



Roaring Brook and East Branch of Roaring Brook
Water Quality Remediation Plan Update 2011
Killington, Vermont





February 17, 2011

Ref: 57336.00

Mr. Padraic Monks
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Department of Environmental Conservation
Vermont Agency of Natural Resources
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Waterbury, Vermont 05671-0301

RE: Water Quality Remediation Plan
Roaring Brook and East Roaring Brook
Killington, VT

Dear Padraic:

We are pleased to present the *Roaring Brook and East Branch of Roaring Brook Water Quality Remediation Plan* ("WQRP"). Vanasse Hangen Brustlin, Inc. has prepared this report on behalf of MTB Killington LLC, AMSC Killington LLC, and SP II Resort LLC (commonly referred to as the tenants-in-common or "TICs") and SP Land Company LLC. This report was prepared in accordance with the 2006 US Environmental Protection Agency Guidance for Assessment, Listing and Reporting Requirements Pursuant to Section 303(d), 305(b) and 314 of the Clean Water Act. According to the above guidance Roaring Brook and the East Branch of Roaring Brook were considered category 4(b) waters whereby a total maximum daily load ("TMDL") alternative, such as this WQRP, would be implemented to achieve water quality standards within a reasonable period of time.

This submittal follows the January 11, 2011 meeting where the WQRP background and general approach were presented to you and other members of the Vermont Department of Environmental Conservation ("VTDEC") staff. The approach outlined in this WQRP accounts for the VTDEC comments received at that meeting and predicts that water quality standards can be achieved within a nine year time frame from plan implementation. Improvements to water quality would be achieved primarily through capture and treatment of stormwater runoff from existing impervious surfaces. In addition, a five phase Master Plan development at the resort, proposed by SP Land Company, LLC to start at year five, will include new development, redevelopment, and conversion of existing impervious surface to forested or open land. Stormwater treatment, up to applicable standards, would be implemented for all new and redeveloped impervious surfaces.

Mr. Padraic Monks

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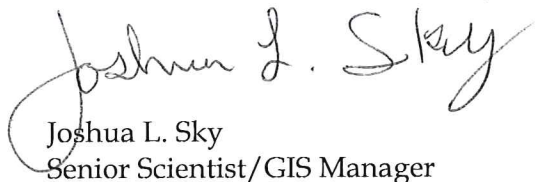
February 17, 2011

In accordance with the 4(b) guidance, a plan for monitoring the progress of the WQRP through water quality sampling has been designed. This plan includes water chemistry sampling during precipitation events and baseflow (dry) conditions. It also includes kick net sampling for aquatic biota (biomonitoring) and the Wolman pebble count for sediment sampling. The results of water quality sampling, as well as an update on plan progress, and plans to modify or update the plan as necessary, would be submitted to the Vermont Department of Environmental Conservation on an annual basis.

VHB, on behalf of the TICs, requests concurrence from VTDEC on the enclosed WQRP with respect to meeting the requirements for a TMDL alternative appropriate for the category 4(b) waters of Roaring Brook and the East Branch of Roaring Brook. Please let us know if you have any comments, questions or wish to discuss the report comments further.

Very truly yours,

VANASSE HANGEN BRUSTLIN, INC.



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**ROARING BROOK AND EAST BRANCH
OF ROARING BROOK WATER QUALITY
REMEDATION PLAN UPDATE 2011**

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& SP LAND COMPANY, LLC***

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February 17, 2011

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Attachment	Size
Water Quality Remediation Plan Map	36"x48"
Stream Geomorphic Assessment Map	34"x36"

1.0 Introduction

1.1 Background

As of May 2007, the Killington Resort ("**Resort**") is owned by MTB Killington, LLC, AMSC Killington, LLC and SP II Resort, LLC, as tenants-in-common, (commonly referred to as the "**TICs**") and is leased and operated by Killington/Pico Ski Resort Partners, LLC ("**KPSRP**"). The business affairs of the TICs and KPSRP are managed by Powdr Corp based in Park City, Utah. SP Land Company, LLC ("**SPLC**") is planning real estate development projects on several land parcels it owns adjacent to the Resort. SPLC is majority held and controlled by Ski Partners LLC headquartered in Dallas, Texas. A portion of the Resort and the SPLC's development parcels are located within the Roaring Brook ("**RB**") and East Branch Roaring Brook ("**EB**") watersheds in the Town of Killington, Vermont. See Site Location Map on page 1 of Appendix 1. Water quality monitoring on both streams has shown that, due to inadequately managed stormwater runoff, Aquatic Life Support ("**ALS**"), a designated use pursuant to Section 3-04(A) of the Vermont Water Quality Standards ("**VWQS**"), is not being met and therefore the streams have been included on the United States Environmental Protection Agency ("**USEPA**" or "**EPA**")-approved Vermont 2008 303(d) List of Impaired Surface Waters in Need of Total Maximum Daily Load ("**TMDL**") or other EPA-approved plan for improving water quality. The 2010 303(d) list, submitted to but not yet approved by the EPA, also includes RB and EB as stormwater impaired waterbodies.

In May 2000, a Water Quality Remediation Plan ("**2000 WQRP**") was prepared by Pioneer Environmental Associates, LLC ("**Pioneer**") for Killington, Ltd, the prior owner of the Resort. As a component of the review of the proposed Act 250 Killington/Pico Resort Master Development Plan, the 2000 WQRP provided an assessment of water quality conditions in the vicinity of the Resort and Pico Mountain at that time, as well as recommended specific management approaches and measures for eliminating or reducing impairments and improving the overall water quality within RB and EB. This current Water

Quality Remediation Plan ("**2011 WQRP**") replaces the 2000 WQRP and updates the strategy and targets for meeting current VWQS in RB and EB.

This WQRP for the RB and EB watersheds has been prepared based on the proposed approach for consideration of these streams as "Category 4(b) waters" pursuant to the 2006 USEPA Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Section 303(d), 305(b) and 314 of the Clean Water Act (EPA, 2005). In coordination with the Vermont Department of Environmental Conservation ("**VTDEC**"), Vanasse Hangen Brustlin, Inc. ("**VHB**") presents this WQRP as an appropriate tool for design, implementation and monitoring of water quality improvement measures for these waters in accordance with VWQS and the above noted guidance. A water quality remediation plan is appropriate for RB and EB, as category 4(b) waters because "...other pollution control requirements (e.g., best management practices ("**BMPs**") required by local, State or Federal authority are stringent enough to implement applicable water quality standards within a reasonable period of time" (ibid., p. 54). In practice, the stormwater control BMPs will include:

- Implementation of new stormwater treatment practices for proposed development
- Reduction of priority sediment sources identified in Stream Geomorphic Assessment ("**SGA**") and watershed assessment
- Potential sediment and excess flow offset measures as a result of operational stormwater permit applications
- On-mountain BMPs for reducing stormwater runoff
- Compliance with construction and operational phase stormwater permit requirements

1.2 WQRP Overview

This WQRP updates and expands on prior information collected by VHB, the Agency of Natural Resources ("**ANR**"), and others which includes results from stream biomonitoring, water chemistry sampling, and sediment sampling as well as hydrologic and sediment washoff modeling and SGA for RB and EB. Current and historic observations of RB and EB stream metrics indicate that water quality impairments stem from past land development

activities and inadequate stormwater runoff control resulting in increased sediment loading and an altered hydrologic regime.

This WQRP is structured to improve water quality in RB and the EB through reducing current sediment loads and peak flows from inadequately treated stormwater runoff thus allowing the affected stream channels to readjust. Future improvements in water quality and ultimate compliance with VWQS will be evaluated through biomonitoring, which measures the populations of macroinvertebrates and compares them with populations typically found in streams known to be attaining VWQS. Streams with aquatic biota metrics that compare favorably to the VT DEC target wadeable stream category and water quality management classification (e.g., Small High Gradient ("SHG"), Class B2, 3) metrics are considered to be attaining ALS criteria.

This WQRP methodology is based on prior successful water quality remediation efforts at similar mountain streams such as Clay and Rice Brook in Warren, VT and so-called Tributary 1 of the North Branch of Ball Mountain Brook in Stratton, VT. Specific elements of this WQRP are:

- An assessment of the existing development and associated stormwater management systems
- An assessment of the geomorphic condition of the streams with a focus on problem areas and sources
- A summary of prior water chemistry and biomonitoring sampling results
- Identifying and ranking potential ongoing sources of sediment loading to the streams based on water quality monitoring, field investigation and modeling
- Modeling of sediment load reductions and peak flow reductions based on a plan for upgrading existing and building new stormwater control measures
- A schedule for implementation of necessary BMPs and other remediation measures
- Continued water chemistry monitoring and biomonitoring to evaluate further progress towards achieving VWQS

In order to fulfill the objectives of this WQRP and to provide the elements listed above, VHB completed the following tasks:

- Review and summarize prior sampling results for water chemistry, biomonitoring, bridge and culvert assessments, and stream geomorphic assessment
- Analyze the current geomorphic stream stability and identify areas of geomorphic instability and their associate sources
- Assess the current capacity of existing stormwater treatment basins through hydrologic modeling
- Update the washoff sediment load analysis for existing and proposed impervious surfaces within each watershed
- Review and revise watershed and subwatershed delineations for RB and EB
- Update previously prepared land cover and land use maps with existing areas of development, including constructed stormwater management systems
- Identify and prioritize potential water quality remediation projects based on the results of tasks 1 through 3 and the proposed development plan
- Review and compare similar streams to RB and EB to determine reasonable targets for sediment loading

The implementation of this WQRP and planned development adjacent to the Resort is designed according to the “net zero” provisions of Act 140 ensuring that, as a result of a single phase of development, sediment loads would be reduced to the natural baseline conditions. As a result of adherence to Act 140 requirements during planned development, the actual instream effect of “net zero” will be a reduction in stormwater runoff and associated sediment loading. The water quality improvements actions proposed herein represent the implementation of the Act 140 provisions for reducing runoff from TICs and SPLC lands. As each phase of development occurs, conformance with the WQRP and applicable VTDEC stormwater permitting criteria will be necessary. Initially, this will take

the form of designing each phase so that the total sediment loading will not exceed the natural baseline condition (aka “net zero” standard).

1.3 WQRP Plan Components

This WQRP details existing conditions, recent remediation measures, monitoring plans and results, and future actions that are expected to lead to attainment of the VWQS within a reasonable period of time. This WQRP provides scientific data and discusses how it will meet the standards for use, as part of the 4(b) “off-ramping” process, which includes the following requirements (USEPA 2005):

1. Statement of the problem causing the impairment

Based on available water quality monitoring data (see Section 3.0 below) and the inclusion on the 303(d) List of Impaired Waters (VTDEC 2008) the primary source of impairment for Roaring Brook and the East Branch of Roaring Brook is excess washoff sediment load combined with altered hydrology (i.e. increased peak flows) from untreated or inadequately treated stormwater runoff from existing impervious surfaces.

2. Description of the proposed implementation strategy and supporting pollution controls

*The proposed implementation strategy for this WQRP will be to control excess sediment and reduce peak flows through installation of stormwater treatment practices (“**STPs**”) to control stormwater runoff. A system of upgraded and newly installed STPs will be used to control runoff from existing impervious surfaces and proposed new development. In addition to STP implementation, priority sources of sediment will be mitigated, on-mountain sediment control BMPs will be implemented and current construction requirements for erosion prevention and sediment control will be adhered to. More detail of the implementation strategy is provided in Section 4.2 below.*

3. Estimate or projection of the time when water quality standards will be met

Implementation of the WQRP will commence during 2011, pending necessary approvals, with projected compliance with VWQS taking place as runoff from existing impervious surface is better treated and controlled. The current plan projects compliance with sediment and hydrologic targets

for EB and RB, through improved treatment of impervious surfaces associated with TICs, SPLC and previously permitted condominium developments, within nine years. Compliance with VWQS, measured through biomonitoring, will follow as macroinvertebrate populations are reestablished in the stream channels. The compliance timeline of nine years can be accomplished solely through actions on TICs and SPLC lands in RB. In EB remediation efforts will include TICs and SPLC lands as well as privately owned condominium associations with existing expired stormwater permits in order to meet the nine year timeframe. Additional details on the timeframe for WQRP implementation measures can be found below in Section 3.4.1.

4. Reasonable schedule for implementing the necessary pollution controls

A reasonable schedule for implementing pollution controls as part of the development of the Resort, described as Interim, Proposed Phase I, and Proposed Phases II - V has been developed. This plan calls for majority of pollution controls for existing impervious surfaces to be implemented over the next nine years resulting in projected compliance with applicable targets and EPA Water Quality Standards. A framework has been prepared for the WQRP to be extended throughout the span of the entire 25 year development plan which would be implemented should additional remediation be required. A detailed description of the implementation schedule is provided in Section 4.3 below.

5. Description of, and schedule for, monitoring milestones for tracking and reporting progress to EPA on the implementation of the pollution controls

A monitoring plan, reusing monitoring locations established in 2005, will be implemented including base flow and event flow water chemistry monitoring, in-stream sediment monitoring and biomonitoring. The details of this monitoring plan are presented below in Section 5.0.

6. Commitment to revise as necessary the implementation strategy and corresponding pollution controls if progress towards meeting water quality standards is not being shown

This WQRP would utilize the results of the monitoring plan to both track progress and to identify additional remediation strategies, if needed, to ensure progress toward meeting VWQS. ANR requires that water quality remediating plans are updated every five years at a minimum.

2.0 Project Background

2.1 Study Area and Regional Setting

The impaired reaches of EB (River Mile ("RM") 0.1 – 0.6) and RB (RM 3.5 – 4.2) and their associated watersheds are located on the north and east facing slopes of the Green Mountains, principally within the boundaries of the Resort and within the Town of Killington, and encompass a total area of approximately five square miles. The main stem of the upper RB originates on the steep gradient of Killington Mountain at an elevation of approximately 4,000 feet and flows generally adjacent to the Killington Road. The total length of the RB stream channel which is described in this plan is approximately 2.4 miles.

From its headwaters at Snowshed Pond (elevation 2,120 feet) EB flows across East Mountain Road and through the Killington Resort Golf Course ("Golf Course") where it joins RB at 1,870 feet, just above Ravine Road. From the confluence point, Roaring Brook merges with several other tributaries before it flows under US Route 4 and enters the Ottauquechee River. Land ownership within the RB and EB watersheds consists of both private (e.g., TICs, SPLC, and other private landowners) and public (e.g., Coolidge State Forest and Town of Killington Roads) parcels (see Figure 1 – Property Ownership Map.)

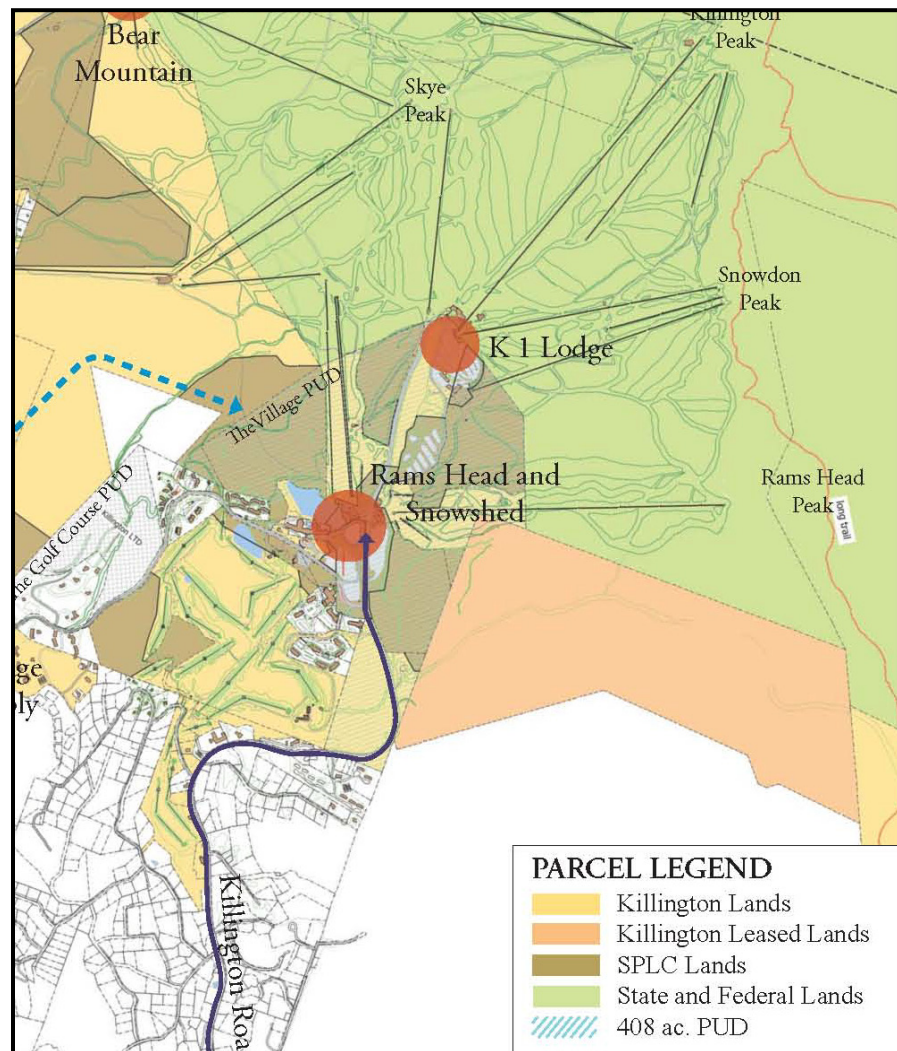


Figure 1 – Property Ownership at Killington Resort (Map by SPLC, 2008)

The Resort has steadily grown since its founding in 1958 to become the largest ski area in the eastern United States. Much of the early development at the Resort, including the construction of Killington Road, most ski trails, the Rams Head Parking Lot, and the original base area including the K-1 Lodge and Parking Lot took place between 1958 and 1981, before stormwater rules and regulations had been adopted in Vermont. As such, stormwater runoff from the developed areas was generally directed to RB and EB via ditches or culverts without any treatment provided. In the mid-1980s development in the area continued with privately owned Pinnacle, Cascades, Mountain Green and Mountain Inn Condominiums. These developments, located below the Snowshed Parking Lot area, were not subject to

VTDEC stormwater discharge permits, and therefore no stormwater BMPs exist for these facilities.

More recent developments, including the re-construction of the K-1 and Rams Head Parking Lots as well as the construction of the Vale Parking Lot, and the Killington Grand Resort Hotel ("**Grand Hotel**") were completed while the Resort was owned by Killington, Ltd. in the mid to late 1990s. These developments were permitted for stormwater discharges and the following BMPs were constructed to treat stormwater: the K-1 Basin, Rams Head Basin, Vale Parking Lot Basin, and the Killington Club House Basin. Likewise the privately owned Fall Line, Edgemont, Trail Creek and Whiffletree Condominiums were built and permitted for stormwater discharges during the mid-1990s. Stormwater BMPs for these private condominiums do not include a basin but instead rely on grassed swales for treatment. The 1990s round of development occurred before the most recent updates to the stormwater rules which included the adoption of treatment standards from the 2002 Vermont Stormwater Management Manual ("**VSM**"). Development on the lands in the vicinity of the Resort has slowed considerably since the construction of the Vale Parking Lot which was under construction in 1995 and the Grand Hotel was built soon thereafter.. There are no other significant changes in the development at The Resort as shown in a comparison of the 1995 aerial imagery with 2009 aerial imagery. (See figure 2 below).

Due to the timing of the development adjacent to the Resort, described above, treatment for stormwater runoff from existing impervious surfaces is either non-existent or significantly undersized. The net effect is that stormwater runoff enters the stream channel carrying excess sediment and also contributes to increased peak discharge rates which degrade the aquatic habitat and has resulted in the stormwater impaired determination for RB and EB. As shown below in Sections 3.3 and 3.4, monitoring results and sediment load modeling indicated that runoff coming from impervious surfaces with no stormwater control, or pre-2002 standard stormwater BMPs, contribute significantly more sediment per unit area than ski trail, golf course and other forested areas. Improvements identified in this WQRP will apply improved stormwater BMPs to TICs and SPLC controlled impervious surfaces, both in areas of existing undertreated impervious surfaces and for proposed new development

areas. In addition the WQRP identifies BMP upgrades for prior permitted entities located in the EB watershed. Broadly speaking, this WQRP ties major stormwater infrastructure improvements to the proposed development plan (See Section 2.3 above) in order to ensure technical compatibility of proposed stormwater BMPs with the proposed land uses.



Figure 2: Most Recent Development at Killington Resort

This WQRP contains specific actions for lands owned and/or controlled by the TICs and SPLC, as well as potential actions, to be determined by VTDEC, for other prior permitted entities in EB. The TICs and SPLC are the majority landowners in RB and EB; they control

approximately 85 out of 152 acres (56 percent) of impervious surface in RB and 20 out of 32 acres (64 percent) in EB. However, a significant portion of impervious surface that is currently discharging untreated or inadequately treated stormwater into RB and EB is owned or controlled by other parties. The schedule of implementation indicates the actions by the TICs and SP Land will effectively meet sediment and hydrologic targets. However, this WQRP also includes information regarding additional projects for previously permitted condominium developments that VTDEC could implement should they be deemed necessary. Additional details regarding the compliance timeframe are detailed below in Section 3.4.1

Water quality data available from 1989 to the present, collected by ANR, VHB, and other consultants, provided the necessary background information needed to design this WQRP. Pioneer conducted a monitoring campaign consisting of biomonitoring, water chemistry sampling and sediment sampling in 2005. In 2006 a Phase I and II SGA was conducted on the RB and EB under contract to VTDEC (Bear Creek Environmental, 2006). During summer 2009, VHB conducted a stream survey and site walkover to document existing conditions. In combination, the historic monitoring data, SGA results, 2005 monitoring results, and the 2009 site visit (see Sections 3.1 to 3.3.5 below) serve as the baseline data used to prepare this WQRP.

2.1.1 Watersheds

VHB has divided the RB and EB watersheds into eight major subwatersheds for the purposes of the WQRP evaluations and review of monitoring data collected during 2005. The SGA data has been summarized according to the ANR stream segment protocol and is detailed in Section 3.1 below. All watersheds are shown on the attached WQRP map. Subsequent sections of this report (with the exception of the SGA summary) are organized by these watershed delineations:

Major Subwatershed A/ Upper Roaring Brook: Major Subwatershed A includes the uppermost reach of RB. This drainage area includes the K-1 Lodge and Parking Lot, the

Vale Parking Lot and the upper portion of Killington Road. The land types within this major subwatershed are comprised of forests, ski trails and relatively large gravel and paved parking areas.

Major Subwatershed B / Ram's Head Brook: Major Subwatershed B includes the area drained by Ram's Head Brook. This drainage area is comprised of ski trails and forest.

Major Subwatershed C / Upper West Branch Roaring Brook: Major Subwatershed C includes the area drained by a portion of the main stem of RB as well as Tributary W-4. The predominant land types within this drainage area are forest and ski trails with some large impervious surfaces. Large impervious areas within the major subwatershed include the Ram's Head Lodge, Ram's Head Parking Lot, a portion of Killington Road, and portions of the Upper Snowshed Parking Lot.

Major Subwatershed D / West Branch Roaring Brook: Major Subwatershed D includes the area drained by the West Branch of RB. Since this drainage area is nearly 100 percent forested and unaffected by development, it has been selected as a potential reference stream.

Major Subwatershed E / Lower Roaring Brook 1: Major Subwatershed E includes the area draining to RB along Killington Road below the Resort. This drainage area has a mix of forested and developed areas such as roads and impervious parking lots. It also has a high proportion of area that is not owned or controlled by the TICs or SPLC.

Major Subwatershed F / Lower East Branch Roaring Brook: Major Subwatershed F includes the area draining to the lower EB below the Trail Creek condominiums. The land types within this area are predominantly forest and golf course with the Fall Line, Edgemont and Whiffletree developments off of East Mountain Road, all of which are not owned or controlled by the TICs or SPLC.

Major Subwatershed G / Upper East Branch Roaring Brook: Major Subwatershed G includes the area draining to the Snowshed Pond and upper reach of the EB. Land types within this drainage area include heavily forested areas, ski trails and impervious surfaces associated with the Snowshed Lodge, portions of the lower Snowshed Parking Lot, and the Grand Hotel.

Major Subwatershed H / Lower Roaring Brook 2: Major Subwatershed H is located below the confluence of RB and EB at the lower reach of the impaired watershed. This drainage area is comprised mainly of small commercial and residential parcels and larger forested tracks. With the exception of a portion of the Golf Course, Wobbly Barn and Lower Administration buildings, the lands within this subwatershed are not controlled by the TICs or SPLC.

Watershed summaries provided for RB include Major Subwatersheds A, B, C, D and E, which comprise all subwatersheds above the EB confluence. EB includes F and G. Watershed H is provided separately. Table 1 details the existing land cover composition of each of the major subwatersheds included in this study.

Table 1: Percentage and Area of Land Cover Type by Major Subwatershed						
Major Subwatershed		Total Acres	Forest	Open	Impervious	Water
RB	A	681	65%	30%	4.8%	0.0%
	B	273	80%	18%	1.4%	0.0%
	C	345	76%	20%	3.8%	0.0%
	D	440	98%	2.0%	0.1%	0.0%
	E	184	59%	23%	18%	0.0%
EB	F	314	68%	26%	5.1%	1.1%
	G	186	60%	27%	8.6%	4.1%
Lower RB	H	790	88%	5.0%	6.7%	0.1%

The locations of the fourteen existing water quality sampling stations along with watershed boundaries are shown on the WQRP Map located in the attached map sleeve,

and described in Table 2. In addition to the 14 general water quality monitoring stations, over 100 locations were sampled for turbidity in 2005. The locations of these stations are also shown on the WQRP Map.

Table 2: Water Quality Monitoring Stations			
Major Subwatershed		Site	Description
RB	A	KP-3:	Located at the mouth of Tributary W-1 (RM 0.1) of Roaring Brook, at an elevation of 2,360 feet.
		KP-10:	Located on upper Roaring Brook, (RM 4.3) at an elevation of 2,470 feet.
	B	KP-5:	Located at the mouth of Rams Head Brook, (RM 0.1) at an elevation of 2,250 feet.
	C	KP-6:	Located on Tributary W-4 of Roaring Brook, (RM 0.3) at an elevation of 2,300 feet.
		KP-11:	Located on Roaring Brook, (RM 3.8) below the Rams Head Brook confluence and approximately 100 linear feet upstream of the snowmaking system intake weir.
		KP-27:	Located on Roaring Brook, just below the Tributary W-4 confluence.
	D	KP-8:	Located on West Branch Roaring Brook, approximately 200 linear feet upstream of the culvert at Killington Road, (RM 0.2) at an elevation of 2,125 feet. This station has been selected as the reference site in this background monitoring evaluation.
	E	KP-24:	Located on a Tributary to Roaring Brook, (RM 0.1) at mouth of the channel at an elevation of 1,900 feet.
		KP-26:	Located on Roaring Brook just above the confluence with the East Branch.
EB	F	KP-14:	Located on the East Branch, (RM 3.2) above East Roaring Brook Road and Golf Course, and below confluence of two tributaries at an elevation of 2,145 feet.
		KP-15:	Located on the East Branch, (RM 0.7) below East Roaring Brook Road and above Golf Course at an elevation of 2,105 feet.
		KP-17:	Located on the East Branch, (RM 0.5) in mid-area of Golf Course, downstream of open section, downstream of pond, immediately below Resort spray disposal area at an elevation of 1,975 feet.
		KP-18:	Located on the East Branch, (RM 0.1) at mouth of the channel at an elevation of 1,855 feet.
	G	KP-25:	Located on the East Branch, (RM 3.5), below the Snowshed Pond dam, upstream of footbridge to Trail Creek at the Resort, at an elevation of 2,150 feet.
Lower RB	H	NA	No Monitoring within Watershed H

2.2 *Regulatory Background and Permit History*

RB and EB have been listed on the State 303(d) list of impaired waters in need of a TMDL since 2000 with the principal cause of the impairments to these water bodies described as stormwater. During the period 2006 through 2009, DEC drafted, and USEPA approved Stormwater TMDLs for twelve urbanized, low elevation stormwater impaired streams in Vermont. To date no stormwater TMDLs have been completed for the higher elevation mountain impaired watersheds. As noted in the introduction, the mountain streams of EB and RB are currently in need of a TMDL or appropriate substitute in order to be removed from the 303(d) listing. Thus, this WQRP is intended to address the water quality impairments through the EPA section 4(b) off-ramping process in place of the development of a TMDL for these watersheds, as detailed above in Section 1.3.

A total of six stormwater discharge permits issued by VTDEC, five of which have expired, provided coverage for operational phase discharges of stormwater runoff from certain impervious surfaces within the impaired portions of the RB and EB watersheds. Permit 2-1009 (expired) was issued in 1985 for a restaurant located on Killington Road in the lower portion of Major Subwatershed H. Permit 1-0357 (expired) was issued in 1983 for the Trail Creek Condominiums and Permit 2-1101 (expired) was issued in 1986 for Fall Line Town Houses. Both of these privately owned developments are on East Mountain Road in EB Major Subwatersheds E and G. Permit 5674-9010 (active) was issued in 2008 for the privately owned Inn of the Six Mountains located Killington Road in RB major Subwatershed E.

Permit 1-0446 (expired) was issued in 1992 for the Resort-owned Rams Head, K-1, and Vale Parking Expansion projects and provided for the construction of the K-1, Vale and Rams Head stormwater basins. Permit 1-1288 (expired) was issued during the late 1990s for the Resort controlled Grand Hotel and included the construction of the basin located off of East Mountain Road (Permits 1-0446 and 1-1288 are found on pages 2 through 8 of Appendix 1). As discussed in Section 3.4, the stormwater infrastructure authorized by these permits treats

only a portion of the runoff associated with existing impervious surfaces in these watersheds.

2.3 *Development Plan*

The TICs and SPLC have collaborated on a development plan for the Resort and surrounding development property owned by SPLC. The implementation of this plan will fundamentally alter the current stormwater treatment controls for both existing impervious surfaces and planned new impervious surfaces. Through a combination of development, redevelopment, upgrades and new stormwater controls to be implemented over a period of time it is anticipated that current impacts to water quality will be reduced to the point where the stream segments associated with this plan are provided the maximum opportunity to recover and ultimately meet ALS attainment. For the purpose of this WQRP the implementation of the development plan, detailed below, has been simplified into four conditions: Existing, Interim, Proposed Phase I, and Proposed Phase II – V.

Existing Conditions (Year 0)

Existing Conditions describes the current condition of the streams in relation to existing land development at the Resort. This condition is summarized in Section 2.1.1 above. Additional data used to describe existing conditions include benchmark water quality monitoring conducted in 2005, a bridge and culvert assessment conducted in 2006, a Phase II SGA conducted in 2007, and biomonitoring conducted most recently in 2007 by the VTDEC. Development of new impervious surface at the Resort over the past five years has been minimal and the data collected over this time period provides an accurate accounting of the streams existing conditions in relation to stormwater runoff from existing impervious surfaces.

Interim Conditions (Years 1 -5)

The Interim Conditions scenario, scheduled to take place over the next five years, incorporates remediation projects for high and moderate priority sediment sources identified within RB and EB watersheds and controlled by the TICs. It also includes plans

for analysis of potential retrofits to the Cat Yard, K-1 Parking Lot, Killington Club House, and the Vale Parking Lot Basins to help improve their capacity to treat runoff from existing impervious surfaces. Ultimately the goal is to provide STPs at the Resort that are designed to the Water Quality Treatment Standards (“**WQTS**”) of the 2002 VSMM. However practical considerations for the future use of the existing basins under the full buildout of the SPLC’s master development plan (“**Master Plan**”) would require interim measures for stormwater control to be considered. For instance, existing space limitations and future planned development, including new STPs, would constrain retrofits of the Cat Yard, K-1, Vale, and Club House Basins. In other cases, Snowshed and Rams Head Parking Lots are due to be redeveloped during proposed Phase I (see below), with new stormwater basins proposed, thus there are no plans to have them retrofitted under interim conditions.

Proposed Phase I (Years 6 – 9)

Proposed Phase I represent the completion of the interim improvements plus the proposed development of Phase I of the Master Plan detailed below. According to the development schedule listed below it is quite likely that interim and proposed Phase I activities will overlap.

- Phase I - Ram’s Head Brook and parts of The Village Core (Years 6-9)
 - Ram’s Head Brook is a proposed development consisting of a mixture of resort townhouses and possible single family lots
 - The Village Core is a proposed redevelopment of Ram’s Head and Snowshed Parking Lots to create the Village Core of resort condominiums, commercial space and a hotel
 - A replacement parking lot and associated stormwater detention basin is proposed adjacent to Killington Road to the west and north of the Mountain Inn (“**Replacement Parking Lot**”)
 - Killington Road will be realigned in The Village Core area

Proposed Phases II – V (Years 10 – 25)

Proposed Phases II to V represent the full buildout of the Master Plan detailed below and is scheduled to take place over the next 25 years.

- Phase II – Snowdon Glades, parts of The Village Core and Killington Road (Years 10-12)
 - Snowdon Glades is a proposed development of condominiums, townhouses, and single family lots
 - The Village Core Phase II would continue the redevelopment which started in Phase I above
 - The upper portion of Killington Road above the Medical Center is proposed to be converted to a ski trail and forest, and Killington Road will be relocated along the existing Vale Road
- Phase III – Yodeler’s Run, The Links and portions of Snowdon Glades (Years 13-15)
 - Yodeler’s Run is a proposed new development consisting of townhouses and single family lots
 - The Links is a proposed new development consisting of golf flats and condominiums
 - Snowdon Glades would continue development started in Phase II
- Phase IV – Snowshed Woods, Killington Club and related improvements (Years 16-20)
 - Snowshed Woods is a proposed new development of condominiums, townhouses and single family lots
 - Killington Club is a proposed redevelopment of the commercial area and parking spaces in the area of the existing Grand Hotel
- Phase V- Vale and The Links (Years 21-25)
 - Vale is a proposed redevelopment of the Vale Parking Lot into townhouses
 - The Links would be a continuation of the development started in Phase III

A conceptual plan showing the phased development is shown below in Figure 3 and potential stormwater detention basin locations associated with the development are shown on the WQRP Map in the map pocket.



Figure 3: Killington Resort/SP Land Conceptual Development Plan

3.0 Roaring Brook and East Branch of Roaring Brook – Existing Water Quality Condition Assessments

3.1 Stream Geomorphic Assessment

Under contract to VTDEC, Bear Creek Environmental (“**BCE**”) conducted a Phase 2 Stream Geomorphic Assessment of the RB watershed in 2005 (Blazewicz, 2006) (see pages 21 through 81 of Appendix 2). As part of that project, Rapid Habitat Assessments (“**RHA**”) and Rapid Geomorphic Assessments (“**RGA**”) were conducted on three RB, EB, and associated tributary streams in the study area. The stream reach classification is based on the statewide methodology established by the VTDEC Rivers Management Program as part

of the Vermont SGA assessment protocols and does not correspond with prior descriptions of the watersheds or stream reaches provide above. Table 3 provides a key to linking the SGA descriptions with those used in the WQRP.

Table 3: SGA- WQRP Key		
SGA Designation	Description	WQRP Major Subwatershed(s)
T6.03	RB Main Channel below SW Impaired Section and Dean Hill Road	NA
T6.03 -S1.01 to S1.02	Unnamed Trib. to RB confluence near Dean Hill Road	H
T6.04	RB Main Channel between Dean Hill Road and elevation 1800 feet	H
T6.05	RB Main Channel from elevation 1800 feet to above Ravine Road	H
T6.05-S1.01	EB Main Channel from confluence with RB to East Mountain Road	F
T6.05-S1.02	EB Main Channel above East Mountain Road	G
T6.06	RB Main Channel from EB confluence to West Branch of Roaring Brook confluence	E
T6.06-S1.01 to S1.02	West Branch of Roaring Brook	D
T6.07	RB Main Channel from confluence of West Branch of Roaring Brook to Confluence of Rams Head Brook	C
T6.07-S1.01	Rams Head Brook	B
T6.08	RB Main Channel above confluence with Rams Head Brook	A

Specific reaches assessed within the study area were T6.06, T6.07, and T6.08. The former two reaches are within Major Subwatershed E and the latter reach is within Major Subwatershed A. Major Subwatersheds B, C and D all contribute to the main stem of RB.

The 2005 BCE report confirms that segments within the RB watershed have been affected by changes in hydrology and sediment associated with stormwater runoff. The upper three reaches of RB appear to be undergoing channel adjustment processes (D-stage channel evolution) due to excess sediment washoff load supplied from gravel parking lots, roads and other existing development areas. The stream type and overall geomorphic condition

are used to assess a channels likelihood of responding to a watershed disturbance or stressor. Reaches T6.06, T6.07 and T6.08 were all rated high with respect to stream sensitivity. Due to the changes that have occurred as well as the locations and settings of these channels, the high sensitivity rating suggests that channel geometry will continue to adjust until sediment loads or peak flows are reduced from current levels.

During July, 2009, VHB's fluvial geomorphologist assessed current channel conditions and processes in RB and EB. The 2009 assessment included RB reaches T6.03, T6.04, T6.05, T6.06, T6.07 and T6.08, as well as EB reaches T6.05-S1.01 and T6.05-S1.02. As a result of the investigation, 29 active sediment sources (see Table 4 below) were identified between RB and EB watersheds. Each source has a proposed remediation methodology, priority rating and location indicated as well as photographic documentation included on the Sediment Source map, table and associated photographs provided on pages 1 through 20 of Appendix 2. The remediation of these individual sources of sediment comprises a portion of the WQRP-designated actions to be completed during the Interim Conditions period.

Table 4: Sediment Sources Identified During the 2009 SGA Site Walkover

Source	Major Subwatershed	Description/Issue	Owner	Priority
1	F	large/high pile of eroding dirt	Private (Whiffletree)	HIGH
2	F	sediment from parking lot through drains, culverts and swales into tributary	Private (Trail Creek)	MODERATE
3	F	gravel road shoulder erosion at culvert outlet	Public Road	LOW
4	F	swale conveying sediment	Public Road	MODERATE
5	G	eroding/bare banks of culvert outlet	TICs/SPLC	LOW
6	G	instable banks and swale	TICs/SPLC	MODERATE
7	A	gravel from parking lot washing into brook	TICs/SPLC	LOW
8	A	rusted out culvert	TICs/SPLC	LOW
9	A	rusted out, perched culvert and instable swale	TICs/SPLC	MODERATE
10	A	gravel washing off road shoulder	TICs/SPLC	LOW

Table 4: Sediment Sources Identified During the 2009 SGA Site Walkover				
Source	Major Subwatershed	Description/Issue	Owner	Priority
11	A	gravel eroding over road shoulder	TICs/SPLC	LOW
12	A	roadside swale conveying sediment	TICs/SPLC	LOW
13	A	instable eroding roadside swale	TICs/SPLC	MODERATE
14	A	eroding dirt roads	TICs/SPLC	HIGH
15	A	eroding headwall to culvert	TICs/SPLC	LOW
16	A	eroding road shoulder into tributary	TICs/SPLC	HIGH
17	A	eroding road shoulder into tributary	TICs/SPLC	HIGH
18	A	instable swale	TICs/SPLC	LOW
19	A	swale conveying sediment	TICs/SPLC	LOW
20	A/B	instable eroding long swale	TICs/SPLC	HIGH
21	B	instable eroding swale	TICs/SPLC	HIGH
22	A	instable swale	TICs/SPLC	LOW
23	C	gravel washing into channel	TICs/SPLC	LOW
24	C	runoff from gravel parking lot	TICs/SPLC	LOW
25	C	runoff from gravel parking lot overloading sediment basin	TICs/SPLC	HIGH
26	E	instable and eroding swales and sand pile	Private (Pinnacle)	HIGH
27	F	gravel washing out from parking lot and eroding culvert outfall	Private (Wiffletree)	HGH
28	F	instable temporary disturbances	Private (Wiffletree)	MODERATE
29	E	eroding swale and sediment filled tributary	Private (Pinnacle)	HIGH

Reach by reach summaries of the 2009 observations by VHB, relative to findings presented in the 2005 Phase 2 SGA report, are included in Section 3.1.1 and 3.1.2.

3.1.1 *Roaring Brook*

T6.03 – Major Subwatershed H

Despite the narrow buffer widths from commercial development on both sides of the channel, the overall reach condition of T6.03 is in relatively good geomorphic condition. There were signs of historic degradation with a recently abandoned floodplain as reported in the 2005 SGA. However, widening appears to be the current dominant

channel process observed as opposed to aggradation noted in the 2005 report. T6.03 is a straightened steep reach and is likely transporting suspended particles through it. There were vertical banks exposed on both sides of the channel in a straight riffle section indicating that widening is occurring within Stage III of the channel evolution model.

T6.04 – Major Subwatershed H

The large, misaligned culvert under Dean Hill Road at the downstream terminus of this reach is causing scour downstream. Although the active flood chute (noted in 2005) indicates some planform adjustments, lateral constraints have caused widening to be the dominant channel process with exposed vertical banks observed in straight riffle sections. There was also a recently abandoned floodplain observed in 2009, indicating historic degradation. Although the 2005 report notes a weak riffle pool bedform, the 2005 report understates the poor in-stream habitat quality throughout the reach which now resembles a planebed bedform system.

T6.05 – Major Subwatershed H

T6.05 is in a relatively good geomorphic condition and has been exposed to much less straightening, resulting in a stable reach undergoing no major adjustment processes (noted in 2005). The prevalence of bedrock and larger boulders acting as natural grade controls in this steeper reach also limits bank erosion. Signs of excess sedimentation and sediment inputs were attributed to washoff and not to in-channel processes (2005 report determined sand and gravel comprised up to 37 percent of substrates). The 2005 report did not mention a very tall mass failure eroding downstream from the concrete barrier to the Golf Course. The mass failure is unstable and could have been caused by natural geologic processes, in-stream planform adjustments, or the influence of the abutting Golf Course.

