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Phase 2 Stream Geomorphic Assessment
Winooski River Watershed
Town of Cabot
Washington County, Vermont

Draft Report
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EXECUTIVE SUMMARY

- The Cabot Conservation Committee retained Bear Creek Environmental to perform a Phase 2 Geomorphic Assessment of seven reaches on the Upper Winooski River Watershed in the Town of Cabot.

- The Phase 2 study focused on stream reaches on the main stem of the Winooski River within the Town of Cabot from the Cabot/Marshfield town line, upstream to above the Village of Cabot.

- Volunteers from the Cabot Conservation Committee and students form the Cabot school assisted with the fieldwork.

- Protocols outlined in the Agency of Natural Resources, Stream Geomorphic Assessment, Phase 2 Handbook were employed. The Phase 2 data were entered into the most current version of the Phase 2 database.

- ArcView shapefiles were constructed from the mapped field data for major parameters such as: bank erosion, grade control structures, bank revetments, beaver dams, debris jams, and depositional features.

- The Phase 1 geomorphic condition is compared to the Phase 2 geomorphic condition in this report. The Phase 1 geomorphic condition ranged from poor, for the lowest 2 reaches assessed, to fair for the other five reaches. Nine of the segments assessed for the Phase 2 study resulted in a geomorphic condition of fair. Two segments resulted in a geomorphic condition of poor, and one segment was good.

- The Phase 2 Rapid Geomorphic Assessment (RGA) was used to evaluate the stage of channel evolution. Most of the segments assessed were found to be in stage 3 of the Schumm Evolution model. These reaches were found to be in fair to poor condition, had undergone historical channel degradation, and were currently undergoing major to minor channel adjustments (e.g. channel widening, lateral migration, and aggradation). During stage 3, rivers typically exhibit significant bank failure. The Phase 2 assessment confirmed bank erosion is high within much of the mainstem.

- In general, the Rapid Habitat Assessment (RHA) rating was similar to the RGA. Nine of twelve segments resulted in a rating of fair for both the RHA and the RGA.

- A high percentage of the Phase 2 segments assessed during 2004 appear to be E channels. This channel type is highly sensitive to change and is dependent upon vegetation for stability. For this reason, the acquisition of easements, streamside plantings, and buffer protection should be a high priority for restoration planning and design work.

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1.0 INTRODUCTION

A phase 1 stream geomorphic assessment was completed during early summer 2004 by Bear Creek Environmental and the Cabot Conservation Committee. The results of the Phase 1 assessment are provided in Bear Creek Environmental (2004). Recommendations were made in the Phase 1 report for reaches to assess during the Phase 2 study. The fieldwork for the Phase 2 assessment was completed during August 2004. A number of volunteers from the Cabot Conservation Committee and the Cabot school assisted Bear Creek Environmental with the Phase 2 study. Gary Gulka and Chris Duff, members of the Cabot Conservation Committee, worked to acquire landowner permission. Calvin Alexander, Molly Pitkin, and Brittany Haworth, students at the Cabot School; Charlie Wanzer, Science Teacher at the Cabot School; and Gary Gulka and Peg Elmer of the Cabot Conservation Committee provided valuable assistance with the fieldwork. Mary Nealon of Bear Creek Environmental was the Field Task Leader for the project.

The Winooski River Watershed has a watershed size of 24.5 square miles just above the confluence of Molly Falls Brook in Marshfield, just south of the Cabot/Marshfield Town lines. The Phase 2 study focused on stream reaches on the main stem of the Winooski River within the Town of Cabot from the Cabot/Marshfield town line upstream to above the Village of

Cabot (Reaches M02 through M07). The combined length of the stream reaches assessed is approximately 6 miles. A reach location map is included below for reference.

