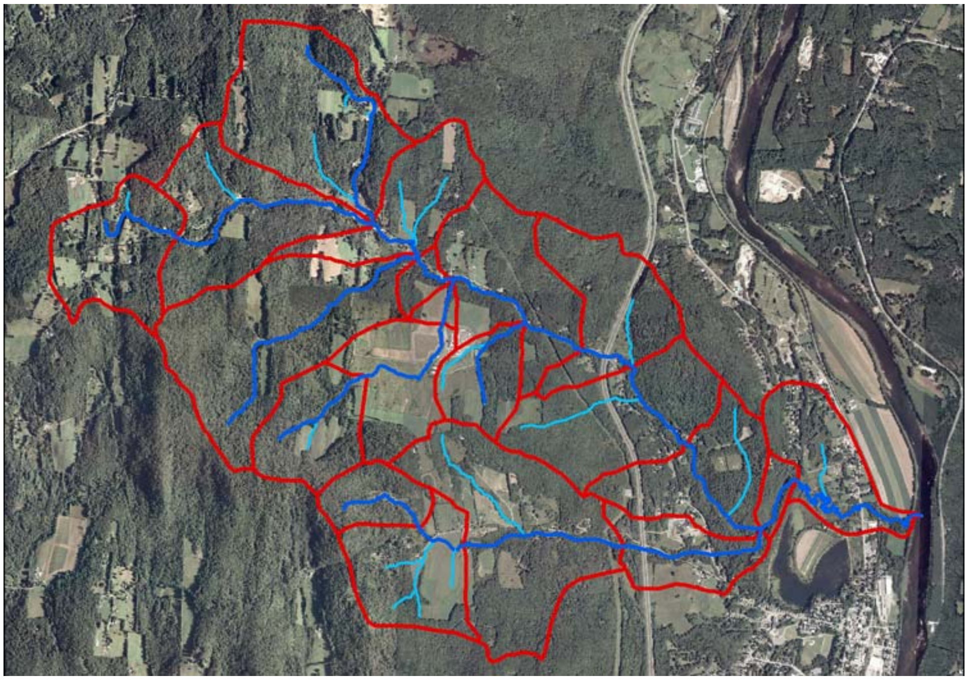
Hubbard Brook Phase 1
Stream Geomorphic Assessment Summary

December 11, 2008



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SWCRPC
SOUTHERN WINDSOR COUNTY
REGIONAL PLANNING COMMISSION

List of Figures

List of Tables

Executive Summary

- Fitzgerald Environmental Associates, LLC. (FEA) was retained by the Southern Windsor County Regional Planning Commission (SWCRPC) in 2008 to carry out Phase 1 assessments on the Hubbard Brook watershed following the VTANR Stream Geomorphic Assessment (SGA) Protocols.

- The Hubbard Brook watershed is located in the towns of Windsor and West Windsor. It has a drainage area of 6.3 square miles and outlets to the Connecticut River east of Route 5, just upstream of downtown Windsor. Its main stem surface waters extend to the west into West Windsor. Four major tributaries and one minor tributary were identified for Phase 1 assessment.

- A total of 20 reaches along 13.1 river miles were identified during the Phase 1 analysis. The Phase 1 SGA approach resulted in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), providing a basis for understanding the natural and human-impacted conditions within the watershed. The SGA data also aided in the identification of specific stressors affecting the physical conditions of the stream channels and structures (e.g., bridges and culverts, bank armoring, etc).

- Approximately two-thirds (65%) of the assessed reaches are found in a confined valley setting that would naturally support sediment transport channels with A or B-type geometry. The remaining reaches (35%) are found in an unconfined valley setting with meandering, depositional C or E-type channel geometry.

- Approximately 73% of the watershed is forested, with agricultural land use representing approximately 21%. Developed lands (4.3%) are found mainly around the village center of Windsor. Wetlands and other surface waters represent 2.2% of the watershed area.

- Impact ratings were developed for each reach using the Phase 1 parameters representing four classes of watershed and reach-scale impacts: 1) Land Cover and Reach Hydrology; 2) Channel Modifications; 3) Floodplain Modifications and Planform Changes; 4) Bed and Bank Conditions. Out of a total possible impact score of 32, the average rating for all reaches was 9.4, with a maximum score of 15 and a minimum score of 2.

- Based on the Phase 1 impact ratings, a total of 9 high-priority reaches are recommended for Phase 2 assessment, including 8 mainstem reaches and 1 tributary reach. The selected reaches have a total channel length of 5.3 miles. In addition, 3 medium-priority reaches were selected for consideration due to their relatively high impact ratings.

1.0 Project Background

1.1 Introduction and Study Goals

The Southern Windsor County Regional Planning Commission (SWCRPC), the Paradise Park Commission (PPC), and the Vermont Department of Environmental Conservation (VTDEC) identified the Hubbard Brook watershed in southeastern Vermont for assessment of fluvial geomorphic conditions. Fitzgerald Environmental Associates, LLC (FEA) was retained by SWCRPC in 2008 to carry out Phase 1 assessments following the Stream Geomorphic Assessment (SGA) Protocols developed by the Vermont River Management Program (RMP). The study was initiated to identify the extent of geomorphic stressors throughout the watershed (e.g., encroachment, development, etc), and to collect preliminary data on the brook's condition within Paradise Park. In the future this data will be used to help locate specific sources of sediment upstream of the park, and identify potential restoration projects at the watershed level.

FEA used the Stream Geomorphic Assessment Tool (SGAT) to develop the baseline GIS data for the watershed in the spring of 2008. During the summer of 2008 the remaining Phase 1 data was collected via windshield surveys and historical research. A total of 20 reaches along 13.1 river miles were identified during the Phase 1 analysis. The Phase 1 SGA approach results in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), providing a basis for understanding the natural and human-impacted conditions within the watershed. The SGA data also aids in the identification of specific stressors affecting the physical conditions of the stream channels and structures (e.g., bridges and culverts).

The overall goal of the RMP is to "manage toward, protect, and restore the fluvial geomorphic equilibrium condition of Vermont rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner," (VTANR, 2007a) achieved through:

- Fluvial erosion hazard mitigation,
- Sediment and nutrient load reduction, and
- Aquatic and riparian habitat protection and restoration

The Phase 1 assessment of the Hubbard Brook watershed provides the basis for identifying reaches for future Phase 2 assessment. Detailed, reach-level data collected from the Phase 2 surveys will be used for project identification and development activities that meet the RMP goals stated above.

2.0 Watershed Background

2.1 Geographic Setting and Land Use History

The Hubbard Brook watershed is located in Eastern Windsor County, Vermont (Figure 1). This area of the state is part of the Lower Connecticut River Basin. The Hubbard Brook watershed has a drainage area of 6.3 square miles and outlets to the Connecticut River east of the Route 5 crossing, just upstream (north) of downtown Windsor. The watershed is found predominately in the town of Windsor, but the headwaters span into West Windsor (Figure 2). Four (4) major tributaries and one sub-tributary were identified in this study. The largest tributary, Kimball Brook, branches off in the Paradise Park west of Lake Runnemede, and extends westward into an agricultural area. The three other tributaries branch off the mainstem in the north or south direction. No labels were present on the USGS topological maps for these tributaries, so the name of the nearest adjacent road was used to reference the tributaries. An unnamed sub-tributary located east of the Southeast State Correctional Facility was also included in this study. This surface water enters the mainstem approximately 2,000 feet upstream of the Interstate-91 crossing.

Land cover data based on imagery from 2006 (NOAA, 2008a) are summarized in Table 1. The Hubbard Brook watershed is drained by a rural watershed, with forest representing the dominant cover type (72.7%). Agricultural lands cover 20.9% of the watershed, with a majority of large farmlands found in the middle of the watershed surrounding the State Farm Prison, and to the south surrounding the headwaters of Kimball Brook. Much of the agricultural lands within the Hubbard Brook watershed are for hay production and pasture land (NOAA, 2008a). There is limited developed land in the watershed, with only 4.3% coverage. Concentrated areas of residential development are primarily found to the east of Interstate-91 in downtown Windsor.

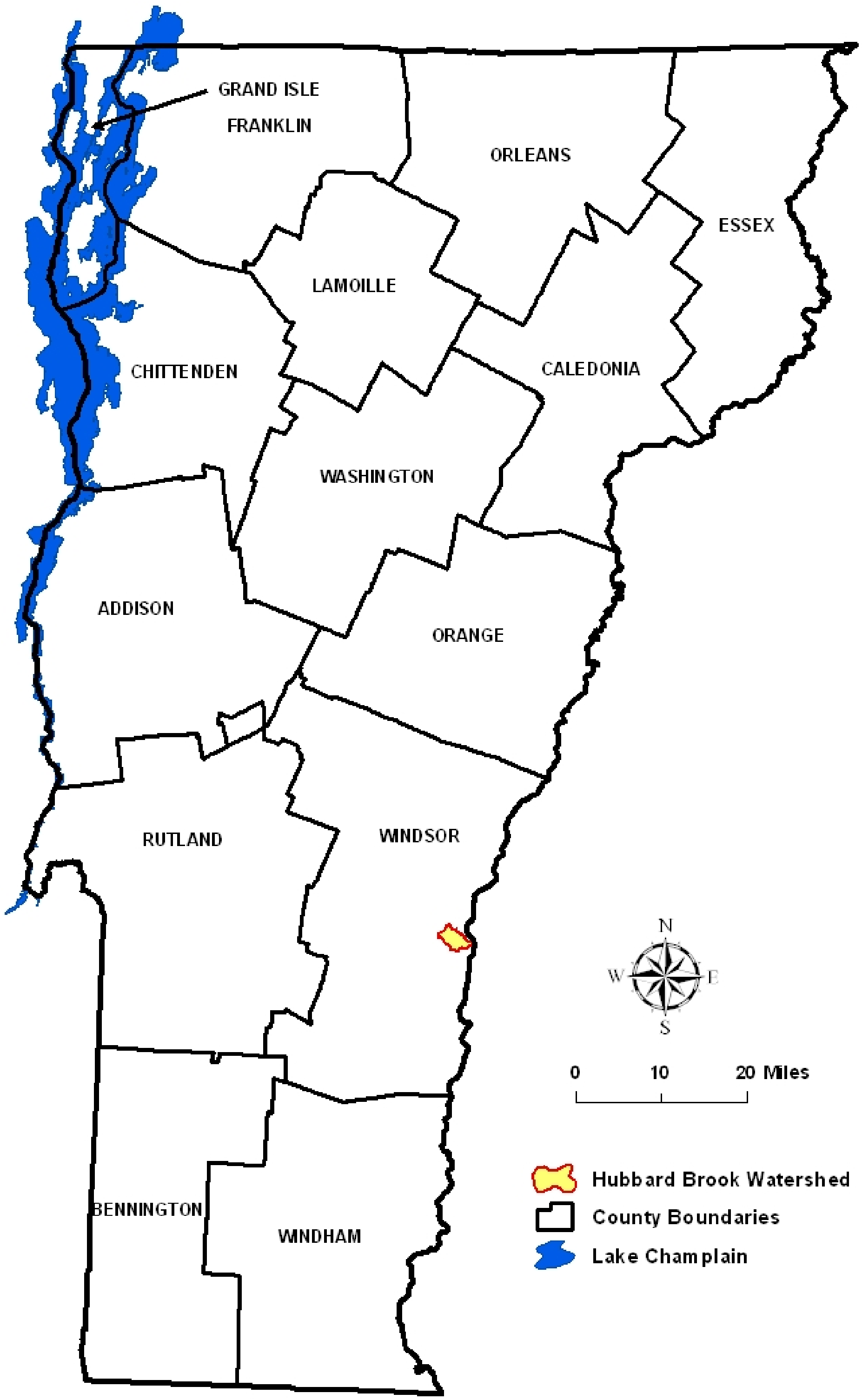

Figure 1. Watershed location map for the Hubbard Brook watershed

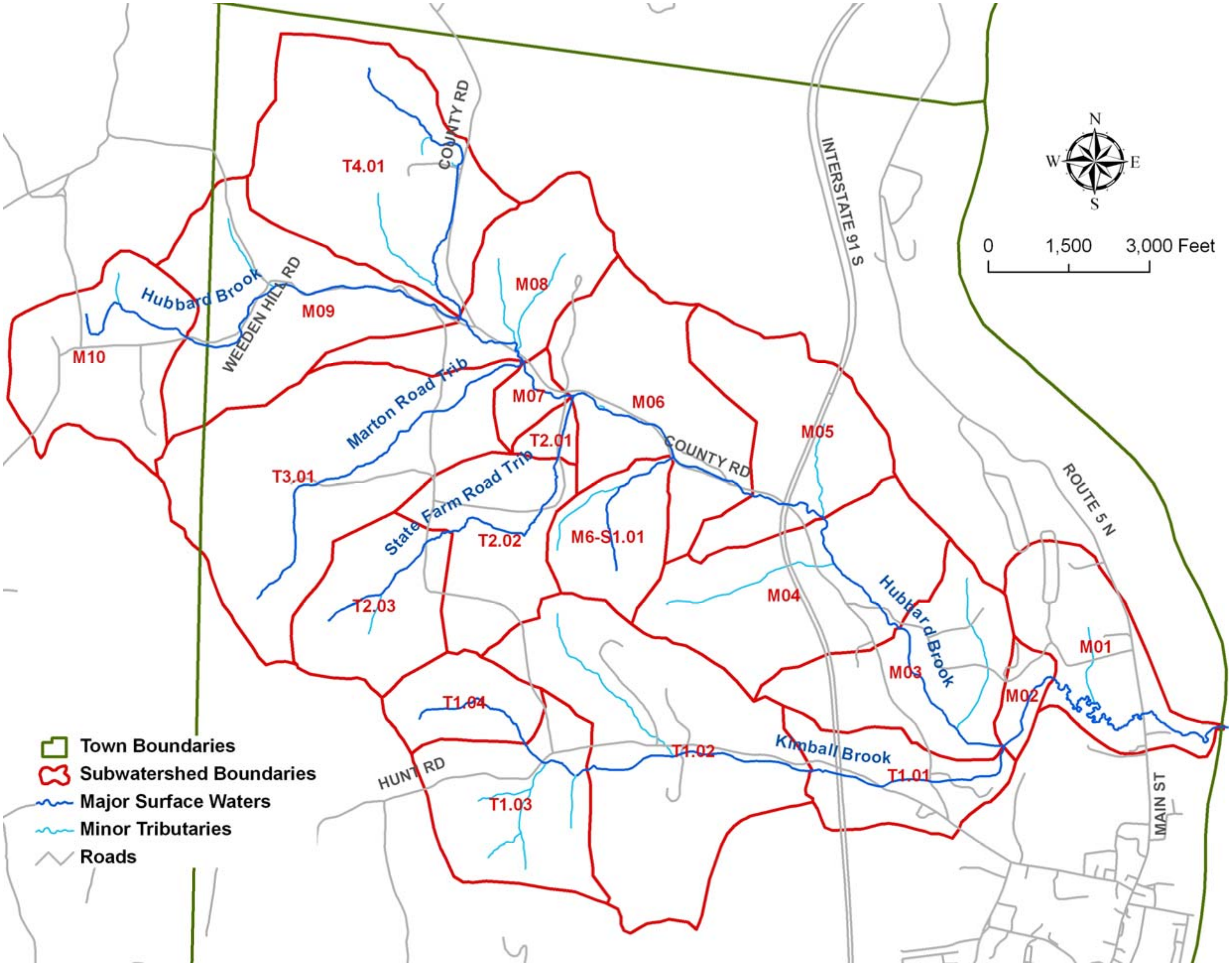

Figure 2. Hubbard Brook subwatersheds, surface waters, roads, and town boundaries

Table 1. Land cover data for Hubbard Brook watershed

Land Cover Type	Coverage
Developed	4.3%
Agriculture	20.9%
Forest	72.7%
Wetland	2.0%
Open Water	0.2%

Historical Land Uses

Historically, the impacts of agricultural practices on the Vermont landscape played an integral role in the legacy effects on waterways like Hubbard Brook. Prior to the deforestation associated with human settlement, the watershed would have been a mixture of deciduous species on the valley floors, as well as large stands of white pines (*Pinus strobus)* in areas that are in younger successional seres. The upper elevations of the watershed may have some transitional species, but it would be mostly hardwoods like maple (*Acer saccharum and Acer rubrum),* American beech (*Fagus grandifolia),* and yellow birch (*Betula alleghaniensis).* Wet and rocky sites on the valley slopes would likely be occupied by eastern hemlock (*Tsuga canadensis).* The deforestation and grazing, largely from sheep farms, likely left over 90 percent of the watershed devoid of trees at one time or another (Albers, 2000). This landscape change had a tremendous impact on waterways like Hubbard Brook. Exposed, highly-erodibe soils (e.g., glacial tills and lacustrine soils) on steep slopes were carried to the valley floors where it aggraded on river bottoms; a legacy that still influences the way Vermont's rivers are managed today.

