Ball Mountain Brook Watershed
Stream Geomorphic Assessment Phase 1and Phase 2 Report
Summer 2004, 2005

Windham County Natural Resource Conservation District
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December 9, 2005

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Acknowledgements

The Windham County Natural Resources Conservation District (Windham County NRCD), and its partners, the West River Watershed Alliance (WRWA) and the Windham Regional Commission (WRC) would like to thank the Vermont Department of Environmental Conservation (Vermont DEC) for awarding the EPA Clean Water Act Section 319 funding, along with its River Management Division and the Connecticut River Joint Commissions for their financial and technical support of the 2004-2005 Ball Mountain Brook stream geomorphic assessment (SGA) project. A special thanks goes to Jeff Nugent, Geographic Information Systems (GIS) specialist with the WRC for creating our GIS database and interfacing with the State's SGAT program. We would also like to thank the town officials of Jamaica, Stratton, and Winhall for their cooperation and assistance with landowner contact and permissions.

Completion of Phase 1windshield surveys, mapping, and research would not have been possible without the conscientious participation of several hardy WRWA volunteers including Kath Martin, Fred Hard, Del Ames and Polly Wilson, and Marie Levesque Caduto. WRWA also provided the services of Program Manager Clay Houston and Intern Mike Euphrat to assist with both Phase 1 and Phase 2 field efforts and data management tasks.

Our grateful thanks also extends to professional SGA consultants, Mary Nealon, Amy Sheldon, and Lisa Godfrey for providing their expert services to complete the Ball Mountain Brook Phase 2 field work, data management, and final report.

Em Richards
Watershed Coordinator,
Windham County NRCD
November 2005

Acronym List

WCNRCD - Windham County Natural Resources Conservation District
WRWA - West River Watershed Alliance
WRC - Windham Regional Commission
VT ANR DEC – Vermont Agency of Natural Resources Department of Conservation
SGA - Stream Geomorphic Assessment
GIS – Geographic Information System
GPS – Global Positioning System
DMS – Data Management System (Developed by the DEC)
SGAT – Stream Geomorphic Assessment Tool
RIT – Reach Indexing Tool
RGA – Rapid Geomorphic Assessment
RHA – Rapid Habitat Assessment
LWD – Large Woody Debris
QA/QC – Quality Assurance/ Quality Check

1.0 Introduction to the Project

The Windham County Natural Resources Conservation District (Windham County NRCD) watershed-based Stream Geomorphic Assessment project was implemented to address erosion occurring in Ball Mountain Brook and its tributaries. Ball Mountain Brook was selected as the focus for the Windham County NRCD's stream assessment efforts for several reasons: 1) A recent non-point source pollution stream assessment report prepared by the Windham Regional Commission (WRC) has identified and assessed 14 significant erosion sites along this stream.[1] 2) Stratton Mountain Corporation, via its water quality master plan, is already addressing sediment impacts to certain stream segments included on the state's 1998 Section 303(d) list. These segments are located in the upper reaches of Ball Mountain Brook and have been affected by increased resort development. Styles Brook, North Branch Brook below Stratton Lake, and several small tributaries are among those targeted for remediation.[2] 3) Rosgen classifications and preliminary physical assessments had been conducted on these Stratton Mountain sub watershed stream sections thus providing a better understanding of the river processes in these sections. 4) Information garnered from the Stratton Mountain projects and from the WRC assessment can be used to make more informed decisions by local and regional officials on where stream bank stabilization should occur along Ball Mountain Brook.

Project Rationale

Sedimentation resulting from instability of stream channels and the resulting channel adjustment processes can generally be traced to anthropogenic sources, such as developments within active floodplains (including dwellings, roads, and bridges), channel management activities (including gravel mining, bank armoring, dredging and channelization), removal or suppression of vegetation in the riparian zone, and changes in watershed hydrology, such as increased stormwater runoff or water diversions. The interactions of these various land uses and their effects on a watershed or river system can be complex, and require thorough evaluation of the many factors through a watershed-wide assessment, in order to achieve effective solutions to water quality impairments.

Reduction of total sediment load, protection and restoration of aquatic and riparian habitats, and enhancement of recreational values is dependent in part upon identification of the root causes of channel instability. The field data-supported determination of the departure from natural reference conditions for a number of morphological attributes is essential to the identification of solutions to stream instability problems and will support justification for allocating resources to address sediment loading and other channel adjustment related stream morphology problems.

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[1] West River Tributaries Non-Point Source Pollution Stream Assessment Report, January 1998. Prepared by the Windham Regional Commission.

[2] Stratton Master Plan, Water Quality Remediation Plan. May, 1999. Prepared by Pioneer Environmental Associates, LLC.

Assessment Overview
The in-stream geomorphic and fisheries habitat Phase 1 and Phase 2 assessments, created by the VT Agency of Natural Resources Department of Environmental Conservation (DEC) River Management Division, provide complete and integrated informational database and summary reports regarding current stream conditions and types of instability within the Ball Mountain Brook watershed that is necessary for landowners, volunteer organizations, and towns to develop, prioritize and implement restoration and corridor protection measures.

The Agency of Natural Resources' (ANR) stream geomorphology assessment protocols have been used to identify and inventory locations of erosion in the Ball Mountain Brook watershed, determine the potential sources of instability, and offers to prioritize stream segments for watershed restoration efforts. Results of the GIS Phase 1 assessment identified potential sources of significant erosion, inventoried anthropogenic disturbances, delineated sub-watershed boundaries, developed stream reaches, and calculated stream and valley conditions. The Phase 2 of the assessment field verified Phase1 data collected at the remote sensing level using in-stream evaluation criteria. During Phase 2 fisheries habitat health and current channel adjustment process were evaluated quantitatively on 26 stream reach sites on the Ball Mountain Brook and major tributaries.

The results of these assessments are stored in a web-based Data Management System (DMS) developed by the VT ANR. The data in the DMS can be queried for various attributes that will eventually prioritize future protection and restoration projects. Volunteers have participated in the field assessments; gaining knowledge about the data collected and providing local knowledge.

General goals of stream geomorphic assessments include:

- Increase awareness of stream processes.
- Identify apparent channel condition and adjustment process.
- Provide an information base for planning restoration or management activities.
- Provide data for flood and erosion hazard mapping

Phase 1 of the Stream Geomorphic Assessment Phase 1 delineated the 33.7 square mile watershed, identified 39 distinct reaches, and collected remote sensing data such as slopes, stream type, land use, riparian buffers, soils, channel and flood plain modifications. This data provided an overall picture of the watershed and how the stream processes are adjusting to historical and current stream alterations. Based on reference stream types, hydrological conditions, and stream sensitivity determinations, Phase 1 observations helped to pinpoint areas where more detailed information would be gathered in Phase 2.

A Phase 2 SGA was a method used to look at factors that may be affecting stream and habitat condition, potential stressors, and apparent channel adjustment processes, based on field data and observation. Data from a Phase 2 SGA are useful tools for watershed planning, conservation planning, or planning passive geomorphic restoration projects. However, a more detailed study (Phase 3) of any particular reach or area is recommended before undertaking any active restoration or active management actions. Collecting more detailed baseline data and establishing monitoring programs, including passive restoration and conservation, would be valuable to track results of a project and adapt as necessary. Data from the assessment were provided to the VT

DEC River Management Program to add to their web-based Data Management System (DMS) of Vermont watersheds.

During August and September 2005, Phase 2 assessments were conducted on 20 reaches of Ball Mountain Brook and its major tributaries. The 2005 study results augment Phase 2 data collected on 6 reaches during the fall of 2004. Through these stream assessments, the Windham County NRCD has increased its knowledge of channel conditions, adjustment, and evolution. Such information can now be provided to landowners, towns, the state, and community members. Analysis from this assessment can also be used to guide town planning and zoning in and near the river and riparian areas, to identify high risk areas and areas in need of restoration or management. This information base can also be used as an educational tool to help improve land use practices in the watershed and limit losses of infrastructure, houses, agricultural land and habitat, and reduce sedimentation and nutrient loading.

The following report compiles and details work from both the Phase 1 and Phase 2 Stream Geomorphic Assessments (SGA) of Ball Mountain Brook and its tributaries. Phase 2 assessments were conducted on main stem reaches as well as on the North Branch, West Hill tributary, Dalewood Road tributary, Kidder Brook, Styles Brook, Brazens Brook, and Sunbowl Brook (Figure 1). The assessments were completed in 2004 and 2005 by the Windham County NRCD and subcontractors. Figure 1.0 presents the GIS mapping of the reaches surveyed as part of the Phase 1 and Phase 2 assessments in Ball Mountain Brook watershed.

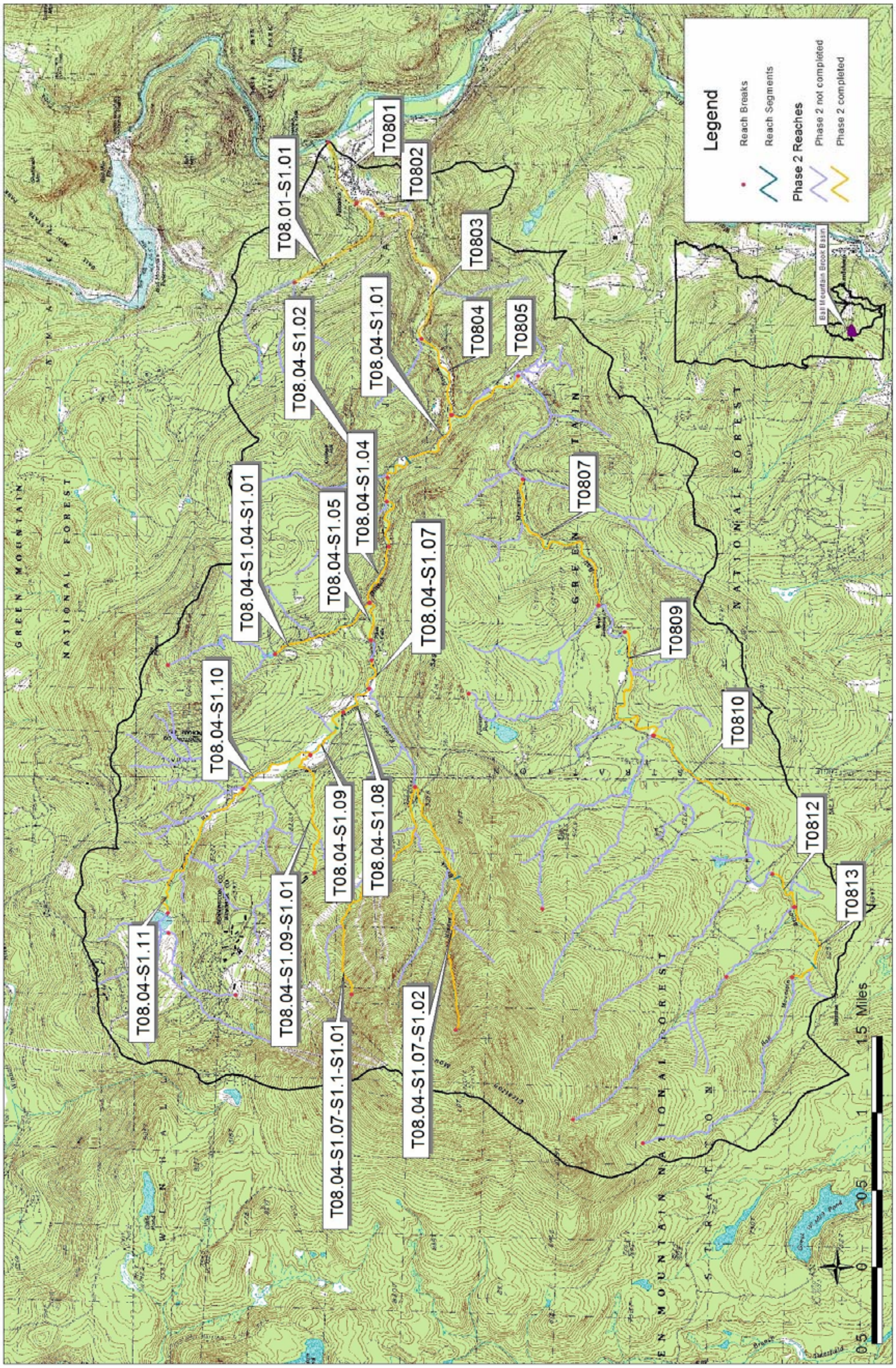

Figure 1.0 GIS topographical map of designated stream reaches in the Ball Mountain Brook watershed

2.0 Historical Background

Ball Mountain Brook and its tributaries flow through the towns of Stratton, Jamaica, and Winhall in south central Vermont. The historical small towns have had several mills, dams, and other structures along the streams. Many stream channels were straightened, bermed, dredged, and otherwise altered to maximize usable land.

