

**Phase II Stream Geomorphic Assessment  
Moose River; Essex and Caledonia Counties  
Concord and St. Johnsbury, Vermont**

**Final Report  
August 2009**



Prepared By:

Tamara Colten-Stevens  
Essex County Natural Resources Conservation District

Phase II Stream Geomorphic Assessment  
Moose River; Essex and Caledonia Counties  
Concord and St. Johnsbury, Vermont

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**Phase II Stream Geomorphic Assessment  
Moose River; Essex and Caledonia Counties  
Concord and St. Johnsbury, Vermont**

**EXECUTIVE SUMMARY**

- The Essex County Natural Resources Conservation District (ECNRCD) performed Phase II Stream Geomorphic Assessment on six (6) reaches in the Moose River watershed within the Towns of Concord and St. Johnsbury.
- The Phase II study focused on stream reaches on the main stem of the Moose River within the Town of East St. Johnsbury, below and through the Town of Concord, and upstream into the Town of North Concord.
- Protocols outlined in the Agency of Natural Resources, Stream Geomorphic Assessment, Phase II Handbook were employed. The Phase II data were entered into the most current version of the Phase II 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 I geomorphic condition is compared to the Phase II geomorphic condition in this report. Phase I geomorphic conditions ranged from fair to reference. All but one of the reaches assessed for the Phase II study resulted in a geomorphic condition of good.
- The Phase II Rapid Geomorphic Assessment (RGA) was used to evaluate the stage of channel evolution. All but one of the segments assessed were found to be in Stage I of the Schumm Evolution Model. The one segment (M13B) that was found to be in Stage II of evolution, was also the single reach with a Phase II geomorphic condition of fair.

- In general, the RGA rating was similar to the Rapid Habitat Assessment (RHA); all reaches and segments rated 'good', with the exception of M13B (fair) for RGA, and all but two (M9 and M10) rated 'good' for RHA.
- The Phase II reaches assessed on the mainstem were found to be of four differing stream types; three were classified as 'C' (slightly entrenched, unconfined streams with a moderately to gentle slope, a moderate to high width to depth ratio (w/d) and a moderate sinuosity), two 'F' (entrenched streams with a moderate to high w/d ratio and low to moderate sinuosity), two 'B' (moderately entrenched, confined or semi-confined streams with a moderate to steep slope, a moderate w/d ratio and a low to moderate sinuosity) and one "D" (multiple thread/braided stream, unconfined with a very high w/d ratio and a low sinuosity).
- Flood damage was observed in several locations (including Concord Village).
- Much of the River's banks were found to be unfettered by development and human infrastructure alterations.

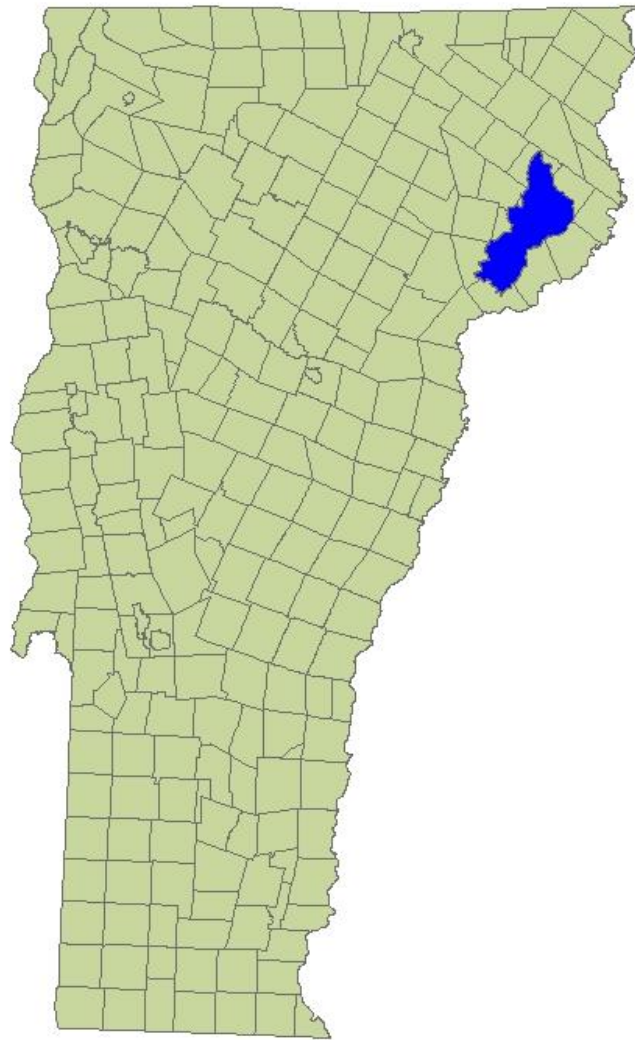
**Phase II Stream Geomorphic Assessment  
Moose River; Essex and Caledonia Counties  
Concord and St. Johnsbury, Vermont**

**1.0 INTRODUCTION**

A Phase II Stream Geomorphic Assessment of the Moose River main stem and its major tributaries (Chesterfield Valley, Kirby Brook, Bog/Umpire Brook and Granby Brook) within the towns of East St. Johnsbury, Concord, Victory, Granby, East Haven, Waterford and Kirby) was undertaken by the Essex County Natural Resources Conservation District (ECNRCD) over the course of two years and completed in 2009. Of the 67 reaches observed for Phase I Stream Geomorphic Assessment, six (6) main stem reaches were selected for Phase II study.