As Vermont's farmers began to move to the Midwest in search of more productive farmland in the mid to late 1800's, the deciduous forests along the mountain slopes began to recover (Albers, 2000). Throughout the early and mid 1900's, as more family farms found on marginal lands were given up, the forests continued to recover. Today, approximately 72 percent of the Hubbard Brook watershed is covered by forest. With the increasing tourism sector in the state, and the need for lumber for second-homes and construction, forestry has replaced agriculture in many of the rural hill slopes of Vermont.

2.2 Geologic and Geomorphic Setting

Geologic Setting

The underlying geology of the Hubbard watershed is comprised of a mixture of rock types from the Lower Devonian and Upper Silurian eras (Doll et al., 1961). The Waits River Formation, which contains a mixture of schist and marble, is found in the western section of the watershed. The Standing Pond Volcanic member is also observed as a subset of the Waits River formation. The Gile Mountain formation, a metamorphic rock type, is found in the eastern section of the watershed. This formation contains a mixture of schists and phyllites.

The presence of Glacial Lake Hitchcock also had a significant effect on the surficial geology of the lower watershed, perhaps as far upslope as reach M04. This lake occupied the Connecticut River Valley from central Connecticut north to St. Johnsbury during the retreat of the Laurentide ice sheet beginning approximately 18,000 years ago (Ridge and Larson, 1990). The great size of the lake, combined with the erosive forces of the glacier moving over bedrock surfaces allowed for the development of annual layering of fine sediments (e.g., varves) throughout the area affected by the lake.

Geomorphic Setting

Hubbard brook is a small drainage basin that enters directly into the Connecticut River. It has one main branch, with four significant tributaries and a minimum of one small sub-tributary. The mainstem of Hubbard Brook has an overall channel slope of 2.6%. The watershed tends to have unconfined valley types where the channel passes through the historic floodplain of the Connecticut River (M01), and becomes confined as it winds its way up into the eastern edge of the Green Mountains. The basin’s largest tributary, Kimball Brook (T1), has an overall channel slope of 6.6%. This tributary enters the main stem in Paradise Park and has a drainage area of 1.3 sq. mi. The other three tributaries and sub-tributary have smaller drainage areas and their slopes vary. The State Farm Road tributary (T2) extends southward in a confined setting. Then, the valley opens on a large terrace before rising again to the headwaters. The Marton Road tributary (T3) is found in a similar setting as the State Farm Road tributary, but it remains confined throughout its ascent into the headwaters. County Road tributary (T4) extends north toward the town of Hartland. The unnamed tributary (M6-S1.01) has the steepest slope (13.2%) and is found in confined valley setting. A summary of the average channel slopes for the main stem and tributaries is found below in Table 2.

Table 2. Average Channel Slopes for Mainstem and Tributary Channels

Channel (SGA Reaches)	Average Slope
Hubbard Brook (M01 - M10)	2.6%
Kimball Brook (T1.01 - T1.04)	6.6%
State Farm Road Tributary (T2.01 - T2.03)	6.5%
Marton Road Tributary (T3.01)	7.1%
County Road Tributary (T4.01)	4.0%
Unnamed Subtributary (M6-S1.01)	13.1%

2.3 Ecological Setting

The entire Hubbard Brook watershed is within the Southern Vermont Piedmont (SP) Biophysical Region (Thompson and Sorenson, 2000). This SP region is found along the eastern border of Vermont and extends from White River Junction down to Massachusetts. It is characterized by gentle rolling hills and bedrock geology that supports Northern Hardwood Forest communities. Some areas of igneous intrusions (e.g., granitic plutons), such as Ascutney Mountain and Black Mountain to the west Brattleboro, support rare communities such as the Pitch Pine-Oak-Heath community. Rich soils of loam and silt along the Connecticut River that once supported extensive areas of silver maple (*Acer saccharinum*) and ostrich fern (*Matteuccia struthiopteris*) were converted to agricultural use during European settlement in the late 18th century. Post-glacial deposits of sand and gravel are common in the river valleys of the SP region, including the mainstem and tributary valleys of the Hubbard Brook watershed.

Elevations within the watershed range from 303 feet at the confluence with the Connecticut River, up to approximately 1261 feet in the headwaters of the Marton Road tributary. With an average annual rainfall of 41.3 inches* (NOAA, 2008b) and a temperate climate, the forest cover is comprised primarily of mixed hardwood tree species, with areas of white pine (*Pinus strobus*) and eastern hemlock (*Tsuga Canadensis*) found within younger growth and along steeper slopes, respectively.

Wetlands occupy several significant areas within the watershed (NWI, 2003). The most concentrated area of wetlands can be found in the lower watershed (M01), north of Lake Runnemede. Upstream of this area wetlands are sparsely encountered on the mainstem until the headwaters (M10), which has several water-saturated areas. The lower-sloped reaches of Kimball Brook (T1.03) and the State Farm Road tributary (T2.02) also have

* Annual rainfall data is taken from Woodstock, Vermont at an elevation of 751 feet.

large wetland areas. Wetlands provide important flood control and water quality protection functions, and support continued inputs of subsurface and groundwater during the low flow periods of the year. These functions are maximized in areas where the wetland is contiguous with the channel and undisturbed by agricultural ditching or development.

3.0 Data Collection

3.1 Data Collection Methods

The Vermont River Management Program (RMP) has invested many person-years of effort into developing a state-of-the-art system of Stream Geomorphic Assessment (SGA) protocols. The SGA protocols are intended to be used by resource managers, community watershed groups, municipalities and others to identify how changes to land use affect hydro-geomorphic processes at the landscape and reach scale, and how these changes alter the physical structure and biological habitat of streams in Vermont. The SGA protocols have become a key tool in the prioritization of restoration projects that will 1) reduce sediment and nutrient loading to downstream receiving waters such as Lake Champlain and the Connecticut River, 2) reduce the risk of property damage from flooding and erosion, and 3) enhance the quality of instream biological habitat. The protocols are based on defensible scientific principles and have been tested widely in many watersheds throughout the state.

The SGA protocols include three phases (VTANR, 2007b):

- **Phase 1**: The Phase 1 SGA approach utilizes the Stream Geomorphic Assessment Tool (SGAT), a GIS extension developed by RMP for the collection of reach and watershed scale data. In addition to the GIS and remote sensing effort, a cursory field assessment ("windshield survey") is included for the verification of stream and valley forms, significant channel features and the location of man-made infrastructure. The Phase 1 SGA approach results in watershed-scale data about the landscape (e.g., soils and land cover) and the stream channel (e.g., slope and form), which provides a basis for understanding the natural and human-impacted conditions within the watershed. The SGA data also aids in the identification of specific stressors affecting the physical conditions of the stream channels and structures (e.g., bridges and culverts). Table 4 summarizes the parameters collected in Phase 1 using the Feature Indexing Tool (FIT), which include those utilized to develop the final impact ratings.

- **Phase 2**: The Phase 2 approach builds upon Phase 1 data through the collection of reach-specific data about the current physical conditions. Characterization of reach conditions utilizes a suite of quantitative (e.g., channel geometry, pebble counts) and qualitative (e.g., pool-riffle habitat) measurements to calculate two indices: Rapid Geomorphic Assessment (RGA) Score; Rapid Habitat Assessment (RHA) score. Using the RGA scores in conjunction with knowledge about the background or "reference" conditions, a sensitivity rating is developed to predict the degree to which the channel will adjust to human impacts in the future. Table 4 summarizes the parameters collected and verified in Phase 2 using the Feature Indexing Tool (FIT).

Table 3. Parameters Collected with FIT

Phase 1 Step	Phase 2 Step	Data Type	Impact	Sub-Impact
3.1	**1.2**	Point	Alluvial Fan	NA
3.2	**1.6**	Point	Grade Control	Dam Ledge Waterfall Weir
NA	**3.3**	Point	Mass Failure	NA
5.5	**5.5**	Point	Dredging	Dredging Gravel Mining Commercial Mining
NA	**4.4**	Point	Debris Jam	NA
NA	**4.6**	Point	Stormwater Input	NA
NA	**4.9**	Point	Beaver Dam	NA
NA	**5.2**	Point	Migration	Neck Cut Off Flood chute Avulsion Braiding
NA	**5.3**	Point	Steep Riffle or Head Cut	Head Cut Steep Riffle
NA	**5.4**	Point	Stream Crossing	Stream Ford Animal Crossing
NA	**3.3**	Point	Gully	NA
6.2	**1.3**	Line	Development	NA
6.1	**1.3**	Line	Encroachment	Berm Improved Path Road Railroad
5.3	**3.1**	Line	Bank Armoring or Revetment	Rip-Rap Hard Bank Other
7.2	**3.1**	Line	Erosion	NA
5.4	**5.5**	Line	Straightening	Straightening With Windrowing

- **Phase 3**: Phase 3 surveys involve the collection of detailed, reach-scale survey data to verify or build upon Phase 2 data. These surveys are typically carried out prior to project development for an "active" channel management approach (e.g., floodplain restoration), or for long-term monitoring purposes.

FEA used SGAT to develop the baseline data layers for the watershed. The remaining Phase 1 data has been collected remotely and with windshield surveys for the 20 reaches along 13.1 river miles. All major human impacts and natural features were indexed in a GIS using the Feature Indexing Tool (FIT; VTANR, 2007b).

3.2 Phase 1 Quality Assurance

The RMP Quality Assurance (QA) protocols outlined in the SGA protocols (VTANR, 2007b) were followed in order to ensure a complete and accurate dataset. RMP staff shared responsibility with FEA for the QA of the finalized Phase 1 dataset. All metadata describing the data sources were entered in the Data Management System (DMS), with extraordinary sources noted in the comments section in Step 7. Two separate QA reviews were completed by RMP staff following the completion of Steps 2 and 7. A written record of QA issues raised by RMP, and responses from FEA is included in Appendix C.

4.0 Results

4.1 Reach Delineations

The 13.1 miles of assessed surface waters within the Hubbard Brook watershed were divided into 20 reaches during the SGAT analysis. Reach divisions were based on changes in valley geometry, channel slope, and the size and influence of tributaries entering the mainstem channel (VTANR, 2007b). Four (4) major tributaries (e.g., drainage area exceeds 10% of mainstem drainage area at confluence) were identified during the SGAT analysis (see Figure 3). Table 4 summarizes data for the mainstem and tributary watersheds. Detailed information about each reach location is found in the reach reports in Appendix B.

Table 4. Mainstem and Tributary Summary Data

DMS ID	Name	Watershed Area (square miles)	Assessed River Length (mi)*	Number of Assessed Reaches*
M	Hubbard Mainstem*	6.3	6.7	11
T1	Kimball Brook	1.3	2.4	4
T2	State Farm Rd. Tributary	0.6	1.4	3
T3	Marton Rd. Tributary	0.7	1.4	1
T4	County Rd. Tributary	0.6	1.1	1

* Includes subtributary reach M6-S1.01 (unnamed subtributary)

4.2 Reference Stream Types

Remotely collected data of valley confinement, channel slope, and sinuosity were used to develop reference stream types for the assessed reaches according to the Rosgen (1994) and Montgomery and Buffington (1997) classification systems. Characterization of reference stream types is based on the channel forms and processes expected in a particular geologic and geomorphic setting without human influences. Detailed information about each reach reference stream type is found in the watershed summary data and reach reports found in Appendices A and B, respectively. Table 5 presents general valley and channel characteristics associated with reference stream types found in the Hubbard Brook watershed.

Table 5. Reference Stream Type Characteristics

Stream Type	Valley Confinement	Channel Slope	Sinuosity	Bedform	Number of Study Reaches*
A	Confined	> 4%	Low	Cascade or Step-pool	9 (45%)
B	Confined	2 – 4%	Low	Step-pool or Plane bed	4 (20%)
C	Unconfined	< 2%	Moderate	Riffle Pool	6 (30%)
E	Unconfined	< 2%	High	Riffle Pool or Dune-Ripple	1 (5.0%)

* Number of reaches and percentage of total reaches represented by type

Figure 3 presents the location of the reference stream types developed for the Hubbard watershed. A majority of the reaches (45%) in the watershed are A-type under reference conditions. This stream type is characterized by channels with very little sinuosity that are found in narrow or semi-confined valley settings. A high degree of slope (>4%) is usually observed with this stream type, making the geomorphic processes dominantly transport based. Thirty (30) percent of the reaches in the watershed are C-type under reference conditions. This stream type is typically characterized by a moderately sinuous channel found in a broad, unconfined valley setting with a balance between the upslope sediment supply and the transport capacity. Only one (1) reach was characterized as an E-type channel, where very broad valley settings and sediment depositional processes support a sinuous channel planfom.

The high slopes observed throughout the watershed (Table 2) make sediment transport the dominant process observed in the basin. Only in areas of negligible slope (e.g., M01) were E-type channels found. Also, in the middle portion of the basin where slope was reduced, C-type channels were common (e.g., T1.03 and T2.02).

4.3 Watershed Geology and Soils

The NRCS soils data (NRCS, 2008) was utilized to review the parent material of the watershed. Figure 4 depicts the main classes of parent materials distributed across the watershed, as well as areas of known and potential alluvial fans. One grade control was observed in the field during the windshield survey and is displayed in Figure 4. This feature was photographed and mapped because of its close proximity to the road. The presence of numerous other grade controls in the headwaters reaches is likely where bedrock outcroppings are present. Detailed geologic information about each reach is found in the reach reports found in Appendix B.

Five alluvial fan locations have been noted in the watershed. Each of these locations marks areas where steep sloped transport reaches have abrupt changes in slope. This rapid change in slope causes the fallout of sediment from the water, resulting in sediment deposition. Alluvial fans are characterized by highly active channels with a propensity for lateral migration and avulsion; even where they have been historically managed (e.g., dredged and straightened). The alluvial fan point located upstream of the confluence with Marton Road tributary can be attributed to the flow of a small ephemeral, or intermittent tributary coming from the north valley slope that seems to behave similarly to the fan points located within the channel.

