name : M2T2.01 008.jpg



File Name : M2T2.01 009.jpg

Mill River Photos - M2T2.1S1.1S1.01



File Name : M2T2.1S1.1S1.01A 001.jpg



File Name : M2T2.1S1.1S1.01A 002.jpg



File Name : M2T2.1S1.1S1.01A 003.jpg



File Name : M2T2.1S1.1S1.01A 004.jpg



File Name : M2T2.1S1.1S1.01A 005.jpg



File Name : M2T2.1S1.1S1.01A 006.jpg



File Name : M2T2.1S1.1S1.01A 007.jpg



File Name : M2T2.1S1.1S1.01A 008.jpg

Mill River Photos - M2T2.02



File Name : M2T2.02A 001.jpg



File Name : M2T2.02A 002.jpg



File Name : M2T2.02A 003.jpg



File Name : M2T2.02A 004.jpg



File Name : M2T2.02A 005.jpg



File Name : M2T2.02B 006.jpg



File Name : M2T2.02B 007.jpg



File Name : M2T2.02B 008.jpg



File Name : M2T2.02B 009.jpg

Mill River Photos - M2T2.2S1.2S2.01



File Name : M2T2.2S1.2S2.01A 003.jpg



File Name : M2T2.2S1.2S2.01A 004.jpg



File Name : M2T2.2S1.2S2.01A 005.jpg



File Name : M2T2.2S1.2S2.01A 006.jpg



File Name : M2T2.2S1.2S2.01A 007.jpg



File Name : M2T2.2S1.2S2.01B 001.jpg



File Name : M2T2.2S1.2S2.01B 002.jpg



File Name : M2T2.2S1.2S2.01B 008.jpg



File Name : M2T2.2S1.2S2.01B 009.jpg

Mill River Photos - M2T2.2S1.2S2.01

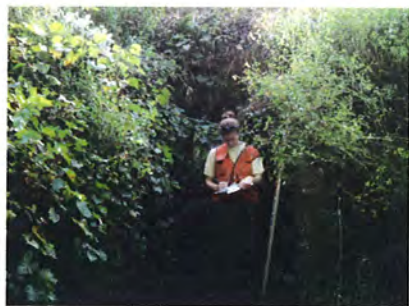


File Name : M2T2.2S1.2S2.01B 010.jpg



File Name : M2T2.2S1.2S2.01B 011.jpg

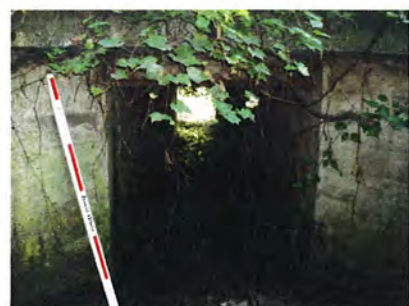
Mill River Photos - M2T2.2S1.2S2.02



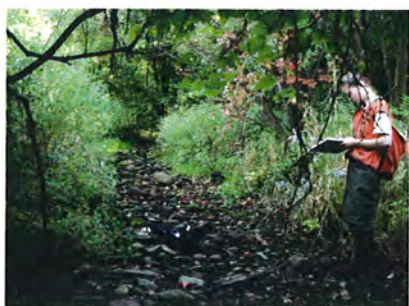
File Name : M2T2.2S1.2S2.02A 001.jpg



File Name : M2T2.2S1.2S2.02A 002.jpg



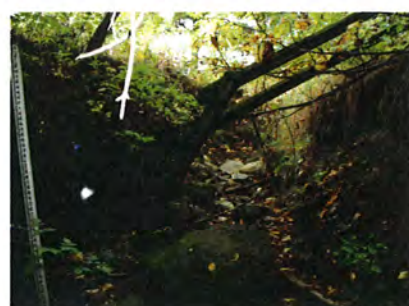
File Name : M2T2.2S1.2S2.02A 003.jpg



File Name : M2T2.2S1.2S2.02A 004.jpg



File Name : M2T2.2S1.2S2.02A 005.jpg



File Name : M2T2.2S1.2S2.02A 006.jpg



File Name : M2T2.2S1.2S2.02A 022.jpg

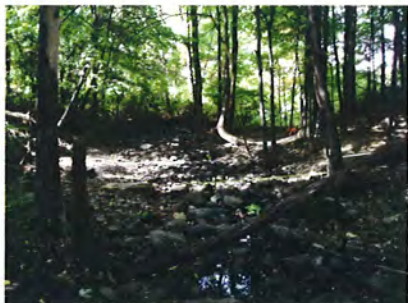


File Name : M2T2.2S1.2S2.02A 023.jpg



File Name : M2T2.2S1.2S2.02A 024.jpg

Mill River Photos - M2T2.2S1.2S2.02



File Name : M2T2.2S1.2S2.02A 025.jpg



File Name : M2T2.2S1.2S2.02B 007.jpg



File Name : M2T2.2S1.2S2.02B 008.jpg



File Name : M2T2.2S1.2S2.02B 009.jpg



File Name : M2T2.2S1.2S2.02B 010.jpg



File Name : M2T2.2S1.2S2.02B 011.jpg



File Name : M2T2.2S1.2S2.02B 012.jpg



File Name : M2T2.2S1.2S2.02B 013.jpg



File Name : M2T2.2S1.2S2.02B 014.jpg

Mill River Photos - M2T2.2S1.2S2.02



File Name : M2T2.2S1.2S2.02B 015.jpg



File Name : M2T2.2S1.2S2.02B 016.jpg



File Name : M2T2.2S1.2S2.02B 017.jpg



File Name : M2T2.2S1.2S2.02B 018.jpg



File Name : M2T2.2S1.2S2.02B 019.jpg



File Name : M2T2.2S1.2S2.02B 020.jpg



File Name : M2T2.2S1.2S2.02B 021.jpg

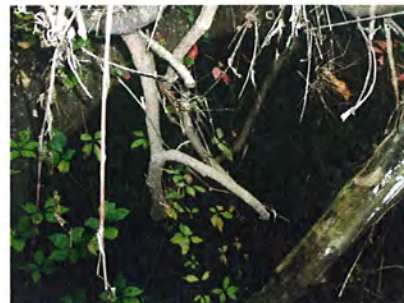
Mill River Photos - M2T2.2S1.03



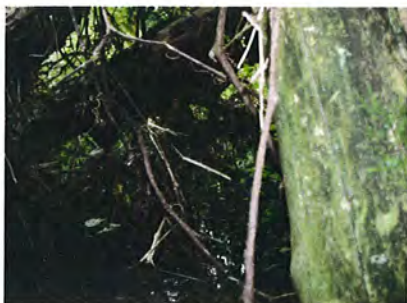
File Name : M2T2.2S1.03 001.jpg



File Name : M2T2.2S1.03 002.jpg



File Name : M2T2.2S1.03 003.jpg



File Name : M2T2.2S1.03 004.jpg



File Name : M2T2.2S1.03 005.jpg



File Name : M2T2.2S1.03 006.jpg



File Name : M2T2.2S1.03 007.jpg



File Name : M2T2.2S1.03 008.jpg



File Name : M2T2.2S1.03 009.jpg

Mill River Photos - M2T2.2S1.03



File Name : M2T2.2S1.03 010.jpg



File Name : M2T2.2S1.03 011.jpg



File Name : M2T2.2S1.03 012.jpg

Mill River Photos - M2T2.2S1.3S3.01



File Name : M2T2.2S1.3S3.01B 000.jpg



File Name : M2T2.2S1.3S3.01B 001.jpg



File Name : M2T2.2S1.3S3.01B 002.jpg



File Name : M2T2.2S1.3S3.01B 003.jpg



File Name : M2T2.2S1.3S3.01B 004.jpg



File Name : M2T2.2S1.3S3.01B 005.jpg



File Name : M2T2.2S1.3S3.01B 006.jpg



File Name : M2T2.2S1.3S3.01B 007.jpg

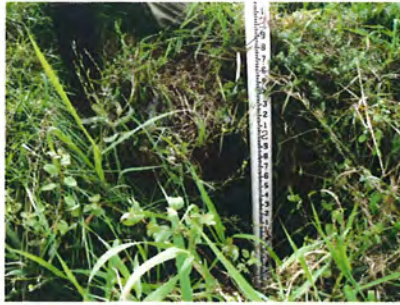


File Name : M2T2.2S1.3S3.01B 008.jpg

Mill River Photos - M2T2.2S1.3S3.01



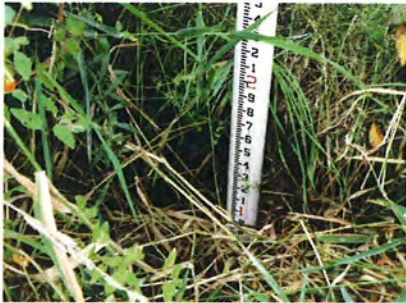
File Name : M2T2.2S1.3S3.01B 009.jpg



File Name : M2T2.2S1.3S3.01B 010.jpg



File Name : M2T2.2S1.3S3.01B 011.jpg



File Name : M2T2.2S1.3S3.01B 012.jpg



File Name : M2T2.2S1.3S3.01B 013.jpg



File Name : M2T2.2S1.3S3.01B 014.jpg



File Name : M2T2.2S1.3S3.01B 015.jpg



File Name : M2T2.2S1.3S3.01B 016.jpg



File Name : M2T2.2S1.3S3.01B 017.jpg

Mill River Photos - M2T2.2S1.3S3.01



File Name : M2T2.2S1.3S3.01B 018.jpg



File Name : M2T2.2S1.3S3.01B 019.jpg



File Name : M2T2.2S1.3S3.01B 020.jpg



File Name : M2T2.2S1.3S3.01B 021.jpg



File Name : M2T2.2S1.3S3.01B 022.jpg



File Name : M2T2.2S1.3S3.01B 023.jpg

Mill River Photos - M2T2.2S1.04



File Name : M2T2.2S1.04 001.jpg



File Name : M2T2.2S1.04 002.jpg



File Name : M2T2.2S1.04 003.jpg



File Name : M2T2.2S1.04 004.jpg



File Name : M2T2.2S1.04 005.jpg



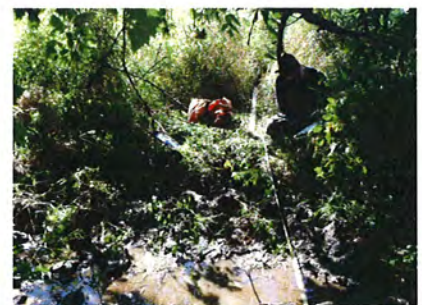
File Name : M2T2.2S1.04 006.jpg



File Name : M2T2.2S1.04 007.jpg



File Name : M2T2.2S1.04 008.jpg



File Name : M2T2.2S1.04 009.jpg

Mill River Photos - M2T2.2S1.04



File Name : M2T2.2S1.04 010.jpg



File Name : M2T2.2S1.04 011.jpg



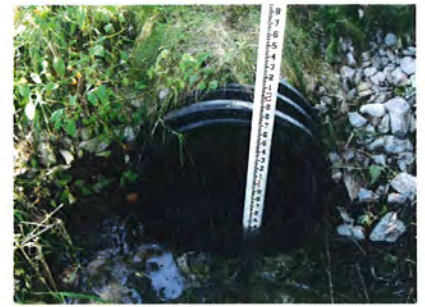
File Name : M2T2.2S1.04 012.jpg



File Name : M2T2.2S1.04 013.jpg



File Name : M2T2.2S1.04 014.jpg

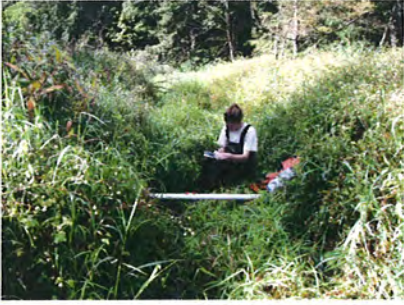


File Name : M2T2.2S1.04 015.jpg



File Name : M2T2.2S1.04 016.jpg

Mill River Photos - M2T2.2S2.01



File Name : M2T2.2S2.01A 001.jpg



File Name : M2T2.2S2.01A 002.jpg



File Name : M2T2.2S2.01A 003.jpg



File Name : M2T2.2S2.01A 004.jpg

Mill River Photos - M2T2.03



File Name : M2T2.03A 001.jpg



File Name : M2T2.03A 002.jpg



File Name : M2T2.03A 003.jpg



File Name : M2T2.03A 004.jpg

Mill River Photos - M2T2.04



File Name : M2T2.04B 001.jpg



File Name : M2T2.04B 002.jpg



File Name : M2T2.04B 003.jpg



File Name : M2T2.04B 004.jpg



File Name : M2T2.04B 005.jpg

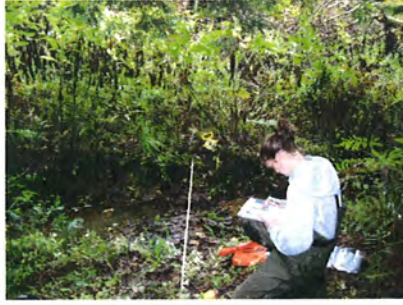


File Name : M2T2.04B 006.jpg

Mill River Photos - M2T2.06



File Name : M2T2.06B 005.JPG



File Name : M2T2.06B 006.JPG



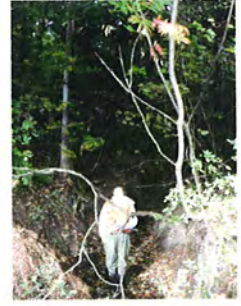
File Name : M2T2.06B 007.JPG



File Name : M2T2.06B 008.JPG



File Name : M2T2.06C 001.JPG



File Name : M2T2.06C 002.JPG



File Name : M2T2.06C 003.JPG



File Name : M2T2.06C 004.JPG



File Name : M2T2.06C 009.JPG

Mill River Photos - M2T2.06



File Name : M2T2.06C 010.JPG



File Name : M2T2.06C 011.JPG



File Name : M2T2.06C 012.JPG

Mill River Photos - M03



File Name : M03 18.jpg



File Name : M03 17.jpg



File Name : M03 16.jpg



File Name : M03 15.jpg



File Name : M03 14.jpg



File Name : M03 13.jpg

Mill River Photos - M04



File Name : M04A 054.jpg



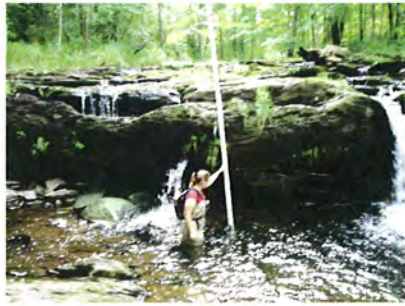
File Name : M04A 055.jpg



File Name : M04A 056.jpg



File Name : M04A 057.jpg



File Name : M04A 19.jpg



File Name : M04A 20.jpg



File Name : M04A 21.jpg

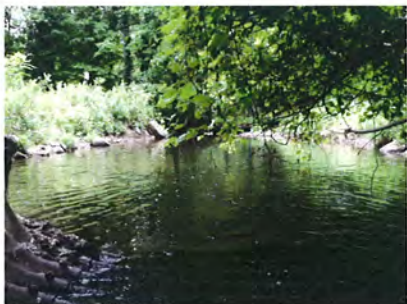


File Name : M04A 22.jpg



File Name : M04A 23.jpg

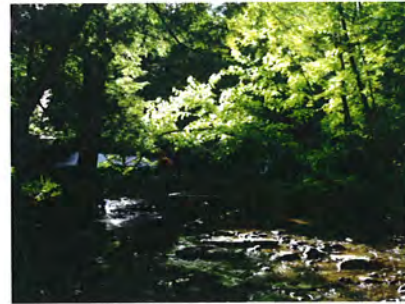
Mill River Photos - M04



File Name : M04A 24.jpg



File Name : M04A 25.jpg



File Name : M04B 026.jpg



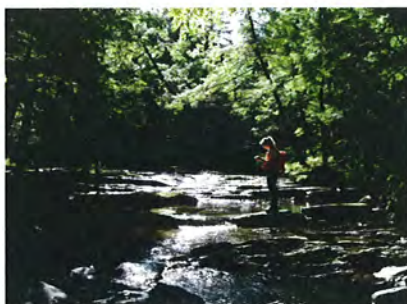
File Name : M04B 027.jpg



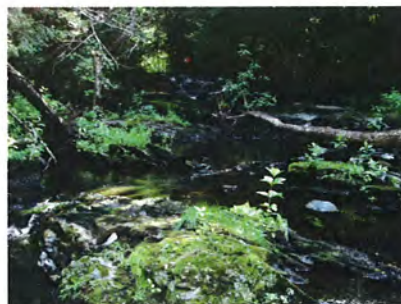
File Name : M04B 028.jpg



File Name : M04B 029.jpg



File Name : M04B 030.jpg



File Name : M04B 031.jpg



File Name : M04B 032.jpg

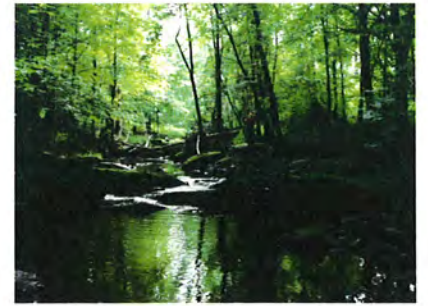
Mill River Photos - M04



File Name : M04B 033.jpg



File Name : M04B 034.jpg



File Name : M04B 035.jpg



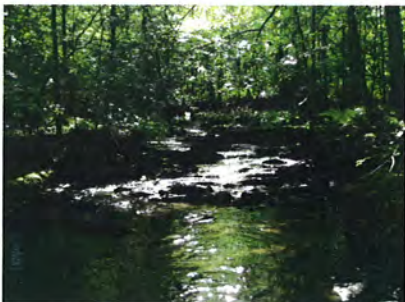
File Name : M04B 036.jpg



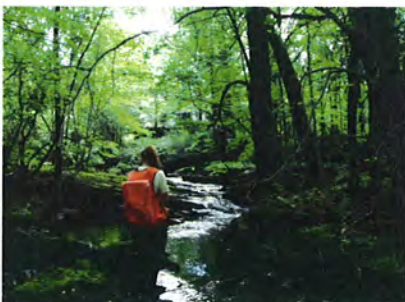
File Name : M04B 037.jpg



File Name : M04B 038.jpg



File Name : M04B 039.jpg



File Name : M04B 040.jpg



File Name : M04B 041.jpg

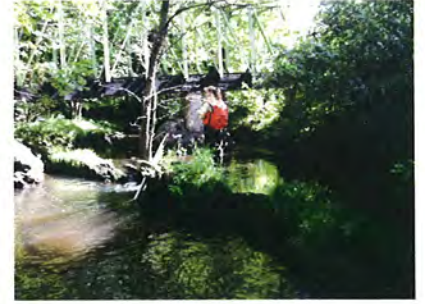
Mill River Photos - M04



File Name : M04B 042.jpg



File Name : M04B 043.jpg



File Name : M04B 044.jpg



File Name : M04B 045.jpg



File Name : M04B 046.jpg



File Name : M04B 047.jpg



File Name : M04B 048.jpg



File Name : M04B 049.jpg



File Name : M04B 050.jpg

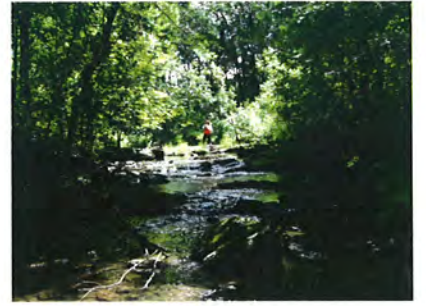
Mill River Photos - M04



File Name : M04B 051.jpg



File Name : M04B 052.jpg



File Name : M04B 053.jpg

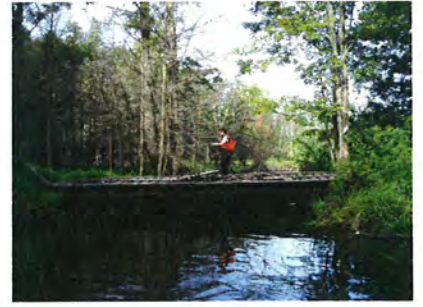
Mill River Photos - M05



File Name : M05 001.jpg



File Name : M05 002.jpg



File Name : M05 003.jpg



File Name : M05 004.jpg



File Name : M05 005.jpg



File Name : M05 006.jpg

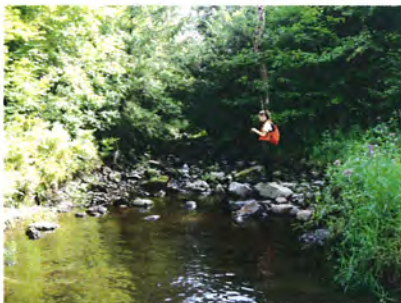


File Name : M05 007.jpg

Mill River Photos - M06



File Name : M06A 001.jpg



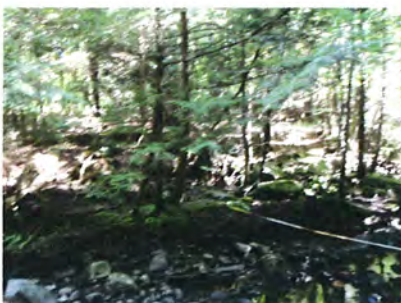
File Name : M06A 002.jpg



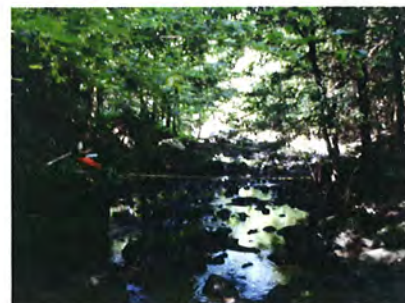
File Name : M06A 003.jpg



File Name : M06A 004.jpg



File Name : M06A 005.jpg



File Name : M06A 006.jpg



File Name : M06B 007.jpg



File Name : M06B 008.jpg



File Name : M06B 009.jpg

Mill River Photos - M06



File Name : M06B 010.jpg



File Name : M06B 011.jpg



File Name : M06B 012.jpg

Mill River Photos - M07



File Name : M07A 013.jpg



File Name : M07A 014.jpg



File Name : M07A 019.jpg



File Name : M07A 020.jpg



File Name : M07B 015.jpg



File Name : M07B 016.jpg



File Name : M07B 017.jpg



File Name : M07B 018.jpg



File Name : M07B 021.jpg

Mill River Photos - M7S1.01



File Name : M7S1.01A 006.jpg



File Name : M7S1.01A 007.jpg



File Name : M7S1.01A 008.jpg



File Name : M7S1.01A 009.jpg



File Name : M7S1.01A 010.jpg



File Name : M7S1.01A 011.jpg



File Name : M7S1.01A 012.jpg



File Name : M7S1.01A 013.jpg



File Name : M7S1.01B 001.jpg

Mill River Photos - M7S1.01



File Name : M7S1.01B 002.jpg



File Name : M7S1.01B 003.jpg



File Name : M7S1.01B 004.jpg

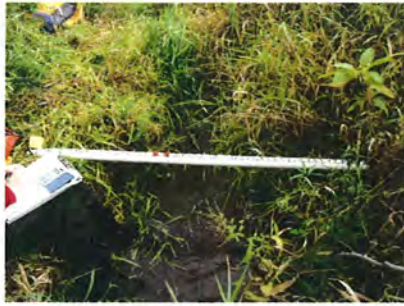


File Name : M7S1.01B 005.jpg

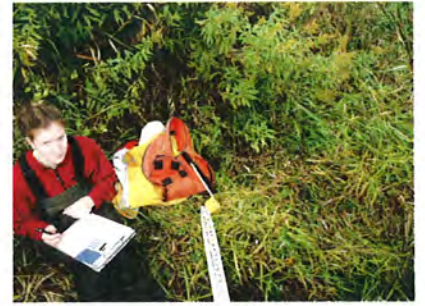
Mill River Photos - M7S2.01



File Name : M7S2.01 001.jpg



File Name : M7S2.01 002.jpg



File Name : M7S2.01 003.jpg



File Name : M7S2.01 004.jpg



File Name : M7S2.01 005.jpg



File Name : M7S2.01 006.jpg



File Name : M7S2.01 007.jpg



File Name : M7S2.01 008.jpg

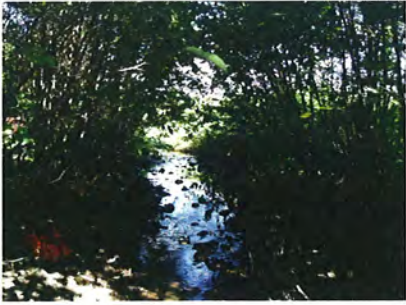


File Name : M7S2.01 009.jpg



File Name : M7S2.01 010.jpg

Mill River Photos - M08



File Name : M08 022.jpg



File Name : M08 023.jpg



File Name : M08 024.jpg



File Name : M08 025.jpg

Rugg Brook Photos - M1T1.01



File Name : M1T1.01A 001.jpg



File Name : M1T1.01A 002.jpg



File Name : M1T1.01A 003.jpg



File Name : M1T1.01A 004.jpg



File Name : M1T1.01A 005.jpg



File Name : M1T1.01A 006.jpg



File Name : M1T1.01A 007.jpg



File Name : M1T1.01B 008.jpg



File Name : M1T1.01B 009.jpg

Rugg Brook Photos - M1T1.01



File Name : M1T1.01B 010.jpg



File Name : M1T1.01B 011.jpg



File Name : M1T1.01B 012.jpg

Stonebridge Photos - Bridges and Culverts 09-01-06



File Name : B+C 001.jpg



File Name : B+C 002.jpg



File Name : B+C 003.jpg



File Name : B+C 004.jpg



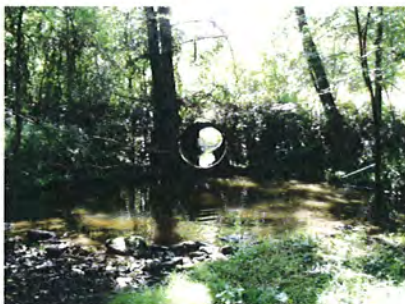
File Name : B+C 005.jpg



File Name : B+C 006.jpg



File Name : B+C 007.jpg



File Name : B+C 008.jpg



File Name : B+C 009.jpg

Stonebridge Photos - Bridges and Culverts 09-01-06



File Name : B+C 010.jpg



File Name : B+C 011.jpg



File Name : B+C 012.jpg



File Name : B+C 013.jpg



File Name : B+C 014.jpg



File Name : B+C 015.jpg



File Name : B+C 016.jpg



File Name : B+C 017.jpg



File Name : B+C 018.jpg



File Name : B+C 019.jpg



File Name : B+C 020.jpg

Stonebridge Photos - Bridges and Culverts 09-08-06



File Name : B + C 001.jpg



File Name : B + C 002.jpg



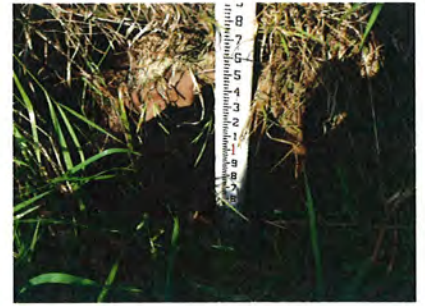
File Name : B + C 003.jpg



File Name : B + C 004.jpg



File Name : B + C 005.jpg



File Name : B + C 006.jpg



File Name : B + C 007.jpg



File Name : B + C 008.jpg



File Name : B + C 009.jpg

Stonebridge Photos - Bridges and Culverts 09-08-06



File Name : B + C 010.jpg



File Name : B + C 011.jpg



File Name : B + C 012.jpg



File Name : B + C 013.jpg



File Name : B + C 014.jpg



File Name : B + C 015.jpg



File Name : B + C 016.jpg



File Name : B + C 017.jpg



File Name : B + C 018.jpg

Stonebridge Photos - Bridges and Culverts 09-08-06



File Name : B + C 019.jpg



File Name : B + C 020.jpg



File Name : B + C 021.jpg



File Name : B + C 022.jpg



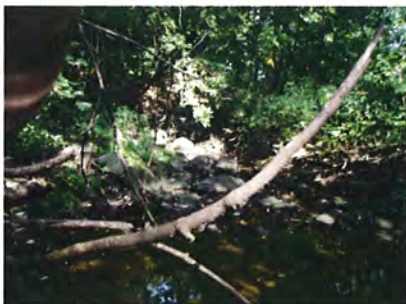
File Name : B + C 023.jpg



File Name : B + C 024.jpg



File Name : B + C 025.jpg



File Name : B + C 026.jpg

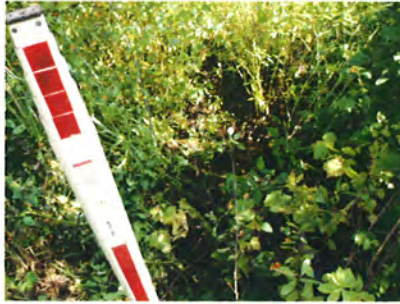


File Name : B + C 027.jpg

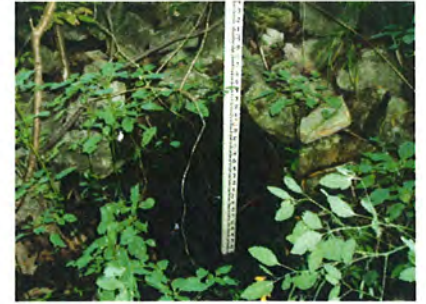
Stonebridge Photos - Bridges and Culverts 09-08-06



File Name : B + C 028.jpg



File Name : B + C 029.jpg



File Name : B + C 030.jpg



File Name : B + C 031.jpg



File Name : B + C 032.jpg



File Name : B + C 033.jpg



File Name : B + C 034.jpg



File Name : B + C 035.jpg



File Name : B + C 036.jpg

Stonebridge Photos - M02



File Name : M02A 001.jpg



File Name : M02A 002.jpg



File Name : M02A 003.jpg



File Name : M02A 004.jpg



File Name : M02A 009.jpg



File Name : M02A 010.jpg



File Name : M02A 011.jpg



File Name : M02A 012.jpg



File Name : M02B 005.jpg

Stonebridge Photos - M02



File Name : M02B 006.jpg



File Name : M02B 007.jpg



File Name : M03 008.jpg

Stonebridge Photos - M2S2.01



File Name : M2S2.01A 001.jpg



File Name : M2S2.01A 002.jpg



File Name : M2S2.01B 008.jpg



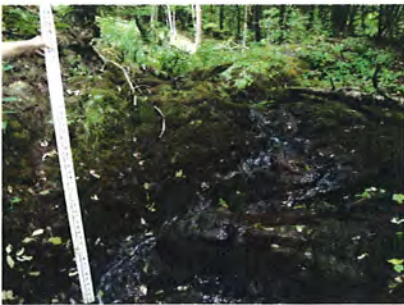
File Name : M2S2.01B 009.jpg



File Name : M2S2.01B 010.jpg



File Name : M2S2.01B 011.jpg



File Name : M2S2.01C 003.jpg



File Name : M2S2.01C 004.jpg



File Name : M2S2.01C 005.jpg

Stonebridge Photos - M2S2.01



File Name : M2S2.01C 006.jpg



File Name : M2S2.01C 007.jpg

Stonebridge Photos - M03



File Name : M03 001.jpg



File Name : M03 002.jpg



File Name : M03 003.jpg



File Name : M03 004.jpg

Stonebridge Photos - M04



File Name : M04 001.jpg



File Name : M04 002.jpg



File Name : M04 003.jpg



File Name : M04 004.jpg

Stonebridge Photos - M05



File Name : M05 001.jpg



File Name : M05 002.jpg



File Name : M05 003.jpg



File Name : M05 004.jpg



File Name : M05 005.jpg



File Name : M05 006.jpg



File Name : M05 007.jpg



File Name : M05 008.jpg



File Name : M05 009.jpg



File Name : M05 010.jpg

Stonebridge Photos - M5S1.01



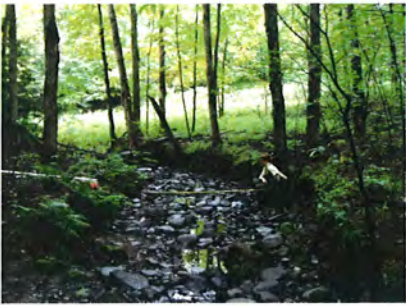
File Name : M5S1.01A 003.jpg



File Name : M5S1.01A 004.jpg



File Name : M5S1.01A 005.jpg



File Name : M5S1.01A 006.jpg



File Name : M5S1.01A 007.jpg



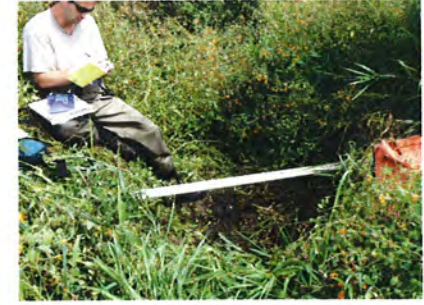
File Name : M5S1.01A 008.jpg



File Name : M5S1.01B 001.jpg



File Name : M5S1.01B 002.jpg



File Name : M5S1.01B 009.jpg

Stonebridge Photos - M5S1.01



File Name : M5S1.01B 010.jpg



File Name : M5S1.01B 011.jpg

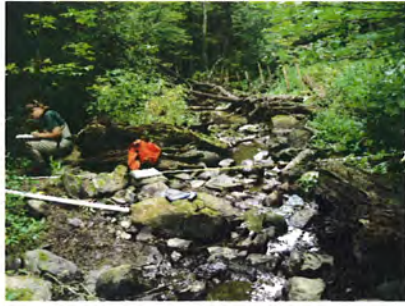


File Name : M5S1.01B 012.jpg

Stonebridge Photos - M06



File Name : M06A 001.jpg



File Name : M06A 008.jpg



File Name : M06A 009.jpg



File Name : M06A 010.jpg



File Name : M06A 011.jpg



File Name : M06A 012.jpg



File Name : M06A 013.jpg



File Name : M06B 002.jpg



File Name : M06B 003.jpg

Stonebridge Photos - M06



File Name : M06B 004.jpg



File Name : M06B 005.jpg



File Name : M06B 006.jpg



File Name : M06B 007.jpg



File Name : M06B 014.jpg



File Name : M06B 015.jpg



File Name : M06B 016.jpg



File Name : M06B 017.jpg



File Name : M06B 018.jpg

Stonebridge Photos - M06



File Name : M06B 019.jpg



File Name : M06B 020.jpg

Missisquoi_Black Hunger Photos - R4S1.1S1.01



File Name : R4S1.1S1.01A 001.jpg



File Name : R4S1.1S1.01A 002.jpg



File Name : R4S1.1S1.01A 003.jpg



File Name : R4S1.1S1.01A 004.jpg



File Name : R4S1.1S1.01B 005.jpg



File Name : R4S1.1S1.01B 006.jpg



File Name : R4S1.1S1.01B 007.jpg



File Name : R4S1.1S1.01B 008.jpg



File Name : R4S1.1S1.01B 009.jpg

Missisquoi_Black Hunger Photos - R4S1.1S1.01



File Name : R4S1.1S1.01B 010.jpg



File Name : R4S1.1S1.01B 011.jpg



File Name : R4S1.1S1.01B 012.jpg



File Name : R4S1.1S1.01B 013.jpg

Missisquoi_Black Hunger Photos - R4S3.03



File Name : R4S3.03A 001.jpg



File Name : R4S3.03A 002.jpg



File Name : R4S3.03A 003.jpg



File Name : R4S3.03A 004.jpg



File Name : R4S3.03A 005.jpg



File Name : R4S3.03A 006.jpg



File Name : R4S3.03A 007.jpg



File Name : R4S3.03A 008.jpg



File Name : R4S3.03A 009.jpg

Missisquoi_Black Hunger Photos - R4S3.03



File Name : R4S3.03A 010.jpg



File Name : R4S3.03A 011.jpg



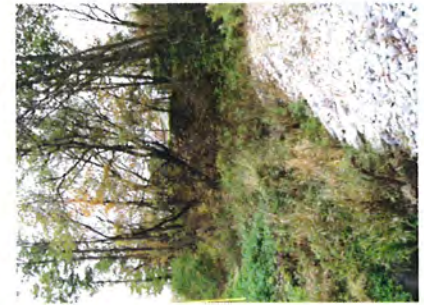
File Name : R4S3.03A 012.jpg



File Name : R4S3.03A 013.jpg



File Name : R4S3.03A 014.jpg



File Name : R4S3.03A 015.jpg



File Name : R4S3.03B 016.jpg



File Name : R4S3.03B 017.jpg



File Name : R4S3.03B 018.jpg



File Name : R4S3.03B 019.jpg

Missisquoi_Mouth Photos - R3S4.01



File Name : R3S4.01 001.jpg



File Name : R3S4.01 002.jpg



File Name : R3S4.01 003.jpg



File Name : R3S4.01 004.jpg

Missisquoi_Mouth Photos - R3S4.02



File Name : R3S4.02 001.jpg



File Name : R3S4.02 002.jpg



File Name : R3S4.02 003.jpg



File Name : R3S4.02 004.jpg

Missisquoi_Mouth Photos - R3S4.03



File Name : R3S4.03 001.jpg



File Name : R3S4.03 002.jpg



File Name : R3S4.03 003.jpg



File Name : R3S4.03 004.jpg



File Name : R3S4.03 005.jpg



File Name : R3S4.03 006.jpg



File Name : R3S4.03 007.jpg



File Name : R3S4.03 008.jpg



File Name : R3S4.03 009.jpg

Missisquoi_Mouth Photos - R3S4.03



File Name : R3S4.03 010.jpg



File Name : R3S4.03 011.jpg

Missisquoi_Mouth Photos - R3S4.04



File Name : R3S4.04A 001.jpg



File Name : R3S4.04A 002.jpg



File Name : R3S4.04A 003.jpg



File Name : R3S4.04A 004.jpg



File Name : R3S4.04A 005.jpg



File Name : R3S4.04A 006.jpg



File Name : R3S4.04A 007.jpg



File Name : R3S4.04A 008.jpg

**A
T
T
A
C
H
M
E
N
T
E**

REACH SUMMARIES

DEER BROOK **REACH SUMMARIES**

M01

M01 begins at the mouth of the Deer Brook, where it empties into Arrowhead Lake, immediately south of Route 104A, and extends approximately 5,500 feet upstream, ending where the valley significantly narrows. The downstream-most 3,400 feet consisted of wetlands, and therefore this portion was not assessed. The Phase 2 stream type of M01B was found to be an E sand stream, which is not considered to be a stream type departure. The incision ratio for this reach was 1.2; however, no active head cuts were observed, and the stream still has access to its floodplain. Aggradational features were dominant throughout the reach, evident as some enlarged bars, and sediment accumulation upstream of obstructions. The aggraded sediment was very fine and felt very soft underfoot. Moderate erosion and bank slumping were noted within the reach; however, the source of at least a portion of the accumulating sediment appears to be coming from the Georgia Industrial Park stormwater runoff, which enters the stream system in M02. The Rapid Geomorphic Assessment (RGA) score for M01B was 0.65 (good), with the stream in Stage III of evolution, and with high sensitivity.