The Moose River (waterbody ID VT15-09), in the Passumpsic River Watershed (Basin #15), flows through both Essex and Caledonia Counties in the Northeastern corner of the State. The Phase II study focuses on stream reaches on the main stem; beginning downstream (M07) in East St. Johnsbury, and heading upstream through the Town of Concord, upstream to the Town of North Concord (M13).

**Moose River Watershed  
Phase II Geomorphic Assessment Project Location Map  
Figure 1.**



50  
Miles

**Legend**

-  Moose River Watershed
-  Vermont Town Boundaries

## 2.0 METHODOLOGY

The study followed the protocols for Phase II Stream Geomorphic Assessment developed by the Vermont Agency of Natural Resources. Information for the assessment came from the Department of Environmental Conservation- River Management Program, the Natural Resources Conservation Service, the Vermont Mapping Program, the Vermont Center for Geographic Information, and windshield surveys. Procedures for Phase II assessment followed those specified in the Vermont Stream Geomorphic Assessment Phase II Handbook (Vermont Agency of Natural Resources, 2005). All assessment data was recorded on the Agency of Natural Resources (ANR) Phase II data sheets, and was entered into the most current version of the ANR Phase I and II data bases. The Phase I database was updated using the field data from the Phase II assessment.

### 2.1 Field Protocols

Seven (7) steps are included in the ANR's Phase II Stream Geomorphic Assessment protocol. The steps are as follows:

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

Parameters and protocols used for each of the above steps are outline in the 2005 Phase II Stream Geomorphic Assessment- Rapid Stream Assessment, Field Protocols- Handbook. Each Phase II reach was walked (and/or canoed) to determine segment breaks if necessary. With the exception of two (2) segments (M12-C and M13-A), all segments were included in the full Phase II assessment.

### 2.2 QA Review

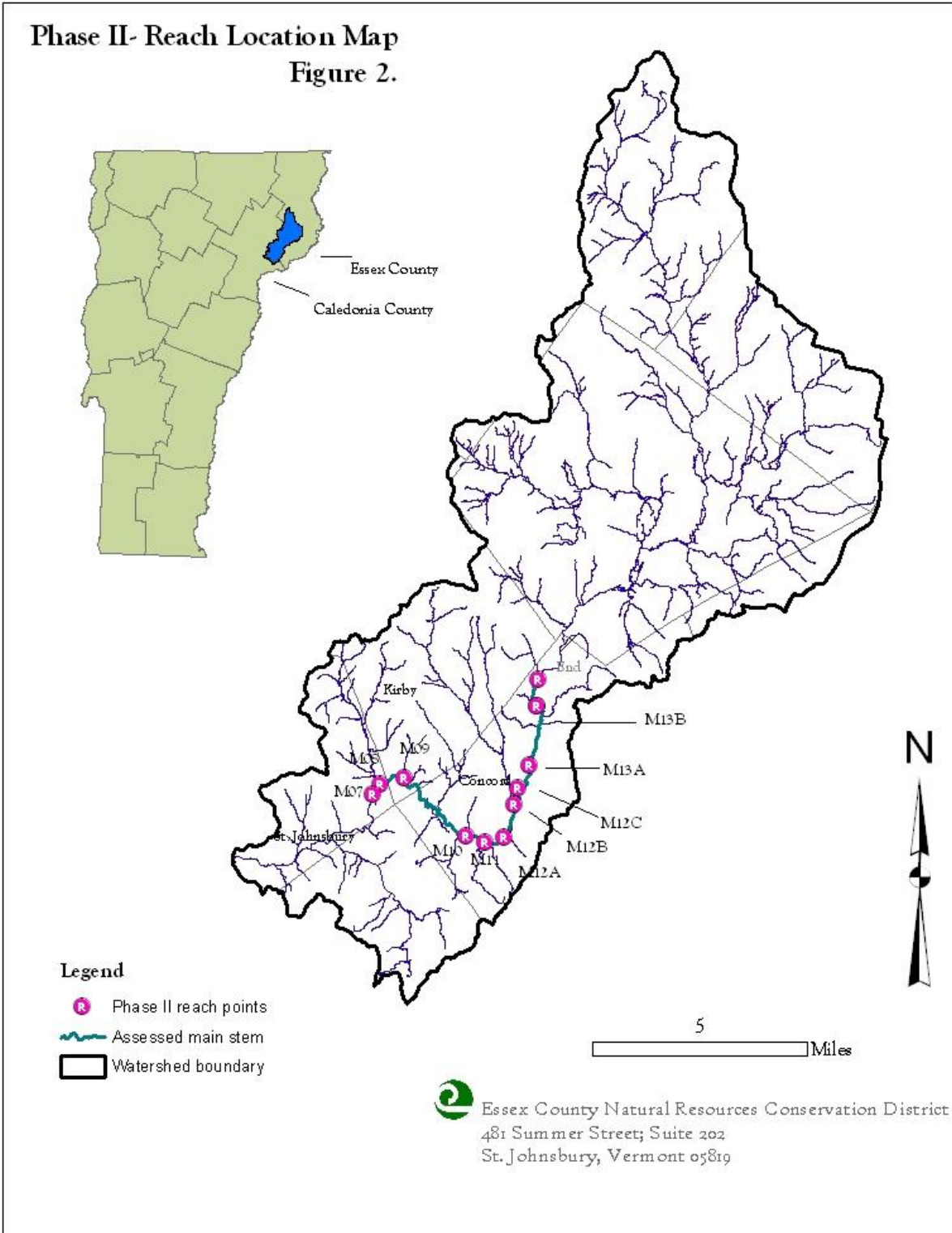
The Phase II Quality Assurance Worksheet was completed by the ECNRCD to document: (a) the tools used to collect the Phase II data, (b) the confidence level in the data, (c) the date the assessment was completed, and (d) the date each Phase I step was checked by state QA teams. The confidence level for Phase II data was rated from moderate to high.

