Phase 1 Stream Geomorphic Assessment
Upper Winooski River Watershed and North Branch & Lower Stevens Branch subwatershed

Towns of Marshfield, Plainfield, Barre, Berlin, East Montpelier, Montpelier, Middlesex, Worcester, Calais, and Elmore
Washington & Lamoille Counties, VT

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Introduction

Winooski Natural Resources Conservation District (NRCD), Central Vermont Regional Planning Commission (RPC), and Friends of the Winooski River conducted the Phase 1 Stream Geomorphic Assessment of the Upper Winooski from Molly's Falls in Marshfield to Gateway Park in Montpelier, the North Branch and Stevens Branch subwatersheds of the Winooski River and 14 significant tributaries. The towns within the watershed's project area are Marshfield, Plainfield, Barre, Berlin, East Montpelier, Montpelier, Middlesex, Worcester, Calais and Elmore, Vermont. See Figures 1 and 2 for the geographic location of the project areas in the Winooski River watershed.

Waterfall on Hardwood Brook, North Branch Reach T6; photo taken by volunteer on 8/18/2006

A Stream Geomorphic Assessment process is divided into three phases, based on VT Agency of Natural Resources protocols. Phase 1, the remote sensing phase, involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies, called "windshield surveys" was conducted during the summer of 2006. The Phase 1 remote sensing techniques allow for large watersheds (100-150 square miles) to be assessed within a few months time. The Phase 1 assessment provides an overview of the general physical nature of the watershed, identifies which reaches are in particular need for restoration, and determines where to pursue more extensive field studies in Phase 2.

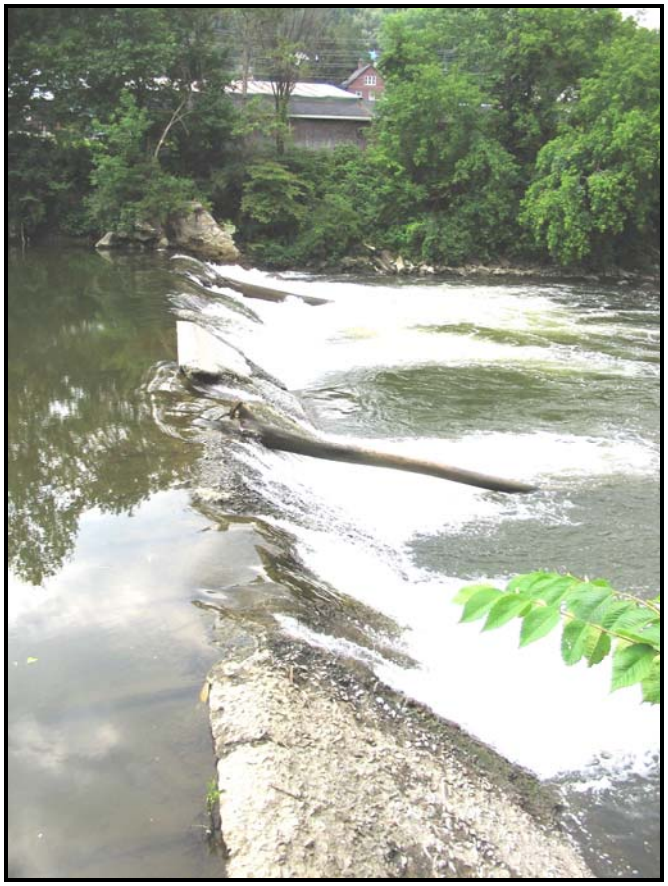
Phase 2, the field assessment phase, involves the collection of field data at the reach or sub-reach level. The Phase 2 assessment identifies specific reaches for protection and restoration projects and the completion of Phase 3 assessments. In Phase 3, the survey-level assessment, the focus is on the final detailed data requirements necessary for design and implementation of river corridor protection or restoration projects.

Background

The Winooski river watershed is approximately 690,000-acres and covers all of Washington County and nearly half of Chittenden County. Parts of the Watershed also extend into Lamoille, Caledonia, Orange, and Addison Counties making the Winooski watershed the largest Vermont watershed emptying into Lake Champlain. The purpose of this assessment was to focus on the headwaters section of the Winooski and significant tributaries (greater than 10% of the watershed area), with special attention toward a major tributary- the North Branch, which is believed to be indicative of the watershed's conditions as a whole.

The North Branch of the Winooski is a sub watershed of the larger Winooski and flows through the towns of Montpelier, Middlesex, Worcester, Calais and Elmore. Figure 1 shows the geographic location of the watershed. The North Branch of the Winooski River begins as a low gradient dune-ripple and plane bed system dominated by cobble and gravel substrate from its headwaters in Elmore to the Worcester Town line. In Worcester, Hardwood Brook, Catamount Brook, Hancock Brook, Worcester Brook, and Minister Brook all flow into the North Branch of the Winooski River (in order, from upstream to downstream). As more tributaries enter the North Branch the stream type transitions to a riffle-pool system. After flowing through the town of Worcester, the North Branch enters Middlesex where Martins Brook joins with the main stem. 2 subtributaries of Martins Brook, Herrick and Patterson Brook were also assessed during this Phase 1 project. A dam located in Middlesex restricts water flow creating the Wrightsville reservoir. The North Branch continues past the dam and enters Montpelier where the system changes to a dune-ripple and plane bed system, dominated by gravel substrate. This stream system is then consistent all the way to its confluence with the Winooski River.

The Upper Winooski River begins at the headwaters in Cabot and flows through Marshfield, Plainfield, East Montpelier, and Montpelier. The Stevens Branch begins in Williamstown and travels through Barre Town, Barre City, Berlin to the confluence with the Winooski River mainstem in Montpelier. This project assessed the portion of the Upper Winooski watershed from Molly's Falls in Cabot to Gateway Park in Montpelier. Tributaries assessed during the Phase 1 project were: Tributary 2 to Winooski River, Great Brook, Nasmith Brook, Tributary 5 to Winooski River, Pond Brook and Gunners Brook. The Stevens Branch subwatershed was also assessed from Barre City to the confluence with the Winooski River.



Run or River dam on Winooski River Reach 18; Photo taken by TJC

Figure 1: *Geographic Location of Winooski River Watershed & North Branch Assessment Area*