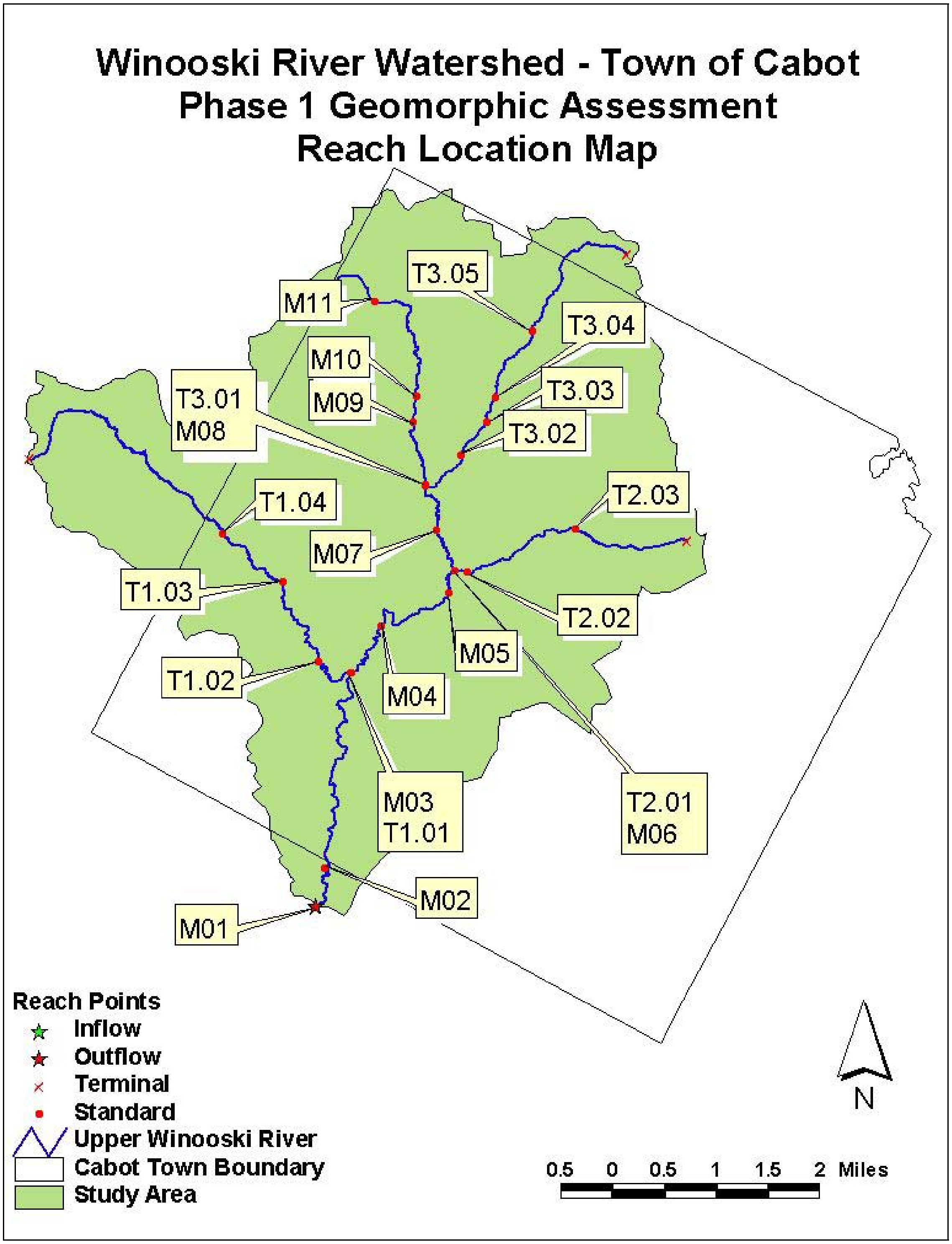

Figure 1. Reach Location Map

2.0 METHODOLOGY

The Phase 2 assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase 2 (Vermont Agency of Natural Resources 2004). All assessment data were recorded on the Agency of Natural Resources (ANR) Phase 2 data sheets, and were entered in to the most current version (version 4) of the ANR Phase I _2 database. The Phase 1 database was updated using the field data from the Phase 2 assessment.

2.1 Field Protocols

The ANR's Phase 2 stream geomorphic assessment protocol includes seven steps. These steps are as follows:

1. Valley and River Corridor
2. Stream Channel
3. Riparian Banks, Buffers and Corridor
4. Flow Modifiers
5. Channel, Bed and Planform Changes
6. Rapid Habitat Assessment (RHA)
7. Rapid Geomorphic Assessment (RGA)

The parameters and protocols used for undertaking each of the above steps are outlined in the Phase 2 Handbook (ANR 2004). The entire length of each Phase 2 reach was walked to determine segment breaks. Only segments characterized as unconfined were included in the full Phase 2 assessment. Bank erosion, grade control structures, bank revetments, beaver dams, debris jams, depositional features, and other important features were mapped within all segments regardless of the confinement. Phase 2 field sheets were not completed for the confined segments.

2.2 QA Review

The Phase 2 – Quality Assurance Worksheet was completed by Bear Creek Environmental to document the tools used to collect the Phase 2 data, the confidence level in the data, the date the assessment was completed, and the date each Phase 2 step was checked by the local and state QA teams. The Microsoft Access Phase 2 database and the ArcView Shapefiles for the Winooski River Phase 2 study were submitted to Shayne Jaquith of the ANR for a QA review in November 2004. A sample QA report is provided on page 1 of Appendix B.

2.3 Reach Locations

As described in the Phase 1 Final Report (Bear Creek Environmental dated November 2, 2004), the stream reaches M02 through M07 were recommended by Bear Creek Environmental for inclusion in the Phase 2 study. With the exception of Reach M04, all the reaches were identified as unconfined, riffle-pool systems in the Phase 1 study. Reach M04 was characterized as a semi confined, plane bed system based on the Phase 1 results and windshield survey. The reach condition from the Phase 1 study for the proposed Phase 2 Assessment reaches range from poor to fair, as shown below in Table 1.

Table 1. Reaches Recommended for Phase 2 Assessment

Reach No.	Channel Length (Miles)	Confinement Type	Channel Slope	Stream Type/ Bed form	Reach Condition
M02	2.6	3-VB	0.40	C5 Riffle-pool	Poor
M03	0.8	3-VB	0.23	C4 Riffle-pool	Poor
M04	1.1	1-SC	1.87	B3 Plane Bed	Fair
M05	0.3	3-VB	0.56	C4 Riffle-pool	Fair
M06	0.6	3-VB	1.03	C4 Riffle-pool	Fair
M07	0.6	3-VB	0.96	C4 Riffle-pool	Fair

2.0 BANKFULL DISCHARGE – CHANNEL DIMENSIONS

Measurements of channel dimensions were made using a depth rod, a cam line, and a hand level at one cross over (riffle) location within each segment. The cross section data was entered in the Vermont Agency of Natural Resources, Phase 3 Stream Geomorphic Assessment

Spreadsheet. Graphs of the cross sections are provided on pages 1 through 12 of Appendix A, and the stream geometry data are summarized on page 13 of Appendix A.

The cross-sectional area calculated from the field measurements was compared to the Vermont Regional Hydraulic Geometry Curves (Vermont Water Quality Division, 2001). Of the twelve locations, seven of the cross sections had a cross-sectional area which was approximately 70 percent of the value predicted from the regional curves. Three of the cross sections had cross sectional areas which matched the regional curves, and two of the cross sections were approximately 55 percent of the predicted value. This inconsistency in bankfull cross-sectional area is likely attributed to the difficulty in finding reliable bankfull indicators due to the considerable amount of bank erosion noted in almost all the segments. The least amount of bank erosion and the best bankfull indicators were found in segments M04-A and M04-B. Given the majority of the segments had measured bankfull cross-sectional areas that were approximately 70 percent of the regional curves, a decision was made to adjust the bankfull cross-sectional areas of the other cross sections. This was accomplished by increasing or decreasing the bankfull depth. A comparison of measured and predicted cross sectional area is found in Table 2. Because the width to depth ratio was so low on all the cross section, this correction had very little impact on the bankfull width.