M02

M02 begins at the upstream end of M01 to approximately 150 feet downstream of the Interstate-89 culverts. M02 was segmented into M02A and M02B due to planform and slope changes, and M02C was segmented as a subreach, as a result of a natural confinement change. M02A consists of the lower two thirds of the reach, and was assessed as an E sand stream, with ripple-dune bed features. M02B is a short segment, extending approximately 1,000 feet upstream of M02A and was assessed as an E gravel stream with plane bed features. M02C makes up the remainder of the reach, and was assessed as a B cobble stream with plane bed features. Each of these segments is considered in regime with their Phase 1 stream types.

In M02A, aggradation was the major adjustment process observed, which was evident as an increase in fine sediment accumulations at constrictions, forming multiple unvegetated bars. The majority of the corridor is forested in the segment; however, moderate to high erosion was noted, and multiple mass failures were observed in bare areas, most consistently on the right valley wall, which is extremely steep. The Georgia Industrial Park is located immediately adjacent to the right valley wall, and is likely responsible for a portion of the sediment input causing aggradation in this segment. The RGA score for M02A was 0.50 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

In M02B, less aggradation and widening were noted, and the substrate was dominated by gravel. The incision ratio (1.1) indicates minor incision. One single active headcut was observed downstream of a stormwater input and may be the result of increased flows during episodic events. Minimal bank erosion and some aggradation were observed. The RGA score for M02B was 0.69 (good), with the stream just beginning Stage III of evolution, and with high sensitivity.

In M02C, some aggradation in the form of side bars was observed; however, the majority of the segment was dominated by plane bed features. The incision ratio (1.7) indicates major historic degradation; however, no active head cuts were observed. Multiple

mass failures and minimal bank erosion were noted. The RGA score for M02C was 0.65 (good), with the stream in Stage III of evolution, and with moderate sensitivity.

M03

M03 extends from M02 to approximately 8,300 feet upstream. The reach is segmented into three parts: M03A, which consists of the lower one quarter of the reach and is assessed as a C gravel stream; M03B, which is considered a subreach, and is assessed as an E gravel stream, and M03C, which was not assessed due to impoundment caused by extensive beaver damming.

M03A was found to be in regime with the Phase 1 assessment stream type. Approximately three quarters of the segment is composed of large culverts, which cross under Interstate-89; therefore a majority of the segment has been extensively straightened. A small amount of bank armoring in the form of rip-rap was observed between the culverts. Despite the straightening and armoring, only minor incision has occurred (1.2), and it is considered to be historic, as no active head cuts were observed. The buffer width was predominantly greater than 100 feet; however, a small portion of the segment had a buffer width of less than five feet, resulting from the interstate encroachment. Despite the extensive human-caused stream alterations, no major problem areas were identified within the segment. The RGA score for M03A was 0.70 (good), with the stream in Stage I of evolution (stable), and with high sensitivity.

M03B was found to be in regime with the Phase 1 assessment stream type, though it was considered a sub-reach. This segment has many breached beaver dams, with a predominantly clay stream bed, and very few riffles. Vegetation types and debris locations suggest recent ponding of the stream, possibly as a result of the beaver activity. The incision ratio (1.3) indicates minor historic degradation; however no evidence of active incision was observed, and the segment has access to its floodplain. The RGA score for M03B was 0.78 (good), with the stream in Stage I of evolution (stable), and with high sensitivity.

M04

This segment was not assessed due to impoundment caused by extensive beaver dams.

M05

M05 was segmented into three segments: M05A, which starts at M04 and extends approximately 1,700 feet upstream, was not assessed due to wetland impoundment; M05B, which is mostly very sinuous and extends from approximately 350 feet downstream of the Town Highway 45 bridge to approximately 2,500 feet upstream; and M05C, which composes the remainder, and has been extensively straightened. Both M05B and M05C were found to be in regime with the Phase 1 stream types.

M05B was assessed as an E sand stream, with riffle-pool bed features. The segment is bordered by hay fields, and was likely straightened historically, but appears to be reestablishing its sinuosity. The incision ratio (1.8) indicates that severe degradation has occurred; however no active headcuts were observed. Minor erosion and aggradation were also noted within the segment. The RGA score for M05B was 0.68 (good), with the stream in Stage II of evolution (but on its way to Stage III), and with high sensitivity.

M05C also runs through farm fields, predominantly pastures, with some crop fields. The planform indicates historic straightening; however, it is unclear if active straightening is occurring. Additionally, cows were not fenced out of the stream, and were observed

crossing the stream near the barn. This segment lacked any significant riparian buffer. The incision ratio for this segment (1.9) indicates major degradation, which appeared to be the active adjustment process. The RGA score for M05C was 0.60 (fair), with the stream in Stage II of evolution, and with very high sensitivity.

M06

M06 was segmented into two: M06A, which extends from M05 to the upstream side of the railroad crossing on the west side of Oakland Station Road, and M06B, which composes the remainder of the reach and was not assessed due to wetland impoundment.

M06A was assessed as an E sand stream, which is in regime with the Phase 1 stream type. The planform indicates historic straightening, and several headcuts were noted, particularly near culverts. The incision ratio was 1.4, though the stream still has some access to its floodplain. The buffer was predominantly greater than 100 feet; however, toward the upstream end of the segment, residential dwellings and small scale farming activities border the stream. The RGA score for M06A was 0.56 (fair), with the stream in Stage II of evolution, and with very high sensitivity.

M5S3.01

M5S3.01 is a small tributary to Deer Brook M05, and begins at the M05 confluence, and extends approximately 1,150 feet upstream. This reach was assessed as an E sand stream. It appears from the planform that the tributary has been historically straightened through the field, which is used for hay. The incision ratio (1.9) indicates major historic incision; however, no evidence of active incision was observed. The entrenchment (2.3) indicates that the stream is slightly entrenched. Additionally, major erosion areas were noted along the reach, where it appears that the stream is attempting to regain its sinuosity. The RGA score for M5S3.01 was 0.64 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

MILL RIVER REACH SUMMARIES

M01

M01 begins at the mouth of the Mill River, where it empties into Lake Champlain, and extends approximately 11,000 feet upstream. M01 was broken down into five segments due to changes in valley confinement and slope. The downstream-most 2,800 feet (M01A) was impounded by wetlands, and therefore was not assessed. Each segment was found to be in regime with the Phase 1 reference stream types.

M01B is very short (approximately 300 feet) and consists of a bedrock gorge, which was assessed as an F boulder stream with step-pool bedforms. Because it is a gorge, bankfull features were very difficult to find; however, the base of woody vegetation on each side of the gorge was used. Based on the cross section, this segment has experienced major degradation (incision ratio = 2.1); however, the segment is inherently stable due to the bedrock grade controls on the stream bed and banks. Per the protocols, an RGA form was not completed for this segment, and the segment was assigned a sensitivity of low.

M01C was considered a subreach and consists of the next 1,100 feet of stream, which was assessed as a B gravel stream with step-pool bedforms. This segment has experienced significant degradation (incision ratio – 1.7); however, no active signs of degradation were observed and the stream appeared to be widening and aggrading. Several bedrock grade controls in the form of ledge or waterfalls were observed throughout the segment. The RGA score for M01C was 0.51 (fair), with the stream in Stage III of evolution, and with high sensitivity.

M01D comprises the next 4,000 feet of stream and was assessed as a C gravel stream with riffle-pool bedforms. Berming and dredging were noted within this segment, as well as road and improved path encroachments. A high incision ratio (1.9) indicates significant degradation; however, no active headcutting was observed within the reach. No natural grade controls were observed within this segment. Overall, the RGA score for the segment was 0.51 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M01E comprises the uppermost 3,200 feet of the reach and was assessed as a B cobble stream with riffle-pool bedforms. Little degradation has occurred within the segment (incision ratio = 1.2). Several bedrock grade controls in the form of ledge and waterfalls were observed throughout the segment. Multiple mass failures were observed throughout the segment, which is likely adding additional sediment to the system. The RGA score for this segment was 0.70 (good), with the segment in Stage IV of evolution, and with moderate sensitivity.

M02

M02 begins at M01 and extends approximately 12,000 feet upstream to approximately 50 feet upstream of the confluence with M2T2.01. M02 was broken down into two segments due to differences in planform. Both segments were found to be in regime with the Phase 1 reference stream type.

M02A consists of the downstream-most 5,000 feet of the reach, which is relatively straighter than the remainder of the reach. This segment was assessed as a C gravel stream, with riffle-pool bed features. The downstream quarter of the reach contained more bedrock grade control features than the rest of the segment, and has also been influenced by the contribution of M1T1.01 (Rugg Brook), which adds fine sediment deposits to the segment. One culvert was assessed on this segment, which is located below an inactive cobble road

farm crossing. The culvert was found to be both a channel and partial floodprone constriction, with major scour occurring downstream. Overall, this stream has experienced minor historic degradation (incision ratio = 1.3), and there is evidence of moderate erosion; however, the stream appears to be stabilizing and has access to its floodplain. The Rapid Geomorphic Assessment (RGA) score for M02A was 0.68 (good), with the stream in Stage IV of evolution, and with high sensitivity.

M02B consists of the remaining 7,400 feet of the reach, and is very sinuous. This segment was assessed as a B sand stream with a c slope, and riffle-pool bed features. The incision ratio (1.7) indicates major degradation, and the stream has lost access to its floodplain (entrenchment = 1.4), indicating a stream type departure from a C stream to a B stream. Moderate erosion was noted throughout the segment, and the buffer was greater than 100 feet and consisted of shrub-sapling/herbaceous vegetation. Moderate beaver activity was observed throughout. Overall, the RGA score was 0.45 (fair), with the stream in Stage III of evolution, and with high sensitivity. A stream type departure of a reference C stream to a B stream was observed.

M03

M03 begins approximately 50 feet upstream of the M02 and M2T2.01 confluence, and extends approximately 4,800 feet upstream. M03 was not segmented, and was assessed as an E gravel stream with riffle-pool features, which is in regime with the Phase 1 reference stream type. In this reach, erosion was the dominant process occurring throughout the reach, evident as undercut banks, overhangs, fracture lines at the top of banks, and bare banks on most outside bends. The incision ratio (1.6) indicates significant degradation; however, no active signs of incision were observed. One culvert was assessed on Polly Hubbard Road, and was found to be a channel and floodprone constriction. Additionally, the landowner indicated that flood waters back up behind the structure, and flood his fields frequently. The RGA score for M03 was 0.58 (fair), with the Stage III of evolution, and with very high sensitivity.

M04

M04 begins at the upstream end of M03 and extends approximately 6,400 feet upstream. M04 was broken down into two segments due to significant bedrock grade control features.

M04A consists of the downstream-most 3,200 feet and was assessed as a C gravel stream with riffle-pool features, which is considered in regime with the Phase 1 reference stream type. One major waterfall was identified at the upstream end of the segment. The dominant process occurring on the segment is widening, which was evident as significant scour and erosion on banks, and major sediment aggradation. One culvert, below Polly Hubbard Road, was assessed in this segment. The culvert was found to be a channel and floodprone constriction, and the stream approaches the culvert at a sharp bend. Major deposition was noted upstream of the culvert, and major scour was noted at the downstream end of the culvert. The RGA score for M04A was 0.53 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M04B consists of the remainder of the reach, and is dominated by multiple bedrock grade control features, and significant waterfalls. The stream type was assessed as a C cobble stream with a b slope, and with cascade bedform features. This segment is considered to be in regime with the Phase 1 reference stream type. Three bridges were assessed in this segment. The first is a small foot bridge, which has a weir constructed on the upstream end

of the bridge. This bridge was found to be a channel and floodprone constriction, with scour occurring downstream of the structure. The second structure is a private bridge constructed for small machinery. The structure was found to be a floodprone constriction, with scour occurring below the bridge. The third structure was also a private bridge constructed for small machinery, and though it was found to be a floodprone constriction, no major problems were identified. The RGA score for M04B was 0.76 (good), with the stream in Stage I of evolution, and with moderate sensitivity.

M05

M05 begins at the upstream end of M04, and extends approximately 5,800 feet upstream, where the valley type changes slightly from a very broad, to broad. M05 was not segmented and was assessed as a C sand stream with ripple-dune features, which is not considered a stream type departure. The downstream portion of the reach, below the Route 7 Bridge, has residential development on both banks; however, a majority of the reach is located in an inactive field with abundant wetlands buffering each side. Major beaver activity was observed at the upstream end of the reach. The Route 7 bridge was assessed in this reach, and was found to be a channel and floodprone constriction, with an alignment issue as the stream approaches the structure. A man-made weir is located immediately upstream of the structure, and bedrock was present throughout. Additionally, an all-terrain vehicle bridge was assessed at the upstream end of the reach. The bridge was found to be a channel constriction, but not a floodprone constriction. An active beaver dam is located approximately 75 feet downstream of the structure. Overall, the incision ratio (1.4) indicates that bed degradation has occurred, and it is considered to still be active, as no erosion was observed throughout the reach. The RGA score for M05 was 0.64 (fair), with the stream in Stage II of evolution, with very high sensitivity.

M06

M06 extends from the upstream end of M05 to approximately 2,300 feet upstream. M06 was broken down into two segments due to planform and slope changes.

M06A is a subreach, and consists of the downstream-most 1,200 feet of the reach. M06A was assessed as a B cobble stream with step-pool bed features, which is considered in regime with its Phase 1 reference stream type. One bedrock grade control was observed in the upstream end of the segment. The incision ratio (1.4) indicates some bed degradation; however, no active evidence of incision was observed. The RGA score for M06A was 0.76 (good), with the stream in Stage II of evolution, and with moderate sensitivity.

M06B consists of the remaining 1,400 feet of the reach and was assessed as an E sand stream with riffle-pool bed features, which is in regime with the Phase 1 reference stream type. The culvert below the railroad crossing was assessed within this segment. The structure was found to be a channel and floodprone constriction, and has a major alignment problem as the stream approaches the culvert. Rock rip rap bank armoring was noted on the upstream left bank, and was found to be intact, and scour was observed on the upstream and downstream ends of the culvert. Overall, the incision ratio (1.2) for this segment indicates minor bed degradation, which is considered to be historic, as the presence of mid channel and side bars, as well as flood chutes and avulsions suggest aggradation and planform change. The dimensions of this segment are very different from M06A, and it appears that the segment has likely been ditched historically. The RGA score for M06B was 0.71 (good), with the stream in Stage II of evolution, and with high sensitivity.

M07

M07 extends from the upstream end of M06, to approximately 3,700 feet upstream. M07 was broken down into two segments due to a significant change in planform, considered to be a result of historic straightening.

M07A consists of the downstream-most 2,000 feet and runs through an inactive farm field with abundant wetlands buffering the stream. The segment was very sinuous and was assessed as an E sand stream with riffle-pool bed features. No major problems were identified in this segment; however, due to the dimensions of this channel, it was likely historically ditched through the farm field, perhaps when the field was actively used. There was one culvert encountered, which was an old oil tank converted to a culvert at a farm crossing. The culvert was found to be a channel constriction; however, it was not a floodprone constriction, and no alignment or deposition/scour problems were identified. The RGA score for M07A was 0.75 (good), with the stream in Stage I of evolution, and with high sensitivity.

M07B consists of the remaining 1,700 feet, and based on the planform and valley type, has likely been significantly historically straightened. The segment was assessed as an E sand, ripple-dune, though most bedforms have been wiped out. Despite significant straightening, the incision ratio (1.1) indicates only minor bed degradation, and the stream still has access to its floodplain. The problem area identified in this segment is immediately downstream of the Oakland Station Road culvert, at the upstream end of the reach. The culvert was identified as a channel and floodprone constriction. Additionally, the slope of the culvert was much lower than the slope of the channel, and the culvert outlet was cascading to the pool below, which was causing undermining of the culvert. The stream has been straightened to parallel the road, and diagonal riffles and other aggradational features were observed in this stretch. Where the stream turns to the west, away from the road, major erosion was noted on two outside bends. The RGA score for M07B was 0.64 (good), with the stream in Stage II of evolution, and with very high sensitivity.

M08

M08 extends from the upstream end of M07 and extends approximately 2,250 feet upstream, to the Georgia-Fairfax town line. M08 was not segmented and was assessed as an E gravel stream with riffle-pool bed features, which is in regime with the Phase 1 reference stream type. The dominant processes identified in this reach were widening, evident as significant scour and erosion on banks, and planform changes, evident as multiple active flood chutes, significant erosion on outside bends, as well as additional deposition and scour features within a typical riffle-pool sequence. A portion of the stream has likely been historically straightened in the road area. The incision ratio (1.3) indicates some historic bed degradation, and the stream is now responding by widening and changing its planform. The RGA score for this reach was 0.51 (fair), with the reach in Stage III of evolution, and with very high sensitivity.

M2T2.01

M2T2.01 is an unnamed tributary to Mill River, which begins approximately fifty feet downstream of the upstream end of M02, and extends approximately 3,200 feet upstream through a farm field. This reach was not segmented and was assessed as a Gc sand stream, which is considered a stream type departure from the Phase 1 reference stream type, which is a C for the valley type. This stream has been historically straightened and dredged through the farm field, which has resulted in an incision ratio of 2.8, and an entrenchment ratio of

1.5. The property owner participates in CREP, and maintains a 20 foot buffer on the left bank, and a 50 foot buffer on the right bank. The farm fields on each side of the stream are ditched to drain flood and rain water into the stream; however, many of the ditches have been silted in. Two bridges were assessed in this reach. The first bridge, which is located below Polly Hubbard Road, was found to be a floodprone constriction. Deposition above, scour below and an alignment problem as the stream approaches the bridge were identified. According to the property owner, the bridge causes flood water to back up during high events, and flood his farm fields, as sometimes run over the road. The second bridge is a farm crossing bridge and was found to be a floodprone constriction, with the only major problem being deposition below. Overall, no major nickpoints or headcuts were identified in the reach, and moderate to high erosion was noted along the stream banks. The RGA score for M2T2.01 was 0.33 (poor), with the stream in adjustment between Stages II and III of evolution, and with extreme sensitivity.

M2T2.02

M2T2.02 is an unnamed tributary of Mill River, and begins approximately 500 feet upstream of the confluence of M2T2.01 and M2T2.1S1.01, and extends approximately 1,800 feet upstream. This reach was divided into two segments due to major changes in the banks and buffers, which changed from virtually no buffer due to agricultural activity, to a wetland buffer.

M2T2.02A comprises the downstream most 750 feet, and was assessed as a G sand stream with a “c” slope, which is a stream type departure from the Phase 1 reference stream type of C. The relatively low sinuosity of the reach suggests that the stream was historically straightened, and likely dredged along the boundary between two agricultural fields. The straightening has caused major incision (incision ratio = 2.2), and the stream has become entrenched (entrenchment ratio = 1.3). No active signs of bed degradation were observed, and extensive scour and erosion were noted along the banks. The current stressor on the segment appears to be beaver activity. Two active beaver dams were observed to affect at least 300 feet of the segment, and has made the segment slow, deep, and very silty. The RGA score for this segment was 0.46 (fair), with the stream in Stage III of evolution, and with extreme sensitivity.

M2T2.02B comprises the remainder of the reach and was assessed as a B sand stream with a “c” slope, which is a stream type departure of the Phase 1 reference stream type of C. This segment flows through a relatively undisturbed wetland. There is evidence of old beaver activity, and the stream has incised (incision ratio = 2.1) and become entrenched, possibly from the breaching of the beaver dams. Moderate erosion was noted along most of the segment. The RGA score for this segment was 0.56 (fair), with the segment in Stage III of evolution, and with high sensitivity.

M2T2.03

M2T2.03 is an unnamed tributary to Mill River, which begins approximately 630 feet north of Reynolds Road, it crosses Reynolds Road approximately 1,000 feet east of the intersection with Georgia Middle Road, and extends approximately 10,000 feet south, ending approximately 1,800 feet south of Pattee Hill Road. This reach was broken into two segments due to property access limitations. M2T2.03A was assessed as an E sand stream with riffle-pool bed features, which is considered in regime with the Phase 1 reference stream type. This reach was surrounded by adjacent wetlands on both sides of Reynolds Road, and evidence of old beaver activity was evident along the entirety of the reach. The

incision ratio (1.8) indicates significant bed degradation; however, only one minor active headcut was observed on the bed. Moderate scour and erosion was noted along the reach, with some aggradation evident as minor side bars. Many breached beaver dams were noted along the segment, and the incision could be a result of the episodic increase in flow once these dams blew out. The RGA score for this segment was 0.64 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M2T2.04

M2T2.04 is an unnamed tributary of Mill River, which begins approximately 2,200 feet downstream of the Plains Road culvert (approximately 1,100 feet northeast of the Decker Road intersection), and extends approximately 5,800 feet upstream. This reach was divided into three segments. The downstream-most segment was impounded by wetlands and could not be assessed, and the upstream-most segment could not be assessed due to landowner permission limitations.

M2T2.04B begins approximately 1,300 feet downstream of the Plains Road culvert, and extends to just upstream of the culvert. The segment was assessed as an E sand stream, which is in-regime with the Phase 1 reference stream type. Based on the existing planform of the stream, it has likely been historically straightened. The stream has incised significantly (incision ratio = 1.8); however, the stream still has access to its floodplain. Moderate scour and erosion was noted along most of the segment, and a 6.5 foot bedrock waterfall was observed at the downstream end of the segment. A mowed path was noted along most of the right corridor, and was approximately five feet out from the top of the bank. The RGA score for this segment was 0.66 (good), with the stream in Stage III of evolution, and with high sensitivity.

M2T2.06

M2T2.06 is an unnamed tributary of Mill River, which begins approximately 5,200 feet west of the Ballard Road Culvert and extends approximately 600 feet east of the culvert. This reach was divided into four segments. M2T2.06A could not be assessed due to property access limitations. M2T2.06B (a subreach) and M2T2.06C were segmented due to changes in depositional features, and M2T2.06D was segmented out because the entire segment is tiled below a cornfield, and therefore was not assessed.

M2T2.06B is considered a subreach, and begins approximately 1,500 feet upstream of the downstream reach point, and extends approximately 1,350 feet upstream. This segment was assessed as an E sand stream with riffle-pool bed features, which is in-regime with the Phase 1 reference stream type. The downstream 250 feet of the segment are impounded by wetlands, and the remainder of the segment is surrounded by wetlands. Low to moderate erosion was noted throughout the segment, and the incision ratio (1.5) indicates that moderate bed degradation has occurred; however, no active signs of incision were observed. The RGA score for this segment was 0.61 (fair), with the segment in Stage III of evolution, and with very high sensitivity.

M2T2.06C extends upstream approximately 980 feet from the upstream end of segment B. The stream was assessed as an F sand stream with riffle-pool bed features, which is a stream type departure from the Phase 1 reference stream type, which is B. This segment is significantly influenced by segment A, which is tiled for approximately 1,200 feet through the corn field located upstream. At the outlet of the tile, a large scour hole, approximately eight feet high was observed. Major incision (incision ratio = 2.1), laterally extensive erosion on both banks for the entirety of the segment, and several headcuts were

observed. These effects were more severe in the upper half of the segment, where non-cohesive sands were noted on both banks. A tributary entering the upper portion of the segment was observed to be rejuvenating. This segment would be a good candidate for future restoration projects. The RGA score for this segment was 0.28 (poor), with the segment in Stage II of evolution, and with extreme sensitivity.

M2T2.1S1.1S1.01

M2T2.1S1.1S1.01 is an unnamed perennial stream to Mill River, and begins approximately 350 feet east of Georgia Middle Road, and extends 3,065 feet upstream. This reach was broken into two segments based on wetland impoundment. M2T2.1S1.1S1.01A was assessed as a B sand stream, which is considered a stream type departure from the Phase 1 reference stream type. The reference stream type is C with a b subslope; however, the stream has been straightened through hay fields and has degraded its bed so significantly (incision ratio = 3.3), that it has become entrenched (entrenchment ratio = 1.4). Moderate erosion was noted throughout the segment, particularly in the portion of the segment located downstream of the Georgia Middle Road culvert. One stormwater input from a roadside ditch was noted on the downstream end of the Montcalm Road culvert. Two culverts (Montcalm Road and Georgia Middle Road) were assessed in this segment. Both culverts were found to be channel and floodprone constrictions, and major erosion was noted downstream of the Georgia Middle Road culvert. The stream was found to be dry upstream of the Montcalm Road culvert, and sediment accumulation has blocked the bottom half of this culvert. The RGA score for this segment was 0.51 (fair), with the stream in Stage II of evolution, and with high sensitivity.

M2T2.2S1.03

M2T2.2S1.03 is an unnamed tributary to Mill River, which begins approximately 200 feet upstream of the Reynolds Road culvert, and extends approximately 5,000 feet upstream through farm fields. This reach was segmented due to property access issues, which prevented assessment of M2T2.2S1.03 B.

M2T2.2S1.03A is comprised of the downstream-most 2,965 feet of the reach and was assessed as an E sand stream with riffle-pool bedform features, which is not considered a stream type departure from the Phase 1 reference stream type. Two culverts were assessed in the downstream end of the segment. Both culverts are channel and floodprone constrictions, and moderate scour and erosion were observed in the vicinity of both culverts. There is also one stormwater input from Reynolds Road within the downstream end of the segment. The downstream portion of the segment appears to be responding to the undersized culverts and stormwater inputs by incising. The upstream portion of the segment runs through a newly cleared pasture. Though there is no buffer, major erosion, and many signs of animal access observed, there is no evidence of historic straightening, as the stream maintained high sinuosity through the pasture. The recent clearing and lack of buffer have resulted in increased fine sediment, observed on the streambed just downstream of the pasture, and throughout the upstream portion of the segment. The RGA score for M2T2.2S1.03A was 0.58 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M2T2.2S1.04

M2T2.2S1.04 is an unnamed tributary to Mill River, which begins approximately 800 feet downstream of the Plains Road culvert, and extends approximately 4,770 feet upstream,

ending above Route 7. This reach was not segmented and was assessed as a B sand stream with riffle-pool features, which is considered in-regime with the Phase 1 reference stream type. The stream is characterized by major active incision (incision ratio = 1.6), with multiple headcuts and eroded, vertical banks observed throughout, as well as multiple mass failures observed downstream of the Plains Road culvert. The middle one third of the reach runs through a cow pasture, and is also incised, but the slope is less than two. The stream contains very low flows, and was dry approximately 250 feet downstream of the upstream reach break. Two major stormwater inputs were observed: the first is located just upstream of the Plains Road culvert and the second is a stormwater drain tied into the Route 7 culvert. Each of the four culverts assessed in this reach were found to be channel and floodprone constrictions, and the culvert located below Plains Road appeared to be in poor condition, with streambed scour causing undermining of the culvert on both ends. The stream appears to be responding to the undersized culverts located throughout the reach, as well as episodic flows from stormwater inputs during rainfall events. The RGA score for this reach was 0.54 (fair), with the stream in Stage II of evolution, and with high sensitivity.

M2T2.2S1.2S2.01

M2T2.2S1.2S2.01 is an unnamed tributary to the Mill River, and the upstream end is located approximately 1,200 feet downstream of the eastern end of Reynolds Road. The reach extends approximately 3,500 feet upstream to this point. This reach was broken into two segments based on the dominant current adjustment process. M2T2.2S1.2S2.01A extends from the downstream end of the reach to approximately 2,500 feet upstream, and M2T2.2S1.2S2.01B comprises the remainder of the reach. Both segments were found to have stream type departures from the Phase 1 reference stream type.

M2T2.2S1.2S2.01A was assessed as a B gravel stream with a “c” slope, which is considered a stream type departure from the Phase 1 reference stream type, which is “C”. The segment was dominated by a very sinuous planform with major erosion on nearly every outside bend. Aggradation from the erosion was also observed in the form of several mid-channel, point, and side bars, as well as diagonal riffles. The incision ratio (1.8) indicates significant bed degradation; however, no active headcutting was present. The RGA score for this segment was 0.38 (fair), with the segment in Stage III of evolution, and with high sensitivity.

M2T2.2S1.2S2.01B was assessed as an F gravel stream with riffle-pool bed features, which is a stream type departure from the Phase 1 reference stream type, which is C. This segment is dominated by multiple large headcuts, rejuvenating tributaries, and significant erosion throughout. A hardpan clay was present as part of the stream bed throughout the segment. The incision is severe for this segment, with an incision ratio of 3.5, and entrenchment of 1.1. This segment of the reach is more severely incised and entrenched, and continues to degrade the bed and transport the eroded sediment downstream. This segment has more residential activity in the left buffer, and there were two stormwater inputs noted on this segment, while the upper 100 feet of the segment were dry. This segment would be a good candidate for a restoration project. The RGA score for this segment was 0.45, with the stream in Stage II of evolution, and with extreme sensitivity.

M2T2.2S1.2S2.02

M2T2.2S1.2S2.02 is an unnamed perennial stream of Mill River and starts approximately 1,200 feet northeast of the eastern-most culvert on Reynolds Road, and

extends approximately 6,700 feet upstream, ending north of Cadieux Road. This reach was broken into two segments due to changes in planform and slope.

M2T2.2S1.2S2.02A comprises the downstream 3,100 feet of the reach and was assessed as a B gravel stream, which is considered in regime with the Phase 1 reference stream type; however, plane bed features were noted throughout the segment, which is a departure from the expected step-pool or riffle-pool features. This segment had minimal running water, and was dominated by small, disconnected pools of water. Extensive erosion and aggradation were noted along the segment. Head cuts were observed downstream of the Route 7 culvert, and are not undermining the culvert at this time, but are definitely a future threat. The incision ratio (1.9) indicates major bed degradation, and some active headcutting was noted along the segment, but was mostly concentrated in the vicinity of the Reynolds Road and Route 7 culverts. These two culverts were found to be channel and floodprone constrictions. This segment would be a good area for possible restoration projects. The RGA score for this segment was 0.40 (fair), with the stream in Stage II of evolution, and with high sensitivity.

M2T2.2S1.2S2.02B comprises the remainder of the reach, and was considered a subreach. The segment was assessed as an E sand stream with riffle-pool bed features. This stream has been historically straightened through crop and pasture land. Cows are accessing the stream in the upper portion of the segment. Moderate incision was observed (incision ratio = 1.5), and moderate erosion was also noted. The dominant buffer width for this segment is 5-25 feet, with no buffer in the pasture. Three culverts were assessed within this segment, and all were observed to be channel and floodprone constrictions. The RGA for this segment was 0.61 (fair), with the stream in Stage II of evolution, and with very high sensitivity.