Deforestation of most of the state occurred in the late 1700s to mid 1800s for farming and herding. With the loss of agriculture and family farms in the area over the last century, much of the land formerly cleared has grown up with secondary forest. Historical roads have been rerouted, bridges have been taken out and the population has focused towards the town villages.

Over the last half century, more development in the stream corridors has taken place along both branches of the stream and around the Stratton Mountain Ski area. New and continuing residential and resort developments are occupying the upper watershed as the area attracts winter sport enthusiasts. Currently most of the land cover is forested, with the most concentrated urban development in the stream corridor areas of Jamaica village and Stratton Mountain

3.0 Assessment Methods

Phase 1 Methods
Between December 2003 and July 2005 data and information about the Ball Mountain Brook watershed were collected by trained community volunteers, Windham County staff, professional consultants hired by the Windham County NRCD and GIS specialists from the WRC. Methods are outlined in the Vermont Agency of Natural Resources, Stream Geomorphic Assessment Phase 1 Handbook, April 2005 edition. The following Phase 1 tasks were completed with training and technical assistance from the Vermont DEC River Management Division:

- Delineated and numbered 39 stream reaches within the watershed
- Created GIS maps of watershed showing reach boundaries
- Reviewed orthographic photos, topographic maps
- Conducted windshield survey of each reach filling out field data sheets
- Photographed and mapped features and conditions at each site
- Compiled data in SGAT database and State DMS
- Submitted data for State DEC quality control check
- Generated Phase 1 reach reports

<u>Phase 1 Database Development</u>
Developed by the State to facilitate data analysis, data calculations and measurements, the State's ArcView extension, SGAT database is operated by a series of steps. The database steps identify types of information needed to determine the condition and sensitivity of the stream reaches within the watershed. In following this "step-by- step" system for the Ball Mountain Brook assessment, information was entered that identified general location information, valley characteristics, (valley slope, valley width, and the degree to which the stream is confined), geology and soils data, land cover, use, hydrology, and instream channel and floodplain modifications. Most of the data entered into the database was gathered from remote sources, such

as topographic maps and orthographic photos. A windshield survey was conducted to obtain preliminary data as well as to check the calculated data against real situations (ground-truthed).

Phase 1 Quality Control
Data were reviewed and updated to reflect existing conditions. The SGAT program automatically populated database tables that were then imported into the State's Phase 1 DMS. The DMS calculated the sensitivity and impact rating for the individual stream reaches. State DEC Quality Assurance staff reviewed the data on-line for quality control purposes.

Phase 2 Methods
Similar to Phase 1 methods, the VT DEC Stream Geomorphic Assessment Protocols (SGA Protocols) (VTANR, April 2005) were used exclusively to conduct the Phase 2 Assessment. Adhering to the State's SGA Protocols, Windham County stream scientists completed the following tasks during the Ball Mountain Brook Phase 2 SGA:

- Obtained permission from landowners along study reaches before performing the assessment along their segment of river;
- Field checked reaches and types identified in Phase I and segmented or modified as necessary;
- Walked the length of each reach to map features and evaluate conditions;
- Collected GPS points of channel features and data locations;
- Photographed and mapped reaches and segments;
- Identified natural and artificial features of the channel and adjacent valley (watershed zone, channel constraints, floodplain terrace, valley slope, habitat barriers);
- Measured channel dimensions, bankfull and flood elevations and depths, width-to-depth ratio, entrenchment ratio, riffle-step distribution, substrate size and verify stream typing;
- Evaluated stream banks, buffer strips, and riparian corridor;
- Documented flow modifiers such as impoundments, springs, wetlands, drainage ditches, constrictions, and condition of the upper watershed;
- Identified evidence of channel bed and planform changes;
- Conducted a Rapid Habitat Assessment (RHA) using the RHA field form developed by VT ANR;
- Conducted a Rapid Geomorphic Assessment (RGA) using the RGA field form developed by VT ANR;
- Entered all data into ANR Stream Geomorphic Assessment Data Management System.

Please refer to the Vermont DEC River Management Section website for more information about the protocols and methods at:
http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm.

Phase 2 Quality Control
The VT ANR Protocols were followed exclusively in conducting the Phase 2 SGA. The project's primary investigator had completed the required Phase 2 training conducted by personnel from the Vermont DEC River Management Division. As part of the VT DEC Quality Control program for stream geomorphic assessments, a member of the VT DEC's River Management Division, Shannon Hill, observed assessment procedures in the field to assure the Protocols were followed

appropriately. All data entered into the States DMS have been reviewed as part of the quality control program.

As part of the Windham County NRCD's project Section 319 requirements, a Quality Assurance Project Plan (QAPP) for the Ball Mountain Brook SGA was submitted to the Vermont Agency of Natural Resources Department of Environmental Conservation, and the U.S. Environmental Protection Agency, Region 1 Office. In compliance with the QAPP, a QA/QC Checklist for Data Entry Reduction and Analysis, Internal Q/A Audit information, and Map, Sketch & Photo Documentation, Data Sheets, Field Forms are kept on file in the Windham County NRCD office in Brattleboro, VT.

Rapid Habitat Assessment

The RHA is useful in determining the ability of a given reach to support aquatic biota, the extent to which a given reach is impaired, and the potential factors affecting habitat. Two separate RHA forms are generally used in the Phase 2 Assessment, one for low gradient streams and one for high gradient streams. Parameters evaluated in the Ball Mountain Brook RHA are summarized as follows:

- Presence of a variety of substrate types suitable for aquatic insect colonization and cover for fish, reptiles and amphibians;
- Degree to which gravel, cobble and boulder particles are surrounded by fine sediments.
- Type of bed material in pools;
- Presence of a variety of water speeds and depths to include fast-shallow, fast-deep, slow-shallow, and slow-deep;
- Variety of pool sizes to include large-shallow, large-deep, small-shallow, small-deep;
- Increase in sediment deposition on the channel bed or bars;
- Degree to which the channel bottom is exposed, reference being minimal channel bed exposed;
- Extent of channel alteration including dredging, straightening, berms, or riprap;
- Frequency of riffles or steps along the channel length;
- Channel sinuosity or degree of channel meandering;
- Amount of bank erosion;
- Amount and types of bank vegetation;
- Width of naturally vegetated riparian buffer.

Please refer to the VT ANR Protocols for more on the RHA (VTANR, April 2005).

Rapid Geomorphic Assessment

The RGA is useful in evaluating current stream processes, departures from a reference condition, and stages of channel evolution for a given reach. Three separate RGA forms are used in the Phase 2 Assessment, one for unconfined streams, one for confined streams, and one for naturally occurring Plane-Bed streams. Parameters evaluated in the Ball Mountain RGA are summarized as follows:

- **Degree of channel degradation or incision** (sharp changes in slope, measured incision and entrenchment ratios, loss of riffle-pool characteristics, floodplain encroachment, historical channel or flow alterations).
- **Degree of channel aggradation** (filling of pools, loss of riffle-pool characteristics, mid-channel or diagonal bars, increases in fine sediments, high width-to-depth ratios, flow alterations, sediment deposition upstream of constrictions).

- **Degree of channel widening** (high width-to-depth ratios, scour on both banks at riffles, mid-channel or diagonal bars, historical channel or flow alterations).
- **Change in channel planform** (bank erosion on outside meander bends, flood chutes or channel avulsions, mid-channel or diagonal bars, additional deposition and scour features, floodplain encroachment, sediment deposition upstream of constrictions).

Refer to the VT ANR Protocols for more on the RGA (VTANR, April 2005).

According to protocols, once a RGA is completed and a "condition" category selected, a stage of channel evolution is selected. One of two channel evolution models can be used; either the F-stage model or the D-stage model.

In the F-stage model, a channel loses floodplain access either by undergoing degradation or a floodplain build-up (Stage II), due to a disturbance. This degradation is typically followed by channel widening (Stage III), then aggradation and planform adjustments (Stage IV), before then regaining stability with regard to its water and sediment loads (Stage V).

In the D-stage model, aggradation, widening, and planform changes are the main adjustment processes, with degradation being limited, sometimes by resistant bed material or grade controls. The D-stage process can include moderate entrenchment and loss of bed features (Stage IIb), channel widening (Stage IIc), bed aggradation, bar formation (Stage IId), and regaining a balance similar to reference condition (Stage III). Please refer to the VT ANR Protocols Appendices for more information on channel evolution models (VTANR, April 2005). Refer to GIS maps in Appendix B for the dominant adjustment processes in Ball Mountain Brook.

Parameters for the Ball Mountain Brook RGA and RHA were scored and assigned to the correlating "condition" category describing departure from a reference condition and degree of adjustment (VTANR, April 2005) as follows:

- Reference – Reaches in dynamic equilibrium, having stream geomorphic processes and habitats found in mostly undisturbed streams.
- Good – Reaches having stream geomorphology or habitat that is slightly impacted by human or natural disturbance, showing signs of minor adjustment, but functioning for the most part.
- Fair – Reaches in moderate adjustment, having major changes in channel form, process or habitat.
- Poor – Reaches experiencing extreme adjustment or departure from their reference (expected) stream type or habitat condition.

In some cases, where a score lies at one end limit of a category, the condition category that best described the reach was be selected. Please refer to the GIS maps in Appendix B for a visual representation.

A "Stream Sensitivity Rating" was then generated for each reach or segment according to stream type and geomorphic condition. The range of sensitivity ratings includes: very low, low, moderate, high, very high, extreme. These indicate the sensitivity of a reach or segment to ongoing disturbance or stressors.

Bridge and Culvert Assessment
Bridge and Culvert Assessments along Ball Mountain Brook and its tributaries were also performed according to the VT ANR Protocols. Bridges and culverts crossing study reaches were assessed and field data entered into the VT ANR Data Management System. Data from these assessments can be used to guide planning for bridge and culvert maintenance or replacement. Refer to the VT ANR Protocols for more on Bridge and Culvert Assessments (VTANR, April 2005).

Planning and Management Strategies
Current fluvial geomorphic research promotes a process-based approach, focusing on restoring the ecological functions of impacted rivers and streams which can then create aquatic habitats in a self-maintaining cycle (Ward et al. 2001). Identifying and addressing factors that limit stream processes is critical to this process so that a natural balance that creates and maintains habitats and geomorphic functions can be restored.

Stream reaches evaluated in this study present a variety of management options. Many of the reaches have been actively managed at some point in the past, or continue to be managed, for varying reasons. Some reaches have not had a history of active management, however may be reacting to watershed changes associated with deforestation, flooding, or changes in flow or sediment load.

Management alternatives for each reach were analyzed and classified under one of the following categories: Active Management, Conservation, Passive Geomorphic Restoration, and Active Geomorphic Restoration.

Active management implies that whatever the current management practices are of a particular reach, they are expected to continue in the short term due to the presence of infrastructure. (i.e. dams will be maintained, dredging will continue, straightening, berms, and riprap will be maintained, roads and buildings will be protected). Under current management practices, these reaches are likely to persist in their respective conditions and stages of channel evolution (the channel evolution process cannot occur if management activities act to keep the channel in its current state). As funding sources for flood-related repairs become more limited, continued active management becomes more costly to towns.