T6.06 – Major Subwatershed E

Reach T6.06 is impacted by the adjacent Golf Course, but is influenced more by the introduction and deposition of fine sediments most likely from untreated stormwater runoff. There were no in-reach or in-stream processes observed as responsible for this condition, indicating that the fine sediments are being introduced from sources upstream.

The 2005 report notes the impacts of historic degradation; however, there were no recently abandoned floodplains observed in 2009. The steep boulder and bedrock dominated reach should provide natural grade controls to buffer impacts of increased flows. The 2005 report also notes that the “reach appears to be actively aggrading and widening”; however, the 2009 site visit found that sediment is being introduced into the reach from upstream and no signs of widening. The prevalence of side bars and eddies dominated by fine sediment is degrading in-stream habitat by filling interstitial substrate spaces.

T6.07 – Major Subwatershed C

As noted in the 2005 report, T6.07 is undergoing the most extreme adjustments from the large amount of introduced sediment. This reach is dominated by the deposition of fine sediments observed (in 2009) throughout the reach. The 2005 report notes that this aggradation has resulted in “major widening and planform” adjustments, however, (in 2009) the aggradation of fine sediments was the dominant and major process as evident by the presence of mid-channel, side and diagonal bars. The excessive sediment load has also caused the buildup of fine sediments upstream of large woody debris jams, causing avulsions, as the hydraulic capacity of the channel has been significantly compromised. In 2009, the presence of fine sediment in the channel was more noticeable downstream of the Ram’s Head Parking Lot indicating that it is likely a major sediment source. In 2009, there was no evidence of historic degradation and there was a consistent accessible floodplain adjacent to the channel.

T6.08 – Major Subwatershed A

Although impacted by the adjacent Killington Road, T6.08 is a relatively stable reach of RB, likely due to the presence of boulders and bedrock acting as natural grade controls. The 2005 report notes that T6.08 is slightly incised; however, there were no signs of historic degradation or recently abandoned floodplains observed in 2009. The most influential impact to this reach are the gravel inputs from the unpaved parking lots on the side of RB and the stormwater drains from unstable roadside swales along the

Killington Road. The unstable swales are conveying fine sediment and gravel into RB as documented in the sediment source table and accompanying photographs.

3.1.2 East Branch of Roaring Brook

T6.05-S1.01 – Major Subwatershed F

T6.05-S1.01 is the first upstream reach of EB from the confluence with RB and was not described in detail in the 2005 report. This reach is heavily impacted from the surrounding Golf Course. Although not as evident as in the main branch of RB, there was evidence of fine sediment deposition which is likely a result of adjacent Golf Course activities. There were signs of historic degradation with the current re-establishment of a new floodplain. The adjacent Golf Course has resulted in some very small and sometimes non-existent buffers along the right and left riparian corridors of T6.05-S1.01. Unstable tributaries to the EB have resulted in the introduction of fine sediment from erosion. The failure (rusted out) and undersized nature of culvert “C-77” (town owned structure) has resulted in erosion at the upstream end of the reach.

T6.05-S1.02 – Major Subwatershed G

T6.05-S1.02 is the second EB reach extending upstream from culvert “C-77” between Trail Creek and Edgemont, under East Mountain Road up to Snowshed Pond. This section of EB tributary is incised with evidence of minor degradation. However, the channel processes in this reach is most influenced by an in-stream beaver pond, which at the time of survey had been deconstructed, resulting in a very sandy and widening channel. This temporary adjustment will change with any future beaver activity.

3.2 Bridge and Culvert Assessment

A Bridge and Culvert Assessment (“BCA”) was conducted throughout the RB watershed within the Resort during the summer of 2007 by Pioneer. Eighty five culverts and eight bridges were assessed with respect to bedload transmission capability, aquatic organism passage and physical condition (see SGA map located in the map pocket). Subsequently, in

2010 the culvert assessment data was supplemented with data provided by James Tomlinson of KPSRP which included additional culverts and assessment data relating to the maintenance conditions of each culvert. A list of the 85 culverts assessed by Pioneer and pictures of the high priority culverts; which were selected based upon the geomorphic and fish passage indicators present at the culvert, as well as the general condition of the structure, is included on pages 1 through 9 of Appendix 3.

Eight culverts, listed in Table 5, were selected as high priority culverts for replacement or repair.

Table 5. Summary of high priority replacement culverts within the Resort					
Culvert ID	Major Subwatershed	Assessment of Deficiency	Recommendation	Culvert Length (ft)	Culvert Diameter (ft)
C-01	A	Undersized culvert	Replace with Larger Structure	100	1.5
C-12	A	Culvert causing downstream erosion	Replace	110	2
C-16	A	Culvert too steep	Reinforce outlet or replace	50	2
C-18	A	Undersized culvert	Replace with Larger Structure	85	2
C-53	E	Culvert causing downstream erosion	Replace	50	1.5
C-81	F	Undersized culvert	Replace with Larger Structure	25	1.5
C-110	A	Portion of culvert is in poor condition	Replace section of culvert	----	----
C-122	A	Culvert partially collapsed	Replace	----	----

Evidence of an upstream sediment obstruction was observed at C-01, C18, and C-81. Such observations generally suggest that a culvert is undersized, since bedload is unable to move appropriately with streamflow downstream through the stream channel. Culvert C-16 had an outflow drop that was two feet or greater which indicates that the culvert was either poorly placed initially or that scouring of the channel below the outlet has occurred subsequent to installation. Four culverts, C-01, C-12, C-18, and C-53 had downstream banks

that were substantially higher than the upstream banks. Such conditions suggest that the downstream banks have been eroded and that either down cutting or widening has occurred. Only C-01 was not identified as having high downstream bank erosion. The proper sizing and placement of these culverts is intended to improve water quality conditions due to a decrease in erosion, scouring, and channel widening.

Culvert C-36, which drains a portion of the K-1 Parking Lot across Vale Road, is undersized and was replaced with a larger diameter pipe during the summer of 2010. Culvert 110 is deteriorating and a section that was failing was replaced in 2010. Culvert 122 is partially collapsed near the outlet and is scheduled to be replaced in 2011. Bridge number 7, located on the Golf Course and spanning over the EB is identified in the SGA and BCA, and was replaced during 2010 with a 60 foot long structure that will allow the bridge abutments to be moved farther from the stream channel.

3.3 Water Quality Sampling

In 2005, background water quality monitoring work was performed by Pioneer. At that time Upper RB and EB watersheds were separated into seven major subwatersheds (described in Section 2.0) for the purposes of presenting and discussing the monitoring data. The locations of the fourteen baseflow sampling stations along with storm event flow stations and watershed boundaries are shown on the WQRP Map located in the map pocket.

The water quality monitoring study included water chemistry sampling (storm event and baseflow), substrate sampling and biomonitoring. In connection with the above study components, temperature, rainfall and hydrologic monitoring were also conducted. The 2005 study represents a comprehensive set of water quality data available for RB and EB; given the lack of subsequent land development and/or STP implementation, it is a reasonable representation of currently existing water quality conditions. A synopsis of the main components of the 2005 report is provided below.

In 2008 VTDEC produced the *Biological and Aquatic Life Use Attainment Assessment of Roaring Brook and Tributaries* (Fiske, 2008). This report summarizes biomonitoring, water chemistry

monitoring, sediment assessments and fish habitat monitoring conducted in RB and EB since 1989. Where applicable, the results of the report are referenced in Sections 3.3.1 through 3.3.4 below.

3.3.1 Storm Event Water Chemistry Sampling

Samples were collected at 55 locations (shown on the WQRP Map) during 6 individual rain events during the summer and fall of 2005 that resulted in significant runoff depths greater than 0.5 inches of rain during a 24-hour period. These samples were analyzed for:

- Turbidity (Nephelometric Turbidity Units ("**NTU**"))
- Conductivity (microsiemens per centimeter ("**umho/cm**"))
- pH (standard units ("**s.u.**".))
- Total Suspended Solids ("**TSS**") -in milligrams per liter ("**mg/L**") if NTU value is greater than 10

The results of the storm event sampling are included on pages 13 through 18 of Appendix 3.

During 2009, VHB reviewed the 2005 data and identified notable event stations that had elevated turbidity and/or conductivity levels and their associated source watersheds. These notable stations - where average NTU observed was greater than 10 - indicated specific watershed locations with excess sediment observed in stormwater runoff. Table 6 below lists each notable event station, average NTU, category and associated drainage area.

Table 6: Notable Turbidity Monitoring Results (2005)				
Stations	Average / Max NTU	Major Subwatershed	Drainage Area	Probable Source
E-10	30.5 / 89.3	A	RB-A19	Killington Road Runoff
E-11	142 / 383	A	RB-A17	Killington Road Runoff
E-12	64.1 / 186	A	RB - A16	Killington Road Runoff
E-14	13.4 / 30.6	A	RB-A16	Killington Road Runoff
E-15	10.2 / 15.7	A	RB-A16	Killington Road Runoff
E-17	14.6 / 25.0	A	RB-A13	Killington Road Runoff
E-18	10.4 / 15.0	A	RB-A13	Killington Road Runoff
E-96	86.0 / 168	A	RB-A15	K-1 Parking Basin Outlet
E-97	13.5 / 28.4	A	RB-A22	Cat Yard Basin Outlet
KP-3	12.0 / 16.0	A	RB-A24	Vale Parking Lot and RB Tributary
E-32	107 / 310	C	RB-A09	Rams Head Parking Basin Outlet
E-33	37.5 / 57.0	C	RB-A07	Snowshed Parking Lot Basin Outlet
KP-27	61.3 / 120	C	RB -A12	RB Channel (Below W-4 Confluence)
E-35	60.3 / 125	D	RB-A14	Pinnacle Condominiums
E-36	21.5 / 33.0	D	RB-A14	RB Tributary
E-38	26.6 / 74.2	D	RB-A27	WWTF Runoff
KP-24	45.7 / 88.0	D	RB-A14	RB Tributary
E-65	57.2 / 212	F	EB-A13	East Mountain Road
E-66	12.1 / 15.2	F	EB-A13	East Mountain Road
E-84	11.0 / 30.0	F	EB-A02	Golf Course Ditch
KP-18	43.5 / 121	F	EB-A02	East Branch Main Stem
E-54	11.2 / 16.0	G	EB-A08	Snowshed Lodge
E-55	26.2 / 73.0	G	EB-A08	Snowshed Lodge
E-56	32.4 / 81.8	G	EB-A03	Snowshed Parking

The review of the monitoring data indicates that, among observed locations, excess sediment, measured as NTU in storm event samples, is disproportionately related to runoff from specific sources. In RB these include the Killington Road (eight locations), the Vale Parking Lot Basin and RB Tributary, The K-1 Basin, Ram's Head parking lot basin, wastewater treatment facility parking, Pinnacle and Mountain Green Condominium runoff. In EB locations include East Mountain Road (two locations adjacent to Whiffletree), a single Golf Course ditch, Snowshed Lodge (two locations) and Snowshed Parking. In addition to these specific sediment sources, elevated turbidity levels were observed within the perennial stream channels. Station E-27 and KP-27 are located on the RB main stem in close proximity to roadway and parking runoff. Stations

E-36 and KP-24 are located on a RB Tributary that receives direct runoff from Pinnacle and Mountain Green Condominiums. Station KP-18, located at the confluence of EB with RB receives water from all of the EB watersheds.

3.3.2 Baseflow Water Chemistry

Samples were collected during low flow conditions during a period from June 2005 through October 2005. These samples were analyzed for the following chemical components:

- Chloride (mg/L)
- Nitrogen, Nitrate (mg/L)
- Total Kjeldahl Nitrogen -TKN (mg/L)
- Total Phosphorus - TP (mg/L)
- Total Dissolved Phosphorus - TDP (mg/L)
- Alkalinity (mg/L)
- Conductivity (umho/cm)
- pH (s.u.)

A summary of the baseflow water chemistry data collection is presented in Table 7 below and in total on pages 10 through 12 of Appendix 3. Our evaluation of the data indicates that mean concentration values of the constituents measured are in compliance with EPA and VWQS (Class B water) recommended values. Among the parameters sampled, there is no indication that anthropomorphic inputs are having an undue negative impact to water quality. The results further emphasize that water quality impacts are primarily due to excess sediment and high peak flows coming from untreated or partially treated stormwater runoff from impervious surfaces.

Table 7: Resort Baseflow Summary Mean Parameter Values							
Watershed		Roaring Brook		East Br. Roaring Brook			
Major Sub-watershed	EPA\ VWQS Guidance Value	D	C	F	F	F	G
Station		KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
pH (s.u.)	6.5-8.5	7.34	7.53	7.60	7.44	7.66	7.53
Alkalinity (mg/L)	> 20	23.0	28.7	47.3	46.8	51.0	53.6
Chloride (mg/L)	< 230	2.0	42.3	26.2	43.2	46.3	72.8
NO ₃ (mg/L)	> 10	0.26	0.50	0.19	0.22	0.28	0.12
TKN (mg/L)	< 0.50	0.143	0.197	0.170	0.225	0.337	0.402
TP (mg/L)	< 0.01	0.007	0.008	0.006	0.007	0.008	0.007
TDP (mg/L)	NA	0.006	0.006	0.006	0.006	0.007	0.005
Conductivity (μ/s)	NA	59.9	197.1	157.8	234.5	252.0	336.9

3.3.3 Sediment Sampling

Two measurements of stream substrate were taken at each monitoring location. These measurements include:

- An estimate of substrate composition using the Wolman Pebble Count Procedure (Harrelson, et al. 1994)
- The percentage of substrate embeddedness (percent fines) using Bovee's quartile estimate guidelines (Bovee 1996)

Substrate monitoring was conducted at 13 monitoring stations within the Upper RB and EB watersheds. Results are shown on pages 19 through 33 of Appendix 3.

Table 8 below includes a summary of embeddedness (a qualitative measure of stream sedimentation) from the 2005 sediment sampling. The majority of stations sampled fall into the 26-50 percent embedded or fair category. Only 2 stations, KP-24 and KP-3, fall

into the 51-75 percent and 76-100 percent embedded categories, respectively. These two stations, previously identified as having high NTU readings during event sampling (see event sampling Section above), drain portions of Killington Road (KP-3) and Major Subwatershed E (KP-24).

Table 8: 2005 Pebble Count Embeddedness Summary			
Percent Embeddedness	Condition Description	Stations	Major Subwatershed
0-25 %	Good	None	NA
26-50 %	Fair	KP-10	A
		KP-5	B
		KP-6, 11, and 12	C
		KP-26	D
		KP-8	E
		KP-14, 15, 17, and 18	F
51-75 %	Poor	KP-24	E
76-100 %	Impaired	KP-3	A

The 2008 *Biological and Aquatic Life Use Attainment Assessment of Roaring Brook and Tributaries* states that amounts of “sand, embeddedness and silt at site on the Roaring Brook main stem are all at levels known to cause stress on the community”. The 2008 assessment corroborates the data collected by Pioneer in 2005 and with the observations of the 2009 walkover by VHB.

3.3.4 **Biomonitoring**

In September of 2005 biomonitoring was conducted at eight sampling locations on RB and EB as shown below in Table 9. The complete monitoring results are included on pages 34 through 70 of Appendix 3. Three of the eight stations including the compliance stations for Major Subwatersheds A, D and E passed ALS thresholds. Five stations, including the compliance stations for Major Subwatersheds B, C, and F failed to meet ALS thresholds.

Table 9: 2005 Biomonitoring Sampling Results				
Station ID	Major Subwatershed	Stream Name	Stream Class	Aquatic Life Use Support
KP-10	A	Roaring Brook	B2-3	Met Biocriteria
KP-5	B	Rams Head Brook (Roaring Brook Tributary)	B2-3	Did not meet Biocriteria
KP-11	C	Roaring Brook	B2-3	Did not meet Biocriteria
KP-27	C	Roaring Brook	B2-3	Did not meet Biocriteria
KP-8	D	West Branch Roaring Brook	B2-3	Met Biocriteria
KP-26	E	Roaring Brook	B2-3	Met Biocriteria
KP-15	F	East Branch Roaring Brook	B2-3	Did not meet Biocriteria
KP-17	F	East Branch Roaring Brook	B2-3	Did not meet Biocriteria
KP-18	F	East Branch Roaring Brook	B2-3	Did not meet Biocriteria

Below is a brief summary of the stations that failed to meet ALS attainment and the specific parameters that were out of compliance:

- Station KP-5, located in Major Subwatershed B did not meet Class B2-3 using the ANR scoring guidelines for SHG streams due to low density, species richness, Ephemeroptera-Plecoptera-Trichoptera ("EPT") index and the Pinkham-Pearson Coefficient of Similarity ("PPCS-FG") - Functional Groups.
- KP-11, located in Major Subwatershed C, was found to be non-supportive of Class B2-3 criteria due to density and percent Oligochaeta.
- Station KP-27, located in Major Subwatershed C, was also non-supportive of richness and metric percent model affinity of orders (PMA-O) biocriteria thresholds.
- Stations KP-15 and KP-18, located in Major Subwatershed F, were out of compliance for density and EPT.
- Station KP-17, located in Major Subwatershed F, was out of compliance due to EPT.

- Station KP-11, did not meet biocriteria due to a high percent Oligochaeta score.

The above stations exhibit scoring metrics that have been commonly observed at similar SHG streams where excess sedimentation is a problem. Specifically, low richness and density scores as well as high percent Oligochaeta are indicative of excess sedimentation.

In the 2008 document, *The Biological and Aquatic Life Use Attainment Assessment of RB and its Tributaries* by the VTDEC a summary of water quality sampling from 1989 through 2007 is provided (Fiske, 2008). EB, which was first sampled in 1989, passed ALS criteria measured through aquatic biota testing, at two of five ANR sampling stations shown on the attached WQRP map. However, subsequent sampling in 1995, 2004, 2005, and 2007 has shown failing results at all stations. In RB, biota sampling first started in 2005 and was again conducted in 2007, with four out of six samples failing to meet criteria. The report, in its entirety is included as Appendix 4.

3.3.5 Monitoring Summary

The following monitoring summary provides a synopsis of the water quality (WQ) results from 2005.

Major Subwatershed A: WQ monitoring results indicated excess sediment from numerous sources in this watershed. Almost half of the event monitoring stations had elevated NTU levels observed and a stream embeddedness of 76-100 percent was observed. Excess sediment in watershed A is likely coming from the Killington Road, the K-1 Parking Lot, Cat Yard, and secondarily from the Vale Parking Lot.

Major Subwatershed B: While this watershed failed to meet ALS requirements, it is believed that this is due to a poor quality sampling location rather than excess runoff, sediment or other anthropomorphic inputs.

Major Subwatershed C: WQ monitoring indicates excess sediment and increased peak flows. Over half of the observed event stations had elevated turbidity levels and biomonitoring results for *Oligochaeta*, a sediment indicator, were above ALS criteria. Major sources of excess sediment in this watershed include a section of the Killington Road, a portion of the Snowshed Parking Lot, and the Ram's Head Parking Lot.

Major Subwatershed D: This largely undeveloped watershed is currently achieving ALS attainment.

Major Subwatershed E: RB is currently in compliance with ALS requirements at Station KP-26 located downstream of Watershed E. However several individual areas of excess sediment inputs have been observed. These include a section of the Golf Course, the area in the vicinity of the wastewater treatment plant and the Pinnacle Condominiums where 51-75% embeddedness was observed.

Major Subwatershed F: Monitoring results indicated excess sediment and flow as well as non-attainment of ALS standards. Individual sediment sources identified include three Golf Course locations and the Fall Line, Whiffletree and Edgemont developments.

Major Subwatershed G: Monitoring results in this watershed include elevated NTU at 3 of the 13 locations sampled. Sources of excess sediment include the Upper Snowshed Parking Lot and Trail Creek Condominiums.

Table 10 summarizes the results of the 2005 water quality sampling effort:

Table 10: 2005 Water Quality Monitoring Summary					
Major Watershed	Major Sub-watershed	Biomonitoring	Base flow - All Parameters	Event Monitoring - NTU	Sediment - Embeddedness
Roaring Brook	A	Not Tested (KP-10 located above all development)	Not Tested	NTU over 10 observed in 10 out of 21 locations sampled	Impaired (76 -100%)
	B	KP-5 Failed - 4 of 7 parameters; likely due to poor sampling location	All parameters within EPA-GV or VWQS	No NTU over 10 in one location sampled	Fair (26-50%)
	C	KP-11 Failed - Density and percent Oligochaeta; likely due to degraded WQ habitat due to sediment	All parameters within EPA-GV or VWQS	NTU over 10 observed in 4 of 7 locations sampled	Fair (26-50%)
	D	KP-15 Passed	All parameters within EPA-GV or VWQS	No NTU over 10 in one location sampled	Not Tested
	E	KP-26 Passed	All parameters within EPA-GV or VWQS	NTU over 10 observed in 4 of 4 locations sampled	Fair (26-50%) overall; Poor (51-75%) at outlet of Pinnacle and Mountain Green Condominiums
East Branch Roaring Brook	F	KP-17 Failed - Density and EPT; likely due to degraded habitat	All parameters within EPA-GV or VWQS	NTU over 10 in 5 out of 14 locations sampled	Fair (26-50%)
	G	KP-15 Failed - EPT; likely due to degraded habitat	All parameters within EPA-GV or VWQS	NTU over 10 in 3 of 13 locations sampled	Fair (26-50%)

Additional stream sampling conducted by VTDEC prior to, and after the 2005 sampling confirms the 2005 monitoring results. Biomonitoring, water chemistry monitoring, and sediment assessments conducted by VTDEC in RB and EB between 1989 and 2007 were the basis for the 303(d) listing. According to VTDEC both streams are described as

impaired and VTDEC states that sediment is the likely stressor that is causing impairment in both RB and EB (Fiske, 2008).

3.4 Sediment and Hydrologic Models

Modeling has been performed to simulate washoff sediment load and stormwater runoff discharge for the RB and EB watersheds. The hydrologic model to determine stormwater runoff discharge was conducted in association with Task 2, and the washoff sediment load model was conducted in association with Task 3 described in Section 1.2 of this report.

The washoff sediment model was performed to calculate the annual and unitized washoff sediment load measured in pounds of TSS from the watersheds for four scenarios: Existing, Interim, Proposed Phase I and Proposed Phases II - V; to estimate the change in sediment loading associated with changes in land cover, land use, and level of stormwater treatment. The three scenarios are described below:

- Existing Conditions (Year 0) include existing subwatersheds, land cover, and land use; with existing STPs providing an estimated percentage of treatment (percentage of sediment removal) associated with the capacities of the existing STPs.
- Interim Conditions (Year 1 – 5) includes the Existing Conditions scenario with applicable retrofits to Snowshed Pond and the Killington Club, K-1, Cat Yard and Vale Basins to increase the amount of sediment captured and reduce peak flows. The percentage of treatment for retrofitted basins has been estimate at 50 to 70 percent of annual TSS.
- Proposed Phase I Conditions (Year 6 –9) represents the incorporation of the interim condition described above with the build-out of Phase I of the proposed development plan. It includes Phase I build-out of the SPLC real estate development projects on several land parcels adjacent to the Resort, and associated stormwater infrastructure that would include STPs that would meet the WQTS and other required standards in the VSMM. The land cover, land use, and impervious areas

would be altered from Existing and Interim Condition Scenarios. The Phase I development is anticipated to take up to 8 years after the development is initiated.

- Proposed Phases II – V Conditions (Year 10 -25) Includes full build-out of the five phase SPLC real estate development projects on several land parcels adjacent to the Resort, and associated stormwater infrastructures which include STPs that would meet the WQTS and other required standards in the VSMM. The land cover, land use, and impervious areas would be altered from Existing and Interim Condition Scenarios.

A parallel set of scenarios has been modeled for the Interim, Proposed Phase I and Proposed Phases II – V conditions in EB which includes upgrades to developments that have previously been issued stormwater permits. These upgrades, presumed to occur during the Interim and Proposed Phase I (year 1 - 9) would include the Whiffletree, Edgemont, Trail Creek and Fall Line condominium stormwater systems. The upgrades for these areas assume that the current system of swales and culverts that convey stormwater are not providing any treatment and that upgrades would bring the systems into compliance with the 2002 VSMM which includes 80 percent sediment removal. These scenarios are described as Prior Permitted Systems Upgrades in the following sections.

The hydrologic modeling has been performed for existing conditions, to assess the current capacity of existing STPs and to determine potential modifications necessary to retrofit the existing STPs, to improve functionality. The model methods and results are described below in Section 3.4.1.

3.4.1 WashOff Sediment Model

Annual sediment loading characteristics within portions of the RB and EB were evaluated for the three scenarios described above.

LOADING ANALYSIS METHODOLOGY

Sediment loads from various land uses within the project area have been determined using the “Simple Method” of Schueler (Schueler 1987). This method is a widely used and accepted approach for the estimation of pollutant (i.e., sediment) loads within a watershed, associated with stormwater runoff (See page 1 of Appendix 5). The method provides a straightforward approach for the comparison of annual sediment loads associated with alternative land uses, combined with treatment and management options. This empirical method is intended to provide reasonable estimates of annual sediment loads, from which decisions can be made regarding the appropriate nonpoint calculations and spreadsheets of sediment loads in the designated watersheds. This method is cited as the appropriate sediment loading method consistent with the procedure dated May 5, 2004 titled, “VTDEC Procedure for Evaluation of Stormwater Discharges and Offsets in Stormwater Impaired Watersheds” (VTDEC 2004).

The Existing Conditions scenario includes the STPs and associated estimated treatment percentages shown in Table 11 below. Treatment percentages were estimated using a shallow estimated ponding depth of 0.5 to 1.0 feet in each basin. This estimate helped to determine the percentage of water quality volume (“WQv”) volume that would be met under the Existing Conditions scenario. This provides a conservative estimation of treatment that would be provided by systems that were not designed to meet the WQTS. The Interim Conditions scenario includes retrofits to provide the WQTS for the Cat Yard Basin, K-1 Parking Lot Basin, Killington Club House Basin, and Vale Parking Lot Basin. Snowshed Pond and the Rams Head Parking Lot Basin would not be retrofitted as it is slated to be redeveloped during Proposed Phase 1 development.. The Existing and Interim Condition scenario treatment percentages are also listed in Table 11.

Table 11: Existing and Interim Condition Scenarios STP Estimated Percent Removal (TSS)			
STP Name	Subwatershed(s)	Existing Estimated Percent Removal (Total)	Interim Percent Removal* (Total)
Cat Yard Basin	RB-A22	14%	50%
Snowshed Pond	EB-A03, EB-A06, EB-A07, EB-A08	40%	50%
K-1 Parking Lot Basin	RB-A15	1%	50%
Killington Club House Basin	EB-A09	18%	50%
Ram's Head Parking Lot Basin	RB-A09	4%	4%
Vale Parking Lot Basin	RB-A03	60%	70%

The Proposed Phases II - V scenario includes existing and proposed STPs that would treat approximately 321 acres of the proposed development area represented by commercial, residential, transportation, open, and wooded areas. The design of the proposed condition developments are not finalized at this time and therefore land use and percent impervious estimations have been made. Similarly, the proposed STPs have not been designed and the assumption has been made that the proposed development would include STPs that would meet the WQTS (80 percent TSS removal).

LOADING ANALYSIS RESULTS

The existing sediment load for the RB Watershed was determined to be approximately 371,000 pounds per year, with a unitized loading of approximately 137 pounds per acre per year. The existing sediment load for the EB Watershed was determined to be approximately 80,700 pounds per year, corresponding to a unitized loading of approximately 161 pounds per acre per year. A simple regression comparing rainfall amounts to unitized sediment loads (see Section 4.5 below) for various mountain watersheds in Vermont indicates that the EB and RB would be on the threshold of compliance with ALS standards at approximately 123 pounds of sediment per acre per year.

Table 12 below and page 2 of Appendix 5 provide a summary of sediment loading analysis results for the RB and EB for each of the four scenarios: Existing, Interim, Proposed Phase I and Proposed Phase II -V. An additional row for EB includes a summary of the sediment loading results with upgrades to prior permitted systems, as described above. The results of this loading analysis show that RB would meet the target of less than 123 pounds per acre per year at the conclusion of the Proposed Phase 1 scenario. According to the modeling results EB would meet the target at the conclusion of Proposed Phase I, where prior permitted stormwater systems are upgraded, or at the conclusion of Proposed Phase II - V if these systems are not included.

Table 12: Comparison of Annual Sediment Loads for Existing, Interim, Proposed Phase I, and Proposed Phases II - V Conditions Scenarios					
Watershed		Existing Conditions (Yr 0)	Interim Conditions (Yrs 1-5)	Proposed Phase I Conditions (Yrs 6-9)	Proposed Phase II - V Conditions (Yrs 10 - 25)
Roaring Brook	Sediment Load (pounds/yr)	371,000	352,000	260,000	277,000
	Unitized Load (pounds/acre/yr)	137	130	96	102
East Branch Roaring Brook	Sediment Load (pounds/yr)	80,700	77,600	62,000	50,000
	Unitized Load (pounds/acre/yr)	161	155	123	103
East Branch Roaring Brook w/ Prior Permitted Systems Upgrades	Sediment Load (pounds/yr)	--	63,000	48,000	36,200
	Unitized Load (pounds/acre/yr)	--	---	98	74

Simple Method spreadsheets for the scenarios have been included in Appendix 5: Existing Conditions is shown on pages 3 through 10, Interim Conditions on pages 11 through 20, Proposed Phase 1 on pages 21 through 30 and Proposed Phase II - V on pages 31 through 50. A graph providing a comparison of the unitized sediment loads on a watershed basis for the scenarios, titled Simple Method Sediment Loading Results, is provided on page 2 of Appendix 5.

The results of the washoff sediment loading analysis demonstrates that upgrading STPs for the Interim condition and implementing STPs for Proposed Phase I conditions (assuming full upgrades of prior permitted systems) would result in significant reductions in sediment load within the RB and EB watersheds that will meet the established target of less than 123 pounds per acre per year (see Figure 4 in Section 4.4, page 54).

3.4.2 Hydrologic Model

The stormwater that discharges into the existing treatment basins, a type of STP, have been modeled using the HydroCAD® hydrologic modeling program. The model has been utilized to help assess the current capacity of existing basins. An engineering feasibility analysis (“EFA”) will be conducted in association with the Master Plan Interim Condition (1-5 years) to determine potential retrofits to certain existing basins in order to better meet applicable WQTS. For this WQRP the applicable WQTS listed in the EFA include (in order of priority) Recharge Volume (“Rev”), Channel Protection Volume (“CPv”), and Water Quality Volume (and WQv.. Groundwater recharge potential has yet to be determined and will be considered on a site by site basis.

As discussed in Section 2 Project Background, Stormwater Permit 1-0466 (expired) includes the K-1, Rams Head, and Vale stormwater basins, and Stormwater Permit 1-1288 (expired) includes the Killington Club House basin. The K-1, Vale, and Killington Club House basins would be analyzed and retrofitted using VTDEC EFA guidelines. The Rams Head basin would not be analyzed as the site will be redeveloped under Proposed Phase 1. The Snowshed Pond has not been analyzed as it was not designed as an STP, however, potential pretreatment options for runoff currently entering Snowshed Pond will be investigated as a component of the EFA. Anticipated retrofits within the basin subwatersheds include pre-treatment of runoff by improvements to existing ditching adjacent to parking areas, upgrades to existing underground collection systems, and retrofits of the existing basins (or similar stormwater pond variants) to provide WQv and CPv treatment and detention.

The existing stormwater systems are undersized and retrofit goals have been generally limited to standards determined by the EFA. Proposed, non-retrofit stormwater systems associated with the proposed real estate development projects have not been designed, but would be constructed according to applicable guidelines and standards.

HYDROLOGIC ANALYSIS METHODOLOGY

The methodology for hydrologic analysis includes the following components:

- Determination of subwatershed boundaries using available site topographic mapping, contours and drainage systems from existing condition site plans, as well as USGS topographic sheets
- Determination of subwatershed area, curve number, and time of concentration using NRCS methods for existing conditions
- Evaluation of existing STP conditions against stormwater treatment standards listed in the VSMM
- Determination of retrofit strategy to upgrade existing STPs

The modeled storm events and associated 24 hour total rainfall amounts for Rutland County, Vermont are provided in Table 13.

Table 13: Rainfall Amounts for Rutland County, Vermont	
Frequency, Duration	Rainfall Amount
1-year, 24-hour	2.3 inches
2-year, 24-hour	2.5 inches
10-year, 24-hour	3.7 inches
100-year, 24-hour	5.9 inches

HYDROLOGIC ANALYSIS RESULTS

Tables 14 and 15 below provide the stormwater treatment standard requirements for each of the existing basins analyzed, the available STP capacity to meet the above mentioned requirements, and what percentage of the requirement would be met under existing conditions. The CPv provided in the existing conditions basins is an estimate determined

based on assumptions of outlet conditions, which will be verified as a component of the EFA, with the analysis updated accordingly. The following tables have been set up for the WQv and CPv VSMM requirements.

Table 14: Water Quality Volume (WQv) Requirements				
STP	WQv provided (cubic ft)	WQv required (cubic ft)	Percent of Requirement	Interim Percent Target
Cat Yard Basin	670	4,970	13.5	50
K-1 Parking Lot Basin	280	28,150	1.0	50
Club House Basin	1187	6,720	17.7	50
Rams Head Basin	650	17,660	3.7	3.7
Vale Parking Lot Basin	2,760	10,970	25.2	70

Table 15: Channel Protection Volume (CPv) Requirements				
STP	CPv required (cubic ft) / (hrs detention)	CPv provided (hrs detention)	Percent of Requirement (based on hrs detention)	Interim Percent Target
Cat Yard Basin	5,180 / 12	1.4	11.7	50
K-1 Lot Basin	27,180 / 12	1.0	8.3	50
Club House Basin	9,680 / 12	2.3	19.2	50
Rams Head Basin	16,620 / 12	2.0	16.7	16.7
Vale Parking Lot Basin	11,640 / 12	2.3	19.2	70

Under existing conditions, approximately 37 acres out of a total of 82.5 acres (45 percent) of TIC and SPLC controlled impervious surface is treated to some degree for CPv by the existing stormwater BMPs. Under interim conditions the same amount of impervious surface would be treated, but the level of effective treatment would increase by implementing the measures identified in the EFA and thus improving CPv to the target values shown in Table 15. For the Proposed Phase I condition the amount of impervious surface is reduced to 79.1 acres due to redevelopment and the area treated increases to 44 acres or 56 percent of the total. As the Interim period ends and proposed development proceeds through all phases, any basins retrofitted or constructed would meet applicable

stormwater system requirements thus further improving CPv. At the conclusion of the Proposed Phase II to V scenarios approximately 102 out of 126 acres (81 percent) of impervious surface would receive CPv treatment equal to 100 percent of the target level.

Summary sheets providing the VSMM stormwater treatment standard requirements for each basin have been provided in Appendix 6.

4.0 Water Quality Remediation Plan

4.1 Overview and Strategy

As stated in Section 1.3 this WQRP is based on the EPA 4(b) “off-ramping” guidance under the Clean Water Act (“CWA”) and is designed to provide treatment for uncontrolled stormwater runoff that contributes to sediment loading and to reduce high peak flows. Runoff control will occur primarily through the retrofits to existing STPs and installation of new STPs to capture and detain stormwater. Secondary implementation measures will include on-mountain BMPs and in-stream projects such as culvert replacements and channel restoration projects.

As the majority landowners within the headwaters of RB and EB, TICs and SPLC have developed a timeline for controlling runoff from impervious surfaces on their lands. The timeline, as introduced in Section 2.3 above, describes aspects of this WQRP under four conditions: Existing, Interim, Proposed Phase I and Proposed Phases II – V. Existing conditions of the lands and water quality of EB and RB have been described in detail in the above sections.

Under Interim conditions, the implementation strategy for the WQRP will be to evaluate and then retrofit existing stormwater collection systems and basins located at the K-1 Parking Lot, the Cat Yard Lot, the Club House, and potentially the Vale Parking Lot. In addition limited parking lot improvements in the Ram’s Head and Snowshed Parking Lots

and other on-mountain BMPs (see Section 4.2 below) are proposed. Upgrades will commence according to the schedule outlined below pending VTDEC approval of this WQRP.

Concurrent with the implementation of the Proposed Phase I of the WQRP, SPLC proposes to redevelop the Village Core base area (including the Ram's Head and Snowshed Parking Lots), and build new housing and parking areas in the Ram's Head Brook (B) and Lower Roaring Brook (E) watersheds. This development, described as Proposed Phase I, will also include the construction of a detention basin to treat runoff from the redeveloped and newly developed areas and is slated to occur over a nine year period, pending necessary approvals and permits.

After Interim Conditions and Proposed Phase I have been implemented, SPLC intends to redevelop and develop areas known as Phases II through V over a 17 year period. These development phases will make use of the areas currently draining to the Vale, Cat Yard and K-1 detention basins which will be further upgraded or completely reconfigured and will also include construction of new detention basins and other STPs to mitigate stormwater runoff. Any STPs associated with these developments will be designed to be in full compliance with applicable stormwater treatment requirements.

As noted in Section 3.4.1, RB is expected to meet the sediment load target within nine years of the implementation of the WQRP. To meet the sediment load target within the same nine year period EB remediation would need to include upgrades to prior permitted systems located at Whiffletree, Edgemont, Trail Creek and Fall Line condominiums. These upgrades would be the responsibility of the individual associations as they are not owned and operated by the TICs or SPLC. Therefore, VHB recommends that VTDEC work with the associations to facilitate stormwater system evaluations and possible upgrades to the WQTS during Interim and Proposed Phase I conditions above in order to achieve compliance within a reasonable timeframe.

The phasing and implementation of the WQRP is weighted so that initial improvements associated with Interim conditions and Proposed Phase I development, occurring over the first nine years of the WQRP, will provide the most significant benefits to WQ in RB and EB. Subsequent WQRP implementation, occurring over the next 17 years of the phased development, is planned continue to enhance the WQ improvements gained during the first nine years.

4.2 *Water Quality Implementation Measures and Schedule*

As part of this WQRP, TICs and SPLC propose to implement the following specific major WQ improvement measures in RB and EB:

Interim Conditions (Year 1 to 5)

Interim conditions WQRP implementation measures are focused on evaluating existing stormwater BMPs with respect to improving sediment retention and reducing peak flows and conducting specific high priority sediment source mitigation projects. As shown in the WQ monitoring and sediment load modeling sections above the undersized basins are not capturing enough sediment and basin retrofitting and upgrading will provide an immediate positive impact to on-site water quality. Potential retrofit options and strategies, subject to the methods outlined under an EFA, are outlined below. In addition the removal of high and moderate priority sediment sources, identified during the 2009 walkover, will also address sediment impacts. Interim improvements are summarized below:

Roaring Brook

High priority sediment sources 14, 16, 17, 20, 21, 25, 26 and 29, identified in Section 3.1 above, would be mitigated. Upper Snowshed Parking lot would be evaluated for potential sediment mitigation practices to be determined through on site analysis. Implementation measures would be limited in scope as this area is slated for subsequent redevelopment under Phase I.

Under Interim Conditions stormwater collection systems and basins that are located at the K-1 Parking and Cat Yard Lots would undergo an EFA and implementation of the following potential upgrades, as follows:

- Regrade where needed to ensure all runoff from impervious surfaces is directed to stormwater collection and treatment systems
- Re-design swales to promote temporary WQv storage, sediment removal and recharge
- Re-design collection pipe/swale system, as needed, to convey runoff to basin without causing erosion
- Re-design existing outlet structure to reduce erosion and maximize detention
- Provide design for outlet swale to ensure channel stability
- Modify snow management plan to prevent snow from being plowed into RB buffer
- Conduct annual water chemistry and sediment monitoring to assess retrofit performance (see Section 5.3 below)

Under Interim Conditions, the Ram's Head Parking Lot stormwater collection system would undergo an evaluation of the following potential upgrades, as follows:

- Conduct bi-annual maintenance on the existing basin to remove stored sediment
- Install check dams in channel to existing Ram's Head Basin to provide additional retention and temporary sediment storage
- Review snow management plan for alternative storage locations

Under Interim Conditions the Vale Parking Lot stormwater collection system would undergo an evaluation, EFA and implementation of improvements as follows:

- Conduct annual water chemistry and sediment monitoring for two years at the basin outlet to assess basin performance (see Section 5.3 below)

- Conduct bi-annual maintenance, as needed, on the existing basin to remove stored sediment
- Determine existing basin performance and conduct EFA to determine potential retrofits or modifications
- Implement potential improvements

East Branch of Roaring Brook Watershed

High priority sediment source 27 identified in Section 3.1 above, would be mitigated.

Snowshed Parking Lot and Killington Club stormwater systems would undergo an evaluation, EFA, and implementation of improvements comprised of the following:

- Confirm CPv and WQv can be met using Snowshed Pond
- Conduct bi-annual maintenance on Club House Basin, as needed, on the existing basin to remove stored sediment
- Conduct and EFA to determine Club House basin performance and potential need for retrofits or modifications
- Implement Club house basin improvements

Interim improvements to the Golf Course will be made according to the outline below:

- Evaluate streambank stabilization needs
- Design and implement streambank and channel restoration projects
- Implement iron seep controls
- Evaluate riparian buffers and develop a plan to restore buffers where feasible

In addition to the above interim projects a stormwater BMP manual will be compiled from existing public guidance documents and professional experience for use at the Resort. The manual will specify procedures and timing for BMP maintenance and cleaning, winter road practices, ditch /swale maintenance and cleaning. The manual will also specify ski trail, waterbar and on mountain road maintenance procedures.

The following culverts will be re-assessed to determine feasibility of replacement: C-01, C-12, C-16, C-18, C-53, C-81, C-110 and C-122. Replacements will be scheduled according to the development timeline and the response of the aquatic biota to other remediation activities.