M2T2.2S1.3S3.01

M2T2.2S1.3S3.01 is an unnamed perennial tributary to the Mill River, and begins approximately 1,200 feet west of Route 7 and extends approximately 3,900 feet upstream, ending just south of Carpenter Hill Road. This reach was dry on the day of the assessment, and was segmented based on access, as the downstream 1,200 feet of the reach could not be assessed (M2T2.2S1.3S3.01A). M2T2.2S1.3S3.01B was assessed as an E gravel stream with a “b” slope and plane bed features. This reach has been extensively altered to accommodate residential properties and roads. The upper approximately 500 feet has been bermed, ditched, and dredged along the north side of Carpenter Hill Road and most recently along the western edge of a field before it enters a forested area. Extensive erosion was noted along the streambanks, being most severe in areas that lacked a sufficient buffer. Four culverts were encountered along the segment, and all were found to be channel and floodprone constrictions. An adjacent property owner indicated that the culvert located across a private driveway just upstream from Towns Common Road frequently plugs with sediment and causes flooding during high rainfall events. According to the property owner, this sediment accumulation has only been occurring since new home construction has increased on Carpenter Hill Road, and did not occur when the land was in agricultural use. Additionally, in the upstream portion of the segment, the culvert below the field crossing was found to be severely undermined by scour. Four stormwater inputs were also noted along the segment including road runoff ditches, and foundation drains. The incision ratio (1.9) indicates significant bed degradation, and active headcuts indicated that this is the current adjustment process. At this time, the entrenchment ratio (2.8) indicates that the

stream still has access to its floodplain. The RGA score for this segment was 0.34 (poor), with the reach in Stage II of evolution, and with very high sensitivity.

M2T2.2S2.01

M2T2.2S2.01 begins approximately 650 feet downstream of the Reynolds Road culvert, and extends approximately 7,785 feet upstream, ending on the southern side of Pattee Hill Road. This tributary was broken into two segments due to property access limitations. M2T2.2S2.01A comprises the downstream most 3,100 feet and was assessed as an E sand stream, which is in regime with the Phase 1 reference stream type. This stream runs through abundant wetlands on both sides of Reynolds Road and evidence of old channels indicates that the stream has moved significantly within its corridor. No major problems were observed in this segment due to the large wetland buffer. The RGA score was 0.71 (good), with the segment in Stage I of evolution, and with high sensitivity.

M7S1.01

M7S1.01 is an unnamed tributary of Mill River, which extends from the confluence with M07 to approximately 7,500 feet upstream. This reach was divided into two segments based on major changes in planform and slope.

M7S1.01A comprises the downstream-most 2,500 feet of the reach, and was assessed as a C sand stream with riffle-pool bed features, which is in-regime with the Phase 1 reference stream type. The lower half of the segment flows through an undisturbed wetland area, and the upper half of the segment has been extensively straightened through an agricultural field. The property owner is now participating in the CREP program, and has planted a buffer of saplings on both banks. Despite the straightening, the stream has only moderately incised (1.5) and has access to its floodplain, and only slight erosion was observed. It appears that the original channel was much wider than it is currently, and has filled and re-vegetated. One bridge and one culvert were assessed within this segment. The structures are within fifty feet of each other and only the culvert below Conger Road was found to be a channel and floodprone constriction, causing deposition above the structure. The RGA for this segment was 0.64 (fair), with the stream in Stage IV of evolution, and with very high sensitivity.

M7S1.01B comprises the remainder of the reach, and was assessed as a C gravel stream with a “b” slope and with riffle-pool bed features, which is in-regime with the Phase 1 reference stream type. The segment was moderately sinuous, with moderate erosion on the banks, and some aggradation in the form of mid-channel bars. Very little incision has taken place (1.1), and the stream has access to its floodplain. The stream flows through a relatively undisturbed forested area. Overall, the dominant process occurring in the channel appeared to be slight widening, with aggradation evident as bars, particularly upstream of debris jams. The RGA score for this segment was 0.75 (good), with the stream in Stage III of evolution, and with high sensitivity.

M7S2.01

M7S2.01 is an unnamed tributary of Mill River, which begins just downstream of the Oakland Station Road culvert, and extends approximately 7,200 feet upstream. This reach was segmented at the Georgia-Fairfax town line; however, this reach probably should have been segmented out more during Phase 1, as the slope on the Fairfax side of the town boundary is approximately 12%, as opposed to approximately 3% on the Georgia side.

M7S2.01A comprises the downstream most 1,798 feet of the reach and was assessed as an E gravel stream with riffle-pool bed features, which is in-regime with the Phase 1 reference stream type. According to the property owner, the stream was moved from its original position, and has been straightened and dredged historically; however, the farmer currently participates in the CREP program, and has planted buffers on both banks of the stream. Several active headcuts and one rejuvenating tributary was observed along the segment; however the stream still has access to its floodplain and has not become entrenched. Low bank erosion was noted along the segment, and little to no aggradation was observed. Three culverts were assessed in this segment. All three were found to be channel and floodprone constrictions; however, no major problems were observed. The RGA for this segment was 0.60 (fair), with the segment in Stage II of evolution, and with very high sensitivity.

STONEBRIDGE BROOK **REACH SUMMARIES**

M02

M02 extends from the Milton – Georgia town line and extends approximately 8,800 feet upstream, to just below the Stone Bridge Road bridge. This reach was broken into two segments, as the upper half of the reach was impounded by extensive beaver activity and was not assessed.

M02A comprises the downstream-most 3,450 feet of the reach and was assessed as an E sand stream with ripple-dune bed features, which is considered in-regime with the Phase 1 reference type. The dominant process observed in this segment was widening, which was evident as slumped or undercut banks, leaning trees, exposed tree roots. Minor side and mid-channel bars were observed as well. Several old breached beaver dams were observed. The segment break was made at an active beaver dam, which extended approximately three feet above water surface. The incision observed (incision ratio = 1.5) and subsequent erosion and widening could be caused by old beaver dams blowing out, and the channel is cutting through these attenuated sediments, and the channel, which is not overly wide at this point, may be trying to regain its “pre-beaver” channel width. The RGA score for this segment was 0.64 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M03

M03 extends from the upstream end of M02, to approximately 7,200 feet upstream, just below the confluence with M3S1.01. M03 was broken into two segments, as the downstream-most 5,200 feet was impounded by wetlands and therefore not assessed. The Stone Bridge Road bridge was assessed at the downstream end of the reach, and no major problems were identified; however, there was evidence of a small beaver dam directly below the bridge, which could become a flood hazard if it is active.

M03B comprises the upstream 2,000 feet of the reach and was assessed as a C sand stream with ripple-dune features, which is considered in-regime with the Phase 1 reference stream type. The segment is surrounded by wetlands and is a wide, slow stream, with few bed features and dominated by very fine sediment. Breached beaver dams were observed throughout the segment, and the most bed variability was observed in the vicinity of these dams. No problems were observed within this segment and the RGA score was 0.76 (good), with the stream in Stage I of evolution, and with high sensitivity.

M04

M04 extends from M03 to approximately 5,400 feet upstream, approximately 100 feet upstream of Sodom Road. M04 was not segmented and was assessed as an E sand stream with ripple-dune bed features. The reach is surrounded by wetlands in a broad valley. Evidence of old beaver activity was noted; however, no recent activity was observed. The stream has responded to breached beaver dams by incising slightly (incision ratio = 1.2), and has widened in areas near the dams; however, no major problems were noted, and the stream appears to be stable. The upstream 200 feet of the segment undergo a natural grade change, and bedrock outcrops and falls were observed. One culvert was assessed under Sodom Road, and was found to be a channel and floodprone constriction, and had an alignment problem with the stream. No other major problems were noted with the culvert,

as the dominant bed material was bedrock. The RGA score for this reach was 0.75 (good), with the stream in Stage I of evolution, and with high sensitivity.

M05

M05 extends from the upstream end of M04 to approximately 5,500 feet upstream, ending 1,100 feet downstream of the Ballard Road culvert. M05 was not segmented and was assessed as an E sand stream with riffle-pool bed features, which is considered in regime with the Phase 1 reference stream type. The reach consisted of a pattern of broad wetland impoundments with a sinuous planform, and confined grade changes with multiple bedrock outcrops. Small active headcuts were observed, as well as moderate erosion, which indicates that widening is beginning to occur. The incision ratio indicates moderate bed degradation, which is still occurring in some locations in the wetland areas; however, it is limited by the channel spanning bedrock grade controls observed periodically. The RGA score for this reach was 0.60 (fair), with the stream just beginning Stage III of evolution, and with very high sensitivity.

M06

M06 extends from the upstream end of M06 to approximately 3,225 feet upstream, ending in a farm pasture. This reach was broken down into two segments due to significant changes in planform and slope.

M06A is a subreach, and comprises the downstream-most 850 feet of the reach. The subreach was assessed as a B gravel stream with plane bed features, which is a stream type departure from the reference Cb conditions. The segment is dominated by a very wide, shallow channel with plane bed features. The incision ratio (1.9) indicates major bed degradation; however, no active headcuts or sharp slope changes were observed and moderate erosion was also noted throughout the segment. The RGA score for the reach was 0.40 (fair), with the stream in Stage III of evolution, and with high sensitivity.

M06B comprises the upstream 2,300 feet of the segment and was assessed as an E gravel stream with riffle-pool bed features. A significant portion of the segment runs through wetland; however, there are hotspots of major erosion along the segment as well, which are located adjacent to a residence. The incision ratio (1.8) indicates major bed degradation, and minor sharp slope increases were noted along the segment, indicating that the incision is ongoing. The upper portion of the segment runs through an active farm pasture, where there is evidence that animals are directly accessing the stream. Three culverts were assessed in this segment and all were found to be channel and floodprone constrictions with alignment problems. Significant undermining was noted on both ends of the downstream-most culvert, as well as the upstream end of the upstream-most culvert located in the pasture. The RGA score for this segment was 0.55 (fair), with the stream in Stage II of evolution, and with very high sensitivity.

M2S2.01

M2S2.01 begins at the confluence with M02 and extends approximately 4,100 feet upstream. This reach was broken into four segments. The downstream most 2,000 feet were segmented due to wetland impoundment from beaver activity. The middle two segments were broken out due to planform and slope changes, and the upper-most segment was separated out due to property access issues.

M2S2.01B extends from the upstream end of M2S2.01A to approximately 460 feet upstream. The segment was assessed as a C sand stream with riffle-pool bed features, which

is considered in-regime with the Phase 1 reference stream type. There is some evidence of old beaver activity in this segment and an increase in fine sediment was observed. Minor erosion was also observed throughout the segment, and the incision ratio (1.5) indicates moderate bed degradation; however, no active headcuts were observed. Overall, aside from the fine sediment aggradation, which could be transported from the upstream segment, no major problems were observed in this segment. The RGA score was 0.63 (fair), with the stream in Stage IV of evolution, and with very high sensitivity.

M2S2.01C extends from the upstream end of M2S2.01B to approximately 700 feet upstream and was assessed as a C gravel stream with a “b” slope, and with predominantly plane bed features. The incision ratio (1.8) indicates major bed degradation; however, no active signs of incision were noted. Minimal erosion was noted within the segment, and aggradation was noted as the dominant adjustment process, which is responsible for the plane bed features. Upstream logging and road runoff were noted as significant sources of sediment to the stream. Despite this increased sedimentation, the stream appeared to be stable. Bedrock outcrops were observed within the corridor, and one bedrock grade control was assessed within the stream channel. The RGA score for this segment was 0.50 (fair), with the segment in Stage IV of evolution, and with very high sensitivity.

M5S1.01

This reach extends from approximately 1,900 feet west of the Ballard and Sodom Road intersection, and 4,600 feet east of Ballard Road. This reach was broken into two segments based on changes in planform and slope.

M5S1.01A comprises the downstream-most 1,200 feet of the reach and was assessed as an E gravel stream with a “b” slope, which is not considered a stream type departure. The segment was dominated by bedrock grade controls and a wide, shallow stream with plane bed features. The majority of the segment runs through forested area, with a greater than 100 foot buffer. Erosion was extensive along the segment, as well as multiple mass failures, and bars formation from the eroded material. The incision ratio (1.9) indicates significant bed degradation; however, no active headcuts were observed. The RGA score for this segment was 0.60 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

M5S1.01B comprises the remaining 5,900 feet of the reach, and was dry above approximately 1,500 feet from the segment break. The segment was assessed as an E sand stream with riffle pool bed features, which is considered in-regime with the Phase 1 reference stream type. The majority of this segment runs through farmland, and animal access to the stream was evident. A farm pond impoundment is located just west of Ballard Road, which appears to be impounded by earth that has revegetated. The dominant buffer vegetation type was herbaceous, and the sinuosity was moderate to low, which indicates that the stream was likely historically straightened through the field. One active head cut was observed along the segment. The stream runs up against the right valley wall in some locations, but has floodplain on the left side of the stream throughout. One culvert below Ballard Road was assessed in this segment. The culvert was found to be a channel and floodprone constriction, and streambed scour was found to be undermining the culvert on both ends. The incision ratio (1.2) and the observed headcut indicate that minor bed degradation is occurring. The RGA score was 0.64 (fair), with the segment in Stage II of evolution, and with very high sensitivity.

MISSISQUOI – BLACK TO HUNGERFORD REACH SUMMARIES

R4S3.01

R4S3.01 is an unnamed tributary of the Missisquoi River (mouth), which extends from the confluence with the Missisquoi River through a residential area and through a pasture. This reach was divided into three segments: the first segmentation was based on a change in the valley width and channel dimensions, and the second segmentation was due to property access limitations in the agricultural field.

R4S3.01A comprises the downstream most 2,095 feet of the reach and was assessed as a C sand stream with riffle-pool bed features, which is in-regime with the Phase 1 reference stream type. The segment flows through a rural residential area along Route 207. This stream was observed to be relatively stable. A few mass failures were noted on the road embankment, which could become a problem in the future. Three culverts were assessed in this segment, and all were determined to be channel and floodprone constrictions; however, no major problems were observed in the channel. The RGA score for this segment was 0.69 (good), with the stream in Stage I of evolution, and with high sensitivity.

R4S3.01 B is a subreach and comprises the next 1,042 feet of the reach. The subreach was assessed as an E sand stream with riffle-pool bed features, which is in regime with the Phase 1 reference stream type. This portion of the stream flows through a higher density residential area, and has moderately incised historically, but is not entrenched. The segment is dominated by continuous riffles, and moderate erosion was observed throughout, as well as potential neck cut-offs. One culvert below Luke Street was assessed in this segment and was found to be a channel and floodprone constriction, with a major alignment problem, and deposition below the downstream end of the culvert. The RGA score for this segment was 0.56 (fair), with the stream in Stage III of evolution, and with very high sensitivity.

R4S1.1S1.01

R4S1.1S1.01 is an unnamed tributary of the Missisquoi River (mouth), which extends from the confluence with the Missisquoi River to just north of Carter Hill Road. This reach was divided into two segments. The upstream segment was not assessed due to wetland impoundment, and the downstream segment (R4S1.1S1.01 A) was assessed as an E sand stream with a “b” slope. This reach flows through a mostly forested area; however, the upstream most 500 feet of the reach flows along the rail trail embankment. This portion of the segment has been straightened, with major erosion, and several active headcuts and nickpoints. Several ATV trails were observed in the forested portion of the segment, including multiple crossings directly on the stream bed and banks. Major erosion was noted on the banks in the vicinity of these crossings. Significant incision has occurred (incision ratio = 1.9); however, the stream still has some access to its floodplain within the narrow valley. The RGA score for this segment was 0.53 (fair), with the stream in Stage II of evolution, and with very high sensitivity.

MISSISQUOI MOUTH REACH SUMMARIES

R3S4.01 (Kelley Brook)

R3S4.01 is the downstream-most reach on Kelley Brook, which is a tributary to the Missisquoi River (mouth). The reach extends from the confluence with the Missisquoi River to approximately 2300 feet upstream. R3S4.01 was not segmented and was assessed as an E sand stream with ripple-dune bed features, which is considered in regime with the Phase 1 reference stream type. This reach has been ditched and straightened along an agricultural field, and was relatively featureless, consisting of fast-flowing runs. Moderate erosion was noted along the banks. The stream, though it has been straightened, is not entrenched, and has not significantly incised. The downstream 200 feet of the reach is more entrenched and incised, and appears to have been cleaned out near the Waugh Farm Road culvert. This culvert is a channel and floodprone constriction, and has major cobble revetments on both ends. The RGA score for this reach was 0.60 (fair), with the reach in Stage III of evolution, and with very high sensitivity.

R3S4.02 (Kelley Brook)

R3S4.02 is part of Kelley Brook, and extends from R3S4.01 to approximately 1,400 feet upstream. This reach was not segmented and was assessed as a G gravel stream with a “c” slope, which is a stream type departure from the Phase 1 reference stream type of C. The reach has also been straightened and ditched, and flows along the side of an agricultural field; however, this reach is significantly more incised and entrenched. This reach had comparatively more bed features, but was still mostly featureless due to the straightening. Moderate bank erosion was noted throughout, as well as two steep riffles, noted at the upstream end of the reach. The RGA score for this reach was 0.50 (fair), with the stream in Stage III of evolution, and with extreme sensitivity.

R3S4.03 (Kelley Brook)

R3S4.03 is part of Kelley Brook, and extends from R3S4.02 to approximately 5,200 feet upstream. This reach was not segmented, and was assessed as an E sand stream with riffle-pool bed features, which is considered in-regime with the Phase 1 reference stream type. The stream flows through a wooded area, with some adjacent wetlands. Overall, the stream is stable, with no incision or entrenchment. Two stormwater inputs were observed flowing into the reach from an adjacent sand pit. The downstream-most input had very high flows, and was observed to be contributing a significant amount of suspended sediment. The input flows into a ponded beaver dam area, and did not appear to be adversely affecting a significant portion of the stream. One bridge and one culvert were assessed within this reach. The bridge is located below the current rail trail and was found to be partially collapsed on the downstream end, and mass failures were observed on both ends of the bridge. The culvert is located below Route 78 and is a channel and floodprone constriction. The upstream end of the culvert is significantly undermined beneath the right wingwall. There were also two large sink holes observed on the road embankment above the upstream end of the culvert. The RGA score for this reach was 0.70 (good), with the reach in Stage I of evolution, and with high sensitivity.

R3S4.04 (Kelley Brook)

R3S4.04 is part of Kelley Brook, and extends from R3S4.03 to approximately 5,500 feet upstream. The reach was segmented due to wetland impoundment at the upstream end of the reach. The downstream segment (R3S4.04A) was assessed as an E gravel stream with riffle-pool bed features, which is in regime with the Phase 1 reference stream type. The stream flows through a wetland area, and there is evidence of old ponded areas and beaver dams; however, no current beaver activity was observed, and the ponds have since drained. Significant incision was measured (1.8); however, the segment is not entrenched. Low to moderate erosion was noted on the stream banks. One culvert was assessed within this segment, and was found to be a channel and floodprone constriction; however, no problems were observed with this culvert. The RGA score for this segment was 0.79 (good), with the segment in Stage III of evolution, and with high sensitivity.

**A
P
P
E
N
D
I
X**

F

June 26, 2007

QA Notes For: **Deer Brook**
Data checked by Jared Carrano (jared.carrano@state.vt.us)
Confirmed by Staci Pomeroy

Data from both Phase 1 and Phase 2 was reviewed. The DMS projects were also used to help support review of data. Information from both phases was used to help look at what may be occurring on the reach/segment as noted in the Phase 2 information. Overall the Deer Brook Phase 2 data seemed well done.

Listed below are comments and the general types of errors/questions for particular steps and then those specific to a reach. These comments and questions are intended to: help insure that the data is as accurate as possible, allow for further explanation by the consultant who collected the data, point out areas where there may be issues that need to be addressed and/or recognized in using the data, and help document things that came up as data was reviewed. After review of the information noted, the consultant should update the document with what steps, if any, were taken to address the comments/questions.

General:

1) The notes and narratives are very detailed and helpful in gaining a clearer picture of exactly what is happening in each reach. These comments and narratives should be referred to when using the data to insure that those nuances or considerations are incorporated in the use of the data.

2) **Updating Phase 1 data.** Part of a phase2 evaluation is to verify or update phase1 information. Please go back and fill in for phase1 whatever information you can confirm from your phase2 assessment. Steps that were commonly missed include : 3.1 Alluvial Fan, 4.3 Buffer Width, 5.1 Flow Reg., 6.3 Channel Bars, 6.4 Meander Migration, and 7.1 Sub-class Slope.

➤ **R.E.A.** – I have updated the Phase 1 data for each reach.

3) **Step 2.10 Riffle Type:** This is meant to capture the type of riffles that characterize the reach. Sedimented riffles are generally meant to describe aggraded riffles within a riffle pool system. If a system aggrades to the point where it is more accurately called plane bed, than a riffle type is not applicable to this system. However, in these systems it's common for slugs of sediment to drop out to create what appears to be sedimented riffles, but these typically lack the associated pool necessary to be a true riffle. This type of feature may more accurately be called a steep riffle or mid channel bar. If it is a situation in which a reach is mostly plane bed, but there are a few aggraded riffles, it is still not necessary to enter a riffle type for Step 2.10. If you chose to enter a riffle type to capture some of the riffle that were in the reach, it is important to include a note which explains their presence in an otherwise plane bed reach. **See: M02 C**

➤ **R.E.A.** – The riffle type for M02 C was changed to “not applicable” in the DMS.

4) The phase2 protocol requires steps 1, 3 and 4 be completed for reaches that cannot be fully assessed due to beaver activity. If the ponding is so severe that no degree of assessment is possible, this should be noted somewhere in the comments. Also, in these cases where a phase2 assessment isn't possible, we ask that you check over the Phase1 data via remote sensing for confirmation. Pay attention to buffers, encroachments, potential straightening, etc. **See: M03 C, M05 A and M06 B.**

➤ **R.E.A.** – I have entered available data for Steps 1, 3, and 4 for M03C, M05A, and M06B in the DMS and on field forms. Also, the Phase 1 data has been updated. **Thank you.**

Also, when a reach is not indexed with FIT – either because it was not assessed or because there were simply no features to index – the Phase1 data will not be updated by default. This is also true if the reach is segmented and any of its segments lack FIT data. This happens because we do not want to replace good phase1 data with partial or non-existent phase2 data. However, when phase2 data is accurate (when there were no features present to be indexed), or when phase1 is incomplete to begin with, it is appropriate to use the “Force Update” option during the FIT upload. This will update those phase1 fields that can only be entered via FIT. For example, if you did not index anything for a segment, the phase1 fields will remain blank. If you use the “Force Update” function it will replace certain blank fields such as grade controls with “none”. This might be confusing. Feel free to contact Staci or myself for clarification. **This is true for reaches M01, M03, M05, M06.**

- **R.E.A.** - The Phase 1 data has been updated using the “Force Update” feature in the DMS. I reviewed the reaches that were not assessed and did not see anything that would need to be FIT’d, such as encroachments or straightening. **Thank you. Good documentation and review.**

5) **Step 3.1 Bank Texture:** Sand is typically not a cohesive material. For sand to be cohesive there would have to be silts and clays holding it together. See M02, M03 B, M05 B and C, and M06.

- **R.E.A.** – I was trying to get across that there was a bit of silt in with the sand by calling it cohesive. I changed the bank texture to “Mix” and explained in the comments for these five segments that it refers to sand with enough silt to make it cohesive. **Good documentation**

6) **Step 4.9:** In several reaches there were beaver dams noted, but no length of stream affected indicated. In the DMS QC notes these are indicated as being “blown out and no stream length affected.” It is appropriate to indicated partial dams in Step 4.9 (as per protocols, page 48). To help better document these cases please, add to your field notes when there are blown out beaver dams in a reach. **See M01 A, M02 B, and M03 A and B.**

- **R.E.A.** – I added a sentence or two into the comments of M01B, M02A, M03A, and M03B about the partial dams not affecting any length of the reach. **Thank you.**

Specific Reach Questions and/or Comments:

- **M01**
 - **Seg A** Was it not feasible to complete steps 1, 3, and 4? These steps are required when beaver dams are inhibiting a full assessment, unless it is not practical. You should at least provide some notes.
 - **R.E.A.** – I have entered as much info for Steps 1, 3, and 4 as I could. Since the reach was totally impounded, we took a detour into the forest and could not walk the entire reach on our way to M01B. **Thank you. Good documentation and review.**
- **M02**
 - **SegB** You have indicated sedimented riffles and multiple bars (aggradation) as well as one head cut (degradation). It is not uncommon for both features to be present in a reach, however, the processes which cause them to form are different. This is why we require you to comment on their simultaneous presence during step x.3 of the online QA process. It is helpful to know where the headcut is in relation to the aggradational features.
 - **R.E.A.** – This headcut was found approximately 150 feet downstream of a stormwater input and is thought to be a localized impact from the increased episodic flows. **Good documentation**

- **SegC** You need to fill out all of Step 2.15 if this reach is a sub-reach.
 - **R.E.A.** – I filled this out and wasn't exactly sure what the reference bedform would be, but entered "step pool" since it is a B stream by reference. **Good documentation**
- **M03** Does the phase1 valley width of 313' seem correct? Segment B is only 100' and segment A is 175' with a human caused change. No width was given for segment C.
 - **R.E.A.** – I changed this to 175' in the Phase 1 DMS, since this was the larger of the two widths and was obtained with a range finder. **Good, please be sure the phase 1 meta data for that parameter is updated to indicate it was a field measurement.**
- **SegB** You need to fill out all of Step 2.15 if this reach is a sub-reach.
 - **R.E.A.** – I filled this out as E, gravel, no sub-slope, and riffle-pool.
- **M05**
 - **SegB** Should the riffle type for this reach really be sedimented? It seems from your incision ration, RGA scores, and your comments in the narrative, that this reach is degrading and so sedimented riffles would not be expected. If they were sedimented, add a comment in the notes section to clarify what is happening.
 - **R.E.A.** – I left the riffle type as sedimented because they were indeed diagonal riffles. I looked at the RGA form; however, and realized that there was a transcription error. 7.1.1 Should be "reference" according to the field forms, and was entered as "good" in the DMS. Additionally, no headcuts were observed in this reach. I checked "historic" in 7.1 to clarify that this is not an active process. Therefore, the sedimented riffles are attributed to the aggradation process that is just starting to occur in the reach. **Good documentation, and review of data to insure it is accurate.**
- **M5S3.01** Phase1 shows a channel slope of 0.015, if this is accurate it would not be appropriate to call it a sub-class slope of b. When the actual slope of the stream falls within the range of slopes that are expected for that stream type, than "none" is the appropriate designation. However, since E and C streams share an expected range of slope, it is not incorrect to give an E channel a sub-slope of C when the slope falls within the typical C range.
 - **R.E.A.** – The Phase 1 is correct and I have changed this on the field forms and DMS, which now have "none" entered in the sub-class slope.

May 2, 2007

QA Notes For: **Mill River**
Data checked by Jared Carrano and reviewed by Staci Pomeroy

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the information noted, the consultant should update this document (preferably in a second color) with what steps, if any, were taken to address the comments/questions.

General:

1) While it is not required during a Phase 2 (Ph2) assessment to update Phase 1 (Ph1) buffer data, we do ask that the accuracy of the Ph1 data be confirmed. In this project, many reaches lack any Ph1 buffer information. This is the type of deficiency that you should identify in your report as a future assessment need.

➤ **R.E.A. – I will include this in the report.**

Additional Phase 1 steps that should be reviewed to be updated are: 6.3- Channel Bar, 6.4 – Meander migration.

➤ **R.E.A. – I have updated these steps.**

Some reaches that were segmented did not appear to have Phase 1 updated; where you are able to confirm that no data can be collected remotely (and you did a great job noting where you did that), you can “Force Phase 1”, and it should update the data for both Phases. Phase 1 step 5.5 “dredging history”, was where this was noticed most.

➤ **R.E.A. – I have forced the Phase update for all reaches except:**

M2T2.04

M2T2.06

M2T2.03

M2T2.2S2.01

M2T2.2S1.03

M2T2.2S1.3S3.01

M7S2.01

These reaches all have segments that may be assessed in the future. Also, there appears to be a problem with the dredging history update – it should be an automatic FIT update, but it didn't appear to work!

2) Great comments where you have them – they are very helpful. However, for some reaches you have left the comment field blank. You should always try to describe in words what you saw, even if it is just to re-iterate what the data is saying. It is also helpful to include a note on what bankfull features were used or your confidence in them. Comments not only help to describe outliers and reach specifics, but

also increase the confidence someone else has when interpreting the data. Comments can go a long way towards increasing data quality, and we strongly urge people to leave as detailed comments as possible for every reach. **Reaches: M01 C and E and M04 A**

- **R.E.A.** – I have added comments to M04A, which I copied from my reach summary, being used in the report. James has added some comments to M01 C and E since he and Bethany performed those assessments.

3) Please fill out all of Step 7 – Historic and STD – with either yes or no. This helps us confirm that you did in fact evaluate the question. **Reaches: M01 C and E and M02 B**

- **R.E.A.** – this has been updated.

4) It is important to compare stream channel widths between phases. When you are in the field, look at the phase 1 channel width and determine if it seems like an accurate reference width. If the Ph2 width is much (10%) smaller than the Ph1 reference, the assessor should consider the accuracy of Ph1 and comment. If the assessor feels that the P1 channel width calculated by the hydraulic geometry curves is inaccurate because the reference stream type (A, B or E channels typically) there should be notes and comments to that effect. Also, watersheds under 10² miles tend to be over estimated. See the Ph2 handbook on channel width about this.

If a reach/segment is in reference or good condition, and you believe the channel width observed in the field is the reference width for that reach/segment, then you should consider updating the Ph1 channel width. If you do this it is important you include documentation that explains your decision. If the reach/segment is not in reference or good condition, this should be addressed as a general note in your report with a list of all reaches where it applies. **Reaches: M02 through M05, M06 B, M08, M2T2.01 through M2T2.04**

You may also want to look at your cross-sections to see if there are other features that could be potential bankfull features. On several of the cross-sections reviewed there often appeared to be other features that would better fit the expected width if chosen as bankfull. One way to help with determining if there should be a change is to use the USGS tool “Stream stats”. This tool allows for the watershed to be drawn at any point along the stream and then it calculates the Q2 discharge (an approximate bankfull discharge); this discharge can then be compared to what was calculated for the cross-section. If the discharge is significantly different than it may be a reason for adjusting the bankfull elevation. The web page for this is: <http://water.usgs.gov/osw/streamstats/Vermont.html> . Staci can help walk you through this. For the reaches noted above, it will be important to look at the cross-sections again to consider if the bankfull feature is correct. It will potentially change your stream types and RGA values if the cross-section changes.

- **R.E.A.** – I have looked through all of the information and feel confident about the P2 channel widths for M03, M06B, M08, M2T2.03A, and M2T2.04B, because these are all E “meadow” streams with watersheds less than 10 square miles, which can result in the P1 channel width being overestimated. In addition, M04 and M05 have watersheds less than 10 square miles, which can result in an overestimated P1 width. With the exception of M04B (explained below), I am confident with these cross sections. In addition, I am confident with the P2 channel widths for M02B, M2T2.01, M2T2.02A, and M2T2.02B, because these channels have undergone severe degradation and are very different from Phase 1 reference conditions. I have added comments to each reach summary.
- For M02A, I am confident with our cross section location and our bankfull features (bankfull was measured in multiple locations along the segment and were within 0.5 feet of the downstream reach). I honestly don’t know why the channel width is so different.

5) We don't typically consider sand to be a cohesive bank material. If a bank is predominantly sand, but is being held together by a finer, more cohesive matrix (i.e. silt/clay) you should call this a "mixture".

Reaches: M06 A, M2T2.2S1.2S2.02-B, M2T2.2S1.3S3.01-B and M7S1.01

- **R.E.A.** – I have changed "sand" to "mix" and added comments that it refers to sand and silt. In the case of M2T2.2S1.3S3.01-B, this was a data entry error and it should have been "non-cohesive".

Reaches:

M01B-E You have average largest particle on bed at 4,000 mm (largest boulder). Those are huge boulders. Please confirm that these were at the riffle.

- **R.E.A.** – There were many large boulders, along with bedrock outcrops observed throughout the entire M01 reach, though in the upper segments, they were less prevalent. M01B and M01C were gorges, with lots of bedrock and boulders, so this average largest is accurate. M01D was completed with Ty out there overseeing, so I am assuming that this measurement was done correctly. M01E also had many bedrock outcrops along with large boulders at riffles.

M01 B Your cross-section suggests that this is an F channel rather than an A channel because the width/depth is much greater than 12.0. F channels can be a natural gorge.

- **R.E.A.** – This has been changed to an F channel, which makes sense, as this segment is a natural gorge.

M01 C Phase 1 slope is < 2%, Phase 2 is a B stream, do you feel the slope for this segment is different than the overall slope? If not than update the sub-slope to "c".

- **R.E.A.** – According to James, who was out with Bethany, the slope was definitely greater than 2% for this segment, with many ledge grade controls.

M01 D You note "likely dredging" in your comments. What evidence did you see that suggested dredging had occurred here? Have you attempted to confirm this or find a location? Can you index a location with FIT?

- **R.E.A.** – Ty was out with Bethany and James on this one. According to James, this comment was made because it appeared that the bermed area in this segment was built up from material from the stream bed. This was indexed originally (and still shows up in SGAT), but it didn't get uploaded properly. It is fixed now.

It seems from your data that you could have scored Step 7.3 Row 4 lower because of the many side bars and flood chutes.

- **R.E.A.** – I have changed this and lowered the score to a 9 from an 11.

It also seems that Step 7.4 Row 4, depending on the degree of dredging you observed, might score lower.

- **R.E.A.** – I have changed this to reflect the dredging. It went from 11 to 9.

Why is planform considered "historic"?

- **R.E.A.** – I think this was referring to the change in planform from dredging/berming, but I have changed this to "no" based on your comment for M2T2.01.

M01 E

You should comment/speculate on how the mass failures are influencing this segment or downstream segments with their input of sediment. Multiple failures averaging 50' can potentially contribute significant sediment to the system.

- **R.E.A.** – I have added this comment, and I have changed 7.2.5 on the RGA form to reflect the increase in sediment supply from the mass failures.

Phase 1 slope is < 2%, Phase 2 is a B stream, do you feel the slope for this segment is different than the overall slope? If not than update the sub-slope to “c”.

- **R.E.A.** – This was another situation where this reach has some bigger grade changes (evident as bedrock grade controls) and is definitely steeper than the P1 slope.

M02 B

Did you say “none” for sub-class slope because it was a B slope? Or because it was a C slope? If this was a channel that degraded from C to B but still has a slope typical of a C stream, you should call it a B sub C stream (“Bc”).

- **R.E.A.** – This should be B sub c stream, and it has been changed in the DMS.

Should 7.3 Widening or 7.4 Planform score lower due to bars, beaver activity, and flood chutes?

- **R.E.A.** – I have looked these over and changed each score to the low end of good, “11”, which doesn’t change the overall score too much and it is still considered in fair condition.