Conservation is an option to consider when stream processes that create and maintain habitats are mostly intact and the stream is in a state of dynamic equilibrium. Such areas of stream would benefit from protection. Some reaches may be candidates for conservation due to their relatively good instream and riparian habitat quality. Such reaches are shown in the assessment to be in reference or good condition and may be undergoing minor adjustment.

Passive restoration removes the factors adversely impacting a reach, such as a dam or continued dredging, and allows the channel to progress to dynamic equilibrium where it regains balance with respect to flow and sediment load. Truly passive restoration, where no actions are taken to change conditions, is an option for some reaches. Other reaches may benefit from varying degrees of actions that could be taken to speed the process. In these reaches, a passive restoration approach could include establishment of a riparian buffer, allowing woody vegetation to colonize the riparian buffer, move land uses such as mowing or grazing outside the buffer, move berms, or reduce sediment inputs.

Active restoration implies physical alteration of the channel to a geometry or state that has been calculated to be sustainable by the channel to improve stream and/or habitat condition. Active restoration can also include such projects as habitat restoration projects, and biotechnical bank stabilization (such as installation of root wads, brush revetments, or bank planting).

4.0 Assessment Results

Phase 1 Summary of Results

Phase 1 of the Ball Mountain Brook Stream Geomorphic Assessment is a general overview of the condition of the watershed, providing background information and reference for the more detailed Phase 2 Assessment.

For each of the 39 designated reaches observed in the Ball Mountain Brook watershed, “reference” stream types were calculated using the Agency of Natural Resources’ DMS (online database) and SGAT ArcView extension. Following established procedures, reference stream types were determined based on the characteristics of the surrounding valley, geology and climate of the stream. Given these considerations, there were five possible reference stream types present in this watershed. See Table 1 for descriptions.

In general Ball Mountain Brook fell into two stream types, B and C. The main stem of Ball Mountain Brook was primarily C, and the North Branch was primarily B. These stream types mean that the stream varies in confinement, or valley type, from “confined” or “semi-confined” to “unconfined” with valley slopes ranging from steep to gentle, refer to Table 2a and 2b.

Topographic maps of the area indicate that valley bottom is narrow with much steeper slopes along the reaches of the North Branch than those along the main stem. The physical characteristics of A and B stream types that contribute to keeping these streams cold and well-oxygenated are their narrow, steep valleys, which are typically still forested, since these valleys are often unsuitable for other land uses. The narrow valley helps shade the stream, and the forest cover slows runoff, shades the ground surface, and enhances groundwater recharge, all of which contribute to cold water temperatures in the stream. In addition, steep, confined valleys result in stream bed forms that are more turbulent (cascades and steps) which, along with cold water temperatures, result in well-oxygenated water. A “C” type stream typically has a gentler gradient and would flow more slowly and thus be wider and warmer. These differences in stream types represent changes in habitat and therefore different species can be expected to be found in each type, with only a few overlapping.

Table 1 Phase 1 – Reference stream typing chart

Reference Stream Type	Confinement (Valley Type)	Valley Slope	Bed Form
A	Narrowly confined (NC)	Very Steep > 6.5 %	Cascade
A	Confined (NC)	Very Steep 4.0 – 6.5 %	Step-Pool

B	Confined or Semi-confined (NC, SC)	Steep 3.0 – 4.0 %	Step-Pool
B	Confined or Semi-confined or Narrow (NC, SC, NW)	Mod.- Steep 2.0 – 3.0 %	Plane Bed
C or E	Unconfined (NW, BD, VB)	Mod.- Gentle < 2.0 %	Riffle-Pool or Dune-Ripple
D	Unconfined (NW, BD, VB)	Mod.- Gentle < 4.0 %	Braided Channel

Source: VTANR April 2005 Phase 1 Handbook

Table 2a Phase 1 Summary of stream types for Ball Mountain Brook

All Reaches					
Stream type	A	B	C	D	E
Number present	2	17	19	0	1
Percentage of the total (39 reaches)	5.13	43.59	48.72	0	2.56

Table 2b Phase 1 Summary of stream types for the two main branches

Main Stem					
Stream type	A	B	C	D	E
Number present	1	2	11	0	0
Percentage of the total (13 reaches)	7.14	14.28	78.57	0	0

North Branch					
Stream type	A	B	C	D	E
Number present	1	15	8	0	1
Percentage of the total (25 reaches)	4	60	32	0	4

Soils and Geology

The stream types also give a general idea of how that section of the stream functions. How it transports material, and how it moves is affected by the local geology and soil types present. The geology determines the source material for any sediment that the stream carries. Streams in areas that are dominated by surficial geology such as glacial till have a tendency to be more erodible than areas dominated by bedrock. This creates a much more sensitive watershed that can react to changes in the stream conditions over very short periods of time.

The geology in the Jamaica/Stratton/Winhall area is primarily glacial till, with little bedrock exposed. This material was deposited by glaciers and is not particularly stable. This yields soils that are also highly erodible. There are four general soil types in the Ball Mountain Brook watershed.

<u>Houghtonville-Rawsonville-Mundale</u>

This soil is the most abundant in the watershed. The majority of the Houghtonville is found on the lower slopes of Stratton Mountain and the surrounding knolls where the headwaters of the Ball Mountain Brook Main Stem and its tributaries is. Generally formed in loamy glacial till on mountains and hills, all three soil types are the common around the stream reaches.

Houghtonville characteristics:

- Found on the slopes of mountains, hills and knolls around the watershed
- Unsuitable for development and forest management due to the steep slopes it is found on, and erosion hazards

Rawsonville characteristics

- Found beneath the Houghtonville soils on the summits, shoulders and backslopes of hills and mountains.
- Unsuitable for development due to slope, depth to bedrock, erosion hazard and equipment limitation.
- Difficult forest management due to windthrow hazards and equipment limitations

Mundale characteristics:

- Found on shoulders and back slopes of mountains and hills
- Steep to very steep, well drained and stony
- Unsuitable for dwellings or forest management due to slope, and erosion hazard

<u>Colton-Adams-Podunk</u>

Found in only two areas of the watershed, at the confluence of Ball Mountain Brook and the West River and possibly in the upper reaches of the North Branch in Bennington County. This soil group is more characteristic of glacial outwash areas and stream terraces.

Colton characteristics

- Found at the mouth of Ball Mountian Brook
- Limitations on sites for dwellings due to poor filtering capacity for septic systems, soils readily absorb effluent and risk ground water contamination.

<u>Worden-Wilmington</u>

This soil group is found in the upper reaches of Ball Mountain Brook's main stem. Formed in compact glacial till on hills and in depression areas, it follows the brook in the valleys for a large portion of the upper watershed. More of the Worden soil is found in this area than the Wilmington soil.

Worden characteristics:

- Found along the upper reaches of Ball Mountain Brook's main stem towards Grout Pond on concave side slopes of hills and ridges
- Windthrow is a hazard for forest management due to high water table and low soil permiability

- Slope and seasonal high water table are the main limitations to dwelling construction. If there is construction, additional waterproofing measures should be considered

Another soil that is found in the valleys is the Monadnock fine sandy loam. It is a deep soil, well drained and moderately steep. The main limitations for development are due to steep slopes.

<u>Stratton-Glebe-Londonderry</u>

Found on most of Stratton Mountain, this soil group is present in most of the headwaters of Ball Mountain Brook, the North Branch and their tributaries. The group forms two soil types on the Mountain.

Londonderry-Stratton complex characteristics:

- Found on the summit of Stratton Mountain
- Forest management concerns are erosion hazards, equipment limitation due to slope, soils, and windthrow hazards.
- Unsuitable for dwellings due to slope and depth to bedrock

Stratton-Glebe complex characteristics:

- Found on the upper slopes of Stratton Mountain
- Forest management concerns are erosion hazards, equipment limitation due to slope, soils, and windthrow hazards.
- Unsuitable for dwellings due to slope and depth to bedrock

Soils along the edge of the watershed in the upper reaches of Ball Mountian Brook and the North Branch around Stratton Mountain are shallow soils or are found on steep slopes. Soils like the Londonderry-Stratton complex, or the Stratton-Glebe complex are the most prone to erosion, and if unprotected can affect the length of the streams with excess amounts of sediment. Other soils may appear more stable in gentle grade slopes, but under steeper conditions can prove just as erodible. Soils that are saturated due to the depth of the water table have the ability to heave in winter conditions and become unstable under rainy or wet conditions. Please refer to Table 3 for a summary of reaches most prone to erosion hazards. For further information please refer to the Soil Survey of Windham County Vermont.

Table 3 – Erodible Reaches

Reach number	Soil type	Erosion Susceptibility
Upper reach of Ball Mountain Brook main stem T0814	Stratton-Glebe/Mundale	High Erodibility (soil depth)
Upper reach of Ball Mountain Brook main stem T0813	Worden	High Water Table
Upper reach tributary of Ball Mountain Brook main stem T0812-S1.01	Colton	High Erodibility (steep slope)
Upper reach tributary of Ball Mountain Brook main stem T0812-S1.02	Stratton-Glebe/Mundale	High Erodibility (soil depth)
Ball Mountain Brook tributary T0809-S1.01	Worden	High Water Table
Kidder Brook T08.04-S1.07-S1.02	Stratton-Glebe/Houghtonville	High Erodibility (soil depth)

Kidder Brook T08.04-S1.07-S1.01	Rawsonville/Houghtonville	High Erodibilty (steep slope)
Sun Bowl Brook T08.04-S1.07-S1.01-S1.01	Rawsonville/Worden	High Erodibility (steep slope) High Water Table
Dalewood Road T08.04-S1.04-S1.01	Mundale/Houghtonville	High Erodibilty (steep slope)
Dalewood Road T08.04-S1.04-S1.02	Rawsonville/Mundale	High Erodibility (steep slope)
Brazen's Brook T0804-S1.09-S1.01	Houghtonville/Worden/Mundale	High Erodibility (steep slope) High Water Table

Due to the severe erodibility of the material in the watershed it can be expected that events such as heavy rains, uncontrolled runoff and flooding can have a serious impact on the stream and the surrounding area. There are natural systems that exist to minimize erosion, however. Types of land cover, land use and other hydrologic features can help to control sediment loss where erosion is considered a hazard. SGA Phase 1 assessed the land cover and reach hydrology in the watershed and stream corridors.

Areas of the watershed where there is large amounts of construction occurring will impact the stream the most. The upper reaches of the North Branch have seen the sharpest increase in development over the last fifty years. The large scale clearing of forest has increased the potential for erosion of the shallow soils in this area.

Phase 2 Results

Table 4 presents results for each reach assessed in the Phase 2 SGA. Included in the table are the reach number, habitat condition category from the RHA, geomorphic condition category from the RGA, stream sensitivity rating, and management recommendations. **More detailed reach by reach description and Phase 2 analysis for the Ball Mountain Brook main stem, North Branch reaches, and Ball Mountain tributaries is presented in Appendix A. For visual representation of the Geomorphic and Habitat Conditions please refer to the corresponding GIS maps in Appendix B.**

Table 4 Summary of results of Phase 2 Stream Geomorphic Assessment

Reach Number	Geomorphic Condition	Stream Sensitivity Rating	Habitat Condition	Recommendations
T08.01 Ball Mountain Brook	Poor, Stream Type Departure	Extreme	Fair	Active Management with potential for active restoration such as stream bank planting.
T08.02 Ball Mountain Brook	Poor, Stream Type Departure	Very high	Fair	Active Management with potential for active restoration such as stream bank planting.
T08.03 Ball Mountain Brook	Poor, Stream Type Departure	Extreme	Fair	Active restoration to reduce velocities and improve habitat.