Table 2. Comparison of Measured and Predicted Bankfull Cross-sectional Area

Segment Number	Measured Bankfull Cross-sectional Area (Sq. Feet)	Predicted[1] Bankfull Cross-sectional Area (Sq. Feet)	Percentage of Predicted Value
M02-A	134	133	101
M02-B	105	133	79
M02-D	123	133	92
M03-A	61.4	88.8	69
M03-B	63.0	88.8	71
M04-A	60.3	85.0	71
M04-B	59.2	85.0	70
M05-A	54.4	74.8	73

[1] Predicted value form Vermont Regional Hydraulic Geometry Curves (2001)

Table 2. Comparison of Measured and Predicted Bankfull Cross-sectional Area			
Segment Number	**Measured Bankfull Cross-sectional Area (Sq. Feet)**	**Predicted[1] Bankfull Cross-sectional Area (Sq. Feet)**	**Percentage of Predicted Value**
M05-B	47.9	74.8	64
M06-A	63.2	60.8	104
M06-B	32.0	60.8	53
M07	31.7	55.9	57

The corrected bankfull dimensions are summarized below in Table 3. As shown in Table 3, the width to depth ratios ranged from low (<12) to moderate (<30). Although point bars were present in many of the segments, the low width to depth ratio indicated that these segments were likely E or G channels. Three of the segments (M02-B, M04-A, and M06-A) were on the borderline for a "G" channel because twice the maximum bankfull depth was within an inch or two of the top of the low bank.

Table 3. Stream Type					
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Sinuosity**	**Sediment Storage Types**	**Stream Type**
M02-A	26.1	13.9	Moderate	Point bars and mid channel bars	C5
M02-B	16.2	10.6	Moderate	Point and mid channel bars	E4*
M02-D	1.3	12.3	Moderate	Point and mid channel bars	G4c
M03-A	22.9	11.0	High	Point	E5
M03-B	28.4	8.77	Moderate	Point and mid channel	E4
M04-A	2.7	21.5	Low	Mid channel and side bars	C3*
M04-B	2.4	25.7	Moderate	Mid and point	C3
M05-A	7.0	14.9	Low	Side	C4
M05-B	19.6	13.1	Moderate	Mid and point bars	C4
M06-A	3.14	13.2	Low	None	E5*
M06-D	7.58	12.2	Low	None	E4
M07	19.1	9.31	Moderate	Mid and point bars	E4
*** These segments are borderline G channels**					

3.0 Phase 2 Results by Reach

The results of the Phase 2 study are summarized below by reach number, and reports from the Phase 2 database are included on pages 2 through 33 of Appendix B. A described above in Section 2.1, a full Phase 2 assessment was only done on the segments, which were identified to be unconfined.

3.1 Reach M02

Reach M02 was split into five segments following the Phase 2 walkover of this reach. The lower end of this M02-A and M02-B were divided into segments based on differences in substrate. M02-A was noted to have sand as the dominant substrate type, while M02-B was gravel dominated. M02-C was split into a new subreach based on a change in substrate and confinement. This reach is primarily a step-pool system, which contains a bedrock falls. M02-D was identified as a subreach because of the change back to an unconfined, riffle-pool system. The upper section of M02-E is a confined section of channel with a ledge grade control above Saw Mill Road. This segment of river contains a 14 foot high dam.

M02-A

The confinement within segment M02-A is very broad. This segment was classified as a C5 channel based on the channel cross section and the pebble count. The substrate was noted to be soft underfoot and approximately 80 percent of the particles were sand. Much of the segment is dominated by runs, as illustrated in Figure 2. Sediment storage bars included mid channel and point bars. The incision ratio was calculated to be 1.7, suggesting the river has only fair access to the floodplain within this segment.

Erosion was prevalent in this section with approximately 60 percent of the left and right bank having bank erosion. The high bank height averages about 5 feet. Hay fields were noted to be the dominant land use within the riparian corridor. The buffer was narrow on both sides (<25 feet in width) and had herbaceous vegetation as the dominant vegetation type.

The stream channel is located close to the valley wall in the upper to mid portion of M02-A. This location of the stream in relation to the valley wall in addition to evidence of historic channel straightening and armoring provide evidence that the channel was moved over to the edge of farm fields. A number of incised tributaries were observed within this segment.

Figure 2. M02-A is dominated by run habitat. The substrate was soft underfoot suggesting aggradation is occurring.

M02-B

Segment M02-B is also classified as having a very broad valley. Based on the cross section and pebble count data, this segment was is a Rosgen E4 channel. This segment was characterized as a having a low width to depth ratio (10.6), a high incision ratio (1.95) and moderate sinuosity, suggesting the river within this segment has poor floodplain access.

Segment M02-B was similar to M02-B in terms of bank erosion and land use. Hay fields were observed to be the dominant land use within the riparian corridor. The buffer width was generally very poor (< 5 feet) and consisted of herbaceous vegetation. Segment M02-B had a high rate of bank erosion, with erosion noted along approximately 60 percent of the left bank and right hank. The high bank height in this section averaged about five feet. Figure 3, shows bank erosion adjacent to Durant cemetery. During fall 2004, the Cabot Cemetery Commission stabilized approximately 300 feet of the right bank with rock riprap.

Figure 3. Bank erosion in segment M02-B adjacent to Durant cemetery. The Cabot Cemetery Commission stabilized approximately 300 linear feet of bank with rock riprap during fall 2004.

Based on a comparison of recent orthophotos (1998) and historic orthophotos from 1982, segment M02-B was noted to have a high rate of meander migration. Migration, or movement of the channel by eroding its outer bank on meander bends, appeared to be the primary mechanism for lateral migration of the channel. Channel avulsions were also noted in this reach both in the field and on the orthophotos. Numerous flood chutes as well as impending neck cutoff were observed in the field. Bed sediment storage bars included point and mid channel.

The river in segment M02-B also appears to have been relocated against the left valley wall in places to move the river to the edge of farm fields. In fact, the river was noted to be sometimes within one bankfull width of the valley wall. Channel straightening was particularly evident at the lower end of this segment.

M02-C

As shown in Figure 4, segment M02-C had a ledge grade control falls at the upper end and a step/pool system at the lower end of this subreach. An old mill site was observed within this segment. Segment M02-C was not included in the Phase 2 study because it is bedrock controlled.