The area of alluvial outwash near the confluence of Kimball Brook and the mainstem could also be a potential location of an alluvial fan; it was not mapped because topographic maps did not show any diagnostic contour lines that suggest the presence of alluvial fans.

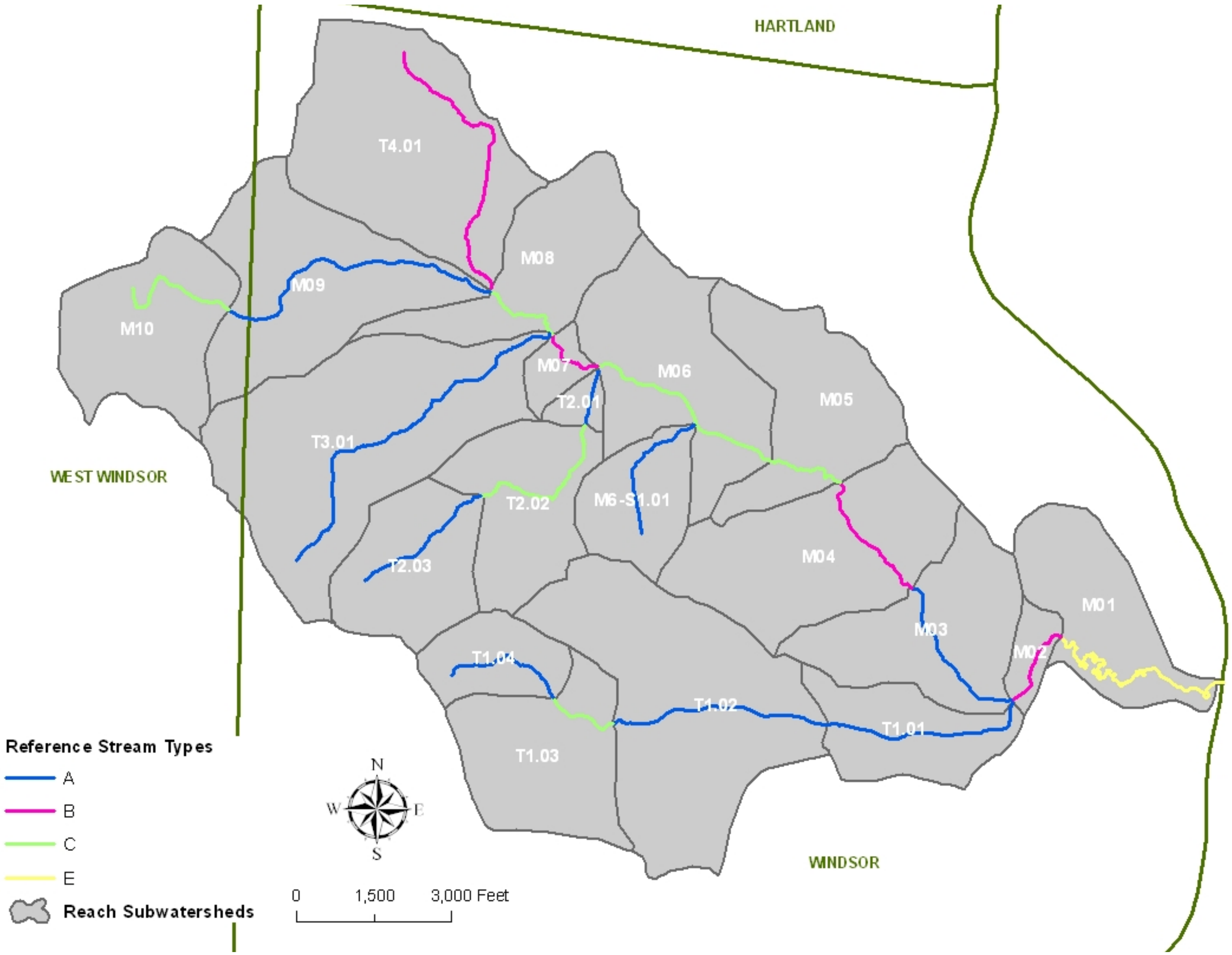

Figure 3. Reference stream types per Rosgen (1994) for the Hubbard Brook watershed

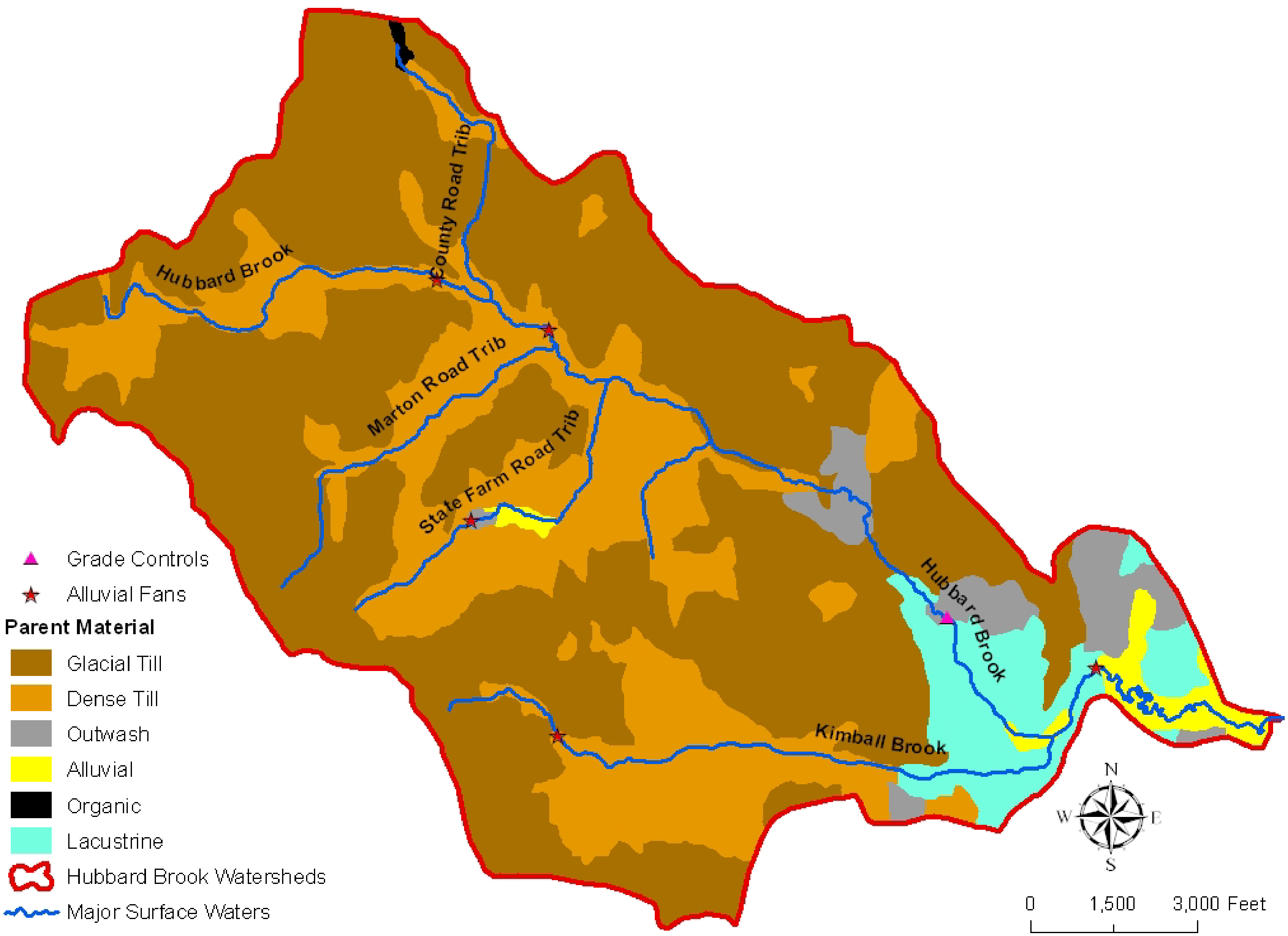

Figure 4. Parent Materials, Alluvial Fans, and Natural Grade Controls within the Hubbard Brook watershed

4.4 Land Cover and Reach Hydrology

Step 4 of the Phase 1 protocols evaluates the impacts of watershed land use, riparian vegetative cover, and other reach-scale controls on hydrologic processes. Conversion of natural forest cover to urban and agricultural land uses in a watershed, even at low levels (e.g., 10% of watershed area), has been shown to have measurable deleterious effects on channel stability and aquatic biota (Paul and Meyer, 2001; CWP, 2003). Loss of forest cover reduces the infiltration capacity of soils, and typically results in increased runoff during infrequent storm events and reduced baseflow during the dry periods of the year. In addition, direct impacts to riparian cover along the river bank and within the corridor are also known to have negative impacts on channel stability (e.g., loss of boundary resistance) and available habitat for biota (e.g., canopy shading, large woody debris, etc.). Other local-scale influences on reach hydrology include adjacent wetlands, small tributaries, and other sources of groundwater inputs. These areas provide important inputs of cooler waters that are critical for microhabitats, especially during the late summer and fall months when water temperatures can become elevated to levels that are harmful to native stenotherms.

Land cover in the Hubbard Brook watershed was summarized with the SGAT tool using data derived from 1992 satellite imagery (VCGI, 2003). This dataset was clipped to the local watershed (e.g., area draining directly to reach) and stream corridor to understand the impacts to each reach at each scale. Impact ratings were automatically generated upon upload of the data to the DMS based on the rankings provided in Table 6. In addition to the DMS summarized data, more recent land cover data was summarized at the watershed scale, as previously reviewed in Table 1 in Section 2.1.

Table 6. SGA Land Use Impact Ratings

Impact Rating	Land Cover Value
High	10% or more of reach watershed is crop and/or urban
Low	Between 2 - 10% of reach watershed is crop and/or urban
Not Significant	Less than 2% of reach watershed is crop and/or urban

Historic land cover data for the reach watershed and corridor scales was reviewed using a series of aerial photographs of the study area from 1963 available through the UVM Baily/Howe Library. The images were georectified and overlain on the subwatershed mapping to understand land use changes over the last 40 years. In general, that watershed was a mixture between agriculture and forest lands in the 1960's, however the forest stands were likely much younger and homogenous. The current dominant land cover type for the entire watershed is forest, because much of the suboptimal farmland was abandoned. Along the mainstem of Lower Hubbard Brook, between Route 5 and Lake Runnemede the land was historically used for agricultural activities (Figure 5). That land has been abandoned sometime within the last 40 years and is now unmanaged wetlands (Figure 6).

The watershed has seen some urbanization since the 1960's, but much of the developed land predates 1963. The upper watershed (M09 and M10) and lower watershed (M01, M02, and M03) have "high" impact scores, as well as tributaries M6-S1.01 and T1 (reaches T1.01 and T1.02). The rest of the watershed received "low" ratings for the watershed land cover with between 5 and 10 percent urban coverage within each subwatershed. The corridor land use was variable with many of the mid-watershed reaches that have had extensive agriculture scoring "high." Several reaches including M02, M03, and T1.04 had less than 5 percent of the corridor developed; because of this those reaches received "not significant" impact ratings.

Riparian buffer widths were estimated remotely and verified in the field where possible during the windshield surveys. Areas where the buffer widths were less than 25 feet were mapped remotely and indexed using the FIT. Areas that received high impact scores for the lack of a healthy riparian buffer were those associated with alluvial and dense till valleys where adjacent lands have been intensively used for agricultural or residential land uses including the presence of roadways. Reaches in this condition include M06, M6-S1.01, M07, M08, T1.03, T2, and T4.01.

Groundwater and small tributary inputs were reviewed for each reach using the National Wetlands Inventory (NWI, 2003) and the Vermont Hydrography Dataset. Additional detailed information about each Step 4 parameter for all reaches is found in the watershed summary data and reach reports found in Appendices A and B, respectively.

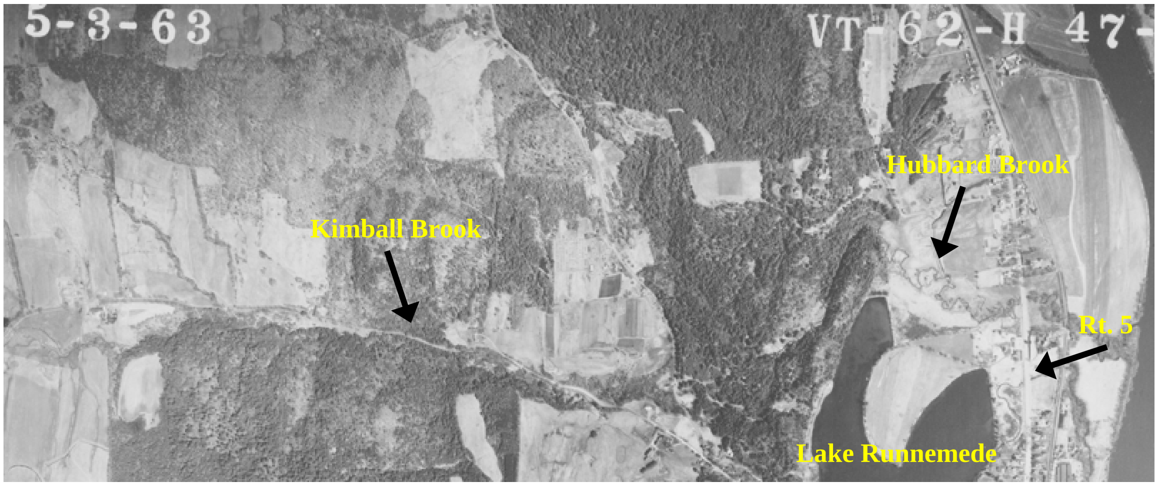

Figure 5. 1963 aerial photograph of the lower Hubbard Brook watershed

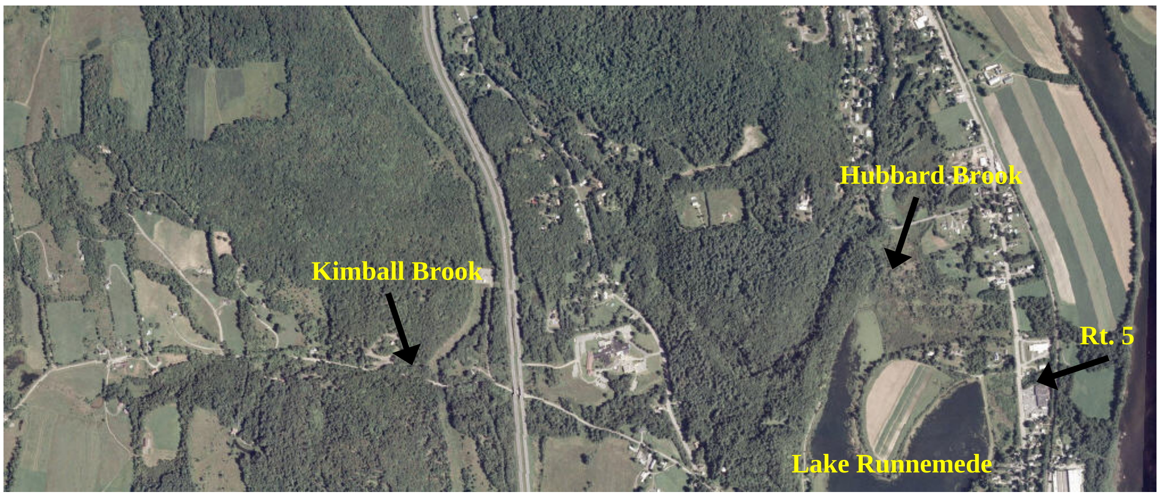

Figure 6. 2003 aerial photograph of the lower Hubbard Brook watershed

4.5 Instream Channel Modifications

Data collected as part of SGA Step 5 aids in the understanding of how direct impacts to the channel boundaries have altered the sediment supply and transport regimes at the reach scale. Flow-regulating structures that span the channel impact the natural flow variability in downstream reaches, and interrupt the sediment supply along the channel network. These features often result in reduced instream habitat as well as channel incision in downstream areas where the sediment transport capacity exceeds the limited supply from upslope. Bridges and culverts that are inadequately sized to accommodate channel forming flows have similar impacts to habitat and sediment transport as flow-regulating structures. In addition, culverts that have severely “perched” outlets create a discontinuity in habitat along the channel by preventing fish passage. Bank armoring, channel straightening, and dredging are human impacts that increase the sediment transport capacity of the channel through the increased resistance to lateral migration and channel slope. Further discussion of the impacts of instream channel modifications is provided in the SGA Phase 1 Handbook (VTANR, 2007b). Reaches with significant impacts from these features are summarized below. Additional detailed information about each Step 4 parameter for all reaches is found in the watershed summary data and reach reports found in Appendices A and B, respectively.