Reach Number	Geomorphic Condition	Stream Sensitivity Rating	Habitat Condition	Recommendations
T08.04 Ball Mountain Brook	Poor, Stream Type Departure	Extreme	Good	Active restoration to reduce velocities such as increasing sinuosity and creating floodplain.
T08.05 Ball Mountain Brook	Fair	High	Good	Conservation through corridor purchase, conservation easements, etc.
T08.07A Ball Mountain Brook	Fair, Stream Type Departure	Very high	Fair	Active restoration to reduce channelization and associated impacts could improve geomorphology and habitat.
T08.07B Ball Mountain Brook	Fair	Very High	Good	Active restoration to reduce channelization and associated impacts could improve geomorphology and habitat.
T08.09 Ball Mountain Brook	Good	High	Good	Passive restoration to allow channel meandering. Active restoration if faster results and more control of the restoration desired. Explore opportunities to reduce fine sediment inputs.
T08.10 Ball Mountain Brook	Good	High	Good	Active restoration to decrease slope and reduce velocities, improve riffles and improve diversity of habitat.
T08.12	Fair	High	Good	Active restoration to increase riffle frequency and habitat condition and reduce bank erosion.
T08.13A Ball Mountain Brook	Good	High	Fair	Passive restoration to continue adjustment and achieve equilibrium.
T08.13B[3] Ball Mountain Brook	N/A	N/A	N/A	Conservation to protect habitat and stream corridor. Management of the culvert and potential culvert enlargement to reduce channel constriction.
T08.04-S1.01A North Branch	Poor, Stream Type Departure	Extreme	Fair	Active restoration to improve habitat, frequency of riffles, and bank stability while protecting road infrastructure.
T08.04-S1.01B North Branch	Fair	High	Good	Active restoration such as moving berms to allow channel to continue adjustment and achieve equilibrium.
T08.04-S1.02 North Branch	Poor, Stream Type Departure	Very high	Good	Active restoration to reduce velocities and improve habitat. Explore opportunities to reduce stressors to this reach such as increased sediment loads and increased velocities from upstream.

[3] Segment contains beaver dams and a large pond, therefore some parameters not assessed according to the VT ANR Protocols (VTANR, April 2005).

Reach Number	Geomorphic Condition	Stream Sensitivity Rating	Habitat Condition	Recommendations
T08.04-S1.03 North Branch	Poor, Stream Type Departure	Extreme	Good	Passive restoration to allow channel to continue adjustment and reach equilibrium. Monitoring recommended to protect nearby houses and the road. Reducing incoming stressors from upstream could alleviate pressures.
T08.04-S1.04 North Branch	Poor, Stream Type Departure	Extreme	Good	Passive restoration to allow channel to reach equilibrium. Active restoration if faster results, reduced sediment inputs, and more control of the restoration desired.
T08.04-S1.05 North Branch	Poor, Stream Type Departure	Very high	Good	Passive restoration to increase habitat value from improved riffle frequency and substrate diversity.
T08.04-S1.07 North Branch	Fair	High	Fair	Active restoration could improve habitat and channel condition while protecting road and house infrastructure.
T08.04-S1.08 North Branch	Good	Moderate	Good	Passive restoration to improve habitat and stream condition. Active restoration if faster results and more control of the restoration desired.
T08.04-S1.09 North Branch	Good	High	Good	Conservation to protect habitat and stream corridor.
T08.04-S1.10 North Branch	Fair	Very high	Fair	Active restoration through establishment of a wooded riparian corridor and increasing channel sinuosity.
T08.04-S1.11 North Branch	Fair	High	Good	Passive restoration to allow adjustment processes to continue. Explore steps to address sediment and flow inputs from upstream and overland sources to relieve pressures on this reach and downstream.
T08.01-S1.01 West Hill Trib.	Good	High	Fair	Active management due to proximity of Rte. 30. Active restoration such as pool creation and reduction of fine sediment inputs from road and development to improve habitat.
T08.04-S1.04-S1.01 Dalewood Road Trib.	Fair	High	Fair	Involve community to reduce storm runoff and sediment inputs to the stream before attempting in-stream restoration.
T08.04-S1.07-S1.02A Kidder Brook	Fair	High	Good	Segment is in National Forest; continue conservation to protect habitat and the stream corridor.

Reach Number	Geomorphic Condition	Stream Sensitivity Rating	Habitat Condition	Recommendations
T08.04-S1.07-S1.02B Kidder Brook	Good	Very Low	Reference	Segment is in National Forest; continue conservation to protect habitat and the stream corridor.
T08.04-S1.07-S1.01-S1.01A Sun Bowl Brook	Fair	Low	Good	Further investigation recommended to determine the source of the sediments, the condition of the culvert at the Sun Bowl Lodge and the reasons for moving the channel at Mountain Road in order to make management recommendations.
T08.04-S1.10-S1.01 Styles Brook	Poor	Very High	Good	Examine opportunities to address increased sediment and flow inputs from the watershed.
T08.04-S1.09-S1.01A Brazen's Brook	Reference	High	Reference	Conservation to protect the stream corridor and habitat.
T08.04-S1.09-S1.01B Brazen's Brook	Good	Moderate	Good	Conservation to protect stream corridor and habitat. Addressing flow and sediment input alterations could alleviate factors contributing to degradation.
T08.04-S1.09-S1.01C Brazen's Brook	Fair	Extreme	Fair	Active restoration to reduce effects of sediment and flow inputs. Examine opportunities to address increased sediment and flow inputs.

Accompanying GIS maps found in Appendix B show the distribution of stream condition (Figure 2.0), channel adjustment process (Figure 3.0), and habitat condition (Figure 4.0) for study reaches and segments throughout the watershed.

5.0 Watershed-Wide Observations

The lower reaches of Ball Mountain Brook and the North Branch appeared to be dominated by large particles (cobbles and boulders) with almost no fines. The fast-deep velocity depth pattern was missing for most of the watershed. Large Woody Debris was scarce in most reaches, and attributed to lack of woody riparian vegetation. The establishment of wooded riparian buffers along all reaches where feasible is highly recommended.

Major flow alterations from upstream included a run-of-river dam and additional runoff from snow making activities. The extent of these alterations was unknown at the time of assessment due to limited access. Further investigation is highly recommended to help determine potential effects on the channels and possible strategies to minimize such. Moderate incision and erosion seen in the watershed could be historical from deforestation or flooding or from increased runoff from development and snowmaking. It was difficult to determine exact sources without further investigation.

Large inputs of fine sediments entered the system from roads and developments in the watershed. Residential and recreational development existed in the upper watershed of the North Branch and development continues in many areas. Working with landowners and developers to minimize effects of these developments is important in improving and protecting the health of the watershed and downstream reaches. Employing steps to reduce increased flow and sediment inputs to the channels is recommended.

Adjacent roads confined many reaches. Opportunities for restoration of planform or floodplain in these reaches are therefore limited; measures taken to mitigate effects of the roads however, could benefit stream and habitat conditions.

Restoration of upstream reaches can alleviate pressures on downstream reaches and an upstream-to-downstream approach to project implementation is recommended.

6.0 Discussion

Human-related Impacts on Stream Habitat and Geomorphology
Unmitigated development results in higher peak storm runoff rates, lower water retention for summer base flows, less buffer for filtering sediment, nutrients and chemicals. New development often requires increased numbers of stream crossings – bridges and culverts, which if not constructed with adequate flow allowances, constrict channel flows and/or floodplain flows.

Some reaches in the Ball Mountain watershed have been straightened (channelized) in order to maximize tillable land or build roads. Channelization refers to alterations in a river channel including: widening and deepening, straightening, levee construction, bank stabilization, and vegetation clearing (Brookes, 1988). As summarized by Brookes (1988) channel straightening leads to increased channel slope, resulting in increased velocities, bed and bank erosion, increased sediment loads, increased flooding, downstream sedimentation, and decreased water quality.

Hortle and Lake (1983) studied the distribution and abundance of fish in channelized and unchannelized sections of the Bunyip River, Victoria. Number of fish species, total biomass of fish, and total numbers of fish were significantly higher in unchannelized sections than in channelized sections. Hortle and Lake (1983) found that effects of channelization were loss of fish habitat (woody debris, bank vegetation, pools) and a change in channel form from relatively shallow and wide with low velocities to narrow and deep with higher velocities. In this case of the Ball Mountain Brook watershed, many reaches have also undergone widening, resulting in wide and shallow channels with high velocities.

Meandering of a channel creates complex habitats such as pools, undercut banks, gravel point bars, and supplies LWD. Creation of these complex habitats is limited or eliminated when the channel is stabilized. When a channel meanders, pools form on the outside of the bends and point bars form on the inside (Kondolf, 1996). As the channel erodes the outside bank, it also creates an overhanging bank that fish and other species use for cover. Straightening channels, as seen in many of the reaches, eliminates channel meandering and thereby important instream habitat.

Importance of Maintaining Natural Features

Features such as wetlands and forest cover across a watershed help to moderate and reduce storm water and sediment runoff by acting as areas of storage during times of high rainfall. This also holds true within the stream corridor where areas of vegetation are maintained. In areas of development, be it residential or farmland, maintaining a vegetated or riparian buffer along the stream also helps to prevent erosion. Root systems of trees, grasses and other vegetation in these areas help to maintain the stream banks and allow them to withstand erosion during high flow events. In areas where the riparian buffer has been removed, lateral erosion occurs more easily, increasing the sediment load of the stream and forcing it to potentially undergo large adjustments over time.

Recent research has demonstrated the importance of large woody debris (LWD) for instream habitat to create fish habitat, shape pools and bars, provide cover, and act as substrate for microorganisms and invertebrates (Cederholm et al., 1997; Connolly and Hall, 1999; Crispin et al., 1993). Lack of woody riparian vegetation, as seen in the North Branch reaches and lower reaches of Ball Mountain Brook, translates to a lack of habitat-enhancing LWD in the channel; if there are no trees on the banks, they cannot fall into the channel as LWD.

Flood Erosion Hazards

Flooding is one of the most common natural hazards in Vermont. The damage caused by rapid changes in the stream channels is called fluvial erosion. The Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program have regulations that cover damage caused by inundation, but very little specifically for fluvial erosion.

As mentioned above, man-made changes, such as straightening and channelization change reach hydrology. Although the floodplain modifications are often planned for vertical and lateral confinement of flood waters, these often result in increased the power and speed of a stream flow. This increased energy during periods of high flow is often magnified beyond the systems capability to counter and control flooding. Unfortunately, we now know that these efforts create more fluvial erosion and facilitate stream degradation and costly shoreline damage.

Results from Phase 1 and Phase 2 Stream Geomorphic Assessments directly contribute to the Fluvial Erosion Hazard mapping program now underway by the Vermont DEC's River Management Division. These GIS maps would be used to assess potential flood hazard risk and provide communities located in the Ball Mountain Brook watershed effective planning tools to address new construction and development issues within floodplains.

Planning for the Future

Reaches assessed in this project are undergoing channel adjustment related to both current and historical land use and channel management practices. Many of these reaches are highly to extremely sensitive to ongoing disturbances. Proactive planning and implementation now can reduce future disturbances and conflicts with the streams limiting damage to land and infrastructure during flood events.

For example, increased impervious surface area could lead to increased storm runoff and peak stream flows (Dunne and Leopold, 1978). This can result in further stream adjustments such as bank erosion, widening, and channel migration, all contributing to sediment and nutrient loading of the West River. In planning for developments, likely increases in percentage of impervious surfaces and resulting stormwater runoff created by the developments should be considered and proactively addressed. Development greatly affects runoff amounts and therefore erosion, sedimentation, and changes in channel dimensions (widening, incision, migration). Facilities to reduce increased runoff and collect sediment, such as detention ponds, sediment basins, rain gardens, and cisterns should be recommended.

Recognizing an appropriate buffer width (which depends on stream characteristics such as stream type, valley setting, soil type, etc.) and allowing woody vegetation to return can alleviate bank erosion and improve stream and riparian habitat.

Undersized bridges and culverts, and those poorly aligned with stream channels, can result in erosion, outflanking, loss of infrastructure, reduced wildlife passage, backup of flood waters, reduction of floodplain function, and debris jam catchers. As bridges and culverts require replacement, sizing new structures according to bankfull and flood-prone widths and placing them in proper alignment with stream channels can alleviate these problems.