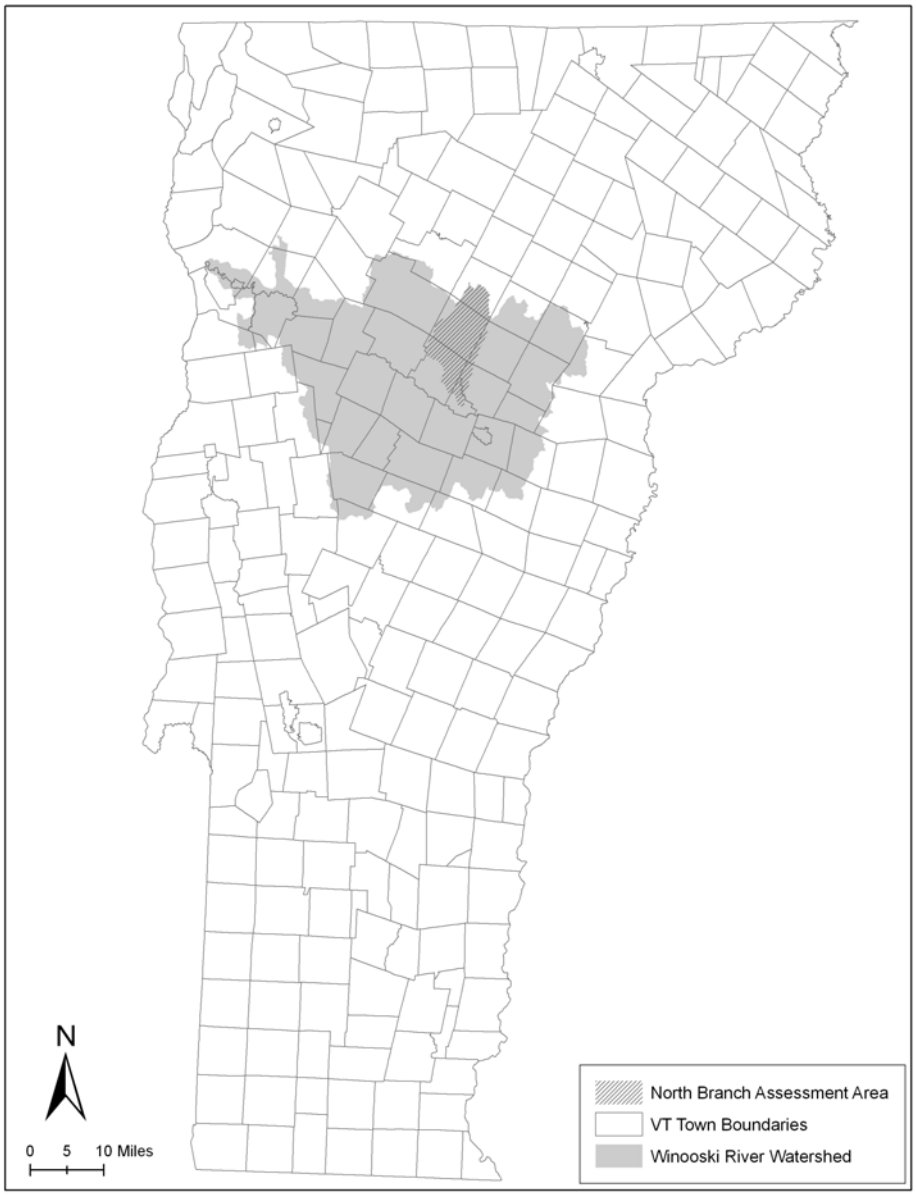
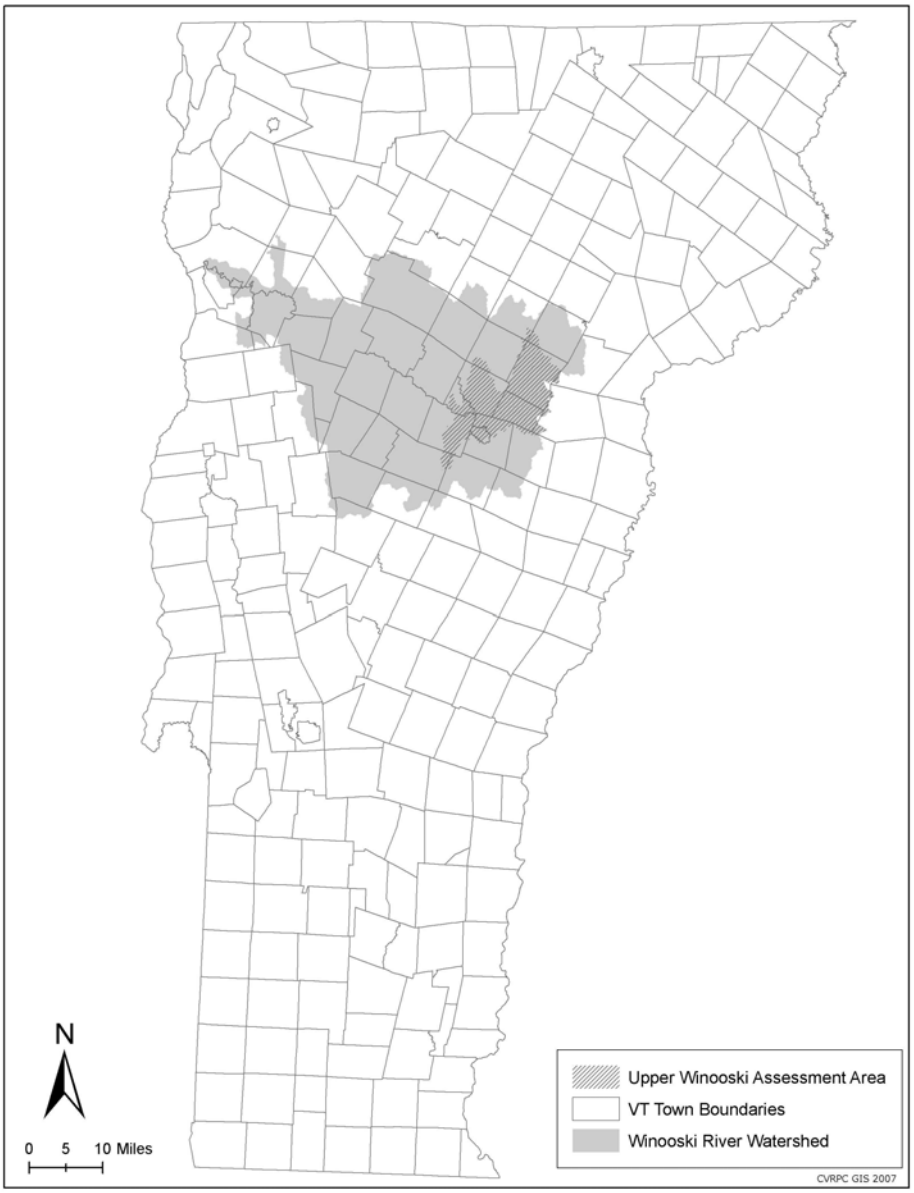


Figure 2: *Geographic Location of Upper Winooski River Assessment Area*



The generalized land uses within the North Branch and the Upper Winooski watersheds are compared in Figures 3 and 4. The urban environment in the two watersheds varies between approximately 5% and 8% respectively, with a predominate portion of each watershed remaining forested.

Figure 3: *Generalized Land Cover/Land Use in North Branch Watershed*

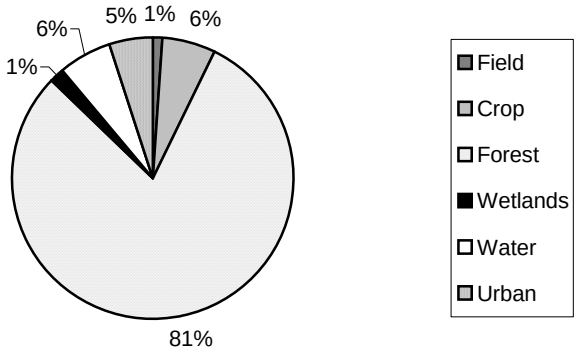
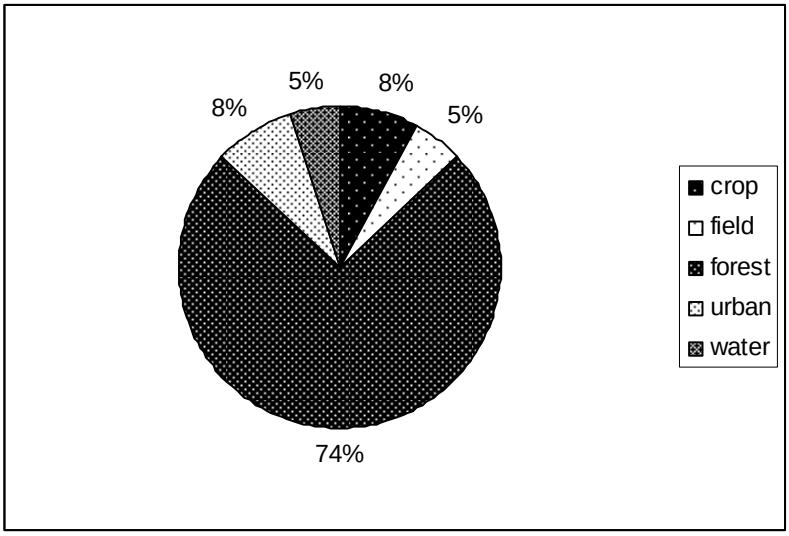


Figure 4: *Generalized Land Cover/Land Use in Upper Winooski Watershed*



Public Participation

In conjunction with the Friends of the Winooski River (FWR), Central Vermont Regional Planning Commission (CVRPC) and Winooski Natural Resources Conservation District (Winooski NRCD), letters were sent in June 2005 to all landowners abutting the section of the North Branch, Upper Winooski and lower Stevens Branch under assessment. The purpose of the letter was to describe to landowners how the physical condition of waterways affects water quality and to notify them of the upcoming assessment. The letter also included information regarding voluntary restoration cost sharing programs that were available.