M04 A

It seems that this reach could score significantly lower for aggradation and planform in Step 7.

- **R.E.A.** – I have looked these over and lowered the scores for aggradation and planform. The overall condition rating of the stream did not change.

You have noted a human-caused change (HCC) in valley width, but the valley width given is the same as the Ph1 width. You have noted just over 10% of the corridor is encroached upon. If that 10% corresponds to the change in valley width, it may have been more useful to segment out that portion of the reach. What was causing the HCC and could this have been segmented? If so, you might note this as a future need.

- **R.E.A.** – I think that I originally didn’t have HCC chosen; however, because of my encroachment, the DMS QA picked that up and wanted me to choose HCC. I have unchecked it, and it does not seem to be tripping any QA alarms. I don’t think that this portion of the reach was substantial enough to be segmented out into its own segment.

Phase 1 slope is > 2%, Phase 2 is a C stream, do you feel the slope for this segment is different than the overall slope? If not than update the sub-slope to “b”.

- **R.E.A.** – Yes, the slope is definitely different than the overall slope, so I have not changed the subslope.

M04 B

You have this noted as a “E-cascade”, and you updated the Phase 1 reference to E-cascade. This is a stream type not typically seen, so it raised a flag. It is worth looking at the cross-section, there does appear to be another bench (at

elevation 4.5) that could be considered for bankfull. This would give a stream type of B. Did you feel confident in the bankfull indicator? Please review and determine if you feel this should still be an E, or if the bankfull indicator should be changed.

- **R.E.A.** – I have revised the cross section data using the original LTOB elevation as bankfull. This has resulted in a stream type of C3b cascade (using the +/- 2 error on the width/depth ratio). I have attached a spreadsheet with the new cross section data (with the old data still attached for reference) and I have also uploaded a new cross section spreadsheet to the DMS. Also, Steps 2 and 7 have been changed in the DMS and a note has been made in the comments section. This also brings the P1 and P2 channel widths to within approximately 10% of each other. Lastly M04A is no longer a subreach, since both segments are C streams.

New M04B Cross Section Data					
Note	Distance	Depth	Note	NEW Distance	New Depth
LVAL	-44	-5.8	LVAL	-39	-5.1
LPRONE	-32	-2.8	LPRONE	-27	-2.1
LTOB	-5	-0.7	LBF	0	0
LBF	0	0		5	0.7
	2	2		7	2.7
LEW	2.5	2.1	LEW	7.5	2.8
	4	2.5		9	3.2
	6	2.7		11	3.4
	8	2.7		13	3.4
THAL	9	2.8		14	3.5
	10	2.7		15	3.4
	12	2.5		17	3.2
	14	2.5		19	3.2
	16	2.5		21	3.2
	18	2.2		23	2.9
REW	19	2.2	REW	24	2.9
	20	0.8		25	1.5
RBF	22	0		27	0.7
RTER	44	-2.4		49	-1.7
Rtrail	69	-3.5		74	-2.8

New Stream Channel Dimensions

_____	33	BF Width
_____	3.5	Max Depth
_____	3	Mean Depth
_____	100	Flood Prone
_____	5.2	Low Bank
_____	11	W/D Ratio
_____	3.03	Entrenchment
_____	1.5	Incision Ratio

M05

What did you observe that suggested Stage IV rather than III? What told you this reach was “currently stabilizing”? Usually, stage IV is associated with “severe erosion” (appendix C) and the beginning of bar stabilization. Mid-channel bars are associated with aggradation (stage III) but flood chutes and

avulsions do support Stage IV. Please re-evaluate this reach, and provide further support for your decision?

There was no erosion noted on this reach, over a mile long, and there are good buffers. What other clues did you see that support that the stream has undergone such adjustment?

- **R.E.A.** – I have changed the channel evolution stage to II to reflect that the stream has incised, and maybe sort of stuck in this stage, or may just be beginning to widen.

The comments you wrote on your field sheet aren't entirely included in the DMS comments. It is useful to know that the cross section was not taken at a good riffle and why it couldn't be taken at a better riffle. The more background you provide the better someone else can interpret your data.

- **R.E.A.** – I have added these comments to the DMS.

M06 A Good note on cross-section location.

M06 B What observations lead you to call this stage II? Incision is very low, plus mid and side bars, flood chutes and avulsions all suggests aggradation and planform. In your narrative you indicate incision is presently occurring. What other clues were there that this was happening? Did this segment appear to be ditched (very narrow width as compared to downstream)?

- **R.E.A.** - This segment was significantly more narrow than the downstream segment, and ran mostly through a farm field, so it definitely could have been ditched. After looking over the data again, this should be Stage III, as no active headcuts were observed. It has been changed in the DMS.

M07A Did this segment appear to be ditched (very narrow width as compared to upstream)?

- **R.E.A.** – Yes, this was very narrow, and at times it was even hard to find the channel in the meadow; however, if it was ditched, it was a very long time ago because it is mostly wetlands around the stream now. Seg B was significantly wider and deeper.

M07 B Should your Buffer width or Riparian Corridor on the right side be switched? You have >100 buffer of Hay and 26 to 50 buffer of shrub/sap.

- **R.E.A.** – Yes, Hay should be dominant, and shrub sapling should be subdominant. This has been changed in the DMS.

Might this reach be beginning Stage III? There are many aggradational features present (bars, steep riffles, sedimented riffles)? In your narrative you noted channel is incising. What clues suggested this? There are no head-cuts or large amounts of erosion noted, so just looking for some of your notes as to what lead you to feel the channel is incising currently.

- **R.E.A.** – I have looked over the notes, and have changed this to Stage III, due to aggradation on the stream bed observed. The condition has also been changed to fair, with very high sensitivity.

Your comment says this reach has "...very few bedforms..." Does that suggest plane bed rather than riffle-pool?

- **R.E.A.** – I have changed this to ripple-dune because the sediment size is so small in this segment.

M2T2.01

The ditches from the farm field that drain into the stream should be counted (FIT'd) as stormwater inputs. This is new in the protocol updates for 2007, so something to keep in mind, and if you can identify them great, but you do not have to go back.

- **R.E.A.** – These inputs have been FIT'd.

Typically, planform is considered historic after reaching Stage V of channel evolution. A channel in Stage III is expected to adjust planform while establishing a new floodplane if allowed to progress through the entire CEM. Channel straightening does not automatically equal historic planform change. Add in your comment that planform change was historic due to straightening, and change “historic” to no (as it will go through planform change again).

- **R.E.A.** – I have changed the RGA form and added comments in Step 5.

M2T2.02 A

If a stream has “likely been straightened” you should FIT straightening. Especially if you believe that the STD from C to G is related to that straightening. If not, you should comment on why you are not confident it was straightened.

- **R.E.A.** – I have FIT'd the historic straightening.

The note suggests that the stream is very wide, but the width is ½ that expected in Phase 1. Does this comment reflect places that are impounded by the beaver dams? Please help clarify this.

- **R.E.A.** – Yes, this refers to the areas impounded/influenced by beaver activity. I have clarified this in the comments in Step 5 on the DMS. I also added a comment that it was difficult to find a good cross section location due to the beaver activity in the segment.

M2T2.02 B

Can you confirm that the riffles were actually “complete” for this reach? With an incision >2.0 and a STD from B to C, I would expect to see eroded riffles.

- **R.E.A.** – I have changed the riffles to eroded (partial or none), since so few riffles were noted through out the segment.

The spacing is notes as 1,000 ft; but the segment is < 1,000 ft; is this spacing looking at the riffles in both segments. Please add a comment if it is.

- **R.E.A.** – I had the wrong segment length on my field sheet – There was one riffle observed over approximately 750 feet, so I revised the spacing to 700 feet.

M2T2.03

Phase 1 has 2 bridge/culverts; Phase 2 has 1. Please confirm which is correct.

- **R.E.A.** – One of the culverts is in M2T2.03 A, and one is in M2T2.03B, which was not assessed, but was FIT'd using remote sensing. It was not added into the Phase 2 DMS because no specifics are known about the structure. A comment has been added to the M2T2.03B DMS about this discrepancy.

M2T2.04 B

Again you suggest straightening but do not index any. Are you able to index this, if not please give more comments as to why.

- **R.E.A.** – I indexed the straightening.

You note a mowed path along the right bank. Is this what you indexed as an Improved Path for corridor encroachments? This should only be used for gravel or paved pathways.

- **R.E.A.** – Yes, I have deleted this encroachment.

M2T2.04 C

The note indicates that encroachments and straightening were determined remotely. These are zero. Would you please add a small note that says “determined remotely.... and there were none” (or to that affect); just to confirm that there is none found remotely and it is not a data upload error. Thanks!

- **R.E.A.** – I have clarified this in the comments section.

M2T2.05

Where is this reach? The up and down reaches were assessed, but this does not exist in the DMS. Even if not assessed it should be included in the DMS.

- **R.E.A.** – This reach was not assessed, as NRPC did not identify a need or want to assess it. I have added it to the DMS and remotely indexed features.

M2T2.06

There is no valley width given for this reach in Ph1. Based on ortho photos, topo maps, and the info you gathered in Ph2, can you give an average valley width for the overall reach?

- **R.E.A.** – The average valley width that I came up with 212.5 feet, so I rounded to 200’ and updated the P1 data.

M2T2.06A

The note indicates that encroachments and straightening were determined remotely. These are zero. Would you please add a small note that says “determined remotely.... and there were none” (or to that affect); just to confirm that there is none found remotely and it is not a data upload error. Thanks!

- **R.E.A.** – I have clarified this in the comments section.

M2T2.06B

Notes says “good floodplain access”; the incision ratio is 1.4; not really very good access. What other clues were there for floodplain access; are there parts of the reach that have it and others that do not? It is true that at higher flows it still has access, but with a 1.4 incision at bankfull flows it no longer does.

- **R.E.A.** – This stream runs through a wetland/meadow area with no encroachments, and it appeared that it was accessing this area during high water events; however, the numbers are more concrete, so I took this comment off!

M2T2.06C

4 head cuts and extremely low RGA scores suggest this is a good place to look at project identification.

- **R.E.A.** – Yes I agree- this was a very, very messed up segment!

Are there still riffle-pool features in this incised reach? Riffle type is noted as NE, but the bedform in step 2.14 is riffle-pool. Please confirm that riffle-pool is correct.

- **R.E.A.** – I think the problem with this assessment is that there was very little water in the channel, so it was hard to determine the bed forms, and riffles could not be evaluated. We felt riffle-pool would be the bedform based on substrate, meanders, and slope.

M2T2.1S1.1S1.01-A Should Ph1 reference stream type be updated? It says it's an A channel in a semi-confined valley, but no valley width is given and slope is in the B channel range. Also Ph2 Seg A has a valley confinement of very broad. Please look at Ph1 data and update as appropriate.

➤ **R.E.A.** – see below.

Ph1 slope is not in the C range, so a sub-class slope of C is not accurate. A sub-class of “b”, is accurate.

➤ **R.E.A.** – I have taken this subslope indicator off.

You say that this is a sub-reach C channel. Does it make sense to call Ph1 a C sub b? Then Ph2 would not be a sub-reach and Ph1 would make more sense considering it's slope.

➤ **R.E.A.** – Yes – I have changed this in the DMS to reflect that the Ph1 is a C sub b and that this segment has undergone a stream type departure to a B.

You have an extremely high incision ratio, 3.3. What is your confidence in the bankfull indicators used? Please comment on this in Step 5.

➤ **R.E.A.** – While it was difficult to find a good cross section location, as this is a very narrow segment, running through a hay field, we did find a riffle with good bench features, so I am confident with the cross section numbers. The cross section was done near the area of some berming, and this segment has undergone significant alteration through this farm field.

You indicate that there are cows accessing the stream. No “animal ford” was noted in step 5.4. Should this be updated?

➤ **R.E.A.** – Yes, this has been FIT'd and uploaded.

M2T2.2S1.03-A You note stormwater inputs in your comments, but you have only indexed one. Since you say these are affecting the downstream portion of the reach, it seems like there may have been more than one. Were there more than one?

➤ **R.E.A.** – There really is only one stormwater input – I have revised my comments to reflect this.

M2T2.2S1.04 5 head cuts is potentially significant. Do you feel your step 7.1 score is appropriate? This might be a good place to look at project identification.

➤ **R.E.A.** – In this case, the stream typed out as a B stream (barely) due to an entrenchment of 2.0, and we felt the slope was mostly accurate as above 2% except for one small portion that is noted in the comments. The confinement; however, determines that the “unconfined” RGA form be used. So even though our entrenchment was 2.0, we felt this was reference, and that it did not count as an STD, so 7.1.2 was rated as “fair” instead of “poor”. We scored it as low as possible in the fair, as the “poor” categories don't quite apply (we didn't see rejuv tribs, plane bed, not HCC to confined, etc).

The valley type is listed as “narrowly”, it should be “narrow”.

➤ **R.E.A.** – This has been changed in the DMS.

M2T2.2S1.2S2.01-A Lots of bars noted, as well as sedimented riffles, but you scored this as Good (12). Does this seem right? You scored 7.2, row 2, as “Good” for presence of

bars (potentially “fair”) and row 5, “Reference”,(potentially “good”) for flow alteration (a known increase in sediment supply might be upstream channel alterations and degradation inundating this downstream reach).

- **R.E.A.** – I agree, and the RGA scores have been changed. The overall condition rating was decreased to 0.38, but the condition is still “fair”.

You have indexed a dam in step 1.6 (grade controls) but you have not noted any impoundments within this reach. A dam is always an impoundment. Was there a dam? If so you must update Step 4.5 as well as Ph1 flow regulation.

- **R.E.A.** – data entry error in SGAT – it should be ledge, instead of dam. This has been fixed and re-uploaded.

M2T2.2S1.2S2.01-B Significant number of head cuts, 6. Were they actually unique head cuts? Is this a place for project ID?

- **R.E.A.** – Yes – this is by far the worst channel I have ever seen. If you look at the photos you will see how big a few of these headcuts are!

M2T2.2S1.2S2.02-A You note that there are head cuts “in the vicinity of the two culverts.” Do these pose a threat to the culverts by threatening to undermine them? Is this a possible project (grade control)?

- **R.E.A.** - The two headcuts observed downstream of the Route 7 culvert and upstream of the Reynolds Road culvert are problematic for the Route 7 culvert if they keep migrating upstream. At this point, they were not close enough to be undermining, but they definitely are a threat. This whole area (including M2T2.2S1.2S2.02-B should be considered for different projects.

Considering all the erosion, head cuts, flood chutes, avulsion and bars, do your scores seem high? For degradation, the presence of 8 head cuts suggests you should score Row 1 as “Poor”, which would cause 7.1 to score poor. Please re-evaluate Step 7 and provide more comments if you feel no adjustments are warranted.

- **R.E.A.** – I have decreased the Step 7.1 score to 4

Also, consider this for project ID.

- **R.E.A.** – Definitely will.

The Phase 2 channel width, 22 ft, is significantly greater than the Phase 1 width, 9 ft. For the valley type the “reference” channel width should be used to calculate the ratio. Was the 22 a “ref.” width or is this an over widened stream. If the Phase 1 width is used it would be a “broad” valley.

- **R.E.A.** – Yes, the P1 width should have been used to calculate confinement. This changes the RGA form, which has been switched over to an “unconfined” RGA form and changed in DMS.

M2T2.2S1.2S2.02-B Note suggested straightening, but none indexed. Please confirm and index if able to or indicate why not able to if needed.

- **R.E.A.** – This has been indexed and uploaded.

M2T2.2S1.3S3.01-B 5 head cuts is potentially significant. Do you feel your step 7.1 score is appropriate? This might be a good place to look at project identification.

- **R.E.A.** – The RGA form has been changed – the score for 7.1 has been changed to a 3, which has changed the condition rating to 0.34, putting the stream in poor condition.

You note hard bank armoring. Can you give a short description in the comments?

- **R.E.A.** – I have added that this was riprap abutting a few culverts in the downstream end of the segment.

Good comments. This sounds like an important reach to talk about in your report.

Phase 1 bridge/culvert = 5, Phase 2 = 4; please confirm which is correct.

- **R.E.A.** – The extra bridge/culvert was identified remotely in an un-assessed segment; however, I don't have any specific info on this structure to enter into Phase 2. I added these comments into the DMS.

Valley width in Phase 1 is “very broad”, Phase 2 is “narrow”, can you update Phase 1?

- **R.E.A.** – this has been updated.

M7S1.01 Can you update the Ph1 valley width?

- **R.E.A.** – I took an average for the reach by averaging the valley widths for each segment together. This came out to be around 250'.

You haven't given any segment lengths. Please update.

- **R.E.A.** – The surface water theme is pretty screwed up here, and there is no way for me to even identify each segment, much less get a length. The SGAT project is now calling the next reach up M7S1.01, instead of the one that we actually assessed.

M7S1.01A Straightened, dredged, head cut – none of these are indexed because there is not a surface water theme. You need to add a comment about there not being a surface water theme and include all the features that could not be indexed. Give lengths for straightening if possible.

- **R.E.A.** – I added comments to Step 5 of this segment outlining the major features observed.

You say that “nearly half of the segment flows through a wetland area...”
Would it be useful to segment this wetland area out?

- **R.E.A.** – The portion through the wetland area was not much different than the portion through the ag field. It has been straightened and was a very narrow ditch!

M7S1.01B There is no erosion noted, what clues were there for the widening noted in the narrative?

- **R.E.A.** – There was moderate erosion noted (see RGA form) – it just wasn't FIT'd because the surface water theme is missing. I have updated the comments section.

Update step 2.14 sub-class slope.

- **R.E.A.** – I am assuming this refers to Phase 1 sub-class slope – it has been entered as “none”.

M7S2.01

Can you update the Ph1 valley width?

- **R.E.A.** – I have updated this in the DMS.

This reach should have been further segmented in Ph1. From the topo maps, it appears that above the highway the channel slope is closer to 12%, below is closer to 3%. Since you segmented due to political boundaries, you might include a note that explains the upper-most section of reach is extremely steep, as this may have bearing on the lower segment. It is unusual to have an E sub-reach within an A reach, and this comment would help clarify this as well.

- **R.E.A.** – I have added this comment to Step 5.

Seg A You have 14 head cuts and rejuvenating tribs but scored degradation as fair. Were there actually 14 head cuts? If so, Step 7.1 should likely score far lower. Also, this is a significant reach to look at during project identification.

- **R.E.A.** – I have changed the RGA form to reflect lower scores, based on the rejuvenating tribs, and the extensive historic straightening. The condition is still “fair” for the segment. This might be a good place for a project – the farmer is already participating in CREP.

Phase 1 bridge/culvert = 4; Phase 2 = 3; please confirm which is correct.

- **R.E.A.** – actually, one of these culverts in Phase 2 should be moved to M07, because the reach point for this trib is actually set upstream of the culvert. So there should only be two in the Phase 2. The other 2 were identified remotely for the unassessed segment (B) of this trib.

QC Report Notes

The RMP's on-line QA process is a new tool meant to both expedite the QA process by using an automated system of data checks, and to increase it's effectiveness. In general, we apologize for any frustrations or inconveniences this new process may have caused due to the handful of “bugs” that made their way into the system. While we have addressed the majority of these issues, it is possible that we may have missed some, and it is likely that new ones will arise as we attempt to further expand the program. We appreciate your patience while we take on this endeavor, and we also encourage you in the future to utilize the new “Bug Report” feature on the DMS to report bugs that you encounter. The more eyes we have looking at this, the better the system will work for everyone.

General

In X.4, when a reach is flagged because it says the confinement types do not agree when they actual do agree, there are two possibilities. One is that the data in Ph1 was stored, but the “Update Calculated Fields” button was not pressed. If you do this, the error should go away (we are working on correcting this, but for now that is what you need to do). The other possibility is because of a bug present when

reaches were segmented and one segment has a different confinement type. This second bug should be fixed soon.

X.4 Valley Widths – it seems they were flagged because the reach was segmented and one or both segments don't match the phase1. This is a bug similar to the one for confinement type that occurs when reaches are segmented. This bug is currently being fixed.

The following reaches are still registered as Provisional for the QC Check on the DMS. Please address:

- M04 A** X.4 is still registering as provisional for this segment because you say there is a HCC in valley width, but Ph1 and Ph2 valley widths are the same. Ph2 width should be the altered width.
- **R.E.A.** – This has been addressed and fixed; however, it still says provisional because my P2 reference bedform is different than the Phase 1. I wrote a justification for this (this is a subreach), but it still registers as “provisional” even after I press “save”.
- M7S1.01** Even though you were not able to index features for this reach, and so some issues cannot be resolved, there are some blanks in this project that can and should be filled in. Sub-reach and segment length for example.
- Please go through the on-line QC Check for both these segments. Fill in whatever information can be filled in, and provide comments explaining why the others could not be (i.e. “Could not FIT because stream layer does not exist”) until both segments register as complete.
- **R.E.A.** – I have added comments about the blank fields; however, it is still saying “provisional” for reconciling Phase 1 and 2 data even though I added a comment and pushed save. This goes for both M7S1.01A and M7S1.01B.

June 26, 2007

QA Notes For: **Stonebridge Brook**
Data checked by Jared Carrano and reviewed by Staci Pomeroy.

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

There are very good notes on the reaches, these should be referred to by users of the data to help capture any nuances with the data.

After reviewing the information noted, the consultant should update this document (preferably in a second color) with what steps, if any, were taken to address the comments/questions.

General:

When a reach is "Not Assessed" we still ask that Steps 1 and 3 get assessed, along with whatever additional data can be gathered. We don't expect any of the in-channel data to be gathered, but corridor data is often still accessible. Please also review the segment from a remote sensing standpoint to determine if there are any parameters that can be captured remotely for FIT work. Also, it's helpful for us if you provide a short note further explaining why a reach wasn't assessed. I.e. "Impounded by beaver activity".

See reaches: M02 B, M03 A, M2S2.01 A, M2S2.01 D

- **R.E.A. – These unassessed reaches have had Steps 0, 1, and 3 filled out in the DMS to the extent possible. FIT work has been determined remotely and uploaded.**

The hydraulic geometry curves used to estimate the expected channel width for a given sub-reach were created using C channels. Therefore, the accuracy of predicting E or A channels is not as accurate as C or B channels. This is one reason why we ask that you consider the Ph1 channel characteristics when in the field, so that you can confirm their accuracy. If a reach is stable (Stage I), and you are confident in your bankfull indicators, you should consider updating Ph1 with the field measured channel width wherever appropriate. **See reaches: M04**

- **R.E.A. – I have updated the Phase 1 channel width for this stream since it is stable.**

You have said that this is a plane bed channel and that the riffle type is Not Applicable. When a reach is plane bed by reference – typically a B stream with a low slope – than it is not expected that there would be any riffles and so “not applicable” is the appropriate choice. However, when a stream is an altered plane bed (i.e. not plane bed by reference) we are encouraging people to choose a riffle type that reflects the process which caused the change to plane bed. So a reach that degraded from a riffle pool to a plane bed because of straightening should have eroded riffles, because the riffles that were once present have since eroded. Conversely, where a plane bed has developed because of an increase in aggradation, the proper choice would be sedimented riffles. Sometimes one occurs and then the other. Where this is the case, you should use your judgment to choose which is most characteristic of the reach, and then provide further detail in the comments section. **See Reaches: M2S2.01 C, M5S1.01 A**

- **R.E.A.** – The M2S2.01C and M5S1.01A riffle types have been changed to “sedimented” to reflect aggradation causing plane bed conditions.

Reach By Reach

M02 A From your data and comments it sounds like this is an old beaver meadow. There were once active damns, which attenuated a good deal of sediment, but they have since blown out and now the channel is cutting back through those deposits. If this is true, it would be helpful to add something about this to the notes in Step 5, because although banks are eroding/slumping and the channel is actively widening, it might not necessarily be over widening. It might be widening back to it’s pre-beaver width.

- **R.E.A.** – I have added this note into the comments.

Notice that the estimated Ph1 width (33’) is much, much wider – almost three times larger – than the measured bankfull width (12’). Looking at the cross-section that you uploaded to the DMS, it seems that there are two places that might look like bankfull. The first is the one that you said was bankfull at a height of 3.4 feet. The other is at the top of the lower bank at a height of 4.6 feet. When we use this higher bankfull bench the bankfull width becomes 29’, much closer to the estimated bankfull. Re-evaluate your field notes and photos. How confident are you in the bankfull indicators for this reach?

- **R.E.A.** – I am pretty confident in my bankfull elevations for this reach, because the first one was located just below woody vegetation (visible in photos). Also, I tried changing the bankfull values and if I use the lower bank elevation, then the incision goes to zero, since there are no shelf features above between that feature and floodprone. Also, this narrower channel width fits in with the possibility that the stream is trying to get back to its pre-beaver width, but it not there yet.

M03 There is one bridge noted in Ph1, but neither segment A or B notes a bridge.

- **R.E.A.** – This is in Segment A, which was unassessed – it has been added in the DMS.

M06 A You have used the incorrect RGA form for this segment. A reach with a Narrow confinement type is still considered Unconfined. When determining confinement ratio in an over-widened reach, you should use the reference channel width (usual Ph1). Since this reach is a sub-reach, the reference width may be larger than Ph1. In this situation, either using Ph1 or Ph2 channel width puts you in the Narrow confinement range.

- **R.E.A.** – I have reassessed this segment as a Cb stream by reference, which has undergone a stream type departure, causing it to be a B stream currently. The DMS has been updated and the unconfined RGA form has been used.

M06 B For step 7.1, degradation, you have a value of 10. Your narrative notes “major existing incision”, and in your comments, that the stream shows signs of incision at two hot spots with significant erosion. There is only about 200 ft of erosion listed on either bank, is the erosion all at these 2 hot spots? Also in step 7.1; row 5 was noted in fair “evidence of significant straightening, gravel mining, avulsion. There is no evidence of this in the field notes. Confirm that this is still an appropriate check; and if yes, please include something in the comments to help clarify what parameters lead you to that conclusion.

- **R.E.A.** – The erosion at these hotspots is really bad in one zone near the residence on the right bank. I clarified this in the comments section. Also, there should have been straightening FIT’d through the ag field portion of the segment. This has been done and uploaded.

M2S2.01 B If this channel was over-widened you should use the reference (Ph1) channel width to calculate valley confinement. When you use the Ph1 width the confinement becomes Very Broad.

- **R.E.A.** – This change has been made in the DMS.

M2S2.01 C It is unclear from the topo maps why the valley width in this segment is so much smaller than the segments downstream. Should this be a Human Caused Change in valley width?

- **R.E.A.** – No, this is not a Human Caused Change in valley width. There were bedrock outcrops (one in the stream) observed here, which narrowed the valley width a bit. I am not sure why it does not show up on topos.

M5S1.01 Currently the Phase 1 valley width has been left blank. Please update Ph 1 with the appropriate width.

- **R.E.A.** – This has been updated.

M5S1.01 B What is being used to impound this farm pond? Is there any type of dam structure or weir? Nothing is noted in Step 1.6. Please provide a bit more on this.

- **R.E.A.** – we couldn't tell what was being used to impound the pond – it just looked like earth and was completely revegetated. I have added this to the comments section.

It seems like this reach should score lower in Step 7 RGA. Step 7.1 should score lower because of the presence of the head cut, and possibly because of the impoundment (if it is trapping sediment, leading to “hungry water” downstream). Other than those, your scores seem justified. Maybe you can provide a comment that explains or at least confirms the apparent stability and “good” condition of this reach despite the gross lack of buffer, the animal crossing, the encroachments, etc. Maybe because of it's small size, low slope and grade controls?

- **R.E.A.** – after reevaluating steps 7.1 and 7.2, the RGA scores were lowered a bit to account more for the impoundment that is altering flow and sediment load. This put the stream in fair condition, with very high sensitivity.

QA Checks

This was flagged in step X.5 because there is currently a “bug” in Ph1 that is affecting some reaches. If you look at the QA Check that says the two phases' confinement types do not agree, the Ph1 confinement is blank. If you click on the link to Ph1, however, you'll see that the field is not actually blank. The problem is that the data was updated at some point, but the “Update Calculated Fields” button was never pressed. If you press this button and go back to the QA Check, you will see that the problem is gone. We apologize for this confusion and inconvenience. **See Reaches: M04 and M05**

- **R.E.A.** – this appeared to be fixed for me when I went to do this.

M05 This reach has not yet registered as “Complete”. You have noted the presence of both multiple headcuts and a sedimented riffle type. When this is the case the check is meant to first ask whether this is correct (i.e. not a data entry mistake) and if it is, it then asks for some additional detail that would give some context for the presence of the two features that form under different scenarios. For example, it might be that the headcuts are occurring downstream of a stormwater input.

- **R.E.A.** – this reach was identified as being in between Stages II and III, and because of the headcuts, we settled on II. I think there is some aggradation starting to occur in certain spots. I have changed the riffle type to “complete” since on the RGA form I have noted the riffles as “mostly complete”.

June 26, 2007

QA Notes For: **Missisquoi – BlackHungerford**
Project Reviewed by Jared Carrano

The review of the Missisquoi-Blackto Hungerford data was done by Staci and Jared Carrano. Data from both Phase 1 and Phase 2 was reviewed. The DMS and ArcView projects were also used to help support review of data. Information from both phases was used to help look at what may be occurring on the reach/segment as noted in the Phase 2 information. Overall the Phase 2 data seemed very well done. Many of the reaches had very good comments and narratives that explained nuances or specific considerations with the data. These comments and narratives should be referred to when using the data to insure that those nuances or considerations are incorporated in the use of the data.

Listed below are comments and the general types of errors/questions for particular steps and then those specific to a reach. These comments and questions are intended to: help insure that the data is as accurate as possible, allow for further explanation by the consultant who collected the data, point out areas where there may be issues that need to be addressed and/or recognized in using the data, and help document things that came up as data was reviewed. After review of the information noted, the consultant should update the document with what steps, if any, were taken to address the comments/questions.

General:

The phase2 protocol requires steps 1, 3 and 4 be completed for reaches that cannot be fully assessed due to beaver activity. If the ponding is so severe that no degree of assessment is possible, this should be noted somewhere in the comments. Also, in these cases where a phase2 assessment isn't possible, we ask that you check over the Phase1 data via remote sensing for confirmation. Pay attention to buffers, encroachments, potential straightening, etc. Once the data has been confirmed that no FIT work can be done for segments of reaches not assessed the "Force Phase 1" can be used in the DMS to update the Phase 1 data with appropriate information from the reach. **See R4S1.1S1.01 B**

- **R.E.A. – I have filled steps 1,3, and 4 of a field form for this segment, and have completed the FIT work based on remote sensing. The "Force Phase 1 update" was selected when importing this data.**

For reach **R4S3.01** much of the data in Phase 1 was not update because segment C could not be assessed to due property access. Please review the reach remotely for any parameters that may be updated via the FIT remotely, and then "Force Phase 1" to update the DMS.

- **R.E.A. – No additional FIT work was needed based on remote sensing. Phase 1 has been updated.**

Reach By Reach

R4S1.1S1.01 Valley type in Phase 1 is “semi-confined” and Phase 2 is “narrow”, please confirm which valley type is correct for the reach.

- **R.E.A.** – I believe that the “narrow” confinement is correct. We measured our valley widths here, and there is no valley width entered in the Phase 1 data. I have updated the Phase 1 valley confinement.

SegA

- Good notes. You might want to include something about the AVT trails in your report.
 - **R.E.A.** – I will include this info in the report.
- Railroads: You have 444’ under both one side and both sides. This seems like a typo.
 - **R.E.A.** – This was a problem that came up when I imported the data from SGAT. I reimported the data and the problem went away.

You have 8 head cuts noted; would not appear degradation is historic (see step 7.1, have degradation with a yes for historic”); confirm these are active head-cuts. Also with 8 head cuts and an incision ratio of 1.93, the score of 9 seems high; please review the data and confirm if this is an appropriate score. Do we need to look at these head-cuts as active restoration to stop the loss of floodplain?

- **R.E.A.** – these are active headcuts - it was a data entry error to say that degradation was historic. In addition, the RGA score was reduced to 6 to take into account the borderline STD (due to high incision ratio). Many of these headcuts are in the area closest to the railtrail, so I am not sure what at this point can be done in that area to alleviate the problem. Controlling the ATV trails; however, would help lower in the segment!

R4S3.01 Sand isn’t cohesive. (**R.E.A.** – changed to “mix” and added a note in the comments section that it refers to sand and silt)

SegA

- You might want to include this note about the road in your report.
 - **R.E.A.** – I will include these comments in the report.
- Please give an explanation in the comments as to the “other “ reason for segmentation or update if a better option has become available
 - **R.E.A.** – This was segmented out due to what we considered to be a pretty dramatic change in the valley confinement, and also the influence from encroachments was different.

SegB

- Please completely fill out sub-reach information in step 2.15 if this is actually a different reference stream type for this segment.
 - **R.E.A.** – I have filled in these fields.

- The bank vegetation on the right bank for step 3.1 is noted as herbaceous / lawn; there is a 26 – 50 ft buffer noted for the right bank. Does this still seem appropriate, to have both these as dominant types.
 - **R.E.A.** – I have switched the buffer dom/subdom buffer widths for the right bank. Dominant is now <5ft and subdominant is 26-50 ft.
- Update Phase 1 steps 5.1, 2.12, 7.1
 - **R.E.A.** – The Phase 1 data has been updated.

June 15, 2007

QA Notes For: **Missisquoi Mouth**
Data checked by Jared Carrano

The questions raised in this Quality Assurance assessment are meant to address potential discrepancies within the data set, uncover data entry errors, or otherwise clarify and confirm those observations that might not have been expected. It is important to take into consideration how data might be viewed or interpreted by the myriad of users who are familiar with the science and protocols but may be unfamiliar with the assessed reaches. While providing notes and comments, try to anticipate the types of questions that may arise due to outliers and exceptions observed within the reach or segment. While attempting to clarify the data for those users wishing to utilize it years after collected, it's better to err on the side of making excessive comments than it is for them to be insufficient.

After reviewing the information noted, the consultant should update this document (preferably in a second color) with what steps, if any, were taken to address the comments/questions.

General:

Please go back through the Ph1 reaches and complete the reference stream type information. If there is no sub-class slope, please indicate "none".

- **R.E.A.** – I have entered all of the Ph1 reference stream type info into the DMS.

After completing a Ph2 assessment, there should not be any fields left as "No Data" in Ph1. See step 6.4 Meander Migration. **Reaches: R3S4.01 and R3S4.02**

- **R.E.A.** – These fields have been updated.

Reach By Reach

R3S4.01 Your cross-sections suggests that this is an E stream type ($W/D < 12$).

- **R.E.A.** – Math error! This is indeed an E stream and it has been changed in the DMS.

R3S4.02 Your cross-section numbers are more suggestive of a Gc stream type than a Bc stream type. An entrenchment of 1.64 is only a hair outside of the +/- 0.2 margin of error, and the width/depth ratio is well within the expected G range.

- **R.E.A.** – I have changed this in the DMS and in Step 7 of the RGA form.