The Microsoft Access Phase II database and the ArcView shapefiles for the Moose River Phase II assessment were submitted to Dana Nagy of the VT ANR, River Management for QA Review in March 2009.

## 2.2 Reach Locations

As described in the Phase I Final Report (Essex County Natural Resources Conservation District dated August 2009), stream reaches M7-M13 on the Moose River main stem were recommended by the ANR-DEC River Management Program for Phase II assessment field work. With the exception of M7 and M13, all of the reaches on the main stem selected for Phase II assessment were narrowly or semi-confined in type.

**Phase II- Reach Location Map**  
**Figure 2.**



<b>REACH NUMBER</b>	<b>CHANNEL LENGTH (MILES)</b>	<b>CONFINEMENT TYPE</b>	<b>STREAM TYPE/BED FORM</b>	<b>REACH CONDITION</b>
<b>M7</b>	<b>.33</b>	<b>Broad</b>	<b>F/Riffle-Pool</b>	<b>Good</b>
<b>M8</b>	<b>.65</b>	<b>NC</b>	<b>F/Plane Bed</b>	<b>Good</b>
<b>M9</b>	<b>2.8</b>	<b>SC</b>	<b>B/Plane Bed</b>	<b>Good</b>
<b>M10</b>	<b>.50</b>	<b>SC</b>	<b>C/Riffle-Pool</b>	<b>Good</b>
<b>M11</b>	<b>.53</b>	<b>SC</b>	<b>C/Plane Bed</b>	<b>Good</b>
<b>M12</b>	<b>2.10</b>	<b>SC</b>	<b>C/Plane Bed</b>	<b>Good</b>
<b>M13</b>	<b>.78</b>	<b>BD</b>	<b>E/Plane Bed</b>	<b>Fair</b>

**Table 1. Reaches Selected for Phase II Stream Geomorphic Assessment**

It should be noted that the parameter measured in Phase I is of ‘natural’ confinement, rather than the ‘actual’ confinement determined in Phase II. The evaluation of confinement allows you to understand whether flood flows are concentrated, thereby more powerful and effective at transporting sediment, as well as to “what degree the valley walls limit the lateral extent of stream meander bends and channel slope adjustment”.

### **3.0 BANKFULL DISCHARGE- CHANNEL DIMENSIONS**

Measurements of channel dimensions were made using a depth rod, a 100’ fiberglass measuring tape, and a hand level at one or two cross over locations within each segment. The cross section data was entered in the Vermont Agency of Natural Resources, Phase III Stream Geomorphic Assessment Spreadsheets.

### **4.0 PHASE II RESULTS BY REACH**

The results of the Phase II study are summarized below by reach number, with Phase II DMS generated reports attached.

#### **4.1 Reach M07**

Reach M07 is the most southerly of the Phase II assessed main stem reaches, flowing above East St. Johnsbury for 1,747’. With a valley width of an estimated 715’ and flat hillside slopes on both of the reach banks, this reach was classified as broad in confinement. Stream type was determined as an F3 with the results of the channel cross section and pebble count. The dominant substrate was found to

be cobble (33%), though course gravels (29%) and boulders (27%) followed closely behind. Only one mid channel bar was documented in this reach. An incision ratio of 1.86 and a high entrenchment value of 1.14 suggest there is poor access to the floodplain in this reach. There was no erosion noted on either bank. Both the right and left banks' riparian corridors were dominated by pasture, with no sub-dominant land use present. Very narrow buffers (<25') of shrubs, herbs and invasive plant species (notably *Polygonum cuspidatum*; Japanese Knotweed) were observed.



**Photo 1. Reach M07 was observed to be a broad, F3 stream with limited buffering and pastures along both its banks.**

#### 4.2 Reach M08

A longer reach than M07 (3,444'), the stream in M08 flowed faster and in a narrower channel. The reach was determined to be a narrowly confined F3 stream type, with a valley width of 163' and a bankfull width of 98'. The substrate composition was found to be similar to the M07 (cobbles, 37%; course gravel, 27%; and boulder 23%) with sedimented riffle types observed. Storage bars were present, though not numerous, with one side bar and one small island noted. An incision ratio of

1.79 and a high entrenchment value (1.04) suggest this section of stream has fair access to its floodplain. Seventy-six feet of erosion was noted on the right bank and rock rip rap was recorded for a total of 391' along the right bank. Corridor encroachments included 3,250' of road (Rte. 2) along the right bank and 615' of railroad to the left. The riparian corridor in M08 was dominated by shrubs and saplings on both banks, with no sub-dominant vegetative type observed. The riparian buffer on both banks was found to be 26-50' in width in most areas with shrubs and saplings dominating and herbaceous plants sub-dominant in vegetation. Minimal springs and seeps were observed as were adjacent wetlands.