Letters were also sent to town managers, town clerks, and chairs of the planning and conservation commissions, and select boards informing them of the assessment process and providing an opportunity to provide comments throughout the multi-year assessment process. Towns were asked to appoint key contacts who could be kept informed of the assessment progress. Assessment progress was also highlighted on the FWR and Winooski NRCD websites. Public forums regarding the project occurred in March 2007 in Marshfield, Worcester, and Montpelier to inform citizens about the importance of the

Phase 1 watershed geomorphic assessment as well as Phase 2 assessment data that has been collected on particular reaches within the watersheds.

Methodology

The Phase 1 assessment was completed following the procedures outlined by the Department of Environmental Conservation (DEC) in the Vermont Stream Geomorphic Assessment Handbook Phase 1 (Vermont Agency of Natural Resources 2004). Stream reaches were defined by creating reach breaks using valley width and slope, geologic makeup, and influence of tributaries. The Stream Geomorphic Assessment Tool or SGAT version 4 (a GIS extension) is used in addition to manual or visual delineations.

A Quality Assurance (QA) Program was established for the data to be reviewed by a team of River Management, RPC, FWR and WNRCD staff to ensure accurate and consistent data collection and reporting. Any errors in field evaluation, data entry, protocol interpretation were identified and all necessary corrections and updates to the data were made before being uploaded to Data Management System (DMS) and made available for public viewing.

All of the data collected was recorded on the Agency of Natural Resources (ANR) Phase 1 data sheets and entered into the most current ANR Phase 1 database. Reach and subwatershed delineations were done by the Friends of the Winooski along with members of CVRPC. CVRPC was in charge of running the SGAT portion of the study (discussed further below). Table 1 indicates the reaches and major tributaries assessed during the Phase 1 process. Figures 5 & 6 show the location of reaches used in the Phase 1 Assessment. The reach number is also included.

Table 1: *Reaches and major tributaries assessed during Phase 1*

	Stream Designation	Number of Reaches	Drainage area at Downstream most location (in square miles)
North Branch			
N. Branch Winooski River	M	19	667.23
Martins Brook	T1	8	44.09
Herrick Brook	T1.S1	4	6.80
Patterson Brook	T1.S2	4	7.63
Minister Brook	T2.01	4	27.59
Worcester Brook	T3	6	15.73
Hancock Brook	T4	5	13.76
Catamount Brook	T5	5	8.24
Hardwood Brook	T6	6	15.39
Subtotal		*61*	*806.51*
Upper Winooski			
Winooski mainstem	R	18	2648.7
Stevens Branch	M1	6	592.7
Tributary 2 to Winooski	M2	3	7.3
Great Brook	M3	9	77.3
Nasmith Brook	M4	7	40.8
Tributary 5 to Winooski	M5	9	26.6
Pond Brook	T1	9	66.3
Gunners Brook	T2	7	33.1
Subtotal		*68*	*3492.8*
Total		**129**	**4299.31**

Beaver dam and pond on Herrick Brook, reach T1.S1.02; photo taken by volunteer on 8/18/06

Old Bridge abutments on Reach 28 on Winooski River in Plainfield; Photo taken by TJC

Figure 5: *North Branch Phase 1 Stream/Reach Identification Map*

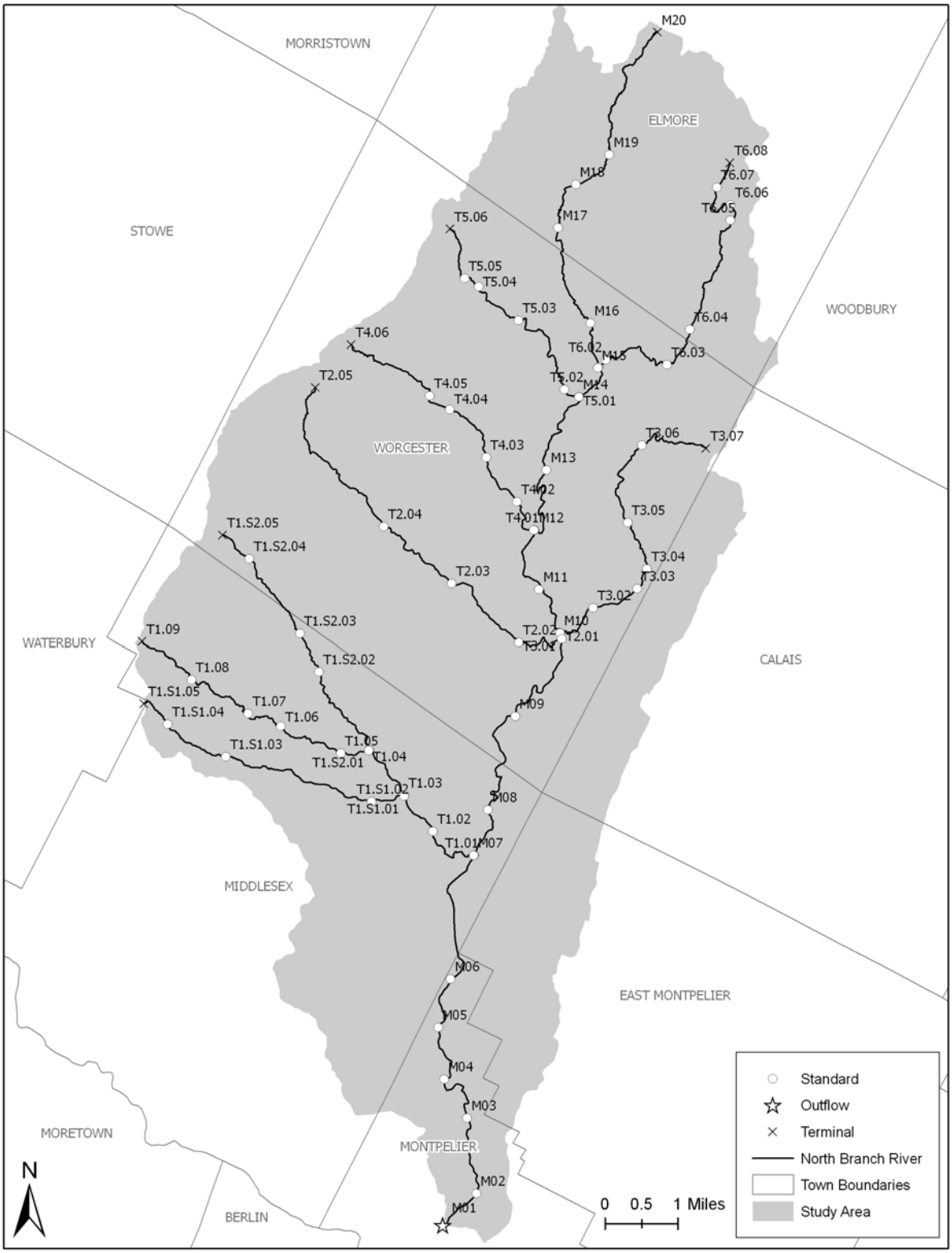
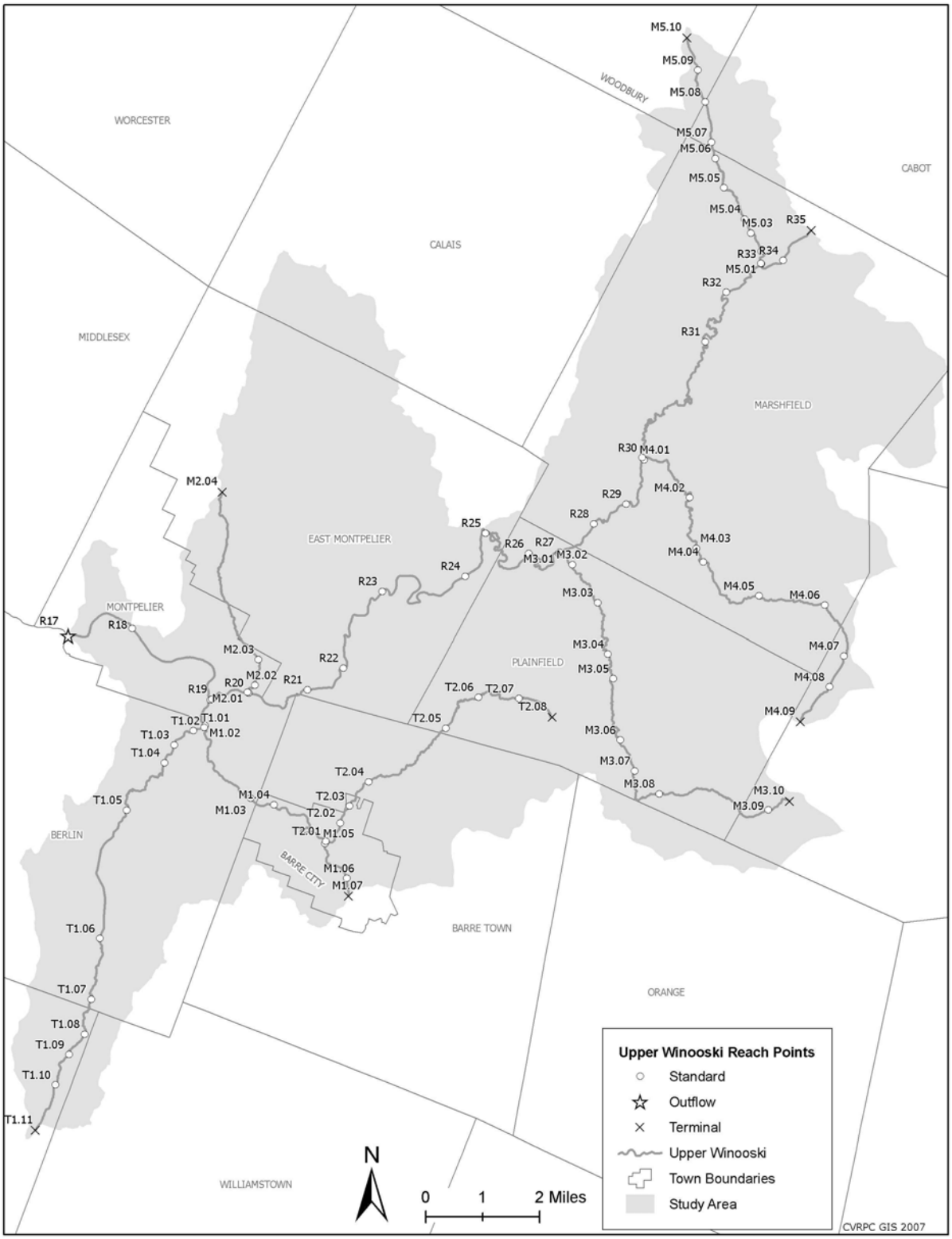