R3S4.04 B Segments and reaches that cannot be assessed because of impoundments or wetlands should still have corridor characteristics collected when possible. The Ph2 Protocol Handbook calls for steps 1, 3 and 4 to be completed.

- **R.E.A.** – This has been completed and also there were no parameters to index remotely in SGAT.

**A
P
P
E
N
D
I
X

G**

Stream Geometry Data

Deer Brook

Reach	Phase 2 Stream Type				Phase 1 Data			Phase 2 Channel Data												RGA			
	Seg- ment	Stream Type	Bed Material	Bed Bedform	Subcl. Slope	Sub Rch?	Channel Slope	Channel width	Bankfull width	Max. depth	Mean depth	Floodpr. width	Abandn FldPln	W/D Ratio	Entrench- ment	Incision Ratio	Stage Evol.	evol. Model.	Cond Conc.	RHA Cond.	QC Stf	Aut	
M01	A					No	0.95	33.35														P	F
M01	B	E	Sand	Dune-Ripple	None	No	1.49	33.35	26.2	3.2	2.34	350.0	4.0	11.20	13.36	1.25	III	F	Good	Fair	P	F	
M02	A	E	Sand	Dune-Ripple	None	No	0.56	29.48	17.4	3.2	2.75	72.0	6.1	6.33	4.14	1.91	III	F	Fair	Good	P	F	
M02	B	E	Gravel	Riffle-Pool	None	No	3.52	29.48	18.5	2.8	2.38	219.0	3.2	7.77	11.84	1.14	III	F	Good	Good	P	P	
M02	C	B	Cobble	Plane Bed	None	Yes	2.49	29.48	25.7	2.7	1.87	40.4	4.5	13.74	1.57	1.67	III	F	Good	Good	P	P	
M03	A	C	Gravel	Riffle-Pool	None	No	0.50	28.57	22.0	2.3	1.5	120.0	2.7	14.67	5.45	1.17	I	F	Good	Fair	P	P	
M03	B	E	Gravel	Riffle-Pool	None	Yes	0.34	28.57	19.3	2.4	1.73	43.0	3.0	11.16	2.23	1.25	I	F	Good	Good	P	P	
M03	C					No	0.38	28.57														P	F
M05	A					No	1.88	22.26														P	F
M05	B	E	Sand	Riffle-Pool	None	No	1.30	22.26	9.6	2.1	1.4	800.0	3.8	6.86	83.33	1.81	II	F	Good	Fair	P	P	
M05	C	E	Sand	Riffle-Pool	None	No	0.87	22.26	6.1	1.4	1.3	206.0	2.6	4.69	33.77	1.86	II	F	Fair	Fair	P	P	
M06	A	E	Sand	Riffle-Pool	None	No	2.50	5.66	3.7	1.2	0.81	119.0	1.7	4.57	32.16	1.42	II	F	Fair	Fair	P	P	
M06	B					No	8.45	5.66														P	F
M5S3.01	0	E	Sand	Riffle-Pool	None	No	1.48	11.49	5.2	1.4	1.2	11.9	2.6	4.33	2.29	1.86	III	F	Fair	Fair	P	F	

Rapid Geomorphic Assessment

Deer Brook

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
M01	A	No											0.00			VB		P	F
M01	B	No	15	None	Yes	10	None	No	12	No	15	No	0.65	Good	III	VB	High	P	F
M02	A	No	10	None	Yes	10	None	No	9	No	11	No	0.50	Fair	III	BD	Very	P	F
M02	B	No	14	None	Yes	14	None	No	13	No	14	No	0.69	Good	III	VB	High	P	P
M02	C	Yes	12	None	Yes	13	None	No	12	No	15	No	0.65	Good	III	SC	Moderat	P	P
M03	A	No	12	None	No	17	None	No	16	No	11	No	0.70	Good	I	BD	High	P	P
M03	B	Yes	15	None	Yes	17	None	No	14	No	16	No	0.78	Good	I	NW	High	P	P
M03	C	No											0.00			VB		P	F
M05	A	No											0.00			VB		P	F
M05	B	No	13	None	Yes	13	None	No	13	No	15	No	0.68	Good	II	VB	High	P	P
M05	C	No	9	None	No	14	None	No	13	No	12	No	0.60	Fair	II	VB	Very	P	P
M06	A	No	10	None	No	11	None	No	14	No	11	Yes	0.58	Fair	II	VB	Very	P	P
M06	B	No											0.00			VB		P	F
M5S3.01	0	No	12	None	Yes	14	None	No	11	No	14	Yes	0.64	Fair	III	NW	Very	P	F

Stream Geometry Data

Mill River

Reach	Phase 2 Stream Type				Phase 1 Data			Phase 2 Channel Data										RGA					
	Seg- ment	Stream Type	Bed Material	Bed Bedform	Subcl. Slope	Sub Rch?	Channel Slope	Channel width	Bankfull width	Max. depth	Mean depth	Floodpr. width	Abandn FldPln	W/D Ratio	Entrench- ment	Incision Ratio	Stage Evol.	evol. Model.	Cond Conc.	RHA Cond.	QC Stf	Aut	
M01	A					No	3.98	51.81														F	F
M01	B	F	Boulder	Step-Pool	None	Yes	38.78	51.81	35.0	2.6	1.6	42.0	5.4	21.87	1.20	2.08				Refere	F	P	
M01	C	B	Gravel	Step-Pool	None	Yes	10.76	51.81	61.4	3.5	2.7	95.7	6.1	22.74	1.56	1.74	III	F	Fair	Good	F	P	
M01	D	C	Gravel	Riffle-Pool	None	No	2.85	51.81	56.8	3.1	2.1	240.8	6.0	27.05	4.24	1.94	III	F	Fair	Good	F	P	
M01	E	B	Cobble	Riffle-Pool	None	Yes	3.64	51.81	49.5	3.2	2.4	88.0	3.8	20.62	1.78	1.19	IV	F	Good	Refere	F	P	
M02	A	C	Gravel	Riffle-Pool	None	No	0.26	44.53	29.0	2.7	2.3	114.0	3.5	12.61	3.93	1.30	IV	F	Good	Good	F	P	
M02	B	B	Sand	Riffle-Pool	c	No	0.18	44.53	25.0	2.3	1.9	37.1	4.0	13.16	1.48	1.74	III	F	Fair	Fair	F	P	
M03	0	E	Gravel	Riffle-Pool	None	No	0.37	30.36	19.0	2.6	1.8	400.0	4.1	10.56	21.05	1.58	III	F	Fair	Good	F	P	
M04	A	C	Gravel	Riffle-Pool	None	No	4.21	29.71	22.0	2.5	1.8	200.0	3.3	12.22	9.09	1.32	III	F	Fair	Fair	F	P	
M04	B	C	Cobble	Cascade	b	No	4.19	29.71	33.0	3.5	3.0	100.0	5.2	11.00	3.03	1.49	I	F	Good	Refere	F	P	
M05	0	C	Sand	Dune-Ripple	None	No	0.78	28.70	22.0	1.8	0.97	132.6	2.6	22.68	6.03	1.44	II	F	Fair	Fair	F	P	
M06	A	B	Cobble	Step-Pool	None	Yes	3.69	26.67	23.0	2.4	2.1	37.7	3.4	10.95	1.64	1.42	I	F	Good	Good	F	P	
M06	B	E	Sand	Riffle-Pool	None	No	3.02	26.67	13.6	2.6	2.1	900.0	3.1	6.48	66.18	1.19	III	F	Good	Fair	F	P	
M07	A	E	Sand	Riffle-Pool	None	No	0.60	25.46	10.0	1.9	1.1	710.0	1.9	9.09	71.00	1.00	I	F	Good	Good	F	P	
M07	B	E	Sand	Dune-Ripple	None	No	0.69	25.46	20.0	3.1	2.0	190.0	3.5	10.00	9.50	1.13	II	F	Fair	Fair	F	P	
M08	0	E	Gravel	Riffle-Pool	None	No	1.11	21.62	14.5	1.9	1.5	171.5	2.4	9.67	11.83	1.26	III	F	Fair	Fair	F	P	
M2T2.01	0	G	Sand	Dune-Ripple	c	No	0.09	30.02	11.0	1.8	1.2	16.0	5.0	9.17	1.45	2.78	III	F	Poor	Fair	F	P	
M2T2.02	A	G	Sand	Dune-Ripple	c	No	0.36	27.64	14.0	1.8	1.4	17.6	3.9	10.00	1.26	2.17	III	F	Fair	Fair	F	P	
M2T2.02	B	B	Sand	Riffle-Pool	c	No	0.54	27.64	7.0	1.5	1.1	12.8	3.2	6.36	1.83	2.13	III	F	Fair	Fair	F	P	
M2T2.03	A	E	Sand	Riffle-Pool	None	No	0.68	16.95	9.0	1.2	0.8	20.8	2.1	11.25	2.31	1.75	III	F	Fair	Fair	F	P	
M2T2.03	B					No	0.43	16.95													F	F	
M2T2.04	A					No	2.07	15.21													F	F	
M2T2.04	B	E	Sand	Riffle-Pool	None	No	1.92	15.21	5.0	1.6	1.1	26.8	2.8	4.55	5.36	1.75	III	F	Good	Fair	F	P	
M2T2.04	C					No	0.80	15.21													F	F	
M2T2.05	0					No	0.56	13.80													F	F	
M2T2.06	A					No	9.17	8.92													F	F	
M2T2.06	B	E	Sand	Riffle-Pool	None	Yes	7.58	8.92	9.0	1.1	0.7	69.4	1.6	12.86	7.71	1.45	III	F	Fair	Fair	F	P	
M2T2.06	C	F	Sand	Riffle-Pool	None	No	13.47	8.92	8.8	1.1	0.7	11.8	2.3	12.57	1.34	2.09	II	F	Poor	Fair	F	P	
M2T2.06	D					No	7.07	8.92													F	F	
M2T2.1S1.1S1.01	A	B	Sand	Riffle-Pool	None	No	7.13	8.05	11.0	1.0	0.7	15.6	3.3	15.71	1.42	3.30	II	F	Fair	Poor	F	P	
M2T2.1S1.1S1.01	B					No	3.88	8.05													F	F	
M2T2.2S1.03	A	E	Sand	Riffle-Pool	None	No	0.91	13.57	5.6	1.3	0.6	23.6	1.7	9.33	4.21	1.31	III	F	Fair	Fair	F	P	

Rapid Geomorphic Assessment

Mill River

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC		
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut	
M01	A	No											0.00						F	F
M01	B	Yes											0.00			SC	Low		F	P
M01	C	Yes	8	None	Yes	12	None	No	8	No	13	No	0.51	Fair	III	SC	High		F	P
M01	D	No	11	None	Yes	13	None	No	8	No	9	No	0.51	Fair	III	NW	Very		F	P
M01	E	Yes	15	None	Yes	12	None	No	15	Yes	14	No	0.70	Good	IV	SC	Moderat		F	P
M02	A	No	15	None	Yes	13	None	No	15	No	11	No	0.68	Good	IV	VB	High		F	P
M02	B	No	5	C to B	Yes	9	None	No	11	No	11	No	0.45	Fair	III	VB	High		F	P
M03	0	No	12	None	Yes	13	None	No	9	No	12	No	0.58	Fair	III	VB	Very		F	P
M04	A	No	15	None	Yes	9	None	No	11	No	7	No	0.53	Fair	III	BD	Very		F	P
M04	B	No	13	None	No	18	None	No	14	No	16	No	0.76	Good	I	BD	Moderat		F	P
M05	0	No	13	None	No	13	None	No	12	No	13	No	0.64	Fair	II	VB	Very		F	P
M06	A	Yes	16	None	Yes	18	None	Yes	15	No	12	No	0.76	Good	I	BD	Moderat		F	P
M06	B	No	15	None	Yes	14	None	No	14	No	14	No	0.71	Good	III	VB	High		F	P
M07	A	No	18	None	No	14	None	No	14	No	14	No	0.75	Good	I	VB	High		F	P
M07	B	No	12	None	Yes	12	None	No	16	No	11	Yes	0.64	Fair	II	VB	Very		F	P
M08	0	No	12	None	Yes	12	None	No	9	No	8	No	0.51	Fair	III	VB	Very		F	P
M2T2.01	0	No	3	C to G	Yes	6	None	No	6	No	11	No	0.33	Poor	III	VB	Extreme		F	P
M2T2.02	A	No	3	C to G	No	11	None	No	9	No	14	No	0.46	Fair	III	VB	Extreme		F	P
M2T2.02	B	No	4	C to B	Yes	15	None	No	11	No	15	No	0.56	Fair	III	VB	High		F	P
M2T2.03	A	No	12	None	Yes	13	None	No	12	No	14	No	0.64	Fair	III	VB	Very		F	P
M2T2.03	B	No											0.00						F	F
M2T2.04	A	No											0.00						F	F
M2T2.04	B	No	13	None	Yes	14	None	No	13	No	13	No	0.66	Good	III	VB	High		F	P
M2T2.04	C	No											0.00						F	F
M2T2.05	0	No											0.00						F	F
M2T2.06	A	No											0.00						F	F
M2T2.06	B	Yes	11	None	Yes	13	None	No	10	No	15	No	0.61	Fair	III	VB	Very		F	P
M2T2.06	C	No	2	B to F	No	11	None	No	3	No	5	No	0.26	Poor	II	NW	Extreme		F	P
M2T2.06	D	No											0.00						F	F
M2T2.1S1.1S1.01	A	No	2	C to B	No	14	None	No	12	No	13	Yes	0.51	Fair	II	VB	High		F	P
M2T2.1S1.1S1.01	B	No											0.00						F	F
M2T2.2S1.03	A	No	12	None	Yes	11	None	No	11	No	12	No	0.58	Fair	III	VB	Very		F	P
M2T2.2S1.03	B	No											0.00						F	F

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
M2T2.2S1.04	0	No	6	None	No	14	None	No	10	No	13	No	0.54	Fair	II	NW	High	F	F
M2T2.2S1.2S2.01	A	No	5	C to B	Yes	8	None	No	9	No	8	No	0.38	Fair	III	VB	High	F	P
M2T2.2S1.2S2.01	B	No	4	C to F	No	13	None	No	6	No	13	No	0.45	Fair	II	VB Extreme		F	P
M2T2.2S1.2S2.02	A	No	4	None	No	10	None	No	10	No	8	No	0.40	Fair	II	SC	High	F	P
M2T2.2S1.2S2.02	B	Yes	10	None	No	14	None	No	12	No	13	No	0.61	Fair	II	VB	Very	F	P
M2T2.2S1.3S3.01	A	No											0.00					F	F
M2T2.2S1.3S3.01	B	No	3	None	No	13	None	No	5	No	6	No	0.34	Poor	II	NW	Very	F	F
M2T2.2S2.01	A	No	17	None	Yes	13	None	No	13	No	16	No	0.74	Good	I	VB	High	F	P
M2T2.2S2.01	B	No											0.00					F	F
M7S1.01	A	No	12	None	Yes	13	None	No	14	Yes	12	Yes	0.64	Fair	IV	VB	Very	F	F
M7S1.01	B	No	17	None	Yes	14	None	No	15	No	14	No	0.75	Good	III	NW	High	F	F
M7S2.01	A	Yes	4	None	No	15	None	No	16	No	13	Yes	0.60	Fair	II	VB	Very	F	P
M7S2.01	B	No											0.00					F	F

Stream Geometry Data

Rugg Brook

Reach	Phase 2 Stream Type				Phase 1 Data			Phase 2 Channel Data										RGA			
	Segment	Stream Type	Bed Material	Bedform	Subcl. Slope	Sub Rch?	Channel Slope	Channel width	Bankfull width	Max. depth	Mean depth	Floodpr. width	Abandn FldPln	W/D Ratio	Entrenchment	Incision Ratio	Stage Evol.	Cond. Model.	RHA Cond.	QC Stf Aut	
M01	0	B	Gravel	Riffle-Pool	c	No	0.38	28.93	15.4	1.9	1.4	21.4	3.8	11.00	1.39	2.00	III	Fair	Fair	F P	
M02	0	B	Gravel	Riffle-Pool	c	No	0.69	28.71	15.4	1.9	1.4	21.4	3.8	11.00	1.39	2.00	III	Fair	Fair	F P	
M03	0	B	Cobble	Riffle-Pool	None	No	0.78	28.46	16.4	2.1	1.4	32.8	4.0	11.71	2.00	1.90	III	Fair	Good	F P	
M05	A	E	Gravel	Dune-Ripple	None	No	0.77	24.81	10.9	2.5	1.8	22.0	5.5	6.06	2.02	2.20	II	F	Fair	Fair	F F
M05	B	E	Gravel	Dune-Ripple	None	No	0.92	24.81	12.3	2.9	2.2	23.0	6.7	5.59	1.87	2.31	II	F	Poor	Fair	F F
M06	A	G	Gravel	Dune-Ripple	c	No	2.81	21.51	11.8	2.9	2.2	17.0	5.2	5.36	1.44	1.79	II	F	Fair	Fair	F F
M06	B	F	Gravel	Riffle-Pool	None	No	1.49	21.51	23.9	1.9	1.5	33.0	3.4	15.93	1.38	1.79	II	F	Fair	Fair	F F
M07	A	B	Gravel	Riffle-Pool	c	Yes	4.81	20.75	15.6	1.2	1.0	26.6	1.5	15.60	1.71	1.25	III	F	Fair	Fair	F F
M07	B	G	Gravel	Riffle-Pool	c	No	3.04	20.75	7.9	1.5	1.3	11.6	2.8	6.08	1.47	1.87	III	F	Fair	Fair	F F
M07	C	G	Gravel	Riffle-Pool	c	No	3.43	20.75	9.7	1.8	1.0	13.3	5.3	9.70	1.37	2.94	II	F	Fair	Fair	F F
M08	A	C	Gravel	Riffle-Pool	b	No	6.36	19.98	21.0	1.6	1.2	63.0	1.7	17.50	3.00	1.06	IV	F	Fair	Good	F F
M08	B	E	Gravel	Plane Bed	None	Yes	2.39	19.98	15.0	2.3	1.7	152.0	2.6	8.82	10.13	1.13	III	F	Fair	Fair	F F
M09	0	B	Gravel	Riffle-Pool	None	No	2.06	15.35	16.3	1.4	1.0	41.3	2.6	16.30	2.53	1.86	IV	F	Good	Good	F F

Rapid Geomorphic Assessment

Rugg Brook

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
M01	0	No	3	C to B	No	12	None	Yes	6	No	10	No	0.39	Fair	III	BD	High	F	P
M02	0	No	3	C to B	No	12	None		6	No	10	No	0.39	Fair	III	BD	High	F	P
M03	0	No	10	None	No	14	None	No	7	No	12	No	0.54	Fair	III	VB	High	F	P
M05	A	No	1	Other	Yes	12	None	No	14	No	11	No	0.48	Fair	II	VB	Very	F	F
M05	B	No	4	Other	No	10	None	No	6	No	6	No	0.33	Poor	II	VB	Very	F	F
M06	A	No	1	C to G	No	13	None	No	9	No	6	No	0.36	Fair	II	VB Extreme		F	F
M06	B	No	2	C to F	No	13	None	No	10	No	8	No	0.41	Fair	II	BD Extreme		F	F
M07	A	Yes	7	None	Yes	7	None	No	12	No	10	No	0.45	Fair	III	SC	High	F	F
M07	B	No	5	C to G	No	15	None	No	10	No	9	No	0.49	Fair	III	VB Extreme		F	F
M07	C	No	4	C to G	Yes	13	None	No	12	No	12	No	0.51	Fair	II	VB Extreme		F	F
M08	A	No	13	None	No	13	None	No	14	No	10	No	0.63	Fair	IV	BD	Very	F	F
M08	B	Yes	14	None	Yes	12	None	No	13	No	12	No	0.64	Fair	III	BD	Very	F	F
M09	0	No	13	None	No	16	None	No	13	No	12	No	0.68	Good	IV	BD	Moderat	F	F

Stream Geometry Data

Stonebridge Brook

Reach	Phase 2 Stream Type				Phase 1 Data			Phase 2 Channel Data													RGA			
	Seg- ment	Stream Type	Bed Material	Bed Bedform	Subcl. Slope	Sub Rch?	Channel Slope	Channel width	Bankfull width	Max. depth	Mean depth	Floodpr. width	Abandn FldPln	W/D Ratio	Entrench- ment	Incision Ratio	Stage Evol.	evol. Model.	Cond RHA	RHA Cond.	QC Stf	Aut		
M02	A	E	Sand	Dune-Ripple	None	No	0.81	33.40	11.6	2.4	1.9	186.6	3.6	6.11	16.09	1.50	III	F	Fair	Fair	F	P		
M02	B					No	0.52	33.40													F	F		
M03	A					No	0.83	28.70													F	F		
M03	B	C	Sand	Dune-Ripple	None	No	2.14	28.70	25.3	2.2	1.3	425.0	2.2	19.46	16.80	1.00	I	F	Good	Good	F	P		
M04	0	E	Sand	Dune-Ripple	None	No	1.11	6.20	6.2	1.8	1.1	166.2	2.2	5.64	26.81	1.22	I	F	Good	Good	F	P		
M05	0	E	Sand	Riffle-Pool	None	No	1.10	14.82	10.0	1.5	1.0	190.0	2.2	10.00	19.00	1.47	II	F	Fair	Fair	F	P		
M06	A	B	Gravel	Plane Bed	None	Yes	2.11	11.94	17.0	1.4	0.7	27.3	2.6	24.29	1.61	1.86	III	F	Fair	Good	F	P		
M06	B	E	Gravel	Riffle-Pool	None	No	0.76	11.94	8.2	1.5	0.8	33.8	2.7	10.25	4.12	1.80	II	F	Fair	Fair	F	P		
M2S2.01	A					No	6.26	13.47													F	F		
M2S2.01	B	C	Sand	Riffle-Pool	None	No	27.84	13.47	16.0	1.3	0.84	104.3	1.9	19.05	6.52	1.46	IV	F	Fair	Fair	F	P		
M2S2.01	C	C	Gravel	Plane Bed	b	No	18.20	13.47	14.4	1.4	0.8	41.1	2.5	18.00	2.85	1.79	IV	F	Fair	Good	F	P		
M2S2.01	D					No	14.57	13.47													F	F		
M5S1.01	A	E	Gravel	Plane Bed	b	No	13.64	7.71	12.0	1.4	1.04	40.4	2.6	11.54	3.37	1.86	III	F	Fair	Fair	F	P		
M5S1.01	B	E	Sand	Riffle-Pool	None	No	2.77	7.71	5.5	1.2	0.7	31.0	1.4	7.86	5.64	1.17	II	F	Fair	Fair	F	P		

Rapid Geomorphic Assessment

Stonebridge Brook

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
M02	A	No	12	None	Yes	14	None	No	11	No	14	No	0.64	Fair	III	VB	Very	F	P
M02	B	No											0.00					F	F
M03	A	No											0.00					F	F
M03	B	No	13	None	Yes	16	None	No	16	No	16	No	0.76	Good	I	VB	High	F	P
M04	0	No	15	None	Yes	14	None	No	15	No	16	No	0.75	Good	I	VB	High	F	P
M05	0	No	11	None	No	12	None	No	11	No	14	No	0.60	Fair	II	VB	Very	F	P
M06	A	Yes	3	C to B	Yes	5	None	No	11	No	13	No	0.40	Fair	III	NW	High	F	P
M06	B	No	10	None	No	13	None	No	9	No	12	No	0.55	Fair	II	VB	Very	F	P
M2S2.01	A	No											0.00					F	F
M2S2.01	B	No	14	None	Yes	10	None	No	13	Yes	13	No	0.63	Fair	IV	VB	Very	F	P
M2S2.01	C	No	10	None	Yes	5	None	No	11	Yes	14	No	0.50	Fair	IV	SC	Very	F	P
M2S2.01	D	No											0.00					F	F
M5S1.01	A	No	11	None	Yes	11	None	No	10	No	13	No	0.56	Fair	III	BD	Very	F	P
M5S1.01	B	No	9	None	No	12	None	No	14	No	16	No	0.64	Fair	II	VB	Very	F	P

Rapid Geomorphic Assessment

Missisquoi Mouth

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
R3S4.01	0	No	13	None	Yes	12	None	No	14	No	11	No	0.63	Fair	III	VB	Very	P	P
R3S4.02	0	No	3	C to G	Yes	14	None	No	10	No	13	No	0.50	Fair	III	VB	Extreme	P	F
R3S4.03	0	No	16	None	No	14	None	No	12	No	13	No	0.69	Good	I	VB	High	P	P
R3S4.04	A	No	16	None	Yes	17	None	No	13	No	17	No	0.79	Good	III	VB	High	P	P
R3S4.04	B	No											0.00					P	F

Rapid Geomorphic Assessment

Missisquoi -

Reach	Seg- ment	Sub- Rch?	Degradation			Aggradation			Widening		Planform		Geo. Score	Geo. Condition	Evol. Stage	Confin- ement Type	Sens- itivity	QC	
			Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic						Stf	Aut
R4S1.1S1.01	A	No	6	None	No	12	None	No	11	No	10	No	0.49	Fair	II	NW	Very	P	P
R4S1.1S1.01	B	No											0.00			BD		P	F
R4S3.01	A	No	15	None	No	13	None	No	14	No	13	No	0.69	Good	I	BD	High	P	P
R4S3.01	B	Yes	11	None	Yes	12	None	No	10	No	12	No	0.56	Fair	III	VB	Very	P	P
R4S3.01	C	No											0.00					P	F



Municipal Guide to Fluvial Erosion Hazard Mitigation

River Management Program
Vermont Agency of Natural Resources

Economic loss and risks to public safety caused by flood and fluvial erosion hazards are experienced most dramatically by individuals and local governments. Local governments are also the most appropriate entities to guide and implement efforts to mitigate these hazards. Armed with a better understanding of ongoing river processes, towns can take action to reduce flood and fluvial erosion hazards, which will enhance public safety, save money, and lead to healthier rivers. The goal of the Vermont Agency of Natural Resources River Management Program is to provide towns with the technical tools, assistance, and funding to understand the river systems, as well as apply this new understanding to take actions to mitigate flood and erosion-related hazards.

This guide has been created to help municipalities address fluvial erosion hazards by exploring mitigation alternatives, introduce the fluvial erosion hazard assessment and mapping process, and outline implementation strategies, community incentives, and available resources.

I) Understanding Fluvial Erosion Hazards

Fluvial Erosion

Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly. Over the last 50 years, flood recovery has cost Vermonters an average of \$14 Million a year. During the period of 1995-1998 alone, flood losses in Vermont totaled nearly \$57 Million.

While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by “fluvial erosion”. Fluvial erosion is erosion caused by rivers and streams, and can range from gradual bank erosion to catastrophic changes in river channel location and dimension during flood events.

One reason for the high cost and frequency of damages associated with fluvial erosion is Vermont’s geography. Vermont is a mountainous state of narrow valleys and powerful, flashy rivers and streams. The climate is extreme, with intense rainstorms, deep snows, and destructive ice jams. These geographic factors alone, however, do not explain the magnitude of fluvial erosion damages in Vermont.



Closer study of our rivers and streams reveals that Vermont’s erosion hazard problems are largely due to pervasive, human-caused alteration during the past 150 to 200 years of our waterways and landscapes they drain.

By end of the 19th century, forests had been cleared from many watersheds, resulting in major changes in watershed hydrology and sediment production. Towns and villages, the centers of commerce, grew on the banks of rivers, whose role in power generation and transportation at first outweighed flood risks. In addition, many development, agriculture, log drives, roads and railways. The legacy of this landscape manipulation is rivers and streams which are unstable and prone to fluvial erosion.

River Fundamentals

The form of a river reflects the complex interaction of many factors, including inputs from its watershed (water, sediment, ice, woody debris) as well as the physiographic setting (geology, soils, vegetation, valley type). Figure 1 illustrates the balance between watershed inputs (water and sediment), channel characteristics (slope and boundary conditions) and the physical response of a channel either by aggradation (sediment deposition), or degradation (scouring of sediment). When all the elements are in balance, a river is said to be in equilibrium. A river in equilibrium can carry its load of water, sediment, and debris, even during high flows, without dramatic changes in the width, depth, or length (slope). A dramatic change in any of these elements will tilt the balance and lead to changes (or adjustment) as a river attempts to move back toward an equilibrium condition. This adjustment is often expressed as fluvial erosion, or major changes in channel dimension and location, as a river attempts to regain equilibrium.

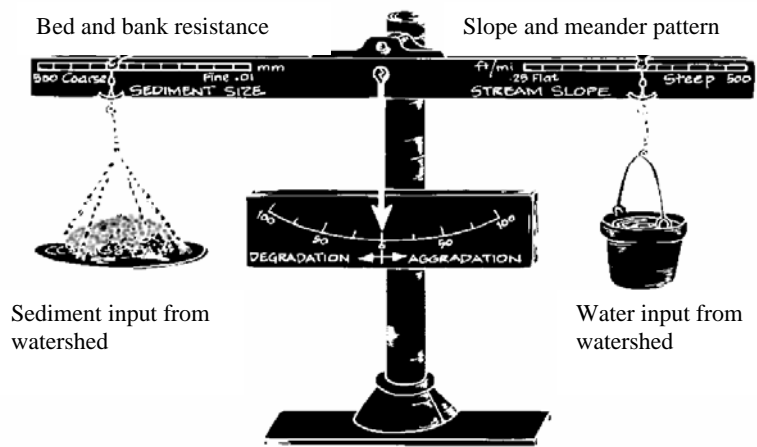


Figure 1. The channel balance (Lane, 1955)

One common mode of channel adjustment seen throughout Vermont is the response of a river to straightening. When a river is straightened, the slope of the channel is increased. As a result, the river has more power, and a greater ability to carry sediment, and begins to incise, eroding the stream bed. The incision leads to a situation where the river becomes disconnected from its floodplain. Without floodplain access, which serves the essential purposes of slowing floodwaters and storing sediment, stream banks are subjected to the full power of flood flows, leading to extensive fluvial erosion. If left alone, the river will eventually erode its banks enough that it can lengthen its channel, regain a more stable slope, and develop a new floodplain at a lower elevation. *For more information about the fundamentals of river systems and the channel evolution process, see Appendix A: Additional Resources.*

The reaction to erosion-related flood losses has historically been additional channel and floodplain manipulation: even more dredging, armoring, berming, and straightening in an attempt to limit flood losses through engineering works. These efforts often exacerbate the problem by further limiting floodplain access and encouraging even more encroachment. The destabilized rivers inevitably break through these man-made barriers and inflict even more extensive and costly flood damages. For decades we have been trapped in this cycle of escalating costs and risk to public safety.

A New Approach to River Management and Hazard Mitigation

Without the expertise and tools to manage fluvial erosion hazards, towns have been helpless to break out of this cycle of repetitive and costly flood damages. In recognition of this problem, the Vermont General Assembly (1997-1998) directed the Agency of Natural Resources (ANR) to identify options for state flood control policy and a state flood control program. The resulting policy is centered on the goal of managing rivers and their corridors to maintain or reestablish the equilibrium condition. To implement this policy, the River Management Program of ANR has developed tools and techniques to understand dynamic river systems and identify appropriate management activities. A major component of this effort is the Fluvial Erosion Hazard (FEH) risk assessment and mapping process. FEH maps identify the location and intensity of fluvial erosion hazards, as well as the area needed by a river to maintain equilibrium.

The benefits of understanding and planning for fluvial erosion hazards are numerous and diverse. It is important to remember that fluvial erosion hazards are just that: *hazards*, which can jeopardize public safety and cause enormous economic losses. As a result, local governments have a responsibility to protect citizens and their property by acknowledging and mitigating (reducing or moderating) fluvial erosion hazards. Fluvial erosion hazard mitigation can lead to enhanced public safety and reduce long-term flood damages. Some fluvial erosion hazard mitigation activities can even lead to additional benefits that are harder to put a price tag on, like healthier rivers, enhanced recreational opportunities, improved aesthetics, and better wildlife habitat.

II) Options for Mitigation

Floods are inevitable, but there are many different approaches that can help reduce flood losses. One common approach in the past has been to intensively manage river channels, by armoring and dredging and through the construction of berms, levees, and floodwalls. In addition to being very costly, these engineering solutions often fail, leading to even more extensive and costly flood damages. This approach has been shown to be unsustainable, and has led to the situation we are in today, trapped in an escalating cycle of increasing flood damages and costly repairs. In addition, this engineering approach has negative impacts on the ecological health of river systems and the wildlife they support.

In recent decades, more environmentally-friendly river restoration techniques (including “natural channel design”) have gained popularity. These techniques, which attempt to restore a more natural channel configuration, can be an effective tool for mitigating fluvial erosion hazards by slowing bank erosion or limiting lateral channel migration. The high cost of designing and installing restoration projects limit the usefulness of restoration as a general approach to flood hazard mitigation. In addition, restoration projects are prone to failure, either during high flow events, or because the design may not have been compatible with river processes.

The first two engineering approaches to mitigating flood losses seek to control the river. Another approach is to remove or relocate existing structures which are threatened by flood hazards. Removal of structures from hazardous areas can be an effective approach when it is feasible. FEMA-funded home buyouts, for instance, were a successful mitigation activity after several of Vermont’s destructive floods in the 1990’s. While removal or relocation is effective, it is generally far too costly to be applied at a broad scale. In addition, many large structures, particularly transportation infrastructure or public facilities, are rarely feasible to remove or relocate. Retrofitting, another engineering approach (which includes elevating and floodproofing) works fine to mitigate inundation hazards but is ineffective for fluvial erosion hazards.

The most cost-effective way to mitigate flood hazards is *avoidance*: limiting human investments in river corridors. In addition to preventing future flood losses to structures built in hazardous areas, this approach limits constraints on a river, allowing them over time to achieve a more stable, equilibrium condition. *For a more extensive discussion of the alternatives mentioned above, please see “Alternatives for River Corridor Management”, located at: www.anr.state.vt.us/dec/waterq/rivers/docs/rv_mngmntalternatives.pdf*

Local Land Use Planning and Regulation

Town planning and zoning can play a central role in mitigating flood and erosion hazards through avoidance. Towns have the ability to regulate land use, encouraging development in appropriate areas and preventing investment in hazardous areas. Pre-disaster mitigation (PDM) planning, FEH overlay districts, setbacks or buffers, and effective flood hazard zoning are all ways a community can mitigate flood and fluvial erosion hazards.

National Flood Insurance Program (NFIP)

Most communities rely on the standards of the flood hazard boundary maps provided by the Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program (NFIP) to determine areas susceptible to flood damage. While participation in NFIP is one important approach to flood hazard mitigation, NFIP maps are based *only* on inundation hazards, and fail to consider fluvial erosion, the cause of most flood damage in Vermont. NFIP maps treat rivers as static, unchanging systems and are frequently based on surveys

completed when a river is deeply incised and has lost access to its floodplain, leading to significant under-representation of flood hazards as the river adjusts.