**Photo 2. In Reach M08, cows were observed grazing up to the right bank of the stream. Additional fencing to keep them out of the river and installation of a riparian buffer would be recommended.**

#### 4.3 Reach M09

By far the longest stretch of stream assessed for this study, M09 and its 14,622' meandered slower and deeper than the reaches of M07 and M08. With a bankfull width of 85', the stream in M09 was found to be a semi-confined B4- plane bed type. M09 was largely dominated by cobble (48%) with bed and bar average largest particles measured at 65.0 mm and 104.0 mm respectfully. Storage bars were more abundant than in M08, with one (1) mid, one (1) point, and two (2) side bars present.

The fairly high incision ratio of 1.54 and a moderate entrenchment value of 1.92 suggest the stream has moderate to good access to its floodplain. The banks of M09 had a boulder/cobble upper material and a lower gravel material type that experienced great amounts of erosion. Four-hundred (400) feet of erosion at 4.5' in height was measured on the right bank and 405' of erosion at five (5) feet in height was measured on the left. Rip rap was found in limited lengths on both the right (145') and left (64') banks. Corridor encroachments were present for much of the reach, with the railroad following the river for 13,113' and Rte. 2 for 334'. Two (2) old railroad abutments were observed in M09, one on either bank, with channel and floodprone constriction noted due to the right bank abutment's presence. The riparian corridor on both banks was dominated by 'crop' (corn). The riparian buffer, where present, consisted of shrubs and saplings with invasives (*P. cuspidatum*) sub-dominant on both banks. On the right bank the buffer was measured to be 0-25' for 8,278' and the left bank; 6,614'. Abundant springs and seeps were noted as were two (2) storm water inputs.



**Photo 3. Though riparian buffers were substantial at the top of Reach M09, 8,278' of the right bank and 6,614' of the left had just 0-25' of vegetation.**



**Photo 4. Japanese Knotweed (*P. cuspidatum*) grew abundantly in many of the reaches riparian buffers.**

#### 4.4 Reach M10

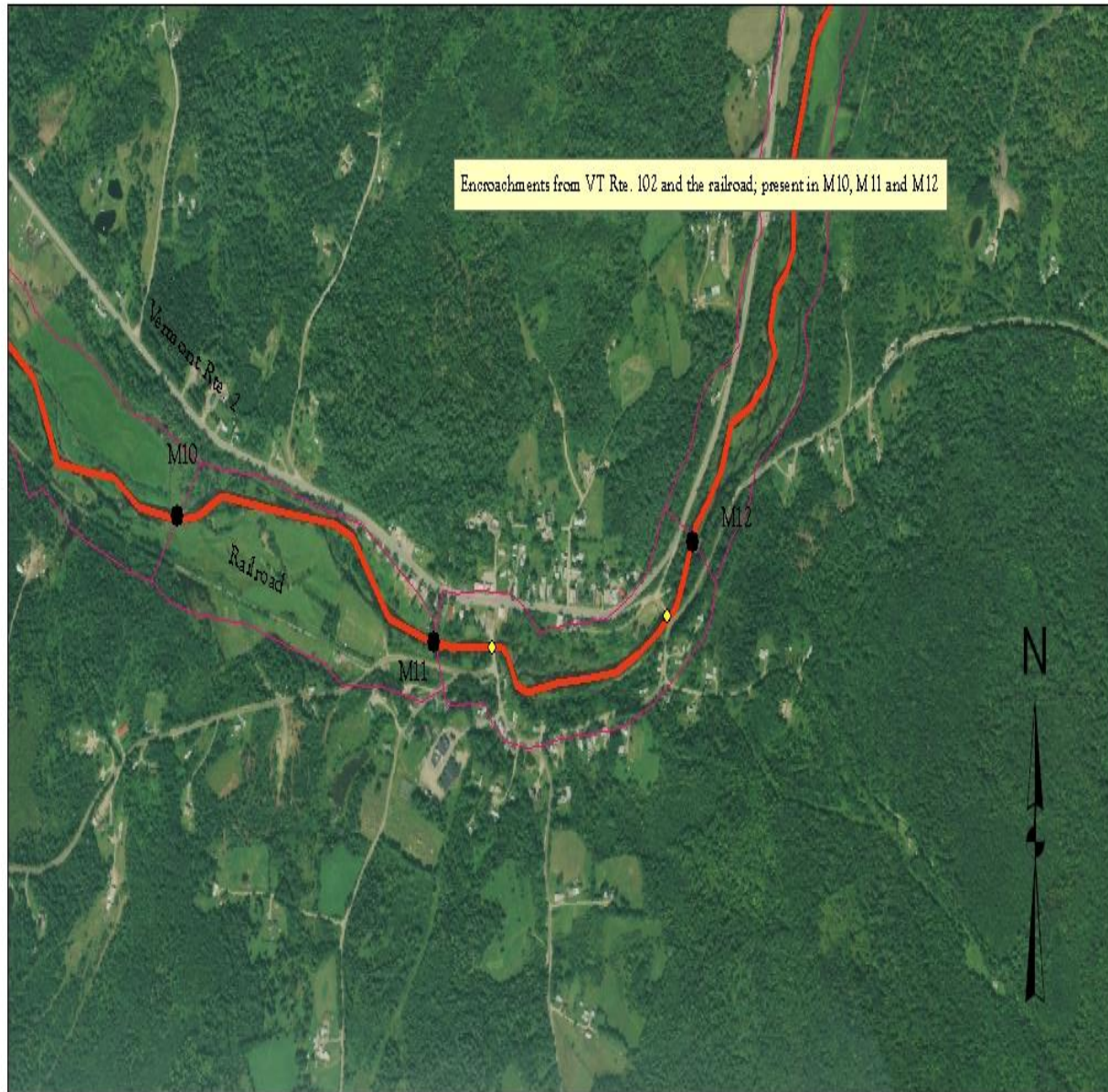
Flowing 2,608' just downstream of the Town of Concord, reach M10 was classified as a semi-confined C3 stream type. Cobble once again was the dominant substrate observed during the pebble count (55%) with the bed and bar average largest particles measured at 96.6 mm and 104.0 mm respectively. Storage bars were abundant, with six (6) side bars, one (1) point bar and ten (10) islands observed. The incision ratio of 1.63, little to no entrenchment (4.78) and a high w/d ratio (39.37) suggest this reach's stream has moderate access to its floodplain. The dominantly undercut banks were sandy in texture although erosion was not as widespread as expected (a mere 12' on the right and 356' on the left). Revetments were not noted on either bank. The riparian corridor was dominated by shrubs and saplings on the right bank (with pasture sub-dominant) and crops dominant on the left. The sub-dominant vegetation for the left bank riparian corridor was shrubs and saplings. The near bank vegetational types of both banks were invasives and herbaceous vegetation, both with poor buffers of 0-25' in width. Springs and seeps were noted as abundant, with minimal adjacent wetlands observed.