Figure 6: *Upper Winooski Phase 1 Stream/Reach Identification Map*



Stream Geomorphic Assessment Tool (SGAT) Remote Sensing, Local Knowledge and Field Verification

Over the course of the study multiple parameters and their respective impacts were calculated, assessed and inventoried. The collection of this data was done using a variety of methods including: SGAT, remote sensing, local knowledge, and windshield surveys. Table 2 is a listing of the many parameters inventoried during this process.

Table 2: Parameters Assessed in Phase 1 Process

Phase 1 Parameter	SGA Protocol Step	Phase 1 Parameter	SGA Protocol Step
Valley side slopes	3.4	Bridge and culverts	5.2
River corridor delineation	3.3	Flow regulation and water withdrawal	5.1
River corridor and reach land use/land cover	4.2	Channel modifications	5.4
Riparian buffer condition	4.3	Floodplain encroachments	6.2
Hydrologic groups	3.5	Dredging	5.5
Soils and geology influences	3.3 & 3.5	Depositional features	6.3
Alluvial fans	3.1	Meander width ratio	6.5
Grade controls	3.2	Stream wavelength	6.6
River corridor development	6.2	Debris jam potential	7.3
Bank armoring	5.3	Dominant bed form and materials	7.1

As discussed previously, the SGAT tool functions within a GIS environment using a variety of parameters. Based on computer generated code and inputs into the GIS, SGAT has the ability to calculate valley width, length, slope, channel length and slope, confinement of the stream, sinuosity and reference channel width.. Using data generated by the SGAT the reference stream type is designated. Table 3 describes the different stream types which are based on what the natural tendency of the channel would be absent of human-related modifications to the channel. Table 4 characterizes the stream type of all assessed reaches within each tributaries sub-watershed and Figures 7 & 8 show the geographical location of the stream types within the study areas.

Table 3: Reference Stream Typing Chart

Stream Type	Confinement	Channel Slope	Bed Material	Bed Form
A/Cascade	Narrowly confined	Very steep	Boulder	Tumbling jet and wake flow
B/Step-pool	Semi Confined	Steep	Cobble	Steps and channel spanning pools
B/Plane Bed	Semi Confined or Narrow	Moderate to Steep	Cobble-gravel	Lacks runs, riffles, and rapids
C or E/Riffle-pool or Dune-ripple	Narrow, Broad or Very Broad	Moderate to Gentle	Gravel or finer	Undulating
D/Braided Channel	Unconfined	Moderate to Gentle	Gravel or finer-cobble boulder	Braided

Stream Typing by Montgomery and Buffington (1997).

Table 4: Reference stream type classification in North Branch & Upper Winooski Project Areas

Stream Type	Cascade	Step-Pool/ Plane Bed	Riffle-Pool	Dune-Ripple	Unclassified	Total
North Branch						
N. Branch Winooski River	0	2	15	1	1	19
Martins Brook	3	3	2	0	0	8
Herrick Brook	3	1	0	0	0	4
Patterson Brook	4	0	0	0	0	4
Minister Brook	2	0	2	0	0	4
Worcester Brook	1	2	2	0	1	6
Hancock Brook	4	1	0	0	0	5
Catamount Brook	4	0	1	0	0	5
Hardwood Brook	0	1	4	0	1	6
Subtotal	*21*	*10*	*26*	*1*	*3*	*61*
Upper Winooski						
Winooski mainstem	0	4	6	8	0	18
Stevens Branch	0	2	4	0	0	6
Tributary 2 to Winooski	0	1	1	0	1	3
Great Brook	0	6	3	0	0	9
Nasmith Brook	0	5	2	0	0	7
Tributary 5 to Winooski	0	6	3	0	0	9
Pond Brook	1	5	1	2	0	9
Gunners Brook	0	3	1	0	3	7
Subtotal	*1*	*32*	*21*	*10*	*4*	*68*
Total						**129**