VHB recommends that VTDEC work with Whiffletree, Edgemont, Trail Creek and Fall Line to evaluate potential upgrades to their prior permitted stormwater systems.

A WQRP update will be conducted following year five in order to reassess goals and targets based on the results of mitigation steps taken during the interim phase.

Proposed Phase I (Year 6 to 9)

Proposed Phase I conditions represent further implementation of the WQRP alongside development (including redevelopment) within RB and EB watersheds. Proposed Phase 1 implementation may overlap with Interim conditions listed above. During this period of the WQRP, additional WQ improvements will be accomplished through redevelopment of existing impervious surface, mitigation of moderate and low priority sediment sources and targeted culvert replacements.

The SPLC Phase I development (description provided in Section 2.3 above) includes redevelopment of the Ram's Head Parking Lot and Lower Snowshed Parking Lot into the Village Core, a new Replacement Parking detention basin, the New Ram's Head Brook development and the realignment of Killington Road through the Village Core area.

Moderate and low priority sediment sources 3 to 13, 15, 18, 19, 22, 23, and 24, identified in Section 3.1, will be mitigated.

In order to provide additional water quality improvements and potentially improve the response time in EB, VHB recommends that VTDEC work with Whiffletree, Edgemont, Trail Creek and Fall Line to facilitate upgrades to their permitted stormwater systems to current VTDEC standards.

Proposed Phases II – V (Year 10 to 25)

Proposed conditions represents the full build-out of the 25+/- year multiple phased SPLC Master Plan adjacent to the Resort. Continued WQ improvements would occur as impervious surfaces are redeveloped or removed. All development proposed for the RB and EB watersheds would conform to applicable Stormwater Manual requirements. Details of the proposed development are provided in Section 2.3 above.

Ongoing WQ monitoring conducted during the initial stages of the project would provide valuable feedback on the success of the WQRP. The need for ongoing monitoring and remediation projects would be assessed depending on the overall progress toward meeting VWQS.

4.3 *Schedule of Implementation*

The TICs and SPLC propose to implement the water quality remediation measures identified in Section 4.2 above according to Table 16 below. This schedule of implementation is targeted so that the majority of untreated or inadequately treated runoff is captured during years one to nine of the WQRP. In addition high and moderate priority sediment sources, under the control of the TICs or SPLC, will be handled during years one to nine of the WQRP. Additional improvements will occur incrementally during years ten through twenty-five as additional development and STPs are designed to capture stormwater runoff from newly developed and existing impervious surfaces. In addition, a schedule for implementing erosion prevention through the elimination of sediment sources identified during the SGA site walkover (Section 3 above and pages 1 through 20 of the Appendix 2) is included.

Table 16: WQRP Implementation Schedule					
Watershed		WQRP Stage			
	Phase	Existing Conditions	Interim	Proposed Phase I	Proposed Phases II to VI
	Year	0	1 to 5	6 to 9	10 to 25
Roaring Brook (Major Subwatershed)	A	Not Meeting Biocriteria	EFA and upgrades for Catyard and K-1 and Vale Parking Lot Basins; High Priority Sed. Sources: 14, 16 & 17 Culvert Assess/Replace: C-01, C-12, C-16, C-18, C-110 and C-122	Moderate and Low priority Sed. Sources: 7, 8, 9, 10, 11, 12, 13, 15, 18, 19 & 22	K-1 and Catyard Redevelopment, Vale Parking Lot Redevelopment to use redesigned basins (Vale, Catyard and K-1), Yodeler's Run Development to use new SW BMPs; Upper Killington Road Removal
	B	Not Meeting Biocriteria	High Priority Sed. Sources: 20 & 21	None	Snowdon Glades Development to use new SW BMP
	C	Not Meeting Biocriteria	Improvements to Ram's Head Parking Lot High Priority Sed. Source: 25	Redevelopment of Ram's Head Parking Lot/ Village Core - New Replacement Parking Basin Realignment of lower Killington Road Low Priority Sed. Sources: 23 & 24	None
	D	Meets biocriteria	None	None	None
	E	Meets biocriteria	Improvement to Upper Snowshed Parking Lot High Priority Sed. Sources: 26 & 29 Culvert Assess/Replace: C-53	Redevelopment of Ram's Head Parking Lot/ Village Core - New Replacement Parking SW Basin	Continued redevelopment of Village Core to use Replacement Parking SW Basin
East Branch of Roaring Brook (Major Subwatershed)	F	Not Meeting Biocriteria	Improvements to Golf Course High Priority Sed. Sources: 1 & 27 Culvert Assess/Replace: C-81	Moderate and Low Priority Sed. Sources: 3 & 4	The Links development/ Redevelopment along East Mountain Road to use newly constructed SW BMPs
	G	Not Meeting Biocriteria	Snowshed Pond and Club House Basin EFA and Improvements; Potential private SW system EFA for Fall Line, Whiffletree, Edgemont and Trail Creek	Redevelopment of Ram's Head Parking Lot/ Village Core to use New Replacement Parking SW Basin Moderate and Low Priority Sed. Sources: 5 & 6; Potential private SW system upgrades for Fall Line, Whiffletree, Edgemont and Trail Creek	Snowshed Woods Development to use newly constructed SW BMPs
All Mountain	NA	Not Meeting Biocriteria	Culvert Re-Assessment; All Mountain BMP Manual WQ Monitoring	Potential Culvert Replacements; WQRP Update	Continued WQ Monitoring
Projected Sediment (lbs / acre / year)	RB	137	130	96	102
	EB	161	155	123/103*	103/74*

*Loading value includes treatment due to upgrades of prior permitted stormwater systems in EB

4.4 Water Quality Benchmarks

Specific hydrologic or flow based targets determined via hydrologic modeling have not yet been established for the high-elevation stormwater impaired watersheds in Vermont. VTDEC has not determined the flow based targets and, as a result, has not yet prepared a TMDL for these watersheds. This being the case, the TICs and SPLC have elected to evaluate similar high elevation streams in Vermont to determine a sediment target, or benchmark, value that provides a reasonable assurance that VWQS will be met as a result of implementation of this WQRP.

In the absence of TMDL targets, several mountain watersheds with similar ski area development patterns have been evaluated with respect to ALS attainment and sediment loading. After comparing the simple method sediment loading results for these watersheds against their biocriteria results a curve for predicting an acceptable unitized sediment load against annual rainfall was established. Table 16 below includes the available Simple Method results and each watershed's biomonitoring ALS attainment status. The curve (see Figure 3 below) indicates that a sediment reduction of 27 pounds/acre/year in RB and a reduction of 51 pounds/acre/year in EB to bring the total load to 123 pounds/acre/year for RB and EB, would be expected to restore stream conditions to a point where the macroinvertebrate populations would recover and ultimately meet VWQS.

Streams shown below in Table 17 and Figure 4, fall into three categories:

- Biocriteria Met – Where the stream has met ALS criteria consistently during recent sampling
- Biocriteria Indeterminate – Where the stream has been both passed and failed ALS thresholds during recent sampling
- Biocriteria Not Met – Where the stream has consistently failed to meet ALS thresholds during recent sampling

Table 17 Summary of Simple Method Results for Mountain Watersheds and Associated Rainfall Values

Watershed	Town, Vermont	Unitized Loads (pounds/acre/year)	Annual Rainfall (inches)
Tributary to Dish Mill Brook	East Burke	42	42.4
Cold Brook	Dover/Wilmington	103	59.6
Jay Branch	Jay	67	54.4
Roaring Brook	Killington	137	55.4
E. Branch Roaring Brook	Killington	161	55.4
N. Branch Deerfield River	Dover	149	57.4
Rice Brook	Warren	91	51.0
Clay Brook	Warren	68	51.0
Chase Brook	Fayston	49	51.0

Green signifies waterbodies that met biocriteria.

Red signifies waterbodies where biocriteria was not met.

Orange signifies waterbodies that were indeterminate with respect to biocriteria

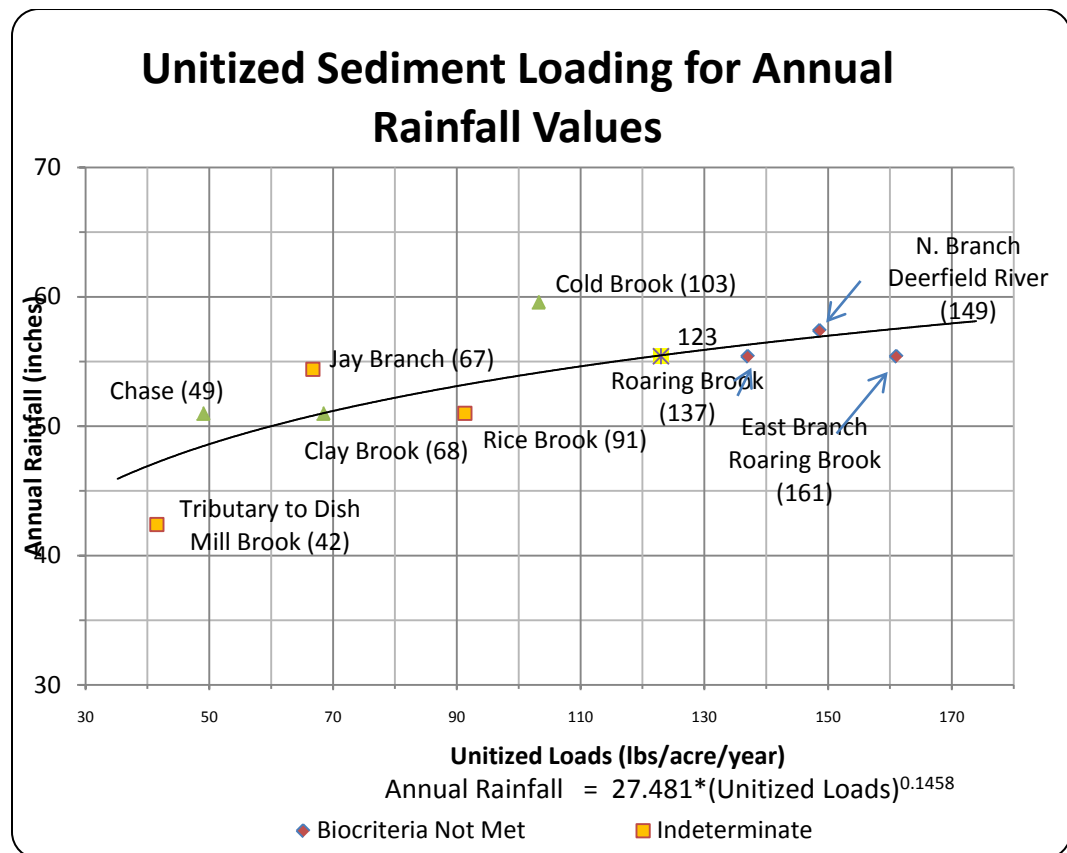


Figure 4 - Sediment Loading Chart Showing Linear Regression and Potential Compliance Point

5.0 Water Quality Monitoring Plan

5.1 Plan Summary

The following WQ monitoring plan is proposed for the first five years of the implementation of this WQRP. This plan is intended to build upon historic monitoring conducted between 1989 and 2007 as well as the 2005 monitoring conducted by Pioneer. The plan will consist of water chemistry monitoring during both baseflow and event flow conditions, sediment assessments (pebble counts), and biomonitoring.

The purpose of the plan is to provide meaningful WQ monitoring data to determine the following:

- Compliance/Non-Compliance of tested parameters with VWQS
- The relative impact of development, WQ remediation projects, and mountain BMPs on specific drainage areas and overall stream health
- The overall effectiveness of the WQRP and progress toward VWQS compliance
- The design, if needed, and implementation of additional remediation projects to ensure VWQS compliance

A Quality Assurance Plan Protocol ("**QAPP**") will be prepared to ensure that sampling is done according to accepted methods and practices.

5.2 Monitoring Locations and Parameters

The following section indicates the water quality sampling locations and parameters. Locations, shown on the WQRP map, were chosen from the locations sampled in 2005.

There are sampling locations at strategic locations on RB, EB and its tributaries with a focus on the proposed remediation and Phase I development areas.

5.2.1 Water Chemistry, Sediment and Biomonitoring

Baseflow water chemistry samples will be analyzed for the following parameters:

- pH
- Chloride
- Conductivity
- Iron (total and dissolved)
- Temperature

Storm event water chemistry samples will be analyzed for the following parameters:

- Turbidity
- Conductivity
- pH
- Total Suspended Solids - if NTU value is greater than 10 NTU

The Wolman pebble count procedure will be used to analyze in stream sediment.

5.3 Schedule and Reporting

VHB has evaluated the background WQ monitoring data and constructed a proposed schedule for the 5 years following the implementation of this WQRP. This schedule is presented below in Table 18 and is based on bi-annual sampling and reporting during interim improvements. Once development is initiated, during years six through nine the plan will be updated to include more rigorous sampling and yearly monitoring reports.

Table 18: Proposed Monitoring Schedule 2011 to 2016						
Watershed	Station	Interim				
		Year 1	Year 2	Year 3	Year 4	Year 5
A	KP-3	Ba, E, S		Ba, E, S		Ba, E, S
	KP-10	Ba, E, S		Ba, E, S		Ba, E, S
	E-11					E
	E-12					E
	E-96					Ba, E
	E-97					Ba, E
B	KP-5					E, S
C	KP-11	S, Bi		Ba, E, S, Bi		Ba, E, S, Bi
	KP-27					Ba, E, S, Bi
	E-27					E
	E-32					E
	E-33					E
D	KP-8	S, Bi		S, Bi		S, Bi
E	KP-24					S
	KP-26	Bi		Bi		Bi
	E-35					E
	E-36					E
	E-38					E
F	KP-15					Ba, S
	KP-17					Ba, S
	KP-18	S, Bi		S, Bi		S, Bi
	E-65					E
G	KP-25					
	E-54					
	E-55					
	E-56					
	E-60					
Note: Shaded cells indicate no sampling proposed						
Ba = baseflow chemistry/E = storm event chemistry/S = sediment assessment/Bi = biomonitoring						

Sampling locations will initially be based on 2005 locations and will consist of the following parameters:

- Baseflow Water Chemistry to be sampled twice per year
 - pH

- Chloride
- Conductivity
- Iron (total and dissolved)
- Temperature
- Turbidity
- Storm Event Water Chemistry to be sampled three times per year
 - pH
 - Conductivity
 - Temperature
 - Turbidity
- Sediment to be sampled once per year
 - Wolman Pebble Count
- Aquatic biota to be sampled once per year
 - Aquatic biota kick net sampling

5.4 Plan Updates

The TICs and SPLC plan to modify the WQRP as necessary if monitoring results indicate that the implementation strategy for WQ improvement needs to be updated. Plan performance will be summarized in WQRP performance reports tied to the monitoring schedule described above. Reports will be submitted to VTDEC in the spring following monitoring and will contain an accounting of all of the monitoring data and remediation activities carried out since the last report. Compliance with ALS standards, determined through biomonitoring at designated locations on RB and EB, for two consecutive years will result in review of this WQRP and discussion of relief from additional implementation measures and monitoring requirements. At a minimum, the WQRP will be reviewed and updated at least every five years for the life of the plan.

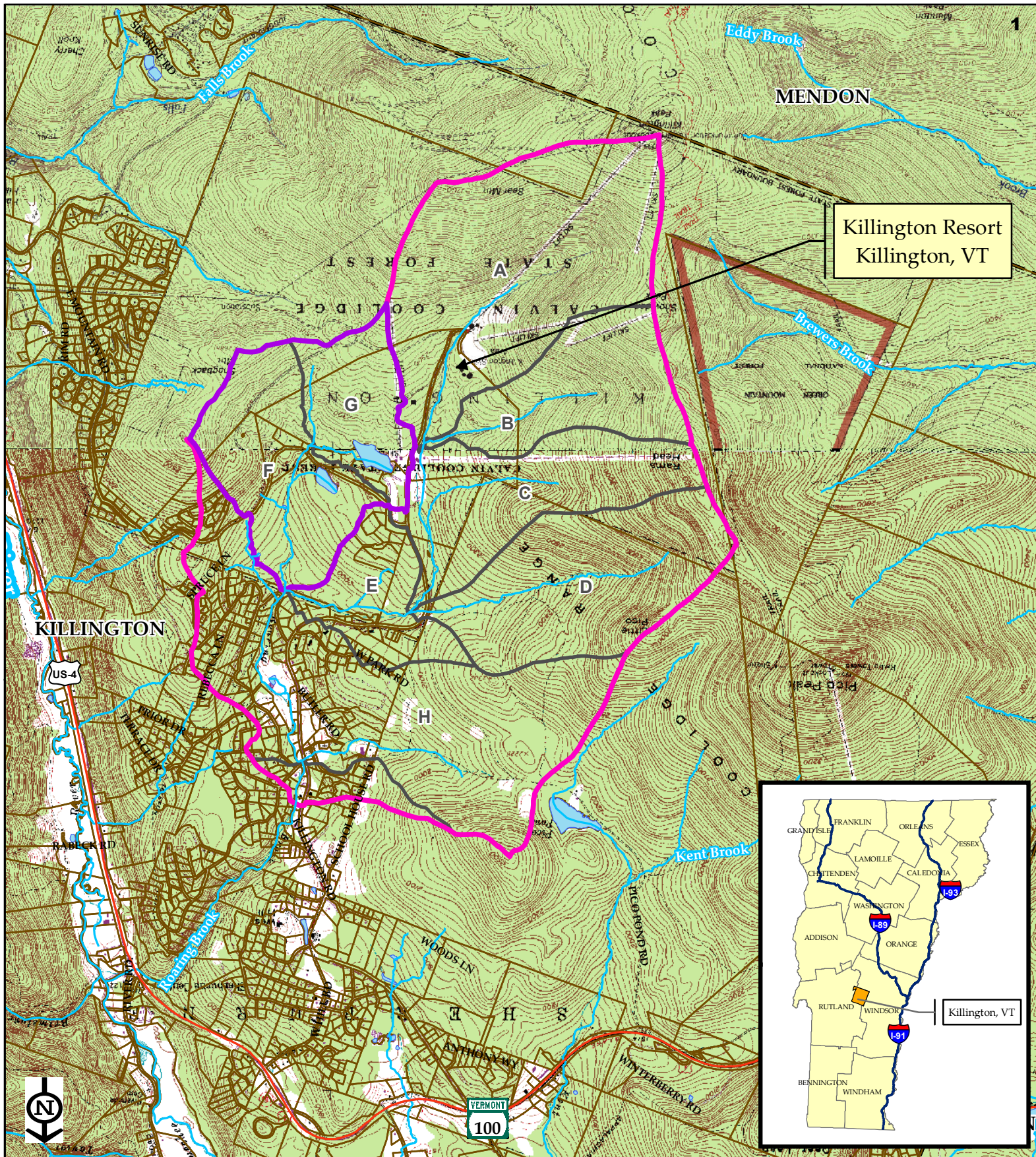
6.0 References

- Bevenger, G.S. 1995. A pebble count procedure for assessing watershed cumulative effects. Research Paper, RM-RP-319. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 17 pp.
- Bovee, K.D. 1986, Development and evaluation of habitat suitability criteria for use in the Instream Flow Incremental Methodology. Instream Flow Information paper 21. U.S. Fish and Wildlife Service Biol. Report 86(7). 235 pp.
- Fiske, Steven A. 2008. Biological and Aquatic Life use Attainment Assessment of Roaring Brook and Tributaries. Vermont Agency of Natural Resources, Waterbury, VT.
- Schueler 1987. Thomas R. Schueler. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs-Metropolitan Washington Council of Governments. July 1987.
- US Environmental Protection Agency 2001. EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5. March 2001.
- USEPA 2005. Guidance for 2006 Assessment, Listing and Reporting Requirements Pursuant to Section 303(d), 305(b) and 314 of the Clean Water Act
- VSWMM 2002. Vermont Stormwater Management Manual, Vermont Agency of Natural Resources. Waterbury, Vermont. 2002.
- VTDEC 2004. VTDEC Procedure for Evaluation of Stormwater Discharges and Offsets in Stormwater Impaired Watersheds. Waterbury, Vermont. Adopted May 5, 2004.
- VTDEC 2004b. East Branch Roaring Brook and Roaring Brook Watershed Permitted Stormwater Discharges. Waterbury, Vermont. Adopted May 5, 2004.
http://www.vtwaterquality.org/stormwater/docs/swimpairedwatersheds/sw_roaringdischarges.pdf

Glossary of Terms

Aggradation:	deposition of sediment
ALS:	Aquatic Life Support as determined by the VT DEC
BCA:	Bridge and Culvert Assessment
BCE:	Bear Creek Environmental
BMP:	Best Management Practices
CPv:	Channel Protection Volume from the VSMM, extended detention time dependent upon the discharge location of the STP.
CWA:	Clean Water Act
EB:	East Branch Roaring Brook
EFA:	Engineering Feasibility Analysis
EPA:	Environmental Protection Agency
EPA-GV:	EPA Guidance Value
IS:	Impervious Surface
KPSRP:	Killington/Pico Ski Resort Partners, LLC
mg/l:	milligrams per liter
NTU:	Nephelometric Turbidity Units
Qp10:	Overbank flood event which occurs on average once every 10 years or has a 10% chance of occurring in a year.
Qp100:	Extreme storm event which occurs on average once every 100 years or has a 1% chance of occurring in a year.
RB:	Roaring Brook
RGA:	Rapid Geomorphic Assessments
RHA:	Rapid Habitat Assessment
RM:	River Mile
SGA:	Stream Geomorphic Assessment
SHG:	Small, High Gradient stream class for B2-3 waters
SPLC:	SP Land Company, LLC
STP:	Stormwater Treatment Practice
s.u.:	standard units for pH
TICs:	Tenants-in-Common; MTB Killington, LLC, AMSC Killington, LLC, and SP II Resort LLC
TMDL:	Total Maximum Daily Load
TSS:	Total Suspended Solids
umho/cm:	microsiemens per centimeter
USEPA:	United States Environmental Protection Agency
VHB:	Vanasse Hangen Brustlin, Inc.
VSMM:	Vermont Stormwater Management Manual (2002)
VTDEC:	Vermont Department of Environmental Conservation
VWQS:	Vermont Water Quality Standards
WQRP:	Water Quality Remediation Plan
WQTS:	Water Quality Treatment Standards
WQv:	Water Quality Volume, the storage needed to capture and treat 90% of the average annual storm water runoff volume.

APPENDIX 1



- Legend**
- East Branch Roaring Brook Watershed
 - Roaring Brook Watershed
 - Subwatershed Boundary
 - Stream
 - Waterbody
 - Town Boundary
 - US Highway

Roaring Brook and East Branch of Roaring Brook Site Location Map Killington, VT

September 15, 2010

3,000 1,500 0 3,000
Feet

Sources: Background - USGS Topos Killington Peak and Pico Peak (2000,1997); Stream (2008), Waterbody (2005), Town Boundary (2007), Roads from VTrans (2009) data provided by VCGI (2010).

VHB Vanasse Hangen Brustlin, Inc.

Prepared by: SEM

STATE OF VERMONT
AGENCY OF NATURAL RESOURCES
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Page 1 of 3

DISCHARGE PERMIT

File No. 11-21
Permit No. 1-0466

In compliance with provisions of 10 V.S.A. 1263

Killington, Ltd.
c/o Carl Spangler, Vice President
Killington Road
Killington, Vermont 05751

and in accordance with "Terms and Conditions" hereinafter specified, the above named permittee is hereby granted permission to discharge stormwater runoff from the Ramshead parking lot expansion at the Killington Ski Area in Killington, Vermont to Roaring Branch Brook and unnamed tributaries to Roaring Brook.

1. Expiration Date: December 31, 1996 Note: This permit, unless revoked, shall be valid until the designated expiration date despite any intervening change in water quality, effluent, or treatment standards or the classification of the receiving waters. However, any such changed standard or classification shall be applied in determining whether or not to renew the permit pursuant to 10 V.S.A. 1263.
Re-apply for a discharge permit by June 30, 1996.
2. Revocation: 10 V.S.A. 1267 provides as follows:
"The Secretary may revoke any permit issued by him pursuant to this subchapter if he finds that the permit holder submitted false or inaccurate information in his application or has violated any requirement, restriction, or condition of the permit issued. Revocation shall be effective upon actual notice thereof to the permit holder."
3. Transfer of Permit: This permit is not transferable without prior written approval of the Secretary. The permittee shall notify the Secretary immediately, in writing, of any sale, lease, or other transfer of ownership of the property from which the discharge originates. The permittee shall also inform the new owner or tenant of his responsibility to make application for a permit which shall be issued in his name. Any failure to do so shall be considered a violation of this permit.
4. Receiving Waters: Roaring Brook and unnamed tributaries of Roaring Brook.

Page 2 of 3
Permit No. 1-0466

5. Manner of Discharge:

S/N 001: Via grass or stone lined roadside swales, through a culvert, then through retention basin "D" which outlets to a rip rapped swale prior to discharge to an unnamed tributary of Roaring Brook.

S/N 002: Via grass lined swales to drop inlets then through drainage pipe, or via a grass lined swale directly, through retention basin "C" which outlets to a rip rapped swale prior to discharge to Roaring Brook.

S/N 003: Via grass lined swales to drop inlets then through drainage pipe to a grass/vegetated swale, through retention basin "A" which outlets to a rip rapped swale prior to discharge to Roaring Brook.

S/N 004: Via grass lined swales to drop inlets then through drainage pipe to retention basin "B" which outlets to a rip rapped swale prior to discharge to Roaring Brook.

S/N 005: Via grass or stone lined roadside swales prior to discharge to an unnamed tributary of Roaring Brook.

6. Wastes Permitted:

S/N 001 - 004: Stormwater runoff from unpaved roads and parking lots, roofs, and natural terrain after treatment of the runoff in grass or stone lined swales and by passage through a retention basin with a rip rapped outlet.

S/N 005: Stormwater runoff from unpaved roads after treatment of the runoff in grass and stone lined swales.

7. Volumes Permitted: Such volumes as required by the discharges specified in No. 5 above.

8. Frequency of Discharge: Daily.

9. Operation and Treatment: Treatment as specified in #6 above. For details on the treatment of stormwater runoff for this project see the Wagner, Heindel & Noyes, Inc. reports entitled "Killington; Ltd., Stormwater Runoff for Proposed Parking Area" dated July 28, 1986, and the "Addendum to Killington Stormwater Runoff for Proposed Parking Area" dated September 5, 1986. See also the Killington Ltd. Conceptual Plan (Sheet #1, revised 10/20/86, annotated 'as built 12/1/91') and detail sheets #2 through #5, revised 12/30/86, annotated 'as built 12/1/91'.

Should erosional problems occur, the permittee shall be required to correct all such problems.

10. Maintenance and Maintenance Reporting Requirements:

All catch basins, swales, retention basins, or other treatment devices or facilities shall be maintained in good operating order at all times and shall be inspected quarterly and cleaned at such other times as necessary to maintain design treatment level.

Page 3 of 3
Permit No. 1-0466

Paved parking lots and roads should be swept on a regular basis when seasonally practicable to minimize contaminants carried to the treatment device by runoff.

NO LATER THAN JANUARY 31 OF EACH YEAR A WRITTEN REPORT SHALL BE SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, NPDES PERMIT SECTION, 103 SOUTH MAIN STREET, WATERBURY, VERMONT 05671-0405, PROVIDING THE DATES AND NATURE OF CLEANING OPERATIONS CARRIED OUT IN THE PRECEDING YEAR.

11. Personnel and Training Requirements: Such personnel and training as necessary to fulfill the requirements of #10 above.
12. Monitoring and reporting Requirement: No monitoring required; reporting requirement as specified in #10 above.
13. Miscellaneous Requirements: None.
14. Issue Date of Permit: 7 January 1992

AGENCY OF NATURAL RESOURCES

Elizabeth A. McLain, Commissioner
Department of Environmental Conservation

By Gary Schultz
Gary Schultz, Director
Permits, Compliance & Protection

Prepared and Reviewed by

Nancy R. Manley
Nancy Manley
Environmental Engineer

TRANSFER APPLICATION -- File No.: 11-21

I, _____, hereby apply for permission to discharge waste into the waters of the State of Vermont under the provisions of Discharge Permit No. 1-0466, previously issued to Killington, Ltd.

Signed: _____

Address: _____

Telephone: _____

File No. 11-12
 Permit No. 1-1288
 PIN No. RU97-0001

STATE OF VERMONT
 AGENCY OF NATURAL RESOURCES
 DEPARTMENT OF ENVIRONMENTAL CONSERVATION

TRANSFERRED
 DISCHARGE PERMIT

In compliance with provisions of 10 V.S.A. 1263 and 1264:

Grand Summit Resort Properties, Inc.
 Killington Ltd.
 Killington Road
 Killington, VT 05751

and in accordance with "Terms and Conditions" hereinafter specified, the above named permittee is hereby granted permission to discharge stormwater runoff from the roadways, parking, and roofs from the Grand Hotel and Conference Center, Killington, VT to Roaring Brook.

1. Expiration Date: June 30, 2002. Note: This permit, unless revoked, shall be valid until the designated expiration date despite any intervening change in water quality, effluent, or treatment standards of the classification of the receiving waters. However, any such changed standard or classification shall be applied in determining whether or not to renew the permit pursuant to 10 V.S.A. 1263.

Re-apply for a discharge permit by December 31, 2001.

2. Revocation: 10 V.S.A. 1267 provides as follows:

"The Secretary may revoke any permit issued by him pursuant to this subchapter if he finds that the permit holder submitted false or inaccurate information in his application or has violated any requirement, restriction, or condition of the permit issued. Revocation shall be effective upon actual notice thereof to the permit holder."

3. Transfer of Permit: This permit is not transferable without prior written approval of the Secretary. The permittee shall notify the Secretary immediately, in writing, of any sale, lease, or other transfer of ownership of the property from which the discharge originates. The permittee shall provide a copy of this permit to the new owner or tenant and shall also inform the new owner or tenant of his responsibility to make application for a permit which shall be issued in his name. Any failure to do so shall be considered a violation of this permit.

Page 2 of 4
Permit No. 1-1288

4. Right of Entry : The permittee shall allow the Secretary or their authorized representative, upon presentation of credentials, to enter the permittee's premises where the effluent sources authorized by this permit are located and at reasonable times to have access to copy any records required to be kept under the terms and conditions of this permit, and to inspect any treatment device, monitoring equipment, or monitoring method required in this permit, and to sample any discharge of pollutants.
5. Receiving Waters: Roaring Brook.
6. Manner of Discharge:
S/N 001: Stormwater from the eastern portion of Grand Hotel building and access road, portions of the adjacent eastern parking areas, and the eastern portion of the Roaring Brook East Road access road collected and conveyed via stone lined swales to Detention Basin 1, then discharging via a controlled outlet structure to a culvert passing under Roaring Brook East Road which in turn discharges to an existing swale flowing through the golf course which discharges Roaring Brook.

S/N 002: Stormwater from the western and north parking areas and the western portion of the Roaring Brook East Road access road collected and conveyed via stone lined swales to Detention Basin 2, then discharging via a controlled outlet structure to an existing culvert which in turn discharges to an existing swale flowing through the golf course and discharging Roaring Brook
7. Wastes Permitted:
S/N 001 through S/N 002 : Stormwater runoff from the buildings, roadways, and parking areas after treatment and control via detention basins.
8. Volumes Permitted and Frequency of Discharge: Such volumes and frequency as required by the discharges specified in No. 6 above
9. Approved Project Design: Treatment as specified in #7 above.

For details on the stormwater treatment for see the DuBois & King, Inc plans and details: Sheets C3 and C4 of 12 dated Mar 1997, C1, C7 of 11, 6 of 6 and 10 of 10 date 4/7/97, C12 of 12 dated 4/17/97, and 1 through 6 of 6 dated May 97, and other supporting information.

By reference the above noted plans are made a part of this permit.
10. Maintenance and Maintenance Reporting Requirements:
a. All swales and related stormwater devices shall be maintained in good operating order at all times and shall be inspected at least **quarterly**, specifically during November and March.

b. All basins and the associated collection systems shall be inspected and cleaned at least **quarterly**, specifically during November and March, to design treatment specifications.

c. Any sediment removed from the swales and detention basin systems shall be disposed of properly and not within 100 feet of Waters of the State.

d. By **SEPTEMBER 30 OF EACH YEAR** a written report shall be submitted to the Department of Environmental Conservation, 103 South Main Street, Waterbury, VT 05671-0405. This report shall include, as a minimum:

i. the dates and details of the cleaning and maintenance operations carried out in the preceding year.

ii. a narrative summarizing the results of the inspections conducted in the preceding year.

e. Should any erosional problems occur, the permittee is required to immediately correct all such problems.

f. Any basins, swales or related stormwater devices used during construction for erosion control shall be inspected and cleaned to design specifications immediately after construction has been completed.

11. Personnel and Training Requirements: Such personnel and training as necessary to fulfill the requirements of #10 above.

12. Monitoring and reporting Requirement: No monitoring required; reporting requirement as specified in #10 above.

13. Other Requirements:

a. The permittee shall implement a snow management plan in order to minimize the discharge of pollutants to Waters of the State. This plan shall consist of plowing the snow into the designated areas within and adjacent to the parking lots and roadways for snow storage.

I. if snow storage occurs in the detention basins, all snow and accumulated sediment shall be removed from the detention basins by no later than March 31.

14. Adverse Impact:

These discharges shall not cause or contribute to conditions that would have an undue adverse effect on the composition of the aquatic biota, the physical or chemical nature of the substrate, species composition, or the propagation of fishes.

Page 4 of 4
Permit No. 1-1288

15. Issue Date of Permit: _____

AGENCY OF NATURAL RESOURCES

Canute E. Dalmasse, Commissioner
Department of Environmental Conservation

By _____
Marilyn J. Davis, Director
Wastewater Management Division

Prepared and Reviewed by

TRANSFER APPLICATION

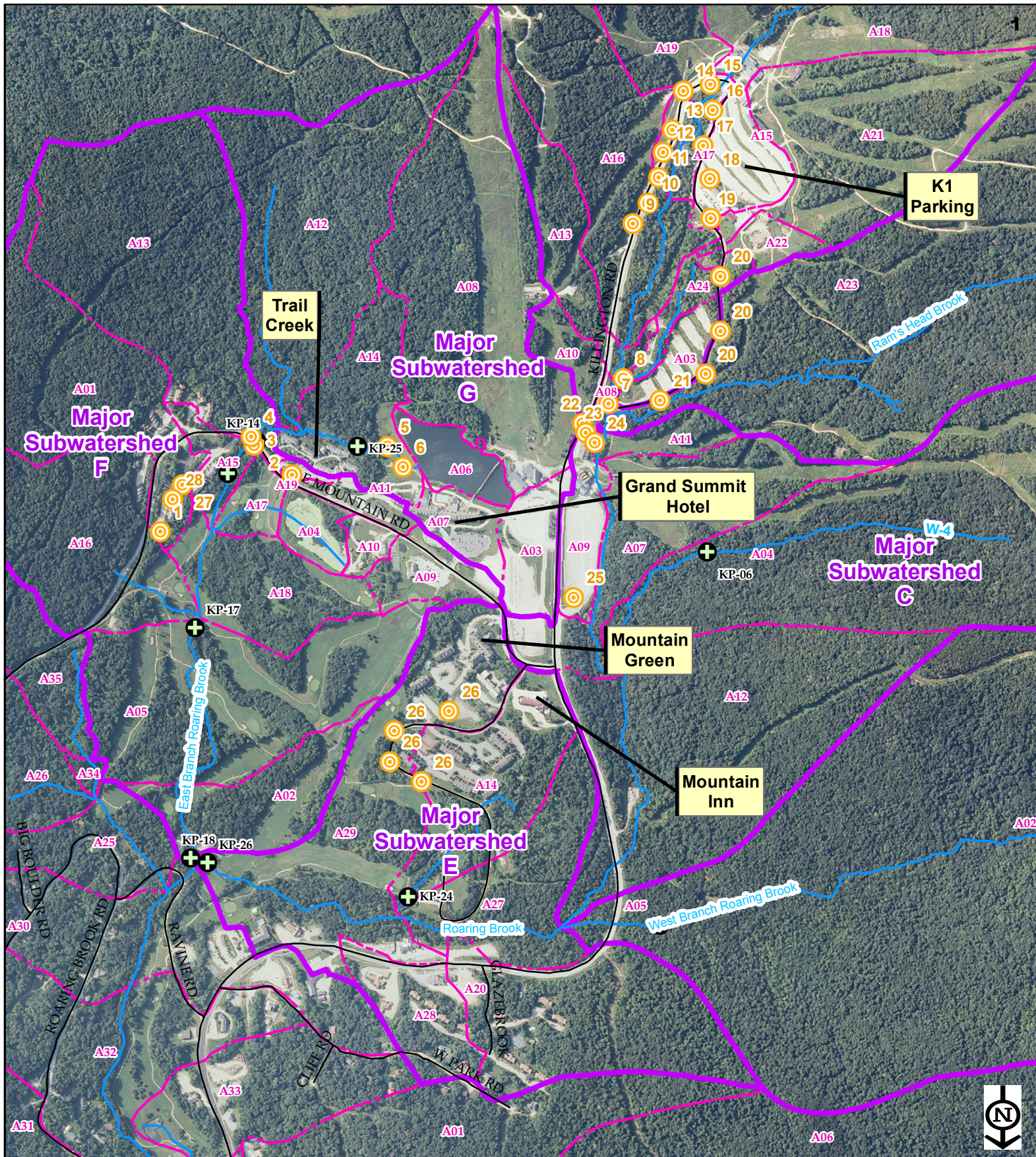
I, _____, hereby apply for permission to discharge waste into the waters of the State of Vermont under the provisions of Discharge Permit No. 1-1288, previously issued to Grand Summit Resort Properties, Inc..







Signed: _____

Address: _____

Telephone: _____

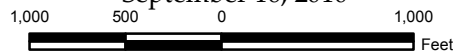
APPENDIX 2



-  Sediment Source Locations
-  MP WQ Monitoring Station
-  Roads
-  Streams (VHD Modified)
-  Major Subwatershed Boundary
-  Subwatershed Boundary

Roaring Brook and East Branch of Roaring Brook Killington Resort, Killington Vermont Sediment Source Point Location Map

September 16, 2010



Sources: NAIP (2009); Source Locations by VHB (July 2009); Roads from VCGI (2007); Streams for VHD from VCGI (2004), Watersheds by VHB (2009).

 **Vanasse Hangen Brustlin, Inc.**

Source #	Description/Issue	Location	Owner	Drainage	Possible Remediation Recommendations	Priority	Watershed
1	large/high pile of eroding dirt	Lower Wiffle Tree Lot	Private (Wiffle Tree)	E. Branch Roaring Brook	stabilize and contain w/removal, regrading, veg and EPSC measures	HIGH	F
2	sediment from lot through drains, culverts and swales into trib	Trail Creek Lot	Private (Trail Creek)	E. Branch Roaring Brook	pave lot, stabilize swales with rock and check dams to be cleaned regularly	MODERATE	F
3	gravel road shoulder erosion at culvert outlet	E. Mountain Road	Public Road	E. Branch Roaring Brook	stabilize/rock outfall	LOW	F
4	swale conveying sediment	E. Mountain Road	Public Road	E. Branch Roaring Brook	extend rocking, install check dams to be cleaned out regularly	MODERATE	F
5	eroding/bare banks of culvert outlet	Grand Resort Hotel	SPLC/Killington	E. Branch Roaring Brook	regrade banks, stabilize with plantings	LOW	G
6	instable banks and swale	Grand Resort Hotel	SPLC/Killington	E. Branch Roaring Brook	stone-line swale and vegetate	MODERATE	G
7	gravel from parking lot washing into brook	Culvert C-22	SPLC/Killington	Roaring Brook	pave lot or out-slope gravel lot	LOW	A
8	rusted out culvert	"E" + "F" Parking Lots	SPLC/Killington	Roaring Brook	replace culvert	LOW	A
9	rusted out, perched culvert and instable swale	Access Road	SPLC/Killington	Roaring Brook	replace culvert, stone-line swale and install check dams to be cleaned out regularly	MODERATE	A
10	gravel washing off road shoulder	Access Road	SPLC/Killington	Roaring Brook	install stabilized swale to stabilized outfall	LOW	A
11	gravel eroding over road shoulder	Access Road	SPLC/Killington	Roaring Brook	stabilize outfall	LOW	A
12	roadside swale conveying sediment	Access Road	SPLC/Killington	Roaring Brook	stone swale and install check dams to be cleaned regularly	LOW	A
13	instable eroding roadside swale	Access Road	SPLC/Killington	Roaring Brook	widen and stone-line swale, install check dams to be cleaned regularly	MODERATE	A
14	eroding dirt roads	Access Road	SPLC/Killington	Roaring Brook	install culvert under road	HIGH	A
15	eroding headwall to culvert	Culvert C-8	SPLC/Killington	Roaring Brook	stabilize headwall	LOW	A
16	eroding road shoulder into trib	Gondola Lot	SPLC/Killington	Roaring Brook	install stabilized roadside swale along Gondola lot	HIGH	A
17	eroding road shoulder into trib	Gondola Lot	SPLC/Killington	Roaring Brook	install stabilized roadside swale along Gondola lot	HIGH	A
18	instable swale	Gondola Lot	SPLC/Killington	Roaring Brook	widen, stone-line and install check dams to be cleaned out regularly	LOW	A
19	swale conveying sediment	Culvert C-36	SPLC/Killington	Roaring Brook	extend stone and check dams down swale to C-36	LOW	A

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Sediment Sources
VHB
September 16, 2010
(cont.)