Impoundments and Flow Regulations

Flow regulations have been reviewed and mapped using the VTANR Dam Inventory (VTANR, 2005), as well as further field observations and discussions with VTDEC staff. These features are summarized below for the mainstem and tributary reaches. Each of the flow regulations indexed with the FIT is considered a run-of-the-river feature (e.g., no current water withdrawals).

Using aerial imagery, a total of three impoundments were observed in the basin. All three of these features were considered large run-of-the-river because the width of the impounded area was larger than that of the channel. The only flow regulation feature located on the mainstem was found in the headwaters reach M10 where the channel has been backed up to create a pond near a residence. The other impoundments were located on Kimball Brook and Marton Road tributary. The Kimball Brook impoundment, located on reach T1.03, was directly upstream of the Hunt Road crossing and a large area used for grazing cattle (Figure 7). The other impoundment is located in the headwaters of reach T3.01, along side of Pond Road. The correctional facility along State Farm Road has a small water withdrawal used to fill their fire pond (Cueto, 2008). The fire pond was too small to show up on the imagery and no water withdrawal was indexed using FIT, because the exact location is unknown.

Bridges and Culverts

The locations and lengths of bridge and culvert crossings were mapped remotely and were verified in the field where possible. A total of 39 structures were noted on the 20 assessed reaches. Reaches M05, M06, M08, M09, T1.01, and T2.01 had impact ratings of “low,” where at least 5 percent of the channel length is occupied by a bridge or culvert. Reach M05 is intersected by Interstate 91, and had the greatest single impact with approximately 200 feet of the channel piped under the highway in a culvert. Culverts and bridges can also act as a constriction point to the channel at various flow depths, or inhibit the passage of wildlife like the perched culvert observed in reach M07 (Figure 8).

Figure 7. Impoundment upstream of Hunt Road

Figure 8. Perched culvert at the State Farm Road Crossing

Bank Armoring

Bank armoring and revetments were noted in as much detail as possible during the windshield surveys. Only one reach had significant amounts of bank armoring. This reach, T2.01 was heavily armored and rip-rapped as part of an effort to stabilize the left bank of the channel where it was encroached upon by the road (Figure 9). In total approximately 1045 feet of the channel bank was stabilized using large boulders piled on a 45º slope to a height of about 25 feet. This effort has significantly affected the natural course of the stream.

Figure 9. Rip-rap on the left bank of reach T2.01 along State Farm Road

Channel Straightening and Dredging

Historic aerial photographs from 1962 and recent NAIP color imagery from 2003 were utilized to identify areas of channel straightening. In addition, field observations were made to verify areas of inferred channel straightening from available mapping. These areas are summarized below for the mainstem and tributary reaches in Table 7.

It is not known whether or not dredging has occurred historically at the alluvial fan locations or elsewhere in the watershed to manage the build up of sediment. Due to the relatively small watershed size (6.3 sq. mi.), the transport capacity of the channel is not as high as it would be for larger drainage basins. Under these conditions areas of large gravel deposition are not as likely to occur, therefore obviating the need for dredging.

Table 7. Summary of Channel Straightening and Dredging

Branch/ Tributary Name	Reach ID	Channel Straightening		Dredging	
		% of Reach	Impact	Type	Impact
Hubbard Mainstem	M01	17.1	Low	None	--
Hubbard Mainstem	M05	59.9	High	None	--
Hubbard Mainstem	M06	4.2	N.S.	None	--
Unnamed Subtributary	M6-S1.01	54.7	High	None	--
Hubbard Mainstem	M10	24.0	High	None	--
Kimball Brook	T1.03	47.7	High	None	--
State Farm Road Tributary	T2.01	90.3	High	None	--
State Farm Road Tributary	T2.02	19.1	Low	None	--

In addition to a high degree of channel straightening in Reach T1.03 (Kimball Brook) this area has been greatly influence by other anthropogenic activities. There, the channelized stream bed has been left open for grazing cattle. Not only does this damage the stream banks, increasing sediment loads, but it acts as a point source for phosphorus and nitrogen pollution (Figure 10).

Figure 10. Cows watering in the channel in Kimball Brook reach T1.03

4.6 Floodplain Modifications and Planform Changes

Due to the historical development of road networks and settlement patterns in the lowland areas of Vermont, many alluvial rivers and their floodplains have been encroachned upon by roads and development over the years. As discussed in the previous section, many of these areas have also been historically manipulated and straightened to maintain an unnaturally steep slope in a state of sediment transport, allowing for a short-term sense of security from flooding and subsequent encroachment of infrastructure in the floodplain. In addition to historic alterations to channel slope in Vermont's alluvial rivers, the lowering of stream beds (e.g., dredging) and the raising of floodplains (e.g., berming) has resulted in an increase in channel depth (VTANR, 2007a). Channel depths have typically been increased through the encroachment on the floodplain by roads, development and railroads and subsequent filling and armoring required to construct and maintain this infrastructure. Increases in impervious cover have also led to the deepening and eventual widening of channels throughout urbanized areas of Vermont (Fitzgerald, 2007).

These human impacts tend to induce a series of channel adjustments that begin with channel incision, leading to widening and eventually a redevelopment of a sinuous planform in alluvial reaches. Reaches with significant impacts associated with the above-described human impacts are summarized below according to the SGA impact ratings listed in Table 8. Reaches affected by an increase in depositional or migrational features are also summarized below. Additional detailed information about each Step 5 parameter for all reaches is found in the watershed summary data and reach reports found in Appendices A and B, respectively.

Table 8. Impact Ratings for Corridor Encroachments and Developmen

Impact Rating	**Impact Criteria**
High	Greater than 20% of reach length affected.
Low	Between 5 - 20% of reach length affected.
Not Significant	Less than 5% of reach length affected.

Encroachments

Following the Phase 1 protocol, any berms, roads, driveways, railroads and/or improved paths found within the stream corridor were indexed using the FIT. These areas were identified using the 2003 NAIP aerial imagery, and were confirmed and/or refined during the field observations. Figure 11 depicts the reaches where encroachment has significantly impacted the stream corridor, with ratings based on the percentage of the reach length that was impacted as indicated in Table 8. All encroachments noted in the watershed were from roads (Figure 12), however further Phase 2 assessments may reveal additional berm encroachments that were not observed remotely or during the windshield surveys.

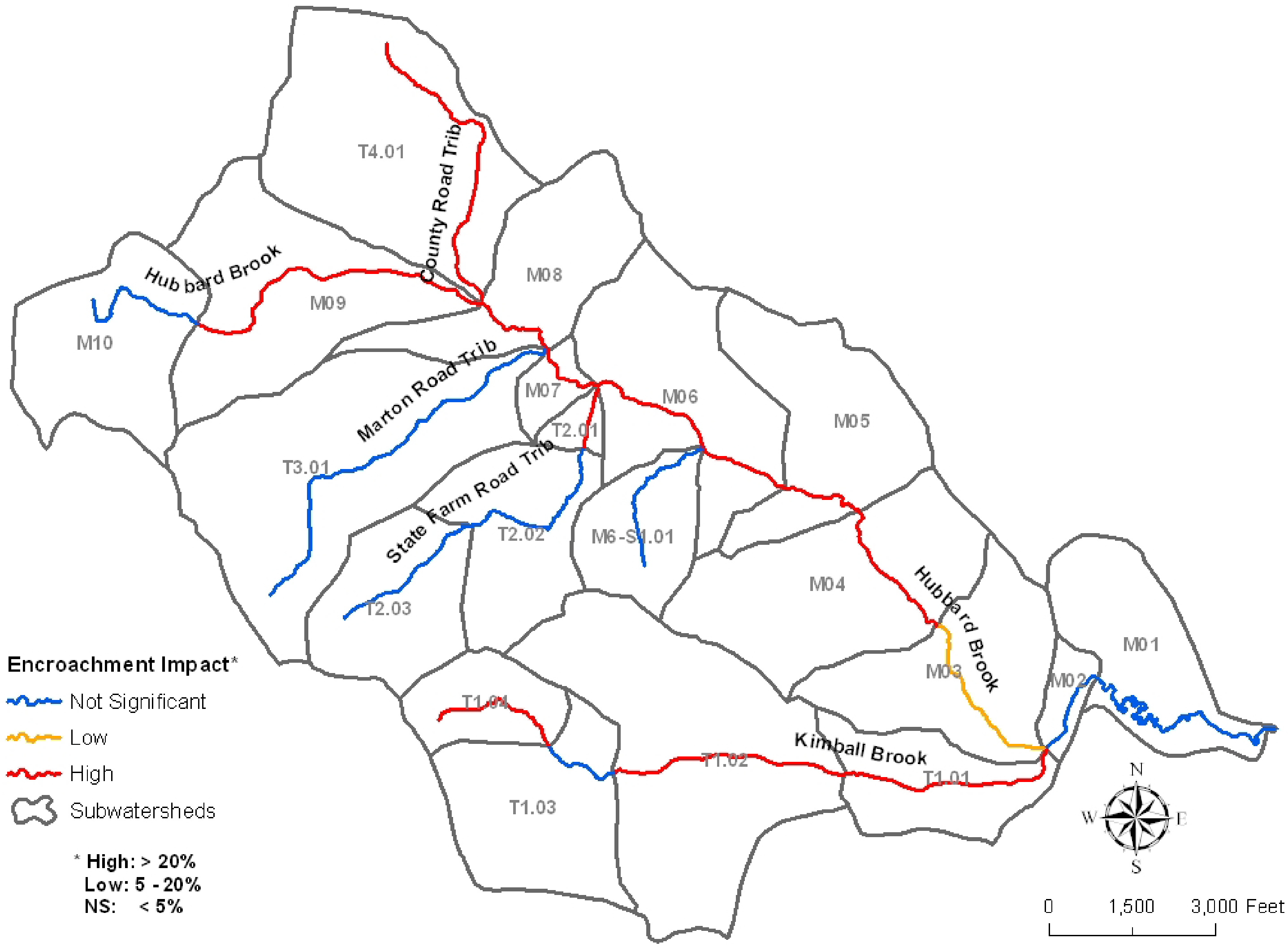

Figure 11. Impacts from corridor encroachments in the Hubbard Brook watershed

Figure 12. Corridor encroachment along Weeden Hill Road in reach M09

Development

The impact of development within the stream corridor was evaluated using the 2003 NAIP aerial imagery, and confirmed and/or refined during the field observations. The presence of development was indexed using the FIT, and impact ratings for each reach were developed based on SGA criteria presented in Table 8. The majority of the development observed on the mainstem was on mid and upper reaches M04, M05, M06, M07, M08 and M10. The lower watershed is either abandoned agricultural land that has since become wetland (M01), or protected in Paradise Park (M02 & M03). These factors keep the lower watershed relatively void of any significant development. With the exception of reach T4.01 and M6-S1.01, the tributaries of the Hubbard Brook were mostly undeveloped. These two reaches had an impact rating of low, from a scattered house or farm that was within the stream corridor.

Depositional Features

Sediment depositional features (e.g., point bars, mid channel bars, etc.) were evaluated using the 2003 NAIP aerial imagery, and were confirmed and/or refined during the field observations. Reaches with multiple types of depositional features indicated where upslope sediment supply exceeded the transport capacity. These areas represent conditions that are favorable for increased lateral channel migration that could endanger adjacent infrastructure and properties. For most of the watershed it was difficult to access the stream channel remotely (due to the channel's small size), or to get a clear sense of the depositional processes at the access points during the windshield surveys. Given the relatively small size of the watershed, and forest cover over much of the area, only about one-half of the reaches were assessed for depositional features. Despite the drawbacks in reach accessibility, several reaches were deemed to have a "low" impact from depositional material and one reach had a "high" impact rating. This reach, M04, had an abundance of sediment on the point bars upstream and downstream of the Juniper Hill Road crossing. Here, the upslope sediment supply greatly exceeds the transport capacity of the channel (Figure 13). Additional detailed data about the types of depositional features and their relative impacts for all reaches are found in the reach reports found in Appendix A.

Figure 13. High degree of deposition on the point bars of reach M04

Meander Migration

Recent and historic aerial photographs and imagery were reviewed to identify areas of channel migration, bifurcation, and avulsions on the Hubbard Brook mainstem and its tributaries. Historical photographs from 1963 were reviewed. For areas where significant channel migration was noted, the historical imagery was georectified using ArcGIS software to transform the mapping into the NAD 1983 State Plane Meter projections. Previous channel locations (1963) were compared with the Vermont Hydrography Dataset stream centerlines developed from the aerial photographs taken in 1994 for the watershed. M01 showed a dramatic change in planform with extensive meander migration. Some of the geomorphic changes that have occurred over the last 40 years are highlighted in Figure 14.