**Photo 5. Storage bars including side bars, point bars and islands were abundant in Reach M10.**

## Corridor Encroachments and Development

Figure 3.



### Legend

-  Bridges and Culverts
-  Road and Railroad Encroachments
-  Corridor

1,500  
Feet

#### 4.5 Reach M11

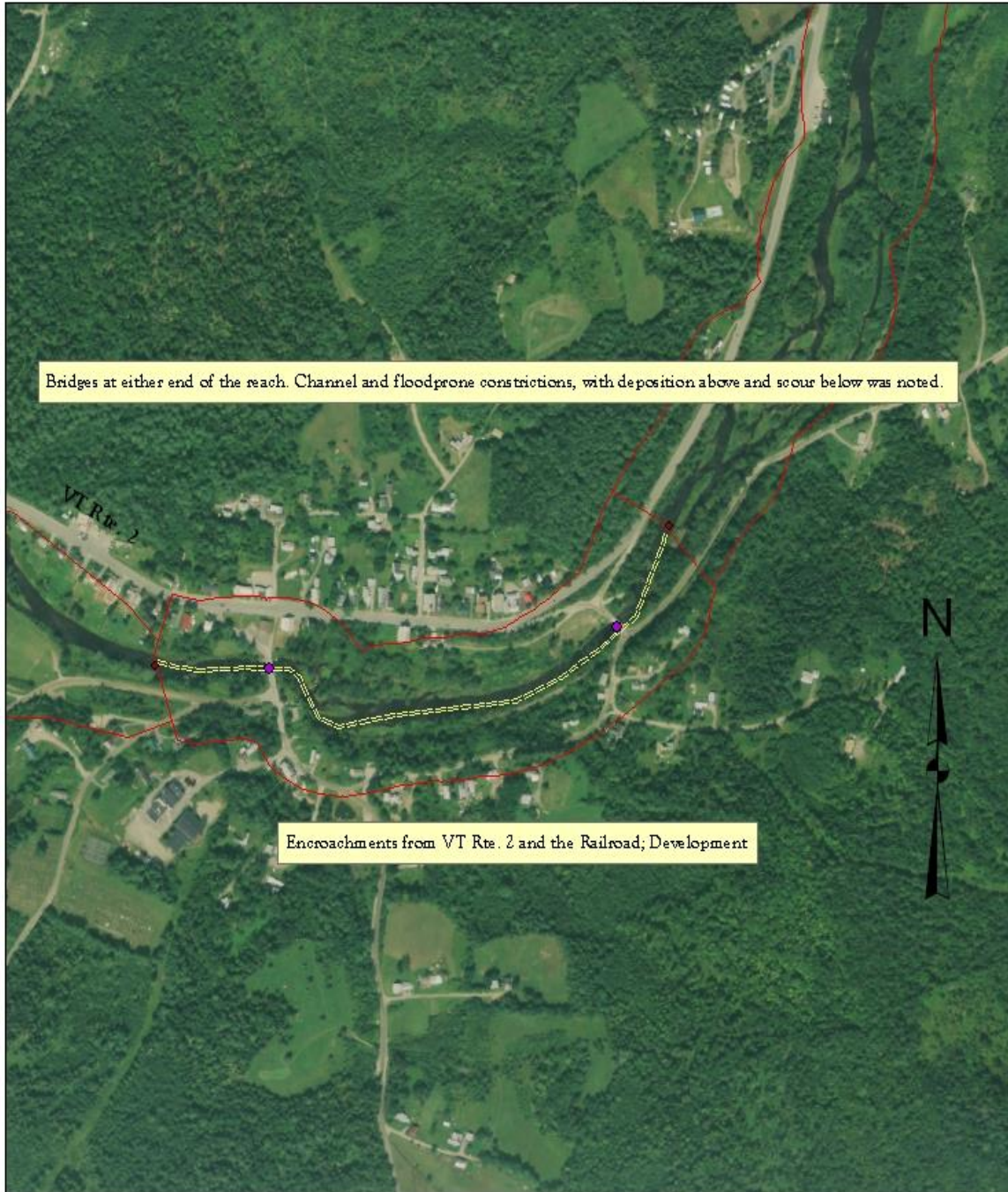
Reach M11 flows 2,806' from just upstream of the Town of Concord, to just downstream of the village. A semi-confined stream M11 was determined to be a C<sub>b</sub> type, with a substrate dominated by cobble (32%), course gravel (28%) and boulders (20%). The incision ratio of 1.0 suggests this reach is not incised. A low entrenchment and high w/d ratio of 30.18 suggest there is great access to the floodplain. Flooding has been documented over the past several years on this reach. Storage bars were present in the reach, with two (2) mid bars, two (2) side bars and two (2) islands documented. Two (2) flood chutes were also noted. Erosion of the boulder/cobble texture banks was surprisingly not present, though rock rip rap was measured on both banks (1,568' on the right and 644' on the left). The riparian corridor was dominated by shrubs and saplings on both banks, with a subdominant land use of residential on both banks as well. The riparian buffer was much broader than expected, with the right dominantly 51-100' in width, consisting of shrubs and saplings and mixed trees, and the left dominantly 26-50' in width, consisting of shrubs and saplings and mixed trees. Corridor encroachments were numerous, as to be expected in a village, with Rte. 2 present for 1,803' on the right bank, railroad for 653' along the left, and development for 2,456' on both. Springs and seeps were minimal with no adjacent wetlands observed. Two constrictions (bridges) were documented in M11, measuring 51' and 90' in width. Both had channel and floodprone constrictions with deposition above and scour below.