Source #	Description/Issue	Location	Owner	Drainage	Possible Remediation Recommendations	Priority	Watershed
20	instable eroding long swale	west side of alphabet parking lot access road	SPLC/Killington	Ram's Head Brook	stabilize swale by widening, stone-lining, install check dams to be cleaned out regularly	HIGH	B
21	instable eroding swale	across from E and F parking lots	SPLC/Killington	Ram's Head Brook	stabilize swale by widening, stone-lining, install check dams to be cleaned out regularly	HIGH	B
22	instable swale	inlet of Culvert C-40	SPLC/Killington	Roaring Brook	stone-line and install check dams to be cleaned out regularly	LOW	A
23	gravel washing into channel	Culvert C-40	SPLC/Killington	Roaring Brook	pave lot or contain gravel by protecting channel opening	LOW	C
24	runoff from gravel parking lot	Culvert C-40	SPLC/Killington	Roaring Brook	pave lot or out-slope and stabilize drainage	LOW	C
25	runoff from gravel parking lot overloading sediment basin	Ram's Head Parking Lot	SPLC/Killington	Roaring Brook	pave lot, stabilize swales with stone-lining and check dams regularly cleaned out	HIGH	C
26	instable and eroding swales and sand pile	Mountain Green and Pinnacle Condos	Private (Pinnacle)	Roaring Brook	contain sand pile, stabilize swales with stone-lining and check dams to be regularly cleaned out	HIGH	E
27	gravel washing out from parking lot and eroding culvert outfall	Upper Whiffle Tree	Private (Whiffle Tree)	E. Branch Roaring Brook	pave lot, stabilize drainage and culvert outfall	HGH	F
28	instable temporary disturbances	Lower Whiffle Tree	Private (Whiffle Tree)	E. Branch Roaring Brook	install EPSC measures	MODERATE	F
29	eroding swale and sediment filled trib	north east corner of Pinnacle Condos	Private (Pinnacle)	Roaring Brook	stabilize swale with added stone, install check dams to be cleaned out regularly	HIGH	E

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB

SOURCE #1



Photograph 1 and 2: Large pile (~40 ft high) of exposed and uncontained dirt in close proximity of a tributary of the East Branch of Roaring Brook. The pile of dirt is located at the northern end of the Lower Whiffle Tree lot and is actively eroding.

SOURCE #2



Photographs 3 and 4: Through a linked system of storm drains, culverts and swales, the unpaved parking lot at Trail Creek Condo Development is conveying sediment into a tributary of the East Branch of Roaring Brook.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB

SOURCE #3



Photograph 5: Gravel run off from the edge of E. Mountain Road is contributing sediment to the East Branch of Roaring Brook around the outlet of culvert “C-77”.

SOURCE #4



Photographs 6 and 7: Across the entrance of “Whiffle Tree” on the south side of E. Mountain Road, a roadside swale is conveying sediment into the East Branch of Roaring Brook.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB

SOURCE #5



Photographs 8 and 9: The banks around the outlet of a culvert are bare of vegetation and eroding. The outlet is located near the KP-25 outfall on the east side of Snowshed Pond.

SOURCE #6



Photographs 10 and 11: There is a heavy iron seep and bare banks conveying sediment to the headwaters of the East Branch of Roaring Brook on the east side of Snowshed Pond.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB

SOURCE #7



Photograph 12: Gravel from the parking lot above the culvert “C-22” inlet is conveying sediment into Roaring Brook over the boulder headwall.

SOURCE #8

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB



Photograph 13: The outlet from the sediment basin from the “E” and “F” parking lots has a rusted out culvert causing iron seepage and a sediment input into a small tributary of Roaring Brook.

SOURCE #9



Photograph 14 and 15: On the east side of the Access Road, a rusted out perched culvert and gravel filled swale is conveying sediment into a small tributary of Roaring Brook.

SOURCE #10

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB



Photograph 16: Roadside gravel on the west side of the access road is washing down towards Roaring Brook.

SOURCE #11



Photograph 17: Gravel is eroding off of a roadside bank down towards Roaring Brook on the west side of the access road.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
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SOURCE #12



Photograph 18: A roadside swale along the east side of the access road is conveying fine sediment and gravel into a tributary of Roaring Brook.

SOURCE #13



Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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Photograph 19: A roadside swale leading to a culvert inlet (on the east side of the access road) is eroding and conveying fine sediment into to a tributary of Roaring Brook.

SOURCE # 14



Photograph 20: A culvert is needed at the confluence of several dirt roads and beginning of the roadside swale. Currently, road dirt/gravel washes into the swale and leading to a small tributary of Roaring Brook.

SOURCE #15



Photographs 21 and 22: The outfall on the river right of culvert “C-8’s” headwall is eroding. Rills are contributing road gravel and sediment into Roaring Brook.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
September 16, 2010
VHB

SOURCE #16



Photographs 23 and 24: There is an eroding, gravel and sediment filled tributary on the river left of Roaring Brook just downstream of culver "C-8" off of the Gondola Road. The tributary enters the woods and conveys sediment into the buffer and stream.

SOURCE #17

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB



Photographs 25 and 26: There is eroding gravel off of the Gondola Road shoulder and into the riparian buffer of Roaring Brook.

SOURCE #18



Photograph 27: There is an eroding swale located in the Gondola parking lot.

SOURCE #19

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB



Photograph 28: Swale conveying sediment needs stone and check dams extended down to culvert “C-36”.

SOURCE #20



Photograph 29 and 30: Instable and eroding swale has clogged a culvert and is contributing sediment to Ram’s Head Brook.

SOURCE #21

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB



Photograph 31 and 32: Swale by "E" and "F" is instable and contributing gravel to the riparian buffer of Ram's Head Brook on river right.

SOURCE #22



Photograph 33: Instable and eroding roadside swale US of culvert "C-40" on the east side of the Access Road.

SOURCE #23

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB



Photograph 34: Gravel is being washed into the day-lighted section of culvert "C-40".

SOURCE #24



Photograph 35: Gravel parking lot has sediment running off into a swale from culvert "C-40" and into Roaring Brook downstream of weir.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB

SOURCE #25



Photographs 36, 37, 38 and 39: These are several unstable and eroding swales overloading sediment to the Ram's Head stormwater basin from the Ram's Head parking lot (Photos 36 and 37) and basin access road (Photos 38 and 39).

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
Sediment Sources
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VHB

SOURCE #26



Photographs 40 and 41: Instable swale in the Mountain Green gravel parking lot and uncontained gravel/sand mound in north corner of parking lot – both conveying sediment to the Pinnacle Condo roadside swale (Photo 42).



Photograph 42: The eastern branch of the Pinnacle Condo tributary and the roadside swale along the Pinnacle Condo Paved Road are both full of sediment.

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
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VHB



Photographs 43 and 44: The instable and eroding swale along Water Treatment dirt Access Road.

SOURCE 27



Photograph 45 and 46: The upper Whiffle Tree condo gravel parking lot (Photo 45) conveys sediment into a tributary of Roaring Brook via a storm drain. The outlet of the storm drain culvert is instable and eroding (Photo 46).

Roaring Brook and East Branch of Roaring Brook – Water Quality Remediation Plan
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SOURCE 28



Photograph 47 and 48: The uncontained temporary soil disturbances in the lower Whiffle Tree Condo parking lot is conveying sediment to a tributary of Roaring Brook at the culvert outlet (Photograph 48).

SOURCE 29



Photographs 49 and 50: A sediment filled tributary to Roaring Brook was followed upstream and ended in this eroding swale at the north corner of the Pinnacle Condos.



Bear Creek Environmental

Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

Final Report
January 26, 2006

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Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

Final Report
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Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

ACKNOWLEDGEMENTS

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Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

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Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

EXECUTIVE SUMMARY

Phase I and Phase 2 Stream Geomorphic Assessments within the Roaring Brook watershed were completed by Bear Creek Environmental during summer 2005. These stream geomorphic assessments provide information about the physical condition of streams within the Roaring Brook watershed and the factors that influence the stability of these systems. The project was funded through the Vermont Clean and Clear Program. The Stormwater Section of the Vermont Department of Environmental Conservation (DEC) sponsored the project, and the VDEC River Management Program provided technical expertise and shared quality control/quality assurance responsibilities with Bear Creek Environmental. The study included Roaring Brook, the East Branch of Roaring Brook, the West Branch of Roaring Brook, Rams Head Creek, and one unnamed tributary. Roaring Brook's watershed was divided into 15 reaches based on confinement, slope, soils, and tributary influence. The Phase 2 study focused on stream reaches on the main stem of the Roaring Brook from the confluence with the Ottauquechee River, upstream to Killington Resort.

The study followed the Phase I and 2 assessment protocol developed by the DEC River Management Program. Information from the study came from the DEC, the Vermont Mapping Program, the Vermont Center for Geographic Information, the Town of Killington, and field data collected by Bear Creek Environmental. The Phase I study used a combination of remote sensing (i.e. mapping) and windshield surveys to understand the stream's response to natural and human disturbances that have influenced the Roaring Brook watershed. The Phase 2 Rapid Stream Assessment included field observations and measurements that are used to verify the Phase I stream geomorphic data, to provide field evidence of channel adjustment processes, and to collect habitat quality data for the study reaches.

The focus of the Phase I study is to evaluate parameters that may cause channel adjustment such as floodplain modifications, channel modifications, and land use. Of the four impact categories measured during the Phase I Assessment, floodplain modification was the category identified as having the greatest potential for causing channel adjustment in the Roaring Brook

watershed. Forty percent of the reaches resulted in an impact rating of high for berms and roads and for corridor development. Land use was also identified as an important factor with River corridor land cover/land use receiving an impact rating of high for about half of the stream reaches. In-stream channel modification was also identified as having the potential to cause channel adjustment in the Roaring Brook watershed. Bridges and culverts, bank armoring and channel straightening received high impact scores. The meander migration, meander width ratio, and meander wavelength indicate that some reaches are in adjustment. Meander width ratios measured on Roaring Brook indicate the river has become straighter and steeper, possibly resulting in degradation and loss of access to its floodplain.

The Phase 2 assessment focused on data collection relating to the stream channel, the riparian corridor, and aquatic habitat. This information can be used in watershed planning, for the establishment of erosion hazard zones, and for the identification of watershed improvement projects. The Phase 2 assessment consists of field notes that are collected through a reach, and the completion of a Rapid Geomorphic Assessment (RGA) and Rapid Habitat Assessment (RHA).

The Phase 2 Rapid Geomorphic Assessment (RGA) is important for understanding the geomorphic stability of a reach. The RGA includes an evaluation of reach condition (departure from reference condition), channel adjustment process, and the reach sensitivity. The reach condition describes the degree of departure of the channel from its reference stream type. Reference streams have no significant channel or floodplain modifications. Reach condition ratings correspond to degrees of expected adjustment. The channel adjustment process is a change in the form of the channel due to natural causes or human impacts. Reach sensitivity describes how sensitive a stream reach is to changes within the watershed, and is dependent upon the existing stream type and the condition of the reach.

Seven of the segments assessed for the Phase 2 study resulted in a geomorphic condition of fair, indicating they are undergoing major adjustment processes. Two segments resulted in a geomorphic condition of good, reflecting minor adjustment is occurring. The Phase 2 Rapid Geomorphic Assessment (RGA) was used to evaluate the stage of channel evolution. Most of the Phase 2 reaches were found to be in fair condition, had undergone historical channel widening or down cutting, and were currently undergoing major to minor channel adjustments. Additionally, much of the Roaring Brook watershed appears to be undergoing a second evolutionary process associated with the build up of sediment that is being washed into the stream channel from gravel parking lots, roads, and development. This is especially evident in the upper reaches of the Roaring Brook watershed, where significant wash off from the Killington Access Road was noted to be filling in pools.

The Rapid Habitat Assessment (RHA) is used to evaluate the physical components of a stream (the channel bed, banks, and riparian vegetation) and how the physical condition of the stream affects aquatic life. The results can be used to compare physical habitat condition between sites, streams, or watersheds, and also serve as a management tool in watershed planning or similar land-use planning. In general, the Rapid Habitat Assessment (RHA) rating was similar to the RGA. Four of nine segments resulted in a rating of fair for the RHA. Five segments resulted in a rating of good.

Three of the eight Roaring Brook mainstem reaches have stream types that are very susceptible to shifts in both lateral and vertical stability caused by direct channel disturbance and changes in the flow and sediment regimes of the contributing watershed. Rates of lateral adjustment are influenced by the presence and condition of riparian vegetation. For this reason, the acquisition of easements, streamside plantings, and buffer protection should be a high priority for restoration planning and design work.

In summary, the Phase I and 2 Geomorphic Assessments provided evidence that the mainstem of Roaring Brook has been significantly altered by floodplain encroachment, channel straightening, and the disturbance of the riparian vegetation. In addition, stormwater from Killington and its associated development have altered both the hydrology and sediment regime of the upper watershed. Recommendations for improvements within the Roaring Brook watershed are provided at the end of this report.



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Phase I and 2 Stream Geomorphic Assessments Roaring Brook Watershed Killington, Vermont

SECTION I: PROJECT OVERVIEW AND BACKGROUND

I.1 PROJECT OVERVIEW

Bear Creek Environmental was retained by the Vermont Department of Environmental Conservation (VDEC) to conduct Phase I and 2 Stream Geomorphic Assessments within the Roaring Brook watershed. Roaring Brook is located in the upper reaches of the Ottauquechee River watershed (Figure 1). The Phase I assessment was conducted on Roaring Brook, the East Branch of Roaring Brook, the West Branch of Roaring Brook, Rams Head Creek, and one other major tributary (Figure 2). The Phase 2 assessment was conducted on the entire main stem of Roaring Brook from the confluence with the Ottauquechee River, upstream to Killington Resort.

Roaring Brook from river mile 1.4 upstream 0.2 miles is listed on the 2004 State of Vermont 303(d) list of impaired waters. On the East Branch of Roaring Brook, there is an impaired segment from river mile 0.1 to river mile 0.6 (Figure 3). Both of these streams have stormwater runoff, land development, and erosion listed as water quality problems within these segments. Impaired uses include aesthetics and aquatic life support. The main objectives of the study were to provide an overview of the general physical characteristics of the watershed, assess the impact of parameters such as land use, channel modification, floodplain modification, erosion and debris/ice-jam potential on each reach, and determine which reaches may be in channel adjustment.

Data and information for the Roaring Brook watershed was obtained from the VDEC and the Vermont Center for Geographic Information (VCGI). Windshield surveys of the watershed were conducted in June 2005. Mary Nealon, Michael Blazewicz and Alyssa Borowske of Bear Creek Environmental visited the majority of the reaches to conduct Phase 2 surveys during the months of June and July 2005. Shannon Hill, scientist with the River Management Program of ANR, joined BCE scientists during the Phase 2 assessment of reaches T6.07 and T6.08.

I.2 BACKGROUND INFORMATION

I.2.1 Description of Study Area

Roaring Brook is a tributary to the Ottauquechee River near Sherburne Center, Vermont and has a watershed size of 5.61 square miles (Figure 1). The Ottauquechee River is within the Connecticut River Basin. The Phase I assessment included stream reaches on Roaring Brook, East Branch of Roaring Brook, West Branch of Roaring Brook, Rams Head Creek, and one unnamed tributary (Figure 2).

The Roaring Brook watershed is located within the Green Mountains of Vermont. The watershed lies just south of Sherburne Pass, which was historically reshaped by ice (Van Diver, 1987). The geologic formation where the Roaring Brook watershed is located is known as the Precambrian massif (Van Diver, 1987). The dominant soil types in the Roaring Brook watershed are glacial till and ice-contact deposits.

With the exception of a few reaches, Roaring Brook flows through a steep gradient valley. Most reaches within the watershed have a slope of approximately 10% and in the upper reaches slopes are much greater. There are only a few reaches where slopes are less than 5%.

The Roaring Brook watershed is dominated by forested land. However, all subwatersheds except one contain agricultural fields or urban land as a sub-dominant land use. Orthophotos from the 1970s show that Roaring Brook was dominated by

forest land. According to town officials, most of the subdivisions currently in Killington were historically agricultural land. The Killington ski area was developed in 1958 and subsequent development around it was mostly constructed in the late 1960s to the mid 1970s. New development within the watershed continues today.

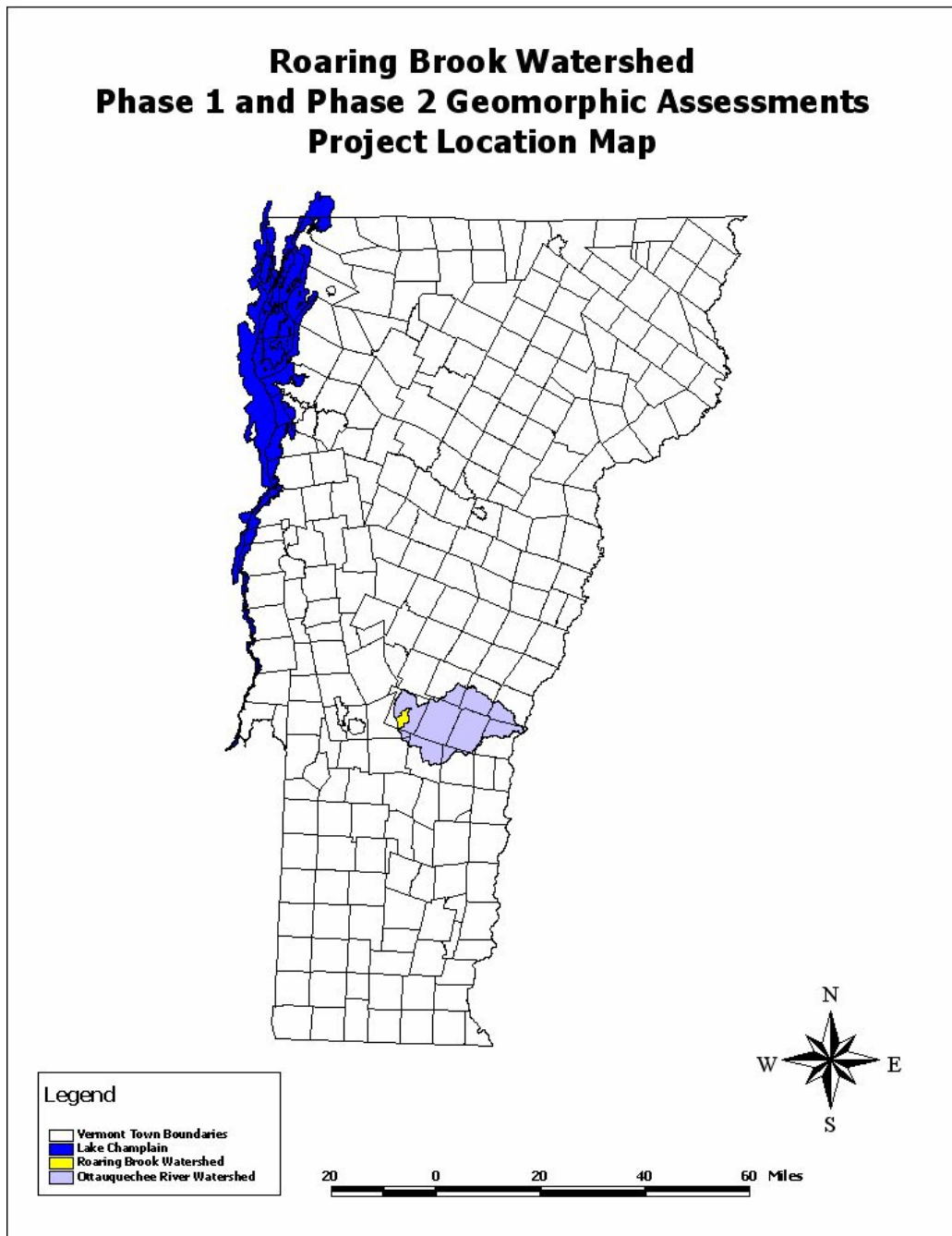


Figure 1. Project Location Map for the Phase 1 and 2 Assessment

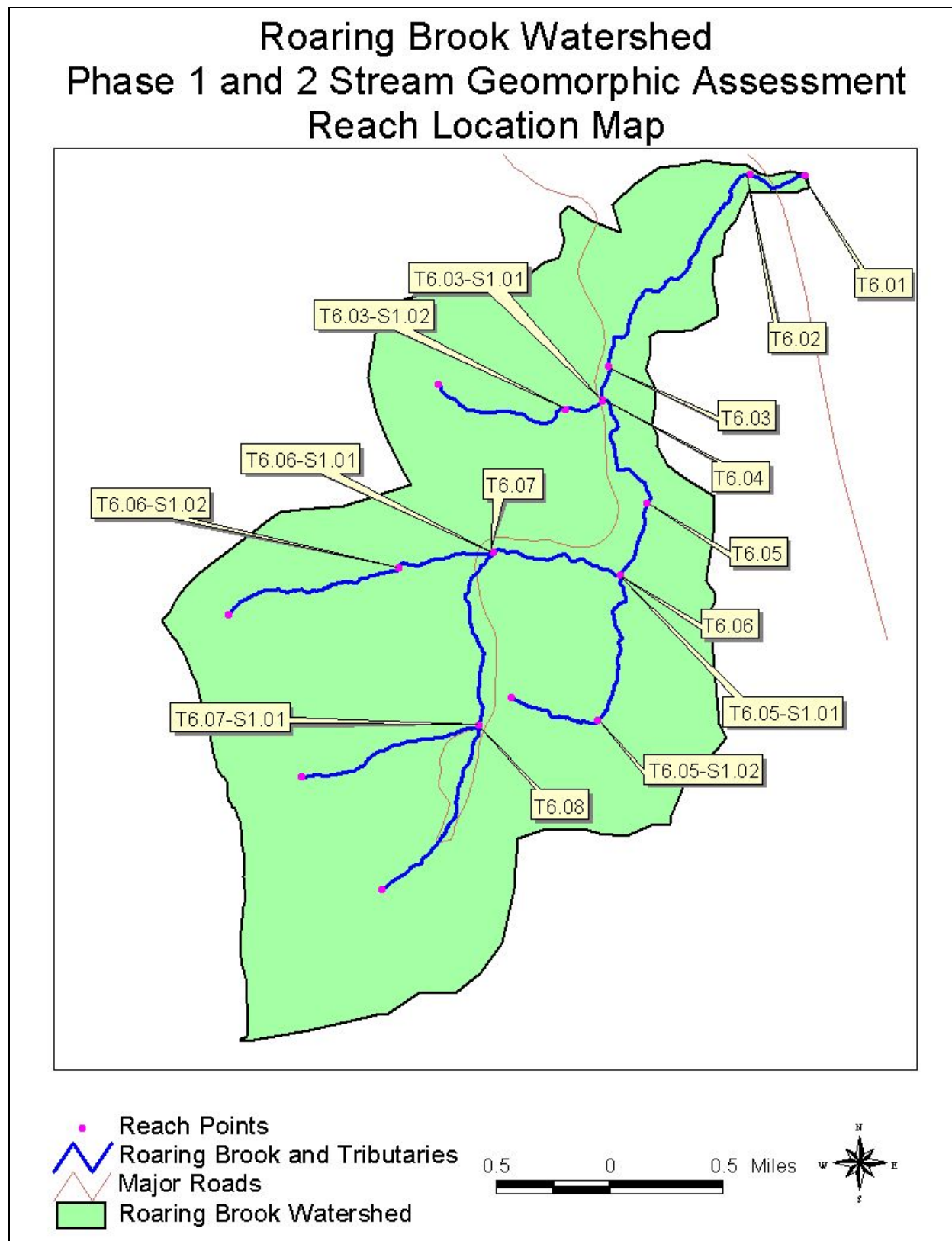


Figure 2. Reach Location Map for the Stream Geomorphic Assessment

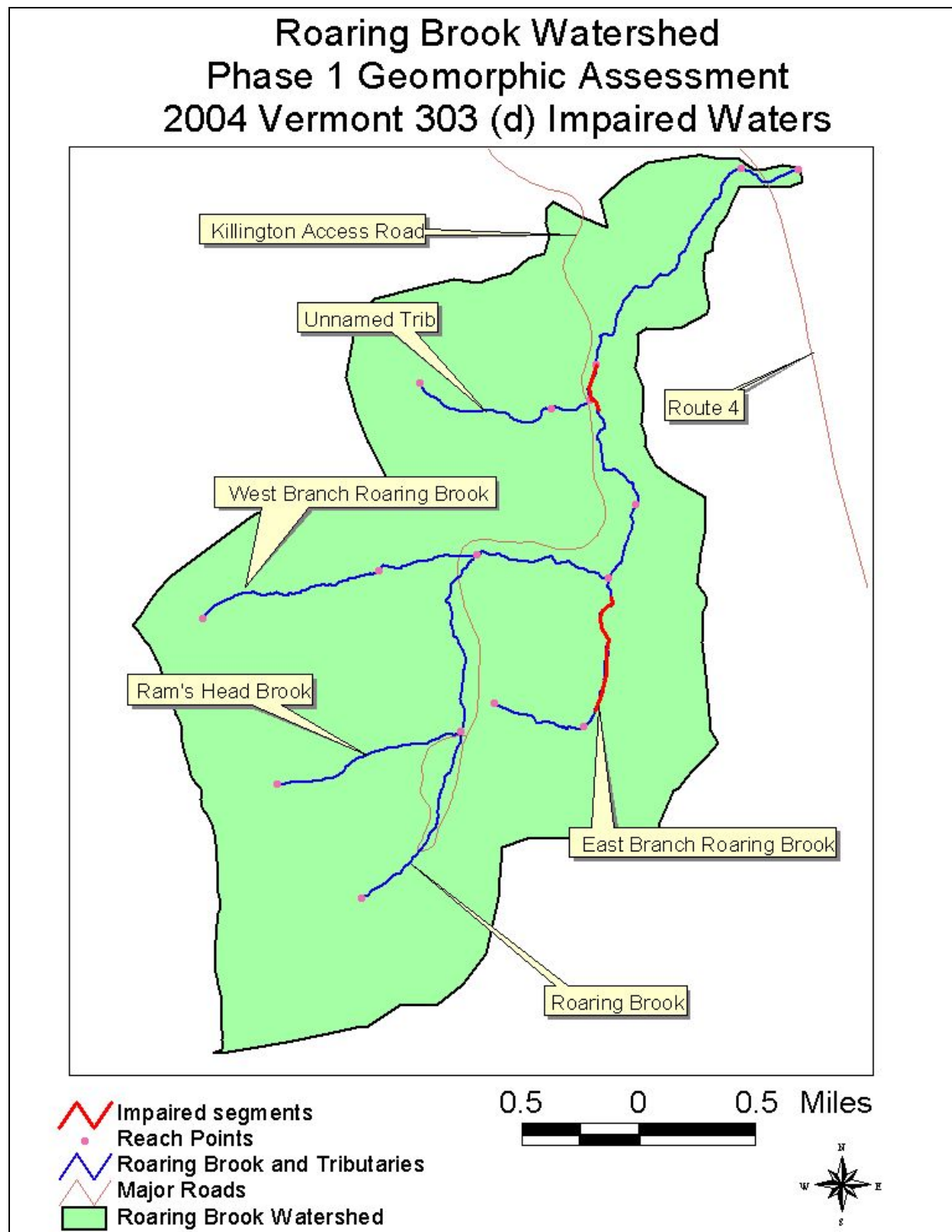


Figure 3. Impaired Segments of Roaring Brook and Tributaries

I.2.2 Flood History

The Killington town clerk was contacted for information regarding the flood history and channel management of the Roaring Brook watershed. According to the town clerk, there are no known problem areas for flooding in the town. They believe that the 1927 flood came through the area, but did not know of any damage as a result of it. There also are no records of channel management practices for the Roaring Brook watershed.

Since there are no USGS stream gages within the Roaring Brook watershed, data from another river was used to better understand the hydrologic history of Roaring Brook. Long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gage on the Ottauquechee River in West Bridgewater, VT (gage #01150900) was obtained. The Ottauquechee River gage was selected because it is located near the confluence of Roaring Brook and the Ottauquechee River. Although the drainage area at the Ottauquechee River gage is much larger (23.4 sq. miles) than the Roaring Brook watershed, it does provide some useful information about when large flood events occurred. The peak flows for the period of record (1985 through the present) are presented below in Figure 4. The peak flows for 2000 and 2002 were close to a 10 year recurrence interval. The peak flow for 1996 was between the ten year and 25 year recurrence interval.

To get a longer period of record for the area, the USGS gage on the Ottauquechee River in North Hartland, VT (gage #01151500) was also obtained. The drainage area at this gage is 221 square miles. The gage provides a continuous record of flow from 1927 through the present. The USGS indicates that the data from the North Hartland gage is affected by regulation or diversion. The long term record (see Figure 5) shows peak discharges for 1948 and 1953 were at the 10 year recurrence interval. The peak flows for 1934, 1949, and 1952 were between a ten year and 25 year recurrence interval. 1936 was approximately a 50 year recurrence interval, while water year 1928 exceeded the 50 year recurrence interval.

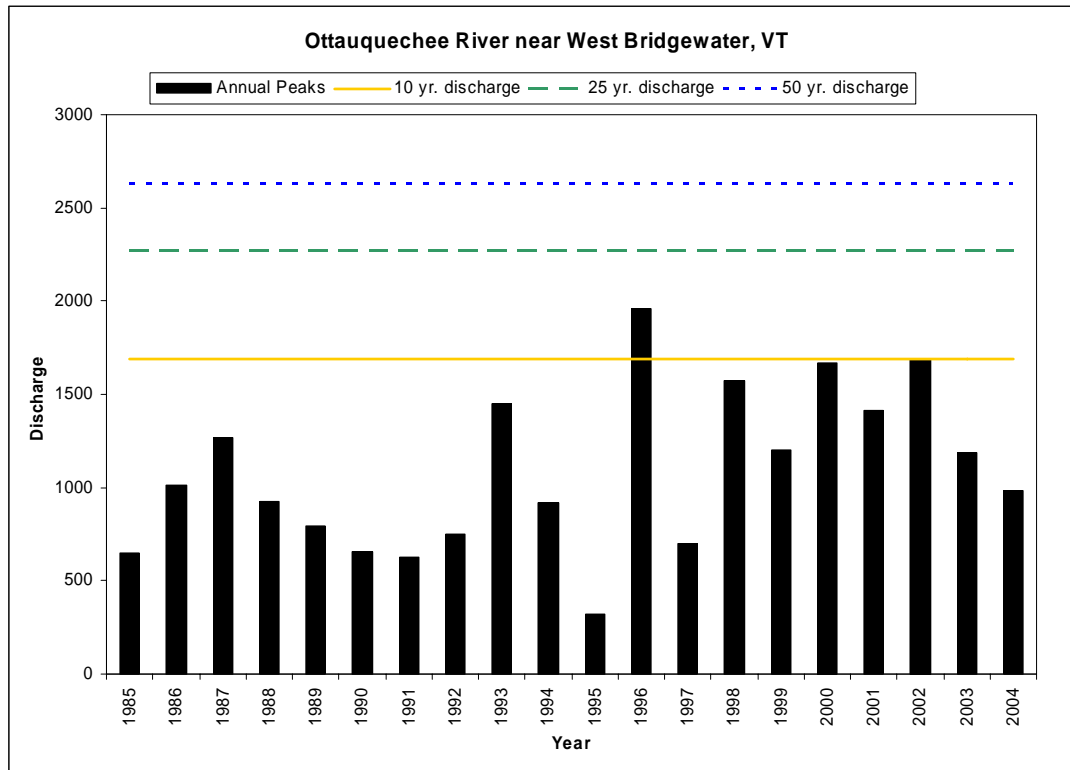


Figure 4. Annual Peak Discharge for Ottawaquechee River near West Bridgewater, VT.

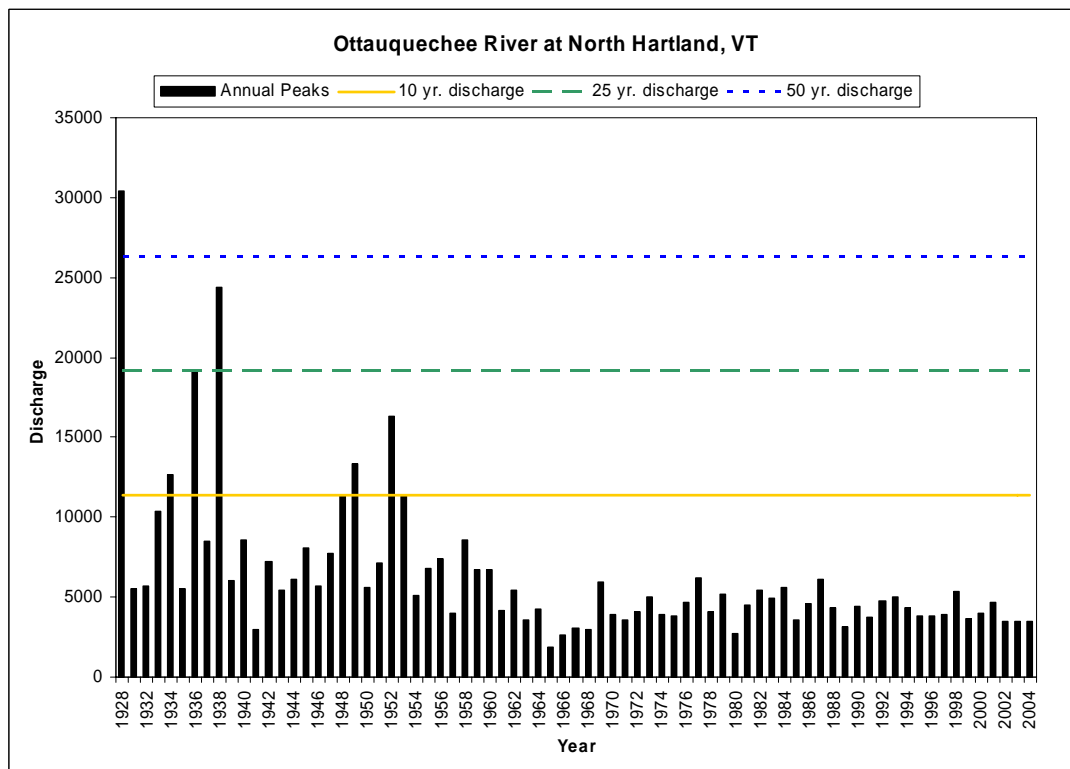


Figure 5. Annual Peak Discharge for Ottawaquechee River at North Hartland, VT.

SECTION 2: PHASE I STREAM GEOMORPHIC ASSESSMENT

2.1 PHASE I METHODOLOGY

The Phase I assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase I (Vermont Agency of Natural Resources 2005a), and used version 3.02 of the Stream Geomorphic Assessment Tool (SGAT) GIS extension. All assessment data were recorded on the Agency of Natural Resources (ANR) Phase I data sheets, and were entered into the DMS.

2.1.1 Phase I Parameters

During the Phase I Assessment, data was collected for each parameter in Table I. The parameters were then rated according to the following menu options (NS – not significant, low impact, high impact or No info –no information). A zero was scored for options NS and No info, a one for low impact and a two for high impact.

Table I. Parameters Included in Impact Scores	
Step #	Parameter
4.1	Watershed Land Cover/ Land Use
4.2	Corridor Land Cover/ Land Use
4.3	Riparian Buffer Width
5.1	Flow Regulations and Water Withdrawals
5.2	Bridges and Culverts
5.3	Bank Armoring and Revetments
5.4	Channel Modifications
5.5	Dredging and Gravel Mining History
6.1	Berms and Roads
6.2	River Corridor Development
6.3	Depositional Features
6.4	Meander Migration / Channel Avulsion
6.5	Meander Width Ratio
6.6	Wavelength Ratio
7.2	Bank Erosion – Relative Magnitude
7.3	Ice and Debris Jam Potential

The reach indexing tool (RIT) was used to document steps 5.3, 5.4, and 6.1. This tool is an extension of ArcView and utilizes the Vermont Hydrography Dataset (VHD) (VCGI, 2003) to automate measuring the length of stream segments. The impacts were entered into an attribute table, which was uploaded to the DMS.

2.1.2 Phase I QA Review

To assure a high level of confidence in the Phase I and 2 SGA data, strict QA/QC procedures were followed by BCE. These procedures involved a thorough in-house review of all data as well as automated and manual QC checks with the DEC River Management Program. The three base shapefiles (valley walls, meander centerlines, and subwatershed) were submitted to Shannon Hill for QA review prior to running the SGAT extension. After Step 2 of the Phase I Assessment was completed, Bear Creek Environmental conducted its own manual QA review of the reference stream types. Then the SGAT project and resultant shapefiles were sent to the River Management Program for another QA review, which included a manual QA review of reference stream types. In early June 2005, Phase I ArcView shapefiles were submitted to Shannon Hill for a QA review following the completion of Step 7 of the Phase I assessment.

BCE conducted its own in-house QA review after all the Phase 2 data were entered into the DMS and the Phase I data were updated. Lengths of armoring, berms, and erosion on field forms were checked against DMS values as well as calculated lengths in GIS shapefiles. Then the Phase 2 GIS shapefiles were submitted to the ANR for a third QA review. Some minor revisions were made by Bear Creek Environmental to the DMS following this review. These changes include updating the meander migration, belt width, and average wavelength parameters.

2.2 PHASE I RESULTS

2.2.1 Reach Locations

The Roaring Brook watershed was divided into 15 reaches for the Phase I Assessment. Page 1 of Appendix A provides the reach locations including reach description, town where the reach is located, and latitude and longitude generated from SGAT. Figure 2 shows the location of study reaches used in the Phase I Assessment. Each point represents the downstream end of the reach.

2.2.2 Reference Stream Types

Reference stream types are defined as stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Stream and valley characteristics including valley confinement, and slope determined through remote sensing were used to determine the reference stream type. The reference reach characteristics were later refined during the windshield survey and Phase 2 assessment. Reference reach typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1996) classification systems.

Page 2 of Appendix A provides a complete listing of reference stream types for each reach within the project area. The reference stream types are shown in Figure 6. The majority of the stream reaches fall within the “B” stream type (see Table 2). The step-pool type streams in this category accounted for approximately 30 percent of the length of assessed reaches, while the one plane bed section accounted for 5 percent of the study area by length. In reference condition, these streams are narrowly confined to narrow, have moderate to steep slopes, and have cobble as bed material.

Five reaches were categorized as “A” type streams by reference. The cascade comprises approximately 9 percent of the study area, by length, and the step-pool comprises 29 percent of the study area. These streams by reference are narrowly confined, have very steep slopes, and boulder or cobble as the dominant bed material.

Four of the 15 reaches (approximately 13 percent of the study area by stream length) fall within the “C” stream type and were noted to be riffle-pool systems. Reference “C” streams are unconfined, have moderate to gentle slopes, and have cobble or gravel as bed material.

One reach, T2.02, was designated as an “F” type stream with a step-pool bed form. The reach comprises approximately 13 percent of the study area by length. This stream reach is narrowly confined, with a very steep slope and is dominated by cobbles as bed material.

Table 2. Reference Stream Type				
Stream Type	Confinement	Channel Slope	Bed Material	Percentage by Channel Length of Assessed Reaches
A/ Cascade	Narrowly confined	Very steep	Boulder	9
A/Step-Pool	Narrowly confined	Very steep	Cobble	29
F/Riffle-pool	Narrowly confined	Very steep	Cobble	14
B/Step-pool	Narrowly confined to Semi confined	Steep	Cobble	30
B/ Plane Bed	Narrow	Moderate to steep	Cobble	5
C/Riffle-pool	Broad or Very Broad	Moderate to gentle	Cobble-Gravel	13

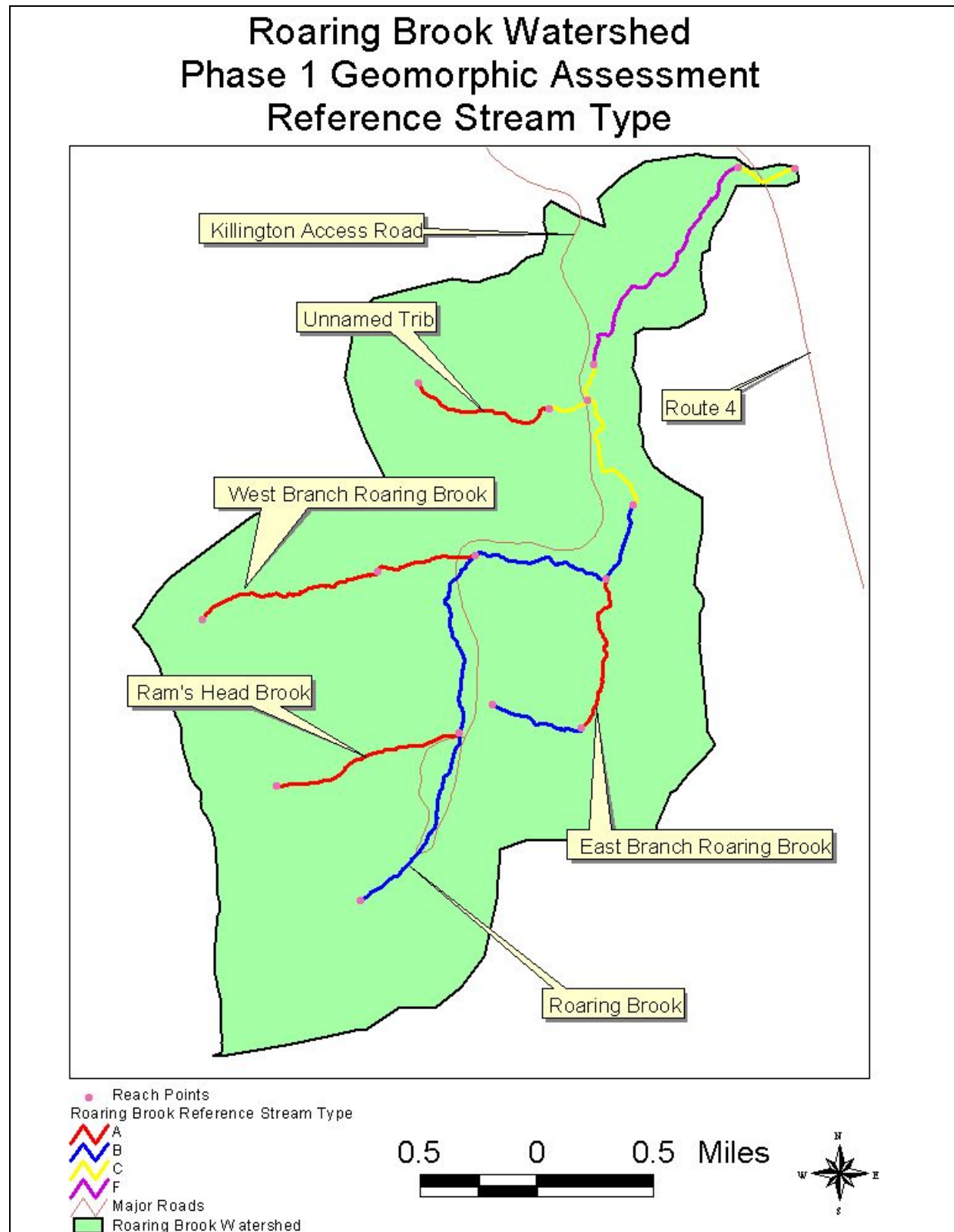


Figure 6. Stream Typing for Phase I Assessment Reaches

2.2.3 Basin Geology and Soils

The characteristics of the Roaring Brook watershed were determined using a combination of soils data, review of topographic maps, and information acquired during the windshield survey. Page 3 of Appendix A, provides a summary of the basin characteristics, such as alluvial fans, grade control structures, geologic materials, valley side slopes, and soil characteristics.