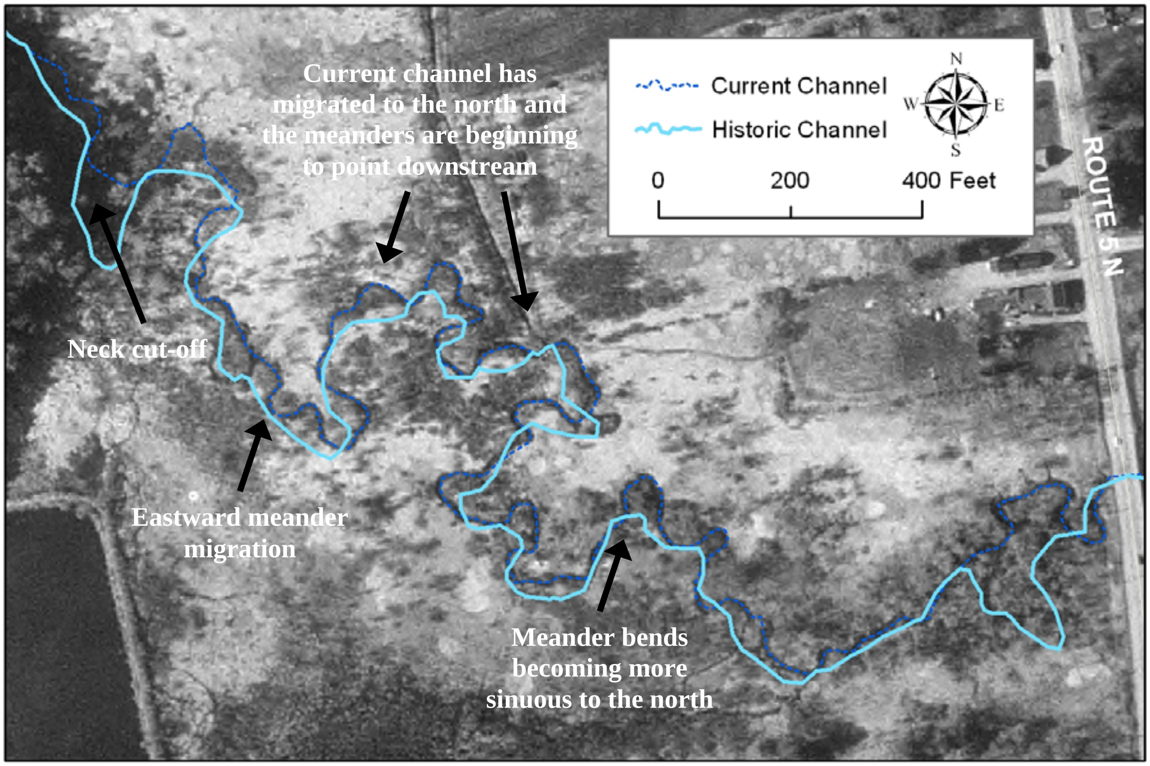

Figure 14. The changes in channel planform from 1963 to 1994 on reach M01

Meander Geometry

For reaches characterized within unconfined valley settings (C or E-type channels), meander geometry was reviewed following the Phase 1 protocols. Shapefiles were developed to indicate the areas where meander width and wavelength was measured. In some cases, multiple meanders were measured and an average of the measurements was entered in the DMS. Where the meander wavelengths and widths fell outside of the range of expected values relative to the predicted channel width, impact ratings of high or low were assigned according to the degree of departure (VTANR, 2007b). Only seven of the 20 total reaches assessed were set in a valley suitable for meander geometry risk assessments. In addition to Reach M01 (Figure 14), M05 and T1.03 also received a "high" impact scores for both meander geometry criteria.

4.7 Bed and Bank Windshield Surveys

Windshield surveys were completed following the initial classification of stream type and substrate based on remotely sensed data alone. Surveys were completed in mid-July on all reaches accessible by public roads. Eighteen (18) of the 20 total reaches in the study area were at least partially accessible by roads and were viewed. Only subtributary M6-S1.01 and M02 were located in inaccessible terrain were not evaluated. The DMS metadata for Step 2 has been revised and indicates whether or not the reach was evaluated in the field. The Phase 1 parameters verified and/or evaluated during the field surveys included:

- General stream and valley geometry, including valley width and confinement, bed substrate, and bedform features (Step 2).
- Grade controls and areas of known or potential alluvial fans (Step 3).
- Impacts on the buffer and stream corridor, including areas of reduced buffer vegetation, road encroachments, and the presence of development within the stream corridor (Steps 4 and 6).
- Types of stream crossing structures (e.g., bridges and culverts), and their potential for causing ice and debris jams (Steps 5 and 7).
- Areas of bank erosion and armoring (Steps 5 and 7).
- Areas of increased sediment deposition and meander migration (Step 6).

Of the parameters listed above, particular attention was paid to recording bank erosion and ice/debris jam potential at the stream crossings. Due to limited direct accessibility on most reaches, bank erosion along the entire channel length was not practical; rather, bank erosion plainly visible along roads or at stream crossings was indexed using the FIT. Therefore the relative length of the reach impacted by bank erosion was likely underestimated compared to typical Phase 2 field observations. Debris and ice jam potential at points of channel constrictions associated with stream crossings and sharp channel bends were recorded in the field. Qualitative ratings of the impact of these areas on sediment and debris continuity were developed and entered into the DMS. Table 9 summarizes those reaches where impacts from bank erosion or ice and debris jam potential were noted.

Table 9. Select Reaches with Observed Bank Erosion or Ice and Debris Jam Potential

Branch or Tributary Name	Reach ID	Bank Erosion		Ice and Debris Jams	
		% of Reach	Height (ft)	Types	Impact
Hubbard Mainstem	M09*	16.4%	3.0	Culvert	High
Kimball Brook	T1.01	0.0%	NE	Multiple**	High
County Rd. Tributary	T4.01*	8.2%	3.0	Culvert	Low

*Both reaches with bank erosion had impact ratings of "low"

** "Multiple" potentials was used when no one source could be identified as dominent

NE: Not evaluated

5.0 Data Analysis

Impact scores have been generated for each of the Phase 1 steps for the 20 study reaches. The Phase 1 dataset in the DMS summarizes these scores under 4 separate impact categories as summarized in Table 11. Impact scores range from zero (“not significant”) to 2 (“high”) depending on the degree of impact recorded for each parameter. The 16 parameters evaluated for impacts and summarized for each study reach are presented in Table 10. Figure 15 presents the impact scores for each study reach, with the scores organized by quartiles. An additional table in Appendix A summarizes the impact scores by reach.

Table 10. Final Impact Score Parameters for Phase 1 Dataset

Phase 1	Phase 1 Parameter	Impact
4.1	Local Watershed Land Cover/Land Use	Land Use
4.2	Corridor Watershed Land Cover/Land Use	
4.3	Riparian Buffer Width	
5.1	Flow Regulations	Channel Modifications
5.2	Bridges and Culverts	
5.3	Bank Armoring	
5.4	Channel Straightening	
5.5	Dredging and Gravel Mining	
6.1	River Corridor Encroachments	Floodplain Modifications and Planform Changes
6.2	River Corridor Development	
6.3	Depositional Features	
6.4	Meander Migration	
6.5	Meander Belt Width Departure	
6.6	Meander Wavelength Departure	
7.2	Bank Erosion	Bed and Bank Conditions
7.3	Debris and Ice Jam Potential	

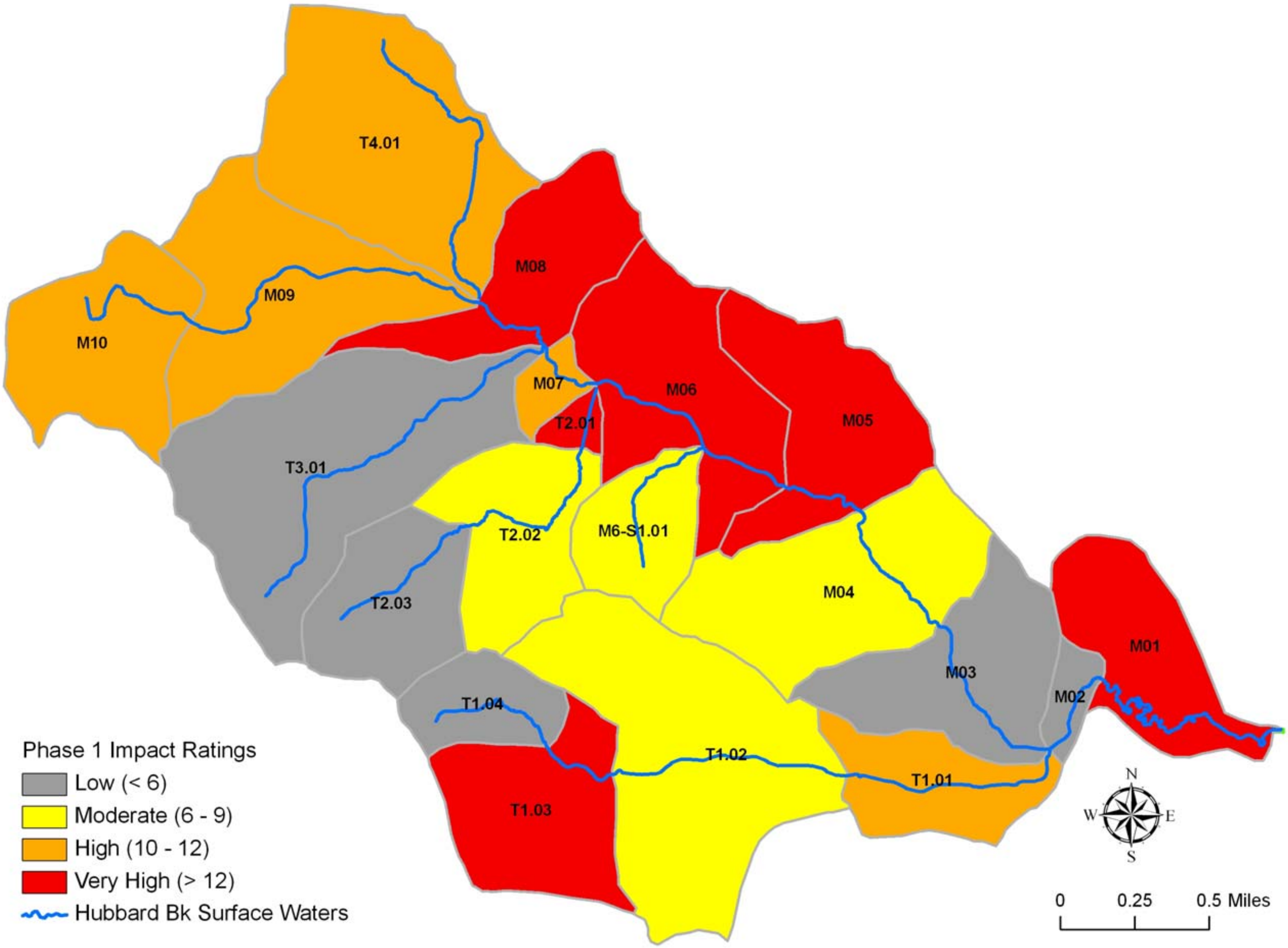

Figure 15. Phase 1 final impact ratings for the Hubbard Brook subwatersheds and reaches

Based on the Phase 1 impact scores, the DMS also develops predictions for channel adjustment processes (VTANR, 2007b). These predictions are based on the dominant impacts recorded for each reach, and are categorized based on the impacts typically associated with the following four channel adjustment processes: 1) Degradation (e.g., channel incision); 2) Aggradation (e.g., increased sediment deposition); 3) Channel widening (e.g., increased bank erosion); 4) Planform Changes (e.g., irregular meander patterns). Using the channel adjustment process ratings, a provisional geomorphic rating is developed for each reach based on the methods outlined in the SGA Phase 1 protocols (page 76; VTANR, 2007b). Table 11 outlines the four possible geomorphic ratings based on the SGA methods. An additional table in Appendix A summarizes the predicted reach adjustment processes, as well as stream sensitivity ratings. Both of these parameters have been used in conjunction with the overall impact scores in developing recommendations for further Phase 2 assessment.

Table 11. SGA Reach Condition Ratings

SGA Rating	Predicted Conditions and Processes
Reference	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.
Good	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.
Fair	In Adjustment – moderate loss of floodplain function; or moderate to major planform adjustments that could lead to channel avulsions.
Poor	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 t

6.0 Phase 2 Recommendations

Using the Phase 1 Impact Ratings as the primary basis for reach selection, a list of high and medium-priority reaches has been compiled for further Phase 2 surveys. Figure 16 presents the selected reaches by location in the watershed. Table 12 summarizes the selected reaches based on watershed location, channel length, and preliminary reference stream type.

High Priority Reaches

Nine (9) reaches are considered high-priority for assessment, including 8 reaches on the main stem and 1 reach on Kimball Brook. The total channel length for the selected reaches is 5.3 miles. Reaches M02 and M03 were considered high priority reaches for phase 2 assessments, despite their lower impact scores, because it will be important to have a continuous dataset of along the channel network from M01 upslope. These reaches received relatively low scores because there were limited roads and areas of development in the vicinity of Paradise Park.

Medium Priority Reaches

Three (3) additional reaches have been included as medium-priority reaches due to their relative impact ranking and location in the watershed. Kimball Brook reaches T1.02 and T2.03 were chosen because of the significant size of the upslope drainage area and their high impact scores. T1.03 had extensive impacts from agricultural activities and could be a potential site for a buffer enhancement project (see Figure 10). State Farm Road tributary, reach T2.01, was also chosen as a medium priority reach because of the extensive restoration project that was done to manage erosion of the left bank. Field observations revealed a mass failure that may be related to the recent restoration efforts.