Reference Stream Type conditions on Winooski mainstem; Photo taken by TJC

Figure 7: *North Branch Reference Stream Type and Location*

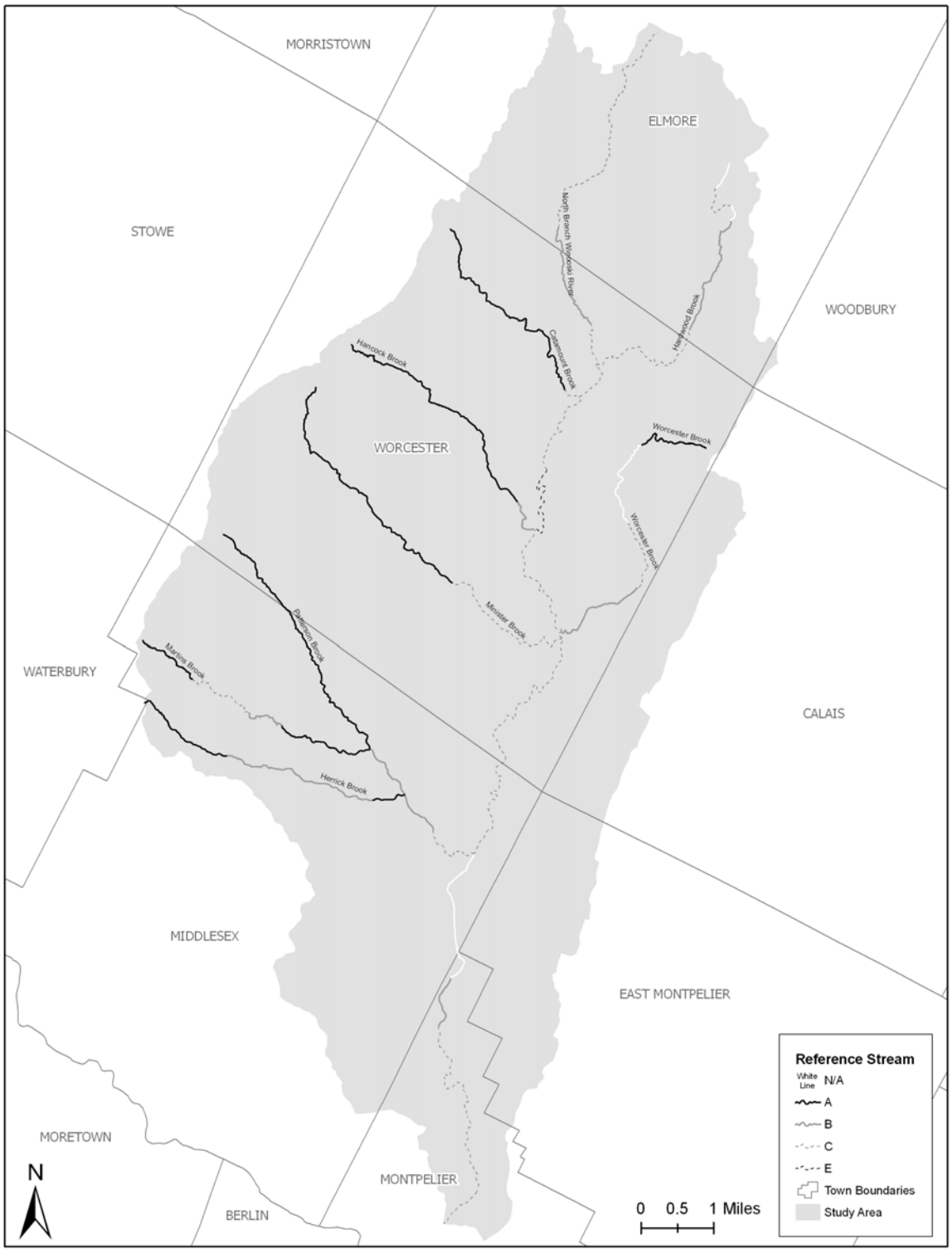


Figure 8: *Upper Winooski Reference Stream Type and Location*

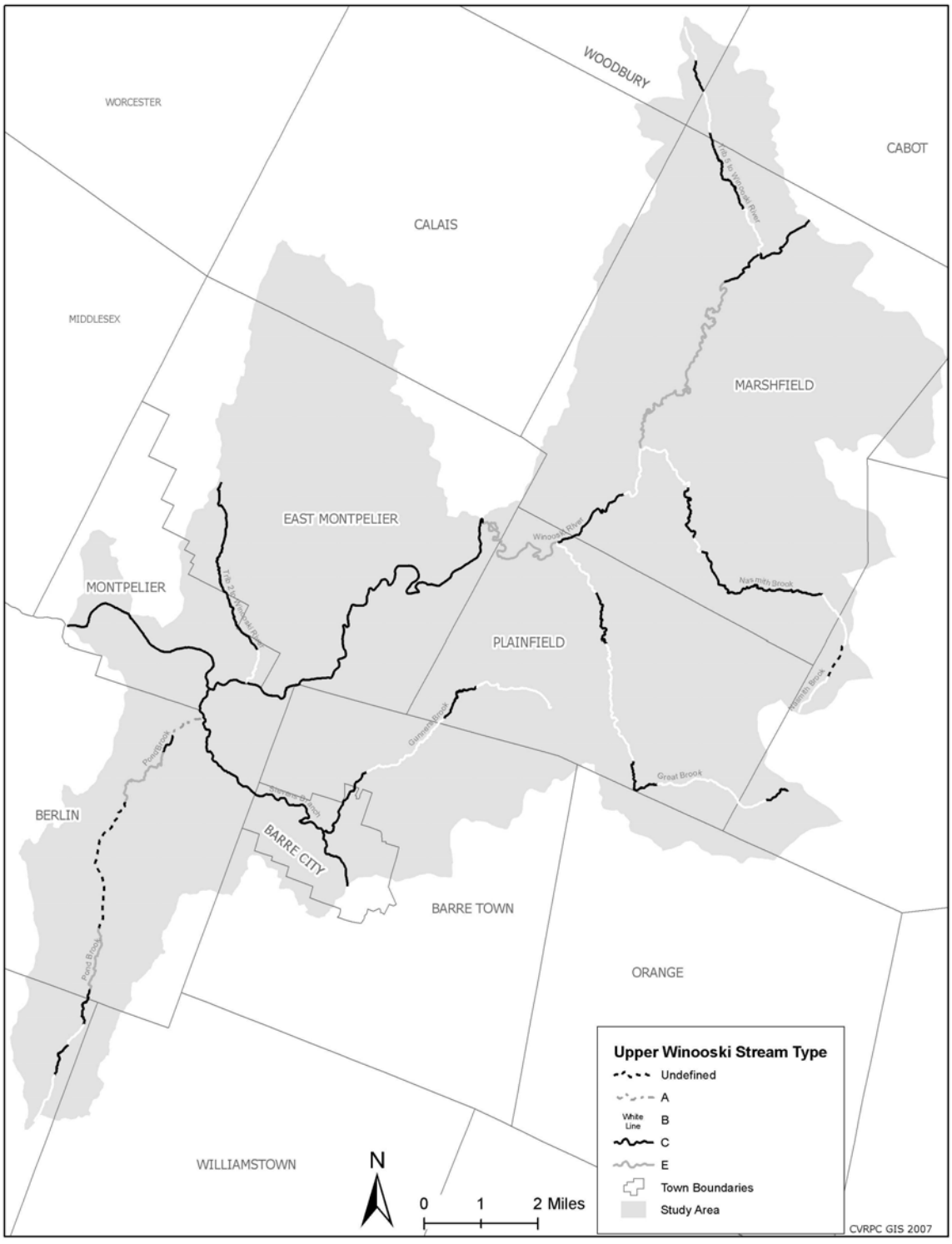


Figure 9: *Areas of Concern along North Branch*

Figure 9 illustrates modifications or human changes to the natural floodplain within the North Branch project area. Identification of Phase 1 channel modifications, such as channel straightening and dredging of the streambed, is important for understanding the holistic function of the watershed. Significant physical stream alterations in a given reach can affect how the system behaves and adjusts to the change both upstream and downstream of that activity. Infrastructure and other development restrict access to

the floodplain which results in lateral confinement. Examples of floodplain modifications and planform (view of river from above) changes studied are: Berms and roads, River Corridor Development, Depositional Features, Meander Migration, and changes in Meander Width Ratio and Wavelength Ratio. In addition to mapping areas of concern cumulative impact ratings for entire tributaries were calculated.