Worse yet, floodplain management based solely on NFIP participation often results in significant development in floodplains, regardless of the physical state of the stream. In many cases, these encroachments are at risk of damage due to fluvial erosion and rob a stream of the opportunity to ever adjust toward equilibrium. Opportunities do exist for towns to use participation in NFIP to minimize encroachment in river corridors. For instance, towns can adopt floodplain regulations more restrictive than the minimum required for participation in NFIP (such activities may also make a town eligible for additional benefits like discounted flood insurance). *More information about the NFIP in Vermont is available in Appendix A: Additional Resources.* While participation in the NFIP is one important element of a town's efforts to mitigate flood hazards, supplemental tools to address the fluvial erosion component of flood damage are clearly needed.

Pre-Disaster Mitigation Planning

The Disaster Mitigation Act of 2000 requires states and local communities to undertake hazard mitigation planning in order to maintain eligibility for disaster recovery and mitigation funding. Vermont's State Hazard Mitigation Plan, as well as the Regional Pre-Disaster Mitigation Plans (developed by Regional Planning Commissions) identify fluvial erosion hazards as a (and in many cases *the most*) significant natural hazard and recommend actions communities can take to mitigate these hazards. For example, the Bennington Regional Hazard Mitigation Plan contains the following language:

"... local Hazard Mitigation Plans should support the implementation of a landslide and fluvial geomorphic hazard assessment and mapping program conducted on a watershed basis prior to any mitigation activities which may potentially affect that watershed. These assessments provide value in identifying unstable and hazardous rivers, stream banks and related infrastructure. Such assessments should, whenever possible, be conducted according to assessment protocols and mapping methodologies published by the VT Department of Environmental Conservation, River Management Program and the VT Geological Survey."

As this passage explains, the FEH mapping and risk assessment process is essential both to identify hazardous areas, and to guide local mitigation activities. Towns, with extensive local knowledge and historical perspective, are ideally equipped to supplement this broad hazard mapping by identifying specific sites known to be susceptible to erosion and flood damages. State and regional pre-disaster mitigation plans clearly identify FEH mapping as an essential first step toward mitigating flood damage in Vermont, and both the State (through the River Management Program) and many Regional Planning Commissions are committed to supporting towns in undertaking this important task.

Setbacks or Stream Buffers

Mandatory setbacks or stream buffers in town zoning and land use regulations, while generally used to protect water quality, can also help mitigate fluvial erosion hazards. Setbacks establish a distance perpendicular to a stream in which certain standards are established regarding land use. Stream buffers are naturally vegetated zones adjacent to a stream which are established or managed to protect the stream from human disturbances. *Links to additional information about buffers and setbacks can be found in Appendix A.*

Setbacks and buffers are simple to develop and administer and can be a useful tool for protecting water quality by filtering surface runoff. By preventing development in hazardous areas immediately adjacent to streams, they also have some limited fluvial erosion hazard mitigation function. Setbacks are generally tied to the location of a stream, which can lead to confusion and conflict as a stream channel location changes over time. Because the primary goal of setbacks and buffers is water quality protection, they often include some areas where no fluvial erosion hazard exists, and miss many areas where there are significant hazards.

Fluvial Erosion Hazard Overlay

Fluvial Erosion Hazard overlay districts are one of the best avoidance strategies for fluvial erosion hazard mitigation. An overlay district is an additional zoning requirement placed on a specific geographic area (in this case the FEH zone) without changing the underlying zoning. The degree of protection afforded by a FEH overlay district depends upon the exact wording, but could include limits on structures, land use activities, or even vegetative condition. Limiting development within an overlay district based on the boundaries of a FEH map has

two major functions. First, it will prevent development in hazardous areas, reducing costly flood losses. Second, it will prevent river corridor encroachment which would increase overall fluvial erosion hazards and even impede a river's natural tendency to adjust toward a more stable, equilibrium condition.

The FEH risk assessment and mapping process provides a sound scientific and technical basis for determining the boundaries of an FEH overlay district. Because overlay district boundaries do not shift as a river channel changes position, this approach can provide a consistent, easy-to-administer tool for mitigating fluvial erosion hazards over a wide geographic area. In the long term, this option will do the best job of minimizing human/river conflicts and limiting losses caused by fluvial erosion. *Model Fluvial Erosion Hazard Overlay District language developed by the River Management Program is included as Appendix C.*

River Corridor Protection

Another way a town can mitigate fluvial erosion hazards is by sponsoring or participating in river corridor protection projects. Protecting from development existing, undeveloped floodplains and low-lying riverine wetlands is one of the best ways to limit flood and fluvial erosion losses in the long run. These areas serve the essential functions of spreading, slowing, and storing floodwaters as well as sediment. In addition, protecting undeveloped land along rivers leaves space for lateral adjustment over time, which is necessary to allow the river to achieve a balanced, equilibrium condition. Protection mechanisms include outright purchase, purchase of development rights, and easement acquisition. The same stream geomorphic assessments which support FEH mapping can also be used to identify these key river corridor areas. Many communities may want to take the additional step of developing a comprehensive River Corridor Management Plan which catalogues strategies and opportunities for corridor protection. The River Management Program, in partnership with area land trusts, is committed to supporting river corridor protection projects, both technically and financially.

Infrastructure Management: Bridges, Culverts, and Roads

The largest single source of flood losses, both in terms of cost and number of people affected, is damage to transportation infrastructure. Infrastructure damage also represents the greatest public safety hazard. All three flood-related fatalities in Vermont since 1995 were associated with washed out culverts on town highways. Public health and safety is also at risk when access to homes and businesses is unavailable, and when emergency services, power, communications, water supply, and wastewater collection and treatment are disrupted due to flood damage to infrastructure.

Town roads, drainage systems, bridges, and culverts commonly experience major destruction during flash floods. Town roads with inadequate stormwater drainage, poor embankment stability, and those which encroach into stream channels and flood prone areas often suffer extensive damage during flood events. See Appendix A for a list of infrastructure management resources.

Bridge and culvert failure during flash floods is often a result of the structures being unable to pass the sediment transported by floodwaters. Even structures that are large enough to pass flood flows can become plugged and fail if they are improperly aligned or graded. Crossing structures which disrupt sediment transport can cause channel instability adjacent to the structure (both up and downstream), which can heighten erosion hazards in those areas.

Infrastructure management informed by an understanding of the fluvial geomorphology of a river system is an important part of a town's flood and erosion hazard mitigation strategy. The River Management Section has developed a rapid bridge and culvert assessment protocol to assess the geomorphic compatibility of bridges and culverts with ongoing river processes. Bridge and culvert assessments can be completed in conjunction with the stream



geomorphic assessments which support FEH mapping to provide a town with the tools needed to manage its transportation infrastructure to reduce flood losses. *See Appendix A for additional information on this topic, including a link to the bridge and culvert assessment protocols.*

Stormwater Management

Development in a watershed increases the amount of impervious surface (pavement, rooftops, etc), which in turn affects the magnitude and timing of runoff. In general, an increase in impervious surface leads to “flashy” (more overland runoff in a shorter amount of time) runoff patterns which can have an affect on flooding, channel stability, and erosion in rivers and streams. While the effect of hydrologic changes due to stormwater is most dramatic in small, heavily developed watersheds, stormwater changes can have an impact on flooding and erosion in many rivers.

A detailed description of stormwater impacts and solutions is beyond the scope of this guide, and many excellent stormwater management resources exist. *Several of these resources are listed in Appendix A.*

III) Understanding the Process

Given the wide variety of fluvial erosion hazard mitigation actions a town can take, individual approaches will vary from town to town. Common to all approaches, however, is the need to understand the exact location and nature of fluvial erosion hazards, as well as the physical imperatives of the river. The FEH mapping process will provide this information, and form a solid foundation for dealing with fluvial erosion hazards at the town level. What follows is a brief summary of the steps a community can take to map fluvial erosion hazards and then develop and implement mitigation measures.

1. Getting Started

Don't wait until after a destructive flood to take action! Now is the time to start working to mitigate fluvial erosion hazards in your community. A good first step is to learn what your town is currently doing to deal with flooding and fluvial erosion. Is your community participating in NFIP? Has your town adopted any setbacks or stream buffers? Which rivers and streams in your community have a history of flood and erosion problems? Are there other areas with a high potential for fluvial conflict? Gathering this initial information will help focus available resources on the areas where mitigation actions can have the greatest impact.

Many resources exist to support fluvial erosion hazard mapping. The River Management Program is committed to providing both technical and financial support to towns interested in undertaking FEH mapping projects. In addition, the RMP is partnering with many of Vermont's Regional Planning Commissions, funded by FEMA Pre-Disaster Mitigation Grants, to support both FEH mapping and implementation. *Appendix A contains a more complete list of funding sources.*

2. Fluvial Erosion Hazard Mapping

The first step in the fluvial erosion hazard mapping process is to complete Phase 1 and 2 Stream Geomorphic Assessments (SGA) for streams to be mapped. Geomorphic assessments may have already been completed or be underway in your region. In Vermont, many different organizations and agencies (including local watershed groups, nonprofit organizations, Natural Resource Conservation Districts, Park Districts, Regional Planning Commissions, as well as town governments) are undertaking or sponsoring geomorphic assessments. Some assessments are carried out by the sponsoring organizations, while many are contracted out to qualified consultants. All geomorphic assessments are conducted according to VTANR's Stream Geomorphic Assessment Protocols, and all assessment data undergoes a thorough quality assurance/quality control analysis by River Management Program staff and is stored on a web-based data management system.

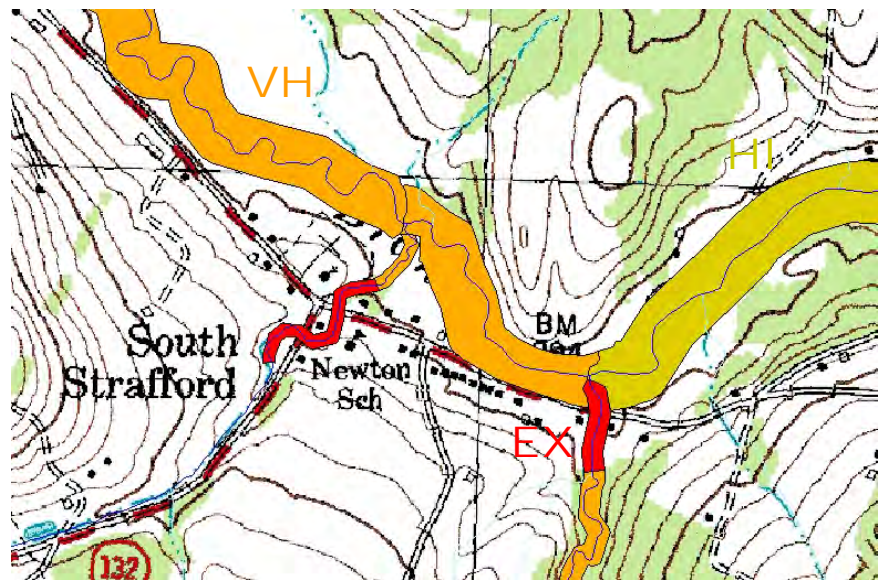
Phase 2 geomorphic assessment data provides the basis for fluvial erosion hazard map development, and must be collected for all portions (called reaches) of a stream to be included in a FEH map. Phase 2 assessments enable FEH mapping by identifying the sensitivity of each reach of a stream. Some streams, due to their setting or physical characteristics are inherently sensitive, and are more likely to experience rapid adjustment in channel

dimension and location. In addition, the inherent sensitivity of a stream may be heightened by human alterations of the channel or watershed.

In the FEH mapping process, stream sensitivity (based on data collected in a Phase 2 assessment) is translated into an area along a stream (the FEH zone) that is needed by the stream to maintain or adjust toward equilibrium. This is also the area that is most likely to experience damage caused by fluvial erosion. FEH zones are based on the concept of meander belt width, the area of a valley occupied by a stream as it winds back and forth (or meanders) in its attempt to achieve a stable slope. The meander belt width is directly related to the width of a stream and the size of the watershed it drains.

Figure 2, an example of a FEH map, illustrates how the width of a FEH zone is scaled to the size of a stream. Smaller tributaries have a narrower FEH zone associated with them. In addition, the width of an FEH zone depends upon its sensitivity. For example, a steep, headwater stream with a bed made up mostly of boulders is extremely stable (Very Low sensitivity). For streams like this, the FEH zone does not extend beyond the width of the channel. In contrast, a meandering, lowland stream with fine substrate is much more prone to lateral migration and sensitive to disturbance (Very High sensitivity). In this case, the FEH zone is a full six channel widths wide. A more detailed description of the FEH mapping process and the supporting science can be found in Appendix B.

Figure 2. FEH zones based on sensitivity



The River Management Program has developed a computer program (a GIS extension), the Stream Geomorphic Assessment Tool (SGAT), to automate the drawing of FEH zones. Once an initial draft FEH map is produced by SGAT, it undergoes a field verification and quality assurance process where manual adjustments can be made (if necessary) to reflect conditions on the ground, resulting in a final, science-based FEH map.

3. Implementation

A fluvial erosion hazard map provides a town valuable insight into the location and nature of fluvial erosion hazards, and can be used to support many effective mitigation options. As outlined in the *Options for Mitigation* section of this guide, avoidance is the most cost effective approach to mitigating fluvial erosion hazards in the long run, and a FEH Overlay District is an important way to limit encroachment along rivers. FEH zone boundaries from the final, science-based FEH map can be translated directly into boundaries of a FEH overlay district, or can be used as a guide for the development of a FEH overlay district that meets the specific needs of a town.

In some cases, zoning regulations (like a FEH overlay district) that place limits on property use can often be perceived as an infringement on the rights of property owners. It is important to remember that these concerns must be balanced against the net benefit (reduced flood damage, enhanced public safety) to the community and society as a whole. Courts throughout the nation have been consistently supportive of the right (and in cases the responsibility) of local governments to restrict the use of some private land (e.g. zoning) in order to benefit the community (and society) as a whole. *Links to more detailed information about this issue ("takings") can be found in the Legal Issues section of Appendix A: Resources.*

The River Management Program is committed to providing continued technical support to towns after they have completed the FEH mapping process and incorporated it into their planning and zoning. This support includes

technical review of conditional use or map amendment requests which arise as towns administer any FEH-based zoning regulations. In addition, the RMP (often in partnership with Regional Planning Commissions) will provide map production and maintenance services related to FEH overlay districts.

In addition to direct support and services, the River Management Program is working to develop an array of incentives to reward towns who are taking an active role in mitigating fluvial erosion hazards. The RMP has already structured the selection process in our River Corridor Grants Program to give preference to communities pursuing FEH overlay districts or proactive FEH mitigation activities. It is anticipated that other State-administered disaster mitigation and recovery funding will eventually be similarly structured.

It is important to note that undertaking the fluvial erosion hazard mapping and risk assessment process is entirely voluntary, and that there are no state regulatory strings attached. The decision to adopt (as well as the responsibility to administer) any zoning regulations supported by FEH mapping belongs solely to the town. When delineating floodways during Act 250 proceedings, ANR uses a technical process similar to the FEH mapping procedure described in this guide. However, ANR is *only* involved in a regulatory role when a development is subject to Act 250.

The huge financial and social impact of flood damage in Vermont, most of which is caused by fluvial erosion, justifies a concerted mitigation effort. Towns are the key entity that can take proactive steps to reverse the costly trend of encroachment, loss, and rebuild. *Avoiding* further encroachment in our river corridors, through effective zoning and planning is the cornerstone of a new and more sustainable relationship with our rivers and streams. Now is the time to act!

APPENDIX A: Additional Resources

River Fundamentals:

Vermont Agency of Natural Resources. 2004. River Corridor Protection and Management Fact Sheet #1. *This document provides an overview of river dynamics, with references to even more detailed information. This document is available online at:* www.anr.state.vt.us/dec/waterq/rivers/docs/rv_rcprotectmanagfactsheet.pdf

National Flood Insurance Program (NFIP):

Federal Emergency Management Agency (FEMA) official NFIP Website:
www.floodsmart.gov

Margaret Torizzo
State National Floodplain Insurance Program Coordinator
103 South Main Street
Waterbury, VT 05671-0408
(802) 241-3759

Pre-Disaster Mitigation Planning

Federal Emergency Management Agency (FEMA) Mitigation Division website:
www.fema.gov/fima/

Vermont Emergency Management mitigation information is available on the web at:
www.dps.state.vt.us/vem/mitigation.htm

Or by contacting:

Ray Doherty, State Hazard Mitigation Officer
103 S. Main Street
Waterbury, VT 05671
800-347-0488 or 802-241-5258
FAX 802-241-5556
[E-mail rdoherty@dps.state.vt.us](mailto:rdoherty@dps.state.vt.us)

Regional Planning Commissions (RPC) are heavily involved in pre-disaster mitigation planning in Vermont. A map showing the location of Vermont's RPC's with phone numbers and links to their websites can be found at:
www.vpic.info/rpcs/

Setbacks and Stream Buffers:

Vermont Agency of Natural Resources. 2005. Riparian Buffers and Corridors Technical Papers, 2005: *This document provides a general overview of the functions of riparian buffers and the supporting science, as well as a bibliography of additional resources. This document is available online at:*
www.anr.state.vt.us/site/html/buff/anrbuffer2005.htm, or by contacting:

Agency of Natural Resources
Center Building
103 South Main Street
Waterbury, VT 05671
(802) 241-3600

Infrastructure Management:

The River Management Program's bridge and culvert geomorphic assessment protocols can be found in Appendix G of the Stream Geomorphic Assessment protocols:
http://www.anr.state.vt.us/dec/waterq/rivers/docs/assessmenthandbooks/rv_weblinkpgappendixs.pdf

The Vermont Better Backroads Program:

Provides technical and financial support for municipalities to deal with infrastructure management issues. More information available at their website:
www.anr.state.vt.us/site/cc/bbroads.htm

Stormwater Management:

Stormwater Section, Water Quality Division
Department of Environmental Conservation
103 South Main Street
Waterbury, VT 05671
www.anr.state.vt.us/dec/waterq/stormwater.htm
(802) 241-3776

NEMO (Nonpoint Education for Municipal Officials) VT

Emma Melvin – Water Quality Educator

(802) 656-9110

emelvin@uvm.edu

Education for municipal officials on nonpoint source pollution, including stormwater.

Funding Sources:

River Management Program River Corridor Grants

Contact: Lauren Moore

103 South Main Street

Waterbury, VT 05671

(802) 241-3593

www.anr.state.vt.us/dec/waterq/rivers.htm

Upper Connecticut River Mitigation and Enhancement Fund

Managed by the Vermont Community Fund and the New Hampshire Community Fund

Details at: www.vermontcf.org/guidelines-forms/mef.html

The Vermont Community Foundation

Three Court Street

P.O. Box 30

Middlebury, VT 05753

Phone: 802-388-3355

Fax: 802-388-3398

info@vermontcf.org

Regional Planning Commissions (RPC)

Vermont has 11 RPC's, 7 of which are currently undertaking FEH mapping and mitigation activities in cooperation with the River Management Program, funded FEMA Pre-Disaster Mitigation Planning Grants.

A map showing the location of Vermont's RPC's with phone numbers and links to their websites can be found at:

www.vpic.info/rpcs/

Legal Issues:

A good general discussion of the legal issues relating to floodplain management can be found at the Association of State Floodplain Managers website: www.floods.org

A more detailed treatment of the "takings" issue and how it relates to town zoning can be found at:

www.floods.org/PDF/EdThomas_Courts_GoodNews_FloodplainManagement.pdf

APPENDIX B: The Technical Process of Mapping Fluvial Erosion Hazards

In an effort to provide to towns the tools needed to mitigate losses due to fluvial erosion, the River Management Program has developed the technical process to assess and map fluvial erosion hazards (FEH). The FEH mapping process is a rigorous, science-based method to define the corridor along a river subject to the highest risk of erosion-related flood losses. The FEH corridor is an important management tool because it is not only area where flood hazards are highest, but also the area that a river needs to utilize (over time) in order to achieve *dynamic equilibrium*. Dynamic equilibrium is a state at which sediment supply and transport are balanced and erosion is minimized. What follows is a brief description of the steps in developing a FEH map.

1) Phase 1 Geomorphic Assessment

This initial phase of geomorphic assessment involves collecting data from maps, aerial photographs, existing studies, and limited field investigations, in order to establish geomorphic reaches and expected or “reference” stream types based on natural factors (geography and geology). In addition, Phase 1 assessments predict expected stream conditions based on watershed and river corridor land use as well as channel and floodplain modifications. Phase 1 investigations identify areas with a high potential for fluvial adjustment and conflict, and help guide decisions about where to conduct Phase 2 assessments.

2) Phase 2 Geomorphic Assessment

Phase 2, the rapid field assessment, involves the collection of detailed field data about channel and floodplain characteristics, ongoing adjustment processes, as well as riparian land use and habitat. Phase 2 assessments identify existing stream type, dimension, and condition. The Phase 2 assessment allows heterogeneous reaches to be further subdivided into segments with similar characteristics. Phase 2 assessments are described as “rapid”, but can take one to two days of field work per one mile reach, depending upon how many segments or sub-reaches are encountered. Phase 2 data is entered into ANR’s web-based Data Management System (DMS), and undergoes a thorough quality assurance/quality control process. *The complete Stream Geomorphic Assessment protocols can be found at: www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm*

FEH Zone Development: Stream Sensitivity

Phase 2 is the level of assessment needed to produce FEH maps, as it allows a stream sensitivity rating to be assigned to each reach or segment of a stream. Table 1 shows how stream sensitivity ratings are assigned based on stream type and geomorphic condition.

Table 1. Vermont ANR Stream Sensitivity Ratings based on geomorphic stream type and condition.

Geomorphic Stream Type Group	Existing Geomorphic Stream Type*	Sensitivity Ratings		
		Reference or Good Condition	Fair-Poor Condition in Major Adjustment	Poor Condition and represents a Stream Type Departure
1	A1, A2, B1, B2,	Very Low	Very Low	Low
2	C1, C2	Very Low	Low	Moderate
3	G1,G2	Low	Moderate	High
4	F1, F2	Low	Moderate	High
5	B3, B4, B5	Moderate	High	High
6	B3c, C3, E3	Moderate	High	High
7	C4, C5, B4c, B5c, E4, E5	High	Very High	Very High
8	A3, A4, A5, G3, F3	High	Very High	Extreme
9	G4, G5, F4, F5	Very High	Very High	Extreme
10	D3, D4, D5	Extreme	Extreme	Extreme

* Geomorphic stream types from the Rosgen (1994) Classification System

The Vermont ANR stream sensitivity ratings are based on the findings of numerous researchers (Lane, 1955; Schumm, 1977; Leopold and Maddock, 1953; Rosgen, 1996; Montgomery and Buffington, 1997; Thorne et al., 1997; Knighton, 1998; Center for Watershed Protection *et.al.* 1999; MacBroom, 1998; Lane, 1995, Simon and Thorne, 1996) and include consideration of the:

Inherent sensitivity of the geomorphic stream type as dictated by the:

- Channel and floodplain geometry in relation to flow and sediment regimes;
- Bed and bank material erodibility, bank stratigraphy, and presence of alluvial fans;
- Occurrence and influence of colluvial and mass failure processes;
- Riparian vegetation; and

The likelihood of major vertical and lateral channel adjustments in response to:

- Changes in flow (flood history, direct human manipulation of flow, and/or alteration of watershed hydrology);
- Changes in sediment supply;
- Channel modification (e.g., channel straightening, armoring, and/or berming); and
- Valley constrictions and floodplain modifications.

Stream sensitivity ratings reflect both the inherent stability of the existing geomorphic stream type and the likelihood of major channel adjustment in response to various stressors (changes in flow, sediment supply, or channel modification). As a result, sensitivity ratings translate directly to fluvial erosion hazard ratings. Fluvial erosion hazard ratings are made up of the two letter abbreviation of the sensitivity rating (**VL**=Very Low; **LW**=Low; **MD**=Moderate; **HI**=High; **VH**=Very High; and **EX**=Extreme) subscripted by the geomorphic stream type group (1-10).

FEH Zone Development: Building a Corridor

The next step of the FEH mapping process is to translate FEH ratings into a meander belt width based river corridor, or fluvial erosion hazard zone. The meander belt width is the area in a river valley needed by a river in order to achieve and maintain equilibrium. Research on the patterns of unconfined, alluvial streams of all sizes throughout the world reveals a consistent relationship: the meander belt width of a river is approximately six times the width of the stream channel at that point (Williams, 1986). This relationship is used in the FEH mapping process to produce a river corridor (the FEH zone) which includes the area adjacent to the stream that is needed by the river to maintain or move toward an equilibrium condition. This is also the area at highest risk of fluvial erosion.

Because some settings (like steep streams in confined valleys or streams with lots of bedrock control) naturally prevent rivers from ever developing such a wide meander belt width, fluvial erosion hazard zones can range from one to six reference bankfull channel widths, as illustrated in Table 2.

Streams with Very Low and Low sensitivity are generally steep, confined streams, with very erosion-resistant bed and banks (bedrock or boulders). These streams are exceptionally stable (unlikely to migrate laterally), so they will have a very narrow FEH zone. In contrast, streams with Very High or Extreme sensitivity are very dynamic and prone to rapid lateral migration, either because they are inherently unstable, or are undergoing adjustment processes that lead to instability. These streams will have a wide FEH zone (6 channel widths), allowing sufficient space for a stream to adjust toward or maintain dynamic equilibrium.

Table 2. Fluvial Erosion Hazard Corridor Widths

Sensitivity	Belt Widths based on reference channel widths
Very Low (VL)	Equal to the reference channel width
Low (LW)	Equal to the reference channel width
Moderate (MD)	Four (4) channel widths
High (HI)	Six (6) channel widths
Very High (VH)	Six (6) channel widths
Extreme (EX)	Six (6) channel widths

Field Verification and Quality Assurance: The Final Steps

Draft FEH Corridor

Once a Phase 2 Stream Geomorphic Assessment is completed (and the data has been entered in the web-based data management system) and FEH ratings assigned, draft FEH corridors can be produced using the Stream Geomorphic Assessment Tool (SGAT). SGAT is a GIS extension which automates the drawing of FEH corridors. In addition to the Vermont River Management Program, most Regional Planning Commissions, and some private consultants are qualified to use SGAT to produce draft FEH maps.

FEH Map Refinement

The River Management Program, in consultation with other involved parties (consultants, town officials, RPC's) will review the FEH corridor to determine if adjustments to the draft map are necessary. Refinements of the FEH corridor include two different methods:

- a. **SGAT redrawing** of the FEH corridor based on revisions to meander centerline and valley wall shape files. Orthophoto analysis and field visits are often necessary to verify the toe of valley wall location. The revised shape files are then used to redraw the FEH corridor using SGAT
- b. **Manual redrawing** of the FEH corridor when field, map, or remote sensing data indicates that a wider or narrower corridor is warranted. Documentation and technical justification is a part of any manual redrawing.

The end result of this process outlined above is a Fluvial Erosion Hazard map, technically approved by the River Management Program. FEH maps will provide a solid basis on which towns can develop planning and zoning strategies to mitigate fluvial erosion hazards.

References

- Knighton, D. 1998. *Fluvial Forms and Processes: A New Perspective*. Oxford University Press. New York.
- Lane, E.W. 1955. The Importance of Fluvial Morphology in Hydraulic Engineering. *Proceedings of the American Society of Civil Engineers, Journal of the Hydraulics Division*, vol. **81**, paper no. 745.
- Lane, S. 1995. The Dynamics of Dynamic River Channels. *Physical Geography Now. Geography*, Volume 80(2), Pages 147-162.
- Leopold, L.B. 1994. *A View of the River*. Harvard University Press. Cambridge, MA.
- Leopold, L.B., and T. Maddock Jr. 1953. *The Hydraulic Geometry of Stream Channels and Some Physiographic Implications*. Geological Survey Professional Paper 252. U.S. Government Printing Office, Washington, D.C.
- MacBroom, J.G. 1998. *The River Book*. Connecticut Department of Environmental Conservation. DEP Natural Resource Center, Technical Publications Program. Hartford, CT
- Montgomery, D., and J. Buffington. 1997. Channel-reach Morphology in Mountain Drainage Basins. *Geological Society of America Bulletin*; v. 109; no. 5; pp 596-611.
- Rosgen, D.L. 1994. A Classification of Natural Rivers. *Catena* (1994) 169-199.
- Rosgen, D.L. 1996. *Applied Fluvial Morphology*. Wildland Hydrology. Pagosa Springs, CO
- Schumm, S.A. 1977. *The Fluvial System*. John Wiley and Sons, New York.
- Simon, A. and C.R. Thorne. 1996. Channel Adjustment of an Unstable Coarse-Grained Stream: Opposing Trends of Boundary and Critical Shear Stress, and the Applicability of Extremal Hypotheses. *Earth Surface Processes and Landforms*, Vol.21. 155-180.

Thorne, C.R., D.R. Hey, and M.D. Newson. 1997. Applied Fluvial Geomorphology for River Engineering and Management. John Wiley & Sons. Chichester, UK.

Vermont Agency of Natural Resources. 2004. Stream Geomorphic Assessment Protocol Handbook. Waterbury, VT

Williams, G.P., 1986. River Meanders and Channel Size. Journal of Hydrology, Vol.88. 147-164.

APPENDIX C: Model Fluvial Erosion Hazard Area Overlay District

(A) PURPOSE

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

(B) APPLICABILITY

The Fluvial Erosion Hazard (FEH) District shall be superimposed over any other zoning districts. All lands to which the FEH District applies must meet the requirements of the underlying zoning districts and the FEH District. Where there is a conflict between the underlying zoning district and the FEH District, the more restrictive regulation shall apply.

(C) FLUVIAL EROSION HAZARD DISTRICT BOUNDARIES

These regulations shall apply in all areas in the Town of _____ that are identified as Fluvial Erosion Hazard Areas on the current Fluvial Erosion Hazard Area zoning map, on file at the _____ Town Office.

(D) DEFINITIONS

For the purposes of this overlay district, the following definitions shall apply:

Accessory Structure: A structure which is: 1) detached from and clearly incidental and subordinate to the principal use of or structure on a lot, 2) located on the same lot as the principal structure or use, and 3) clearly and customarily related to the principal structure or use. For residential uses these include, but may not be limited to garages, garden and tool sheds, playhouses, and in-ground swimming pools which are incidental to the residential use of the premises and not operated for gain.

Development: See Land Development.

Fluvial Erosion Hazard Area: The land area adjacent to stream channels subject to fluvial erosion processes or other channel adjustments as delineated on the current Fluvial Erosion Hazards Area Map.

Land Development: The construction, reconstruction, conversion, structural alteration, relocation or enlargement of any building or other structure, or any mining, excavation or landfill, or any changes in the use of any building or other structure or land or extension of use of land.

Minor Improvement: Any repairs, reconstruction, or improvement of a structure, the cost of which is less than fifty (50) percent of the market value of the structure.

Substantial Improvement: Any repair, reconstruction or improvement of a structure, the cost of which equals or exceeds fifty percent of the market value of the structure either: (a) before the improvement or repair is started, or (b) if the structure has been damaged and restored, before the damage occurred. For the purpose of administering flood hazard area regulations, this definition excludes the improvement of a structure to comply with existing municipal or state health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions.

(E) PERMITTED USES

1. Existing development.
2. The removal of a structure of building in whole or in part.
3. Silvicultural activities not involving the use of structures and conducted in accordance with Vermont Department of Forest and Parks Acceptable Management Practices.
4. Agricultural activities not involving the use of structures and conducted in accordance with Vermont Department of Agriculture Acceptable Agricultural Practices.

5. Minor residential building improvements to existing structures located within a FEH Area that do not result in a decrease of the existing structure setback from any stream.

(F) CONDITIONAL USES

1. Residential accessory structures that do not result in a decrease of the existing structure setback from any stream.
2. Substantial improvements to existing structures located within a FEH Area that do not result in a decrease of the existing structure setback from any stream.
3. Construction of driveways and/or access roads
4. Buried utility lines, including power, telephone, cable, sewer, and water
5. Excavation and grading of land associated with any other use or development activity

(G) PROHIBITED USES

The following activities and uses are prohibited in the FEH District:

1. Storage areas or facilities for floatable materials, chemicals, explosives, flammable liquids, or other hazardous or toxic materials, are prohibited within the FEH District.
2. All development within the FEH Area not specifically allowed by subsections (E) and (F).

(H) DISTRICT STANDARDS

The following standards and procedures apply to all conditional uses within the overlay district.

1. Application Submission Requirements

Application for land development listed in subsection (F) shall be reviewed and approved by the Development Review Board as a conditional use under Section _____ prior to the issuance of a zoning permit. In addition to the application requirements set forth in Section _____, applications for conditional use approval shall include:

- a. A statement of purpose and need of the proposed development
- b. A description of alternatives considered to proposed development, including alternate locations on site, especially outside of the Fluvial Erosion Hazard Area.
- c. General location map including the relative locations of the existing development, the proposed development, the FEH District, and the nearest public road.
- d. Identification of the shortest horizontal distance from the proposed development to the center line (or top of nearest bank if not possible to measure to the center line) of any stream.
- e. Identification of the horizontal distance from the centerline of the nearest public road to the center line (or top of nearest bank if not possible to measure to the center line) of any stream.
- f. Such other information deemed necessary by the Development Review Board for determining the suitability of the site for the proposed development.

2. Application Review Procedures

- a. Referral to Vermont Department of Environmental Conservation (DEC): In reviewing an application for a Conditional Use Permit, the Development Review Board will forward application materials to the River Management Program (RMP) of the Vermont DEC for review and comment. The Development Review Board will schedule a hearing in accordance with Section _____, although such hearing shall be scheduled for a date not less than thirty (30) days from the submission of the application materials to the RMP. Failure of the RMP to provide comments within thirty (30) days of submission of the application materials by the Zoning Board of Adjustment shall not be cause for the Board to delay the hearing.
- b. Development Standards: The Development Review Board will consider the application and any comments provided by the RMP to ensure that all development within the FEH Overlay District meets the following standards:
 - i. No reasonable alternative location for the proposed development outside of the FEH area is available on the site.
 - ii. The proposed development will not increase the susceptibility of the property, including existing and proposed, to fluvial erosion damage.

- iii. The proposed development will not increase the potential for damage to other properties due to fluvial erosion.
- iv. The proposed development will not increase the potential of materials being swept onto other lands or into the stream and causing damage to others from fluvial erosion.
- v. The proposed development will not cause an undue burden on public services and facilities including roads, bridges, culverts, and emergency service providers during and after fluvial erosion events.
- vi. New development may be allowed within the FEH District if based on a review by the RMP it is determined that the proposed development is not located or should not be located within the FEH area and that the new development complies with all other standards in i. through v. above.

