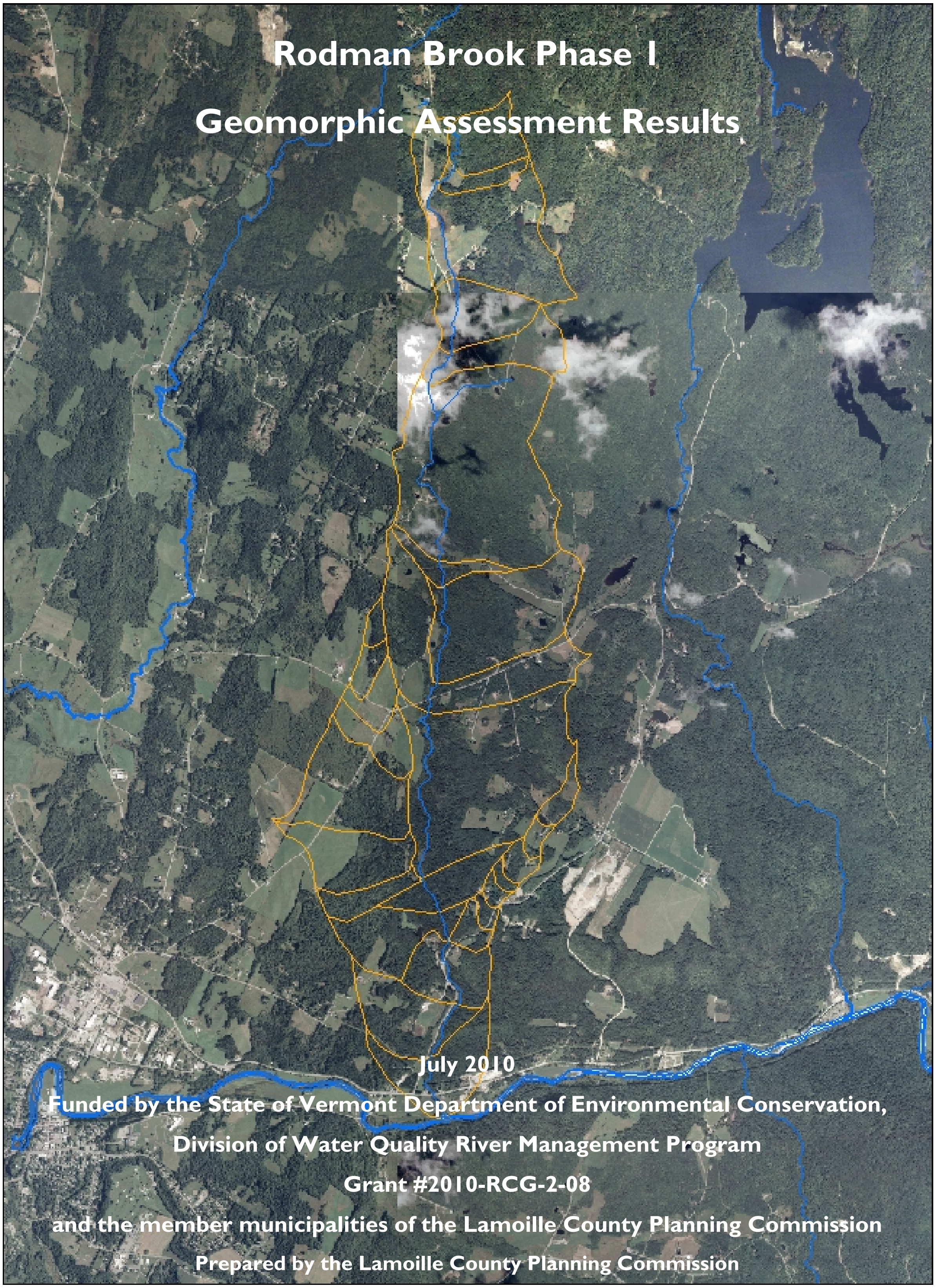
Rodman Brook Phase 1

Geomorphic Assessment Results



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Prepared by the Lamoille County Planning Commission

Introduction

Watershed planning in Vermont is experiencing rapid and positive change. The most significant changes are the growing recognition of environmental concerns and the broad acceptance of public participation in decision making processes. Currently the Agency of Natural Resources (ANR) is actively involved in watershed and corridor planning throughout the State.