10 foot diameter culvert on Martins Brook, reach T1.04; photo taken by volunteer on 8/18/06

Impact Rating Methodology and Reach Results

Summary

The following areas in Phase 1 were specifically highlighted for data interpretation in the North Branch and Upper Winooski River subwatershed project areas:

Watershed Land Cover/Land Use
Corridor Land Cover/Land Use
Riparian Buffer Width
Channel Straightening
Dredging and Gravel Mining History
Depositional Features
Meander Width Ratio

Watershed Land Cover/Land Use

Lakes, wetlands, and perennial vegetation play an important role in a watershed by storing water and trapping sediment, which helps reduce flood peaks and maintain summer base flows in rivers and streams. Urban development and cropland typically increase the peak and change the duration of stormwater and sediment runoff events. SGAT extension was used to evaluate this parameter.

High Impact Rating scores indicate 10% or more of the reach watershed is in cropland and/or urban use.

Results Summary

The following reaches recorded high impact ratings for watershed land use/land cover:

North Branch	
T1.01-.06	Martins Brook
T1.S1.01 – .03	Herrick Brook
T1.S2.04	Patterson Brook
T3.01	Worchester Brook
Upper Winooski	
R17-34	Winooski River
M1.01-.06	Stevens Branch
M2.01-.03	Tributary 2 to Winooski River
M3.01-.04	Great Brook
M5.01-.03; .09	Tributary 5 to Winooski River
T1.01-.09	Pond Brook
T2.01-.07	Gunners Brook

Corridor Land Cover/Land Use

Land use/land cover within the stream corridor, is particularly important with respect to sediment deposition and erosion during annual flood events. A river corridor is the width of land in the valley through which the stream moves; the Phase 1 process considers this distance to be 8 times the channel width from the toe of the valley wall. This corridor includes land on both sides of the stream unless the stream is moving against the valley wall. The healthy river corridor provides floodplain function to attenuate floodwaters and store sediment, ice, and other debris from the watershed, protects water quality by creating roughness to slow down the power of the stream, and enables the stream to adjust in order to maintain stable, equilibrium conditions. Wetlands, ponds, and perennial vegetation moderate stormwater and sediment runoff, while impervious surfaces within urban areas and the exposed soils found in cropland have the potential to increase watershed inputs.

High Impact Rating scores indicate 10% or more of the reach corridor is crop and/or developed.

Results Summary

The following reaches recorded high impact ratings for corridor land use/land cover:

North Branch	
M01-05; 07-14; 16-18	North Branch Winooski River
T1.01 - .03	Martins Brook
T1.S1.01; .03	Herrick Brook
T1.S2.02	Patterson Brook
T2.01 - .03	Minister Brook
T3.01-.04	Worchester Brook
T4.01-.03	Hancock Brook
T6.01	Hardwood Brook
Upper Winooski	
R17-34	Winooski River
M1.01-.06	Stevens Branch
M2.01	Tributary 2 to Winooski River
M3.01-.07	Great Brook
M4.01;.03	Nasmith Brook
M5.01-.04; .06-.07	Tributary 5 to Winooski River
T1.01;.03-.04;.08-.10	Pond Brook
T2.01-.07	Gunners Brook

Streambank erosion along North Branch, Reach M9; photo taken by volunteer on 8/18/2006

Riparian Buffer Width

The riparian buffer is the area of land directly adjacent to the channel from the top of the channel's banks out into the floodplain that is covered with native woody vegetation. Riparian buffers protect and enhance water quality, fish and wildlife habitats, aesthetics, and recreational values associated with streams. Maintaining this buffer zone, in a natural unmanaged condition, impacts water quality, streambank stability, aquatic habitat, and essential wildlife corridors. Streams without riparian vegetation often experience high rates of lateral erosion and may see such large increases in sediment as they undergo major adjustment of channel dimension, pattern, and profile. Orthophotos were used to estimate the percent of each buffer width category along the right and left banks.

High Impact Rating scores indicate that 75% of the reach has little or no buffer (0-25 feet) on one or both banks.

Results Summary

The following reaches recorded high impact ratings for riparian buffer width:

North Branch	
M17	North Branch Winooski River
Upper Winooski	
R27-28	Winooski River
M1.01;.04-.05	Stevens Branch

Agricultural land use without adequate riparian buffer; reach 25 of Winooski River; photo taken by TJC

Channel Straightening

Channel straightening is the process of changing the natural path of a river through activities such as windrowing and straightening. A channelized stream may degrade, or cut down vertically into its bed and cause the channel to lose access to its floodplain. The sediment resulting from the degradation process is re-deposited downstream of the channelized area. This results in aggradation or building-up, of the channel bed in this downstream area. Aggradation can result in channel widening, bank instability, and other channel responses, most of which are detrimental to both riparian land and aquatic habitat. Interviews with natural resource professionals, and review of orthophotos and topographic maps were used to examine this parameter.

Rock rip rap bank to protect home on Martin's Brook, reach T1.03; photo taken by volunteer on 8/16/06

High Impact Rating scores indicate that greater than 20% of the reach had been channelized.

Results Summary

The following reaches recorded high impact ratings for channel modifications:

North Branch	
M01-02; 05; 09; 11-12; 16; 18	North Branch Winooski River
T2.01 - .02	Minister Brook
T4.02-.03	Hancock Brook
T6.03	Hardwood Brook
Upper Winooski	
R18-19;21-25;28-30;32-34	Winooski River
M1.01-.02;.05	Stevens Branch
M2.01	Tributary 2 to Winooski River
M3.01	Great Brook
M5.01	Tributary 5 to Winooski River
T1.01;.03	Pond Brook
T2.01	Gunners Brook

Dredging and Gravel Mining History

Dredging and mining gravel bars from a channel may initiate a channel evolution process. Such activities straighten and steepen the channel and cause the river to cut down and erode its bed. The stream channel eventually aggrades with sediment supplied from upstream reaches as head cuts in the streambed move up-valley. Information and records from DEC's Stream Alteration Engineer were used to determine the relative frequency and volume of gravel extraction.

High Impact Rating scores indicate that the reach was historically used for commercial gravel mining and/or dredged for flood remediation.

Results Summary

The following reaches recorded high impact ratings for dredging and gravel mining history:

North Branch	
M08	North Branch Winooski River
T1.01-.03; .05	Martins Brook
T2.01-.03	Minister Brook
T3.02-.03	Worchester Brook
T4.01-.04	Hancock Brook
Upper Winooski	
R20	Winooski River
M3.01-.05	Great Brook
M5.01	Tributary 5 to Winooski River
T1.01;.04	Pond Brook

Depositional Features

An unvegetated sediment bar is a sign that the bar was recently formed or is continually growing. Mid-channel bars, large unvegetated point bars, and delta bars may indicate an increased sediment load (from upstream) and the high likelihood that the streambed is actively aggrading and/or undergoing rapid lateral movement. The sediment sources for these bars may be from bank failures or the degradation of the channel upstream. It may also be from upland watershed management sources. Orthophoto interpretation and windshield surveys were used to evaluate this parameter.

Point bar development & bank erosion, Hancock Brook reach T4.01; photo taken by volunteer on 8/18/06

High Impact Rating scores indicate numerous, large unvegetated mid-channel, point and/or delta bars present.

Results Summary

The following reaches recorded high impact ratings for depositional features:

North Branch	
M04; 08; 12-14; 16-18	North Branch Winooski River
Upper Winooski	
R21,23;25-26;29-32	Winooski River
M3.02-.05;.09	Great Brook
M5.05	Tributary 5 to Winooski River
T1.04;.06	Pond Brook
T2.04	Gunners Brook

Large island development, Stevens Branch M1.01; photo taken by The Johnson Company

Meander Width Ratio

The meander belt width is the horizontal distance between the opposite banks of fully developed meanders. Unconfined, gravel-based streams in shallow-sloped valleys that are in regime have belt widths generally in the range of 5 to 8 times the width of the channel. Higher values may indicate that the stream, possibly due to an increase in fine sediment, has started to aggrade and become more sinuous, decreasing its channel slope as it migrates laterally. Lower values may indicate that the stream has become straighter and steeper, possibly degrading its bed and losing access to its floodplain. Orthophotos and topographic maps were used to determine the reach's average belt width.