There were no alluvial fans identified within the study reaches. Grade control structures such as ledge and dams were noted during the windshield survey. Channel spanning ledge was noted in six of the 15 reaches (T6.01, T6.02, T6.05, T.06, and T6.07 and T6.08). Ledge acts as a grade control by keeping the base elevation of a river from being lowered, and prevents the river from incising in that location. Only one dam, Snowshed Pond, is located within the study area. Snowshed Pond is located at the upper end of reach T6.05-S1.02. One reach, T6.07, had multiple grade controls which included ledge and a weir used for snowmaking water withdrawals. The steepness of the valley side slopes was determined using a combination of a topographic map and the soils layer. The valley side slope steepness was variable, but overall steep to extremely steep side slopes dominated the watershed.

The dominant surficial geology of the Roaring Brook watershed consists of glacial till and ice-contact deposits (see page 4 of Appendix A). With one exception, the reaches characterized as “C” channels within the Roaring Brook watershed have ice-contact deposits as the dominant geologic material. As shown on page 5 of Appendix A, these soils are rarely flooded and have severe to very severe erodibility. T6.03, a “C” type stream, had a dominant soil type that is frequently flooded and moderate erodibility. The rest of the reaches have till as the dominant geologic materials. These soils are rarely flooded and have very severe erodibility.

2.2.4 Land Cover – Reach Hydrology

The land use within a watershed plays an important role in the hydrology of the receiving waters. The percentage of urban and cropland development within the

watershed are factors which change a watershed's response to precipitation. The most common effects of urban and cropland development is increasing peak discharges and runoff by reducing infiltration and travel time (United States Department of Agriculture 1986). The land use/land cover within the stream corridor itself is also an important parameter to evaluate. This land use/land cover plays an important role in the sediment deposition and erosion which occurs during annual flood events (Vermont Agency of Natural Resources 2004).

As outlined in the Phase I handbook, impact ratings were assigned for watershed land cover/land use and stream corridor land cover/land use as follow:

- High – 10% or more is crop and/or urban
- Low – Between 2 and 10 % is crop and/or urban
- NS – Not Significant – Less than 2 % is crop and/or urban

The land cover/land use information is provided on pages 6 through 8 of Appendix A. Eleven of the reaches resulted in a watershed /land use impact rating of low and the rest were not significant. The dominant land cover/land use within the river corridor was forested land for all but three reaches. These three reaches had urban land as their dominant land use. Seven of the fifteen reaches resulted in a high impact rating for corridor land cover/use.

Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion. As summarized on page 9 of Appendix A, one of the stream reaches, T6.03, had over 75 percent of the reach with little or no buffer on both banks. This stream reach, which lacks a high quality riparian buffer, is at a significantly higher risk of experiencing high rates of lateral erosion. Two more reaches (T6.05 and T6.05-S1.02) had 50 percent of their reach with little or no buffer. One stream reach, T6.04, had a buffer on the left side of the stream between 26 and 50 feet that comprised 65 percent of the reach.

2.2.5 Historic Channel Modifications

Channel modifications may impact a stream reach by affecting the hydraulics and the sediment regime. Historic channel modifications were assessed in this Phase I study by evaluating flow regulations, bridges and culverts impacts, bank armoring, windrowing, straightening, and dredging. The percentage by length of reach impacted by one or more of these channel modifications was estimated and is summarized in Report Number 5 (see Appendix A pages 10 and 11).

Flow Regulations

Two reaches within the Roaring Brook watershed were rated as high impact for flow regulation. T6.07, located on the main stem has a weir in the channel that has affected sediment depositional patterns in the channel. The upper reach on the East Branch of Roaring Brook has an onstream impoundment, which is disrupting natural sediment transport within the reach.

Bridges and Culverts

As part of the Phase I Stream Geomorphic Assessment, the number of bridges and culverts within the study reach were counted by identifying stream crossings on the topographic map and orthophotos. These stream crossings were confirmed during the windshield survey. The percentage of the reach impacted by stream crossing structures was estimated during the windshield survey and from orthophotos. Impact ratings for bridge and culverts were evaluated by determining the percentage of the reach length that is channelized, has split flow, or makes a sharp “S” bend upstream or downstream of bridges or culverts. The impact from bridge and culverts on stream dimension, pattern or profile was high for three reaches, T6.01, T6.03, and T6.03-S1.01. The remaining reaches appeared to be low or not significant.

Bank Armoring

The amount of bank armoring within a watershed is often indicative of the occurrence of channel processes, which result in bank erosion. Bank armoring, also called

revetments, can be made of a variety of material including wooden cribs, gabions, logs, and rock riprap. The most common type of revetment in Vermont is rock riprap. The following criterion was used to provide an impact rating for human placed bank armoring.

H	High – Greater than 30% of the reach length is armored
L	Low – Between 10 and 30% of the reach length is armored
NS	Not Significant – Less than 10% of the reach length is armored
No Info	Bank armoring has not been evaluated for the entire reach and impact at the reach level is unknown

Rock riprap and log revetments were the only types of revetments noted within the study area. Bank armoring was noted in seven of the 15 reaches. Of these reaches, armoring received an impact rating of high for two of the reaches (T6.01 and T6.03) and low or not significant for the remaining reaches.

Channel Modifications (Windrowing and Straightening)

During the windshield survey evidence of historic channelization projects were recorded. The total reach length (in feet) and the percentage of the reach length directly impacted by the channel modification were noted. Categories considered as part of the Step 5.4 (channel Modifications) included the following menu options:

- Straightening – Manual straightening of a channel without windrowing.
- With Windrowing – pushing gravel up from the stream bed onto the top of either bank as part of the straightening of the river.
- None – No known channel straightening.
- Not evaluated – All data sources have not been evaluated.

Channel straightening was identified by reviewing orthophotos and through field confirmation during the windshield and Phase 2 survey. Portions of stream reaches that have been historically channelized or straightened are shown below in Figure 7. Five reaches were given an impact rating of high due to channel straightening while five other

reaches had an impact rating of low. Reach T6.01 was also identified as being straightened with windrowing.

Dredging History

Since the Roaring Brook watershed is so small (<10 square miles), there are no records at the Vermont Agency of Natural Resources regarding the dredging and gravel mining history of the Roaring Brook watershed. However, when some reaches were straightened, some dredging probably occurred as well.

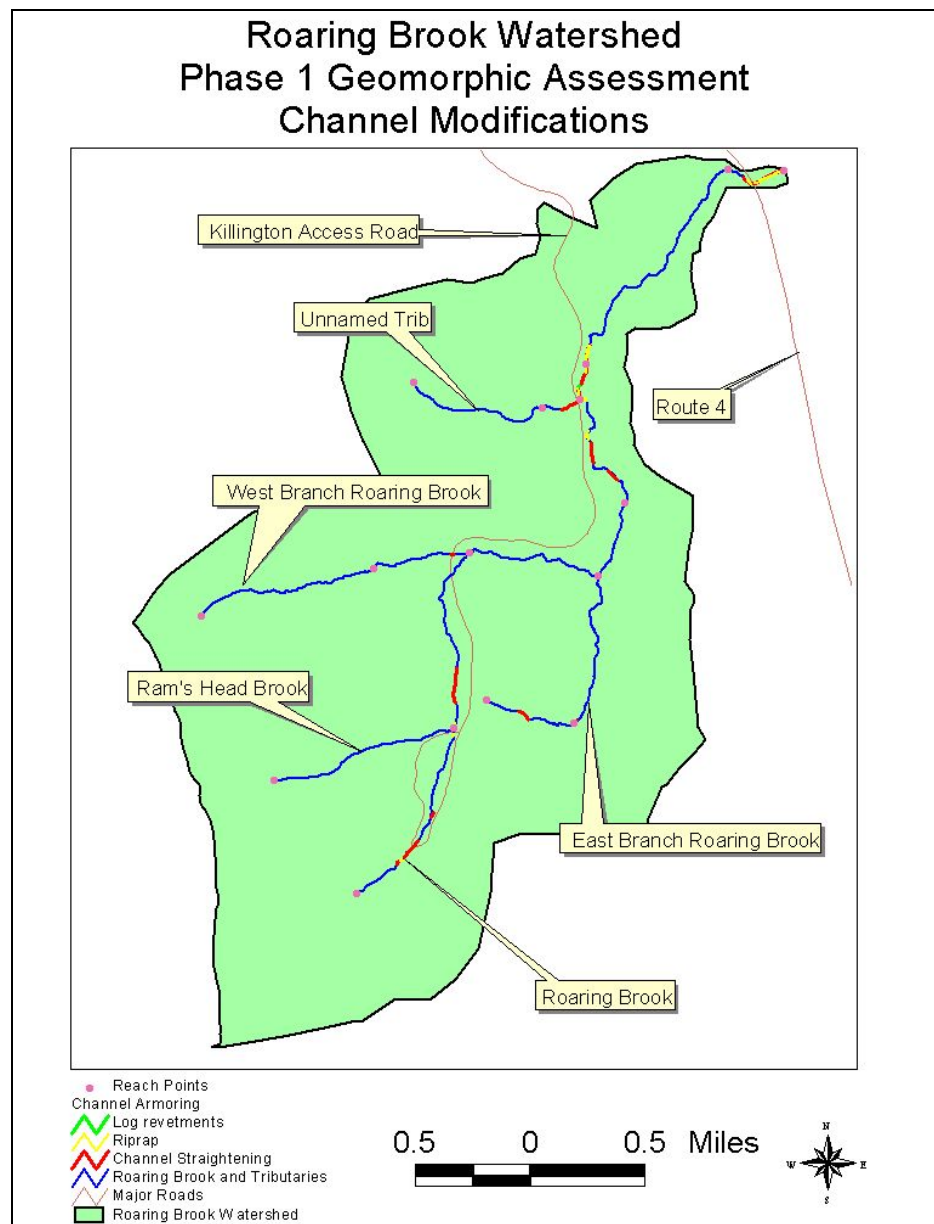


Figure 7. In-stream Channel Modifications Identified for Phase I Reaches

2.2.6 Floodplain Modifications

In this step of the Phase I assessment, careful attention is paid to infrastructure and other development which restricts access to the floodplain, resulting in vertical or lateral confinement of flood flows. The parameters included in this step are: Berms and Roads, River Corridor Development, Depositional Features, Meander Migration/Channel Avulsion, Meander Width Ratio, and Wavelength Ratio. Some of the primary factors, which may influence floodplain function for Roaring Brook, are discussed below: Report 6, which is included on pages 12 and 13 of Appendix A, contains the Phase I information for Floodplain and Planform changes.

Berms and Roads

An estimate of the percentage of the river corridor length along which berms, roads, railroad, or improved paths run parallel to the stream was estimated using information from maps, orthophotos, and the windshield survey. Reaches where berms, roads, railroads or improved paths were located along 20 percent or more of the river corridor were given impacted ratings of high. The following reaches on the main stem of Roaring Brook received an impact rating of high for berms and roads: T6.01, T6.03, T6.04, T6.07, and T6.08. One reach on the unnamed tributary, T6.03-S1.01, also had an impact rating of high for berms and roads. The remaining reaches, except for those on Rams Head Creek and the West Branch of Roaring Brook, had an impact rating of low.

River Corridor Development

The river corridor development parameter looks at whether developments within the river corridor are effectively decreasing the belt width. The percentage of the reach length with houses, fill, parking lots or other development within the river corridor was tabulated using maps, orthophotos, and knowledge from the windshield survey. Six of the 15 reaches (T6.01, T6.03, T6.03-S1.01, T6.04, T6.05-S1.02, and T6.07) had an impact rating of high for river corridor development.

Depositional Features

The 1990s orthophotos series (1:5000) as well as results from the windshield survey were used to evaluate depositional features within the Roaring Brook watershed. The presence of bars (mid channel or point bars) and deltas were noted in each of the study reaches. The ANR has included depositional features as a component of the Phase I analysis because these features are indicative of an increased sediment load and a high likelihood that the streambed is actively aggrading and/or undergoing lateral migration. An unvegetated bar indicates the bar has recently formed or is in the process of growing.

Six of the 15 reaches (T6.02, T6.04, T6.06, T6.07, T6.08, and T6.03-S1.01) had multiple depositional features present. Most of these reaches were on the main stem. In all cases the impact was rated as low or not significant.

Meander Migration

Orthophotos were used to evaluate areas where Roaring Brook and its tributaries have migrated, bifurcated, or avulsed¹. Current orthophotos from 1994 and historic orthophotos from 1976 were overlaid to compare the location of the river channel over time. The current and the historic orthophotos span a range of approximately 20 years. In addition to the orthophoto analysis, Phase 2 field surveys helped to verify channel avulsions and islands on the main stem of Roaring Brook. One reach on the main stem of Roaring Brook, T6.08, received an impact rating of high for meander migration, while eight reaches received an impact rating of low. Avulsions, often associated with debris jams, appeared to be the primary mechanism for lateral migration of the Roaring Brook. T6.05-S1.02, which flows through a wetland, appeared to have migrated by eroding its outer bank on meander bends.

¹ An avulsion is a change in planform resulting from a meander cut-off.

Meander Width and Wavelength

The 1990 series (1:5000) orthophotos in conjunction with topographic maps were used to determine the meander belt width and the meander wavelength for streams typed in Step 2.10 as C or E riffle-pool or ripple dune reference stream types (i.e. unconfined systems). The topographic maps were used to determine the valley direction, while the most current orthophoto series was used to provide the accurate location of channel meanders.

The meander belt width is the horizontal distance between to opposite, outside banks on fully developed meanders. The meander width ratio is calculated by dividing the average belt width for the reach by the bankfull width. The ANR Phase I protocol considers unconfined, gravel dominated streams with moderate to gentle gradients, which are in regime, to have belt widths in the range of 5 to 8 times the channel width. Half of the unconfined reaches (2 out of 4) fell outside of the range expected for channels which are in regime. Two of the study reaches (T6.03 and T6.03-SI.01) were rated as high impact for meander width ratio, and the other two reaches, which are on Roaring Brook, received an impact rating of not significant.

The reaches with the high impact ratings had meander width ratios less than 5. These low values may indicate the stream has become straighter and steeper, possibly resulting in degradation and loss of access to its floodplain. Field observations confirm that in several locations the Roaring Brook has been straightened, has incised, and/or has lost access to its floodplain.

The meander wavelength consists of two bend ways. The wavelength ratio is calculated by dividing the average wavelength by the bankfull channel width. Leopold 1994 and Williams 1985 (cited in Vermont Agency of Natural Resources, 2005a) have shown unconfined, gravel dominated streams in shallow-sloped valleys to have wavelengths in the range of 10 to 12 times the channel width. Three of the reaches resulted in a high impact rating for meander wavelength while one reach received an impact rating of low.

For two of these reaches (T6.03 and T6.03-S1.01), the wavelength ratio was one, suggesting the stream is currently straightened and will likely aggrade and become more sinuous.

2.2.7 Bed and Bank Windshield Survey

The dominant bed form, dominant bank material, bank erosion/bank height, and debris/ice jam potential were recorded during the windshield survey, and these results are summarized in on pages 14 and 15 of Appendix A. The dominant bed form and dominant bank material were previously discussed under Section 4.2, Stream Typing. The amount of bank erosion observed along a reach and the bank height were evaluated in conjunction with each other to provide a bank erosion impact rating. Bank erosion was rated as low or not significant for all of the reaches. The locations of bank erosion are illustrated in Figure 8.

Debris/Ice Jam Potential

Undersized culverts or bridges with spans less than the average channel width were the primary factors identified as potential for ice and debris jams. These structures, which are likely to cause constrictions during high flow events may result in lateral erosion or channel avulsions or may even endanger infrastructure. Two reaches received an impact rating of high for debris/ice-jam potential. Five reaches received an impact rating of low for debris/ice jam potential.

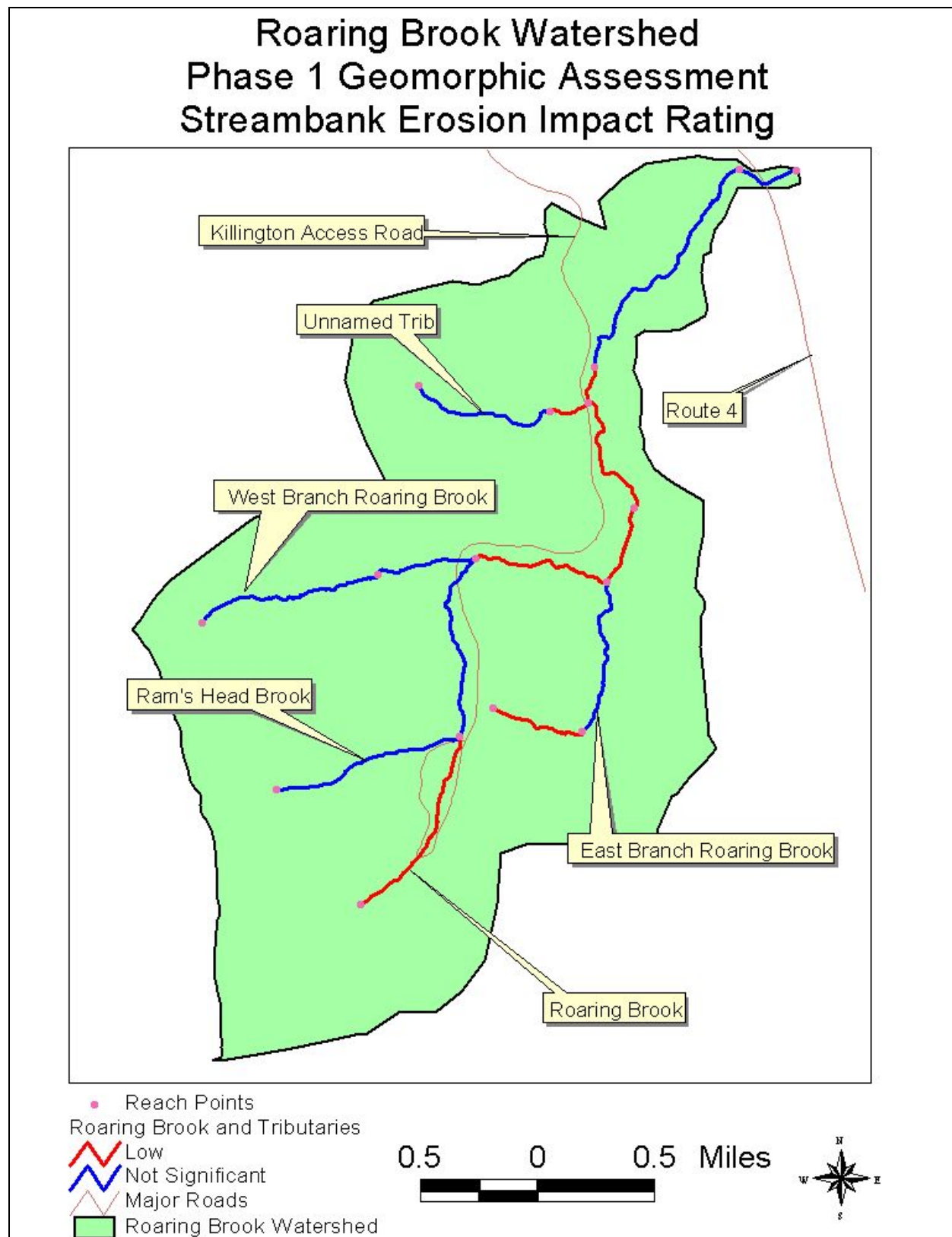


Figure 8: Streambank Erosion Impact Rating for Roaring Brook Watershed

2.3 PHASE I DATA ANALYSIS

2.3.1 Phase I Impact Scores

The Phase I evaluates parameters that may cause channel adjustment. These parameters are grouped into four major categories: land use, in-stream modifications, floodplain modifications, and bed and bank windshield survey. For each parameter, the maximum impact score for the entire watershed is 30 (15 reaches times impact score of 2). As shown below in Figure 9, the corridor land use parameters in the land use category received a high impact rating for the watershed. The parameters berms and roads, river corridor development and channel modifications also resulted in high scores.

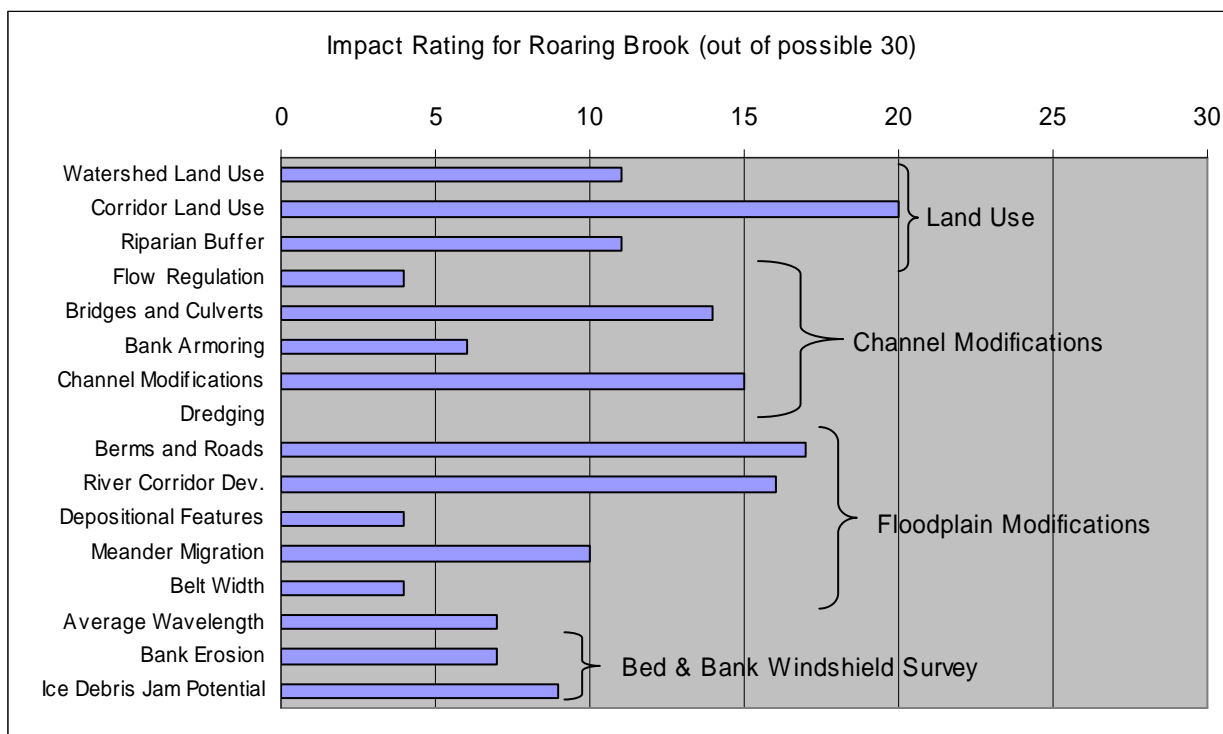


Figure 9: Impact Rating for Roaring Brook Watershed by Parameter and Category

The total impact scores for the Phase I assessment are provided on page 16 of Appendix A and the reach conditions are mapped below in Figure 10. The adjustment process and reach condition are summarized on page 17 of Appendix A.

Only one reach (T6.03) resulted in a reach condition of poor. This reach has undergone significant channel and floodplain modifications which may have resulted in a change in planform, profile, and dimension such that the stream is no longer in balance with the flow and sediment regime of its watershed.

Streams in fair condition are fully in adjustment and are experiencing major and rapid changes due to recent floodplain and channel modifications, land cover changes, and/or loss of riparian buffer. The majority of the unconfined stream reaches were in the fair category, while only one of the confined stream reaches (T6.08), located in the headwaters at the Killington ski resort was rated in fair condition by the Phase I DMS.

The streams in the good category have experienced some degree of human-induced change to their watershed, floodplain and/or channel and appeared to be undergoing only minor adjustments. None of the Phase I reaches resulted in a reach condition of good.

A reference reach has no significant channel or floodplain modifications and has a forested buffer, adjacent to the channel. In other words, these reaches are close to the natural condition. Streams in reference condition were found in the headwaters and were all A, B or F type streams (i.e. confined). None of the unconfined stream channels scored as a reference reach.

Figure 11 shows that the Phase I reach condition is generally related to proximity of roads or development. For the most part, the reaches rated as reference by the DMS were confined streams that require narrower belt widths. The reaches rated as fair or poor were typically unconfined streams located in the more highly developed areas of the watershed.

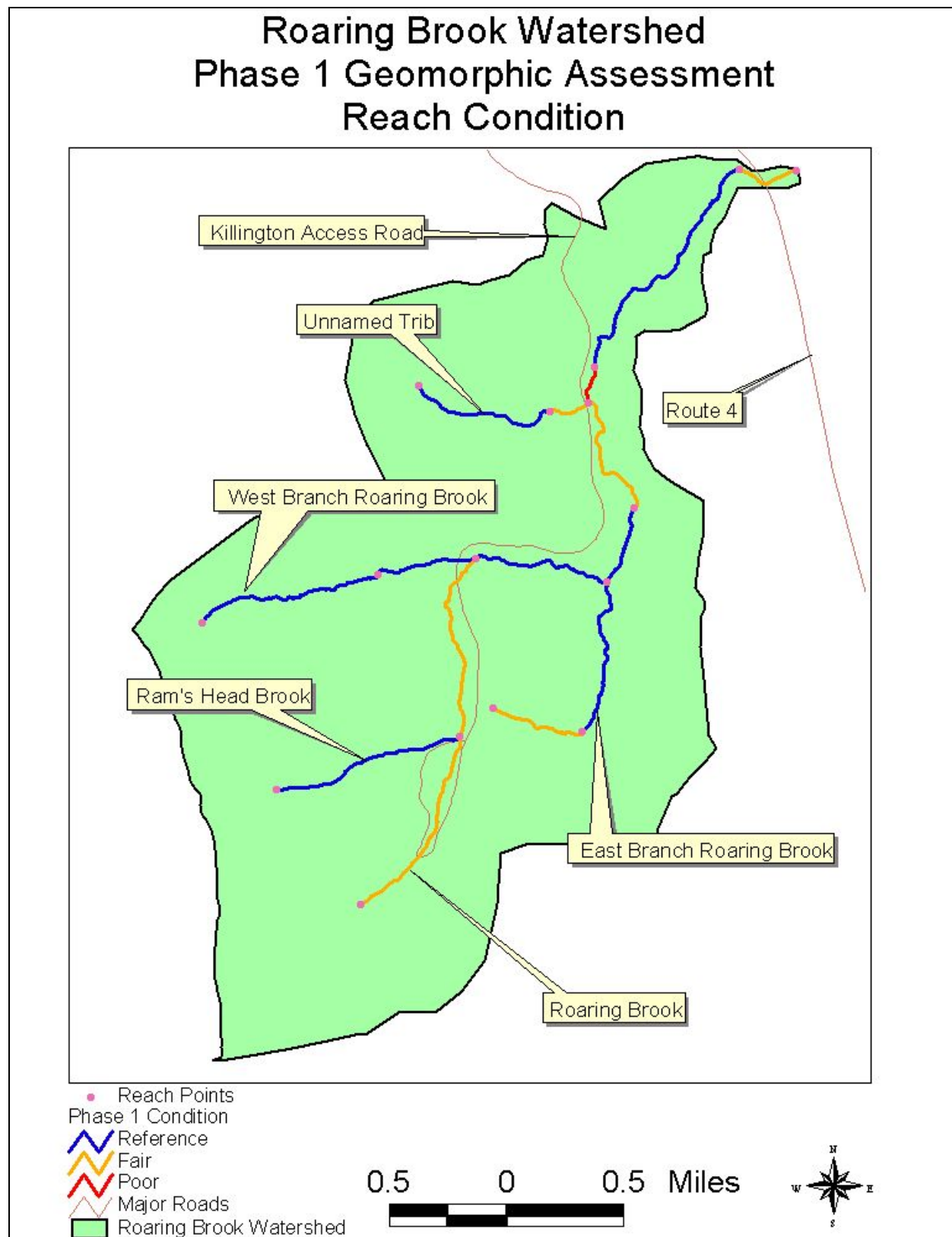


Figure 10: Reach Condition for Roaring Brook Watershed

Table 3: Reach Condition for Unconfined Streams				
Reach Number	Confinement	Total Impact Score	Watershed Size (square miles)	Reach Condition (from Phase I Database)
T6.01	BD ²	17	5.61	Fair
T6.03	VB ³	21	4.92	Poor
T6.03-S1.01	VB	18	0.63	Fair
T6.04	VB	14	4.25	Fair
T6.05-S1.02	NW ⁴	11	0.38	Fair
T6.07	NW	15	1.97	Fair

Table 4: Reach Condition for Confined Streams				
Reach Number	Confinement	Total Impact Score	Watershed Size (square miles)	Reach Condition (from Phase I Database)
T6.02	NC ⁵	7	5.58	Reference
T6.03-S1.02	NC	5	0.58	Reference
T6.05	SC ⁶	10	3.95	Reference
T6.05-S1.01	NC	7	0.75	Reference
T6.06	SC	9	2.96	Reference
T6.06-S1.01	NC	3	0.73	Reference
T6.06-S1.02	NC	1	0.56	Reference
T6.07-S1.01	NC	4	0.35	Reference
T6.08	SC	13	1.11	Fair

² Broad³ Very Broad⁴ Narrow⁵ Narrowly confined⁶ Semi-confined

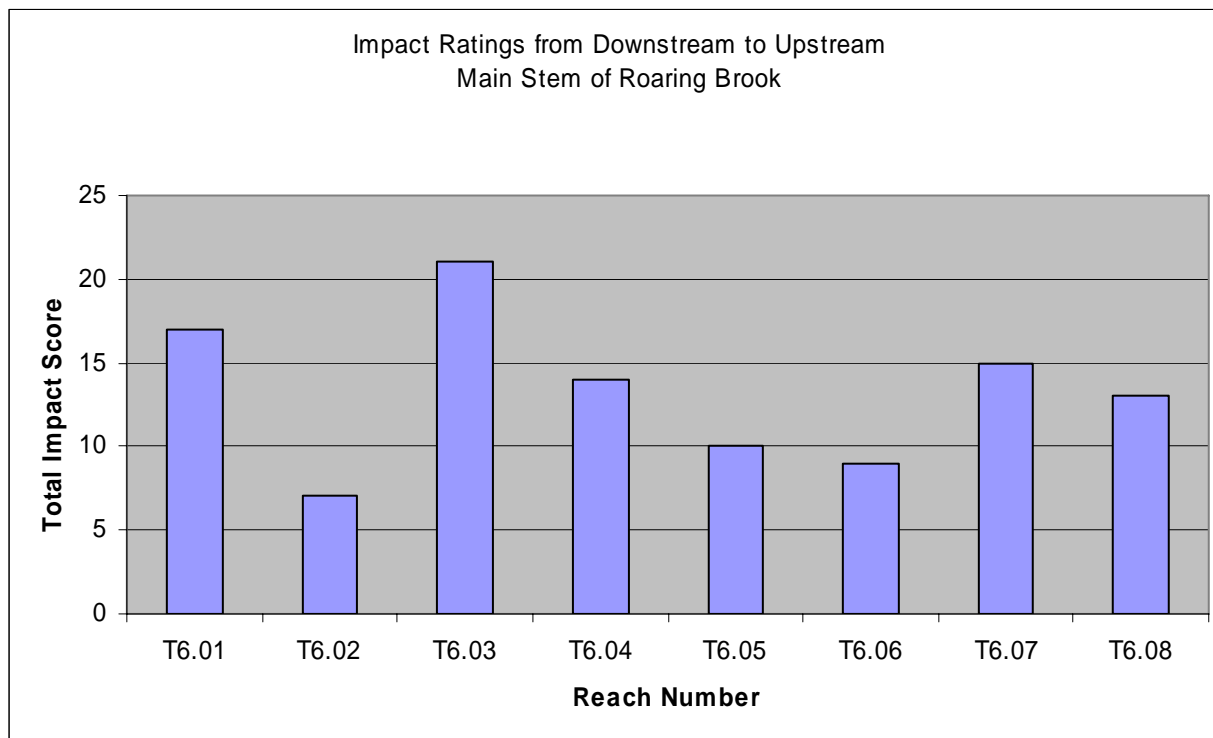


Figure 11: Impact Ratings from downstream to upstream on the main stem of Roaring Brook

2.3.2 Phase I Adjustment Processes

Page 17 of Appendix A, provides a summary of the primary adjustment processes that were predicted based on the Phase I Stream Geomorphic Assessment. The Phase I data suggest that most of the stream reaches are experiencing more than one type of channel adjustment process. Based on the Phase I data, degradation and planform adjustment were identified as the primary adjustment factors in the Roaring Brook watershed.

2.3.3 Phase I Reach Sensitivity

The stream sensitivity is automated in the DMS based on the existing stream type and condition of each reach. Highly sensitive reaches are more likely to be in adjustment, and are very sensitive to land use changes within the watershed. Seven of the 15 reaches resulted in a high sensitivity, while seven reaches had moderate sensitivity. One only reach, T6.06-S1.02, a high gradient stream with boulder substrate resulted in a sensitivity of very low.

SECTION 3: PHASE 2 STREAM GEOMORPHIC ASSESSMENT

3.1 PHASE 2 METHODOLOGY

The Phase 2 assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase 2 (Vermont Agency of Natural Resources 2005b). All assessment data were recorded on the Agency of Natural Resources Phase 2 data sheets, and were entered in to the ANR Stream Geomorphic Assessment data management system (DMS). The Phase I database was updated using the field data from the Phase 2 assessment.

3.1.1 Phase 2 Field Protocols

The ANR's Phase 2 stream geomorphic assessment protocol includes seven categories of investigation. These categories are as follows:

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

The parameters and protocols used for undertaking each of the above steps are outlined in the Phase 2 Handbook (Vermont Agency of Natural Resources 2005b). The entire length of each Phase 2 reach was walked to determine segment breaks. Bank erosion, grade control structures, bank revetments, debris jams, depositional features, stormwater inputs, flood chutes and other important features were mapped within all segments.

3.1.2 Phase 2 QA/QC Review

The DMS and the ArcView Shapefiles for the Roaring Brook Phase 2 study were submitted to Shannon Hill of the ANR for a quality assurance (QA/QC) review in October 2005. The Phase I DMS and ArcView shapefiles were updated by Michael Blazewicz and Pamela DeAndrea based on the Phase 2 field assessment work during the

Phase 2 QA/QC process in late September 2005. Mary Nealon and Michael Blazewicz provided QA/QC to critical components of the RGA data in October of 2005.

3.2 PHASE 2 RESULTS

The results of the Phase 2 study are summarized below by reach number, and reports from the Phase 2 database are included on pages I through I8 of Appendix B.

3.2.1 Reach T6.01

Reach T6.01 was segmented by BCE scientist due to a change in the Roaring Brook's slope, bedform, presence of grade control, and a change in the amount of historic channel modification.

Segment T6.01-A

Segment T6.01-A is the first reach in Roaring Brook. It begins at the confluence with the Ottauquechee River and continues upstream to a bridge crossing with VT Route 100. This reach drains the entire Roaring Brook watershed, an area of 5.6 square miles. The historic land use in segment T6.01-A has reverted back to forest and the reach currently has a healthy riparian buffer and a closed channel canopy. This segment is a "C" channel with a plane bed form. It has been significantly influenced by historic channel straightening and dredging and berming (windrowing) which occurred many years ago. The incision ratio of this reach, 1.35, indicated historic channel degradation. As shown below in Figure 12, the incision, along with the large berms and boulders that armor both banks, has eliminated floodplain access for most of this reach. Widening and planform adjustment also appears to have been limited by the bank armor. The straightness of the reach creates effective transport of sediments. Minor aggradation is occurring throughout much of the reach until the confluence of the Ottauquechee River, (Figure 13) where a large depositional feature exists.



Figure 12: T6.01-A was historically straightened and has become a plane bed stream. Note the high rock berm on the left side of the photograph that was used by a past landowner to prevent the river from accessing its floodplain.



Figure 13: Large depositional feature (delta) at the confluence of Roaring Brook and the Ottauquechee River.

Segment T6.01-B

Segment T6.01-B is also a “C” type channel, however with bedrock grade control at the downstream end and a more natural planform, this segment has retained its bedform as a step-pool system. Despite grade control at the lower end of this reach, there appears to have been some incision that has occurred. The incision ratio measured was 1.61. Minor aggradation and widening was also found to be occurring within this reach. Riparian conditions along the stream were generally excellent, with a closed riparian canopy (see Figure 14) except near the bridge crossing of VT Route 4.



Figure 14: Segment T6.01-B has a step-pool bedform and good riparian conditions.

3.2.2 Reach T6.02

Reach T6.02 is a very long reach (6321 feet) through a steep valley. The channel slope through this reach ranges from 5-8%. Although the reach has multiple islands associated with debris jams (and thus rated lowest in planform adjustment), the reach was found to

be overall in good geomorphic condition. T6.02 does not appear to be undergoing any major channel evolution process.

Riparian conditions along almost the entire reach were excellent. Although there was some noticeable deposition of fine sediments, the reach scored well in the rapid habitat assessment due to its many deep pools, abundant large woody debris, and healthy riparian corridor (Figure 15).

The exception to these conditions is found at the very upstream end of this reach, where, for 425 feet, the stream runs between two parking lots, has rip-rapped banks, and no riparian buffer.



Figure 15: T6.02 is a naturally wide, highly entrenched channel with excellent riparian conditions.

3.2.3 Reach T6.03

Reach T6.03 is a short reach (840 feet) that begins behind the Pickle Barrel restaurant where the valley wall of the Roaring Brook opens up and the stream becomes less

entrenched. This reach is the first reach that has been greatly affected by commercial development in the stream corridor and appears to have been historically straightened in some areas. Twenty-five to fifty percent of the banks have been armored with rock rip-rap and log revetments. The riparian buffer of both banks, which averages between 25 and 50 feet, has been significantly disturbed by human activities. Three stormwater outfalls empty into this reach. The combination of these human encroachments, historic channel straightening, and other effects have caused some major degradation to occur. An incision ratio of 1.6 was measured in the field. It appears that the stream is currently undergoing minor aggradation (fine particles made up 32% of the pebble count) and widening in response to these impacts (Figure 16).



Figure 16: Active aggradation and widening of Reach T6.03.

3.2.4 Reach T6.04

Reach T6.04 begins just above a culvert on Roaring Brook Road and continues upstream for 3206 feet until a change in confinement occurs near the lower portion of the

Killington golf course. This reach has also been impacted by historic channel straightening and floodplain encroachment. The current incision ratio was measured to be 1.8, indicating major historic degradation. There was some evidence of current widening as the river attempts to rebuild a new lower floodplain bench. However, it remains wide and shallow, and is a slightly entrenched “C” type channel with a weak riffle pool bedform (Figure 17). T6.04 is actively responding to sediment which is being stored in the form of point and side bars. One active flood chute and an island were noted along the reach indicating that the reach is also undergoing minor planform adjustment. This planform adjustment, however, is limited by the Killington Access Road and the Killington Golf Course which have encroached on the historic floodplain of this reach, effectively changing the valley width by cutting off access to westward channel planform migration. The current riparian corridor is dominated by commercial buildings on the left bank and residential buildings along the right valley wall. The left bank would benefit from riparian buffer restoration as it is dominated by only a 5-25 foot wide buffer. Three stormwater outfalls empty into this reach.



Figure 17: Typical cross-section along reach T6.04 with weak riffle-pool bedform. The brook has historically incised and is showing some evidence of channel widening.

3.2.5 Reach T6.05

Reach T6.05 begins at the lower end of the Killington Golf Course and continues upstream to the culvert at Ravine Road. Reach T6.05 has no major adjustment process occurring (see Figure 18). None the less, the cumulative evidence of minor degradation, aggradation, planform adjustment and widening showed that this reach is being affected by upstream activities and is only in fair geomorphic condition.



Figure 18: Reach T6.05 has no major adjustment processes occurring. It was likely cobble dominated by reference but is currently dominated by coarse and fine gravels.

Reach M6.05 had a relatively low incision ratio of 1.2 and was found to have remained, or have evolved back to a “B” channel. It retains a weak step-pool bedform that has high amounts of sand and fine gravel (37%) for a stream with a 3.7% slope. The major riparian land use in this reach is the Killington Golf Course which dominates the left corridor.