The purpose of this summary is to outline the methods used to study the Rodman Brook, define the top water quality issues to be addressed, and outline steps to begin protecting and restoring the Rodman Brook.

The Phase I assessment of the Rodman Brook was conducted by the Lamoille County Planning Commission (LCPC) during June of 2006. The assessment was conducted according to the protocols of the Vermont Agency of Natural Resources geomorphic assessment. A bridge and culvert assessment was also conducted on the Rodman Brook using the Vermont Agency of Natural Resources standards.

The results of the Phase 1 study concluded overall that the river is in fair condition. Geomorphic processes are taking place throughout the reaches (sections of brook with similar characteristics such as slope, valley width, and tributary influence), especially in those reaches that are being encroached by roads. Sediment buildup has occurred and the degradation (a progressive lowering of the channel bed due to scour) of some channels are evident in the lower reaches. Degradation is an indicator that the stream's discharge and/or sediment load is changing.

Background

The Rodman Brook is located in the towns of Hyde Park and Morristown, Vermont, and flows into the Lamoille River which flows into Lake Champlain. Most of the river flows through forested land, with portions running through agricultural land and residential development. The approximately six mile river drains a 4.25 square mile watershed. There are 15 reaches, or segments, which were assessed on the main stem of the river (see Figure 1).

Rodman Brook is located mostly within the town of Hyde Park. The brook flows down the middle of the town, and about a third of the brook (the downstream end) flows through Morristown.