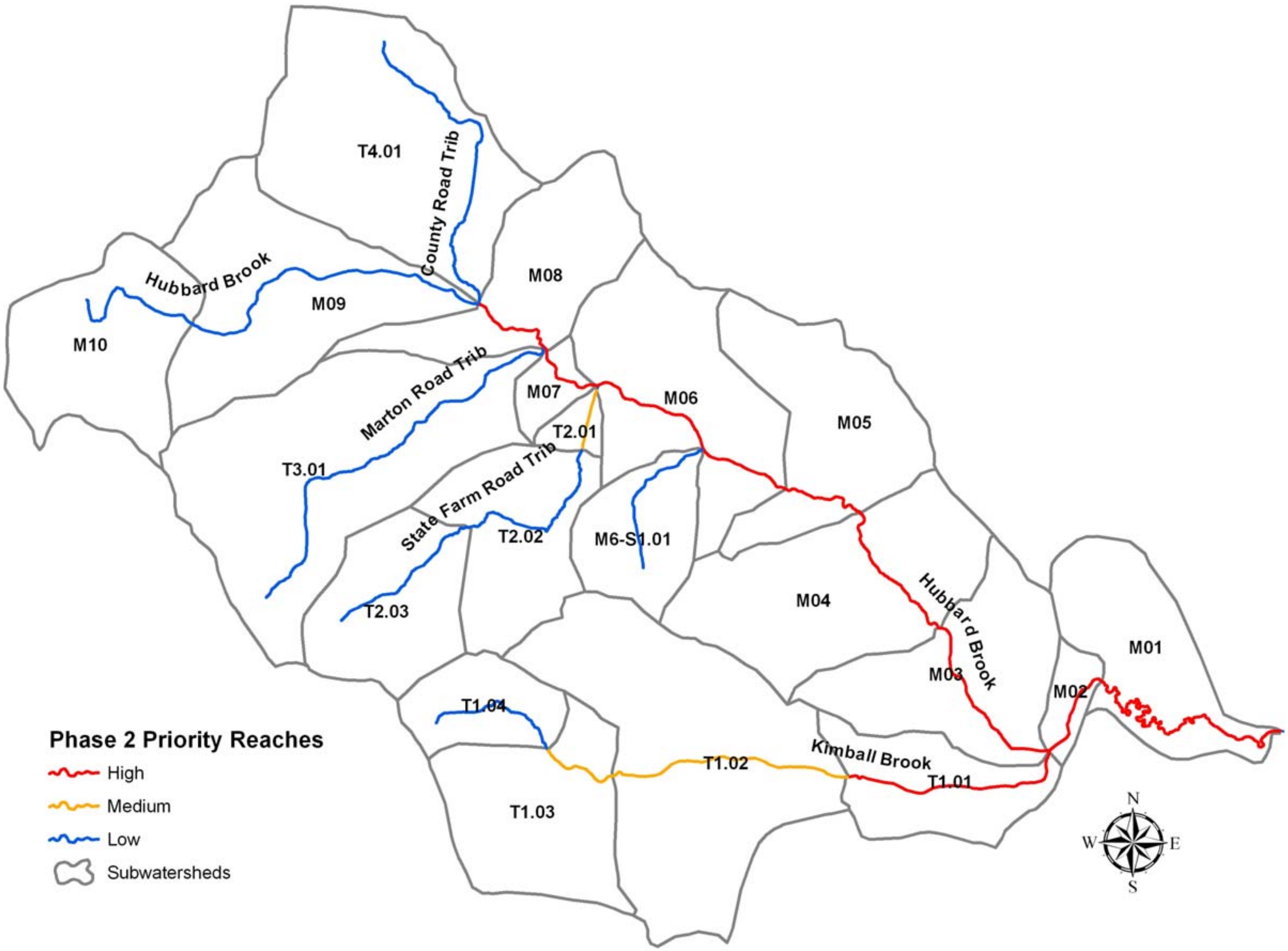

Figure 16. Selected reaches for Phase 2 assessment

Table 12. Selected Reaches for Phase 2 Assessments

Reach ID	Surface Water	Channel Length (ft)	Stream Type	Bed Material	Bedform	Impact Score	Phase 2 Priority
M01	Hubbard Brook	6,763	E	Gravel	Dune-Ripple	14	High
M02	Hubbard Brook	1,788	B_c	Cobble	Riffle-Pool	2	High
M03	Hubbard Brook	3,388	A	Cobble	Step-Pool	4	High
M04	Hubbard Brook	2,801	B_c	Gravel	Riffle-Pool	9	High
M05	Hubbard Brook	1,630	C_b	Cobble	Riffle-Pool	15	High
M06	Hubbard Brook	4,190	C_b	Cobble	Riffle-Pool	13	High
M07	Hubbard Brook	1,313	B	Cobble	Plane Bed	10	High
M08	Hubbard Brook	1,767	C_b	Cobble	Riffle-Pool	13	High
T1.01	Kimball Brook	4,131	A	Cobble	Step-Pool	10	High
T1.02	Kimball Brook	4,393	A	Cobble	Step-Pool	8	Medium
T1.03	Kimball Brook	1,483	C_b	Gravel	Riffle-Pool	14	Medium
T2.01	State Farm Rd. Tributary	1,106	A	Cobble	Step-Pool	14	Medium

--	# of Reaches	Miles
*High Priority Reaches	**9**	**5.3**
**High and Medium Priority Reaches	**12**	**6.6**

7.0 Conclusions

The following are some of the key conclusions from this work that will help the SWCRPC and PPC look forward to additional data collection and restoration planning in the watershed.

- Approximately two-thirds of reaches are dominated by sediment transport processes, with the remaining dominated by depositional processes under natural conditions. However, sediment transport processes in the upper watershed have likely been increased by extensive stream corridor and floodplain encroachment from County Road. This may be resulting in increased deposition of sediment in the lower reaches of the watershed in the vicinity of Paradise Park.

- Increased sediment deposition in Reach M01 below Paradise Park is likely attributable to a high sediment supply from upslope reaches, the redevelopment of a meandering channel form following past channel straightening, and the presence of beaver dams in areas that were historically managed to be free of beavers.

- The highly erodible glacio-lacustrine soils in the lower watershed cause naturally high rates of hill slope erosion and gully formation in the steep areas around Paradise Park. Runoff from the paved roads on steep terrain around the park (e.g., Juniper Hill Road) needs to be properly managed to prevent additional gully formation on the steep slopes leading down to the park.

- Additional work to inventory stormwater conveyances and outfalls directly to Hubbard and Kimball Brooks would be highly valuable and supportive of Phase 2 geomorphic assessment data. Stormwater outfalls draining directly to the channel that carry large amounts of fine sediment could be targeted for mitigation. Financial assistance is available from the Vermont Clean and Clear and Better Backroads programs for these purposes.

8.0 References

Albers, J., 2000, Hands on the Land: A History of the Vermont Landscape, MIT Press, Cambridge, MA.

Cueto, J., 2008, Personal communication with Jeffrey Cueto, Vermont Water Quality Division.

CWP (Center for Watershed Protection), 2003, Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph: 39-49.

Doll, C.G., Cady, W.M., Thompson, J.B., and M.P. Billings, 1961, Centennial Geologic Map of Vermont: Vermont Geologic Survey, Available at: www.anr.state.vt.us/dec/geo/centmap.htm. Accessed October, 2007

Fitzgerald, E. P., 2007, Linking urbanization to stream geomorphology and biotic integrity in the Lake Champlain Basin, Vermont [M.S. Thesis]: Burlington, Vermont, University of Vermont, 121 p.

Montgomery, D. R., & Buffington, J. M., 1997, Channel-reach morphology in mountain drainage basins, *Geological Society of America Bulletin*, 109(5), 596-611.

NOAA (National Oceanic and Atmospheric Administration), 2008a, Land Cover Analysis Data for New England – Coastal Change Analysis Program. Accessed May, 2008 and available at: http://www.csc.noaa.gov/crs/lca/ccap.html

NOAA (National Oceanic and Atmospheric Administration), 2008b, National Climatic Data Center - Free Weather Station Records. Accessed June, 2008 and available at: http://www.ncdc.noaa.gov/oa/mpp/freedata.html

NRCS (Natural Resources Conservation Service), 2008, Soil Survey Data for Windham County, Posted to VCGI (www.vcgi.org) February 18, 2008.

NWI (National Wetlands Inventory), 2003, US Fish and Wildlife Service Digital Publication of the National Wetlands Inventory Data from 1983. Available at: www.vcgi.org. Accessed April, 2007

Paul, M. J., and J. L. Meyer, 2001, Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333-365.

Ridge, J.C. and Larsen, F.D., 1990, Re-evaluation of Antevs' New England varve chronology and new radiocarbon dates of sediments from Glacial Lake Hitchcock: Geological Society of America, v. 102, p. 889-899

Rosgen, D. L., 1994, A classification of natural rivers, Catena, 22(3), 169 - 199.

Thompson, E.H., and E.R. Sorenson, 2000, Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont, Vermont Department of Fish and Wildlife and The Nature Conservancy.

VCGI (Vermont Center for Geographic Information), 2003, Land Cover/Land Use Spatial Data for Vermont, Imagery dates: 1991 through 1993, Available at: www.vcgi.org

VTANR (Vermont Agency of Natural Resources), 2005, Vermont Dam Inventory, Accessed June, 2008 at: www.vcgi.org

VTANR (Vermont Agency of Natural Resources), 2007a, Vermont Agency of Natural Resources River Corridor Planning Guide, Draft dated July 11, 2007. Accessed in August, 2007 at: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_restoration.htm

VTANR (Vermont Agency of Natural Resources), 2007b, Stream Geomorphic Assessment Handbook - Phase 1 & 2 Protocols. Vermont Agency of Natural Resources Publication. Available at: http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm.

VTDEC (Vermont Department of Environmental Conservation), 2008, Draft List of Priority Surface Waters Outside the Scope of Clean Water Act Section 303(d).

Appendix A

Watershed Summary Data

Hubbard Brook Preliminary Stream Types (Step 2)

Reach ID	Elevation Up (ft.)	Elevation Down (ft.)	Valley Length (ft.)	Valley Slope (%)	Channel Length (ft.)	Channel Slope (%)	Sinuosity	Watershed Area (sq. mi.)	Channel Width (ft.)	Valley Width (ft.)	Confinement Ratio	Confinement Type*	Reference Stream Type	Bedform
M01	322	303	3695	0.51	6763	0.28	1.83	6.26	29.4	464	15.8	VB	E	Dune-Ripple
M02	340	322	1687	1.07	1788	1.01	1.06	5.98	28.8	95	3.3	SC	B	Riffle-Pool
M03	480	340	3300	4.24	3388	4.13	1.03	4.6	25.7	60	2.3	SC	A	Step-Pool
M04	531	480	2600	1.96	2801	1.82	1.08	4.27	24.8	100	4	NW	B	Riffle-Pool
M05	570	531	1430	2.73	1630	2.39	1.14	3.82	23.6	112	4.7	NW	C	Riffle-Pool
M06	685	570	4060	2.83	4190	2.74	1.03	3.48	22.7	105	4.6	NW	C	Riffle-Pool
M07	718	685	1275	2.59	1313	2.51	1.03	2.34	19.1	75	3.9	SC	B	Plane Bed
M08	766	718	1600	3.00	1767	2.72	1.1	2.29	18.9	85	4.5	NW	C	Riffle-Pool
M09	1158	766	5900	6.64	6079	6.45	1.03	0.77	11.7	35	3	SC	A	Step-Pool
M10	1210	1158	2676	1.94	2803	1.86	1.05	0.32	8	218	27.3	VB	C	Riffle-Pool
M6-S1.01	996	621	2760	13.59	2852	13.15	1.03	0.17	6.1	12	2	NC	A	Cascade
T1.01	580	340	4100	5.85	4131	5.81	1.01	1.32	14.8	35	2.4	SC	A	Step-Pool
T1.02	837	580	4210	6.10	4393	5.85	1.04	1.11	13.7	25	1.8	NC	A	Step-Pool
T1.03	883	837	1467	3.14	1483	3.10	1.01	0.45	9.2	180	19.5	VB	C	Riffle-Pool
T1.04	1168	883	2470	11.54	2574	11.07	1.04	0.14	5.5	20	3.6	SC	A	Step-Pool
T2.01	791	688	1100	9.36	1106	9.31	1.01	0.55	10.1	18	1.8	NC	A	Step-Pool
T2.02	867	791	3173	2.40	3349	2.27	1.06	0.52	9.8	226	22.9	VB	C	Riffle-Pool
T2.03	1173	867	2875	10.64	2978	10.28	1.04	0.25	7.2	25	3.5	SC	A	Step-Pool
T3.01	1261	720	7350	7.36	7621	7.10	1.04	0.67	11	30	2.7	SC	A	Step-Pool
T4.01	1012	767	5875	4.17	6055	4.05	1.03	0.56	10.2	50	4.9	NW	B	Step-Pool

* NC = Narrowly-confined; SC = Semi-confined; NW = Narrow; ; BD = Broad; VB = Very Broad

Hubbard Brook Impact Ratings (Step 8)

	Step Number[†] with Impact Score*																Total
Reach ID	4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.2	7.3	Score
M01	2	2	1	0	0	0	1	0	0	0	1	2	2	2	0	1	14
M02	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
M03	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	4
M04	1	2	0	0	0	0	0	0	2	1	2	0	0	0	0	1	9
M05	1	2	0	0	1	0	2	0	2	2	0	0	2	2	0	1	15
M06	1	2	2	0	1	0	0	0	2	1	1	0	2	0	0	1	13
M07	1	2	2	0	0	0	0	0	2	2	0	0	0	0	0	1	10
M08	1	2	2	0	1	0	0	0	2	2	0	0	2	0	0	1	13
M09	2	2	1	0	1	0	0	0	2	0	1	0	0	0	1	2	12
M10	2	1	1	2	0	0	2	0	0	1	0	0	1	1	0	0	11
M6-S1.01	2	1	2	0	0	0	2	0	0	1	0	0	0	0	0	0	8
T1.01	2	2	0	0	1	0	0	0	2	0	1	0	0	0	0	2	10
T1.02	2	2	0	0	0	0	0	0	2	0	1	0	0	0	0	1	8
T1.03	1	2	2	2	0	0	2	0	0	0	0	0	2	2	0	1	14
T1.04	1	0	1	0	0	0	0	0	2	0	0	0	0	0	0	0	4
T2.01	1	2	2	0	1	2	2	0	2	0	1	0	0	0	0	1	14
T2.02	1	1	2	0	0	0	1	0	0	0	0	0	1	1	0	0	7
T2.03	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	1	5
T3.01	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	1	5
T4.01	1	2	2	0	0	0	0	0	2	1	0	0	0	0	1	1	10

* 0 = Not Significant or No Data; 1 = Low; 2 = High

† Step 4: Land Cover and Reach Hydrology
Step 5: Channel Modifications
Step 6: Floodplain Modifications and Planform Changes
Step 7: Bed and Bank Condition

Hubbard Brook Predicted Channel Adjustment Processes (Step 9)

	9.1 Predicted Adjustment Scores				9.2 Reach Condition		9.3 Reach
Reach ID	**Degradation**	**Aggradation**	**Widening**	**Planform**	**Project***	**Statewide***	**Sensitivity**
M01	5	**7**	5	**7**	Fair	Good	High
M02	4	2	2	0	Good	Reference	Moderate
M03	4	2	2	0	Good	Reference	High
M04	4	3	2	0	Good	Reference	Moderate
M05	**9**	5	3	8	Fair	Good	Moderate
M06	5	**7**	5	**7**	Fair	Good	Moderate
M07	6	**7**	5	5	Fair	Good	Moderate
M08	7	7	5	**9**	Poor	Good	Moderate
M09	7	**9**	5	2	Fair	Good	High
M10	**8**	**8**	7	**8**	Poor	Fair	Moderate
M6-S1.01	6	**7**	**7**	0	Fair	Good	Very Low
T1.01	7	**8**	5	2	Fair	Good	High
T1.02	**6**	**6**	5	0	Fair	Good	High
T1.03	6	9	7	**10**	Poor	Fair	High
T1.04	4	2	0	0	Reference	Reference	Very Low
T2.01	**9**	7	5	0	Fair	Good	High
T2.02	3	4	2	3	Good	Reference	Moderate
T2.03	2	4	2	0	Good	Reference	High
T3.01	4	4	2	0	Good	Reference	High
T4.01	4	**5**	4	4	Fair	Good	Moderate

* Conditions relative to the Saxtons River watershed ("project") versus overall Vermont ("statewide")

Note: **Bold** values indicate the dominant adjustment processes (when moderate to severe; value > 5)

Appendix B

Phase 1 Reach Reports

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M01**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location
1.1 Reach Description: **From the confluence with the Connecticut River, this reach extends**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.38**

Step 2. Stream Type
2.1 Elevation Upstream: **322**
2.1 Elevation Downstream: **303**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3695** feet. **0.70** Miles.
2.3 Valley Slope: **0.51** %
2.4.Channel Length: **6763** feet. **1.28** Miles.
2.5 Channel Slope: **0.28** %
2.6 Sinuosity: **1.83**
2.7 Watershed Area: **6** Square Miles
2.8 Channel Width: **29** feet.
2.9 Valley Width: **464** feet.
2.10 Confinement Ratio: **16**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **E**
Bedform: **Dune-Ripple**
Sub-class Slope: **None**
Bed Material: **Gravel**

Step 3. Basin Characteristics:
3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Alluvial** **98.2** %
3.3 Sub-dominant Geological Mat.: **Glacial**
3.4 Left Valley Side **Flat**
3.4 Right Valley Side **Flat**
3.5 Soils
Hydrologic Group: **C** **97.5** %
Flooding: **Frequent** **97.5** %
Water Table Deep: **1.5** **97.5** %
Water Table Shallow: **0.0** **97.5** %
Erodibility: **slight** **0.3** %

7.4 Comments:
Reach has appeared to move a lot since the 1960's and may have had extensive historic straightening, prior to taking on the typical E-type geometry.