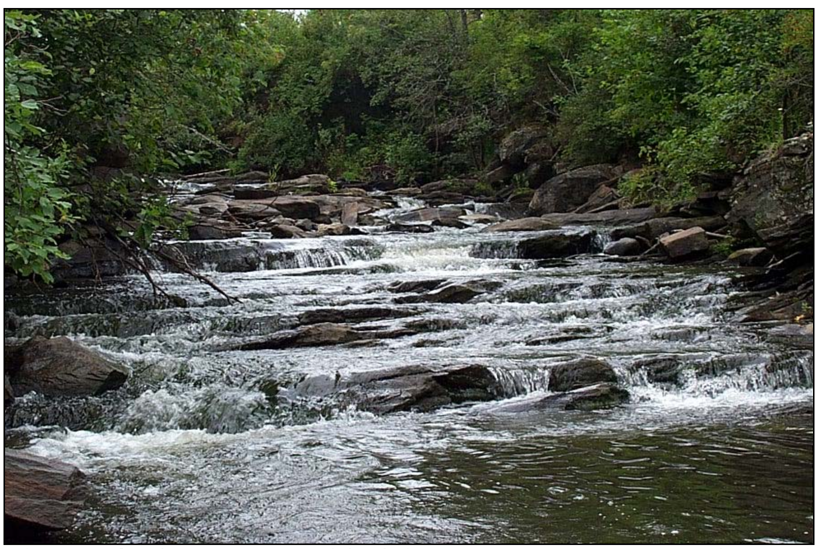

Figure 4. Segment M02-C is ledge a controlled falls with a step/pool system at the lower end. An old mill was observed within this reach during the Phase 2 walkover.

M02-D

Segment M02-D is located between to major grade control structures (the ledge by the dam above Saw Mill Road and the ledge by the old Mill in segment M02-C). M02-D is has a very broad valley, but the floodplain is cutoff due to channel incision. The incision ratio was found to be 2.2 and the entrenchment ratio was only 1.3, supporting the finding that this segment has very poor access to its floodplain. The cross section information suggests this segment is a G4c stream type. Directly below Saw Mill Road for approximately 2000 feet, the river exhibits some plane bed characteristics, and is a long continuous riffle. As shown below in Figure 6, the river has been straightened and historic riprap was noted along both banks in this upper section.

Figure 5. Charlie Wanzer, high school science teacher in Cabot holds the rod to measure the bank height. The low bank height within this segment was close approximately 8 feet, providing evidence that the Winooski is incised in this location.

Because of the significant historic channel straightening within this section, the sinuosity is only low. The river is sometimes within one bankfull width of the left valley wall, suggesting the river was relocated at one point at the edge of farm fields. Ledge was noted along the left bank of the large bend within this reach. Bank erosion was recorded to be high (50%) on the right bank where the buffer width was typically less than 5 feet wide. Along the left bank, where the buffer width was generally greater than 100 feet, the bank erosion was only about 13 percent.

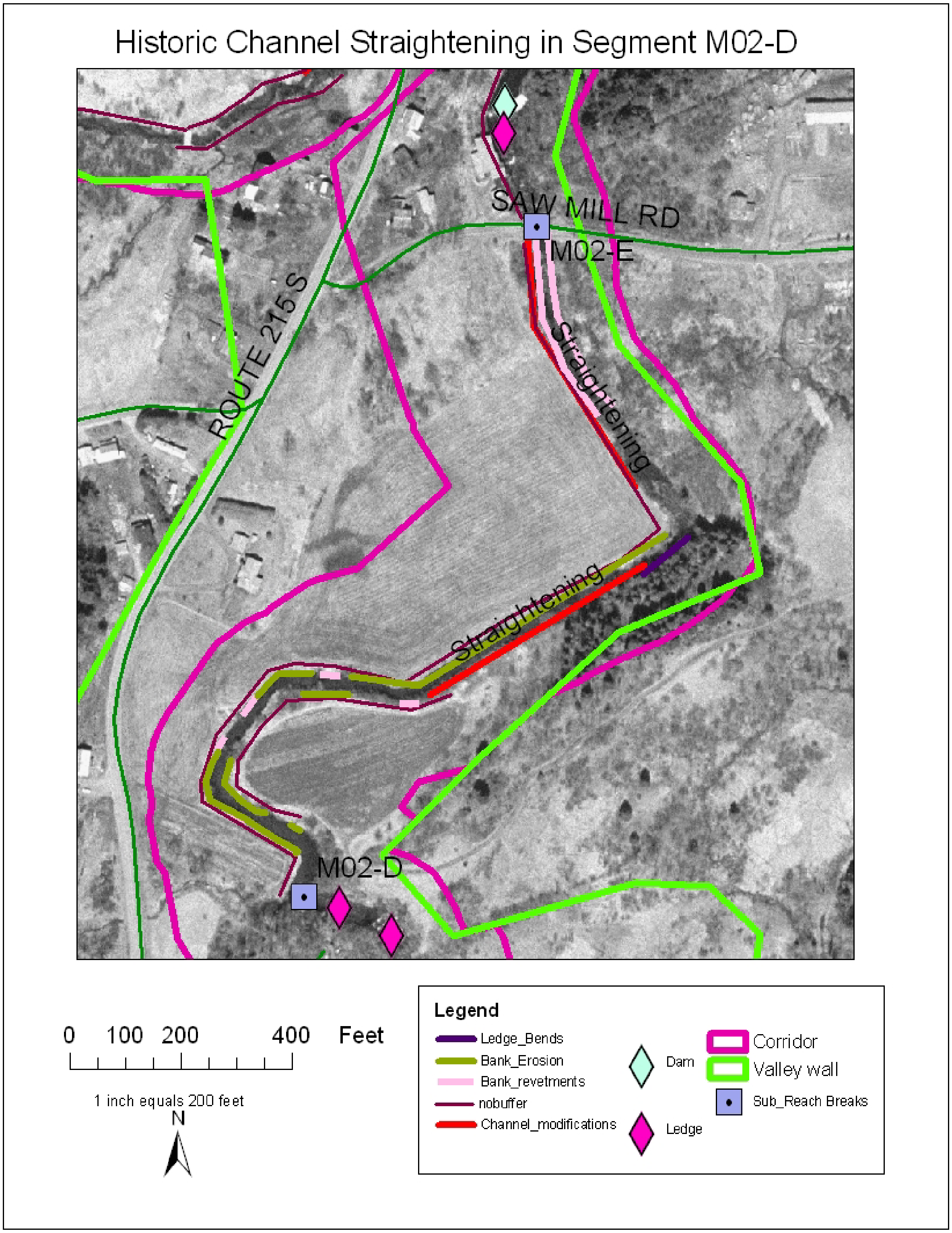

Figure 6. Historic channel straightening within segment M02-D. The reach is bordered by ledge grade control on the downstream end and a dam and ledge grade control on the upstream end.