**Photo 6. Reach M11, just above the Town of Concord.**

## Encroachments and Development in Town of Concord

Figure 4.



Legend

-  Encroachment and Development
-  Bridges and Culverts
-  Reach Points
-  Corridor

1,500

Feet

#### 4.6 Reach M12

M12 was segmented into three (3) due to channel dimensions. One of these segments (M12C) was not assessed due to the high depths of the water.

##### M12A

M12A encompasses a very braided section of the River's main stem. From the Montgomery and Buffington (1997) and Rosgen (1996) stream type bed form classifications, a braided feature is a "multiple channel system found on steep depositional fans and deltas. The channel gradient is generally the same as the valley slope. Ongoing deposition leads to high bank erosion rates. Bed features result from the convergence/divergence process of local bed scour and sediment deposition. Unvegetated islands may shift position frequently during runoff events. High bankfull widths and very low meander (belt) widths". With a bankfull width of 121', this segment was classified as a D3, plane bed stream type. The substrate of this segment was dominated by cobble (39%) and large woody debris was found in greater numbers than in previous reaches (25). Storage bars were abundant in segment M12A, with five (5) mid channel bars, two (2) diagonal bars, and four (4) islands observed. Six (6) flood chutes were noted. The incision ratio of 1.0, coupled with little to no entrenchment allow this well buffered stream segment great access to its floodplain.

Erosion was not observed on either of the stream's banks, though rock rip rap was measured on both the right and left banks (838' and 57' respectively). Corridor encroachment included 3,307' of Rte. 2 and 57' of railroad. The riparian corridor was dominated by forest on both sides of the river, with a sub-dominant of hay on the left. The buffer width on both banks was impressive with 51-100' in width on the right and >100' (with a sub-dominant of 26-50') on the left. The near bank vegetation type for the right bank was shrub and sapling, with herbaceous dominant on the left. Springs and seeps were noted as minimal with no adjacent wetlands present. One (1) bridge (Fournier Bridge) was observed in M12A (48' in width). Channel and floodprone constriction with deposition above the bridge was determined a problem at this site. A grade control of ledge (1.5' in height) was documented just below this bridge.



**Photo 7. The bridge at the bottom of Reach M12A.**



**Photo 8. A large number of woody debris, necessary for fish habitat, was noted on the multiple thread of Reach M12A.**

### M12B

M12B ran 2,423' upstream of the Fournier Bridge. M12B was determined to be a very broad B3 plane bed stream with good access to its floodplain in most locations. The pebble count determined that cobble was again the dominant substrate present, at 46%. Storage bars were present, with one (1) mid channel bar, two (2) side bars and five (5) islands present. Three (3) flood chutes were noted. Moderately to good access to its floodplain is suggested with an incision of 1.26 and entrenchment of 1.22. Erosion was non-existent on the right bank and minimal (67') on the left bank. Rock rip rap was noted along 87' of the left bank. Both the right and left banks of M12B had a riparian corridor dominated by forest with riparian buffers of greater than 100' in width. Both banks were dominated by coniferous trees and sub-dominated by shrubs and saplings. Springs and seeps were noted as minimal, with minimal adjacent wetlands observed. Beaver activity was noted though no dams were present. While no constrictions were present, ledge of 2' in total height was observed just below the channel cross section location.