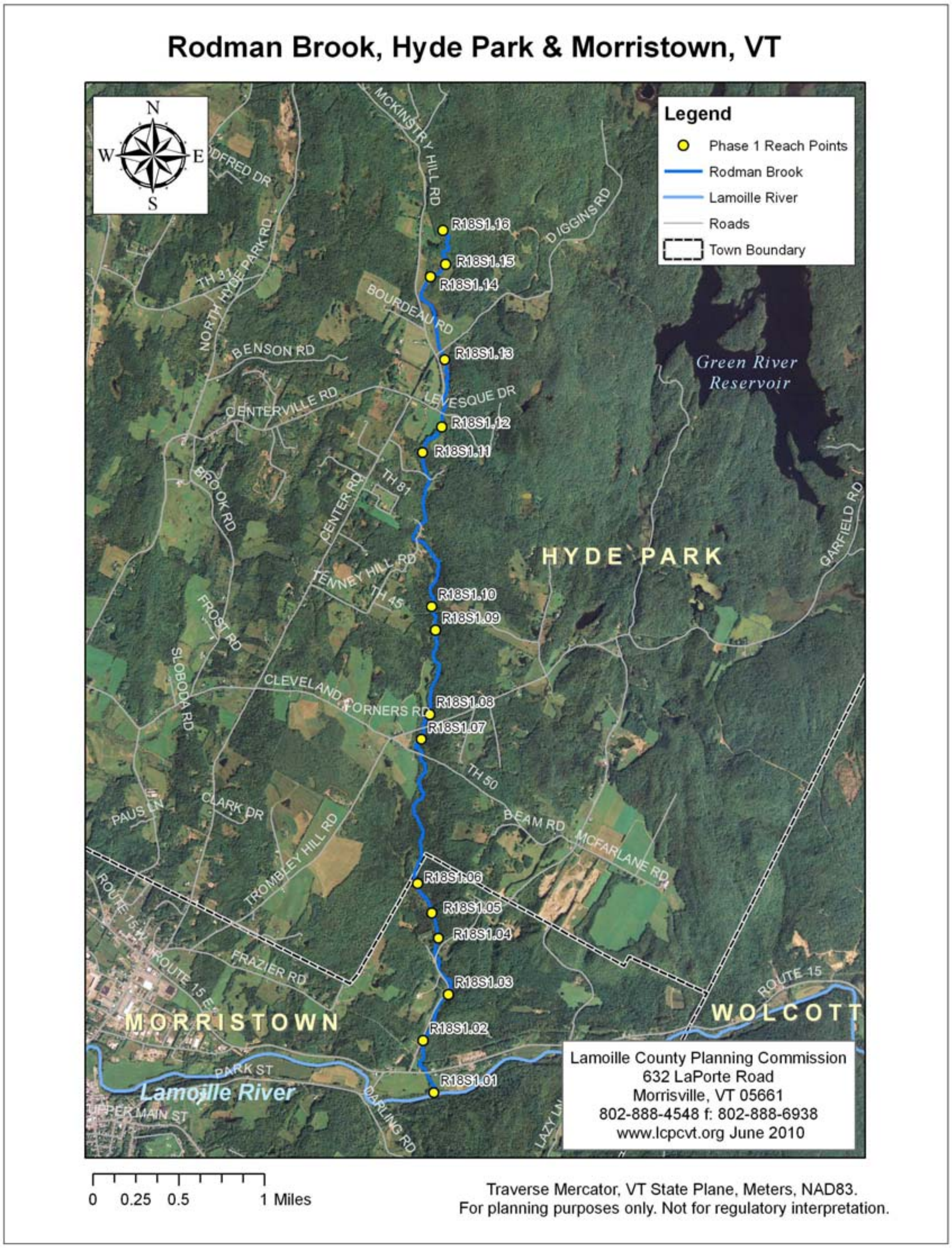

Figure 1.

Flood History

According to the Vermont Agency of Natural Resources document "Municipal Guide to Fluvial Erosion Hazard Mitigation" (2006a), "Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly." The guide documents that over the last 50 years, flood recovery has cost the state an average of $14 million a year and that during the period of 1995-1998 alone, flood losses in Vermont totaled almost $57 million. Of particular concern for towns are properties near streams. It notes that, "While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by "fluvial erosion". Fluvial erosion is erosion caused by rivers and streams, and can range from gradual bank erosion to catastrophic changes in river channel location and dimension during flood events."

The Municipal Guide further documents that, "Closer study of our rivers and streams reveals that Vermont's erosion hazard problems are largely due to pervasive, human-caused alteration during the past 150 to 200 years of our waterways and landscapes they drain. By end of the nineteenth century, forests had been cleared from many watersheds, resulting in major changes in watershed hydrology and sediment production. Towns and villages, the centers of commerce, grew on the banks of rivers, whose role in power generation and transportation at first outweighed flood risks. In addition, many watersheds were changed by development, agriculture, log drives, roads and railways." The legacy of this landscape manipulation is rivers and streams, such as the Elmore Branch, which are unstable and prone to fluvial erosion (Vermont Agency of Natural Resources 2006a).

In order to better understand the flood history of Rodman Brook, long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gauge on the Lamoille River in Johnson, VT were obtained (USGS 2007). Johnson Village sits upstream and is approximately 8 miles west of the Rodman Brook. Ninety-three years of record are available for the Lamoille River gauge at Johnson, VT which provides a continuous record of flow from 1912 through the present.

The long term record on the Lamoille gauge shows major flood events also occurred in the years 1912, 1936, 1973, 1984, 1995 and 1997. The graph below (Figure 2) provides a flood frequency analysis for the Lamoille River gauge.