High Impact Rating scores indicate the meander width ratio is less than 3 or greater than 10, well outside the 5-8 range of reaches within regime.

Results Summary

The following reaches recorded high impact ratings for meander width ratio:

North Branch	
M01-02; 04; 07; 09; 11; 13-14	North Branch Winooski River
T1.01; .07	Martins Brook
T2.01-.02	Minister Brook
T3.03-.04	Worchester Brook
T5.01	Catamount Brook
T6.01-.03; .06	Hardwood Brook
Upper Winooski	
R18;20;24-25;27;31;33-34	Winooski River
M1.01-.02;.05-.06	Stevens Branch
M2.01;.03	Tributary 2 to Winooski River
M4.04;.08	Nasmith Brook
M5.01;.09	Tributary 5 to Winooski River
T1.01;.03;.08;.10	Pond Brook
T2.02;.06	Gunners Brook

Debris jam along Catamount Brook, reach T5.02; photo taken by volunteer on 8/18/06

North Branch and Upper Winooski Impact Scores/Reach Condition

One aspect of the Phase 1 analysis is that it measures the impact that multiple factors (outlined above) have on the condition of a single reach. These cumulative impacts are compiled and then given a score, determining if the stream is in reference (ideal), good, fair or poor condition. Table 5 depicts the percentages of reaches within the two project areas that had particular impact scores. Figures 10 & 11 denote the reach scores for each reach assessed within the North Branch watershed and Upper Winooski River watershed, respectively. These reach condition scores can be used to prioritize sections for further assessment and identify areas to maintain protection or plan future restoration projects. Within the North Branch watershed, reach condition was generally found to be in reference to fair condition with some good reaches and only several sections rated in poor condition.

Table 5: Phase 1 Impact Scores in North Branch & Upper Winooski Project Areas

Phase 1 Impact Scores	
Reach Condition	***% of Reaches in North Branch Watershed***
Reference	32%
Good	13%
Fair	45%
Poor	3%
Reach Condition	***% of Reaches in Upper Winooski Watershed***
Reference	35%
Good	25%
Fair	40%
Poor	0%

Having over a quarter of the reaches in both the North Branch and the Upper Winooski assessed as in reference condition is certainly encouraging, however 45% & 40%, respectively, of the reaches assessed are impaired (fair condition) and warrant further assessment and corridor planning. Only two out of the 61 North Branch reaches assessed were found to be in poor condition. There is certainly room for improvements as the goal of river restoration is to move the watershed back towards its natural processes and a state of equilibrium.

Signs of Degradation on Reach 31Winooski River; Photo taken by TJC

Figure 10: *Reach Condition along the North Branch*

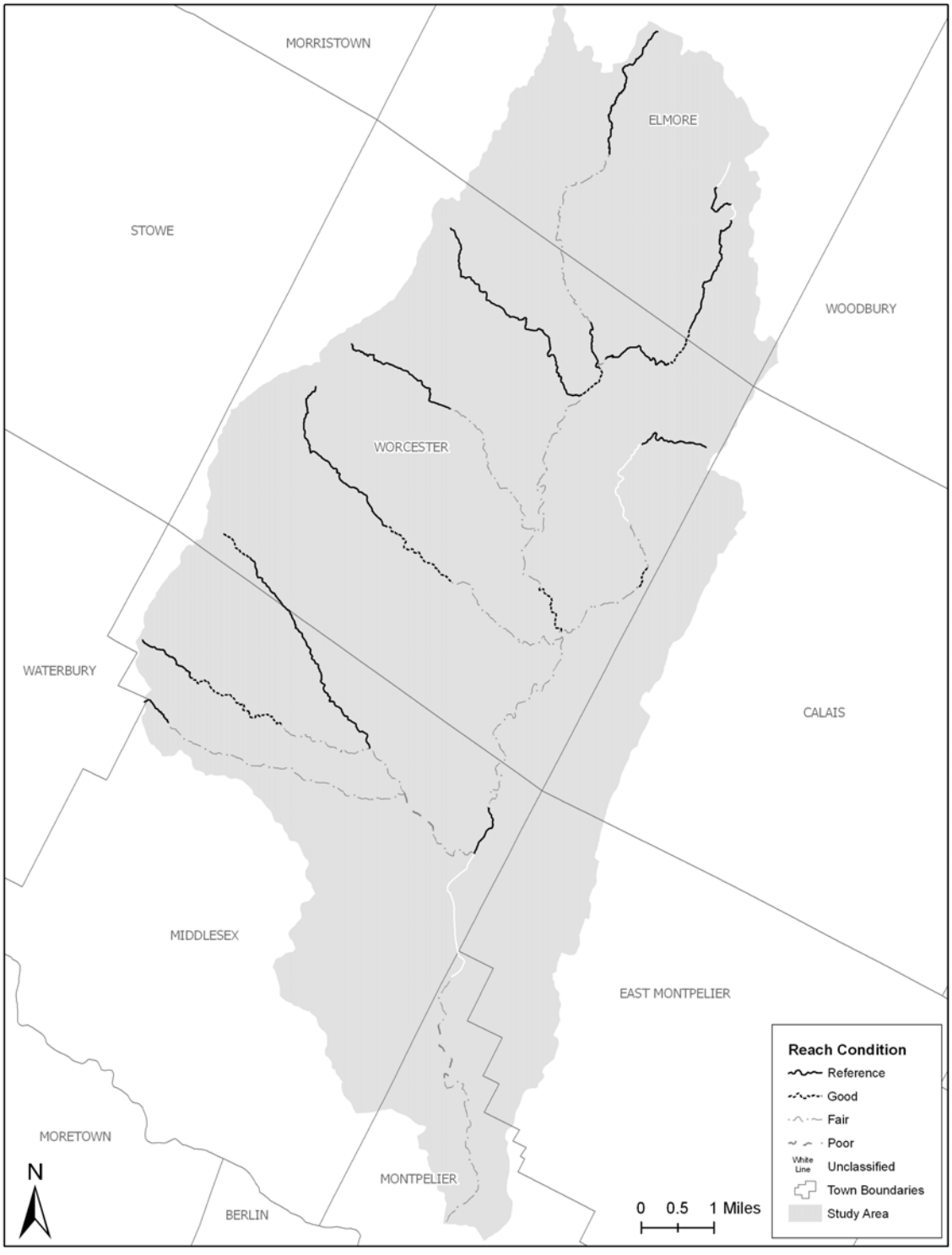
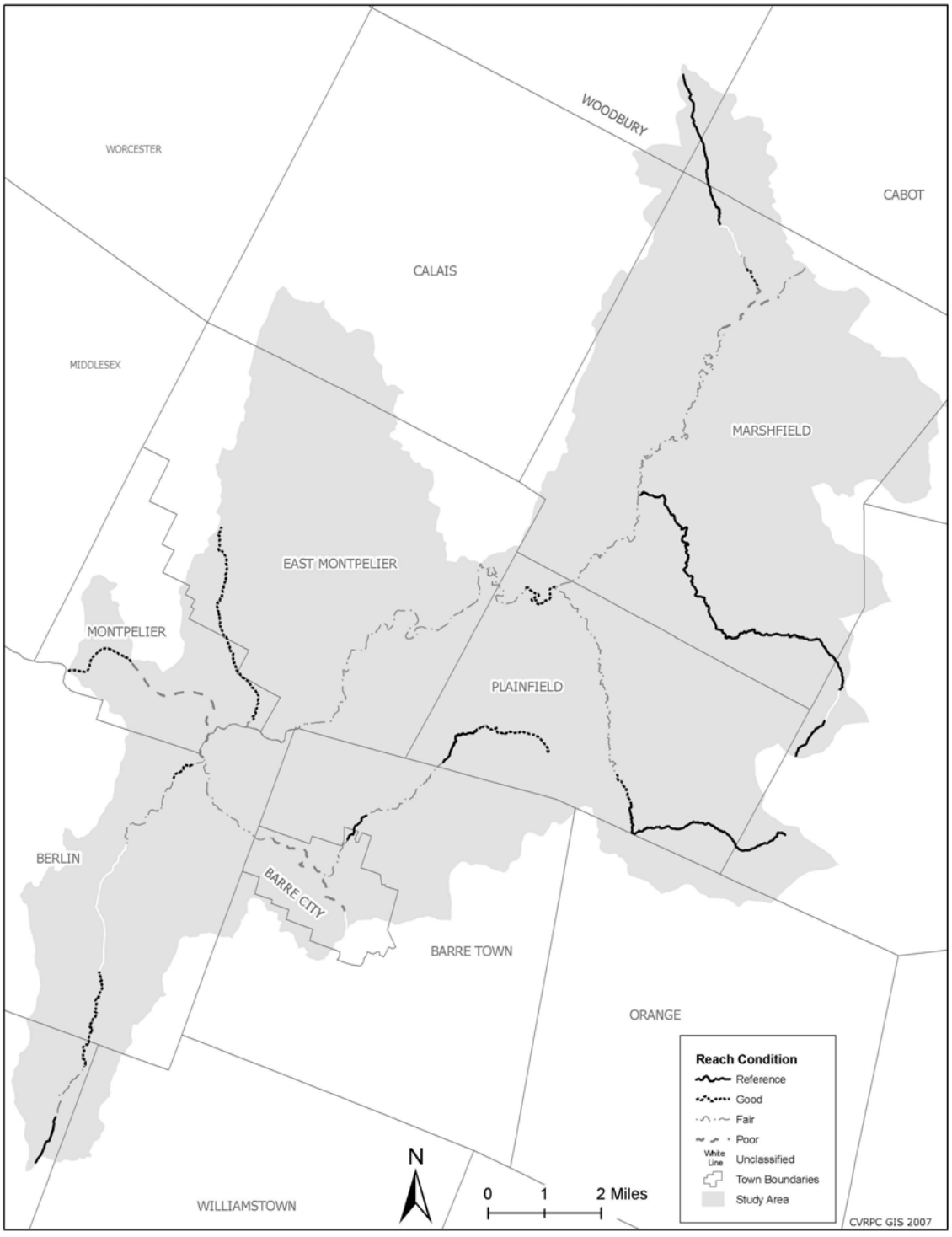