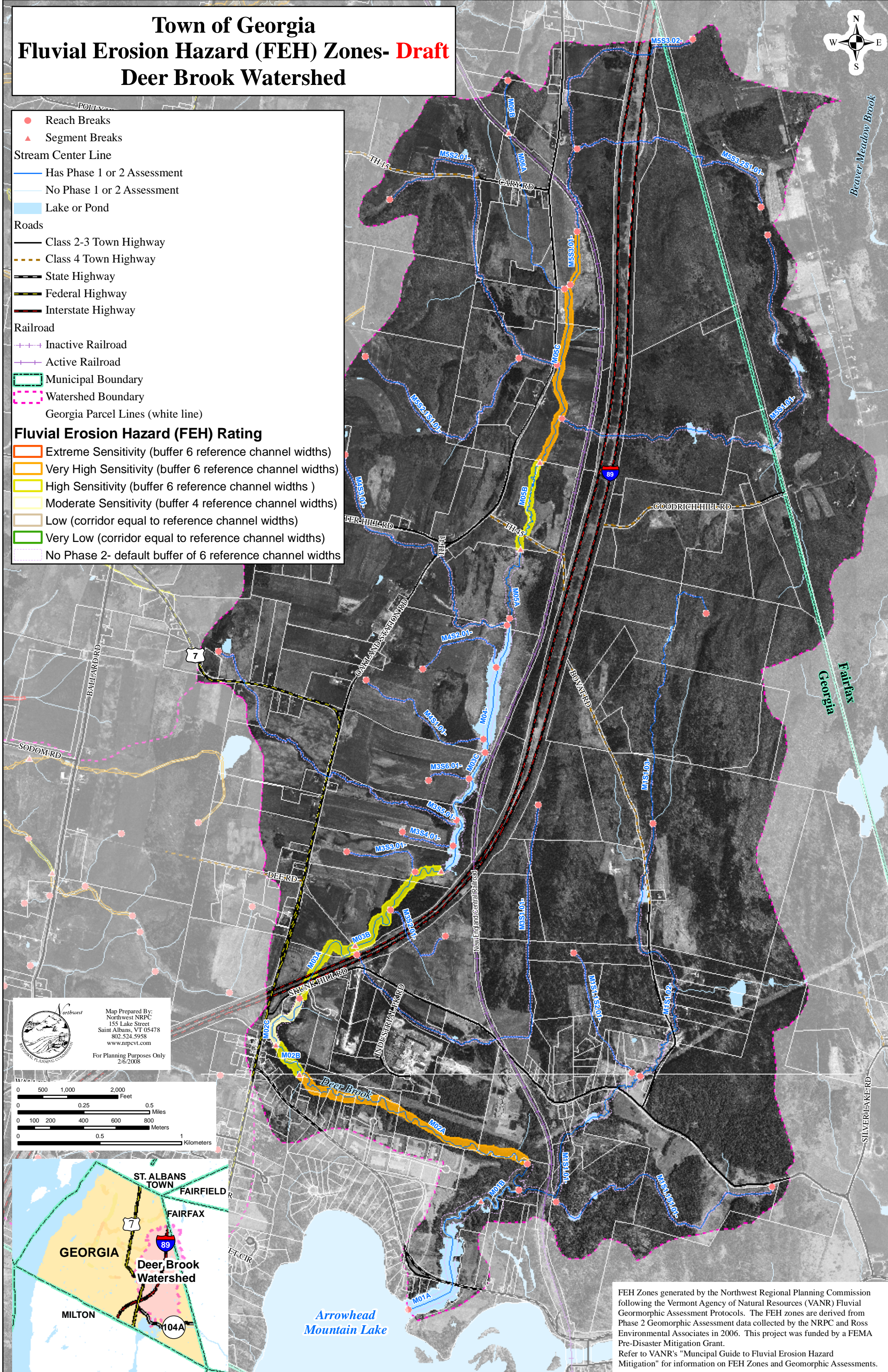
(I) WARNING AND DISCLAIMER OF LIABILITY

The provisions of this section do not imply that land outside the designated FEH Overlay District is free from fluvial erosion hazards. Further, these provisions shall not create any liability on the part of the town, or any employee thereof, for damages that result from reliance on these regulations or any administrative decision lawfully made hereunder.

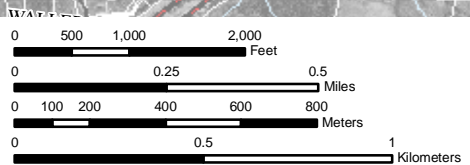
Town of Georgia Fluvial Erosion Hazard (FEH) Zones- **Draft** Deer Brook Watershed



- Reach Breaks
 - ▲ Segment Breaks
 - Stream Center Line
 - Has Phase 1 or 2 Assessment
 - - - No Phase 1 or 2 Assessment
 - Lake or Pond
 - Roads
 - Class 2-3 Town Highway
 - - - Class 4 Town Highway
 - == State Highway
 - == Federal Highway
 - == Interstate Highway
 - Railroad
 - - - Inactive Railroad
 - - - Active Railroad
 - Municipal Boundary
 - Watershed Boundary
 - Georgia Parcel Lines (white line)
- Fluvial Erosion Hazard (FEH) Rating**
- Extreme Sensitivity (buffer 6 reference channel widths)
 - Very High Sensitivity (buffer 6 reference channel widths)
 - High Sensitivity (buffer 6 reference channel widths)
 - Moderate Sensitivity (buffer 4 reference channel widths)
 - Low (corridor equal to reference channel widths)
 - Very Low (corridor equal to reference channel widths)
 - No Phase 2- default buffer of 6 reference channel widths

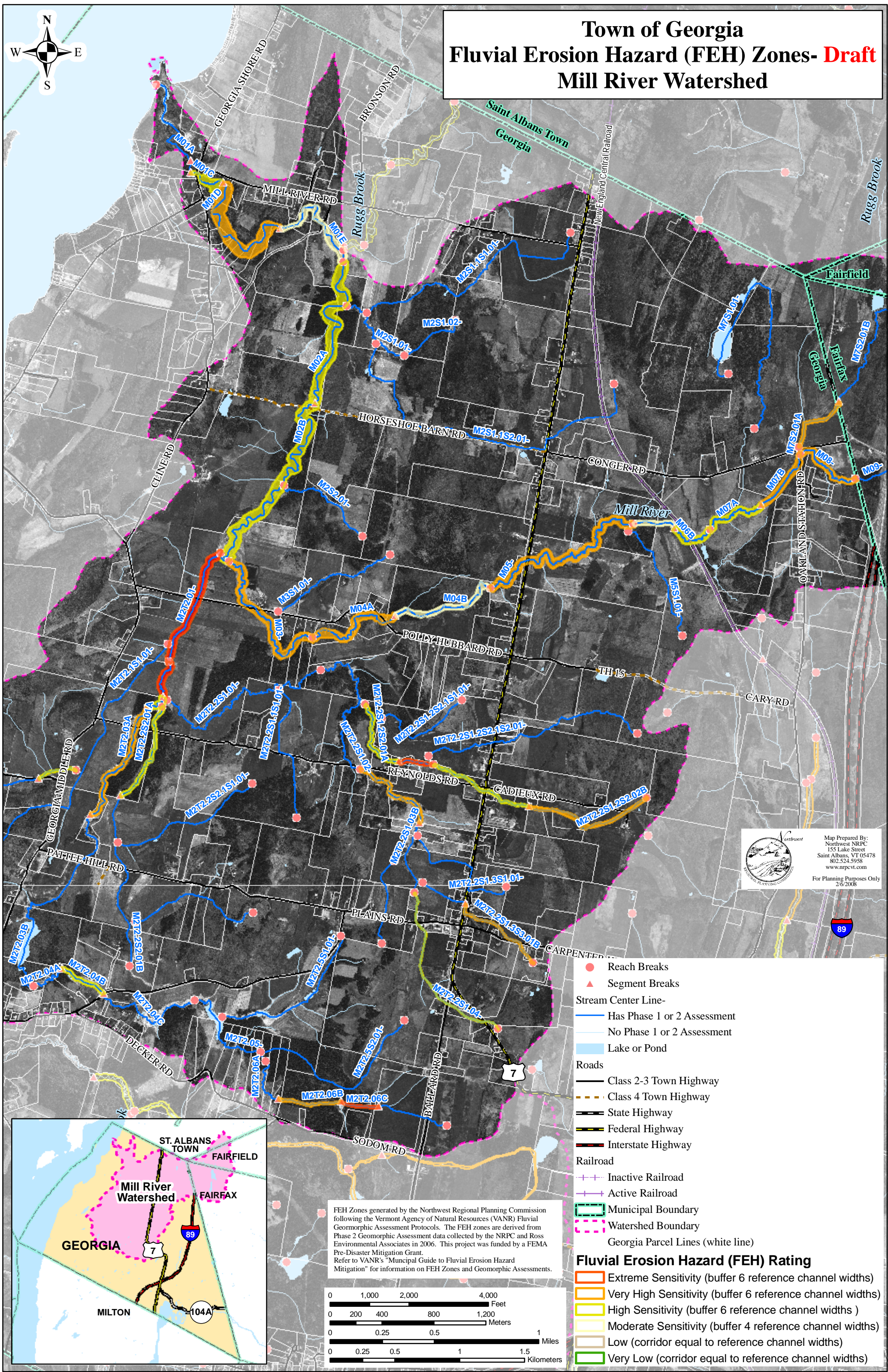


Map Prepared By:
Northwest NRPC
155 Lake Street
Saint Albans, VT 05478
802.524.5958
www.nrpcvt.com
For Planning Purposes Only
2/6/2008



FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collected by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant. Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.

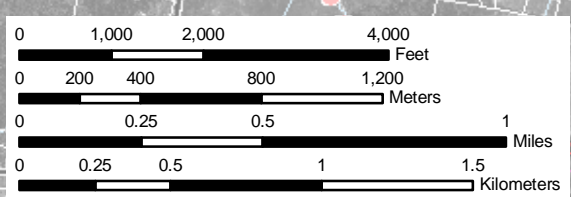
Town of Georgia Fluvial Erosion Hazard (FEH) Zones- **Draft** Mill River Watershed



Map Prepared By:
Northwest NRPC
155 Lake Street
Saint Albans, VT 05478
802.524.5958
www.nrpcvt.com
For Planning Purposes Only
2/6/2008



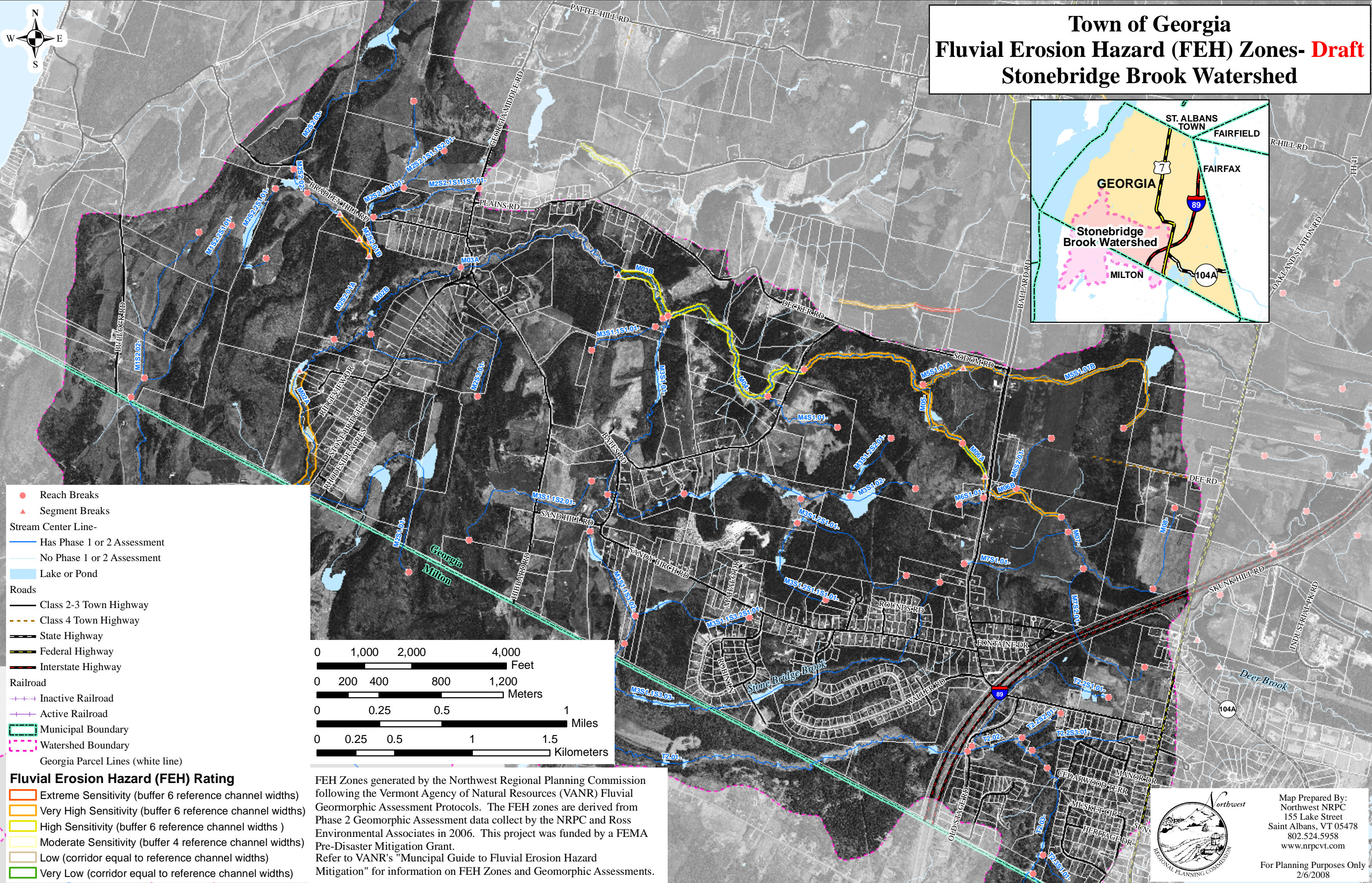
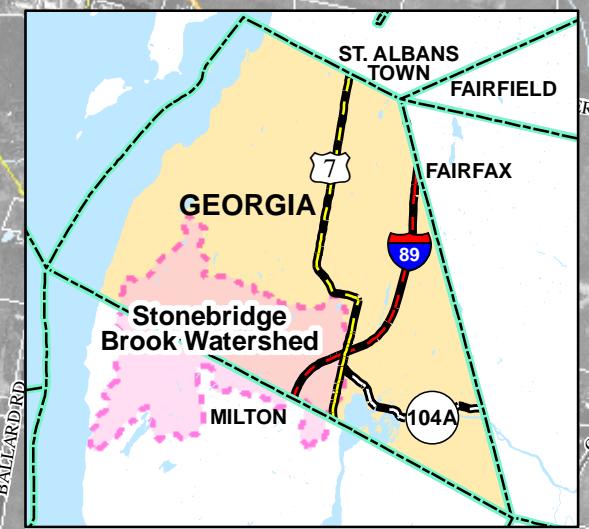
FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collected by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant. Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.



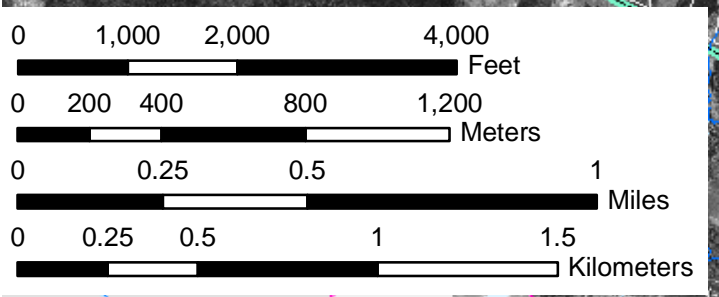
- Reach Breaks
 - ▲ Segment Breaks
 - Stream Center Line-
 - Has Phase 1 or 2 Assessment
 - No Phase 1 or 2 Assessment
 - Lake or Pond
 - Roads
 - Class 2-3 Town Highway
 - - - Class 4 Town Highway
 - == State Highway
 - == Federal Highway
 - == Interstate Highway
 - Railroad
 - - - Inactive Railroad
 - Active Railroad
 - Municipal Boundary
 - - - Watershed Boundary
 - Georgia Parcel Lines (white line)
- Fluvial Erosion Hazard (FEH) Rating**
- Extreme Sensitivity (buffer 6 reference channel widths)
 - Very High Sensitivity (buffer 6 reference channel widths)
 - High Sensitivity (buffer 6 reference channel widths)
 - Moderate Sensitivity (buffer 4 reference channel widths)
 - Low (corridor equal to reference channel widths)
 - Very Low (corridor equal to reference channel widths)



Town of Georgia Fluvial Erosion Hazard (FEH) Zones- **Draft** Stonebridge Brook Watershed



- Reach Breaks
- ▲ Segment Breaks
- Stream Center Line-
 - Has Phase 1 or 2 Assessment
 - No Phase 1 or 2 Assessment
- Lake or Pond
- Roads
 - Class 2-3 Town Highway
 - - - Class 4 Town Highway
 - State Highway
 - Federal Highway
 - Interstate Highway
- Railroad
 - +++ Inactive Railroad
 - Active Railroad
- Municipal Boundary
- Watershed Boundary
- Georgia Parcel Lines (white line)



- ### Fluvial Erosion Hazard (FEH) Rating
- Extreme Sensitivity (buffer 6 reference channel widths)
 - Very High Sensitivity (buffer 6 reference channel widths)
 - High Sensitivity (buffer 6 reference channel widths)
 - Moderate Sensitivity (buffer 4 reference channel widths)
 - Low (corridor equal to reference channel widths)
 - Very Low (corridor equal to reference channel widths)

FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collect by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant. Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.



Map Prepared By:
Northwest NRPC
155 Lake Street
Saint Albans, VT 05478
802.524.5958
www.nrpcvt.com

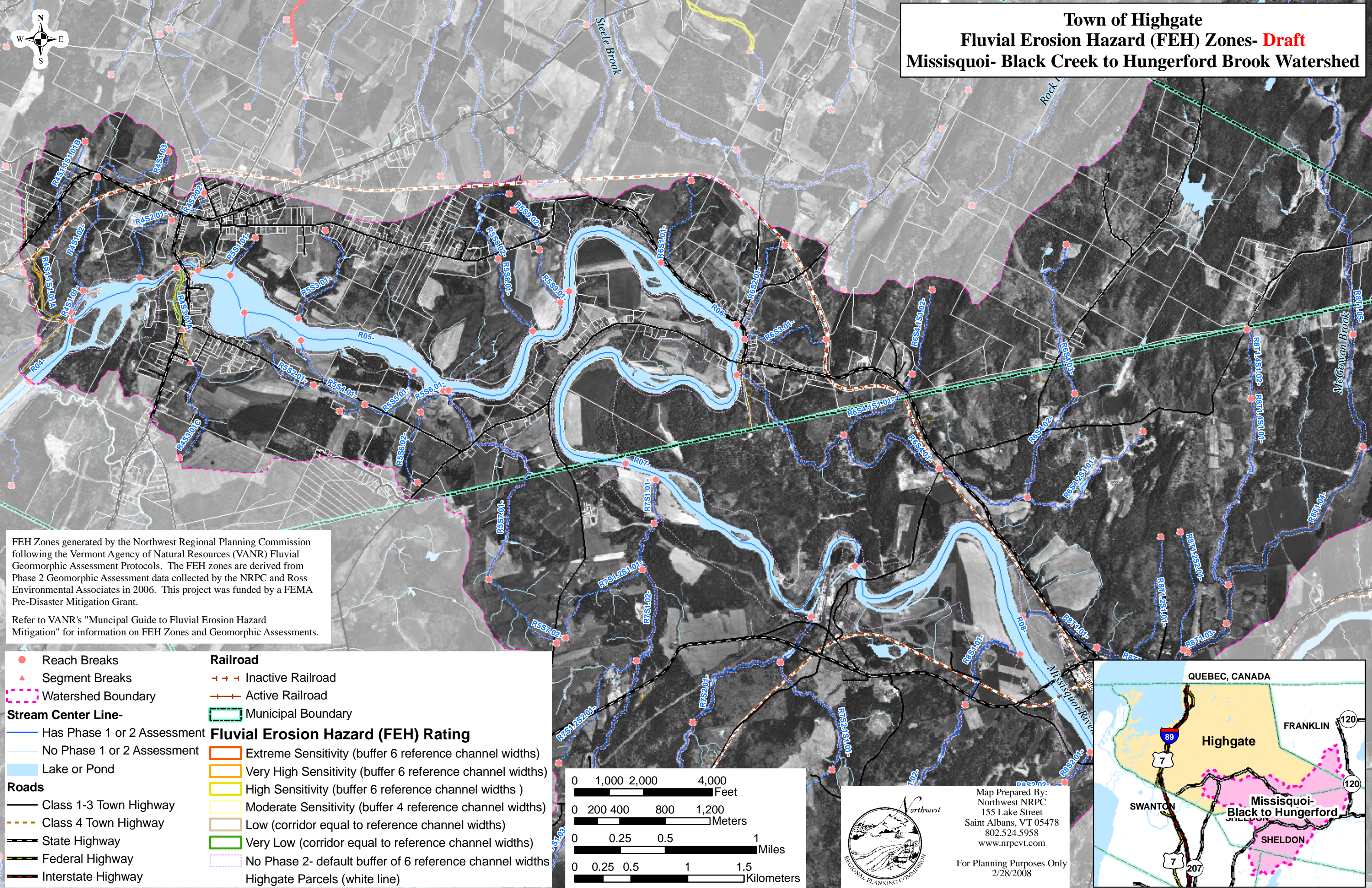
For Planning Purposes Only
2/6/2008

Town of Georgia- FEH Corridor Widths by Reach

Watershed	Reach\Segment ID	Option	Reference	Sensitivity	Buffer Belt	Total FEH
		1 or 2	Channel Width (r.c.w.)		Width	
Deer Brook	M01	1	33.35	NA	6 X r.c.w.	200.10
Deer Brook	M02A	2	29.48	Very High	6 X r.c.w.	176.88
Deer Brook	M02B	2	29.48	High	6 X r.c.w.	176.88
Deer Brook	M02C	2	29.48	Moderate	4 X r.c.w.	117.92
Deer Brook	M03	1	28.57	NA	6 X r.c.w.	171.42
Deer Brook	M03A	2	28.57	High	6 X r.c.w.	171.42
Deer Brook	M03B	2	28.57	High	6 X r.c.w.	171.42
Deer Brook	M04	1	25.01	NA	6 X r.c.w.	150.06
Deer Brook	M05	1	22.26	NA	6 X r.c.w.	133.56
Deer Brook	M05B	2	22.26	High	6 X r.c.w.	133.56
Deer Brook	M05C	2	22.26	Very High	6 X r.c.w.	133.56
Deer Brook	M06	1	5.66	NA	6 X r.c.w.	33.96
Deer Brook	M06A	2	5.66	Very High	6 X r.c.w.	33.96
Deer Brook	M1S1.01	1	17.23	NA	6 X r.c.w.	103.38
Deer Brook	M1S1.02	1	13.95	NA	6 X r.c.w.	83.70
Deer Brook	M1S1.03	1	8.42	NA	6 X r.c.w.	50.52
Deer Brook	M1S1.1S1.01	1	8.50	NA	6 X r.c.w.	51.00
Deer Brook	M1S1.1S2.01	1	5.76	NA	6 X r.c.w.	34.56
Deer Brook	M3S1.01	1	8.36	NA	6 X r.c.w.	50.16
Deer Brook	M3S2.01	1	5.87	NA	6 X r.c.w.	35.22
Deer Brook	M3S3.01	1	3.86	NA	6 X r.c.w.	23.16
Deer Brook	M3S4.01	1	4.90	NA	6 X r.c.w.	29.40
Deer Brook	M3S5.01	1	7.26	NA	6 X r.c.w.	43.56
Deer Brook	M3S6.01	1	5.70	NA	6 X r.c.w.	34.20
Deer Brook	M4S1.01	1	4.77	NA	6 X r.c.w.	28.62
Deer Brook	M4S2.01	1	4.29	NA	6 X r.c.w.	25.74
Deer Brook	M4S3.01	1	10.01	NA	6 X r.c.w.	60.06
Deer Brook	M5S1.01	1	12.51	NA	6 X r.c.w.	75.06
Deer Brook	M5S2.01	1	10.97	NA	6 X r.c.w.	65.82
Deer Brook	M5S2.1S1.01	1	7.51	NA	6 X r.c.w.	45.06
Deer Brook	M5S3.01-	2	11.49	Very High	6 X r.c.w.	68.94
Deer Brook	M5S3.02	1	10.81	NA	6 X r.c.w.	64.86
Deer Brook	M5S3.2S1.01	1	8.20	NA	6 X r.c.w.	49.20
Mill River	M01	1	51.77	NA	6 X r.c.w.	310.62
Mill River	M01B	2	51.77	NA	6 X r.c.w.	310.62
Mill River	M01C	2	51.77	High	6 X r.c.w.	310.62
Mill River	M01D	2	51.77	Very High	6 X r.c.w.	310.62
Mill River	M01E	2	51.77	Moderate	4 X r.c.w.	207.08
Mill River	M02A	2	44.53	High	6 X r.c.w.	267.18
Mill River	M02B	2	44.53	High	6 X r.c.w.	267.18
Mill River	M03-	2	30.36	Very High	6 X r.c.w.	182.16
Mill River	M04A	2	29.71	Very High	6 X r.c.w.	178.26
Mill River	M04B	2	29.71	Moderate	4 X r.c.w.	118.84
Mill River	M05-	2	28.70	Very High	6 X r.c.w.	172.20
Mill River	M06A	2	26.67	Moderate	4 X r.c.w.	106.68
Mill River	M06B	2	26.67	High	6 X r.c.w.	160.02

Watershed	Reach\Segment ID	Option 1 or 2	Reference Channel Width (r.c.w.)	Sensitivity	Buffer Belt Width	Total FEH Corridor (feet)
Mill River	M2T2.5S2.01	1	5.79	NA	6 X r.c.w.	34.74
Mill River	M3S1.01	1	5.24	NA	6 X r.c.w.	31.44
Mill River	M5S1.01	1	5.32	NA	6 X r.c.w.	31.92
Mill River	M7S1.01	1	10.29	NA	6 X r.c.w.	61.74
Mill River	M7S2.01	1	10.38	NA	6 X r.c.w.	62.28
Mill River	M7S2.01A	2	10.38	Very High	6 X r.c.w.	62.28
Rugg Brook	M01-	2	28.93	High	6 X r.c.w.	173.58
Rugg Brook	M02-	2	28.71	High	6 X r.c.w.	172.26
Rugg Brook	M03-	2	28.46	High	6 X r.c.w.	170.76
Stonebridge Brook	M01	1	35.73	NA	6 X r.c.w.	214.38
Stonebridge Brook	M02	1	29.48	NA	6 X r.c.w.	176.88
Stonebridge Brook	M02A	2	29.48	Very High	6 X r.c.w.	176.88
Stonebridge Brook	M03	1	24.82	NA	6 X r.c.w.	148.92
Stonebridge Brook	M03B	2	24.82	High	6 X r.c.w.	148.92
Stonebridge Brook	M04-	2	13.35	High	6 X r.c.w.	80.10
Stonebridge Brook	M05-	2	11.71	Very High	6 X r.c.w.	70.26
Stonebridge Brook	M06A	2	9.17	High	6 X r.c.w.	55.02
Stonebridge Brook	M06B	2	9.17	Very High	6 X r.c.w.	55.02
Stonebridge Brook	M07	1	7.38	NA	6 X r.c.w.	44.28
Stonebridge Brook	M08	1	2.56	NA	6 X r.c.w.	15.36
Stonebridge Brook	M1S1.01	1	12.17	NA	6 X r.c.w.	73.02
Stonebridge Brook	M1S2.01	1	10.72	NA	6 X r.c.w.	64.32
Stonebridge Brook	M1S2.02	1	6.76	NA	6 X r.c.w.	40.56
Stonebridge Brook	M1S2.2S1.01	1	4.31	NA	6 X r.c.w.	25.86
Stonebridge Brook	M2S1.01	1	7.34	NA	6 X r.c.w.	44.04
Stonebridge Brook	M2S2.01	1	10.51	NA	6 X r.c.w.	63.06
Stonebridge Brook	M2S2.01	1	10.51	NA	6 X r.c.w.	63.06
Stonebridge Brook	M2S2.01B	2	10.51	Very High	6 X r.c.w.	63.06
Stonebridge Brook	M2S2.01C	2	10.51	Very High	6 X r.c.w.	63.06
Stonebridge Brook	M2S2.02	1	7.58	NA	6 X r.c.w.	45.48
Stonebridge Brook	M2S2.03	1	6.18	NA	6 X r.c.w.	37.08
Stonebridge Brook	M2S2.1S1.01	1	5.55	NA	6 X r.c.w.	33.30
Stonebridge Brook	M2S2.1S1.1S1.01	1	2.89	NA	6 X r.c.w.	17.34
Stonebridge Brook	M2S2.1S1.1S2.01	1	2.90	NA	6 X r.c.w.	17.40
Stonebridge Brook	M2S2.2S1.01	1	4.02	NA	6 X r.c.w.	24.12
Stonebridge Brook	M2S3.01	1	6.28	NA	6 X r.c.w.	37.68
Stonebridge Brook	M3S1.01	1	20.04	NA	6 X r.c.w.	120.24
Stonebridge Brook	M3S1.02	1	8.24	NA	6 X r.c.w.	49.44
Stonebridge Brook	M3S1.1S1.01	1	2.34	NA	6 X r.c.w.	14.04
Stonebridge Brook	M3S1.1S2.01	1	5.84	NA	6 X r.c.w.	35.04
Stonebridge Brook	M3S1.1S3.01	1	16.11	NA	6 X r.c.w.	96.66
Stonebridge Brook	M3S1.1S3.02	1	16.06	NA	6 X r.c.w.	96.36
Stonebridge Brook	M3S1.1S3.03	1	14.99	NA	6 X r.c.w.	89.94
Stonebridge Brook	M3S1.1S3.2S1.01	1	4.33	NA	6 X r.c.w.	25.98
Stonebridge Brook	M3S1.2S1.01	1	5.56	NA	6 X r.c.w.	33.36
Stonebridge Brook	M3S1.2S1.1S1.01	1	3.96	NA	6 X r.c.w.	23.76
Stonebridge Brook	M3S1.2S2.01	1	2.58	NA	6 X r.c.w.	15.48

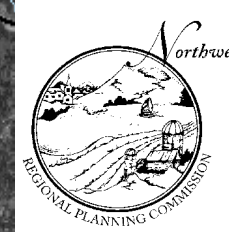
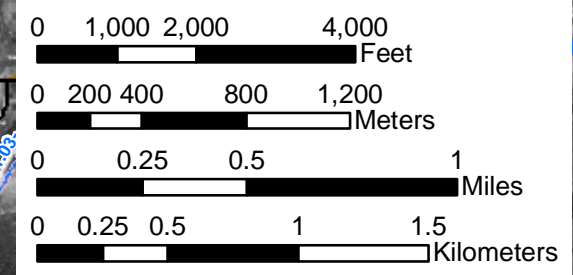
**Town of Highgate
Fluvial Erosion Hazard (FEH) Zones- Draft
Missisquoi- Black Creek to Hungerford Brook Watershed**



FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collected by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant.

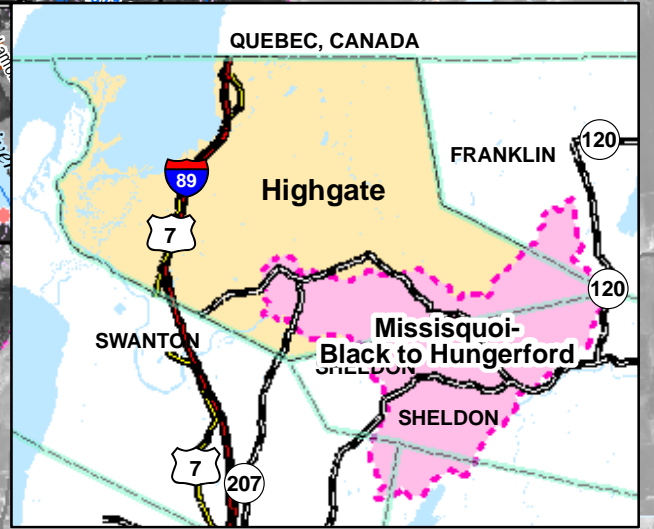
Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.