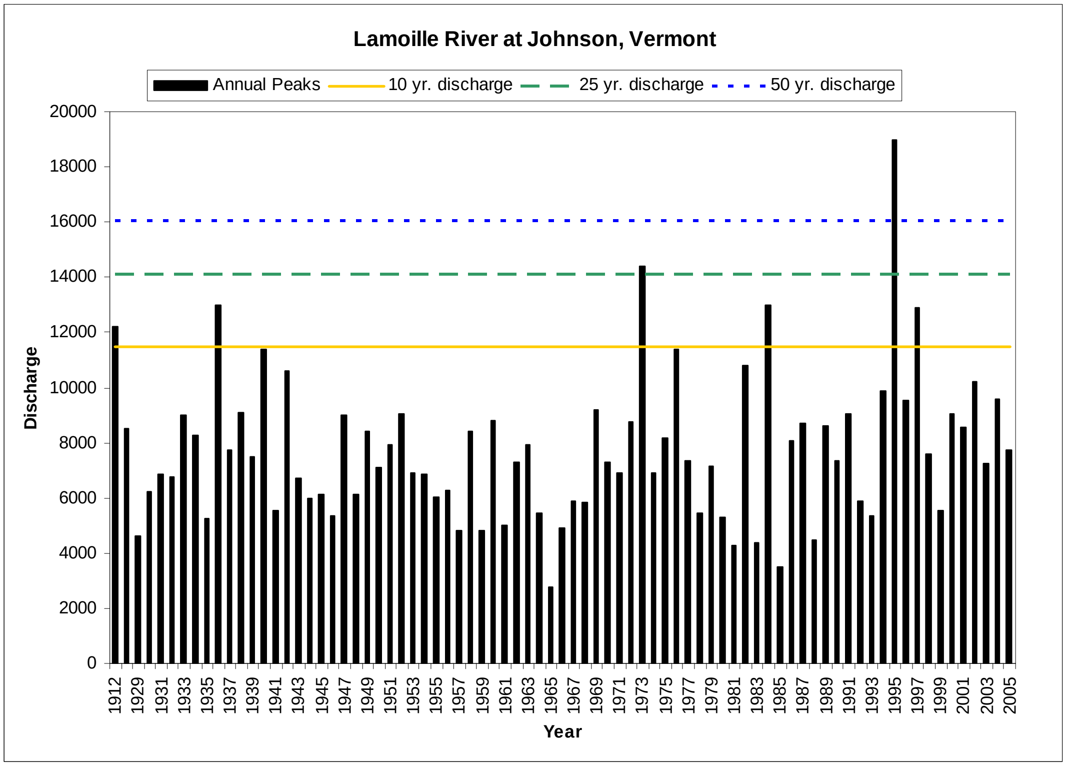

Figure 2

Phase I Watershed Assessment Methodology and Results

Phase I Watershed Assessment Methodology

Stream reaches were defined by creating reach breaks using valley width and slope, geologic materials, and tributary influence. Fifteen reaches were delineated on the Rodman Brook main stem within Lamoille County. Reaches were numbered to efficiently organize, track, and communicate reach-related data. After stream reaches were defined, watershed, sub-watershed, and reach watershed areas were delineated. See Figure 1 for a stream reach identification map.

Stream Geomorphic Assessment Tool

Using the Stream Geomorphic Assessment Tool (SGAT), numerous parameters were calculated including: valley width, length, and slope; channel length and slope; stream confinement; sinuosity; and reference channel width (see glossary for definitions). Based on this data, reference stream types were classified according to characteristics of the valley, geology, and climate of the stream. The reference stream type describes the natural channel tendency of channel form and process in the absence of human-related changes to the channel.

SGAT, Remote Sensing, Local Knowledge, and Field Verification:

Using a combination of SGAT, remote sensing, local knowledge, and windshield surveys, (field verification) the following parameters and their respective impacts were inventoried and/or calculated, and assessed. Individually, the parameters are designed to describe the basic physical features of the river and each reach. Together, the parameters form an overall picture of the stream and the watershed.

- Valley side slopes
- River corridor delineation
- River corridor and reach land use and land cover
- Riparian buffer condition
- Hydrologic groups
- Soils and geology influences
- Alluvial fans
- Grade controls
- River corridor development
- Bank armoring
- Bridge and culverts
- Flow regulation and water withdrawal
- Channel modifications
- Floodplain encroachments
- Dredging and channel mining history
- Depositional features
- Meander migration

• Meander width ratio
• Stream wavelength
• Debris jam potential
• Dominant bed form and materials

Rodman Brook Report Impact Rating Methodology and Reach Results Summary

The following parameters are assigned impact ratings of Not Significant to High Significance, based on certain criteria for each impact type. These parameters are used because they can be effectively measured using maps and other remote sensing tools. They also examine watershed influences which may be producing channel adjustments. After all the impacts are looked at, a reach can be further evaluated for the degree to which much cumulative impacts are affecting the reach and how it compares to other reaches in the watershed. This evaluation helps with focusing resources for additional assessments of the river.

Phase I Parameters highlighted for data interpretation:

☐ Watershed Land Cover/Land Use
☐ Corridor Land Cover/Land Use
☐ Riparian Buffer Width
☐ Channel Modification
☐ Depositional Features
☐ Meander Migration
☐ Bridge and Culvert Survey-using the ANR Appendix G datasheet

Watershed Land Cover/Land Use:

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

High impact rating scores indicate 10% or more of the reach watershed cover is crop and/or urban. Reaches R18S1.01-R18S1.07 (downstream and south of Trombley Hill Rd in Morristown and Hyde Park) and R18S1.11- R18S1.13 (upstream and north of Trombley Hill Rd in Hyde Park) recorded high impact ratings for watershed land use land cover.