M02-E

Segment M02-E provides a significant grade control due to the Clark's Saw Mill dam and the bedrock below the dam. Based on records from the Vermont Dam Safety Program, Clark's Saw Mill dam has a length of 135 feet and is 14 feet high. Segment M02-E was not included in the full Phase 2 assessment because it is bedrock controlled.

Figure 7. Clark's Saw Mill Dam and ledge provide a significant grade control at the upper end of Reach M02.

3.2 Reach M03

The downstream end of reach M03 starts at the confluence of Jug Brook, and is just upstream of Clark's saw Mill dam. Reach M03 was split into two segments because of the strong influence of Clark's Saw Mill dam on the downstream end of the reach (see Figure 8), and also because of differences in substrate composition. The median substrate particle size for M03-A is sand, while M03-B was gravel dominated.

Reach M03 has a very broad valley. The sinuosity within reach M03 is moderate to high. Given the low width to depth ratios, the high sinuosity, the very broad valley, and the abundant wetlands within this reach, this reach is likely a Rosgen E channel. E channels are highly dependent upon riparian vegetation for bank stability. Extensive lateral bank erosion was observed in reach M03 on most outside bends, as shown in Figure 9. As illustrated in Figure 10, most of reach M03 has no buffer (<25 feet) on both sides of the channel. Based on the high bank lateral bank erosion and the historic and active flood chutes, reach M03 appears to undergoing extreme planform adjustment.

Figure 8. Segment M03B above Jug Brook Confluence.

Figure 9. Extensive lateral bank erosion on outside bends in reach M03.

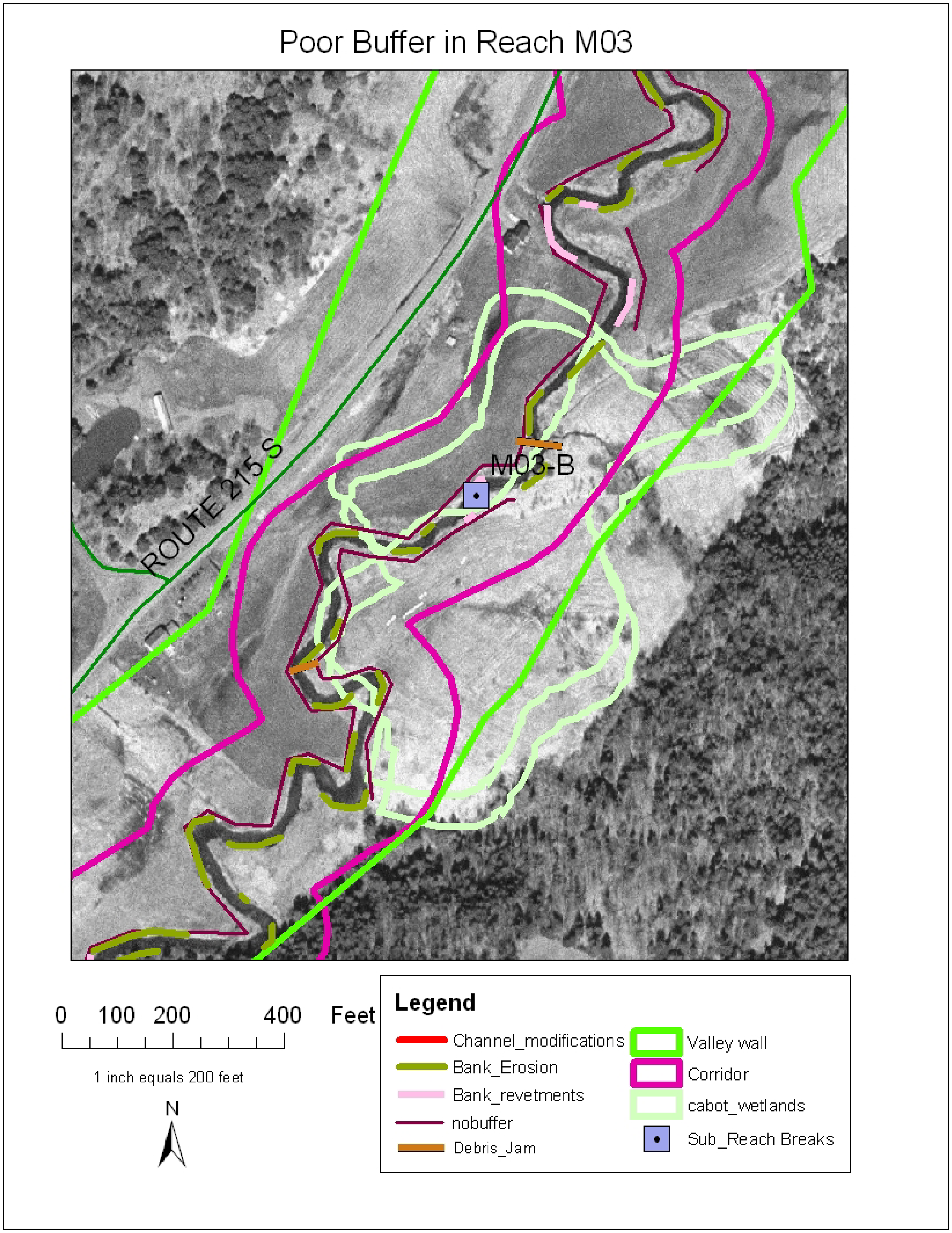

Figure 10. The majority of reach M03 has no buffer (<25 feet) on both sides of the channel.

3.3 Reach M04

Reach M04 is located above the Route 215 S. bridge, below the Village of Cabot. The reach was broken into three segment based on confinement and sinuosity. Reach M04-A is located at the downstream end of the reach along Mitchell's property. This reach is a C3 riffle/pool system, has a very broad valley, and low sinuosity. A 300 foot berm was noted to be along the right bank in this segment. This historic berm was likely constructed to protect the farm field from high flow events. The cross section measurement indicates this segment has poor access to its floodplain, and is almost a G3c stream type. A ledge, grade control section (see Figure 11) exists at the upstream end of M04-A.

Figure 11. Ledge grade control section at upstream end of segment M04-A.