Figure 11: *Reach Condition along the Upper Winooski*



Results Discussion

The current dominant land cover for a majority of the reaches assessed in the North Branch and the Upper Winooski subwatersheds are forest. In the North Branch, the headwater tributaries originate in high forested elevations characterized by steep valley walls. These tributaries are typically step-pool and plane bed systems dominated by cobble and boulder substrate. Most of the lower (downstream) reaches are characterized by riffle-pool gravel systems that are in fair condition. It is in these lower

reaches where much of the channel modification has occurred because of their dominant urban land cover.

Overall streams with dominant land cover type of urban or crop were most highly affected. Reaches in the upper headwaters were commonly in reference or good condition. The reaches with greatest impacts were along the North Branch mainstem. This is only natural given that it is the lower tributary reaches and the North Branch mainstem which are the most heavily influenced by transportation infrastructure, urban development, channel modifications and floodplain encroachments. It remains concerning that much of the lower reaches were in fair condition and two of the assessed reaches are found to be in poor condition.

In the Upper Winooski project area, tributary headwater reaches remain in reference and good, demonstrating stable condition and only minor channel adjustments. The dominant bedforms are step-pool and plane bed dominated by cobble substrate. As land-use and human influences become more common further downstream, nearer the confluence with the main stem of the Winooski River, reach conditions are rated fair and channel adjustment processes are actively occurring. These riffle-pool, sand dominated systems are more sensitive to change. This project's section of the lower Stevens Branch and main stem of the Winooski remain consistently in fair condition, with documented channel modifications and land cover changes due to transportation infrastructure (berms and roads) and urban development (bridges and culverts) within the river corridor.

Next Steps for the North Branch Winooski Watershed Assessment

Friends of the Winooski River, Central Vermont Regional Planning Commission and Winooski Conservation District will conduct the second phase of the geomorphic assessment on priority reaches within the watershed starting in summer and ending in fall of 2007. Priority reaches were identified for the Phase 2 assessment through the evaluation of substantial high impact ratings during the Phase I process. The following reaches in Table 5 indicate the reaches to be addressed in the Phase 2 assessment:

Table 6: Prioritized reaches for Phase 2 assessment in North Branch & Upper Winooski

Reach Id	Stream Name	Towns	Length in Miles	Impact Total
		North Branch Subwatershed		
M08	North Branch Winooski River	Middlesex, Worcester	1.97	12
M09	North Branch Winooski River	Worcester	1.71	14
M10	North Branch Winooski River	Worcester	0.87	7
M11	North Branch Winooski River	Worcester	1.05	15
M12	North Branch Winooski River	Worcester	1.42	13
M13	North Branch Winooski River	Worcester	1.36	12
M14	North Branch Winooski River	Worcester	0.58	10
M15	North Branch Winooski River	Worcester	0.73	3
M16	North Branch Winooski River	Elmore, Worcester	1.62	12
T2.01	Minister Brook	Worcester	0.85	15
T2.02	Minister Brook	Worcester	1.38	12
T2.03	Minister Brook	Worcester	1.41	8
T3.01	Worcester Brook	Worcester	0.71	9
T3.02	Worcester Brook	Worcester	0.70	10

T3.03	Worcester Brook	Worcester	0.34	10
T3.04	Worcester Brook	Worcester	0.80	9
T4.01	Hancock Brook	Worcester	0.61	8
T4.02	Hancock Brook	Worcester	0.82	9
T4.03	Hancock Brook	Worcester	0.95	12
T6.01	Hardwood Brook	Worcester	0.21	11
M01	North Branch Winooski River	Montpelier	0.65	16
M02	North Branch Winooski River	Montpelier	1.17	15
M03	North Branch Winooski River	Montpelier	0.95	11
M04	North Branch Winooski River	Montpelier	0.91	18
M05	North Branch Winooski River	Montpelier	0.78	18
M07	North Branch Winooski River	Middlesex	0.75	10
M17	North Branch Winooski River	Elmore	0.83	11
M18	North Branch Winooski River	Elmore	0.72	14
T1.01	Martins Brook	Middlesex	0.95	12
T1.02	Martins Brook	Middlesex	0.68	13
T1.03	Martins Brook	Middlesex	0.86	10
T1.03	Martins Brook	Middlesex	0.86	10
		Upper Winooski Subwatershed		
R18	Winooski River	Montpelier	2.4	23
R19	Winooski River	Montpelier	0.77	19
R22	Winooski River	East Montpelier	1.94	18
R25	Winooski River	East Montpelier	2.27	22
R28	Winooski River	Marshfield	0.87	18
R29	Winooski River	Marshfield	1.17	18
R30	Winooski River	Marshfield	3.94	21
R31	Winooski River	Marshfield	2.02	20
R32	Winooski River	Marshfield	0.89	22
R33	Winooski River	Marshfield	0.51	21
R34	Winooski River	Marshfield	0.81	19
M1.01	Stevens Branch	Montpelier	0.55	23

These reaches will be the focus of the Phase 2 Rapid Geomorphic and Fisheries Habitat Assessments. This second phase of assessment will field verify data collected at the remote sensing level of the first assessment using in-stream quantitative criteria to determine fisheries habitat health and stream stability. The results of this assessment will be used to direct water quality improvement projects throughout the Upper Winooski and North Branch subwatersheds. Current stream conditions and types of instability will provide the basis for the alternatives analysis and a prioritization of restoration reaches and restoration strategies within the basin. Reaches identified as reference streams will be targeted for additional protection.

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