7.0 Next Steps

Planning:

- Under the guidance of the State DEC Basin Planner, develop a collaborative effort between town government officials, road maintenance departments, local agencies, and riparian landowners, helping further the work to protect both community and stream resources.

- Town officials with assistance from State DEC technical experts using SGA report information, select and plan projects that protect or restore the floodplain, the stability of the river and the riparian habitat.

- Planning Commissions consider the development of a watershed-wide stream corridor management section within the town plan. Such a guideline can help direct land use and watershed planning and assist in emergency management planning.

Funding:

- The WRWA, Windham County NRCD, and State DEC to work with town officials, to investigate available funding sources for specific projects.
  Consider such sources as:
    - Connecticut River Joint Commissions
    - US Forest Service Challenge Grants
    - Municipal Grants

Section 319 Funding
NRCS WHIP program funding

Implementation:

- VT DEC to incorporate data from this assessment into a Fluvial Erosion Hazard Mapping of the area, a new program of the VT ANR River Management Division. (Use information to bolster and support funding applications)
- VT DEC Watershed Coordinator provide coordination and technical assistance for project implementation

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Glossary of Terms

Aggradation – The build up of sediment in a streambed.

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

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

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

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

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

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

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

Floodprone width – The area outward from the channel that is at an elevation that could be inundated by a flood.

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

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

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

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

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

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

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

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

Rosgen classification – A widely used method for classifying streams based on common patterns in stream and channel morphologies

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

Appendix A

Reach by Reach Summary and Analysis

Ball Mountain Brook Main Stem
North Branch Reaches
Ball Mountain Tributaries

Reach by Reach Summary: Ball Mountain Brook

TO8.01 – Ball Mountain Brook

Historical degradation led to stream type departure from C riffle-pool to F plane-bed and a "poor" condition rating. The channel appeared entrenched, over-widened and straightened with riprap and berms present in many areas. Aggradation of large particles (cobbles) was present throughout the channel with no organized bars. The channel appeared to be in Stage II of the F stage channel evolution process. This was shown by lost access to floodplain, bankfull discharges now contained within the channel, and an increase in channel slope through straightening. As a consequence the channel has taken on a plane bed form. The stream sensitivity to ongoing disturbance or stressors was rated as "extreme."

The habitat in this reach was assessed in "fair" condition with all parameters rated fair except where less than 25' of riparian buffer was observed, resulting in a "poor" condition for that parameter. Embeddedness was rated "good" due to the large particle sizes and lack of fines.

Two bridges were assessed in this reach. Both of them had sediments accumulating upstream. Both of the structures were intact. Bats and birds were noted inside the upstream structure. Neither structure appears to constrict the channel or the flood-prone width, however the channel did not appear to have floodplain access at this time due to entrenchment.

This is an important reach to the community. It is the most developed reach in the watershed and it is also the largest, in terms of watershed size. It provides recreational opportunity to residents, including a beautiful swimming hole. Channel spanning bedrock provides grade control at the up stream end of the reach, in the swimming hole area.

This reach is near the center of Jamaica Village. Infrastructure and houses near the channel make it a likely candidate for active management through continued channelization. Reducing potential future stressors to the stream including reduction of upstream sediment loading and limiting flow alterations could reduce future conflicts. Opportunities for bank planting along this reach to improve habitat condition should be investigated.

T08.02 – Ball Mountain Brook

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

This reach experienced a stream type departure from a C type to an F Plane Bed with cobble substrate. Degradation, widening, and planform adjustments were marked as "Historic" on the field sheets. The channel adjustment processes narrative indicates incision, widening, and aggradation are the current adjustment processes. The overall stream condition was "poor" and the reach was rated as "very highly" sensitive to ongoing disturbance. Historical encroachment, straightening, and confinement by roads and development are noted, which is similar to T08.01.

Habitat for the reach was assessed in “fair” condition. Vegetated riparian buffer width was low. Riffles were noted as being infrequent and one velocity depth pattern was missing. Channelization occurred on most of the reach, removing habitat, and there was little variety of channel substrates.

This reach is near the center of Jamaica Village. Infrastructure and houses near the channel likely will spur continued active management of this reach. Reducing potential future stressors to the stream including reduction of upstream sediment loading and limiting flow alterations could reduce future conflicts. Opportunities for bank planting along this reach to improve habitat condition should be investigated.

T08.03 – Ball Mountain Brook

Historical degradation has led to stream type departure from C riffle-pool to F plane-bed and a “poor” condition rating. The reach appeared to be over-widened and entrenched. Aggradation of large particles with some braided sections and reduction of flood-prone width through berming has led to minor plan form adjustment. Flood chutes and bank erosion on outside bends were noted. There was one head-cut through what could be flood-related sediment. Upstream of this there was a 20’ high 75’ long eroding bank on the left bank. There was one mass failure on an upper bank, which could be contributing sediment. There was an avulsion at the up stream end of the reach. The channel appeared to be in Stage III of the F stage channel evolution process. The stream sensitivity rating for this reach was “extreme.”

Habitat was assessed in “fair” condition for this reach. There was little riparian buffer, especially on the left bank and few substrate types were present for epifaunal colonization and fish cover. Aggradation of large particles, as seen here, is better for habitat than accumulations of fines; however, water does not fill the channel.

There was one bridge in this reach and it was both a channel and flood-prone constriction. It had aggradation in the form of a steep riffle observed up stream and a scour pool downstream. Over all the structure was intact and in good shape.

This reach is defined by berming, historic degradation, and a human-caused change in the valley type from unconfined to confined (by berms) with floodwaters contained within the channel. The road was adjacent to the stream for the majority of the reach. There was a swimming hole at the down stream end of the reach and a few bedrock outcrops.

This is a good candidate for active geomorphic restoration as some road and house infrastructure was present along the reach, confining the channel in areas. Restoration here could help reduce stream velocities entering the village of Jamaica. Riparian planting could help increase habitat value and protect the banks. Another recommendation is to monitor the steep riffle (possible headcut) noted in the reach (see project shape files).

T08.04 – Ball Mountain Brook

Historical degradation has led to stream type departure from C plane-bed to F plane-bed and a “poor” condition rating. There was evidence of old erosion and undercut trees with little “active” erosion. The stream appears historically widened and degraded. Current stream adjustment processes appear to be aggradation and planform. The reach appears to be in Stage III (widening, with minor aggradation and planform, although difficult to pinpoint due to berm, riprap and road impacts) of the F stage adjustment process. The stream sensitivity rating for this reach is "extreme."

Berming was prevalent throughout the reach. There was one island and one area of bedrock that provided a nice swimming hole. There was a steep riffle upstream of a bedrock outcrop, signaling aggradation. There was one left bank gully and berms and riprap along sections of both banks.

Habitat was assessed in "good" condition overall. Less than 25' of riparian buffer was observed on the right bank. A fast-deep velocity/depth pattern was missing along this reach as well as most of the reaches in the watershed. Channel flow status was low for this reach, with the riffle substrate being mostly exposed. In-stream habitat appears impacted by the presence of riprap. There were a few pools in this reach.

There were two bridges in this reach. The downstream bridge appears to constrict the channel, with sediment accumulating upstream and scour downstream. The upstream bridge appears to constrict the flood-prone width and has scour below it. If the channel avulses at either bridge, the stream will likely follow the road. Both bridges appear new and in good shape.

This is also a candidate for active geomorphic restoration, again due to the presence of infrastructure. Opportunities exist for creation of floodplain areas and increased sinuosity in this reach and could be explored to decrease channel slope and velocities entering Jamaica village.

T08.05 – Ball Mountain Brook

This reach did not appear entrenched, remaining a C Riffle-pool stream type. It appeared to have widened historically with the current adjustment process being planform with minor aggradation, (stage IIc of the D-stage channel adjustment process). There were several islands, flood chutes and abandoned channels. This reach was assessed in "fair" condition and as being "highly sensitive" to present and future stressors.

Habitat was assessed in "good" condition with woody debris, snags and undercut banks and all four velocity/depth patterns present. Diversity of habitat appears better than the downstream reaches. There was little channelization present. Riffle substrates were still mostly exposed with some bank erosion. The right bank had 25-50' of riparian buffer. The reach generally had floodplain access but some areas did not.

There were no bridges or culverts in this reach.

This reach is upstream of the confluence with the North Branch and the watershed above it is primarily in the National Forest. Houses and camps on the right bank have encroached into the riparian zone. This could be a good candidate for conservation through corridor purchase.

T08.07A and B – Ball Mountain Brook

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

Segment A

Segment A is assessed in “poor” condition due to a stream type departure from a C to an F type. Channel alterations in the form of dredging and straightening and a change in valley type were noted. Mid channel and side bars were noted. Steps were assessed as incomplete and the channel dominated by run areas. The channel appears to have incised historically, with current adjustment processes being major aggradation, widening and planform. The sensitivity rating for the segment is “very high.”

Habitat was assessed in “fair” condition. Sediment deposition, exposed channel substrate, channelization, bank instability, and limited steps are factors affecting the habitat condition.

Active restoration to reduce channelization and associated impacts could improve geomorphology and habitat while protecting road and house infrastructure.

Segment B

Extensive channel alterations in the form of straightening, dredging, and windrowing were noted. The segment appeared incised and over widened and appeared to be moving back and forth through flood chutes. Steps were limited and runs dominated the channel. The segment has experienced a stream type departure from a C to a B Plane-Bed type.. Side bars and islands were noted. The segment was assessed in “fair” condition and “very highly sensitive” (using the sensitivity rating for a C type channel) to ongoing disturbance.

Habitat was assessed in “good” condition. Sediment deposition, exposed channel substrate, channelization, and limited steps were factors affecting the habitat condition.

Active restoration to reduce channelization and associated impacts could improve bed variability and habitat while protecting the road and houses.

T08.09 – Ball Mountain Brook

This reach appeared “in regime”, remaining a C riffle-pool stream type with a gravel bed. Minor planform adjustments were noted with bank erosion on outside meander bends and the presence of flood chutes. More bank erosion was noted in this reach than other reaches assessed in this study. Multiple mid-channel, side, point, and diagonal bars were observed. This reach showed signs of planform changes and may have been straightened at one time to create fields as suggested by the odd “stepped” planform. Overall the reach appeared in “good” condition retaining access to its floodplain but also “highly sensitive” to ongoing disturbances.

Habitat was also assessed in “good” condition, although there was some loss of riparian buffer on the left bank and some areas of bank erosion. Moderate deposition of fine sediment was noted and large particles appeared fairly embedded.

There were no bridges or culverts in this reach.

Passive geomorphic restoration could allow for reestablishment of an equilibrium slope through channel meandering. Investigating steps to reduce additional inputs of fine sediment (other than those caused by in-reach erosion and planform adjustment) to the reach is recommended to improve habitat value. As an alternative to passive restoration, active restoration projects could be implemented that would increase sinuosity in the short-term while limiting inputs of fine sediments from the reach itself that affect habitat value.

T08.10 – Ball Mountain Brook

This reach was not entrenched, remaining a C Riffle-pool stream type. It widened historically with the current adjustment process being planform with minor aggradation. Multiple mid-channel, side, point, and diagonal bars were observed as well as avulsions, islands and flood chutes. The reach was assessed in “good” condition and in Stage IIc of the D-stage evolution process. The reach was “highly sensitive” to ongoing disturbance.

Habitat was assessed in “good” condition, although there was little to no riparian buffer on the left bank due to the road. Some mix of substrates was lacking, particles were somewhat embedded with a slight increase in fine sediment. Frequency of riffles, bank stability, and bank vegetation were all in reference condition.

One bridge crossed this reach for a private drive. The span constricted the flood-prone width. A steep riffle (deposition) was upstream of the structure and a pool (scour) downstream. Riprap on the banks under the bridge encroached into the streambed.