Segment M04-B begins upstream of the ledge, grade control section. M04-B has moderate sinuosity and is less incised than M04-A. With the exception of some bank erosion, Section M04-B had good habitat, as shown in Figure 12. A full Phase 2 assessment was not conducted on segment M04-C, which includes the section of river from the commercial section of the village downstream to the upper end of segment

M04-B . Segment M04-C is semi-confined and has a plane bed form for much of the segment.

Figure 12. Good habitat was noted in Reach M04-B. This reach contained a good mix of substrate types and frequent pools.

Bank erosion was less prevalent in segments M04-A and M04-B than other parts of the main stem; erosion was noted on less than 10% of the right and left banks. The higher quality buffer in both segments most likely plays a factor in the lower bank erosion noted. The dominant buffer width in segment M04-B was 26-50 feet on both sides and consisted typically of mixed trees. Although the buffer width in segment M04 was 5-25 feet, this buffer generally was made up of shrubs-sapling or mixed trees.

3.4 Reach M05

The existing stream type for both segments in reach M05 is C4. It is possible that this reach is an E-4 reference stream type, but is currently experiencing some widening. As shown in Figure 13, Reach M05 was split into two segments based on differences in riparian vegetation and sinuosity. The upper segment (M05-B) is dominated by herbaceous vegetation both on the near bank and within the riparian buffer, while the

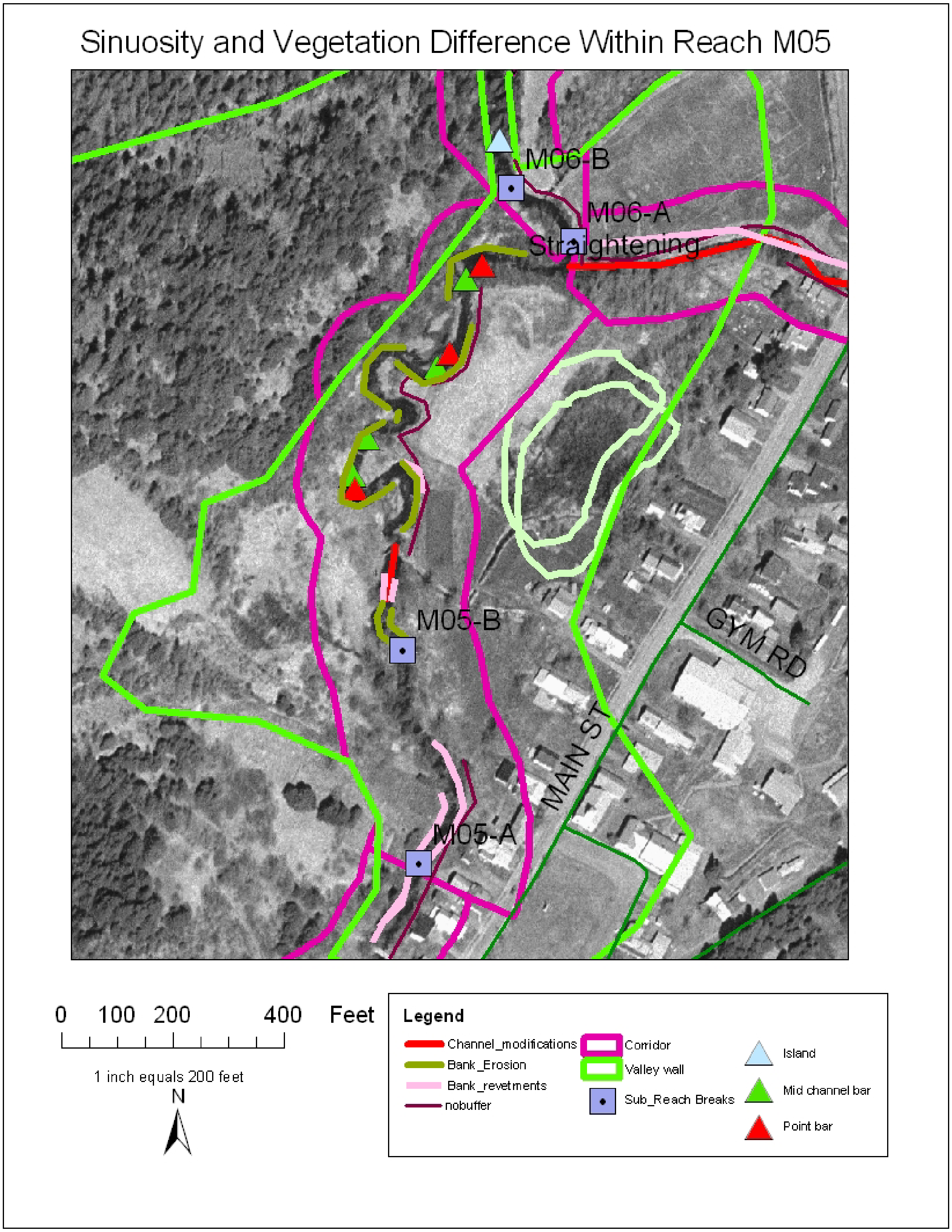

Figure 13. Reach M05 was split into segments based on differences in sinuosity and vegetation

lower segment M05-B typically had shrubs-sapling on the near bank and shrubs-saplings or deciduous trees within the buffer. M05-B was noted to have moderate sinuosity, and M05-A has low sinuosity. Reach M05-B has unvegetated point bars and mid channel bars, and flood chutes, while M05-A has side bars. Significant lateral bank erosion was observed on the outside bends in reach M05-B (see Figure 14).

Figure 14. Segment M05-B was noted to have extensive lateral bank erosion on the outside bends.

Segment M05-B has an incision ratio of 1.4, indicating the river has fair to good access to the floodplain. The incision ratio for Reach M05-A was only 1.8, suggesting the river has fair access to the floodplain.

3.5 Reach M06

Reach M06 was divided into four segments for purposes of the Phase 2 assessment. As presented in Figure 15, the lower segment (M06-A) is a low gradient section, located directly above the confluence of Tributary 2 and adjacent to the recreation field.

Segment M06-B is a higher gradient, narrowly confined rock gorge as shown in Figure 16.

Figure 15. Reach M06-A is characterized as a low gradient, sand dominated channel.

Figure 16. Segment M06-B is a narrowly confined, bedrock controlled section of the Upper Winooski River.