3.2.6 Reach T6.06

Roaring Brook reach T6.06 begins at a tributary above Ravine Road and continues upstream for 3284 feet to the intersection of another tributary below the Killington Access Road. Riparian conditions within the reach varied. Buffer width ranged from over 100 feet to zero feet depending on the proximity to the golf course, or development on the Killington Access Road. A large waterfall at the upstream end and bedrock within the mid-segment are providing grade control to the reach.

Historic degradation, floodplain encroachment, and the introduction of sediments not formed from within the stream channel (allochthonous), have affected this reach greatly. It was found to be a weak step-pool channel that is being impacted by large amounts of sediment (41% of substrate count). There were multiple mid-channel and side bars through the reach. The reach appears to be actively aggrading and widening as it looks to regain access to its floodplain and transport and store the abundant allochthonous sediments that are within the channel (Figure 19).

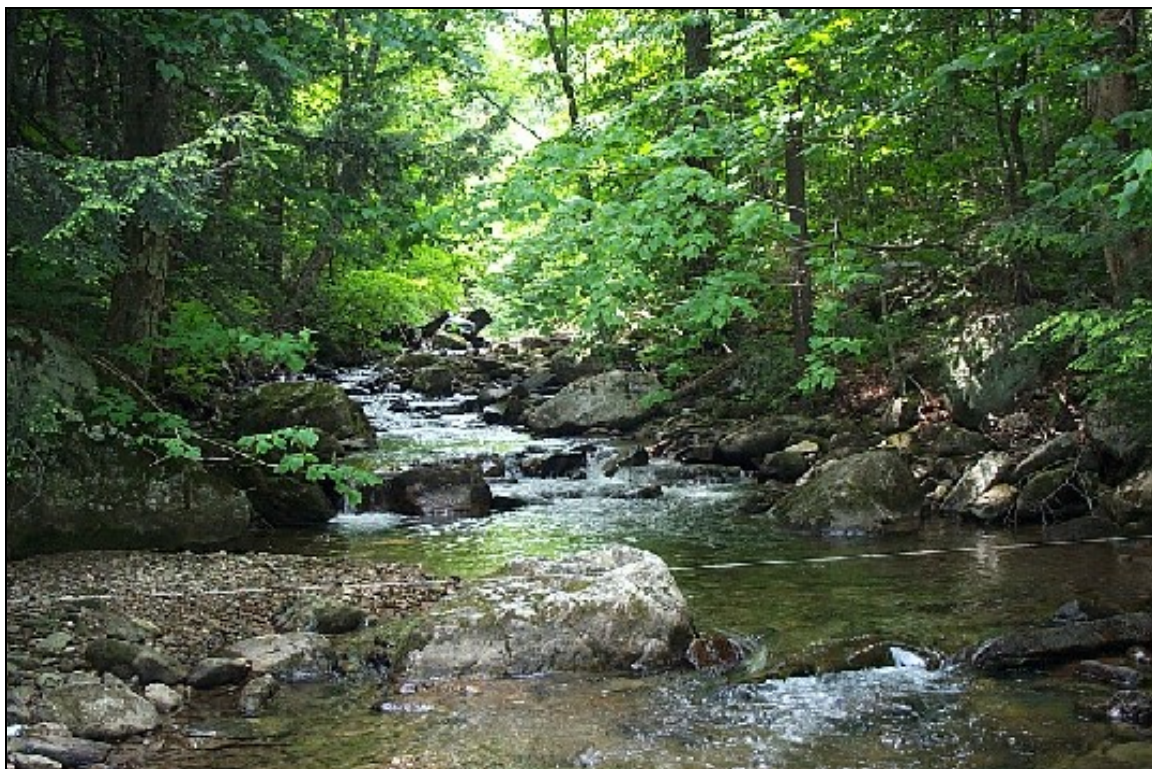


Figure 19: Typical cross-section along reach T6.06. Deposits of gravel (left side of photo), are common throughout this reach.

3.2.7 Reach T6.07

Roaring Brook reach T6.07 begins below the Killington Access Road and continues upstream to the confluence with a tributary above the Ram's Head parking lot. Reach T6.07 was found to be in extreme adjustment due to aggradation, and was also undergoing major widening and minor planform adjustments. An incision ratio of 1.35 indicates that the stream may have historically degraded. Currently 40% of the bottom substrates are comprised of sand and fine gravels (Figure 20), creating fair habitat. It was moderately entrenched "B" type channel that has multiple, mid, point, side, and diagonal bars as a result of increased allochthonous sediment in the channel (Figure 21). In general, there is a healthy riparian corridor along the reach, except at its upper end where a major parking lot for Killington Ski Area (Ram's Head) encroaches on the river corridor. The parking lot is bermed along the brook and stormwater is channeled down slope into a stormwater retention basin that then drains into the stream. This is one of two stormwater outfalls observed on this reach that is causing sedimentation of Roaring Brook.



Figure 20: Major sediment buildup at a debris jam along T6.07.



Figure 21: Typical cross-section along reach T6.07. Note the abundant fine sediment that has filled in much of the stream bottom. Habitat in this reach was rated as fair due to excessive sediment and lack of deep pools.

3.2.8 Reach T6.08

Reach T6.08 is the highest reach assessed in the Roaring Brook. It begins above the Ram's Head parking lot at elevation 2250 feet and continues under the Killington base lodge upstream to elevation 2640 feet. T6.08 drains a watershed area of only 1.1 square miles. Like most reaches surveyed on the Roaring Brook, T6.08 is slightly incised with an incision ratio of 1.31 (see Figure 22). As shown in Figure 23, the channel is actively adjusting through major aggradation and widening. This step-pool system has one mid channel bar and several side bars indicating abundant sediment in the channel. Habitat within reach T6.08 has been greatly impacted by stormwater runoff. Seven stormwater outfalls drain into this reach bringing allochthonous sediment into the system. Wash off from the Killington Access Road was noted to be a significant contributor of sediment to the upper Roaring Brook watershed. Large gullies, draining road runoff, were noted along Reach T6.08, and pools were filled in with road materials.



Figure 22: Typical cross-section along reach T6.08.



Figure 23: Abundant road gravels and sediment are entering the Roaring Brook system at Reach T6.08.

3.3 GEOMORPHIC CONDITION SUMMARY

Understanding the response to changes in the sediment regime, hydrology, and the channel area and planform of the Roaring Brook is highly useful for informing restoration efforts.

3.3.1 Channel Management History

Natural and anthropogenic impacts alter the delicate equilibrium of sediment and discharge in natural stream systems and set in motion a series of morphological responses (e.g. incision, widening, aggradation, and/or planform change) as the channel tries to reestablish equilibrium. Small to moderate changes in slope, discharge or sediment supply can alter sediment transport capacity and channel geometry; while large changes can transform stream types of entire reaches (Ryan 2001). Human-induced practices that have contributed to stream instability within the Roaring Brook watershed include:

- Channelization
- Berming
- Alteration of woody riparian vegetation
- Flood plain encroachments
- Urbanization (increase stormwater runoff)
- Poor road maintenance practice and infrastructure installation (Figure 24)
- Loss of wetlands

These anthropogenic practices have altered the delicate balance between water and sediment discharges. Channel morphologic responses to these practices contribute to channel bed degradation and/or aggradation that further create unstable channels.

These morphologic changes tend to migrate both upstream and downstream contributing to system-wide instability. (Ryan 2001)



Figure 24: Undersized culverts, like this one on reach T6.08, disrupt the sediment transport capacity of the stream and often lead to both upstream and downstream destabilization.

3.3.2 Reach Condition

The reach condition is determined using the RGA protocol, and is based on the degree of departure of the channel from its reference stream type (Vermont Agency of Natural Resources 2005b). The reference stream type for each of the Phase 2 reaches was previously identified in Figure 6. Of the 9 segments where Phase 2 RGA's were conducted on Roaring Brook, seven segments rated in the fair category and only two segments rated in the good category (Table 5). There does not appear to be any correlation between location in the watershed and condition of the reach. Instead, stream condition in the Roaring Brook seems more related to corridor land use (Figure 25).

Table 5. Phase 2 Reach Condition for Roaring Brook			
Segment Number	Existing Stream Type	RGA Score	Reach Condition
T6.01-A	C3b	0.55	Fair
T6.01-B	C3b	0.61	Fair
T6.02	F3b	0.65	Good
T6.03	C4b	0.58	Fair
T6.04	C4	0.65	Good
T6.05	B4	0.64	Fair
T6.06	B4a	0.53	Fair
T6.07	B4a	0.40	Fair
T6.08	B4a	0.53	Fair

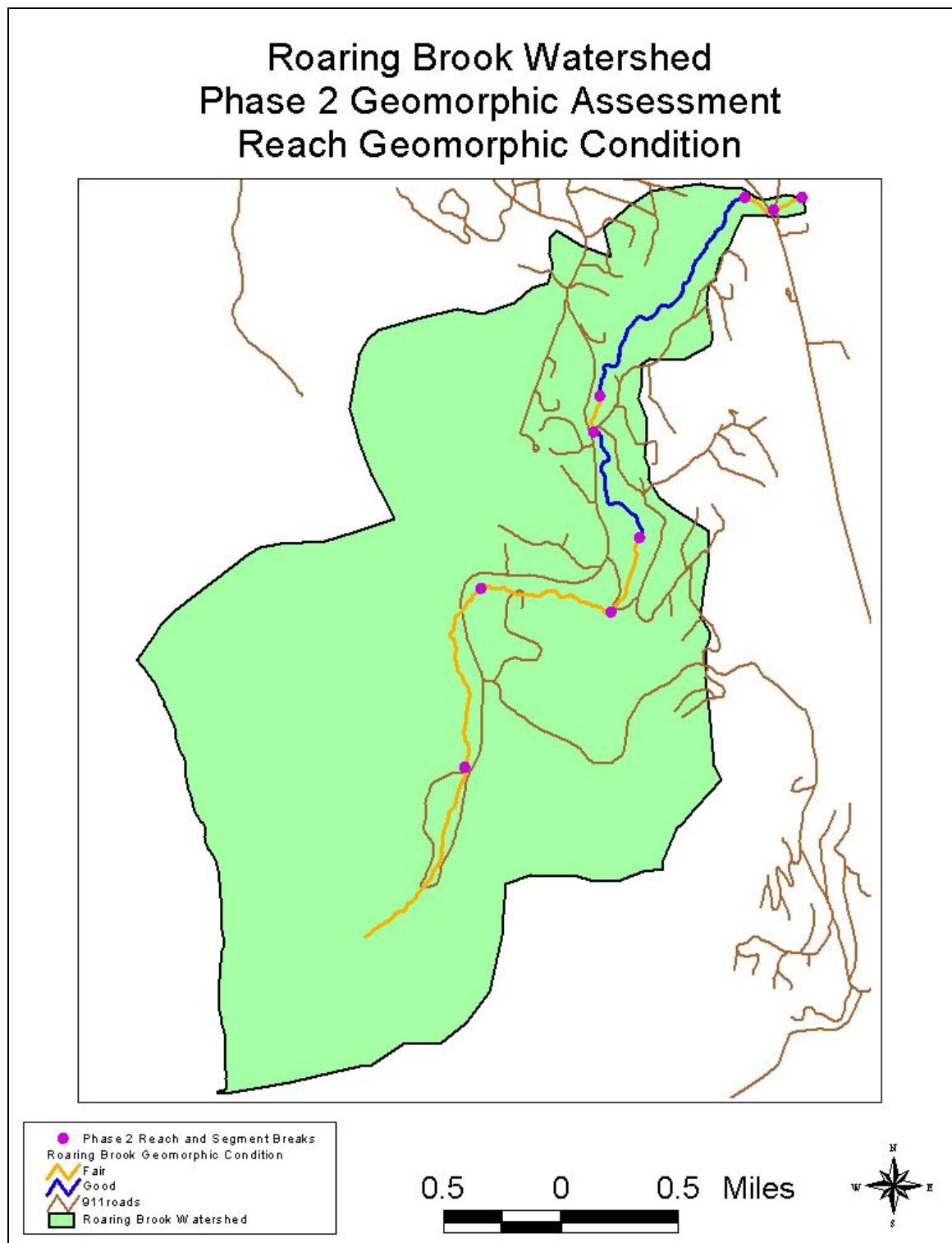


Figure 25: Phase 2 Geomorphic Condition in the Roaring Brook Watershed.

3.3.3 Channel Evolution

The reach condition ratings of Roaring Brook indicate that many of the reaches are actively in a process of minor or major geomorphic adjustment. The most common adjustment processes seem to be historic degradation, active aggradation, planform change, and widening.

Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform is the channel shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other adjustment processes such as aggradation and widening. Channel widening occurs when streamflows are contained in a channel as a result of degradation or floodplain encroachment, or when sediments overwhelm the stream channel and the energy is concentrated into both banks.

The quantity of sediment and sediment size is proportional to the slope of the stream and the amount of water the stream is discharging. A change in any one of these variables will result in a corresponding change in the other variables to achieve equilibrium. A large change in one of these variables will be followed by channel evolution as the stream works to regain equilibrium through incision, aggradation, widening, or planform change. According to ANR's F-stage channel evolution model (Appendix C) the stages of channel evolution include:

- A pre-disturbance period
- Incision – Channel degradation and headcutting
- Aggradation and channel widening
- The gradual formation of a stable channel with access to its flood plain at a lower base of elevation.

In many areas of the Roaring Brook, this channel evolution process is occurring in response to changes in its sediment, slope, and/or discharge associated with the human influences on the watershed. Table 6 refers to the channel evolution of each study reach.

Table 6. Stream Type and Channel Evolution Stage						
Segment Number	Entrenchment Ratio	Width to Depth Ratio	Reference Stream Type	Existing Stream Type	Channel Evolution Stage	Major Adjustment Process
T6.01-A	5.1	16	C	C3b	III	Aggradation Widening Planform
T6.01-B	4.1	13	C	C3b	III	Aggradation Widening Planform
T6.02	1.1	30	F	F3a	I	Planform
T6.03	4.9	16	C	C4b	III	Aggradation Widening
T6.04	9.8	15	C	C4	III	Widening Planform
T6.05	2.2	19	B	B4	III	Aggradation Widening Planform
T6.06	1.8	16	B	B4a	III	Aggradation Widening Planform
T6.07	2.2	25	B	B4a	III	Aggradation Widening
T6.08	2.1	19	B	B4a	III	Aggradation Widening
Red bold lettering - denotes extreme adjustment process Bold Black lettering – denotes major adjustment process Black lettering (no bold) – denotes minor adjustment process						

Much of the Roaring Brook watershed has retained its natural character, however, many segments have been impaired by floodplain encroachments, undersized structures, and changes in hydrology and sediment associated with stormwater. In terms of the channel evolution model, the Roaring Brook main stem generally appears to be in stage III of the “F” channel evolution model as summarized on page 19 of Appendix B. The channel has undergone historic degradation and widening. All of the cross sections on study reaches were found to be incised. The incision ratio through most of the Roaring Brook ranged

form I.2 to I.8. The incision ratio 31.8 for Reach T6.02 is naturally high due to its “F” stream type). The width to depth ratio, particularly in the upper watershed indicated the channel was over wide. These findings are in agreement with the Center for Watershed Protection et al. (1999) study that found Roaring Brook to be in a transitional phase with most of the stress manifesting as channel widening.

Additionally, much of the Roaring Brook watershed appears to be undergoing a second evolutionary process (D-stage channel evolution) associated with excess allochthonous sediment that is being washed into the stream channel from gravel parking lots, roads, and development. This is especially evident in reaches 6.06, 6.07 and 6.08 where aggradation is a major channel adjustment process (Table 6).

3.3.4 Stream Sensitivity

Sensitivity refers to the likelihood that a stream will respond to a watershed or local disturbance or stressor, such as; floodplain encroachment, channel straightening or armoring, changes in sediment or flow inputs, and/or disturbance of riparian vegetation. Assigning a sensitivity rating to a stream is done with the assumption that some streams, due to their setting and location within the watershed, are more likely to be in an episodic, rapid, and/or measurable state of change or adjustment. A stream’s inherent sensitivity may be heightened when human activities alter the setting characteristics that influence a stream’s natural adjustment rate including: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially those undergoing degradation or aggradation, may become acutely sensitive (Vermont Agency of Natural Resources 2005b).

Figure 26 is a map presenting the existing stream types found in the Roaring Brook watershed. The stream sensitivity of these reaches, generalized according to stream type and geomorphic condition per the ANR protocol, is depicted in Table 7 and in Figure 27. Reach T6.02 and T6.03 were rated as having very high sensitivity, while the remaining Phase 2 segments were high sensitivity.

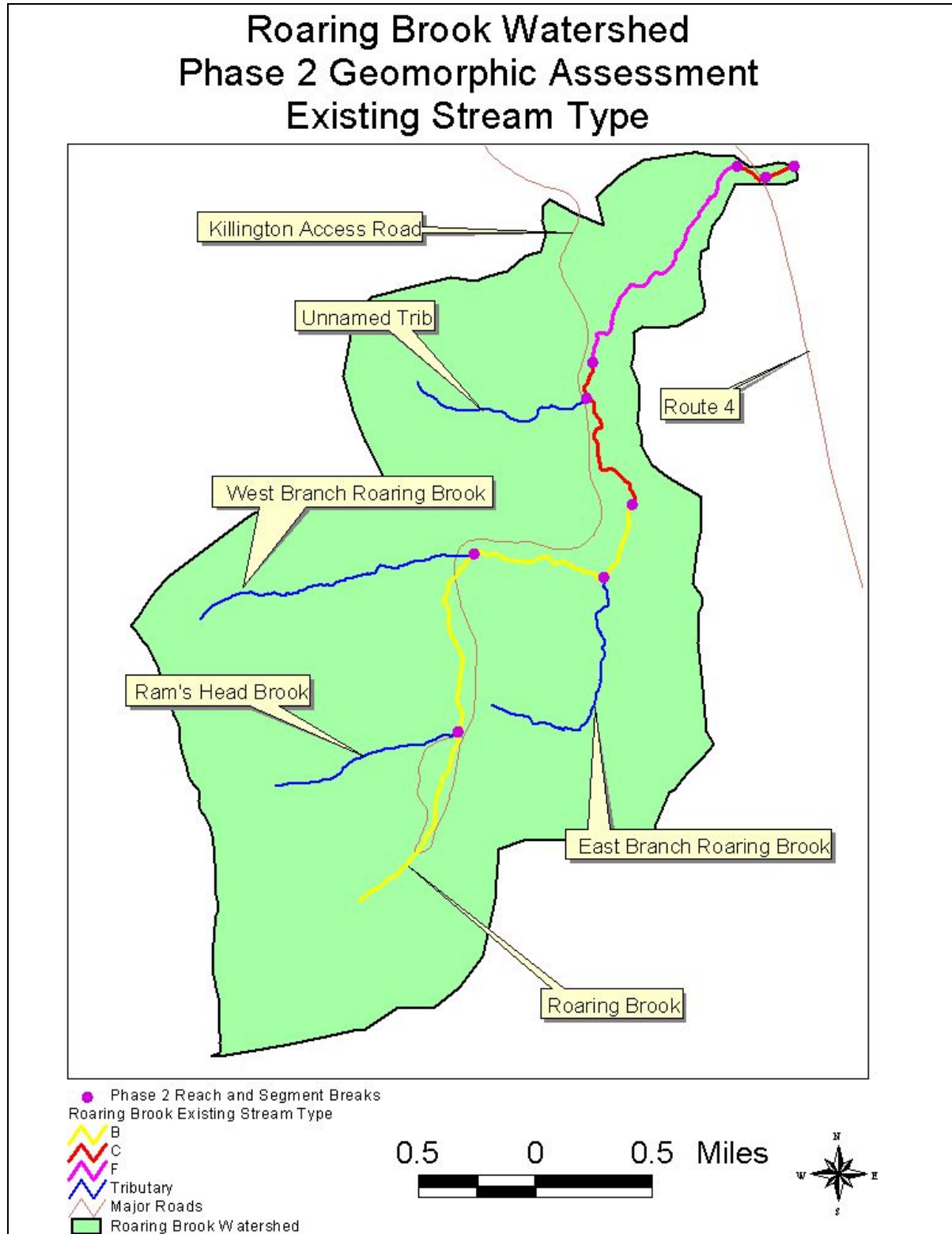


Figure 26: Phase 2 Stream Types in the Roaring Brook Watershed.

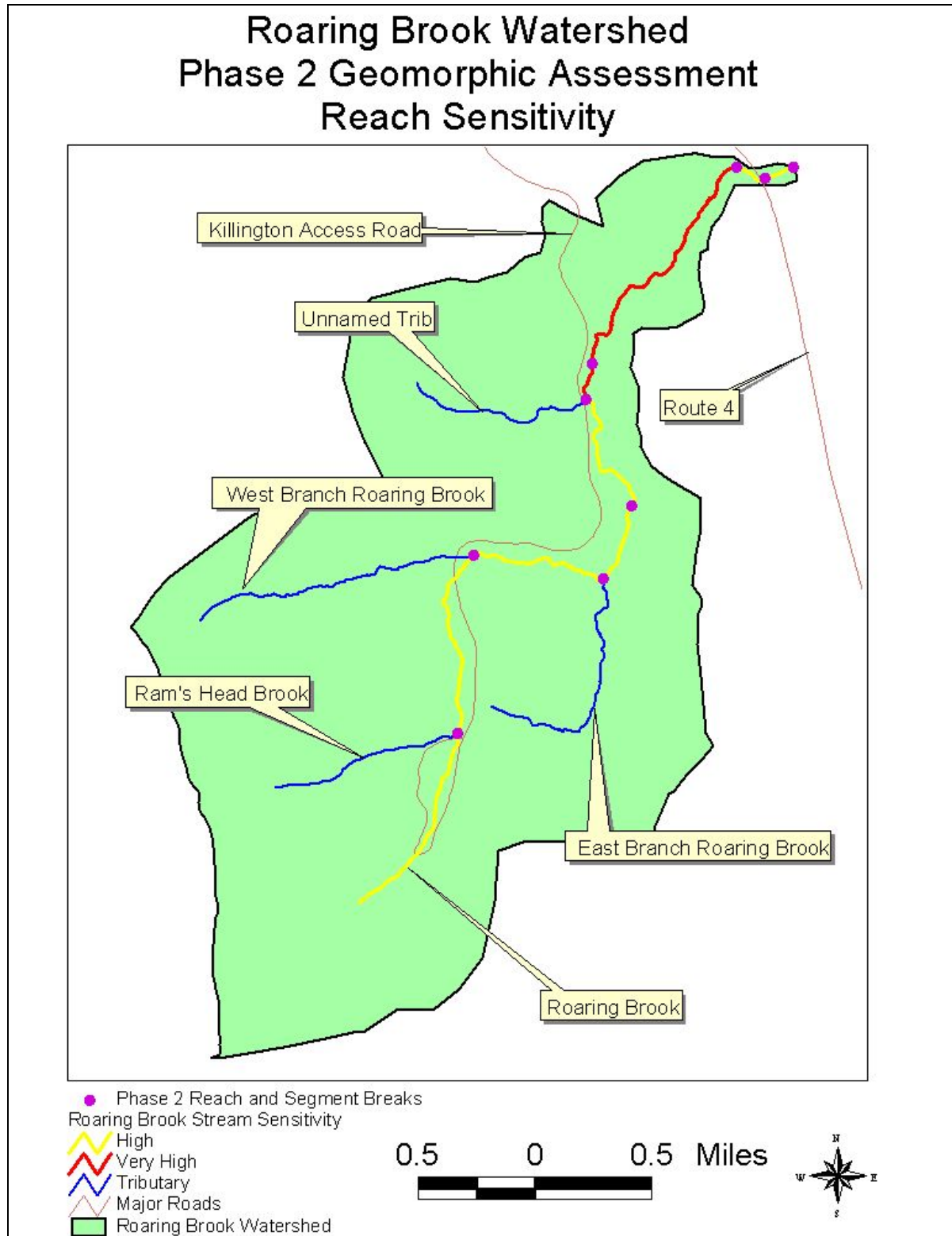


Figure 27: Phase 2 Stream Sensitivity in the Roaring Brook Watershed

Table 7. Stream Sensitivity for Phase 2 Reaches				
Segment Number	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
T6.01-A	C3b	No	Fair	High
T6.01-B	C3b	No	Fair	High
T6.02	F3a	No	Good	Very High
T6.03	C4b	No	Fair	Very High
T6.04	C4	No	Good	High
T6.05	B4	No	Fair	High
T6.06	B3	No	Fair	High
T6.07	B4	No	Fair	High
T6.08	B4	No	Fair	High

3.4 PHASE 2 HABITAT EVALUATION

The Rapid Habitat Assessment (RHA) is used to evaluate the physical components of a stream (the channel bed, banks, and riparian vegetation) and how the physical condition of the stream affects aquatic life. The results can be used to compare physical habitat condition between sites, streams, or watersheds, and also serve as a management tool in watershed planning or similar land-use planning.

The results of the Rapid Habitat Assessment (RHA) are provided on page 20 of Appendix B. Table 8 below shows a comparison of the habitat condition based on the RHA and the geomorphic condition based on the Rapid Geomorphic Assessment (RGA). For four of the nine segments, both the RHA and the RGA resulted in ratings of fair. Two segments shared an RHA and RGA rating of good. Three segments, T6.01-A, T6.01-B and T6.06 both had good RHA results despite fair RGA ratings (Figure 28). In general the study reaches lacked strong bedform features (several were plane bed) and the diversity of habitat features that this brings. Additionally, sediment contributions of sand and fine gravel from the watershed, as well as

localized contributions from banks that were eroding as the river adjusts, have created an embedded river bottom along much of the study area (Figure 26). Many reaches had significant intrusion into their river corridor and lacked adequate riparian buffers. Overall, the RHA score was similar to the RGA score, implying that the ecological health of the Roaring Brook is intricately tied to the geomorphic condition of the stream.

Table 8. Comparison of RHA and RGA for Phase 2 Reaches				
Segment Number	RGA Score	RHA Score	Rating RGA	Rating RHA
M6.01-A	0.55	0.65	Fair	Good
M6.01-B	0.61	0.81	Fair	Good
M6.02	0.65	0.72	Good	Good
M6.03	0.58	0.51	Fair	Fair
M6.04	0.65	0.68	Good	Good
M6.05	0.64	0.62	Fair	Fair
M6.06	0.53	0.69	Fair	Good
M6.07	0.40	0.47	Fair	Fair
M6.08	0.53	0.60	Fair	Fair



Figure 26: Reach T6.07 rated “fair” for habitat. The reach lacked in-stream woody habitat, riparian vegetation, a riffle-pool system due to historic straightening, and was heavily embedded with fine particles of sand.



Figure 27: Reach T6.02 rated “good” for habitat. The reach had an abundance of in-stream woody habitat, excellent riparian vegetation and riparian buffer, a diversity of substrates, and a diversity of velocity and depth patterns including many deep pools.

SECTION 4: OUTREACH AND EDUCATION

Prior to the start of the Roaring Brook watershed assessment, Bear Creek Environmental met with John Cole of Killington Resort as well as Jennifer Callahan, DEC Stormwater, and Shannon Hill, ANR River Management, to generate a discussion of the project, listen to Killington's concerns and input, and to provide Killington with an introduction to the Geomorphic Assessment protocol.

SECTION 5: RECOMMENDATIONS

Based on the 2005 Phase I and 2 Assessments of the Roaring Brook watershed, Bear Creek Environmental recommends the following:

1. Implement stormwater and sediment control efforts whenever possible. Sedimentation of Roaring Brook, particularly from gravel parking lots and drainage swales along the Killington Access Road, could be reduced through better road maintenance and stormwater treatment and retention.
2. The Town of Killington should consider adopting a zone ordinance to limit further floodplain encroachment and to protect riparian buffers.
3. The reference stream type for much of the main stem of the Roaring Brook within the Killington town line appears to be "C". C type stream channels are highly dependent upon vegetation for stability. For this reason, the establishment and protection of vegetated buffers should be high priority in restoration planning and design work. Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion.
4. Develop and implement a river corridor protection plan. The implementation of a river corridor protection plan goes a long way towards reducing fluvial erosion hazards and minimizing land use conflicts. As a starting point, fluvial geomorphic relationships can be used to determine the width of a river corridor which is needed to accommodate the meander geometry under equilibrium conditions. As discussed in the Defining River Corridors Fact Sheet, prepared by the Vermont DEC River Management Programs, rivers with gentle gradients and narrow to broad valleys require a meander belt width of 6 times the channel width to accommodate the meanders. At the lowest end of the Phase 2 study area, this equates to a meander belt width of 144 feet (or approximately 72 feet on each side of the meander center line). The River Corridor Plan would also provide some structure for identifying river restoration and corridor protection project types and effective approaches.

5. Conduct a bridge and culvert survey following ANR protocols to gather specific information about undersized structures in the Roaring Brook watershed. Replace undersized structures when opportunities and/or funding become available.
6. Carefully consider the stream type, evolution stage, and sensitivity before conducting any active geomorphic restoration projects in the main channel of Roaring Brook.

SECTION 6: REFERENCES

- Center for Watershed Protection; Aquafor Beech, Ltd.; Lori Barg; and Robert Kort. 1999. Watershed Hydrology Protection and Flood Mitigation Project: Phase II- Technical Analysis, Stream Geomorphic Assessment, Final Report, September 1999.
- NCDC. 2005. National Climatic Data Center website. <http://www.ncdc.noaa.gov/oa/ncdc.html>
- Ryan, Jim. 2002. Stream stability assessment of Rutland County, Vermont. Washington, Vermont.
- Schumm, S.A. 1977. The fluvial system. John Wiley and Sons, New York.
- Schumm, S.A. 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publication (ISBN-0918664-56-5), Littleton, CO.
- United States Department of Agriculture. 1986. Urban Hydrology for Small Watersheds. Soil Conservation Service, Engineering Division, Technical Release 55. Washington, D.C.
- Van Diver, Bradford B. 1987. Roadside Geology of Vermont and New Hampshire. Mountain Press Publishing. Missoula, Montana.
- Vermont Agency of Natural Resources. 2005a. Vermont Stream Geomorphic Assessment Phase I Handbook. Watershed Assessment Using Maps, Existing Data, and Windshield Surveys. Waterbury, Vermont
- Vermont Agency of Natural Resources. 2005b. Vermont Stream Geomorphic Assessment Phase 2 Handbook. Rapid Stream Assessment, Field Protocols. Waterbury, Vermont
- Vermont Agency of Natural Resources. (Not dated). Defining River Corridors Fact Sheet. Vermont DEC River Management Program. Waterbury, Vermont.
- Vermont Center for Geographic Information, Inc. (VCGI). 2003. Vermont Hydrography Dataset. Waterbury, Vermont.
- Vermont Water Quality Division. 2001. Vermont Regional Hydraulic Geometry Curves. Waterbury, Vermont.

APPENDIX 3

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
 Killington, Vermont
 Bridge & Culvert Summary
 VHB
 September 16, 2010

Culvert ID	Geomorphic and Fish Data Passage Parameter				Culvert Replacement Priority	Killington Resort Owned?
	Upstream Sediment Obstruction	2ft. or Greater Outflow Drop	Downstream Banks Substantially Higher Than Upstream Banks	High Downstream Bank Erosion		
C-01	<input checked="" type="checkbox"/>	----	<input checked="" type="checkbox"/>	----	High	Yes
C-02	----	----	<input checked="" type="checkbox"/>	----	Low	Yes
C-03	----	----	----	----	None	Yes
C-04	----	----	<input checked="" type="checkbox"/>	----	Low	Yes
C-05	----	----	----	----	None	Yes
C-06	----	----	----	----	None	Yes
C-07	----	<input checked="" type="checkbox"/>	----	----	Moderate	Yes
C-08	----	----	----	----	None	No
C-09	----	----	----	----	None	Yes
C-10	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	----	High	No
C-11	----	----	----	----	None	No
C-12	----	----	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	High	Yes
C-13	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-14	----	----	<input checked="" type="checkbox"/>	----	Low	No
C-15	----	----	----	----	None	No
C-16	----	<input checked="" type="checkbox"/>	----	<input checked="" type="checkbox"/>	High	Yes
C-17	----	----	----	----	None	No
C-18	<input checked="" type="checkbox"/>	----	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	High	Yes
C-19	----	<input checked="" type="checkbox"/>	----	----	Moderate	No
C-20	----	----	----	----	None	Yes
C-21	----	----	----	----	None	No
C-22	----	----	----	----	None	No
C-23	----	----	<input checked="" type="checkbox"/>	----	Low	No
C-24	----	----	<input checked="" type="checkbox"/>	----	Low	Yes
C-25	----	----	----	----	None	Yes
C-26	----	----	----	----	None	Yes
C-27	----	----	----	----	None	Yes
C-28	----	----	----	----	None	Yes
C-29	----	<input checked="" type="checkbox"/>	----	----	Moderate	Yes
C-30	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-31	----	----	----	----	None	Yes
C-32	----	----	----	----	None	Yes
C-33	----	----	----	----	None	Yes
C-34	<input checked="" type="checkbox"/>	----	----	----	Moderate	No
C-35	<input checked="" type="checkbox"/>	----	----	----	Moderate	No
C-36	<input checked="" type="checkbox"/>	----	----	----	Moderate	No
C-37	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-38	----	----	----	----	None	Yes
C-39	----	----	----	----	None	Yes
C-40	----	----	----	----	None	No
C-41	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-42	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-43	----	----	----	----	None	Yes
C-44	----	----	----	----	None	Yes
C-45	----	----	----	----	None	Yes
C-46	----	----	----	<input checked="" type="checkbox"/>	Low	Yes
C-47	<input checked="" type="checkbox"/>	----	----	----	Moderate	Yes
C-48	<input checked="" type="checkbox"/>	----	----	----	Moderate	No
C-49	----	----	<input checked="" type="checkbox"/>	----	Low	No
C-50	----	<input checked="" type="checkbox"/>	----	----	Moderate	No

Culvert ID	Geomorphic and Fish Data Passage Parameter				Culvert Replacement Priority	Killington Resort Owned?
	Upstream Sediment Obstruction	2ft. or Greater Outflow Drop	Downstream Banks Substantially Higher Than Upstream Banks	High Downstream Bank Erosion		
C-51	-----	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	-----	High	No
C-52	-----	-----	-----	-----	None	Yes
C-53	-----	-----	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	High	Yes
C-54	<input checked="" type="checkbox"/>	-----	<input checked="" type="checkbox"/>	-----	High	No
C-55	<input checked="" type="checkbox"/>	-----	-----	<input checked="" type="checkbox"/>	High	No
C-56	<input checked="" type="checkbox"/>	-----	<input checked="" type="checkbox"/>	-----	High	No
C-57	<input checked="" type="checkbox"/>	-----	-----	-----	Moderate	No
C-58	<input checked="" type="checkbox"/>	-----	-----	-----	Moderate	No
C-59	<input checked="" type="checkbox"/>	-----	<input checked="" type="checkbox"/>	-----	High	No
C-60	-----	-----	<input checked="" type="checkbox"/>	-----	Low	Yes
C-61	-----	-----	<input checked="" type="checkbox"/>	-----	Low	Yes
C-62	-----	-----	-----	-----	None	Yes
C-63	-----	-----	-----	-----	None	Yes
C-64	-----	-----	-----	-----	None	Yes
C-65	-----	<input checked="" type="checkbox"/>	-----	<input checked="" type="checkbox"/>	High	Yes
C-66	-----	-----	-----	-----	None	Yes
C-67	-----	-----	-----	-----	None	Yes
C-68	-----	-----	-----	-----	None	No
C-69	-----	-----	-----	-----	None	Yes
C-70	-----	-----	-----	-----	None	Yes
C-71	-----	-----	-----	-----	None	Yes
C-72	-----	-----	<input checked="" type="checkbox"/>	-----	Low	Yes
C-73	-----	-----	-----	-----	None	Yes
C-74	<input checked="" type="checkbox"/>	-----	<input checked="" type="checkbox"/>	-----	High	No
C-75	-----	-----	-----	-----	None	No
C-76	-----	-----	-----	-----	None	Yes
C-77	-----	-----	-----	<input checked="" type="checkbox"/>	Low	No
C-78	-----	-----	-----	-----	None	No
C-79	-----	-----	-----	-----	None	Yes
C-80	-----	-----	-----	-----	None	Yes
C-81	<input checked="" type="checkbox"/>	-----	-----	<input checked="" type="checkbox"/>	High	Yes
C-82	-----	<input checked="" type="checkbox"/>	-----	-----	Moderate	No
C-83	-----	-----	-----	-----	None	Yes
C-84	-----	-----	<input checked="" type="checkbox"/>	-----	Low	Yes
C-85	-----	<input checked="" type="checkbox"/>	-----	-----	Moderate	No



Culvert C-01



Culvert C-10



Culvert C-12



Culvert C-16



Culvert C-18



Culvert C-51



Culvert C-53



Culvert C-54



Culvert C-55



Culvert C-56



Culvert C-59



Culvert C-65



Culvert C-74



Culvert C-81

Roaring Brook and East Branch of Roaring Brook - WQRP
Background Baseflow Chemistry 2005
Station Summary by Metric Sampled

Average pH (s.u.)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	7.34	7.53	7.60	7.44	7.66	7.53

Average Alkalinity (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	23.0	28.7	47.3	46.8	51.0	53.6

Average Chloride (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	2.0	42.3	26.2	43.2	46.3	72.8

Average NO ₃ (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	0.26	0.50	0.19	0.22	0.28	0.12

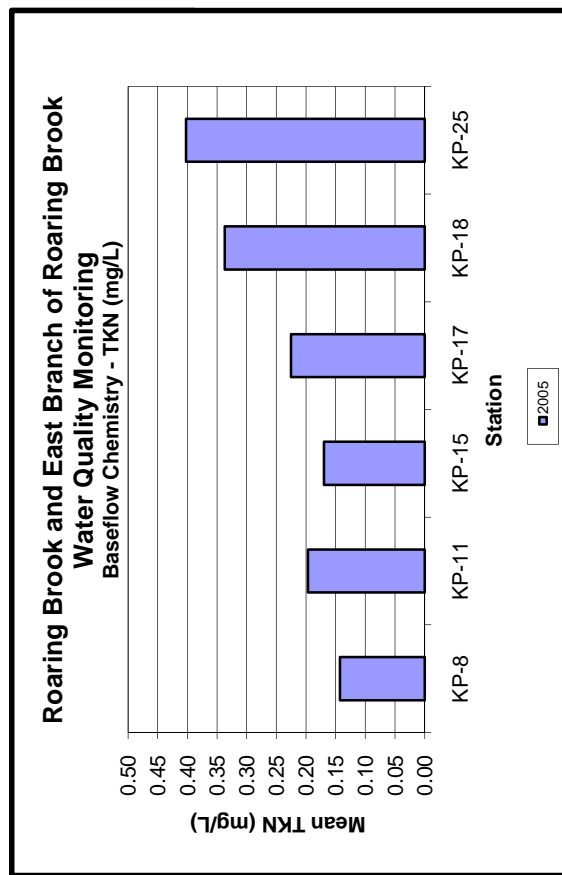
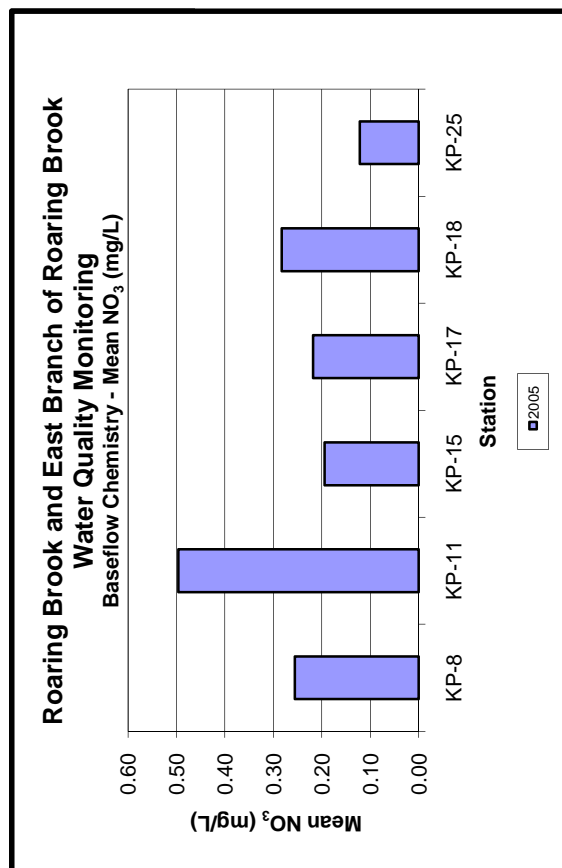
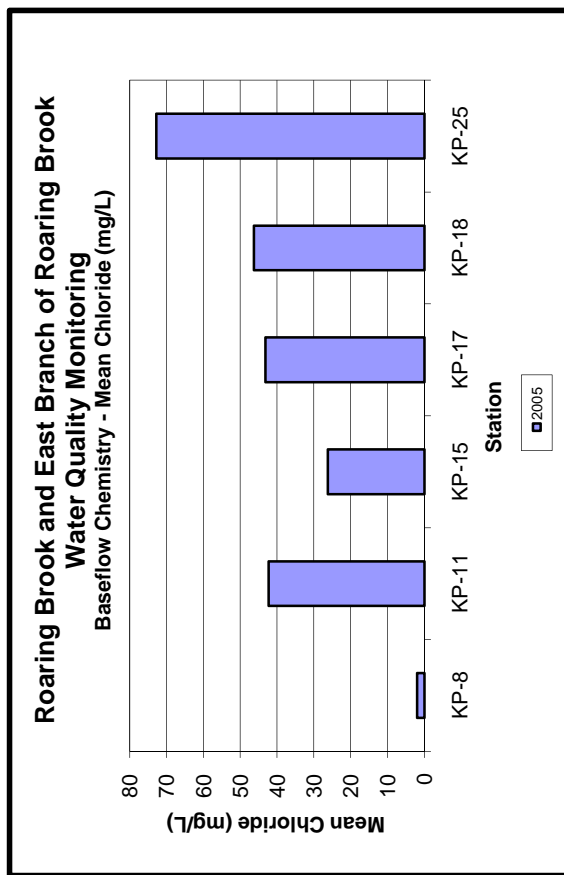
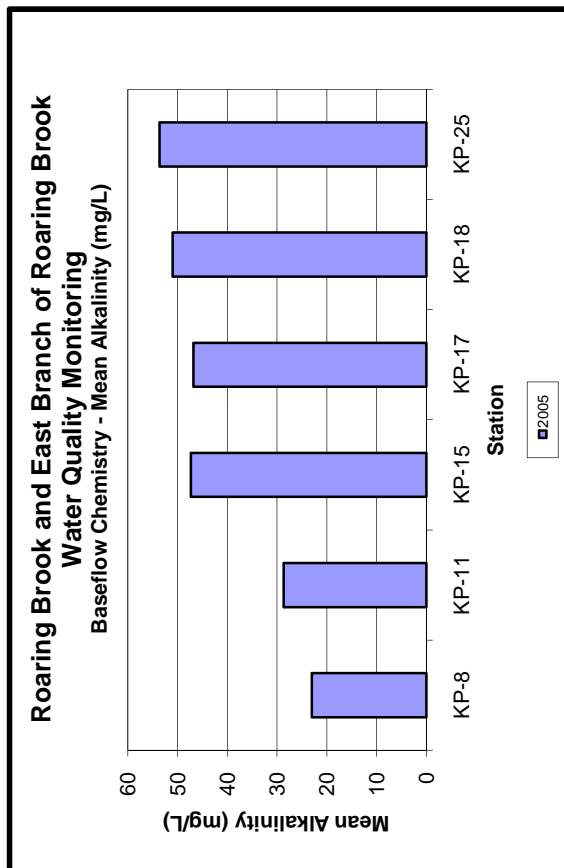
Average TKN (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	0.143	0.197	0.170	0.225	0.337	0.402