Because of the proximity of the road limiting the valley width for this reach, this could be a candidate for active restoration to decrease slope and alleviate stream power, improve riffles and improve diversity of habitat.

T08.12 – Ball Mountain Brook

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

This reach was typed as a B Riffle-Pool stream type, a departure from its C type reference condition. The reach appeared incised and had some signs of bank erosion, indicating minor widening and planform changes. Flood chutes and bars were noted along the reach, signaling the reach may be in stage IV of the F-stage channel evolution process. Overall, the reach was assessed in “fair” condition and “highly sensitive” to ongoing disturbance.

Habitat was assessed in “good” condition. Riparian and bank vegetation were in “good” to “reference” condition, but bank stability and lack of frequent riffles were factors affecting the habitat condition.

Active restoration could be employed to increase riffle frequency and habitat condition and reduce bank erosion.

T08.13 A and B – Ball Mountain Brook

This reach was segmented due to the presence of three beaver dams in the upstream portion of the reach, upstream of the culvert. Following the SGA Protocols, the downstream segment (A) was assessed, while the upstream segment (B) was only assessed for steps 1, 3, and 4.

Segment A

Segment A was slightly incised but remained a C Riffle-pool stream type. It appeared to be slightly widened historically with the current adjustment process being minor planform and aggradation. Multiple flood chutes and side, point, and diagonal bars were observed. The segment was assessed in "good" condition and in Stage IIc of the D-stage evolution process. The segment is "highly sensitive" to ongoing disturbance.

Habitat was assessed in "fair" condition, lacking a strong mix of substrates and fast-deep flow. The substrate was moderately embedded with deposition of fine sediment present. Some bank erosion was observed.

One large culvert was present in this reach. The culvert constricted the channel width and sediment was observed upstream of the culvert and a pool downstream. The floor of the culvert had rusted through in several places. A beaver dam was just upstream of the culvert.

Due to relatively little infrastructure adjacent to the channel (one culvert at a road crossing) Segment A could be a candidate for passive restoration, as it is currently in adjustment.

Segment B

Segment B consisted of one large beaver pond and two other beaver dams. The segment was away from development except for crossing the road in the culvert. One area of bank erosion was observed.

Segment B is a good candidate for conservation again due to little infrastructure and because it appears to be in regime. The culvert in this reach will require maintenance and could be resized to reduce the channel constriction.

Reach by Reach Summary: North Branch Reaches

T08.04S1.01 A and B – North Branch

This reach was segmented into two sections because of the proximity of the road and confinement by berms on the downstream portion and floodplain access on the upstream portion. It is questionable whether some in-channel boulders or steps (rock veins) in this reach were natural or were placed during road maintenance.

Segment A

Segment A was confined by the adjacent road and berms, reducing its confinement from broad to semi-confined. Segment A had experienced a stream type departure from a C riffle-pool to an F plane-bed type. This segment had lost access to its floodplain (is entrenched and incised).

Current adjustment processes appear to be aggradation and widening, Stage III of the F-stage channel evolution process. The segment was assessed in “poor” condition with “extreme” sensitivity to ongoing disturbance.

Habitat for Segment A was assessed in “fair” condition. The reach lacked riparian vegetation along the road and had moderately unstable banks. There was one mass failure about 100 feet high by 200 feet wide in the segment. Channelization from road construction, berms and riprap also lowered the habitat value. The segment lacked a good mix of substrates and riffles were infrequent.

Segment A would be a good candidate for active restoration. The proximity of the road limits the potential for passive restoration, as the road infrastructure may need to be protected. Restoration in this reach could be designed to improve habitat, frequency of riffles, and bank stability.

Segment B

Segment B was moderately incised but retained access to its floodplain and remained a C riffle-pool stream. This segment appeared to be in “fair” condition and in Stage IIc of the D-stage adjustment process, with widening and planform adjustments. The channel had recently avulsed in one area and areas of braiding were noted. Aggradation of large particles was evident in the segment. Sensitivity to ongoing disturbance is “high”.

Habitat in Segment B was assessed in “good” condition. The segment was lacking some mix of substrates, frequent riffles, and left bank riparian buffer.

An old abutment constricted the channel at the downstream end of the segment. Some deposition was noted upstream of the abutment, however that could also be related to the nearby bedrock and bend.

There were no bridges or culverts in this reach.

Segment B could be a candidate for active restoration. This segment is not in close proximity to the road, although it is constrained by berms. Moving the berms away from the channel to the roadside could allow the channel to continue adjustment and regain a dynamic equilibrium state.

T08.04S1.02 – North Branch

This reach was also confined by the road and berms on the left bank, changing the confinement designation from “narrow” to “narrowly confined”. Historical degradation led to stream type departure from B plane-bed to F plane-bed and a “poor” condition rating. The channel appeared to be in Stage II of the F stage channel evolution process, attempting to widen, but being confined by the road and berms. The sensitivity of this reach to ongoing stressors is “very high”.

The habitat for this reach was assessed in “good” condition. Channelization had reduced habitat value. Two of the four velocity depth patterns were missing, fast deep and slow deep. Much of the channel substrate was exposed (not under water), however this was difficult to assess in these reaches due to the very large sediment size. As with other reaches along the road, there was little to no riparian buffer along the left bank.

There were no bridges or culverts in this reach.

Opportunities for this reach are limited due to the close proximity of the road and limited valley width. Some active restoration could allow for velocity reduction and improved habitat. Reducing stressors to this reach such as increased sediment loads and increased velocities from upstream could alleviate pressures and potential for conflict in this reach (as well as in downstream reaches).

T08.04S1.03 – North Branch

This reach had become entrenched, losing access to floodplain and resulting in a stream type departure from a C riffle-pool to an F riffle-pool (although the riffles and pools were not very well defined) and a "poor" condition rating. This reach did have some floodplain access at bends and at the flood chute. The reach had also widened in the past. Multiple flood chutes, mid-channel and side bars and erosion on outside meander bends signaled planform adjustment. This reach appeared to be in Stage IV of the F-stage channel adjustment process and "extremely" sensitive to ongoing disturbances.

Habitat was assessed in "good" condition, but lacked adequate riparian buffer and vegetative protection on the left bank. There were some areas of erosion on banks and two mass failures were present. Channelization also affected habitat value and widening has exposed some channel substrate.

A bedrock ledge acted as a grade control and had created a swim hole at the upstream end of the reach. Steep riffles in these lower reaches of the North Branch were partly attributed to aggradation of large particles and partly to steep slope.

There were no bridges or culverts in this reach.

An opportunity for passive restoration exists in this reach with monitoring to protect nearby houses and the road. Active restoration could provide more control over stream restoration processes if desired. Reducing incoming stressors from upstream could alleviate pressures.

T08.04S1.04 – North Branch

This reach had been confined by the road and berms along the left bank and had lost some valley width but remained semi-confined. Entrenchment had led to a stream type departure from B step-pool to F step-pool and a "poor" condition rating. The current adjustment process appeared to be planform (stage 3 of the F stage adjustment process) as shown by mid, side, and diagonal bars and bank erosion on outside bends. Minor aggradation was evident with more fine particles in contrast to downstream reaches that have aggradation of large particles. Large particles (boulders) were present in this reach as well, bifurcating flow and trapping sediment. The reach appeared "extremely sensitive" to ongoing disturbances.

Habitat was assessed in "good" condition. The reach had little to no riparian buffer on the left bank. Channelization for the road had affected habitat value. Deposition of fine sediment was present in the reach and channel substrate was mostly exposed as a result of widening and aggradation. Fast, deep water was missing.

One 125 foot-high mass failure was present along the stream bank. Other smaller mass failures were present on high banks (above the stream bank) and may contribute to sediment while not leading to streambank instability. Algae growth was noted on the bed of this reach.

There were no bridges or culverts in this reach.

This reach was now confined by the road, but was historically confined by the valley. The reach appeared to be in planform adjustment, which, if allowed to continue, could reduce slope and velocities over time. If inputs of fine sediments are considered to be of concern, active restoration measures could be employed.

T08.04S1.05 – North Branch

This reach was not confined by the road and had a broad confinement type. This reach appeared to be entrenched, leading to a stream type departure from B plane-bed to F plane-bed. The channel appeared to be in Stage III of the F stage channel evolution process. Current adjustments were minor aggradation, widening and planform. The stream was assessed in “poor” condition and the sensitivity of this reach to ongoing stressors was “very high”.

Habitat was assessed in “good” condition with “good” to “reference” bank and riparian vegetation. Riffles were infrequent and the reach lacked some mix of substrates. Fast deep water was missing in this reach as well as most other reaches on the North Branch. One mass failure was present, estimated to be about 100 feet high.

Pikes Falls act as a natural grade control upstream of this reach

This reach could benefit from passive restoration with the goal of increased habitat value from improved riffle frequency and substrate diversity.

T08.04S1.07 – North Branch

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

Past channel straightening had occurred on this reach, resulting in historical degradation. Steep riffles and head cuts were noted along with flood chutes and mid channel bars. The bed had lost definition and become a Plane-Bed. The stream type was B with a slope subclass of c and cobble bed material. The RGA indicated the reach was in “fair” condition with major aggradation and minor widening, and planform adjustments (stage III of the F-stage channel evolution process). Stream sensitivity was “high”. The RGA was incomplete in terms of channel evolution and adjustment process.

Habitat was assessed in "fair" condition. The right bank had little riparian buffer and vegetative protection. Riffles were infrequent and only 2 of the 4 velocity/depth patterns were present. Sediment deposition, channel flow, and channel alteration were all fair.

Active restoration could improve habitat and channel condition while protecting road and house infrastructure.

T08.04S1.08 – North Branch

The stream was assessed in "good" condition. The reach had access to floodplain, although it appeared moderately incised. Pikes Falls Road had encroached on the valley width, changing confinement from very broad to broad. The channel appeared to be in Stage IIc of the D-stage channel adjustment process, although it was difficult to assess because the adjustments happening in the reach were minor. Current adjustments were minor aggradation and planform, signaled by multiple flood chutes, mid-channel and side bars, and minor sediment build-up. This reach remained a C riffle-pool stream type and was "moderately sensitive" to ongoing disturbance.

Habitat for this reach was also assessed in "good" condition. Riffles were relatively infrequent and the right bank riparian buffer was only 25-50 feet wide. Deposition of sediment was also impacting habitat in this reach. A good mix of substrates and velocity-depth patterns were also lacking.

Two culverts were present in this reach, acting as grade controls. Both culverts constricted the channel and were misaligned with the channel. The downstream culvert had a scour pool downstream and the upstream culvert had sediment deposition (steep riffle) upstream and scour downstream.

The downstream 308 feet of reach T08.04S1.09 was similar to this reach and may be considered as part of this reach.

As this reach is in minor adjustment and in good condition, passive restoration could be effective to improve habitat and stream condition. However, if more rapid habitat improvement is desired, active restoration could be pursued. A brownish-black biofilm was noted on the bed in this reach and water quality testing is recommended.

T08.04S1.09 – North Branch

The downstream 308 feet of this reach is similar to T08.04S1.08 and was considered part of that reach, rather than a separate segment, which would be more cumbersome. The upstream portion of this reach, considered the whole reach, was typed an E ripple-dune stream type and would be by reference. The Phase I reference stream type has been updated to reflect this. The stream was in "good" condition and in regime. Some bank erosion and deposition of fine sediment were observed in the reach. The reach appears "highly sensitive" to continued stressors.

Impacts from upstream such as increased sediment from roads, increased runoff from snowmelt, and sediment and flow alterations from a run-of-river dam upstream may have contributed to the sediment deposition, incision, and erosion in this reach as well as other reaches.

The habitat of this reach was assessed in "good" condition as assessed for a low gradient stream. Sinuosity was lower than expected for a low gradient stream. Banks were moderately unstable, showing signs of erosion. Moderate deposition of fine sediment was present.

Sand on the bed was observed to be coarser than what was in the banks. Possible explanations for this are that fine sediments are being carried downstream, or that the sand in the bed was coming from road or storm runoff.