Because this reach is bedrock controlled, a geomorphic assessment of this reach is not warranted. Segment M06-C, located above the bedrock grade control is heavily influenced by two beaver dams (see Figure 17). This area appears to have had extensive beaver influence over at period of time. For this reason, this segment is functioning more like a wetland than a fluvial system. Therefore, a phase 2 assessment of this segment is not appropriate.

Figure 17. Beaver dams are influencing the Winooski River within Segment M06-C. This segment is acting more like a wetland than a fluvial system.

The upper segment of reach M06, segment D, has a broad valley. There is an extensive ledge grade control at the upstream end of the reach. The reach typically has a high quality riparian zone, as shown below in Figure 18. Trees are the dominant near bank and buffer vegetation. The buffer on the left side is generally greater than 100 feet in width, while the right buffer width was within the range of 51-100. The reach is moderately incised and has an incision ration of 1.4.

Segment M06-D is an E4 riffle-pool system with low sinuosity. The occurrence of riffles is about 10 times the channel width. This segment did not have any bed sediment storage bars. No significant channel bed and planform changes were noted within this segment.

Figure 18. Segment M06-D has a high quality buffer and near bank vegetation.

3.6 Reach M07

Reach M07 begins at the upstream end of the grade control section in reach M06-D and extends to the confluence of Tributary 3. The confinement of Reach M07 is very broad. Reach M07 was classified as a Rosgen E4 channel, based on the field data. The incision ratio was found to be 1.7, suggesting the river in this segment has only fair access to its floodplain. The overall sinuosity was moderate. At the upstream end of the reach, the sinuosity was low due to historic channel straightening. This reach appeared to be exhibiting significant planform adjustment, based on the extensive lateral bank erosion (see Figure 19) on the outside bends, especially in the mid to lower end of the reach. Additional evidence of planform adjustment included flood chutes and impending neck cut-offs.

The dominant buffer width was less than five feet on both sides. Shrub-sapling was the dominant vegetative type in both the near bank and buffer, although herbaceous vegetation occurred in the near bank in some locations. Hayfields dominated both the right and left riparian corridor.

Figure 19. Reach M07 appears to be undergoing significant lateral migration. There is also some evidence of degradation and channel widening.

5.0 RAPID GEOMORPHIC ASSESSMENT (RGA)

The phase 1 and phase 2 stream geomorphic assessment results are compared in Table 4 below, and are summarized on page 34 of Appendix B. The Phase 1 database predicted that the most downstream reaches (M02 and M03) were in poorest condition. Based on the Phase 2 Rapid Geomorphic Assessment (RGA), all but one segment (M04-B) was found to be in fair condition. The Phase 1 database did not result in a large enough difference in the adjustment process scores to have a high level of confidence in which adjustment process was dominant. Based on the RGA, degredation and planform adjustment appeared to be the primary adjustment processes on the main stem of the Winooski River in Cabot. This may indicate that the river has incised and is going through active lateral migration to rebuild the floodplain. The

Phase I meander migration analysis confirms that lateral migration is occurring.

Table 4. Comparison of Phase I Data and Phase 2 (RGA) Stream Geomorphic Conditions

Phase I Data						**Phase 2 Data**		
Reach/ Segment	Total Impact	Con-fine-ment	Stream Type	Phase I Adjustment Process	Phase I Condition	Stream Type	Primary Phase 2 Adjustment Processes	Phase 2 Condition
M02-A	20	VB	C5	Multiple	Poor	C5	Multiple	Poor
M02-B	20	VB	C5	Multiple	Poor	E4*	Degradation and Planform	Fair
M02-D	20	VB	C5	Multiple	Poor	G4c	Degradation and Widening	Fair
M03-A	19	VB	C4	Aggradation, planform	Poor	E5	Planform and widening	Fair
M03-B	19	VB	C4	Aggradation, planform	Poor	E4	Planform and widening	Fair
M04-A	15	SC	B3	Degredation, Aggredation	Fair	C3*	Degradation	Fair
M04-B	15	SC	B3	Degredation, Aggredation	Fair	C3	Degradation	Good
M05-A	17	VB	C4	Aggredation, planform	Fair	C4	Degradation	Fair
M05-B	17	VB	C4	Aggredation, planform	Fair	C4	Multiple	Poor
M06-A	14	VB	C4	Planform	Fair	E5*	Degredation and Aggredation	Fair
M06-D	14	VB	C4	Planform	Fair	E4	Degredation	Fair
M07	15	VB	C4	Planform	Fair	E4	Multiple	Fair

* These segments are borderline G channels

Channel Evolution Model

The Phase 2 RGA was used to evaluate the stage of channel evolution. Schumm (1977 and 1984) has described five stages of channel evolution. These stages as described in the ANR Phase 2 manual (ANR 2004) are as follows:

I. Stable – in regime, reference to good condition. Insignificant to minimal adjustment; planform is moderate to highly sinuous.

II. Incision – Fair to poor condition, major to extreme channel degradation. High flow events are contained in the channel, and channel slope is typically increased.

III. Widening – Fair to poor condition, major to extreme widening and aggradation.

IV. Stabilizing – Fair to good condition, major reducing to minor aggradation, widening and planform adjustments

V. Stable – In regime, reference to good condition. Insignificant to minimal adjustment.

In terms of the channel evolution model, the upper Winooski River main stem generally appears to be at stage III in the channel evolution model (see page 35 of Appendix B). The channel has undergone historic degradation, and the system is regaining equilibrium by moving laterally; there is some evidence that the channel is starting to widen. Bank erosion is prevalent, particularly on the outside meander bends as the channel moves to rebuild the floodplain. Unvegetated mid channel bars and point bars confirm the channel is undergoing extensive lateral migration. As sinuosity increases, the channel slope decreases. Active flood chutes are another indication that the main channel is shifting back and forth as the terrace side slopes erode. In a number of the segments (M02-A, M05-B, and M06-A), aggredation was evident.

All of the cross sections were found to be incised. The incision ratio ranged form 1.4 to 2.2. Seven of the 12 cross sections were found to have a bankfull elevation that is approximately one mean bankfull depth lower than the top of the low bank. This is illustrated below in Figure 20.

The cross section data for segments M02-D and M06-A indicate the new bankfull elevation is at an elevation lower than the low bank elevation minus the mean bankfull depth. This may be indicative of channel straightening/dredging, which may have historically occurred within the segments. Both segments M02-D and M06-D had incision ratios close to 2, reflecting these sections of the Winooski have poor access to their floodplain.