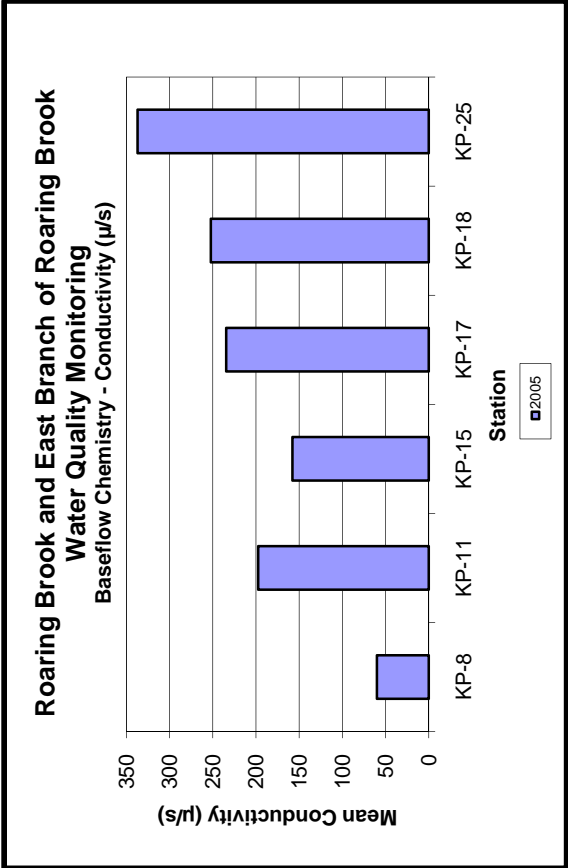
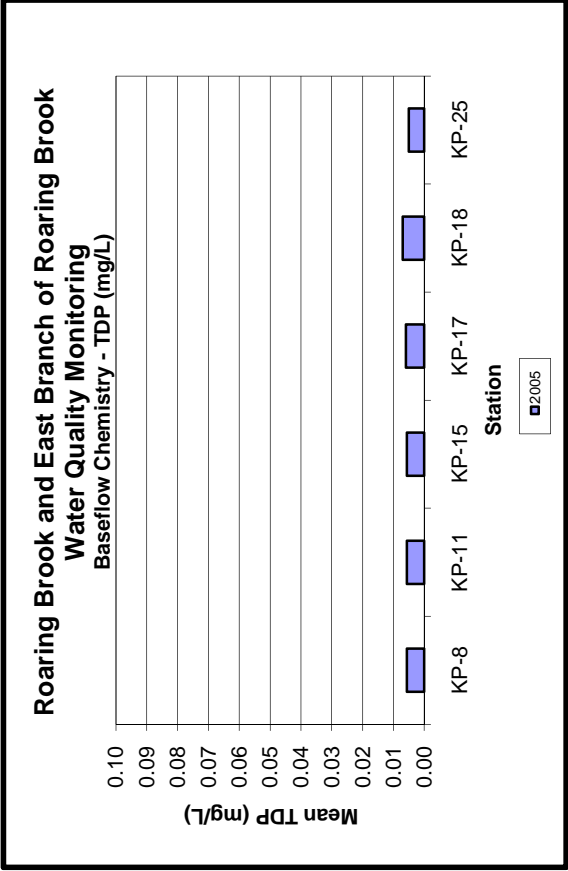
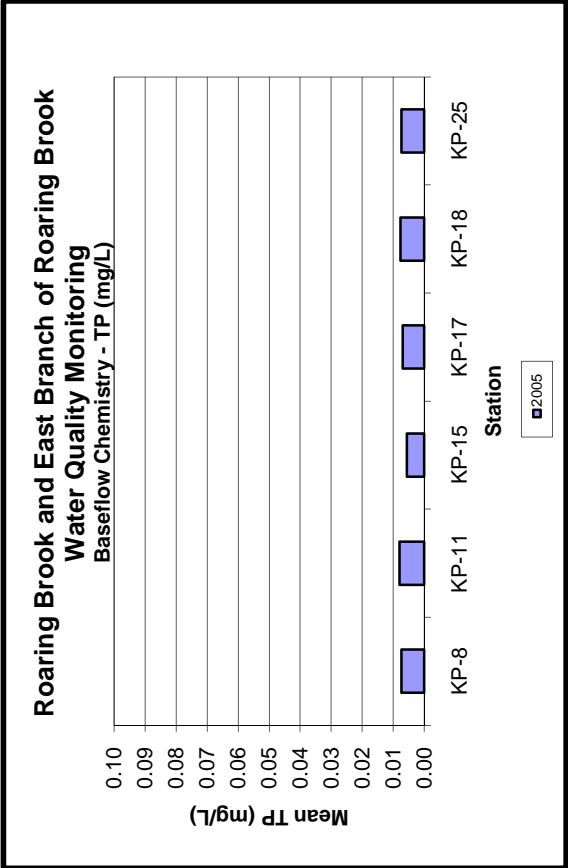
Average TP (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	0.007	0.008	0.006	0.007	0.008	0.007

Average TDP (mg/L)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	0.006	0.006	0.006	0.006	0.007	0.005

Average Conductivity (μ/s)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	59.9	197.1	157.8	234.5	252.0	336.9

Average Conductivity (μ/s)						
	KP-8	KP-11	KP-15	KP-17	KP-18	KP-25
2005	12.5	11.8	13.1	14.0	14.3	13.5





Roaring Brook and East Branch of Roaring Brook
WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
8/31/05 Total rainfall = 1.31 inches. Sampler - Thomas Shea							
Subwatershed A							
KP-10	Roaring Brook, downstream from K-1 lodge and below Killington Road	15:08	15.5	193.7	7.36		0.64
E-6	Culvert outlet on right bank of Roaring Brook, just below K-1 Lodge	15:15	11.7	208.4	7.31		1.6
E-9	West side of Killington Road below K1 Base Lodge	15:24	15.8	239.4	7.22		17.9
E-10	West side of Killington Road, below E-09	15:26	16.9	229.9	7.45		89.3
E-11	West side of Killington Road, adjacent to KP-10	15:32	20.9	180.5	7.71		383
E-12	West side of Killington Road, approximately 350 linear feet down slope of E-11	15:30	18.7	158	7.51		186
E-13	West side of Killington Road, approximately 460 linear feet down slope of E-12	15:45	20.5	302.3	8.02		3.24
E-14	West side of Killington Road, approximately 350 linear feet down slope of E-13	15:40	20.2	165	7.64		30.6
E-15	West side of Killington Road, approximately 310 linear feet down slope of E-14	15:50	19.9	220.3	7.66		15.7
E-17	West side of Killington Road, approximately 220 linear feet down slope of E-15	15:53	20.0	372.3	8.02		11.5
E-22	Detention Basin Outlet, Left bank Roaring Brook	10:24			7.85		1.18
Subwatershed C							
KP-11	Roaring Brook, upstream of snowmaking diversion weir	9:55			7.5		1.88
E-32	River right side of Roaring Brook, detention basin outfall at Ram's Head Parking Lot	9:30	19.0	413.9	6.99		5.69
Subwatershed D							
KP-8	Reference station located on the West Branch of Roaring Brook above Killington Road	8:50	15.6	78.5	7.51		0.26
9/15/05 Total rainfall =1.23 inches. Samplers - Pete Etchells and Eric Hebert							
Subwatershed A							
KP-3	Tributary to Roaring Brook below Vale Lot and just upstream of confluence	11:21	16.2	243.2	6.92		16.0
KP-10	Roaring Brook, downstream from K-1 lodge and below Killington Road	9:00	14.2	124.6	6.39		1.5
E-6	Culvert outlet on right bank of Roaring Brook, just below K-1 Lodge	9:15	10.2	198.6	6.53		0.2
E-9	West side of Killington Road below K1 Base Lodge	9:25	13.9	138.5	6.18		1.0
E-10	West side of Killington Road, below E-09	9:30	14.5	145.2	6.42		1.0
E-11	West side of Killington Road, adjacent to KP-10	9:45	18.4	403.7	7.70		28.0
E-12	West side of Killington Road, approximately 350 linear feet down slope of E-11	9:55	17.3	164.2	7.24		3.7
E-13	West side of Killington Road, approximately 460 linear feet down slope of E-12	10:20	18.5	219.6	7.36		2.6
E-15	West side of Killington Road, approximately 310 linear feet down slope of E-14	10:45	17.8	231.5	7.17		6.0
E-16	Open channel to Roaring Brook, approximately 350 linear feet upstream of KP-03	10:40	14.8	208.4	6.67		5.0
E-17	West side of Killington Road, approximately 220 linear feet down slope of E-15	10:58	18.4	415.8	7.50		25.0
E-19	Open channel to Roaring Brook, approximately 160 linear feet downstream of KP-03	12:29	16.6	253.6	6.55		6.4
E-20	Open channel to Roaring Brook, approximately 60 linear feet downstream of E-19 and 220 linear feet downstream of KP-03	12:21	15.2	239.3	6.86		4.5
E-22	Detention Basin Outlet, Left bank Roaring Brook	11:52	17.6	398.7	7.35		10.1
E-23	River left side of Roaring Brook, approximately 50 linear feet downstream of KP-05	11:53	13.8	113.6	6.26		0.6

WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
E-96	Outlet of detention basin from K1 parking lot	13:58	19.0	764.0	7.74		52.0
E-97	Outlet of Cat Yard detention basin	13:45	16.8	172.3	6.83		1.5
E-98	Outlet of roadside culvert on the east side of the road connecting the Vail and K1 parking lots	13:28	16.9	458.1	6.91		8.4
E-99	Outlet of Vail detention basin	11:40	17.6	401.3	7.15		10.0
Subwatershed B							
KP-5	Ram's Head Brook, just above confluence with Roaring Brook	12:10	13.4	78.4	6.19		0.4
Subwatershed C							
KP-11	Roaring Brook, upstream of snowmaking diversion weir	13:03	15.3	239.2	6.96		4.1
E-26	River left side of Roaring Brook, adjacent to KP-11 and upstream of intake weir	12:40	13.5	142.6	6.76		1.0
E-27	Open channel to Roaring Brook, approximately 100 linear feet downstream of KP-11 on right bank	12:55	19.0	620.0	7.82		23.0
E-32	River right side of Roaring Brook, detention basin outfall at Ram's Head Parking Lot	8:45	18.5	482.8	7.80		96.0
Subwatershed F							
KP-14	East Branch of Roaring Brook, just above East Mountain Road	12:05	15.8	105.6	6.41		1.5
KP-15	East Branch of Roaring Brook, just below East Mountain Road	13:30	16.0	146.0	6.78		1.2
KP-17	East Branch of Roaring Brook, 200 feet downstream of golf course pond	14:11	16.7	324.1	6.94		1.6
E-65	Roadside ditch along the south side of East Mountain Road, adjacent to KP-14	12:24	15.2	71.3	6.36		0.5
E-74	Tributary to East Branch Roaring Brook as it crosses the Hole 11 fairway	14:50	17.3	682.0	7.09		1.4
E-75	Roadside ditch along gravel road connecting Hole 16 tee to East Mountain Road	13:58	16.4	870.0	6.92		1.6
E-80	Small Tributary to East Branch Roaring Brook between Hole 12 and Hole 13	14:22	16.9	242.7	6.76		1.4
E-84	Ditch along cart path near the Hole 13 Green	14:32	17.1	381.3	7.10		1.4
Subwatershed G							
KP-25	Tributary to East Branch of Roaring Brook below Snowshed Pond, just upstream of foot bridge	11:05	16.2	368.6	6.87		3.0
E-47	Open channel near eastern perimeter of Snowshed Pond	10:14	15.1	42.7	6.06		0.75
E-48	Path along the southern perimeter of Snowshed Pond	10:04	15.4	43.0			
E-49	Path along the southern perimeter of Snowshed Pond	9:57	15.6	73.2			
E-50	Open channel draining into Snowshed Pond from the south	9:50	15.4	213.0	7.19		1.4
E-54	At gravel parking lot east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	9:30	16.4	680.0	7.26		16.0
E-55	At gravel driveway east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	9:38	15.6	36.6	6.21		3.3
E-56	Eastern perimeter of Snowshed Base Lodge parking lot	9:14	19.2	368.9	7.48		10.0
E-57	Western perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	9:24	17.6	149.4	6.94		5.1
E-58	Southern perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	10:49	18.5	268.7	7.30		3.1
E-59	Downstream side of culvert discharging from Snowshed Pond	10:33	16.1	393.3	6.59		13.0
E-60	Downstream side of culvert discharging seepage from Snowshed Pond	10:26	16.0	410.1	6.71		13.0
E-61	Drainage channel entering river left into East Branch Roaring Brook behind Trail Creek at Killington Resort Villages	11:13	15.9	270.1	6.27		4.7

WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
9/26/05 Total rainfall = 0.79 inches. Sampler - Thomas Shea							
Subwatershed A							
E-22	Detention Basin Outlet, Left bank Roaring Brook	16:27	12.3	124.5	7.85		5.92
E-23	River left side of Roaring Brook, approximately 50 linear feet downstream of KP-05	16:30	15.7	25	7.12		9.58
E-96	Outlet of detention basin from K1 parking lot	15:56	16.0	701	7.84	72	168
E-97	Outlet of Cat Yard detention basin	16:00	14.8	448.8	7.60	10	28.4
E-99	Outlet of Vail detention basin	15:40	15.8	329.5	7.76		3.97
Subwatershed B							
KP-5	Ram's Head Brook, just above confluence with Roaring Brook	16:25	12.5	58.7	7.11		2.51
Subwatershed C							
KP-11	Roaring Brook, upstream of snowmaking diversion weir	16:10	15.5	220.7	7.37		4.57
E-26	River left side of Roaring Brook, adjacent to KP-11 and upstream of intake weir	16:15	12.7	106.8	7.26		1.92
E-27	Open channel to Roaring Brook, approximately 100 linear feet downstream of KP-11 on right bank	16:05	16.7	642	7.96	34	48.0
E-32	River right side of Roaring Brook, detention basin outfall at Ram's Head Parking Lot	16:47	15.2	140.5	7.80	98	117
E-33	West side of Killington Road, opposite of East Mountain Road	15:10	16.6	225.7	7.61	8	17.9
Subwatershed D							
KP-8	Reference station located on the West Branch of Roaring Brook above Killington Road	17:35	14.3	67.2	7.12		6.50
Subwatershed E							
KP-24	Tributary to Roaring Brook behind WWTF, just upstream of ATV bridge	17:05	16.0	479.9	7.54	127	88.0
E-35	Upslope of Old Mill Road on the northern perimeter of Pinnacle Condominiums	16:55	17.9	40.3	7.09	68	51.3
E-36	Unnamed tributary to Roaring Branch, upslope of the tee on Hole 8 at the Killington Golf Course	17:03	17.0	85.1	7.23	47	29.9
E-38	Sampled below road to WWTF and below Pinnacle Condos	17:08	16.2	494.4	7.38	89	74.2
Subwatershed F							
KP-14	East Branch of Roaring Brook, just above East Mountain Road	17:20	14.6	135.4	7.28	38	19.8
KP-18	On the East Branch Roaring Brook, approximately 10-15 feet upstream of the confluence with the Roaring Brook	17:40	15.5	275.3	7.45	134	121
E-65	Roadside ditch along the south side of East Mountain Road, adjacent to KP-14	17:23	15.2	93.7	7.77	268	212
E-66	Roadside ditch along the north side of East Mountain Road, across the road from KP-14	17:15	17.3	24.1	7.30	12	15.2
Subwatershed G							
E-55	At gravel driveway east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	14:40	17.4	69.5	7.84	123	73.0
E-56	Eastern perimeter of Snowshed Base Lodge parking lot	15:20	18.1	395.3	7.74	24	81.8
E-57	Western perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	15:24	15.8	124.4	7.40		6.00
9/29/05 Total rainfall = 0.71 inches. Sampler - Thomas Shea							
Subwatershed C							
KP-27**	Roaring Brook, downstream of W-4 Tributary confluence	12:55	11.7	111.5	6.9	680	120
E-32	River right side of Roaring Brook, detention basin outfall at Ram's Head Parking Lot	13:05	12.2	106.5	7.9	730	310
E-33	West side of Killington Road, opposite of East Mountain Road	13:00	12.4	78.7	6.9	160	57
Subwatershed D							
KP-8	Reference station located on the West Branch of Roaring Brook above Killington Road	12:50	11.9	42.9	6.6	64	14
Subwatershed G							
KP-25	Tributary to East Branch of Roaring Brook below Snowshed Pond, just upstream of foot bridge	14:45	12.3	213.8	6.9		9.5
E-48	Path along the southern perimeter of Snowshed Pond	14:35	12.2	30.6	6.7		2

WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
E-49	Path along the southern perimeter of Snowshed Pond	14:30	11.8	46.2	6.7		6.1
Subwatershed F							
KP-14	East Branch of Roaring Brook, just above East Mountain Road	13:40	12.1	82.2	6.7	50	11
KP-15	East Branch of Roaring Brook, just below East Mountain Road	1:45	12.1	98.2	7.0	62	15
KP-17	East Branch of Roaring Brook, 200 feet downstream of golf course pond	14:10	12.3	180.3	6.9	66	19
KP-18	On the East Branch Roaring Brook, approximately 10-15 feet upstream of the confluence with the Roaring Brook	12:24	12.7	214.6	7.0		7.9
KP-18A	Roaring Brook just above Ravine Road	12:43	12.4	184.1	7.7	1600	300
E-65	Roadside ditch along the south side of East Mountain Road, adjacent to KP-14	13:35	12.5	142.2	7.1	24	15
E-74	Tributary to East Branch Roaring Brook as it crosses the Hole 11 fairway	14:05	12.5	314.5	6.9	36	17
E-75	Roadside ditch along gravel road connecting Hole 16 tee to East Mountain Road	13:56	12.5	338.9	6.7		3.4
E-77	Drainage swale directly behind Hole 16 tee	14:00	12.8	362.6	6.7		8.5
E-84	Ditch along cart path near the Hole 13 Green	12:31	12.5	185.5	6.8	180	30
Subwatershed E							
KP-24	Tributary to Roaring Brook behind WWTF, just upstream of ATV bridge	13:20	12.8	302.4	7.1	150	48
E-35	Culvert outlet behind Pinnacle Condos, off road to WWTF	13:12	13.5	77.1	6.8	130	125
E-36	Drainage swale just upgradient from Hole 8 Tee, near the WWTF	13:28	12.8	361.6	6.7	98	33
E-38	Sampled below road to WWTF and below Pinnacle Condos	13:22	13.2	100.1	6.6		4.4
10/13/05 Total rainfall = 0.24 inches. Samplers - Pete Etchells and Eric Hebert							
Subwatershed A							
KP-3	Tributary to Roaring Brook below Vale Lot and just upstream of confluence	10:45		179.2	6.76		12.5
KP-10	Roaring Brook, downstream from K-1 lodge and below Killington Road	8:40		78.4	6.59		2.0
E-6	Culvert outlet on right bank of Roaring Brook, just below K-1 Lodge	8:27		198.3	6.61		1.2
E-9	West side of Killington Road below K1 Base Lodge	8:52		93.4	6.71		0.4
E-10	West side of Killington Road, below E-09	8:59		93.3	6.53		1.1
E-11	West side of Killington Road, adjacent to KP-10	12:16		257.3	7.15		16.0
E-12	West side of Killington Road, approximately 350 linear feet down slope of E-11	12:24		129.2	6.86		2.6
E-15	West side of Killington Road, approximately 310 linear feet down slope of E-14	12:50		513.0	7.84		10.0
E-16	Open channel to Roaring Brook, approximately 350 linear feet upstream of KP-03	11:05		114.0	6.60		2.0
E-17	West side of Killington Road, approximately 220 linear feet down slope of E-15	12:58		419.3	7.74		7.2
E-18	West side of Killington Road, approximately 240 linear feet down slope of E-17 and adjacent to KP-03.	13:10		296.8	7.48		15.0
E-19	Open channel to Roaring Brook, approximately 160 linear feet downstream of KP-03	10:32		175.9	6.85		10.0
E-20	Open channel to Roaring Brook, approximately 60 linear feet downstream of E-19 and 220 linear feet downstream of KP-03	10:38		177.0	6.71		14.0
E-22	Detention Basin Outlet, Left bank Roaring Brook	9:15		391.5	7.14		0.8
E-23	River left side of Roaring Brook, approximately 50 linear feet downstream of KP-05	9:17		74.9	6.48		0.2
E-96	Outlet of detention basin from K1 parking lot	11:48		906.0	7.79		38.0
E-97	Outlet of Cat Yard detention basin	11:36		136.5	6.71		10.5
E-98	Outlet of roadside culvert on the east side of the road connecting the Vail and K1 parking lots	11:25		165.7	7.15		0.45
E-99	Outlet of Vail detention basin	9:38		388.1	7.09		0.63
Subwatershed B							

WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
E-21	Ram's Head Brook just above KP-5	9:25		65.8	6.49		0.2
Subwatershed C							
KP-6	Tributary W-4 to Roaring Brook, above ski trail	13:55		49.1	6.65		0.25
KP-11	Roaring Brook, upstream of snowmaking diversion weir	10:20		123.5	6.65		2.3
E-26	River left side of Roaring Brook, adjacent to KP-11 and upstream of intake weir	9:49		121.2	6.54		0.25
E-27	Open channel to Roaring Brook, approximately 100 linear feet downstream of KP-11 on right bank	10:15		245.5	7.01		12.0
E-32	River right side of Roaring Brook, detention basin outfall at Ram's Head Parking Lot	8:15		953.0	7.01		3.7
Subwatershed E							
KP-24	Tributary to Roaring Brook behind WWTF, just upstream of ATV bridge	13:52	10.0	961.0	6.84		1.0
E-35	Culvert outlet behind Pinnacle Condos, off road to WWTF	13:41	11.5	514.0	6.65		4.5
E-36	Drainage swale just upgradient from Hole 8 Tee, near the WWTF	14:04	10.2	1112.0	6.84		1.6
E-38	Sampled below road to WWTF and below Pinnacle Condos	14:13	10.2	328.4	6.34		1.1
Subwatershed F							
KP-14	East Branch of Roaring Brook, just above East Mountain Road	10:35	10.1	188.0	6.70		2.4
KP-15	East Branch of Roaring Brook, just below East Mountain Road	11:31	9.9	212.2	6.69		1.5
KP-17	East Branch of Roaring Brook, 200 feet downstream of golf course pond	12:06	9.9	303.3	6.82		2.0
KP-18	On the East Branch Roaring Brook, approximately 10-15 feet upstream of the confluence with the Roaring Brook	12:45	9.7	309.2	7.05		1.6
E-65	Roadside ditch along the south side of East Mountain Road, adjacent to KP-14	10:44	9.3	65.7	6.45		1.2
E-66	Roadside ditch along the north side of East Mountain Road, across the road from KP-14	11:18	9.8	334.7	6.71		9.0
E-67	Roadside ditch along north side of East Mountain Road, across the road from KP-14	11:10	9.6	1070.0	7.10		2.25
E-69	Wooded area along north side of East Mountain Road across the road from KP-14	13:10	9.8	444.1	6.91		1.7
E-74	Tributary to East Branch Roaring Brook as it crosses the Hole 11 fairway	11:42	9.6	324.5	6.82		1.9
E-75	Roadside ditch along gravel road connecting Hole 16 tee to East Mountain Road	11:50	10.2	928.0	6.93		2.6
E-77	Drainage swale directly behind Hole 16 tee	11:55	10.2	663.0	6.82		3.3
E-80	Small Tributary to East Branch Roaring Brook between Hole 12 and Hole 13	12:17	10.1	250.9	6.61		1.4
E-84	Ditch along cart path near the Hole 13 Green	12:27	9.6	369.7	6.87		1.5
Subwatershed G							
KP-25	Tributary to East Branch of Roaring Brook below Snowshed Pond, just upstream of foot bridge	10:15	12.2	313.1	6.94		4.3
E-47	Open channel near eastern perimeter of Snowshed Pond	9:22	9.2	34.2	6.28		0.34
E-48	Path along the southern perimeter of Snowshed Pond	9:14	9.8	36.9	6.38		0.45
E-49	Path along the southern perimeter of Snowshed Pond	9:10	9.2	61.4	6.41		1.45
E-50	Open channel draining into Snowshed Pond from the south	8:56	9.7	176.7	7.05		1.4
E-54	At gravel parking lot east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	8:42	10.6	1633.0	7.59		9.8
E-56	Eastern perimeter of Snowshed Base Lodge parking lot	8:30	12.3	307.3	6.81		5.5
E-57	Western perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	8:35	11.8	482.0	7.63		2.5
E-58	Southern perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	9:49	10.9	77.9	6.63		0.7
E-59	Downstream side of culvert discharging from Snowshed Pond	9:41	12.1	306.1	7.02		4.6
E-60	Downstream side of culvert discharging seepage from Snowshed Pond	9:36	12.2	305.6	6.96		4.1

WATER QUALITY 2005
BACKGROUND EVENT-BASED WATER CHEMISTRY
Sampling Summary - 2005

ROARING BROOK WATERSHED

STA. #	Sampling Location/Description	Time of sampling	Water Temperature	Conductivity	pH*	Total Suspended Solids (TSS)*	Turbidity*
			°C	umho/cm	S.U.	mg/L	NTU
E-61	Drainage channel entering river left into East Branch Roaring Brook behind Trail Creek at Killington Resort Villages	10:22	10.2	308.6	6.79		7.4
10/25/05 Total rainfall = 0.69 inches. Sampler - Pete Etchells							
Subwatershed A							
KP-3	Tributary to Roaring Brook below Vale Lot and just upstream of confluence	10:21	3.0	140.7	6.58		7.6
E-13	West side of Killington Road, approximately 460 linear feet down slope of E-12	11:12	3.0	293.8	6.70		0.9
E-14	West side of Killington Road, approximately 350 linear feet down slope of E-13	11:21	2.8	707.0	6.84		3.5
E-16	Open channel to Roaring Brook, approximately 350 linear feet upstream of KP-03	10:40	3.4	210.8	6.69		1.3
E-18	West side of Killington Road, approximately 240 linear feet down slope of E-17 and adjacent to KP-03.	11:38	2.4	621.0	6.98		5.8
E-19	Open channel to Roaring Brook, approximately 160 linear feet downstream of KP-03	10:11	3.0	129.5	6.70		7.1
E-20	Open channel to Roaring Brook, approximately 60 linear feet downstream of E-19 and 220 linear feet downstream of KP-03	10:15	2.8	140.5	6.54		7.2
E-98	Outlet of roadside culvert on the east side of the road connecting the Vail and K1 parking lots	10:55	0.9	333.1	6.84		2.2
Subwatershed B							
KP-5	Ram's Head Brook, just above confluence with Roaring Brook	9:58	4.7	50.9	6.45		0.3
E-21	Ram's Head Brook just above KP-5	11:48	4.2	41.7	6.53		0.4
Subwatershed C							
KP-6	Tributary W-4 to Roaring Brook, above ski trail	9:35	4.9	30.5	6.07		0.2
KP-27**	Roaring Brook, downstream of W-4 Tributary confluence	8:49	4.1	180.2	6.61		2.5
Subwatershed G							
E-48	Path along the southern perimeter of Snowshed Pond	12:18	3.6	17.8	6.25		1.6
E-49	Path along the southern perimeter of Snowshed Pond	12:15	3.7	21.2	6.36		1.1
E-50	Open channel draining into Snowshed Pond from the south	12:30	4.7	48.4	6.48		2.0
E-54	At gravel parking lot east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	12:52	3.1	474.0	6.99		7.9
E-55	At gravel driveway east of Snowshed Base Lodge, adjacent to path across Snowshed Pond	12:42	2.8	23.9	6.32		2.4
E-58	Southern perimeter of Grand Hotel along the hotel commercial road and the northern perimeter of Snowshed Pond	13:20	4.2	139.5	6.77		2.5
E-59	Downstream side of culvert discharging from Snowshed Pond	13:33	4.6	144.6	6.83		4.0
E-60	Downstream side of culvert discharging seepage from Snowshed Pond	13:40	4.4	143.6	6.79		4.1

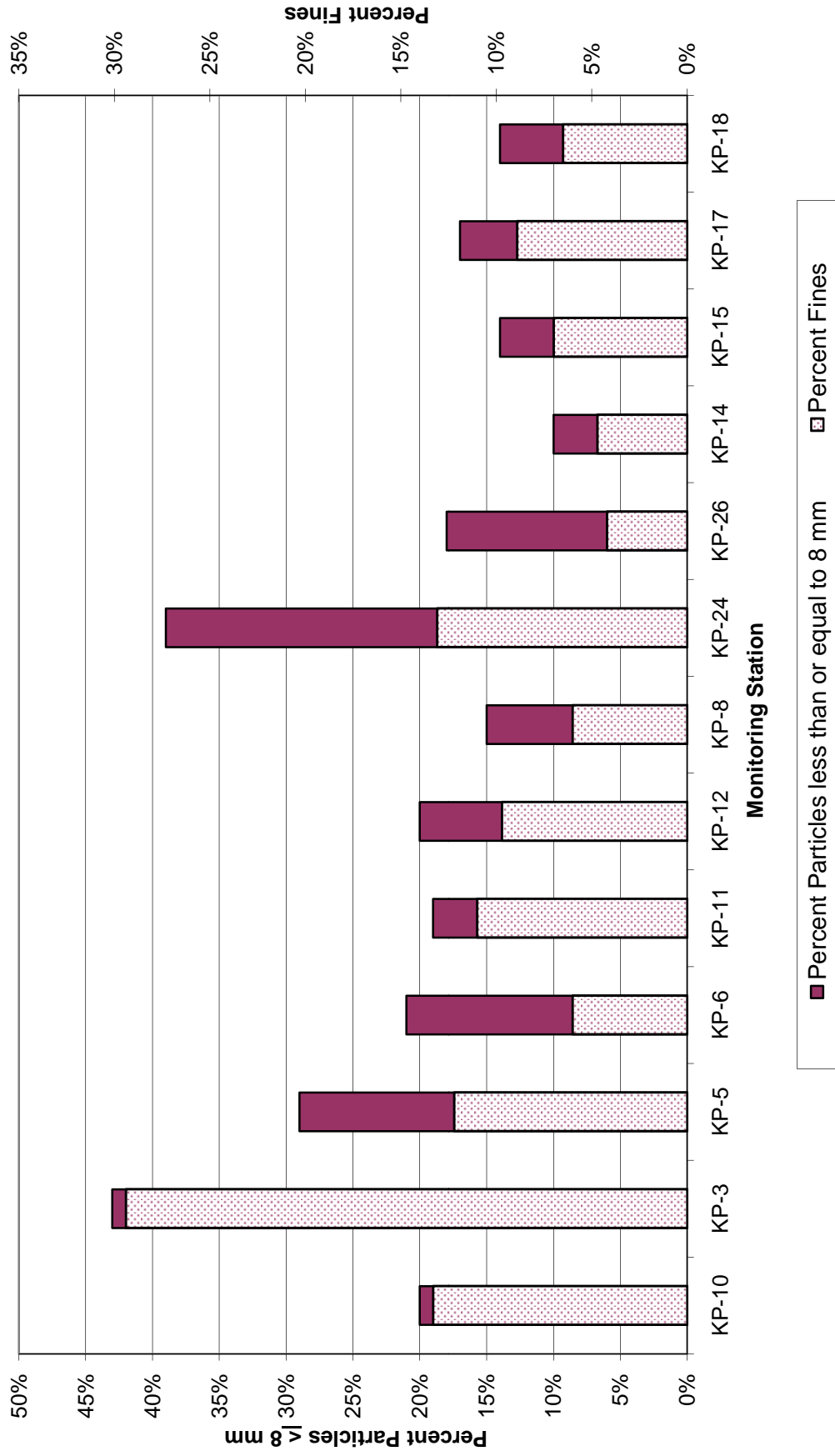
*Data obtained from Endyne Laboratory Report Sheets for the following constituents on the following dates: 8/31/05 - pH, Turbidity. 9/26/05 - pH, TSS, Turbidity. 9/29/05 - TSS.

** Sampled from Roaring Brook above Access Rd.
Blank indicates perimeter not sampled

**Roaring Brook and East Branch of Roaring Brook
Water Quality Monitoring 2005
2005 SUBSTRATE DATA SUMMARY**

Pebble Count and Sediment Monitoring Observation Summary							
Station	Location	Drainage Area (sq miles)	2005 Observations				
			Channel Slope	D50 (mm)	Estimated Embeddedness	% Particles ≤ 8 mm	% Fines
Roaring Brook Watershed							
Subwatershed A							
KP-10	Roaring Brook		5%	32-64	26-50%	20%	13%
KP-3	Tributary W-1 of Roaring Brook		5%	8-16	76-100%	43%	29%
Subwatershed B							
KP-5	Rams Head Brook		6%	16-32	26-50%	29%	12%
Subwatershed C							
KP-6	Tributary W-4of Roaring Brook		10%	32-64	26-50%	21%	6%
KP-11	Upper Roaring Brook, below confluence with Rams Head Brook	5.75	4%	32-64	26-50%	19%	11%
KP-12	Upper Roaring Brook - Below confl. with W-4	5.78	6%	32-64	26-50%	20%	10%
Subwatershed D							
KP-8	Reference Station, West Branch of Roaring Brook		4%	32-64	26-50%	15%	6%
Subwatershed E							
KP-24	Tributary to Roaring Brook above mouth of channel	0.45	5%	8-16	51-75%	39%	13%
KP-26	Roaring Brook above the confluence of East Branch		2%	32-64	26-50%	18%	4%
Subwatershed F							
KP-14	East Branch, Roaring Brook - Above East Mountain Road	0.42	7%	32-64	26-50%	10%	5%
KP-15	East Branch, Roaring Brook - Above Golf Course	8.98	10%	64-128	26-50%	14%	7%
KP-17	East Branch, Roaring Brook - Mid-area of Golf Course, Below IDP Spray Field	9.38	4%	32-64	26-50%	17%	9%
KP-18	East Branch, Roaring Brook - in lower golf course at mouth	9.12	8%	64-128	26-50%	14%	7%

Roaring Brook and East Branch of Roaring Brook Water Quality Restoration Plan
Substrate Monitoring 2005
Percentage of Fines and Particles ≤ 8 mm



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 8/31/05

Samplers: TDS, PWE

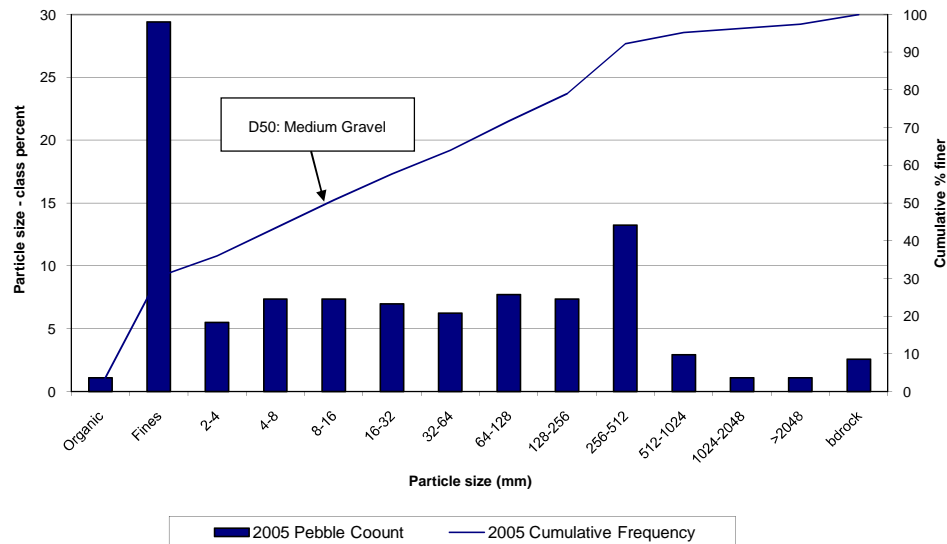
Sample Location: KP-3, Tributary W-1 of Roaring Brook

(sampling began at culvert inlet above station flagging and continued upstream to next culvert outlet)

Station Habitat Observations	Sample #1	Sample #2	Sample #3
Canopy cover:	60%	60%	65%
Embeddedness:	75-100%	75-100%	50-75%
Bank stability:	25-50%	50-75%	0-25%
% Slope:	7%	4%	5%

		Number of Observations			Summary of Samples	% of Total	Total Cumulative Frequency (%)
Category	Median Size (mm)	Sample #1	Sample #2	Sample #3			
Organic	Organic	2	1	0	3	1.1	1
Fines	Fines	35	31	14	80	29.4	31
Very small gravel	2-4	4	7	4	15	5.5	36
Small gravel	4-8	7	11	2	20	7.4	43
Medium gravel	8-16	8	8	4	20	7.4	51
Coarse gravel	16-32	6	5	8	19	7.0	58
Very coarse gravel	32-64	4	7	6	17	6.3	64
Small & med. cobble	64-128	5	11	5	21	7.7	72
Large cobble	128-256	5	12	3	20	7.4	79
Small boulder	256-512	15	10	11	36	13.2	92
Medium boulder	512-1024	4	1	3	8	2.9	95
Large boulder	1024-2048	1	0	2	3	1.1	96
Very large boulder	>2048	2	1	0	3	1.1	97
Bedrock	bdrock	2	3	2	7	2.6	100
Sample Size		100	108	64	272	100	
Longitudinal Distance (feet)		100	100	55			
D50 Particle Size	Medium Gravel						
Dominant Size Class	Fines						

Centex Destination Properties/Killington WQ Monitoring
KP-3 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 8/31/05

Samplers: TDS, PWE

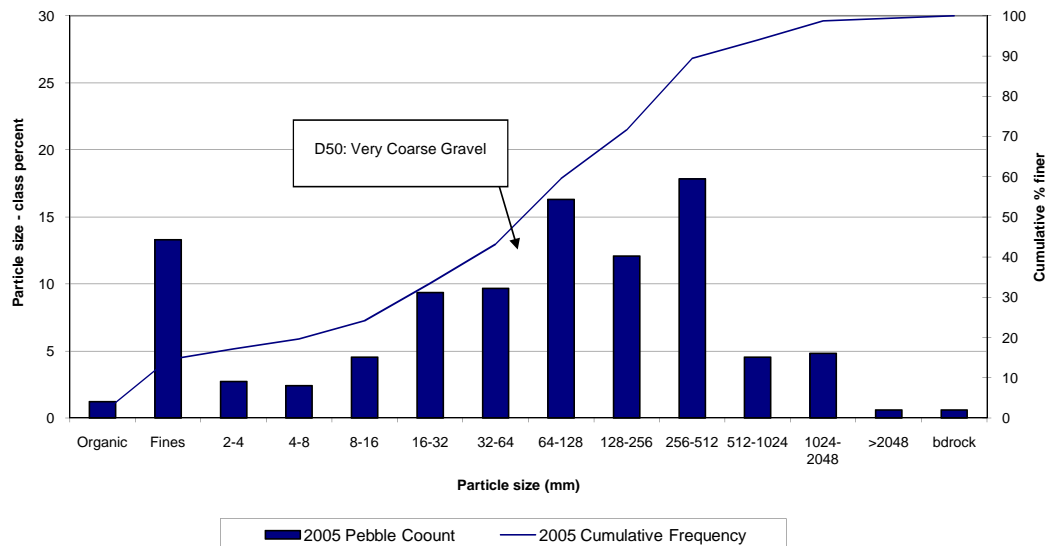
Sample Location: KP-10, Roaring Brook

(sampling began at station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2	Sample #3
Canopy cover:	75%	60%	55%
Embeddedness:	25-50%	25-50%	25-50%
Bank stability:	50-75%	75-100%	50-75%
% Slope:	8%	4%	4%