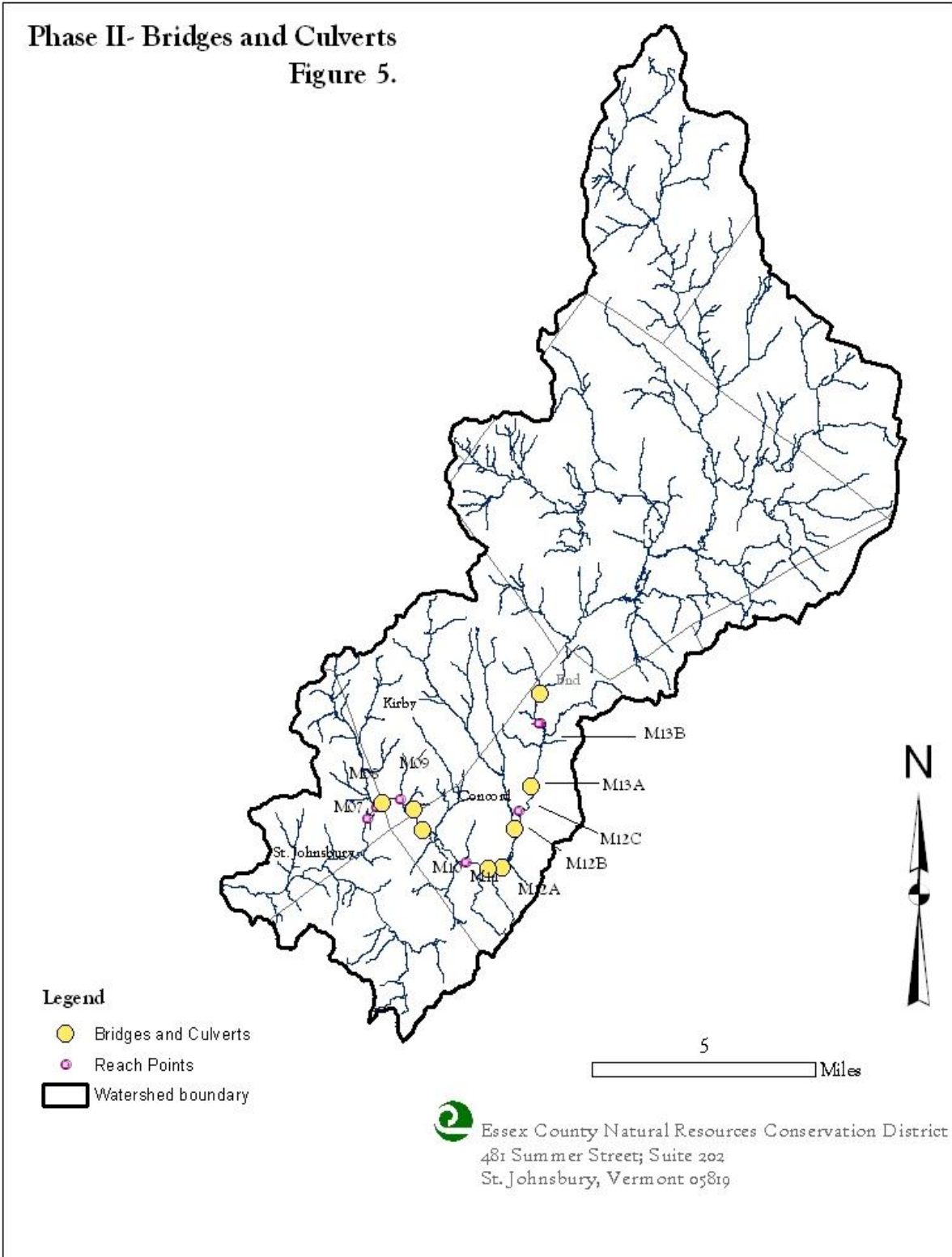
**Photo 9. Fournier Bridge. Dividing Reaches M12B and M12A.**



**Photo 10. Reach M12B had good access to its floodplain in most locations.**

**Phase II- Bridges and Culverts**

**Figure 5.**



### **M12C**

Not assessed.

### **4.7 Reach M13**

Reach M13 was segmented into two (2) due to channel dimensions, though M13A was not assessed because of high water.

### **M13A**




Not assessed.