Corridor Land Cover/Land Use:
Land use/land cover within the stream corridor is particularly important with respect to sediment deposition and erosion during annual flood events. Wetlands, ponds, and perennial vegetation moderate stormwater and sediment runoff, while impervious surfaces (impenetrable surfaces such as rooftops, sidewalks and roads) within urban areas and the exposed soils found in cropland have the potential to increase watershed inputs.

High impact rating scores indicate 10% or more of the reach corridor cover is crop and/or developed. Reaches R18S1.01- R18S1.03 (downstream reaches that begin at the confluence with the Lamoille River), R18S1.07 (south of Trombley Hill Rd in Hyde Park), and R18S1.12-R18S1.14 (north of Trombley Hill Rd), received high impact rating scores.

Riparian Buffer Width:
The riparian buffer is the area of land directly adjacent to the channel along the channel's banks and floodplain that is covered with woody vegetation and largely unmanaged. Riparian buffers protect and enhance water quality, fish and wildlife habitats, aesthetics, and recreational values associated with streams. Streams without riparian vegetation often experience high rates of lateral erosion and may see such large increases in sediment that they undergo major adjustment of channel dimension, pattern, and profile. Orthophotos were used to estimate the percent of each buffer width category along the right and left banks.

High impact rating scores indicate that 26% of the reach has little or no buffer (0-25 feet) on one or both banks. Reaches R18S1.02 (downstream reach that begin at the confluence with the Lamoille River), R18S1.12, R18S1.13, and R18S1.14 (north of Centerville Rd in Hyde Park) received high impact rating scores for riparian buffer width.

Channel Modifications:

Channelization is the process of changing the natural path of a river through activities such as windrowing (pushing gravel up from the stream bed onto the top of either bank as part of the straightening of the river) and straightening. A channelized stream may degrade, or cut down vertically into its bed and cause the channel to lose access to its floodplain. If floodplain access is lost, the banks will erode until new floodplains are formed. The sediment resulting from the degradation process is re-deposited downstream of the channelized area. This results in aggradation, or building up, of the channel bed in this downstream area. Aggradation can result in channel widening, bank instability, and other channel responses, most of which are detrimental to both riverside land and aquatic habitat. Reviews of orthophotos and topographic maps were used to examine this parameter.

High impact rating scores indicate that greater than 20% of the reach had been channelized. Reaches R18S1.01- R18S1.03 (downstream reaches that begin at the confluence with the Lamoille River), R18S1.10, and R18S1.13 (north of Trombley Hill Rd in Hyde Park) received high impact scores. The percent of channelization for these high impact scores ranged from 34.1% to 62.2%.

Dredging and Gravel Mining History:

Dredging and mining gravel bars from a channel may initiate a channel evolution process. Such activities straighten and steepen the channel and cause the river to cut down and erode its bed. The stream channel eventually aggrades with sediment supplied from upstream reaches as headcuts (an abrupt change in the slope of the channel bed caused by erosion) in the streambed move up-valley. These headcuts occur where there is an abrupt vertical drop in the stream bed. They often resemble a small waterfall or, when not flowing, headcuts will resemble a very short cliff or bluff. Information and records from DEC's Stream Alteration Engineer was used to determine the relative frequency and volume of gravel extraction.

High Impact Rating scores indicate that the reach was historically used for commercial gravel mining and/or dredged for flood remediation. None of the reaches studied along Rodman Brook had any significant dredging or gravel mining.

Depositional Features:

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

High impact rating scores indicate numerous, large unvegetated mid-channel, point and/or delta bars present. There were no reaches on Rodman Brook that received high impact scores during this Phase 1 assessment.

Meander Migration/ Channel Avulsions:

Some amount of lateral migration is natural in most alluvial stream systems, but the rate of migration may be increased in streams due to changes in the sediment supply and/or sediment transport capacity of the channel. Comparisons of paths of the channel from similarly scaled orthophotos, including black and white half meter resolution imagery from 1995 and one meter color National Agriculture Imagery Program imagery from 2003 and 2006, were used to identify channel migration, bifurcation, and/or avulsions. Channel migration occurs as the channel erodes its outer banks on meander bends. Bifurcation describes when the stream has split into two or more active channels. An avulsion describes a channel plan form change due to meander cutoffs.

High impact rating scores indicate frequent occurrences of channel migration, bifurcation, and/or channel avulsions along the reach. R18S1.01 (which flows into the Lamoille in Morristown) was the only reach on Rodman Brook that received a high impact score for this parameter.