This reach is a potential candidate for conservation as the stream corridor has few encroachments.

T08.04S1.10 – North Branch

Beaver were active at both ends of the reach. A beaver dam and pond were present upstream and a beaver dam was in the downstream portion of the reach, although the landowner dug out the dam to avoid flooding the meadows. The reach appeared to have been straightened, pushing the channel up against the left valley wall, at some time for fields and now for the Stratton Mountain Golf School on the right bank.

The stream was assessed in "fair" condition and remained a C riffle-pool stream type. Historical degradation through straightening and flow regulations led to incision and incomplete riffles. Current adjustment processes were aggradation and minor planform (Stage IIc of the D-stage adjustment process). Large depositions of fine sediments were observed in the channel as well as diagonal riffles and mid channel bars. Sensitivity of this reach to continued disturbance was "very high".

Habitat was assessed in "fair" condition. The right bank vegetation was heavily impacted, having little to no riparian buffer. Riffles were infrequent, and few types of bed substrate were present. Fine sediment was impacting habitat value with large deposits of fines and bed substrate mostly embedded.

The stream crossed a private drive through a triple culvert. The landowner noted that flow passes over the drive during high flows. The floodplain was filled by the drive. A scour pool was downstream of the culvert and woody debris obstructed the upstream end.

Establishment of a riparian corridor here could allow the stream to achieve an equilibrium planform. Given the current land use along the right bank (an established golf school), active restoration to achieve the equilibrium planform may be preferable to passive restoration so processes could be more controlled. In either case, establishment of a wooded riparian buffer would be beneficial.

T08.04S1.11 – North Branch

The condition rating for this reach was "fair". The reach appeared incised but had access to floodplain and remained a C riffle-pool stream type. The reach had widened historically and current adjustment processes appear to be aggradation and minor planform. Large increases in fine sediments may be stormwater or road inputs from upstream. A large impoundment (run-of-river dam) was just upstream of this reach. This reach was "highly sensitive" to ongoing stressors.

The habitat in this reach was assessed in "good" condition. Major factors affecting habitat value in this reach were embeddedness of bed substrates from fine sediment and large deposits of fine sediment. Roads impacted the left bank riparian buffer.

Three culverts and one bridge were present in this reach. All structures constricted the channel and had sediment deposition at the upstream end. All but the upstream culvert had scour pools at the downstream end.

The run-of-river dam upstream of this reach acted as a sediment trap as overflow was from the surface of the pond. On a windshield survey, fine sediment was observed just downstream of the dam and could be from roads, pond overflow, or the adjacent golf course. At the golf course, banks appeared filled to elevate the floodplain/terrace. The stream was likely without floodplain access at floodprone stage in this area. This was a very cursory assessment due to conflicts with gaining access other than from a car.

A passive restoration approach could be employed here as little infrastructure encroaches on the channel. Investigating and addressing sediment and flow inputs from upstream and overland sources is recommended to relieve pressures on this reach and downstream reaches.

Reach by Reach Summary: Tributary Reaches

T08.01S1.01 – West Hill Tributary

Route 30 and Route100 dominated this reach, which share its narrow valley. Signs of old mills, roads and stone walls are apparent along the reach.

This reach was assessed in "good" condition and in regime. The stream type was A step-pool. Minor aggradation and planform adjustments were occurring in the reach. One culvert and three bridges constricted the channel and were causing sediment deposition upstream. This reach was "highly sensitive" to ongoing disturbance.

The habitat in this reach was assessed in "fair" condition. Riparian vegetation and buffer were highly impacted by the road. Riffles are infrequent and only two of the four velocity/depth patterns were present: fast, shallow and slow, shallow. Fine sediment, likely from road inputs, was deposited on the bed and had embedded the larger particles. Channelization was present along most of the reach, reducing habitat value.

Opportunities for this reach are limited due to the close proximity of the road and limited valley width. This reach will likely require continued management. Some active restoration could allow for velocity reduction and improved habitat. Reducing sediment inputs to this reach such as from the road and from development could alleviate pressures and improve habitat in this reach.

T08.04S1.04S1.01 – Dalewood Road Tributary

The Phase I data for this reach listed it as unconfined, having a narrow confinement, but being within 0.2 of a confined ratio. Because the current road and historical roads acted to confine this reach, it was assessed as confined. This reach had multiple flood chutes, mid channel and side bars. Fine sediment was deposited in the channel and may be from the adjacent road or from the drained beaver pond upstream. Some bank erosion was observed on outside meander bends. Several bedrock ledges acted as grade controls in this reach. The reach was slightly incised and was a B plane-bed type. Current adjustment processes appeared to be aggradation and minor widening and planform (Stage IIc of the D-stage adjustment process). The stream was assessed in “fair” condition and “highly sensitive” to ongoing disturbances.

Habitat was also assessed in “fair” condition for this reach. The left bank had little riparian buffer while the right bank riparian buffer was “good.” Many deposits of fine sediment were observed and bed substrate was mostly embedded. Channel flow status was low with riffle substrates mostly exposed.

Four culverts were on this reach, all constricting the channel width. One culvert outlet was at grade, two were cascades and one was a free fall. All four had scour pools at their downstream ends.

Significant development was occurring in this watershed with many new homes and gravel roads observed. A road ran adjacent to the channel along much of the reach. It appeared as though there had been historical development in this watershed as well (old road beds, abutments, stone walls). An increase in storm runoff and sedimentation from road runoff can be anticipated.

Actively involving the Dalewood Road community in watershed management could be an effective means of improving watershed and stream health. Reduction of sediment inputs is key and could be achieved through a better back roads project. Employing what could be termed “externally active” or “socially active” restoration techniques, such as involving the community and reducing external sediment sources, to eliminate stressors to this reach is recommended before attempting passive or active in-stream restoration.

T08.04S1.07S1.02 A and B – Kidder Brook

This reach was divided into two segments based on different bed types. It was anticipated that the downstream segment would have a different stream type, although both segments are B types. The downstream segment had a plane-bed, rather than a step-pool form. The Phase I reference stream type for this reach is B step-pool.

Segment A

Segment A was typed a B plane-bed stream type with cobble substrate. The segment was assessed in “fair” condition. The channel appeared incised and entrenched, but still a B stream type. It may be that the reference stream type for this reach was actually a C and this represented a STD from C to B, Stage IIb of the D-stage process. Current adjustments were minor aggradation and planform. The segment was “highly sensitive” to continued disturbance.

Habitat for segment A was assessed in “good” condition. Some areas of bank erosion were noted. Only two of the four velocity/depth patterns were present, missing slow, deep and fast, deep. Moderate deposition of fine sediment was observed in the channel.

One culvert was present in the segment, constricting the channel and acting as a grade control. Sediment was depositing upstream of the culvert and a scour pool was downstream. Scour downstream was also undermining the culvert, footer, and wing walls.

Segment A was located inside National Forest boundaries and is recommended for continued conservation to protect habitat and the stream corridor.

Segment B

Segment B was assessed in “good” condition. This reach had some floodplain area adjacent to steps and where not confined by bedrock. This was shown in the cross section. Such a cross section location was chosen because it was at the head of a step and was accessible to safely measure a cross section. The entrenchment ratio measured in this area points to a C stream type, however other factors such as bedrock controls, valley and slope point to a B stream type. Areas at the head of steps may be C type areas as the channel can gain access to floodplain in these areas. Currently, minor aggradation and planform adjustments were present. The channel appeared to have widened in the past, which could be flood related or a result of historical logging in the watershed. The upper watershed was undeveloped at the time of assessment. Several bedrock ledges acted as grade controls in this segment. One area of bedrock gorge constricted the channel. This segment had a “very low” sensitivity to ongoing disturbance.

Habitat for Segment B was assessed in “reference” condition, making it the only reach in the 2005 study assessed as such.

Segment B is located inside National Forest boundaries and is recommended for continued conservation to protect habitat and the stream corridor.

T08.04S1.07S1.01S1.01 – Sun Bowl Brook

This reach was only assessed downstream of the Sun Bowl Lodge culvert and segmented at this point, because the landowner, Stratton Mountain Corporation, had not granted permission to cross their property to access the stream. Thus this stream reach was assessed from within the streambed and at public access points.

Segment A

This segment was assessed in “fair” condition. Multiple flood chutes, islands, mid channel and side bars were noted. The segment appeared moderately incised but remained a B step-pool stream type. Current adjustment processes appear to be widening, aggradation (possibly due to increased sediment inputs), and some planform as indicated by flood chutes and some bank erosion. The stream sensitivity to ongoing disturbance was “low”.

Habitat was assessed in "good" condition. Stream banks were moderately unstable in this segment. Sediment deposition was prevalent and streambed substrates were more than 50% surrounded by fine sediment. The segment lacked a strong mix of substrates.

Two culverts were in this segment, only one of which, the culvert at Mountain Road, was assessed due to access limitations. The culvert constricted the channel and acted as a grade control. The outlet was a cascade with a scour pool downstream. The floodplain was filled by the roadway and sediment was depositing upstream of the culvert. The upstream culvert (at the Sunbowl Lodge) was filled to half of its depth with sediment at the downstream end.

Further investigation of this reach is recommended to determine the source of the sediments, the condition of the culvert at the Sun Bowl Lodge and the reasons for moving the channel at Mountain Road in order to make management recommendations.

T08.04-S1.10-S1.01 - Styles Brook

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

Although the RGA field sheet indicated a stream type departure noting that this reach should be a C type, this reach was typed as a B with mostly step-pool features and some areas of G and F stream types. A relatively large amount of large woody debris (130 pieces) was noted. Signs of historical degradation included change in slope, entrenchment and incision, change in bed type from riffle-pool to step-pool, change in valley type, channel alterations (dredging, straightening, windrowing), and flow increases. Current adjustment processes are major widening and planform. Sediment deposition upstream of culverts was noted. The stream was assessed in "poor" condition and was "very highly sensitive" to ongoing disturbances.

Habitat was assessed in "good" condition. Bank stability, mix of substrates, and channel flow status were assessed as in "fair" condition. Some deposits of fine sediment and embedded particles were also affecting habitat condition.

Examine opportunities to address increased sediment and flow inputs from the watershed before attempting any active restoration.

T08.04-S1.09-S1.01A, B, and C - Brazen's Brook

This reach was assessed in 2004 by another assessment team. Therefore we are unfamiliar with the details of the assessment and will only comment on what we can glean from the field sheets. Bridge and culvert assessments were not performed on this reach.

Segment A

This segment was assessed as being an E riffle-pool stream type in "reference" condition (in regime). Only minor localized slope increases were noted. Sensitivity of the segment was rated as "high."

Habitat was assessed in “reference” condition. Mix of substrates, pool substrate and pool variability were assessed in “good” condition.

This segment would be a good candidate for conservation to protect the stream corridor and habitat.

Segment B

The geomorphic condition for this segment was assessed in “good” condition and the stream was typed as a B step-pool. The aggradation and planform parameters were rated as “reference.”. The segment appeared incised historically with current minor widening adjustments. Some bank erosion was noted as well as islands formed near debris jams. The segment appeared to be in stage V of the F-stage channel evolution process and sensitivity of this segment to ongoing disturbance was “moderate.”

Habitat was assessed in “good” condition. Some channel substrate was noted as exposed. Some areas of erosion were noted on the right bank.

This segment would be a good candidate for conservation to protect the stream corridor and habitat. Addressing flow and sediment input alterations could alleviate factors contributing to degradation.

Segment C

This segment was typed as a D braided stream with extreme aggradation, and major widening and planform adjustments. An increase in sediment deposition and flows were noted. Flood chutes, increased bar formation, and areas of braiding were noted. The segment was assessed in “fair” condition and in stage IId of the D-stage channel evolution process. Sensitivity of this segment was “extreme.”