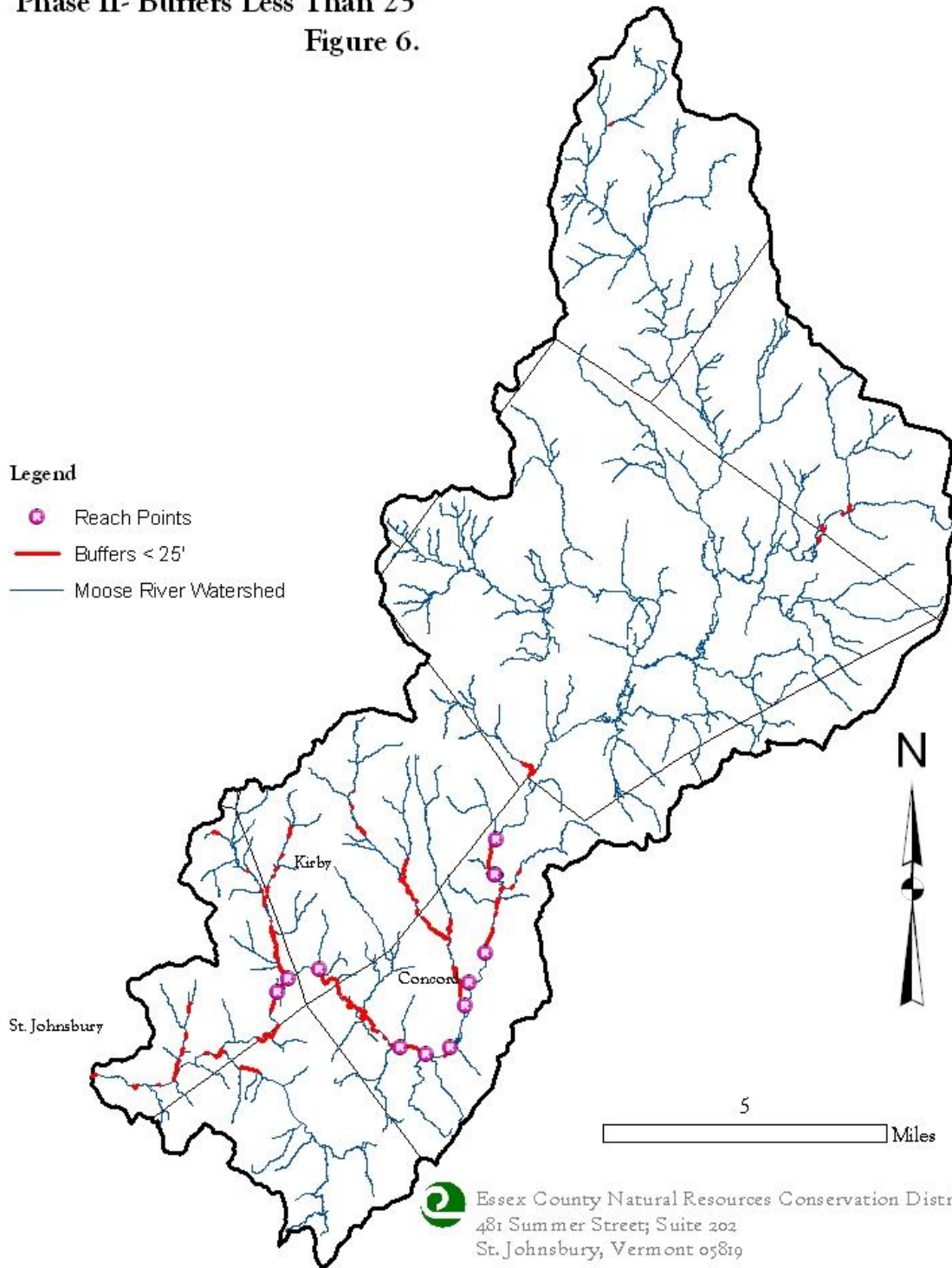
### **M13B**

M13B flowed for 4,122' with a bankfull width of 93' at the channel cross section location. The segment was classified as a broad C3 step pool. The waters of M13B were fast flowing and deep (5.8' maximum depth at the channel cross section location) so a complete pebble count for substrate composition was not performed. Sixty-two (62) pebbles were counted, revealing a dominantly cobble stream (25% of 62) followed by boulders (18% of 62). The incision ratio of 1.53 and little to no entrenchment (4.28) suggest this stream has fair access to its floodplain. Erosion was present to a lesser degree on both banks (210' on the right; 282' on the left) with no noted revetments. The riparian corridor in M13B was dominated by residential development on the right bank (sub-dominant crop) and crops on the left bank (sub-dominant shrubs and saplings). The riparian buffers of herbaceous, sub-dominated by shrubs and saplings was minimal, with 0-25' in width dominating. Springs and seeps were minimal and minimal adjacent wetlands were noted.

**Phase II- Buffers Less Than 25'**  
**Figure 6.**

**Legend**

-  Reach Points
-  Buffers < 25'
-  Moose River Watershed





**Photo 11. The waters of Reach M13 were deep and fast moving.**

## 5.0 RECOMMENDATIONS

Riparian buffers provide numerous environmental and recreational benefits to a stream, the groundwater in the watershed system, and the downstream areas.

Stream damage can be minimized and water quality enhanced through the establishment and maintenance of riparian buffers. Research has continually shown that there are many benefits to protecting and restoring buffers along a stream, including an increase in ground water infiltration, provision of cooler waters (suitable to many northern dwelling fish species), a decrease in streambank erosion, the filtering of sediments and pollutants commonly found in runoff, floodwater storage, and increase in wildlife habitat and recreational areas.

While much of the Moose River's main stem assessed in this study was found to have sufficient riparian buffers with mixed tree species, shrubs and herbs, other areas, particularly in Reaches M7, M9, M10 and M13, were documented as having very inadequate (0-25') buffers from providing the above mentioned benefits to the watershed.

Recommendations of the Essex County Natural Resources Conservation District would be for the establishment of forested riparian buffers in coordination with landowners and the Towns of St. Johnsbury and Concord in Reaches M7, M9, M10 and M13. In addition, fencing and installation of riparian buffer, where necessary, is recommended for Reach M08 below Concord Village, where cows can be observed grazing up to the bank of the stream.

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