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **71.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Field**
Current Dominant land Cover: **Wetland** **39.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w/ less than 25 ft.:	**234**	**212**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **2** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **1157** **17 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms and Roads old **0.0** ft. **0.0**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **Point**
6.4 Meander Migration: **Multiple**
6.5 Meander Width: **50.0** Ratio: **1.7**
6.6 Wavelength: **90.0** Ratio: **3.1**

Step 7. Windshield Survey
7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Bend**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	2 High	1 Low	0 N.S.	0 N.S.	0 N.S.	1 Low	0 N.S.	0 Unk.	0 N.S.	1 Low	2 High	2 High	2 High	0 N.S.	1 Low	14

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M02**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Confined area that extends from the reach break to the confluence**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.39**

Step 2. Stream Type

2.1 Elevation Upstream: **340**
2.1 Elevation Downstream: **322**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1687** feet. **0.32** Miles.
2.3 Valley Slope: **1.07** %
2.4.Channel Length: **1788** feet. **0.34** Miles.
2.5 Channel Slope: **1.01** %
2.6 Sinuosity: **1.06**
2.7 Watershed Area: **6** Square Miles
2.8 Channel Width: **29** feet.
2.9 Valley Width: **95** feet.
2.10 Confinement Ratio: **3**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **B**
Bedform: **Riffle-Pool**
Sub-class Slope: **c**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Glacial Lake** **68.1** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Extremely Steep**

3.5 Soils

Hydrologic Group: **B** **95.6** %
Flooding: **None/Rare** **68.1** %
Water Table Deep: **6.0** **68.1** %
Water Table Shallow: **6.0** **68.1** %
Erodibility: **Severe** **68.1** %

7.4 Comments:

Potential alluvial fan on the lower reach were the slope changes rapidly and the valley widens.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **73.0** %
Current Sub-Dominant Land Cover: **Urban**

4.2 Corridor

Historic Land Cover: **Shrub**
Current Dominant land Cover: **Forest** **53.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**None**	**None**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **0.0** ft. **0.0**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 Unk.	0 N.S.	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	0 N.S.	2

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M03**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location
1.1 Reach Description: **Reach extends up from confluence with Kimball Brook to the reach**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.40**

Step 2. Stream Type
2.1 Elevation Upstream: **480**
2.1 Elevation Downstream: **340**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3300** feet. **0.63** Miles.
2.3 Valley Slope: **4.24** %
2.4.Channel Length: **3388** feet. **0.64** Miles.
2.5 Channel Slope: **4.13** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **5** Square Miles
2.8 Channel Width: **26** feet.
2.9 Valley Width: **60** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:
3.1 Alluvial Fan: **None**
3.2 Grade Control: **Ledge**
3.3 Dominant Geologic Mat.: **Glacial Lake** **77.6** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **B** **100.** %
Flooding: **None/Rare** **82.2** %
Water Table Deep: **6.0** **77.6** %
Water Table Shallow: **6.0** **77.6** %
Erodibility: **Very Severe** **82.2** %

7.4 Comments:
The potential for ice and debris jams is unknown because this reach was only accessed upstream, at the reach break with M04.

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **74.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **56.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**None**	**None**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms and Roads old **171.2** ft. **5 %**

	One Side		Both Sides	
Road:	**171.2**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**109**	ft.	**0.0**	ft.

6.3 Channel Bars: **Point**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	1 Low	0 N.S.	1 Low	0 N.S.	0 N/A	0 N/A	0 N.S.	0 N.S.	4

Hubbard Brook

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M04**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location
1.1 Reach Description: **Paralleling County Rd. this reach extends through a confined forest**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.40**

Step 2. Stream Type
2.1 Elevation Upstream: **531**
2.1 Elevation Downstream: **480**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2600** feet. **0.49** Miles.
2.3 Valley Slope: **1.96** %
2.4.Channel Length: **2801** feet. **0.53** Miles.
2.5 Channel Slope: **1.82** %
2.6 Sinuosity: **1.08**
2.7 Watershed Area: **4** Square Miles
2.8 Channel Width: **25** feet.
2.9 Valley Width: **100** feet.
2.10 Confinement Ratio: **4**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **B**
Bedform: **Riffle-Pool**
Sub-class Slope: **c**
Bed Material: **Gravel**

Step 3. Basin Characteristics:
3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **39.1** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **B** **60.4** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **6.0** **65.3** %
Water Table Shallow: **6.0** **65.3** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:
The windshield survey indicates that the lower portion of this reach has nice C-type geometry with gravel substrate. However, the higher slope and confinement in the upper reach is the

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover: **Shrub**
Current Dominant land Cover: **Forest** **75.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **45.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**26-50**	**None**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms and Roads old **594** ft. **21 %**

	One Side		Both Sides	
Road:	**594**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**547**	ft.	**0.0**	ft.

6.3 Channel Bars: **Point**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey
7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	2 High	1 Low	2 High	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	9

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M05**
Topo Maps: **HARTLAND, WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **From the reach break this reach extends upstream to just**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.41**

Step 2. Stream Type

2.1 Elevation Upstream: **570**
2.1 Elevation Downstream: **531**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1430** feet. **0.27** Miles.
2.3 Valley Slope: **2.73** %
2.4.Channel Length: **1630** feet. **0.31** Miles.
2.5 Channel Slope: **2.39** %
2.6 Sinuosity: **1.14**
2.7 Watershed Area: **4** Square Miles
2.8 Channel Width: **24** feet.
2.9 Valley Width: **112** feet.
2.10 Confinement Ratio: **5**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **b**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Ice-Contact** **51.9** %
3.3 Sub-dominant Geological Mat.: **Till**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **B** **51.3** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.5** **51.3** %
Water Table Shallow: **1.5** **51.3** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Channel heavily impacted by the Interstate-91 crossing.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **75.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Shrub**
Current Dominant land Cover: **Urban** **35.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**26-50**	**26-50**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **3** **12** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **975.9** **59 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **916** ft. **56 %**

	One Side		Both Sides	
Road:	**916**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**571**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **23.6** Ratio: **1.0**
6.6 Wavelength: **23.6** Ratio: **1.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	0 N.S.	0 N.S.	1 Low	0 N.S.	2 High	0 N.S.	2 High	2 High	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	1 Low	15

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M06**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No**
Quality Control Status: **Step 2 done**

Step 1. Reach Location
1.1 Reach Description: **From the reach break this reach extends upstream to the confluence**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.41**

Step 2. Stream Type
2.1 Elevation Upstream: **685**
2.1 Elevation Downstream: **570**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4060** feet. **0.77** Miles.
2.3 Valley Slope: **2.83** %
2.4.Channel Length: **4190** feet. **0.79** Miles.
2.5 Channel Slope: **2.74** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **3** Square Miles
2.8 Channel Width: **23** feet.
2.9 Valley Width: **105** feet.
2.10 Confinement Ratio: **5**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **b**
Bed Material: **Cobble**

Step 3. Basin Characteristics:
3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **C** **100.** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **51.4** %
Water Table Shallow: **1.0** **51.4** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:
Sediment load in upper reach is high from the bank failures in T2.01 that have since been addressed by a massive bank armoring effort.

Step 4. Land Cover - Reach Hydrology
4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **75.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Urban** **48.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**51-100**	**51-100**
Sub-dominant:	**0-25**	**0-25**
Length w/ less than 25 ft.:	**304**	**596**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications
5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **3** **5** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **176** **4 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications
6.1 Berms and Roads old **3622.0** ft. **86 %**

	One Side	Both Sides
Road:	**3476** ft.	**145** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**729** ft.	**0.0** ft.

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **65.0** Ratio: **2.9**
6.6 Wavelength: **200.0** Ratio: **8.8**

Step 7. Windshield Survey
7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	2 High	1 Low	1 Low	0 N.S.	2 High	0 N.S.	0 N.S.	1 Low	13

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M07**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No**
Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **A short reach that extends from the reach break up to the crossing**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **718**
2.1 Elevation Downstream: **685**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1275** feet. **0.24** Miles.
2.3 Valley Slope: **2.59** %
2.4.Channel Length: **1313** feet. **0.25** Miles.
2.5 Channel Slope: **2.51** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **2** Square Miles
2.8 Channel Width: **19** feet.
2.9 Valley Width: **75** feet.
2.10 Confinement Ratio: **4**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **B**
Bedform: **Plane Bed**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**

3.5 Soils

Hydrologic Group: **C** **100.** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **100.** %
Water Table Shallow: **1.0** **100.** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Note: Based on limited field observations and the channel slope, this reach was characterized as planebed. Phase 2 assessors should verify whether or not the reach is planebed by

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **80.0** %
Current Sub-Dominant Land Cover: **Urban**

4.2 Corridor

Historic Land Cover: **Forest**
Current Dominant land Cover: **Urban** **30.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**51-100**	**>100**
Sub-dominant:	**0-25**	**None**
Length w/ less than 25 ft.:	**327**	**0**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **3** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **720.0** ft. **54 %**

	One Side	Both Sides
Road:	**720.0** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**388** ft.	**0.0** ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	10

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M08**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Another short reach that is heavily influenced by road crossings. It**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **766**
2.1 Elevation Downstream: **718**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1600** feet. **0.30** Miles.
2.3 Valley Slope: **3.00** %
2.4.Channel Length: **1767** feet. **0.33** Miles.
2.5 Channel Slope: **2.72** %
2.6 Sinuosity: **1.10**
2.7 Watershed Area: **2** Square Miles
2.8 Channel Width: **19** feet.
2.9 Valley Width: **85** feet.
2.10 Confinement Ratio: **5**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **b**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **C** **53.5** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **53.5** %
Water Table Shallow: **1.0** **53.5** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Potential alluvial fan coming from the steep slopes of the tribs that enter into the left side of the channel.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **80.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Shrub**
Current Dominant land Cover: **Urban** **47.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**51-100**	**51-100**
Sub-dominant:	**26-50**	**0-25**
Length w/ less than 25 ft.:	**43**	**467**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **3** **6** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1414.5** ft. **80 %**

	One Side	Both Sides
Road:	**1414.5** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**1105** ft.	**0.0** ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **55.0** Ratio: **2.9**
6.6 Wavelength: **170.0** Ratio: **9.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	0 N.S.	2 High	0 N.S.	0 N.S.	1 Low	13

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M09**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Long reach heavily affected by Weeden Hill Rd. the reach ends at a**
1.2 Towns: **West Windsor, Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **1158**
2.1 Elevation Downstream: **766**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **5900** feet. **1.12** Miles.
2.3 Valley Slope: **6.64** %
2.4.Channel Length: **6079** feet. **1.15** Miles.
2.5 Channel Slope: **6.45** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **12** feet.
2.9 Valley Width: **35** feet.
2.10 Confinement Ratio: **3**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Extremely Steep**
3.5 Soils
Hydrologic Group: **C** **81.9** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **81.9** %
Water Table Shallow: **1.0** **81.9** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Lots of road crossings and extensive impacts from the encroachment throughout reach. Potential alluvial fan on the lower reach were the slope changes and the valley widens.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **78.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Urban** **46.0** %
Current Sub-Dominant Land Cover: **Forest**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**26-50**	**0-25**
Length w/ less than 25 ft.:	**0**	**328**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **5** **6** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **5452** ft. **89 %**

	One Side		Both Sides	
Road:	**5452**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**149**	ft.	**0.0**	ft.

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **997.11 ft.**
7.2 Bank Height: **3.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	2 High	1 Low	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	1 Low	0 N.S.	0 N/A	0 N/A	1 Low	2 High	12

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Hubbard Brook Mainstem** Reach **M10**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No**
Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Final mainstem reach that extends from the reach break at the final**
1.2 Towns: **West Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.45**

Step 2. Stream Type

2.1 Elevation Upstream: **1210**
2.1 Elevation Downstream: **1158**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2676** feet. **0.51** Miles.
2.3 Valley Slope: **1.94** %
2.4.Channel Length: **2803** feet. **0.53** Miles.
2.5 Channel Slope: **1.86** %
2.6 Sinuosity: **1.05**
2.7 Watershed Area: **0** Square Miles
2.8 Channel Width: **8** feet.
2.9 Valley Width: **218** feet.
2.10 Confinement Ratio: **27**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Hilly**
3.5 Soils
Hydrologic Group: **D** **91.3** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **1.5** **87.6** %
Water Table Shallow: **0.0** **87.6** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Given the quality of the aerial photography used it was hard to accurately discern good meanders for the meander wavelength and width calculations. A small meander downstream of the run of the river

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **70.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **67.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**26-50**	**0-25**
Length w/ less than 25 ft.:	**0**	**350**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **Impoundment**
Type: **Large Run of River**
Use: **Other**
5.2 Bridges and Culverts: **2** **2** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **671** **23 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **33.0** ft. **1 %**

	One Side	Both Sides
Road:	**33.0** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**224** ft.	**0.0** ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **25.0** Ratio: **3.1**
6.6 Wavelength: **50.0** Ratio: **6.3**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **No Data**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	1 Low	1 Low	2 High	0 N.S.	0 N.S.	2 High	0 N.S.	0 N.S.	1 Low	0 N.S.	0 N.S.	1 Low	1 Low	0 N.S.	0 N.S.	11

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Unnamed Subtributary** Reach **M6-S1.01**
Topo Maps: **HARTLAND, WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Small unnamed tributary that boarders the southeast side of the**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.42**

Step 2. Stream Type

2.1 Elevation Upstream: **996**
2.1 Elevation Downstream: **621**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2760** feet. **0.52** Miles.
2.3 Valley Slope: **13.59** %
2.4.Channel Length: **2852** feet. **0.54** Miles.
2.5 Channel Slope: **13.15** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **0** Square Miles
2.8 Channel Width: **6** feet.
2.9 Valley Width: feet.
2.10 Confinement Ratio: **0**
2.10 Confinement Type: **---**
2.11 Reference Stream Type: **A**
Bedform: **Cascade**
Sub-class Slope: **None**
Bed Material: **Bedrock**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **C** **87.4** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **77.0** %
Water Table Shallow: **1.0** **77.0** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Reach receiving impacts from the penitentiary and its surrounding agricultural fields.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **65.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **44.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**0-25**	**>100**
Sub-dominant:	**>100**	**0-25**
Length w/ less than 25 ft.:	**1115**	**373**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **1561** **54 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **0.0** ft. **0.0**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**523**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	1 Low	2 High	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	0 Unk.	1 Low	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	0 N.S.	8

Hubbard Brook Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Kimball Brook** Reach **T1.01**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **The first reach of Kimball Brook begins at the confluence with the**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.40**

Step 2. Stream Type

2.1 Elevation Upstream: **580**
2.1 Elevation Downstream: **340**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4100** feet. **0.78** Miles.
2.3 Valley Slope: **5.85** %
2.4.Channel Length: **4131** feet. **0.78** Miles.
2.5 Channel Slope: **5.81** %
2.6 Sinuosity: **1.01**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **15** feet.
2.9 Valley Width: **35** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Glacial Lake** **78.0** %
3.3 Sub-dominant Geological Mat.: **Till**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **B** **78.8** %
Flooding: **None/Rare** **99.3** %
Water Table Deep: **6.0** **82.5** %
Water Table Shallow: **6.0** **82.5** %
Erodibility: **Very Severe** **99.3** %

7.4 Comments:

Reach had a lot of observable aggradation of fine sediments through the Paradise Park area. Mid-reach, several large jams were noted upstream of the Hunt Rd. crossing.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **66.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **37.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**51-100**	**51-100**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **5** **6** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1234.8** ft. **29** %

	One Side	Both Sides
Road:	**1079** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**155** ft.	**0.0** ft.
6.2 Development:	**0.0** ft.	**0.0** ft.