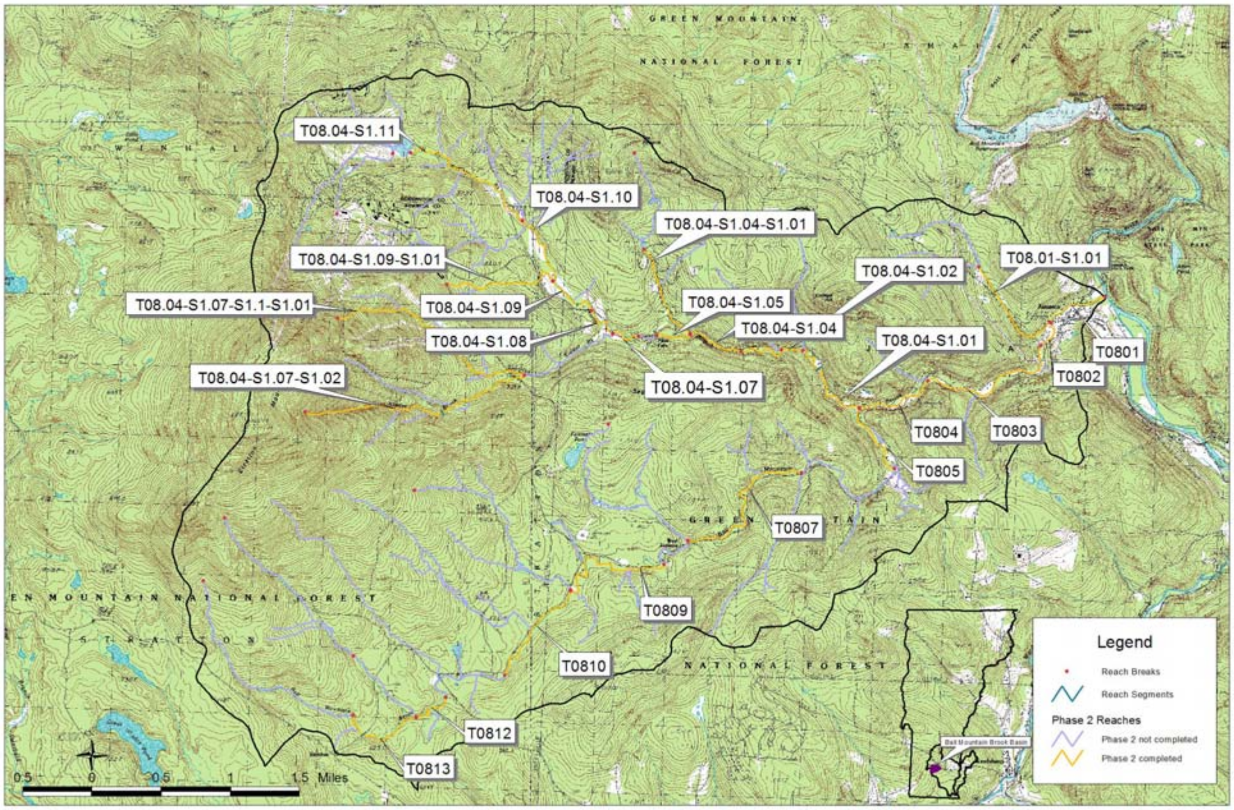
Habitat was assessed in “fair” condition, with pools noted as lacking and heavy deposits of fine sediment. Sediment deposition was also noted as affecting habitat condition. Some areas of bank erosion were noted on both banks.

Active restoration may be the best alternative to reduce effects of sediment and flow inputs. Examine opportunities to address increased sediment and flow inputs from the watershed.

Appendix B

ArcGIS Maps

Phase 2 Reaches:



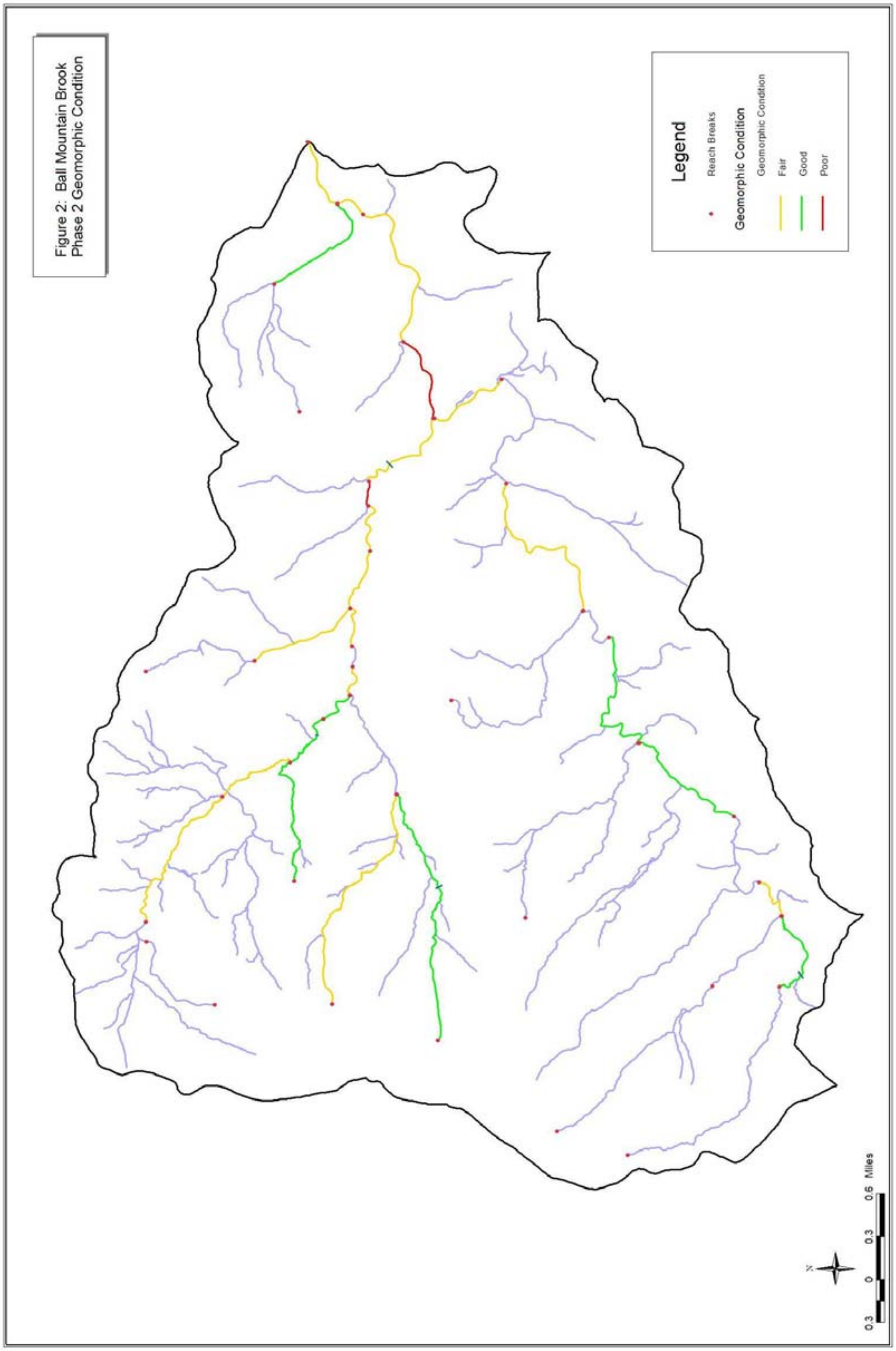
GIS topographical map of designated stream reaches in the Ball Mountain Brook watershed.

For the following two maps please reference the following:
Parameters for the Ball Mountain Brook RGA and RHA were scored and assigned to the correlating "condition" category describing departure from a reference condition and degree of adjustment (VTANR, April 2005) as follows:

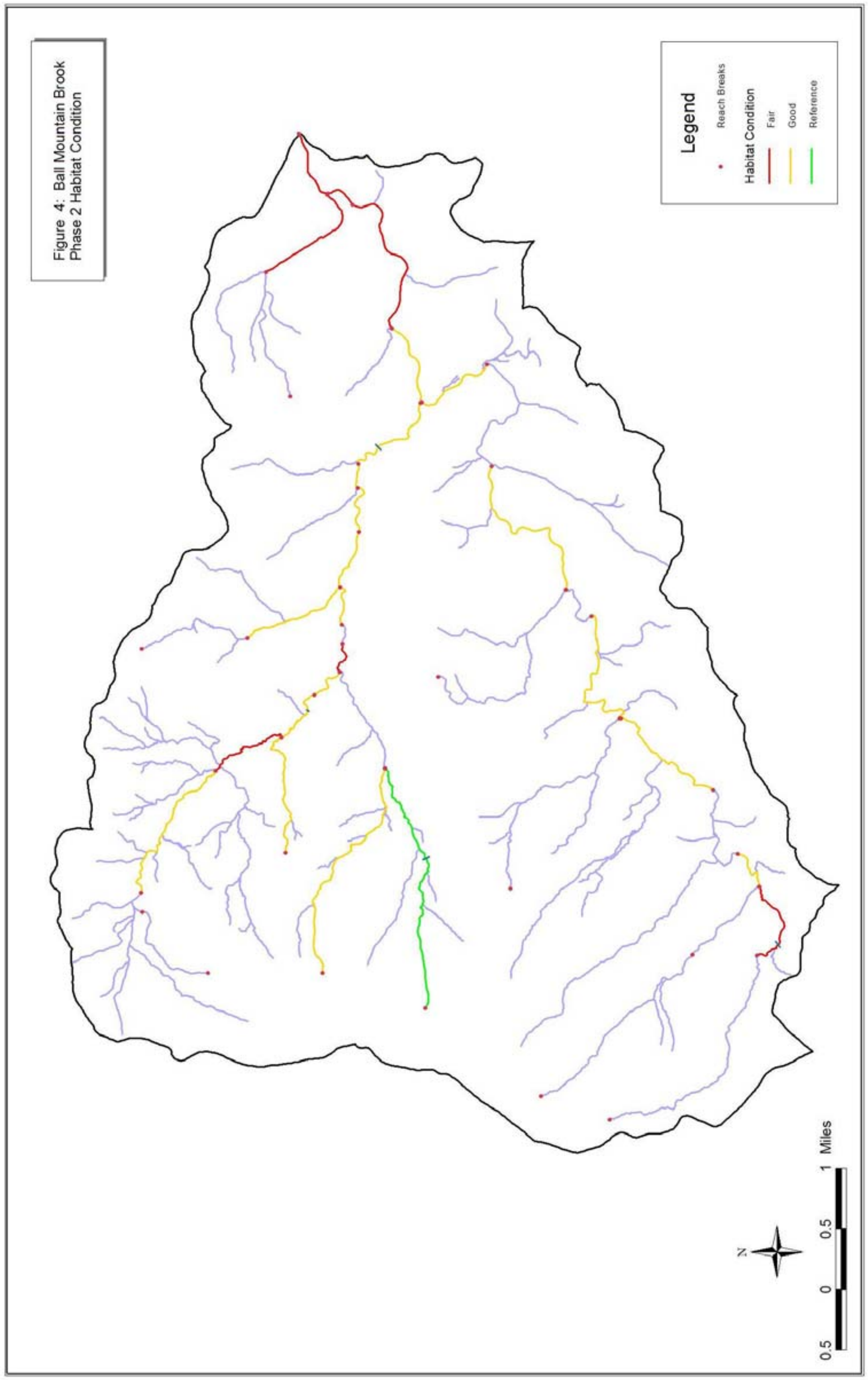
- Reference – Reaches in dynamic equilibrium, having stream geomorphic processes and habitats found in mostly undisturbed streams.
- Good – Reaches having stream geomorphology or habitat that is slightly impacted by human or natural disturbance, showing signs of minor adjustment, but functioning for the most part.
- Fair – Reaches in moderate adjustment, having major changes in channel form, process or habitat.
- Poor – Reaches experiencing extreme adjustment or departure from their reference (expected) stream type or habitat condition.

:

Phase 2 Geomorphic Condition



Phase 2 Habitat Condition:



Phase 2 Dominant Adjustment Processes