Segments M03-B, M05-B, and M06-D were found to have bankfull elevations that were higher than the low bank height minus the mean bankfull depth. A likely explanation for the less incised channel in segments M03-B and M05-B may be explained by the extensive lateral migration, which has occurred. As the channel has moves laterally, it appears to be building a new floodplain at a lower elevation.

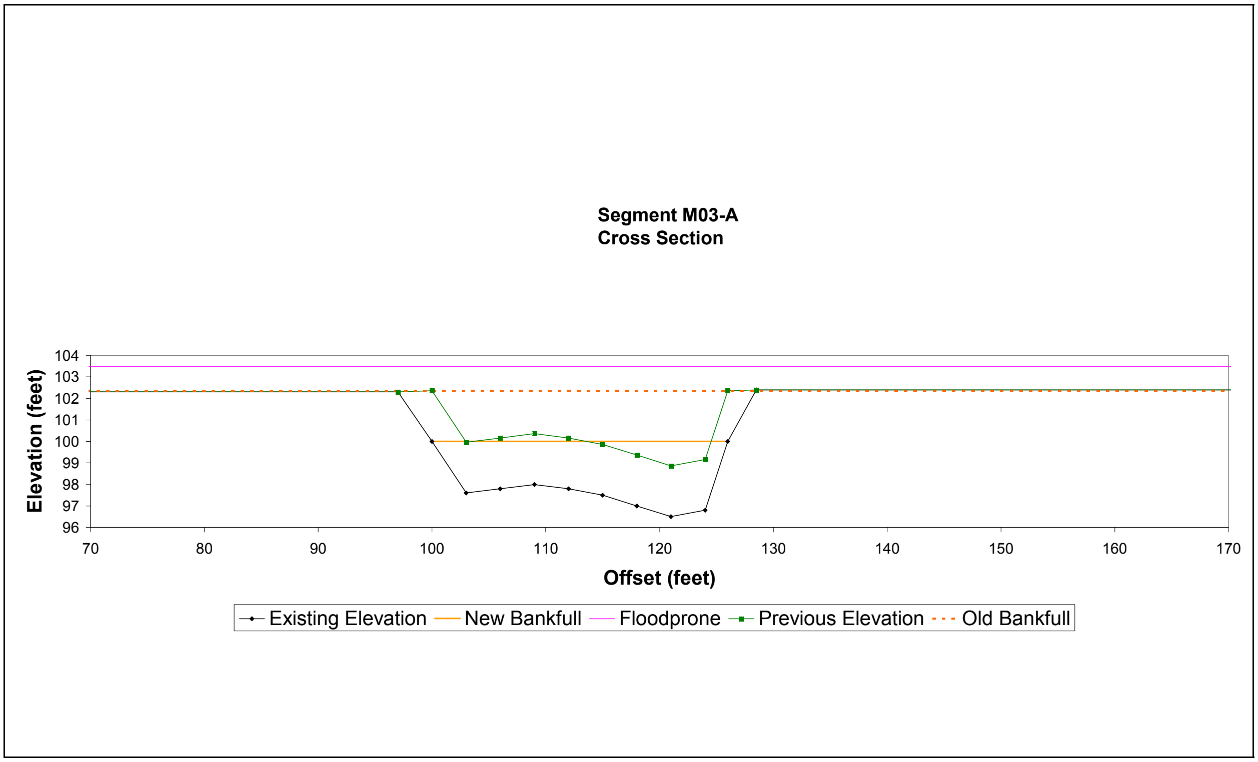

Figure 20. The field measurements from cross section M03-A indicate the channel has incised by the mean bankfull depth.

6.0 RAPID HABITAT ASSESSMENT (RHA)

The results of the Rapid Habitat Assessment (RHA) are provided on page 36 of Appendix B. Table 5 below shows a comparison of the habitat condition based on the RHA and the geomorphic condition based on the RGA. For nine of the twelve segments, both the RHA and the RGA resulted in ratings of fair. The most downstream segment (M02-A) had a rating of poor for both habitat condition and geomorphic condition. Segment M05-B had a rating of fair for habitat, but a rating of only poor for geomorphic condition. Segment M04-B resulted in a rating of good for both geomorphic and habitat condition. This reach appeared to be the closest to being in regime. Overall, the RHA score was similar to the RGA score.

Table _. Comparison of RHA and RGA for Phase 2 Reaches

Segment Number	Rating RHA	Rating RGA
M02-A	Poor	Poor
M02-B	Fair	Fair
M02-D	Fair	Fair
M03-A	Fair	Fair
M03-B	Fair	Fair
M04-A	Fair	Fair
M04-B	Good	Good
M05-A	Fair	Fair
M05-B	Fair	Poor
M06-A	Fair	Fair
M06-D	Fair	Fair
M07	Fair	Fair

7.0 RECOMMENDATIONS

Based on the Phase 2 Assessment performed during 2004, Bear Creek Environmental recommends the following:

1. Flag the water surface elevation during near bankfull events to confirm the bankfull depth.

2. Perform a Phase 2 assessment of the mainstem above reach M07 to determine if these reaches are undergoing adjustment. This would provide additional information for restoration design and planning.

3. The reference stream type for much of the mainstem of the Winooski between the Cabot/Marshfield town line appears to be E. E stream channels are highly dependent upon vegetation for stability. For this reason, the establishment and protection of vegetated buffers should be high priority in restoration planning and design work. Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion.

4. The Cabot Conservation Commission has recently received a River Corridor Development Grant for the ANR to develop a river corridor protection plan. The implementation of a river corridor protection plan goes a long way towards toward reducing fluvial erosion hazards and minimizing land use conflicts. As a starting point, fluvial geomorphic relationships can be used to determine the width of a river corridor which is needed to accommodate the meander geometry under equilibrium conditions. As discussed in the Defining River Corridors Fact Sheet, prepared by the Vermont DEC River Management Programs, rivers with gentle gradients and narrow to broad valleys require a meander belt width of 6 times the channel width to accommodate the meanders. At the lower end of the Phase 2 study area, this equates to a meander belt width of 210 feet (or approximately 105 feet on each side of the meander center line).

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