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Multiple**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	2 High	0 N.S.	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	1 Low	0 N.S.	0 N/A	0 N/A	0 N.S.	2 High	10

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Kimball Brook** Reach **T1.02**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **This reach extends from the reach break, in a confined setting, to the**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.41**

Step 2. Stream Type

2.1 Elevation Upstream: **837**
2.1 Elevation Downstream: **580**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **4210** feet. **0.80** Miles.
2.3 Valley Slope: **6.10** %
2.4.Channel Length: **4393** feet. **0.83** Miles.
2.5 Channel Slope: **5.85** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **14** feet.
2.9 Valley Width: **25** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Narrowly Confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Extremely Steep**
3.5 Soils
Hydrologic Group: **C** **100.** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **99.0** %
Water Table Shallow: **1.0** **99.0** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **72.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **54.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**26-50**	**None**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **0** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1578** ft. **35 %**

	One Side		Both Sides	
Road:	**1578**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Bridge**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
2 High	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	1 Low	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	8

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Kimball Brook** — Reach **T1.03**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** — Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **The stream is in an unconfined setting in this reach and cuts across**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.42**

Step 2. Stream Type

2.1 Elevation Upstream: **883**
2.1 Elevation Downstream: **837**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1467** feet. **0.28** Miles.
2.3 Valley Slope: **3.14** %
2.4.Channel Length: **1483** feet. **0.28** Miles.
2.5 Channel Slope: **3.10** %
2.6 Sinuosity: **1.01**
2.7 Watershed Area: **0** Square Miles
2.8 Channel Width: **9** feet.
2.9 Valley Width: **180** feet.
2.10 Confinement Ratio: **20**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope: **b**
Bed Material: **Gravel**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Hilly**

3.5 Soils

Hydrologic Group: **D** **92.4** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **1.5** **92.4** %
Water Table Shallow: **0.0** **92.4** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Cows were observed in the channel during the windshield survey. Potential alluvial fan on the upper reach were the slope changes rapidly and the valley widens, near the ponded area.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **68.0** %
Current Sub-Dominant Land Cover: **Field**

4.2 Corridor

Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **18.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**0-25**	**0-25**
Sub-dominant:	**51-100**	**26-50**
Length w/ less than 25 ft.:	**717**	**692**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **Impoundment**
Type: **Large Run of River**
Use: **Other**
5.2 Bridges and Culverts: **2** **4** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **707** **47 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **0.0** ft. **0.0**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **9.2** Ratio: **1.0**
6.6 Wavelength: **9.2** Ratio: **1.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	2 High	0 N.S.	0 N.S.	2 High	0 N.S.	0 Unk.	0 N.S.	0 N.S.	0 N.S.	2 High	2 High	0 N.S.	1 Low	14

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Kimball Brook** Reach **T1.04**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **From the reach break at the valley floor, T1.04 extends up to the**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.49**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **1168**
2.1 Elevation Downstream: **883**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2470** feet. **0.47** Miles.
2.3 Valley Slope: **11.54** %
2.4.Channel Length: **2574** feet. **0.49** Miles.
2.5 Channel Slope: **11.07** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **0** Square Miles
2.8 Channel Width: **6** feet.
2.9 Valley Width: feet.
2.10 Confinement Ratio: **0**
2.10 Confinement Type: **---**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Boulder**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **C** **62.6** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **6.0** **49.0** %
Water Table Shallow: **6.0** **49.0** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

A small dirt road or improved path was noted along the upper end of this reach and was indexed as encroachment accordingly.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **85.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Shrub**
Current Dominant land Cover: **Forest** **49.0** %
Current Sub-Dominant Land Cover: **Crop**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**None**
Length w/ less than 25 ft.:	**314**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **0** **0** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **915** ft. **35 %**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**915**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	2 High	0 N.S.	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	0 N.S.	4

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **State Farm Road Tributary** Reach **T2.01**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **State Farm Rd. brook begins at the confluence with M06 and extends**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **791**
2.1 Elevation Downstream: **688**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **1100** feet. **0.21** Miles.
2.3 Valley Slope: **9.36** %
2.4.Channel Length: **1106** feet. **0.21** Miles.
2.5 Channel Slope: **9.31** %
2.6 Sinuosity: **1.01**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **10** feet.
2.9 Valley Width: **18** feet.
2.10 Confinement Ratio: **2**
2.10 Confinement Type: **Narrowly Confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Extremely Steep**
3.4 Right Valley Side **Very Steep**
3.5 Soils
Hydrologic Group: **C** **100.** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **100.** %
Water Table Shallow: **1.0** **100.** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

The entire left bank of this reach has been heavily rip-rapped to prevent the erosion of the State Farm Rd. One "natural" meander bend was engineered into the channel during the

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **64.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Urban** **51.0** %
Current Sub-Dominant Land Cover: **Field**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**0-25**	**>100**
Sub-dominant:	**None**	**51-100**
Length w/ less than 25 ft.:	**1106**	**0**

4.4 Ground Water Inputs: **None**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **9** %
5.3 Bank Armoring: **94 %**
Left **1045** Right **0.0**
5.4 Channel Straightening: **999** **90 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1085** ft. **98 %**

	One Side		Both Sides	
Road:	**1085**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **Side**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Bend**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	1 Low	2 High	2 High	0 N.S.	2 High	0 N.S.	1 Low	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	14

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **State Farm Road Tributary** — Reach **T2.02**
Topo Maps: **HARTLAND, WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No**
Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **This reach is not accessible due to the prison, but the channel goes**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **867**
2.1 Elevation Downstream: **791**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **3173** feet. **0.60** Miles.
2.3 Valley Slope: **2.40** %
2.4.Channel Length: **3349** feet. **0.63** Miles.
2.5 Channel Slope: **2.27** %
2.6 Sinuosity: **1.06**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **10** feet.
2.9 Valley Width: **226** feet.
2.10 Confinement Ratio: **23**
2.10 Confinement Type: **Very Broad**
2.11 Reference Stream Type: **C**
Bedform: **Riffle-Pool**
Sub-class Slope:
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **54.9** %
3.3 Sub-dominant Geological Mat.: **Alluvial**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Hilly**
3.5 Soils
Hydrologic Group: **C** **91.8** %
Flooding: **None/Rare** **63.2** %
Water Table Deep: **1.5** **36.8** %
Water Table Shallow: **0.0** **36.8** %
Erodibility: **Severe** **63.2** %

7.4 Comments:

Expected to be a C-type channel by reference because of the valley shape and the lack of sinuosity that would have greatly lowered the channel slope.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **67.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Field**
Current Dominant land Cover: **Forest** **23.0** %
Current Sub-Dominant Land Cover: **Field**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**0-25**	**0-25**
Sub-dominant:	**26-50**	**26-50**
Length w/ less than 25 ft.:	**1604**	**2790**

4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **640** **19 %**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **159** ft. **4 %**

	One Side	Both Sides
Road:	**159** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**0.0** ft.	**0.0** ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **34.0** Ratio: **3.5**
6.6 Wavelength: **68.0** Ratio: **6.9**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Not Evaluated**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	1 Low	2 High	0 N.S.	0 N.S.	0 N.S.	1 Low	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	1 Low	1 Low	0 N.S.	0 N.S.	7

Hubbard Brook — Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **State Farm Road Tributary** Reach **T2.03**
Topo Maps: **WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **From the reach break the channel extends to its terminal point above**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.50**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **1173**
2.1 Elevation Downstream: **867**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **2875** feet. **0.54** Miles.
2.3 Valley Slope: **10.64** %
2.4.Channel Length: **2978** feet. **0.56** Miles.
2.5 Channel Slope: **10.28** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **0** Square Miles
2.8 Channel Width: **7** feet.
2.9 Valley Width: feet.
2.10 Confinement Ratio: **0**
2.10 Confinement Type: **---**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **Yes**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **92.7** %
3.3 Sub-dominant Geological Mat.: **Ice-Contact**
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**

3.5 Soils

Hydrologic Group: **C** **88.9** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.0** **63.6** %
Water Table Shallow: **1.0** **63.6** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Potential alluvial fan located downstream of Watson Rd. where the slope changes and the valley widens.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed

Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **82.0** %
Current Sub-Dominant Land Cover: **Field**

4.2 Corridor

Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **38.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**0-25**	**0-25**
Length w/ less than 25 ft.:	**340**	**453**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **1** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **0.0** ft. **0.0**

	One Side		Both Sides	
Road:	**0.0**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	1 Low	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 Unk.	0 N.S.	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	5

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **Marton Road Tributary** Reach **T3.01**
Topo Maps: **HARTLAND, WINDSOR**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **A long reach beginning at the confluence with the mainstem reach**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **1261**
2.1 Elevation Downstream: **720**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **7350** feet. **1.39** Miles.
2.3 Valley Slope: **7.36** %
2.4.Channel Length: **7621** feet. **1.44** Miles.
2.5 Channel Slope: **7.10** %
2.6 Sinuosity: **1.04**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **11** feet.
2.9 Valley Width: **30** feet.
2.10 Confinement Ratio: **3**
2.10 Confinement Type: **Semi-confined**
2.11 Reference Stream Type: **A**
Bedform: **Step-Pool**
Sub-class Slope: **None**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **Dam**
3.3 Dominant Geologic Mat.: **Till** **100.** %
3.3 Sub-dominant Geological Mat.:
3.4 Left Valley Side **Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **C** **86.4** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **2.5** **38.2** %
Water Table Shallow: **1.5** **38.2** %
Erodibility: **Very Severe** **100.** %

7.4 Comments:

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **86.0** %
Current Sub-Dominant Land Cover: **Field**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **47.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer	Left Bank	Right Bank
Dominant:	**>100**	**>100**
Sub-dominant:	**51-100**	**None**
Length w/ less than 25 ft.:	**0**	**0**

4.4 Ground Water Inputs: **Minimal**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **Impoundment**
Type: **Large Run of River**
Use: **Other**
5.2 Bridges and Culverts: **2** **1** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **313** ft. **4 %**

	One Side		Both Sides	
Road:	**313**	ft.	**0.0**	ft.
Railroad:	**0.0**	ft.	**0.0**	ft.
Berm:	**0.0**	ft.	**0.0**	ft.
Improved Path:	**0.0**	ft.	**0.0**	ft.
6.2 Development:	**0.0**	ft.	**0.0**	ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **0.00 ft.**
7.2 Bank Height: **0.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	1 Low	0 N.S.	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N/A	0 N/A	0 N.S.	1 Low	5

Hubbard Brook

Phase 1 - Reach Summary Report

Basin: **Lower Connecticut**
Stream Name: **County Road Tributary** Reach **T4.01**
Topo Maps: **HARTLAND**
Date Last Edited: **Sun, November 30, 2008**
Watershed: **Black & Otttauquechee Rivers**
Sub-watershed: **Connecticut River -- White River to Sugar River**
Is Reach an Impoundment? **No** Quality Control Status: **Step 2 done**

Step 1. Reach Location

1.1 Reach Description: **Tributary begins at the confluence with M08 and extends to its**
1.2 Towns: **Windsor**
1.3 Downstream Latitude: **43.51**
1.3 Downstream Longitude: **-72.43**

Step 2. Stream Type

2.1 Elevation Upstream: **1012**
2.1 Elevation Downstream: **767**
2.1 Is Gradient Gentle? **No**
2.2 Valley Length: **5875** feet. **1.11** Miles.
2.3 Valley Slope: **4.17** %
2.4.Channel Length: **6055** feet. **1.15** Miles.
2.5 Channel Slope: **4.05** %
2.6 Sinuosity: **1.03**
2.7 Watershed Area: **1** Square Miles
2.8 Channel Width: **10** feet.
2.9 Valley Width: **50** feet.
2.10 Confinement Ratio: **5**
2.10 Confinement Type: **Narrow**
2.11 Reference Stream Type: **B**
Bedform: **Step-Pool**
Sub-class Slope: **a**
Bed Material: **Cobble**

Step 3. Basin Characteristics:

3.1 Alluvial Fan: **None**
3.2 Grade Control: **None**
3.3 Dominant Geologic Mat.: **Till** **92.8** %
3.3 Sub-dominant Geological Mat.: **Other**
3.4 Left Valley Side **Very Steep**
3.4 Right Valley Side **Steep**
3.5 Soils
Hydrologic Group: **D** **52.8** %
Flooding: **None/Rare** **100.** %
Water Table Deep: **6.0** **37.2** %
Water Table Shallow: **6.0** **37.2** %
Erodibility: **Very Severe** **92.8** %

7.4 Comments:

Channel is encroached upon by County Rd. and in several areas the channel has eroded the banks and parts of the roadbed.

Step 4. Land Cover - Reach Hydrology

4.1 Watershed
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **81.0** %
Current Sub-Dominant Land Cover: **Urban**
4.2 Corridor
Historic Land Cover: **Forest**
Current Dominant land Cover: **Forest** **41.0** %
Current Sub-Dominant Land Cover: **Urban**

4.3 Riparian Buffer — Left Bank / Right Bank
Dominant: **>100** **>100**
Sub-dominant: **0-25** **0-25**
Length w/ less than 25 ft.: **676** **1261**
4.4 Ground Water Inputs: **Abundant**

Step 5. Instream Channel Modifications

5.1 Flow Regulation - (old): **None**
Type: **None**
Use:
5.2 Bridges and Culverts: **5** **2** %
5.3 Bank Armoring: **0.0**
Left **0.0** Right **0.0**
5.4 Channel Straightening: **0.0** **0.0**
5.5 Dredging History: **None**

Step 6. Floodplain Modifications

6.1 Berms and Roads old **1824** ft. **30 %**

	One Side	Both Sides
Road:	**1824** ft.	**0.0** ft.
Railroad:	**0.0** ft.	**0.0** ft.
Berm:	**0.0** ft.	**0.0** ft.
Improved Path:	**0.0** ft.	**0.0** ft.
6.2 Development:	**754** ft.	**0.0** ft.

6.3 Channel Bars: **No Data**
6.4 Meander Migration:
6.5 Meander Width: **N/A** Ratio: **0.0**
6.6 Wavelength: **N/A** Ratio: **0.0**

Step 7. Windshield Survey

7.1 Bank Erosion: **496.24 ft.**
7.2 Bank Height: **3.00 ft.**
7.3 Ice/Debris Jam Potential: **Culvert**

4.1	4.2	4.3	5.1	5.2	5.3	5.4	5.5	6.1	6.2	6.3	6.4	6.5	6.6	7.1	7.2	Total
1 Low	2 High	2 High	0 N.S.	0 N.S.	0 N.S.	0 N.S.	0 N.S.	2 High	1 Low	0 N.S.	0 N.S.	0 N/A	0 N/A	1 Low	1 Low	10

APPENDIX C.

QA SUMMARY (CD-ROM)

APPENDIX D.

WINDHSIELD SURVEY PHOTOS & LOG (CD-ROM)