● Reach Breaks	Railroad
▲ Segment Breaks	--- Inactive Railroad
--- Watershed Boundary	--- Active Railroad
Stream Center Line-	--- Municipal Boundary
--- Has Phase 1 or 2 Assessment	Fluvial Erosion Hazard (FEH) Rating
--- No Phase 1 or 2 Assessment	Extreme Sensitivity (buffer 6 reference channel widths)
--- Lake or Pond	Very High Sensitivity (buffer 6 reference channel widths)
Roads	High Sensitivity (buffer 6 reference channel widths)
--- Class 1-3 Town Highway	Moderate Sensitivity (buffer 4 reference channel widths)
--- Class 4 Town Highway	Low (corridor equal to reference channel widths)
--- State Highway	Very Low (corridor equal to reference channel widths)
--- Federal Highway	--- No Phase 2- default buffer of 6 reference channel widths
--- Interstate Highway	Highgate Parcels (white line)

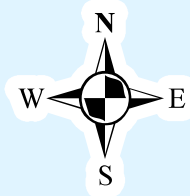


Map Prepared By:
Northwest NRPC
155 Lake Street
Saint Albans, VT 05478
802.524.5958
www.nrpcvt.com

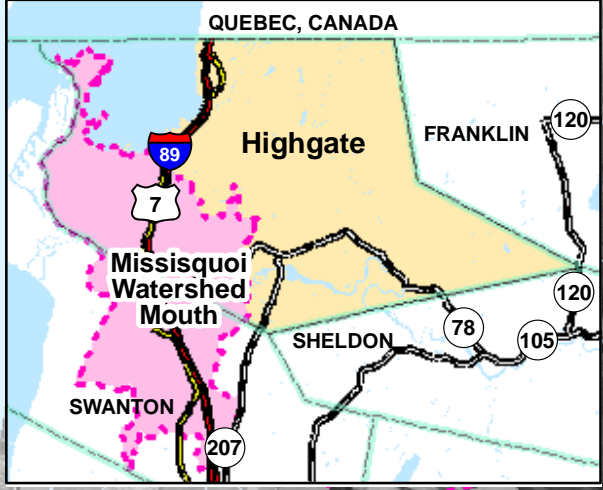
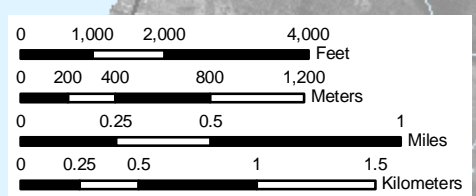
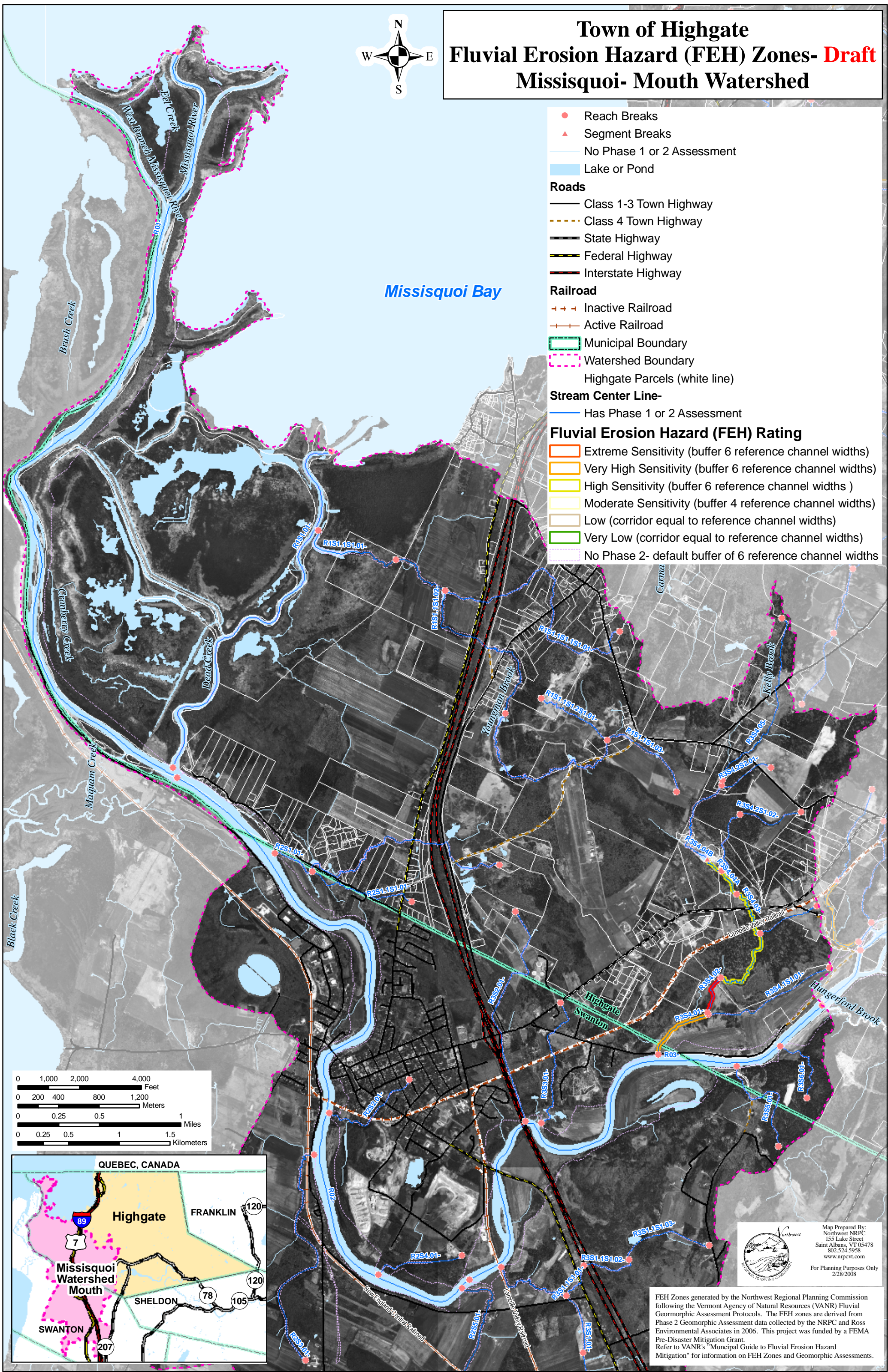
For Planning Purposes Only
2/28/2008



Town of Highgate Fluvial Erosion Hazard (FEH) Zones- **Draft** Missisquoi- Mouth Watershed



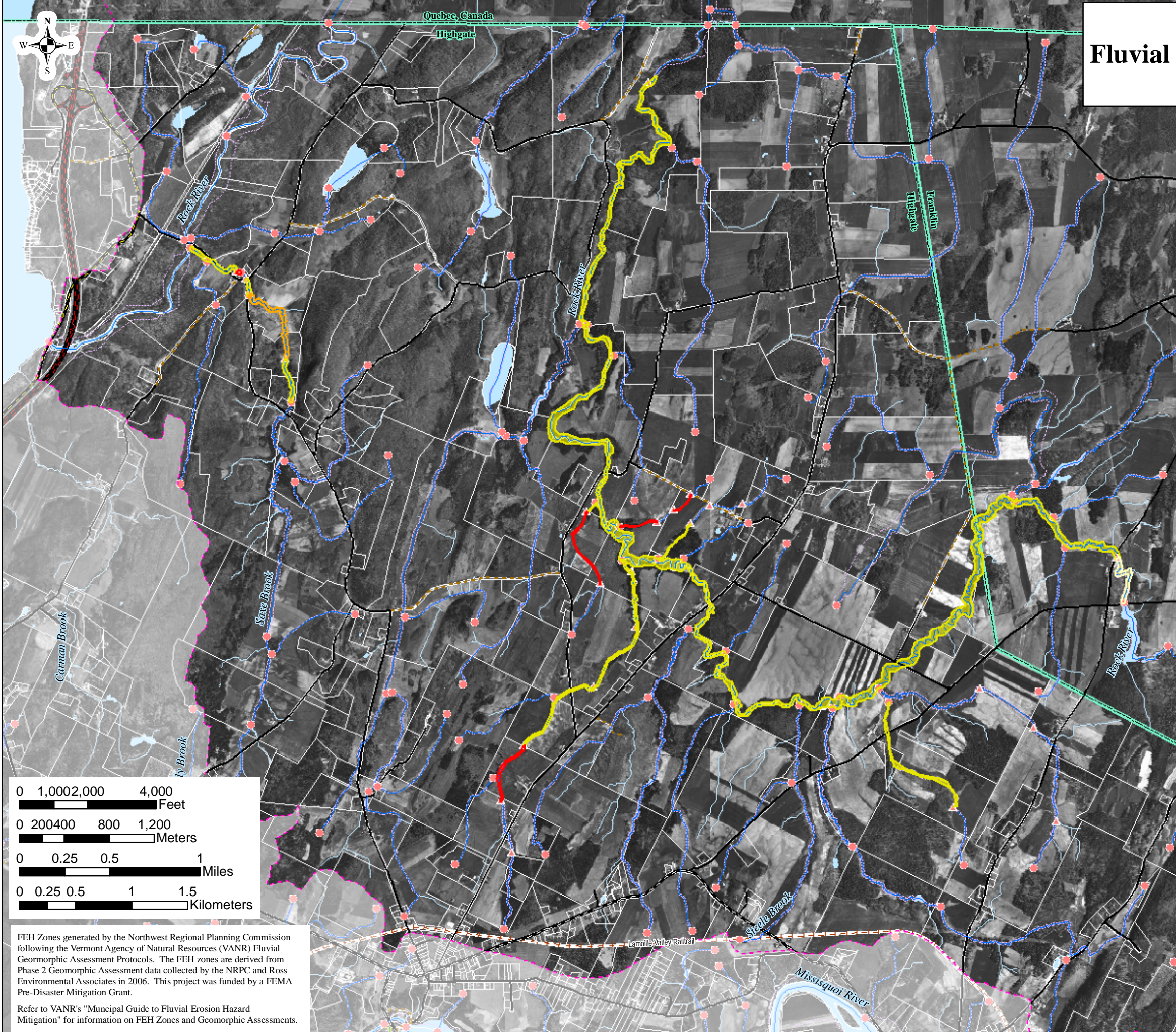
- Reach Breaks
- ▲ Segment Breaks
- No Phase 1 or 2 Assessment
- Lake or Pond
- Roads**
- Class 1-3 Town Highway
- - - Class 4 Town Highway
- == State Highway
- == Federal Highway
- == Interstate Highway
- Railroad**
- - - Inactive Railroad
- - - Active Railroad
- ▭ Municipal Boundary
- ▭ Watershed Boundary
- ▭ Highgate Parcels (white line)
- Stream Center Line-**
- Has Phase 1 or 2 Assessment
- Fluvial Erosion Hazard (FEH) Rating**
- Extreme Sensitivity (buffer 6 reference channel widths)
- Very High Sensitivity (buffer 6 reference channel widths)
- High Sensitivity (buffer 6 reference channel widths)
- Moderate Sensitivity (buffer 4 reference channel widths)
- Low (corridor equal to reference channel widths)
- Very Low (corridor equal to reference channel widths)
- ▭ No Phase 2- default buffer of 6 reference channel widths



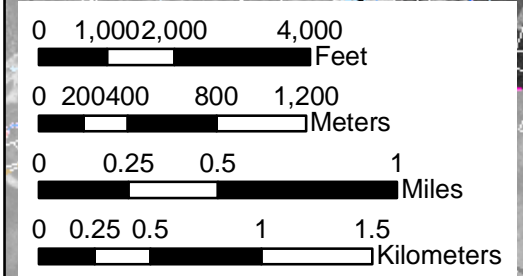
Map Prepared By:
 Northwest NRPC
 155 Lake Street
 Saint Albans, VT 05478
 802.524.5958
 www.nrpcvt.com
 For Planning Purposes Only
 2/28/2008

FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collected by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant. Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.

Town of Highgate Fluvial Erosion Hazard (FEH) Zones- **Draft** Rock Watershed



- Reach Breaks
- ▲ Segment Breaks
- Stream Center Line-**
 - Has Phase 1 or 2 Assessment
 - No Phase 1 or 2 Assessment
- Lake or Pond
- Roads**
 - Class 1-3 Town Highway
 - - - Class 4 Town Highway
 - State Highway
 - Federal Highway
 - Interstate Highway
- Railroad**
 - - - Inactive Railroad
 - Active Railroad
- Municipal Boundary
- Watershed Boundary
- Highgate Parcels (white line)
- Fluvial Erosion Hazard (FEH) Rating**
 - Extreme Sensitivity (buffer 6 reference channel widths)
 - Very High Sensitivity (buffer 6 reference channel widths)
 - High Sensitivity (buffer 6 reference channel widths)
 - Moderate Sensitivity (buffer 4 reference channel widths)
 - Low (corridor equal to reference channel widths)
 - Very Low (corridor equal to reference channel widths)
 - No Phase 2- default buffer of 6 reference channel widths

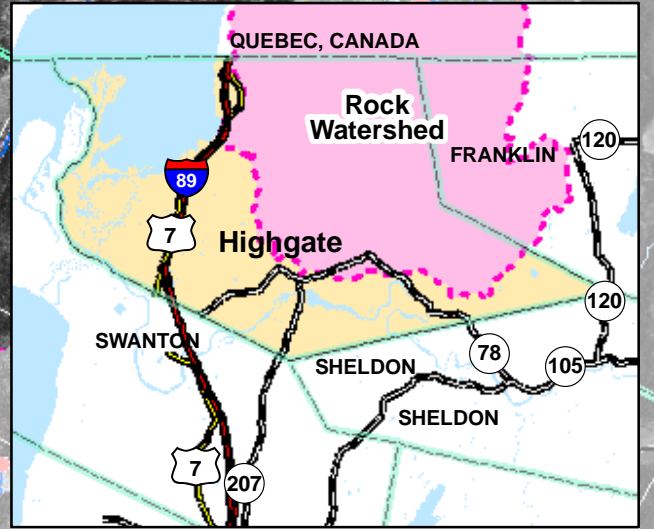


FEH Zones generated by the Northwest Regional Planning Commission following the Vermont Agency of Natural Resources (VANR) Fluvial Geomorphic Assessment Protocols. The FEH zones are derived from Phase 2 Geomorphic Assessment data collected by the NRPC and Ross Environmental Associates in 2006. This project was funded by a FEMA Pre-Disaster Mitigation Grant.

Refer to VANR's "Municipal Guide to Fluvial Erosion Hazard Mitigation" for information on FEH Zones and Geomorphic Assessments.

Map Prepared By:
Northwest NRPC
155 Lake Street
Saint Albans, VT 05478
802.524.5958
www.nrpcvt.com

For Planning Purposes Only
2/28/2008



Town of Highgate- FEH Corridor Widths by Reach

Watershed	Reach\Segment	Option	Reference Channel Width (r.c.w.)	Sensitivity	Buffer Belt Width	Total FEH Corridor (feet)
	ID	1 or 2				
Missisquoi- Black to Hungerford	R04	1	291.02	NA	6 X r.c.w.	1746.12
Missisquoi- Black to Hungerford	R05	1	290.71	NA	6 X r.c.w.	1744.26
Missisquoi- Black to Hungerford	R06	1	290.14	NA	6 X r.c.w.	1740.84
Missisquoi- Black to Hungerford	R07	1	289.29	NA	6 X r.c.w.	1735.74
Missisquoi- Black to Hungerford	R08	1	288.33	NA	6 X r.c.w.	1729.98
Missisquoi- Black to Hungerford	R4S1.01	1	7.91	NA	6 X r.c.w.	47.46
Missisquoi- Black to Hungerford	R4S1.02	1	5.61	NA	6 X r.c.w.	33.66
Missisquoi- Black to Hungerford	R4S1.03	1	3.82	NA	6 X r.c.w.	22.92
Missisquoi- Black to Hungerford	R4S1.1S1.01	1	5.44	NA	6 X r.c.w.	32.64
Missisquoi- Black to Hungerford	R4S1.1S1.01A	2	5.44	Very High	6 X r.c.w.	32.64
Missisquoi- Black to Hungerford	R4S2.01	1	4.08	NA	6 X r.c.w.	24.48
Missisquoi- Black to Hungerford	R4S2.02	1	3.10	NA	6 X r.c.w.	18.60
Missisquoi- Black to Hungerford	R4S3.01	1	6.49	NA	6 X r.c.w.	38.94
Missisquoi- Black to Hungerford	R4S3.01A	2	6.49	High	6 X r.c.w.	38.94
Missisquoi- Black to Hungerford	R4S3.01B	2	6.49	Very High	6 X r.c.w.	38.94
Missisquoi- Black to Hungerford	R5S1.01	1	3.85	NA	6 X r.c.w.	23.10
Missisquoi- Black to Hungerford	R5S2.01	1	3.74	NA	6 X r.c.w.	22.44
Missisquoi- Black to Hungerford	R5S3.01	1	4.74	NA	6 X r.c.w.	28.44
Missisquoi- Black to Hungerford	R5S4.01	1	3.68	NA	6 X r.c.w.	22.08
Missisquoi- Black to Hungerford	R5S5.01	1	3.22	NA	6 X r.c.w.	19.32
Missisquoi- Black to Hungerford	R5S6.01	1	3.02	NA	6 X r.c.w.	18.12
Missisquoi- Black to Hungerford	R5S6.02	1	2.73	NA	6 X r.c.w.	16.38
Missisquoi- Black to Hungerford	R5S7.01	1	9.15	NA	6 X r.c.w.	54.90
Missisquoi- Black to Hungerford	R5S7.02	1	4.19	NA	6 X r.c.w.	25.14
Missisquoi- Black to Hungerford	R5S8.01	1	5.15	NA	6 X r.c.w.	30.90
Missisquoi- Black to Hungerford	R5S8.02	1	4.26	NA	6 X r.c.w.	25.56
Missisquoi- Black to Hungerford	R5S9.01	1	2.76	NA	6 X r.c.w.	16.56
Missisquoi- Black to Hungerford	R5S9.02	1	2.21	NA	6 X r.c.w.	13.26
Missisquoi- Black to Hungerford	R6S1.01	1	3.79	NA	6 X r.c.w.	22.74
Missisquoi- Black to Hungerford	R6S2.01	1	5.45	NA	6 X r.c.w.	32.70
Missisquoi- Black to Hungerford	R6S3.01	1	3.87	NA	6 X r.c.w.	23.22
Missisquoi- Black to Hungerford	R6S4.01	1	16.78	NA	6 X r.c.w.	100.68
Missisquoi- Black to Hungerford	R6S4.02	1	13.20	NA	6 X r.c.w.	79.20
Missisquoi- Black to Hungerford	R6S4.03	1	7.45	NA	6 X r.c.w.	44.70
Missisquoi- Black to Hungerford	R6S4.1S1.01	1	6.62	NA	6 X r.c.w.	39.72
Missisquoi- Black to Hungerford	R6S4.1S1.02	1	4.87	NA	6 X r.c.w.	29.22
Missisquoi- Black to Hungerford	R6S4.2S1.01	1	7.01	NA	6 X r.c.w.	42.06
Missisquoi- Black to Hungerford	R7S1.01	1	12.07	NA	6 X r.c.w.	72.42
Missisquoi- Black to Hungerford	R7S1.02	1	11.98	NA	6 X r.c.w.	71.88
Missisquoi- Black to Hungerford	R7S1.03	1	6.18	NA	6 X r.c.w.	37.08
Missisquoi- Black to Hungerford	R7S1.2S1.01	1	4.10	NA	6 X r.c.w.	24.60
Missisquoi- Black to Hungerford	R7S1.2S2.01	1	4.87	NA	6 X r.c.w.	29.22
Missisquoi- Black to Hungerford	R7S2.01	1	17.57	NA	6 X r.c.w.	105.42
Missisquoi- Black to Hungerford	R7S2.02	1	13.34	NA	6 X r.c.w.	80.04
Missisquoi- Black to Hungerford	R7S2.03	1	10.05	NA	6 X r.c.w.	60.30
Missisquoi- Black to Hungerford	R7S2.04	1	6.36	NA	6 X r.c.w.	38.16

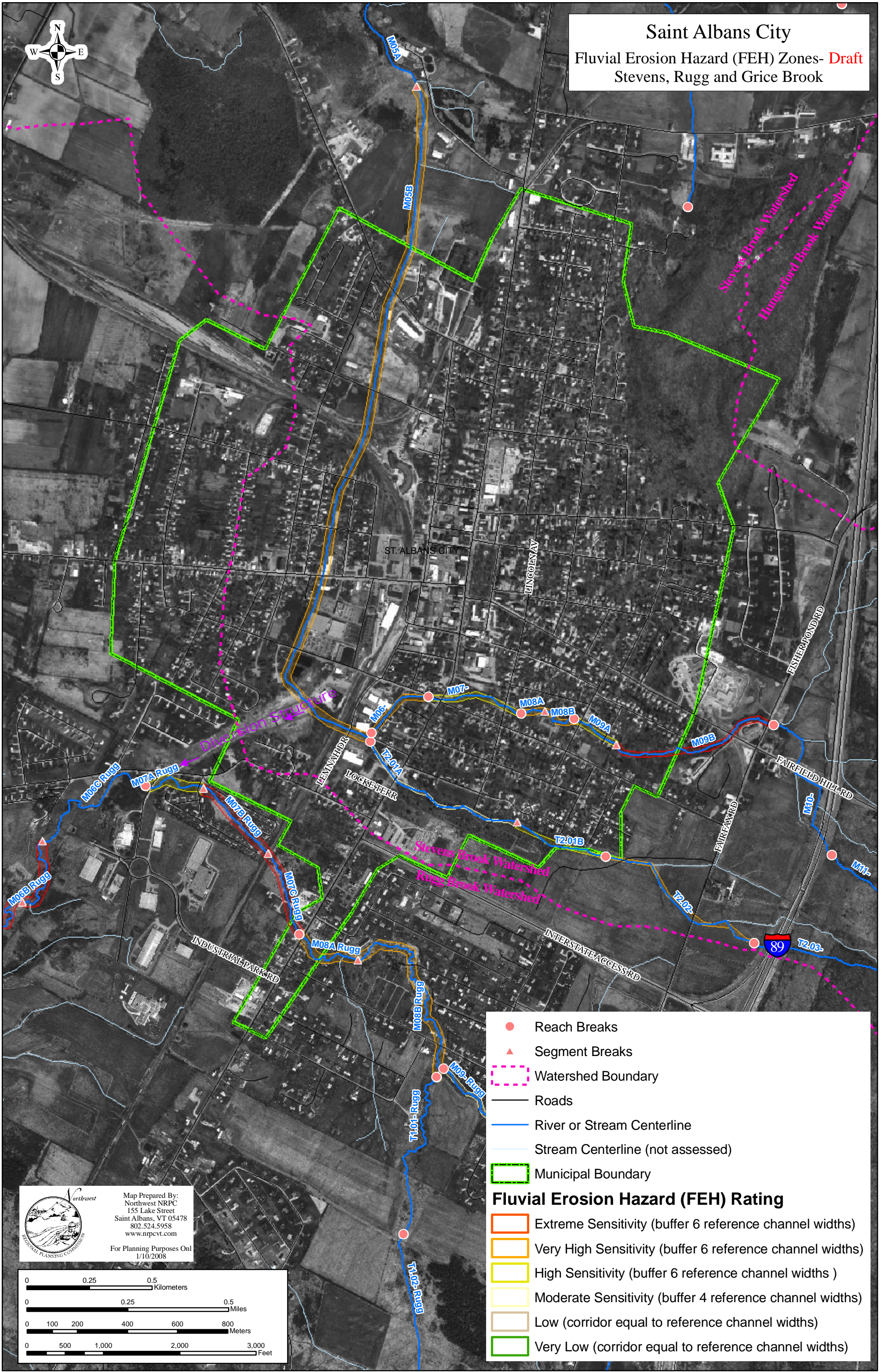
Watershed	Reach\Segment ID	Option 1 or 2	Reference Channel Width (r.c.w.)	Sensitivity	Buffer Belt Width	Total FEH Corridor (feet)
Missisquoi- Mouth	R3S1.02	1	7.72	NA	6 X r.c.w.	46.32
Missisquoi- Mouth	R3S1.02	1	7.72	NA	6 X r.c.w.	46.32
Missisquoi- Mouth	R3S1.1S1.01	1	5.98	NA	6 X r.c.w.	35.88
Missisquoi- Mouth	R3S1.1S1.02	1	5.50	NA	6 X r.c.w.	33.00
Missisquoi- Mouth	R3S1.1S1.03	1	4.92	NA	6 X r.c.w.	29.52
Missisquoi- Mouth	R3S2.01	1	7.11	NA	6 X r.c.w.	42.66
Missisquoi- Mouth	R3S3.01	1	4.70	NA	6 X r.c.w.	28.20
Missisquoi- Mouth	R3S4.01	1	15.34	NA	6 X r.c.w.	92.04
Missisquoi- Mouth	R3S4.01-	2	15.34	Very High	6 X r.c.w.	92.04
Missisquoi- Mouth	R3S4.02	1	13.25	NA	6 X r.c.w.	79.50
Missisquoi- Mouth	R3S4.02-	2	13.25	Extreme	6 X r.c.w.	79.50
Missisquoi- Mouth	R3S4.03	1	13.04	NA	6 X r.c.w.	78.24
Missisquoi- Mouth	R3S4.03-	2	13.04	High	6 X r.c.w.	78.24
Missisquoi- Mouth	R3S4.04	1	11.60	NA	6 X r.c.w.	69.60
Missisquoi- Mouth	R3S4.04A	2	11.60	High	6 X r.c.w.	69.60
Missisquoi- Mouth	R3S4.05	1	6.50	NA	6 X r.c.w.	39.00
Missisquoi- Mouth	R3S4.1S1.01	1	4.94	NA	6 X r.c.w.	29.64
Missisquoi- Mouth	R3S4.1S1.03	1	2.40	NA	6 X r.c.w.	14.40
Missisquoi- Mouth	R3S4.2S1.01	1	4.44	NA	6 X r.c.w.	26.64
Missisquoi- Mouth	R3S4.2S1.02	1	3.28	NA	6 X r.c.w.	19.68
Missisquoi- Mouth	R3S4.2S2.01	1	4.48	NA	6 X r.c.w.	26.88
Missisquoi- Mouth	R3S5.01	1	4.95	NA	6 X r.c.w.	29.70
Missisquoi- Mouth	R3S6.01	1	3.52	NA	6 X r.c.w.	21.12
Rock	M01	1	76.46	NA	6 X r.c.w.	458.76
Rock	M02	1	73.06	NA	6 X r.c.w.	438.36
Rock	M03	1	72.52	NA	6 X r.c.w.	435.12
Rock	M04	1	50.53	NA	6 X r.c.w.	303.18
Rock	M04B	2	50.53	High	6 X r.c.w.	303.18
Rock	M05	1	45.07	NA	6 X r.c.w.	270.42
Rock	M05-	2	45.07	High	6 X r.c.w.	270.42
Rock	M06	1	36.58	NA	6 X r.c.w.	219.48
Rock	M06-	2	36.58	High	6 X r.c.w.	219.48
Rock	M07	1	25.84	NA	6 X r.c.w.	155.04
Rock	M07A	2	25.84	High	6 X r.c.w.	155.04
Rock	M07B	2	25.84	Moderate	4 X r.c.w.	103.36
Rock	M08	1	23.64	NA	6 X r.c.w.	141.84
Rock	M09	1	22.85	NA	6 X r.c.w.	137.10
Rock	M09C	2	22.85	High	6 X r.c.w.	137.10
Rock	M09D	2	22.85	High	6 X r.c.w.	137.10
Rock	M09F	2	22.85	High	6 X r.c.w.	137.10
Rock	M10	1	13.78	NA	6 X r.c.w.	82.68
Rock	M10-	2	13.78	High	6 X r.c.w.	82.68
Rock	M11	1	11.24	NA	6 X r.c.w.	67.44
Rock	M1S1.01	1	17.22	NA	6 X r.c.w.	103.32
Rock	M1S1.01A	2	17.22	High	6 X r.c.w.	103.32
Rock	M1S1.01B	2	17.22	Extreme	6 X r.c.w.	103.32
Rock	M1S1.02	1	16.54	NA	6 X r.c.w.	99.24
Rock	M1S1.02B	2	16.54	High	6 X r.c.w.	99.24

Watershed	Reach/Segment ID	Option 1 or 2	Reference Channel Width (r.c.w.)	Sensitivity	Buffer Belt Width	Total FEH Corridor (feet)
Rock	M5S11.02	1	10.38	NA	6 X r.c.w.	62.28
Rock	M5S11.03	1	8.87	NA	6 X r.c.w.	53.22
Rock	M5S11.3S1.01	1	3.82	NA	6 X r.c.w.	22.92
Rock	M5S2.01	1	6.01	NA	6 X r.c.w.	36.06
Rock	M5S2.01A	2	6.01	High	6 X r.c.w.	36.06
Rock	M5S2.01B	2	6.01	Extreme	6 X r.c.w.	36.06
Rock	M5S3.01	1	3.90	NA	6 X r.c.w.	23.40
Rock	M5S3.01A	2	3.90	Extreme	6 X r.c.w.	23.40
Rock	M5S3.01C	2	3.90	Extreme	6 X r.c.w.	23.40
Rock	M5S4.01	1	10.14	NA	6 X r.c.w.	60.84
Rock	M5S4.01A	2	10.14	High	6 X r.c.w.	60.84
Rock	M5S4.01B	2	10.14	High	6 X r.c.w.	60.84
Rock	M5S4.01C	2	10.14	High	6 X r.c.w.	60.84
Rock	M5S4.01D	2	10.14	High	6 X r.c.w.	60.84
Rock	M5S4.01E	2	10.14	Extreme	6 X r.c.w.	60.84
Rock	M5S4.1S1.01	1	3.53	NA	6 X r.c.w.	21.18
Rock	M5S4.1S2.01	1	3.82	NA	6 X r.c.w.	22.92
Rock	M5S5.01	1	4.62	NA	6 X r.c.w.	27.72
Rock	M5S5.01A	2	4.62	High	6 X r.c.w.	27.72
Rock	M5S6.01	1	3.05	NA	6 X r.c.w.	18.30
Rock	M5S7.01	1	10.54	NA	6 X r.c.w.	63.24
Rock	M5S7.1S1.01	1	7.75	NA	6 X r.c.w.	46.50
Rock	M5S8.01	1	3.35	NA	6 X r.c.w.	20.10
Rock	M5S9.01	1	6.23	NA	6 X r.c.w.	37.38
Rock	M6S1.01	1	12.56	NA	6 X r.c.w.	75.36
Rock	M6S1.1S1.01	1	6.65	NA	6 X r.c.w.	39.90
Rock	M6S1.1S1.01A	2	6.65	High	6 X r.c.w.	39.90
Rock	M6S2.01	1	20.65	NA	6 X r.c.w.	123.90
Rock	M6S2.1S1.01	1	10.21	NA	6 X r.c.w.	61.26
Rock	M6S2.1S2.01	1	12.08	NA	6 X r.c.w.	72.48
Rock	M6S2.1S2.1S1.01	1	8.27	NA	6 X r.c.w.	49.62
Rock	M6S2.1S3.01	1	8.36	NA	6 X r.c.w.	50.16
Rock	M7S1.01	1	5.38	NA	6 X r.c.w.	32.28
Rock	M7S2.01	1	6.82	NA	6 X r.c.w.	40.92
Rock	M9S1.01	1	7.14	NA	6 X r.c.w.	42.84
Rock	M9S2.01	1	4.45	NA	6 X r.c.w.	26.70
Rock	M9S3.01	1	7.02	NA	6 X r.c.w.	42.12
Rock	M9S3.02	1	3.63	NA	6 X r.c.w.	21.78
Rock	M9S4.01	1	6.89	NA	6 X r.c.w.	41.34

Saint Albans City

Fluvial Erosion Hazard (FEH) Zones- Draft

Stevens, Rugg and Grice Brook

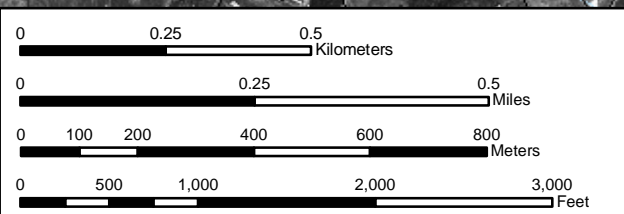


- Reach Breaks
- ▲ Segment Breaks
- Watershed Boundary
- Roads
- River or Stream Centerline
- Stream Centerline (not assessed)
- Municipal Boundary

Fluvial Erosion Hazard (FEH) Rating

- Extreme Sensitivity (buffer 6 reference channel widths)
- Very High Sensitivity (buffer 6 reference channel widths)
- High Sensitivity (buffer 6 reference channel widths)
- Moderate Sensitivity (buffer 4 reference channel widths)
- Low (corridor equal to reference channel widths)
- Very Low (corridor equal to reference channel widths)

Map Prepared By:
 Northwest NRPC
 155 Lake Street
 Saint Albans, VT 05478
 802.524.5958
 www.nrpcvt.com
 For Planning Purposes Only
 1/10/2008



Saint Albans City- FEH Corridor Widths by Reach

Watershed	Reach/Segment ID	Option	Reference	Sensitivity	Buffer Belt Width	Total FEH Corridor (feet)
		1 or 2	Channel Width (r.c.w.)			
Rugg Brook	M02	1	28.71	NA	6 X r.c.w.	172.26
Rugg Brook	M02C	2	38.57	Very High	6 X r.c.w.	231.42
Rugg Brook	M03	1	28.46	NA	6 X r.c.w.	170.76
Rugg Brook	M04	1	27.29	NA	6 X r.c.w.	163.74
Rugg Brook	M05	1	24.81	NA	6 X r.c.w.	148.86
Rugg Brook	M05A	2	24.81	Very High	6 X r.c.w.	148.86
Rugg Brook	M05B	2	20.65	Very High	6 X r.c.w.	123.9
Rugg Brook	M05B	2	24.81	Very High	6 X r.c.w.	148.86
Rugg Brook	M06	1	21.51	NA	6 X r.c.w.	129.06
Rugg Brook	M06-	2	12.86	Very High	6 X r.c.w.	77.16
Rugg Brook	M06-	2	12.86	Very High	6 X r.c.w.	77.16
Rugg Brook	M07	1	20.75	NA	6 X r.c.w.	124.5
Rugg Brook	M08	1	19.98	NA	6 X r.c.w.	119.88
Rugg Brook	M08A	2	12.38	Very High	6 X r.c.w.	74.28
Rugg Brook	M08A	2	12.38	Very High	6 X r.c.w.	74.28
Rugg Brook	M08A	2	19.98	Very High	6 X r.c.w.	119.88
Rugg Brook	M08B	2	12.38	Very High	6 X r.c.w.	74.28
Rugg Brook	M08B	2	19.98	Very High	6 X r.c.w.	119.88
Rugg Brook	M09	1	15.35	NA	6 X r.c.w.	92.1
Rugg Brook	M10	1	15.12	NA	6 X r.c.w.	90.72
Rugg Brook	M11	1	11.01	NA	6 X r.c.w.	66.06
Rugg Brook	T1.01	1	11.52	NA	6 X r.c.w.	69.12
Rugg Brook	T1.02	1	11.02	NA	6 X r.c.w.	66.12
Rugg Brook	T1.03	1	4.94	NA	6 X r.c.w.	29.64
Rugg Brook	T2.02-	2	6.64	Very High	6 X r.c.w.	39.84
Rugg Brook	T2.02-	2	6.64	Very High	6 X r.c.w.	39.84
Stevens Brook	M01	1	28.93	NA	6 X r.c.w.	173.58
Stevens Brook	M01-	2	28.93	High	6 X r.c.w.	173.58
Stevens Brook	M01-	1	39.04	NA	6 X r.c.w.	234.24
Stevens Brook	M02-	2	28.71	High	6 X r.c.w.	172.26
Stevens Brook	M02A	1	38.57	NA	6 X r.c.w.	231.42
Stevens Brook	M02B	2	38.57	Very High	6 X r.c.w.	231.42
Stevens Brook	M03-	2	28.46	High	6 X r.c.w.	170.76
Stevens Brook	M03A	2	26.78	Moderate	4 X r.c.w.	107.12
Stevens Brook	M03A	2	26.78	Moderate	4 X r.c.w.	107.12
Stevens Brook	M03B	2	26.78	High	6 X r.c.w.	160.68
Stevens Brook	M04-	2	21.29	Moderate	4 X r.c.w.	85.16
Stevens Brook	M04-	2	21.29	Moderate	4 X r.c.w.	85.16
Stevens Brook	M05A	1	20.65	NA	6 X r.c.w.	123.9
Stevens Brook	M06A	2	21.51	Extreme	6 X r.c.w.	129.06
Stevens Brook	M06B	2	21.51	Extreme	6 X r.c.w.	129.06
Stevens Brook	M07-	2	12.67	High	6 X r.c.w.	76.02
Stevens Brook	M07-	2	12.67	High	6 X r.c.w.	76.02
Stevens Brook	M07A	2	20.75	High	6 X r.c.w.	124.5
Stevens Brook	M07B	2	20.75	Extreme	6 X r.c.w.	124.5
Stevens Brook	M07C	2	20.75	Extreme	6 X r.c.w.	124.5