Meander Width Ratio:

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

High impact rating scores indicate the meander width ratio is less than 3 or greater than 10, well outside the 5-8 range of reaches within regime. Reaches R18S1.01 and R18S1.02 received high impact ratings. Reach RI8SI.01 begins at the confluence with the Lamoille River and continues for about 2000 feet. Reach RI8SI.02 extends 1700 feet north, parallel to Garfield Road.

Bridge and Culvert Field Verified Data:

A watershed-wide bridge and culvert inventory and assessment was conducted to determine if stream crossings were contributing to localized stream bank erosion, sedimentation, and impaired fish passage. The Agency of Natural Resources Bridge and Culvert Phase 1 protocols were used (ANR, 2003). Bridge spans and culvert diameter measurements were compared to calculated bankfull width measurements. The bankfull width, also known as the channel forming flow, is directly related to watershed drainage area. The bankfull flow is the discharge at which the majority of erosion and deposition takes place. Undersized bridges and culverts are not designed to accommodate both flow and sediment. During flood events, large point bars can consequently deposit upstream of undersized bridges and culverts. During catastrophic flood events, crossings can become outflanked, taking out large sections of roads and driveways. Significant sediment discharges to waterways can result. Sedimentation of the river poses water quality and aquatic habitat concerns.

Six bridges and culverts were assessed on the Rodman Brook main stem. There were no bridges or culverts along the Rodman Brook that received high impact rating scores. High impact scores are assigned if >20% of the reach length is channelized, has split flow, or makes a sharp "s" bend upstream or downstream of bridges or culverts. However, all six of the structures were undersized and the widths ranged from 44% to 78% of the bankfull width.

Current Stream Geomorphic Conditions

As part of this assessment, land use, encroachments, and buffer condition were analyzed within 150 feet on each side of the river. The headwaters of the stream are located in land with sparse residential development adjacent to the steep McKinstrey Hill Road. There is a section that has been dammed by beavers at the upstream end of the stream. There are a few significant bedrock grade controlled sections of the river which will help maintain stability in those areas. There was one section along the river corridor where some logging activity has taken place very close to the channel (see Figure 3).

Figure 3. Trees cleared on river bank

The results of the assessment concluded that overall, the river is in fair condition on a scale that includes the following four classifications: poor, fair, good and reference. (See glossary for definitions.) There were a few sections that had significant bedrock grade controls, and much of the stream had an adequate riparian buffer. Of the 15 reaches assessed on the main stem of Rodman Brook, three reaches (R18S1.01, R18S1.02, and R18S1.03) had total impact scores of 21, 21, and 15 respectively, out of a possible score of 32. A total impact score greater than 12 is considered high. Encroachments from Garfield Road within the river corridor accounted for the majority of these high impact scores on Rodman Brook.

Predicted Stream Channel Adjustment Processes

The Rodman Brook is undergoing a variety of geomorphic processes specifically in the lower reaches where historically the channel has been adjusted by human activity. Reaches R18S1.01-R18S1.03, R18S1.07 and R18S1.12 are undergoing the most active adjustments including degradation, aggradation, planform adjustment, and widening. Aggradation and degradation are the major adjustment process on most of these reaches as multiple channel bars indicate. Planform adjustment is the major adjustment process for reach R1S81.12. This process changes the shape and size of meander bends and the overall path the river follows. If further development and modifications within the floodplain are avoided, the river will establish a stable condition on its own. The middle reaches are in fair to good reach condition with healthy riparian buffer widths as well as having the potential to be conservation areas for the river corridor.

Additional Assessment Work

A Phase 2 assessment has been completed on reaches R18S1.01-R18S1.03. However, additional assessment work would provide further information and prediction on how the river will evolve in this area and should be considered as land use decisions are being made within the corridor. Also, as bridges and culverts are replaced, they should be adequately sized to meet the river's bankfull width. Avoiding encroachments and land uses that conflict with the river's evolution will mitigate the costs of managing the river and decrease the potential for flood damage. Future field studies focusing particularly on high total impact and poor project reach conditions can help area residents and municipal officials craft short-term and long-term management plans.

References

Wetland, Woodland, Wildland: A guide to the Natural Communities of Vermont. Elizabeth H. Thompson and Eric R. Sorenson. 2000

Glossary

Aggradation: A progressive buildup or raising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that the stream discharge and/or bed load characteristics are changing. Opposite of degradation.

Avulsion: A channel plan form change due to meander cutoffs.

Bifurcation: When a stream has split into two or more active channels.

Channel length: Length of channel, in feet, for the main stem or tributary from the reach point to the next upstream reach point.

Channel slope: Channel slope is the difference in elevation at the upstream end of the channel and the downstream end of the channel divided by the channel length.

Degradation: A progressive lowering of the channel bed due to scour.

Fair (reach) condition: In equilibrium but may be in transition into or out of the range of natural variability – minor erosion or lateral adjustment but adequate floodplain function; any adjustment from historic modifications nearly complete.

Good (reach) condition: In equilibrium but may be in transition into or out of the range of natural variability – minor erosion or lateral adjustment but adequate floodplain function; any adjustment from historic modifications nearly complete.

Poor (reach) condition: In adjustment and stream type departure **-** may have changed to a new stream type or central tendency of fluvial processes – significant channel and floodplain modifications may have altered the channel geometry such that the stream is not in balance with the flow and sediment produced in its watershed.

Reach: Section of river with similar characteristics such as slope, confinement (valley width), and tributary influence.

Reference channel width: Width of the channel in feet of reference channel. Reference stream types are based on the valley type, geology and climate of a region and describe what the channel would look like in the absence of human-related changes to the channel, floodplain, and/or watershed.

Reference (reach) condition: In equilibrium – no apparent or significant channel, floodplain, or land cover modifications; channel geometry is likely to be in balance with the flow and sediment produced in its watershed.

Sinuosity: The channel length divided by valley length.

Straightening: The removal of meander bends, often done in towns and along roadways, railroads, and agricultural fields.

Stream confinement: The valley width divided by the channel width.

Valley length: Length in feet of valley line drawn.

Valley slope: Valley slope is calculated as the difference between the elevation of upstream reach point and the elevation of reach point divided by the valley length.

Valley width: Width of valley in feet.

Windrowing: Pushing gravel up from the stream bed onto the top of either bank as part of the straightening of the river.

Appendix A. Phase 1 - Step 1. Reach Locations

Basin: **Lamoille** Watershed: **Lamoille River** Sub-watershed: **Lamoille River -- headwaters to Gihon River**

SGAT Version: **4.56** Quality Assurance Status **Step 7 done**

Reach ID	Stream Name	Excluded?	Towns	Description
R18S1.01	Rodman Brook		Morristown	Begins at the confluence with the Lamoille River, and continues for about 2000 feet. This segment continues for about 1100 feet after crossing Route 15.
R18S1.02	Rodman Brook		Morristown	Continues for about 700 feet.
R18S1.03	Rodman Brook		Morristown	Continues for about 2000 feet, and about 560 feet past Garfield Road.
R18S1.04	Rodman Brook		Morristown	Continues for just over 900 feet.
R18S1.05	Rodman Brook		Morristown	Continues for about 925 feet to a tributary entering from the northwest.
R18S1.06	Rodman Brook		Hyde Park, Morristown	Continues for just over a mile, about 675 feet past TH50
R18S1.07	Rodman Brook		Hyde Park	Continues for about 925 feet, about 510 feet after crossing Cleveland Corners Road.
R18S1.08	Rodman Brook		Hyde Park	Continues for about 2800 feet, ending about 125 feet downstream of a tributary entering from the east.
R18S1.09	Rodman Brook		Hyde Park	Continues for about 950 feet, about 350 feet upstream of a small pond.
R18S1.10	Rodman Brook		Hyde Park	Continues for about 1.1 miles to about 835 feet upstream of where the channel crosses Solar Drive.
R18S1.11	Rodman Brook		Hyde Park	Continues for about 1150 feet to a tributary entering from the east. This reach ends about 460 feet downstream of Levesque Road.
R18S1.12	Rodman Brook		Hyde Park	Continues for about 2350 feet, ending about 250 feet downstream of Diggins Road.
R18S1.13	Rodman Brook		Hyde Park	Continues for about 2825 feet, ends at a tributary entering from the north.
R18S1.14	Rodman Brook		Hyde Park	Continues for about 700 feet. There are no significant reference points along this reach.
R18S1.15	Rodman Brook		Hyde Park	Continues for about 1300 feet, into the headwaters of the stream