Category	Median Size (mm)	Number of Observations			Summary of Samples	% of Total	Total Cumulative Frequency (%)
		Sample #1	Sample #2	Sample #3			
Organic	Organic	0	2	2	4	1.2	1
Fines	Fines	9	17	18	44	13.3	15
Very small gravel	2-4	4	2	3	9	2.7	17
Small gravel	4-8	3	1	4	8	2.4	20
Medium gravel	8-16	3	6	6	15	4.5	24
Coarse gravel	16-32	11	8	12	31	9.4	34
Very coarse gravel	32-64	9	9	14	32	9.7	43
Small & med. cobble	64-128	14	25	15	54	16.3	60
Large cobble	128-256	12	18	10	40	12.1	72
Small boulder	256-512	18	17	24	59	17.8	89
Medium boulder	512-1024	12	1	2	15	4.5	94
Large boulder	1024-2048	13	3	0	16	4.8	99
Very large boulder	>2048	1	1	0	2	0.6	99
Bedrock	bdrock	1	1	0	2	0.6	100
Sample Size		110	111	110	331	100	
Longitudinal Distance (feet)		100	100	99			
D50 Particle Size	Very coarse gravel						
Dominant Size Class	Small boulder						

Centex Destination Properties/Killington WQ Monitoring
KP-10 Pebble Counts: 2005



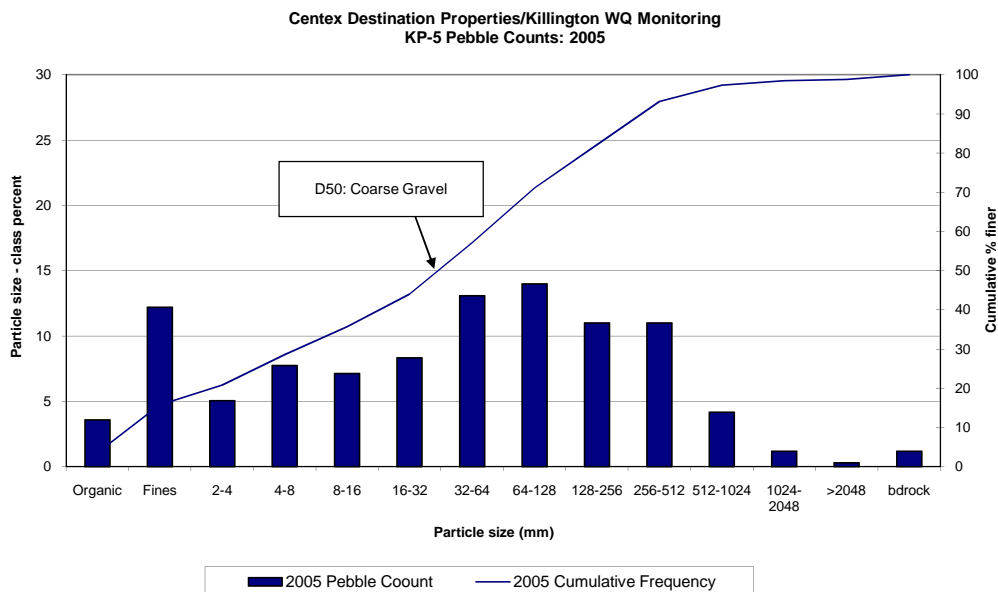
Roaring Brook and East Branch of Roaring Brook
 Water Quality Monitoring 2005
 SUBSTRATE DATA COLLECTION
 Sampling Date: 8/31/05
 Sample Location: KP-5, Ram's Head Brook
 (sampling began at station flagging and continued upstream)

Samplers: TDS, PWE

Station Habitat Observations	Sample #1	Sample #2	Sample #3
Canopy cover:	95%	85%	90%
Embeddedness:	25-50%	25-50%	50-75%
Bank stability:	50-75%	50-75%	25-50%
% Slope:	6%	8%	3%

		Number of Observations					
Category	Median Size (mm)	Sample #1	Sample #2	Sample #3	Summary of Samples	% of Total	Total Cumulative Frequency (%)
Organic	Organic	3	5	4	12	3.6	4
Fines	Fines	15	9	17	41	12.2	16
Very small gravel	2-4	7	7	3	17	5.1	21
Small gravel	4-8	13	9	4	26	7.7	29
Medium gravel	8-16	6	7	11	24	7.1	36
Coarse gravel	16-32	6	12	10	28	8.3	44
Very coarse gravel	32-64	12	17	15	44	13.1	57
Small & med. cobble	64-128	14	17	16	47	14.0	71
Large cobble	128-256	13	14	10	37	11.0	82
Small boulder	256-512	7	21	9	37	11.0	93
Medium boulder	512-1024	5	6	3	14	4.2	97
Large boulder	1024-2048	2	1	1	4	1.2	99
Very large boulder	>2048	1	0	0	1	0.3	99
Bedrock	bdrock	2	2	0	4	1.2	100
Sample Size		106	127	103	336	100	
Longitudinal Distance (feet)		101	120	100			
D50 Particle Size		Coarse gravel					
Dominant Size Class		Small and medium cobble					

NOTE: Did not collect samples from log jam (~20 feet) located between sample 2 and 3



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/31/05

Samplers: TDS, SRW

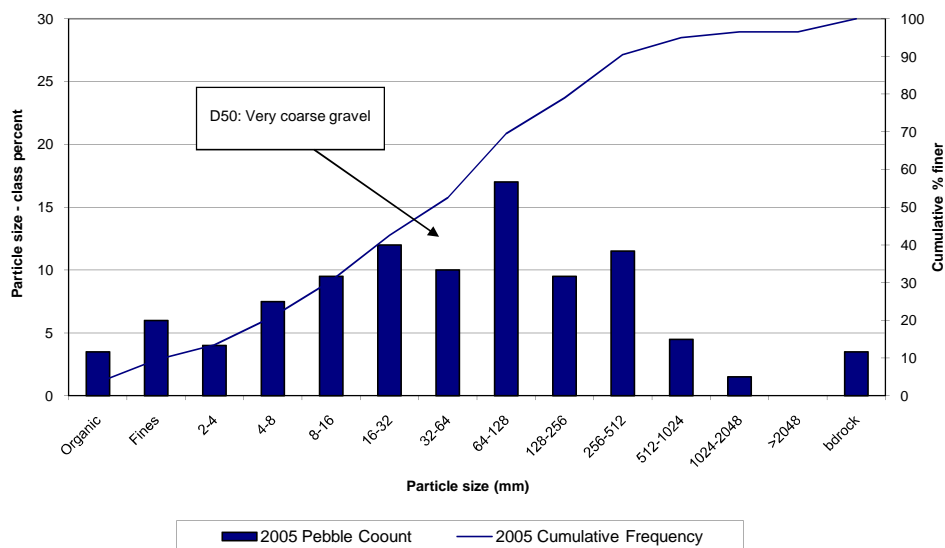
Sample Location: KP-6, Tributary W-4 to Roaring Brook)

(sampling began at station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	85%	90%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	9%	10%

Category	Number of Observations			Summary of Samples	% of Total	Total Cumulative Frequency (%)
	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	3	4	7	3.5	4
Fines	Fines	5	7	12	6.0	10
Very small gravel	2-4	4	4	8	4.0	14
Small gravel	4-8	8	7	15	7.5	21
Medium gravel	8-16	8	11	19	9.5	31
Coarse gravel	16-32	7	17	24	12.0	43
Very coarse gravel	32-64	11	9	20	10.0	53
Small & med. cobble	64-128	18	16	34	17.0	70
Large cobble	128-256	12	7	19	9.5	79
Small boulder	256-512	11	12	23	11.5	91
Medium boulder	512-1024	3	6	9	4.5	95
Large boulder	1024-2048	2	1	3	1.5	97
Very large boulder	>2048	0	0	0	0.0	97
Bedrock	bdrock	7	0	7	3.5	100
Sample Size		99	101	200	100	
Longitudinal Distance (feet)		100	98			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Small & med. Cobble					

Centex Destination Properties/Killington WQ Monitoring
KP-6 Pebble Counts: 2005



**Roaring Brook and East Branch of Roaring Brook
Water Quality Monitoring 2005
SUBSTRATE DATA COLLECTION**

Sampling Date: 8/31/05

Samplers: TDS, PWE

Sample Location: KP-11, Roaring Brook

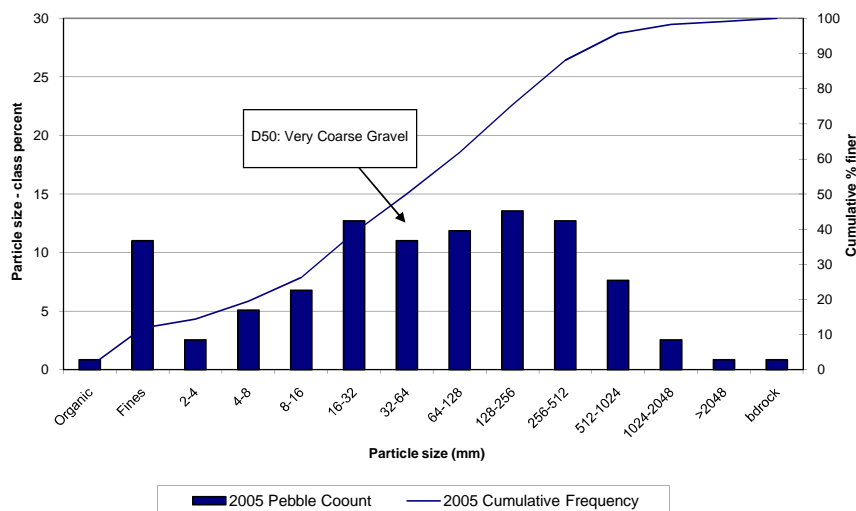
(sampling began at edge of trees above weir and continued upstream to just below culvert)

Station Habitat Observations	Sample #1
Canopy cover:	50%
Embeddedness:	25-50%
Bank stability:	50-75%
% Slope:	4%

Number of Observations					
Category	Median Size (mm)	Sample #1	Summary of Samples	% of Total	Total Cumulative Frequency (%)
Organic	Organic	1	1	0.8	1
Fines	Fines	13	13	11.0	12
Very small gravel	2-4	3	3	2.5	14
Small gravel	4-8	6	6	5.1	19
Medium gravel	8-16	8	8	6.8	26
Coarse gravel	16-32	15	15	12.7	39
Very coarse gravel	32-64	13	13	11.0	50
Small & med. cobble	64-128	14	14	11.9	62
Large cobble	128-256	16	16	13.6	75
Small boulder	256-512	15	15	12.7	88
Medium boulder	512-1024	9	9	7.6	96
Large boulder	1024-2048	3	3	2.5	98
Very large boulder	>2048	1	1	0.8	99
Bedrock	bdrock	1	1	0.8	100
Sample Size		118	118	100	
Longitudinal Distance (feet)		118			
D50 Particle Size	Very coarse gravel				
Dominant Size Class	Large cobble				

NOTE: Did not collect samples from immediately above the diversion weir

Centex Destination Properties/Killington WQ Monitoring
KP-11 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/31/05

Samplers: TDS, SRW

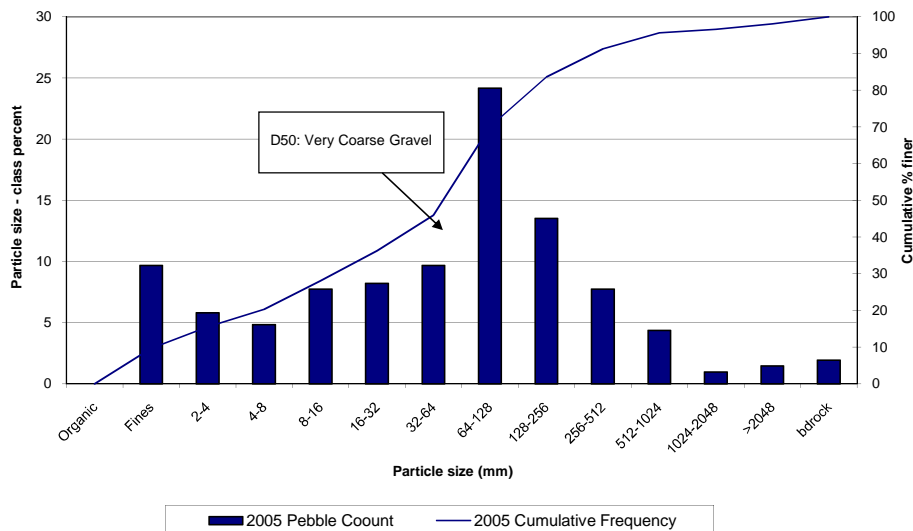
Sample Location: KP-12, Roaring Brook below Tributary W-4 confluence

(sampling began 250 feet below the confluence of Tributary W-4 continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	75%	80%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	5%	6%

Category	Number of Observations			Summary of Samples	% of Total	Total Cumulative Frequency (%)
	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	0	0	0	0.0	0
Fines	Fines	8	12	20	9.7	10
Very small gravel	2-4	8	4	12	5.8	15
Small gravel	4-8	7	3	10	4.8	20
Medium gravel	8-16	8	8	16	7.7	28
Coarse gravel	16-32	12	5	17	8.2	36
Very coarse gravel	32-64	12	8	20	9.7	46
Small & med. cobble	64-128	21	29	50	24.2	70
Large cobble	128-256	13	15	28	13.5	84
Small boulder	256-512	4	12	16	7.7	91
Medium boulder	512-1024	4	5	9	4.3	96
Large boulder	1024-2048	1	1	2	1.0	97
Very large boulder	>2048	2	1	3	1.4	98
Bedrock	bdrock	1	3	4	1.9	100
Sample Size		101	106	207	100	
Longitudinal Distance (feet)		100	100			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Small & med. Cobble					

Centex Destination Properties/Killington WQ Monitoring
KP-12 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/31/05

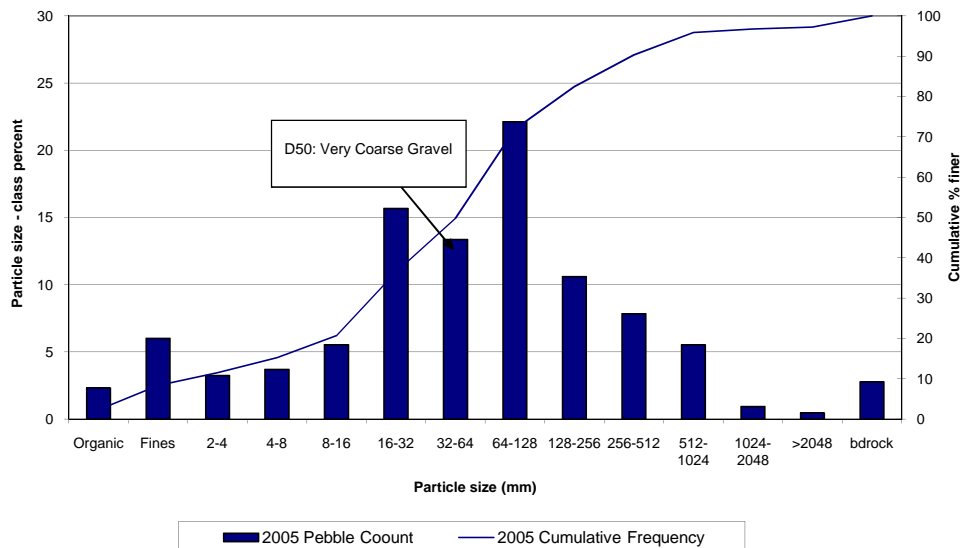
Samplers: TDS, SRW

Sample Location: KP-8, Reference Station, West Branch of Roaring Brook
(sampling began at station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	90%	80%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	5%	2%

		Number of Observations		Summary of Samples	% of Total	Total Cumulative Frequency (%)
Category	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	3	2	5	2.3	2
Fines	Fines	6	7	13	6.0	8
Very small gravel	2-4	3	4	7	3.2	12
Small gravel	4-8	4	4	8	3.7	15
Medium gravel	8-16	6	6	12	5.5	21
Coarse gravel	16-32	11	23	34	15.7	36
Very coarse gravel	32-64	13	16	29	13.4	50
Small & med. cobble	64-128	20	28	48	22.1	72
Large cobble	128-256	15	8	23	10.6	82
Small boulder	256-512	8	9	17	7.8	90
Medium boulder	512-1024	4	8	12	5.5	96
Large boulder	1024-2048	2	0	2	0.9	97
Very large boulder	>2048	1	0	1	0.5	97
Bedrock	bdrck	5	1	6	2.8	100
Sample Size		101	116	217	100	
Longitudinal Distance (feet)		100	100			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Small & med. Cobble					

Centex Destination Properties/Killington WQ Monitoring
KP-8 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/31/05

Samplers: TDS, SRW

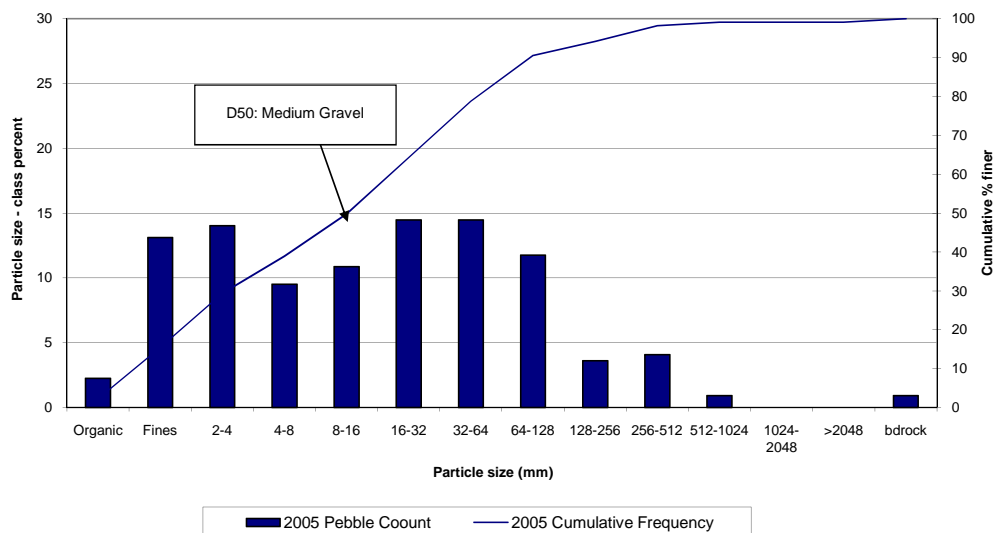
Sample Location: KP-24, tributary to Roaring Brook above mouth of channel)

(sampling began 100 feet below station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	80%	45%
Embeddedness:	50-75%	50-75%
Bank stability:	75-100%	50-75%
% Slope:	5%	4%

Category	Number of Observations			Summary of Samples	% of Total	Total Cumulative Frequency (%)
	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	3	2	5	2.3	2
Fines	Fines	18	11	29	13.1	15
Very small gravel	2-4	11	20	31	14.0	29
Small gravel	4-8	9	12	21	9.5	39
Medium gravel	8-16	14	10	24	10.9	50
Coarse gravel	16-32	21	11	32	14.5	64
Very coarse gravel	32-64	20	12	32	14.5	79
Small & med. cobble	64-128	14	12	26	11.8	90
Large cobble	128-256	3	5	8	3.6	94
Small boulder	256-512	4	5	9	4.1	98
Medium boulder	512-1024	2	0	2	0.9	99
Large boulder	1024-2048	0	0	0	0.0	99
Very large boulder	>2048	0	0	0	0.0	99
Bedrock	bdrock	1	1	2	0.9	100
Sample Size		120	101	221	100	
Longitudinal Distance (feet)		98	100			
D50 Particle Size	Medium gravel					
Dominant Size Class	Coarse and very coarse gravel					

Centex Destination Properties/Killington WQ Monitoring
KP-24 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/31/05

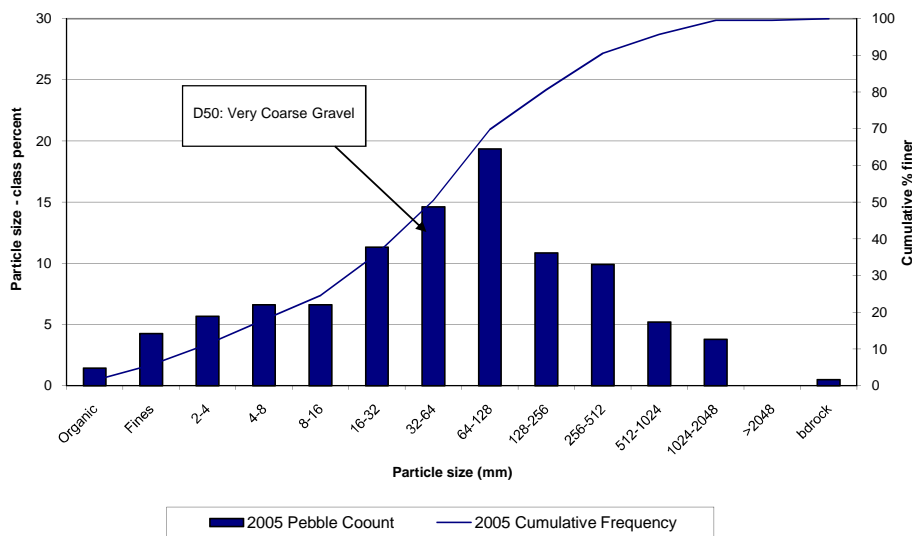
Samplers: TDS, SRW

Sample Location: KP-26, Roaring Brook above confluence of East Branch of Roaring Brook
(sampling began just above confluence and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	40%	0%
Embeddedness:	25-50%	25-50%
Bank stability:	50-75%	50-75%
% Slope:	2%	2%

		Number of Observations		Summary of Samples	% of Total	Total Cumulative Frequency (%)
Category	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	0	3	3	1.4	1
Fines	Fines	7	2	9	4.2	6
Very small gravel	2-4	6	6	12	5.7	11
Small gravel	4-8	9	5	14	6.6	18
Medium gravel	8-16	6	8	14	6.6	25
Coarse gravel	16-32	13	11	24	11.3	36
Very coarse gravel	32-64	13	18	31	14.6	50
Small & med. cobble	64-128	16	25	41	19.3	70
Large cobble	128-256	13	10	23	10.8	81
Small boulder	256-512	12	9	21	9.9	91
Medium boulder	512-1024	8	3	11	5.2	96
Large boulder	1024-2048	6	2	8	3.8	100
Very large boulder	>2048	0	0	0	0.0	100
Bedrock	bdrock	1	0	1	0.5	100
Sample Size		110	102	212	100	
Longitudinal Distance (feet)		103	100			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Small & med. Cobble					

Centex Destination Properties/Killington WQ Monitoring
KP-26 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/27/05

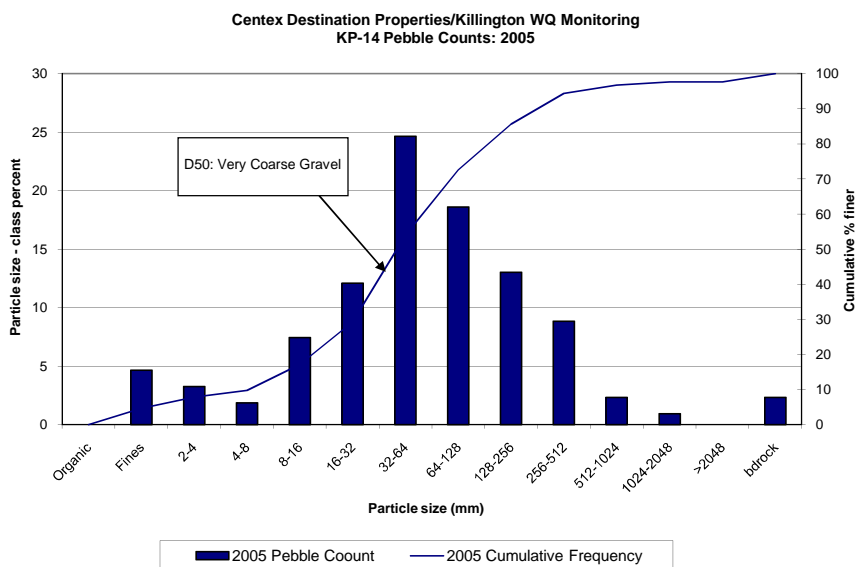
Samplers: TDS, SRW

Sample Location: KP-14, East Branch of Roaring Brook above East Mountain Road
(sampling began at station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	75%	70%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	7%	6%

		Number of Observations		Summary of Samples	% of Total	Total Cumulative Frequency (%)
Category	Median Size (mm)	Sample #1	Sample #2			
Organic	Organic	0	0	0	0.0	0
Fines	Fines	5	5	10	4.7	5
Very small gravel	2-4	4	3	7	3.3	8
Small gravel	4-8	3	1	4	1.9	10
Medium gravel	8-16	9	7	16	7.4	17
Coarse gravel	16-32	11	15	26	12.1	29
Very coarse gravel	32-64	22	31	53	24.7	54
Small & med. cobble	64-128	18	22	40	18.6	73
Large cobble	128-256	12	16	28	13.0	86
Small boulder	256-512	16	3	19	8.8	94
Medium boulder	512-1024	4	1	5	2.3	97
Large boulder	1024-2048	1	1	2	0.9	98
Very large boulder	>2048	0	0	0	0.0	98
Bedrock	bdrock	0	5	5	2.3	100
Sample Size		105	110	215	100	
Longitudinal Distance (feet)		101	100			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Very coarse gravel					

NOTE: Sampling was not conducted in short section located between sample #1 and #2. This is a confluence with a small tributary with a very deep pool.



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/27/05

Samplers: TDS, SRW

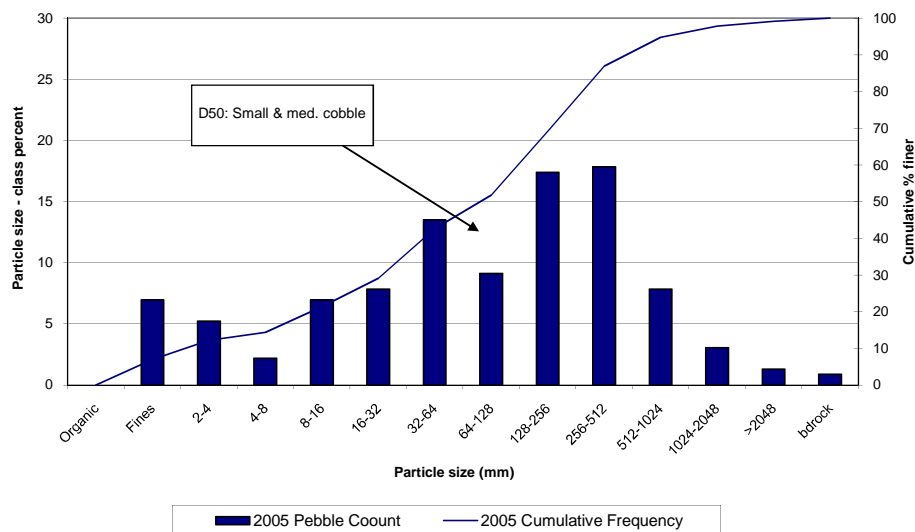
Sample Location: KP-15, East Branch of Roaring Brook

(sampling began 100 below station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	85%	80%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	5%	15%

Number of Observations						
Category	Median Size (mm)	Sample #1	Sample #2	Summary of Samples	% of Total	Total Cumulative Frequency (%)
Organic	Organic	0	0	0	0.0	0
Fines	Fines	10	6	16	7.0	7
Very small gravel	2-4	4	8	12	5.2	12
Small gravel	4-8	3	2	5	2.2	14
Medium gravel	8-16	6	10	16	7.0	21
Coarse gravel	16-32	10	8	18	7.8	29
Very coarse gravel	32-64	19	12	31	13.5	43
Small & med. cobble	64-128	11	10	21	9.1	52
Large cobble	128-256	20	20	40	17.4	69
Small boulder	256-512	22	19	41	17.8	87
Medium boulder	512-1024	9	9	18	7.8	95
Large boulder	1024-2048	3	4	7	3.0	98
Very large boulder	>2048	0	3	3	1.3	99
Bedrock	bdrock	0	2	2	0.9	100
Sample Size		117	113	230	100	
Longitudinal Distance (feet)		85	100			
D50 Particle Size	Small & med. Cobble					
Dominant Size Class	Small boulder					

Centex Destination Properties/Killington WQ Monitoring
KP-15 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/27/05

Samplers: TDS, SRW

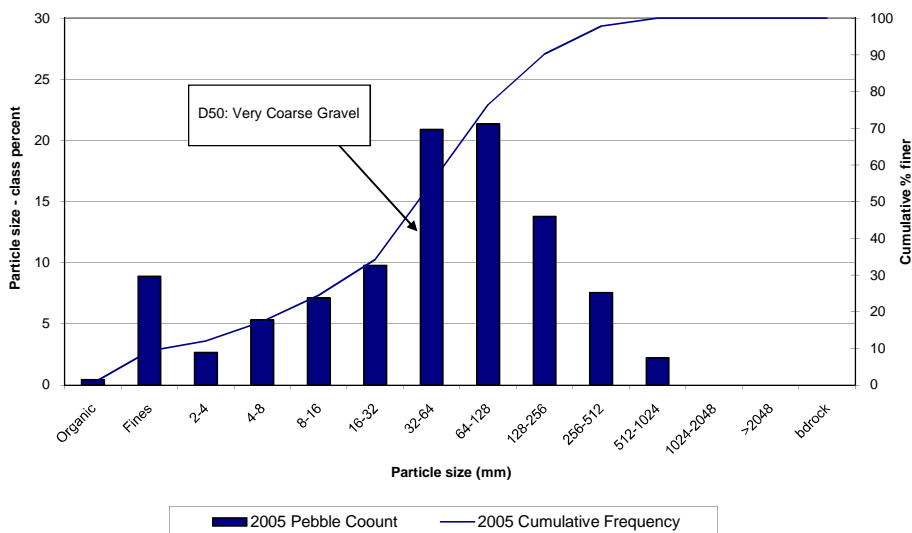
Sample Location: KP-17, East Branch of Roaring Brook

(sampling began 100 below station flagging and continued upstream)

Station Habitat Observations	Sample #1	Sample #2
Canopy cover:	80%	65%
Embeddedness:	25-50%	25-50%
Bank stability:	75-100%	75-100%
% Slope:	4%	3%

	Number of Observations					
Category	Median Size (mm)	Sample #1	Sample #2	Summary of Samples	% of Total	Total Cumulative Frequency (%)
Organic	Organic	1	0	1	0.4	0
Fines	Fines	10	10	20	8.9	9
Very small gravel	2-4	3	3	6	2.7	12
Small gravel	4-8	7	5	12	5.3	17
Medium gravel	8-16	10	6	16	7.1	24
Coarse gravel	16-32	10	12	22	9.8	34
Very coarse gravel	32-64	21	26	47	20.9	55
Small & med. cobble	64-128	23	25	48	21.3	76
Large cobble	128-256	19	12	31	13.8	90
Small boulder	256-512	9	8	17	7.6	98
Medium boulder	512-1024	5	0	5	2.2	100
Large boulder	1024-2048	0	0	0	0.0	100
Very large boulder	>2048	0	0	0	0.0	100
Bedrock	bdrock	0	0	0	0.0	100
Sample Size		118	107	225	100	
Longitudinal Distance (feet)		100	100			
D50 Particle Size	Very coarse gravel					
Dominant Size Class	Small and medium cobble					

Centex Destination Properties/Killington WQ Monitoring
KP-17 Pebble Counts: 2005



Roaring Brook and East Branch of Roaring Brook

Water Quality Monitoring 2005

SUBSTRATE DATA COLLECTION

Sampling Date: 10/27/05

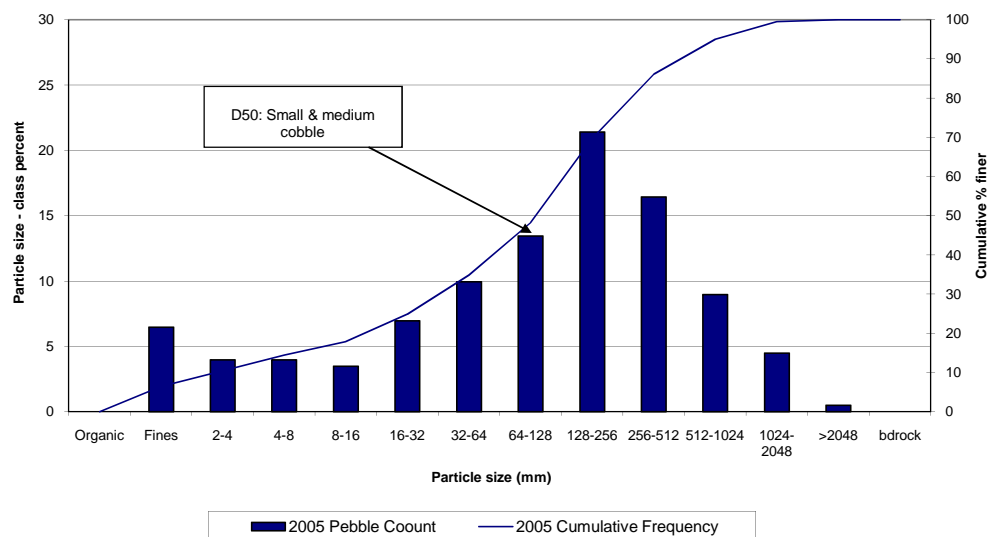
Samplers: TDS, SRW

Sample Location: KP-18, East Branch of Roaring Brook above confluence of Roaring Brook
(sampling began just above confluence and continued upstream to culvert outlet)

Station Habitat Observations	Sample #1
Canopy cover:	10%
Embeddedness:	25-50%
Bank stability:	75-100%
% Slope:	8%

Number of Observations					
Category	Median Size (mm)	Sample #1	Summary of Samples	% of Total	Total Cumulative Frequency (%)
Organic	Organic	0	0	0.0	0
Fines	Fines	13	13	6.5	6
Very small gravel	2-4	8	8	4.0	10
Small gravel	4-8	8	8	4.0	14
Medium gravel	8-16	7	7	3.5	18
Coarse gravel	16-32	14	14	7.0	25
Very coarse gravel	32-64	20	20	10.0	35
Small & med. cobble	64-128	27	27	13.4	48
Large cobble	128-256	43	43	21.4	70
Small boulder	256-512	33	33	16.4	86
Medium boulder	512-1024	18	18	9.0	95
Large boulder	1024-2048	9	9	4.5	100
Very large boulder	>2048	1	1	0.5	100
Bedrock	bdrock	0	0	0.0	100
Sample Size		201	201	100	
Longitudinal Distance (feet)		140			
D50 Particle Size		Small & med. Cobble			
Dominant Size Class		Large cobble			

Centex Destination Properties/Killington WQ Monitoring
KP-18 Pebble Counts: 2005



Project Roaring Brook and East Branch of Roaring Brook
Stations Background Water Quality Monitoring 2005
Stream Summary
Location Roaring Brook and E. Br. Roaring Brook
Sample Date NA
Sample Date 9/23/2005

Metric/Station	Roaring Brook						E. Br. Roaring Brook		
	KP-05	KP-08	KP-10	KP-11	KP-26	KP-27	KP-15	KP-17	KP-18
Density	133.0	702.0	361.5	226.0	361.0	384.0	237.0	397.5	276.0
Richness	23.5	34.5	34	29	32.5	24.5	34	32.0	33.0
EPT	14	21.5	22	17.5	20.5	17	14	11.0	14.5
PMA-O	60.3	70.1	62.6	65.7	69.8	42.3	68.8	63.7	73.8
BI	1.13	1.37	1.24	1.41	1.54	0.82	1.56	3.50	2.82
%Oligo	2.4	8.5	5.4	24.8	2.0	8.1	4.2	2.4	6.3
EPT/EPT+C	0.95	0.96	0.93	0.96	0.93	0.96	0.83	0.55	0.68
PPCS-F	0.31	0.59	0.55	0.60	0.49	0.42	0.57	0.57	0.58
Outcome	Fail	Pass	Pass	Fail	Pass	Fail	Fail	Fail	Fail

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-05
Stream Ram's Head Brook **Class** Small, High Gradient, B2-3
Location River Mile 0.1
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				FFG
				KN-1	KN-2	Old BI	New BI	
02.03.003.00	DIPTERA	BEZZIA	sp	2	2	3	6	PRD
02.05.017.00	DIPTERA	CORYNONEURA	sp			2	4	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	1	1	3	5	CG
02.05.098.00	DIPTERA	RHEOTANYTARSUS	sp		5	3	6	CF
02.05.108.00	DIPTERA	TANYTARSUS	sp			3	6	CF
02.05.114.02	DIPTERA	TVETENIA	bavarica	3	2	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp	2	2	2	1	CG
02.14.005.00	DIPTERA	SIMULIUM	sp			2	5	CF
02.19.001.00	DIPTERA	ANTOCHA	sp	1		3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	1		2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	4	5	2	2	PRD
02.19.016.00	DIPTERA	TIPULA	sp	3		3	6	SRD
03.01.001.09	EPHEMEROPTERA	BAETIS	tricaudatus			3	6	CG
03.01.001.91	EPHEMEROPTERA	BAETIS	sp a	3		3	6	CG
03.01.007.00	EPHEMEROPTERA	PLAUDITUS	sp	1		2	5	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	1		2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	1	2	2	4	CG
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp		1	1	0	SCR
04.05.003.00	TRICHOPTERA	DIPLECTRONA	sp	1	2	0	0	CF
04.05.006.00	TRICHOPTERA	PARAPSYCHE	sp	20	8	0	0	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alheda	2		2	3	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	10	7	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp	2		1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	1		1	3	SCR
04.09.018.00	TRICHOPTERA	PYCNOPSYCHE	sp	1	1	2	4	SRD
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	38	77	0	0	CF
04.14.005.00	TRICHOPTERA	POLYCENTROPUS	sp			3	6	PRD
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	1		1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1		0	0	PRD
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	14	17	0	0	PRD
05.04.000.01	PLECOPTERA	NEMOURIDAE	imm		1	0	2	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid		1	1	0	SRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	3	4	1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus	1		1	0	SRD
07.02.001.00	MEGALOPTERA	SIALIS	sp	1	1	3	6	PRD
16.01.001.00	GORDIIDA	GORDIUS	sp		1	0	0	0
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid		3	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid		4	0	0	CG

TOTAL 119 147

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-05
Stream Ram's Head Brook **Class** Small, High Gradient, B2-3
Location River Mile 0.1
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	119	147	133
Species Richness	26	21	23.5
EPT Richness	17	11	14
Bio Index (0 to 5)	0.78	0.51	0.65
Bio Index (0 to 10)	1.37	0.88	1.13
% dominant taxa	31.9	52.4	42.2
EPT/EPT+C	0.96	0.94	0.95
EPT/Richness	0.65	0.52	0.60
% Model Affinity (orders)	63.0	57.6	60.3
PPCS - functional groups	0.33	0.29	0.31
Major Groups:			
Coleoptera (%)	0.0	0.0	0.0
Diptera (%)	14.3	11.6	12.9
Ephemeroptera (%)	5.0	1.4	3.2
Trichoptera (%)	64.7	65.3	65.0
Plecoptera (%)	15.1	15.6	15.4
Oligochaeta (%)	0.0	4.8	2.4
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.8	0.7	0.8
Odonata (%)	0.0	0.0	0.0
Other (%)	0.0	0.0	0.0
Total (%)	100.0	99.3	99.7
Feeding Groups:			
Collector Gatherer (%)	10.1	9.5	9.8
Collector Filterer (%)	59.7	67.3	63.5
Predator (%)	22.7	19.7	21.2
Shredder - Detritus (%)	5.9	2.0	4.0
Shredder - Herbivore (%)	0.0	0.0	0.0
Scraper (%)	1.7	0.7	1.2
Total (%)	100	99.3	99.7

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-05
Stream Ram's Head Brook **Class** Small, High Gradient, B2-3
Location River Mile 0.1
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	133.0	≥300	Fail	≥400	Fail	≥500	Fail
Richness	23.5	≥27	Fail	≥31	Fail	≥35	Fail
EPT	14	≥16	Fail	≥19	Fail	≥21	Fail
PMA-O	60.3	≥45	Pass	≥55	Pass	≥65	Fail
BI	1.13	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	2.4	≤12	Pass	≤5	Pass	≤2	Fail
EPT/EPT+C	0.95	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-F	0.31	≥0.40	Fail	≥0.45	Fail	≥0.50	Fail
Outcome		Does Not Meet Class B2-3					
Metrics not in compliance with Class B2-3 thresholds		Density, Richness, EPT, PPCS-F					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	>22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET					
River: Rams Head 0.1RM		Project: Killington		Station: KP-5	
Collection Date: September 23, 2005		Time: 1345		Personnel: C. Szal	
Gear: 560 um kicknet				Effort Time: 2 min.	
Collection flow: H - <u>M</u> - L		Weather: Cloudy		Water temp: 14 C	
Substrate composition (%):					
Bedrock:		Coarse gravel (>.05-2.5"): 15		Silt:	
Boulder (>10"): 20		Gravel (>0.05-0.5"): 15		Clay:	
Cobble (2.5-10"): 30		Sand (0.002-0.05"): 20		CPOM:	
Embeddedness (%): (0-5) Excellent		(5-25) Very good		(25-50) <u>Good</u>	
		(50-75) Fair		(>75) Poor	
Canopy (%): 100 90 <u>80</u> 70 60 50		40 30 20 10 0		Overhead: Open / <u>Closed</u>	
Bank stability (%): Excellent (>80)		Good (50-79)		Fair (25-49) <u>Poor</u> (<25)	
Bank vegetation (%):					
Softwood Hardwood		<u>Mixed</u> Brush		Grass	
Predominant surrounding land use: Forest and ski area					
Periphyton (%):					
Diatom:		Filamentous green:		Moss:	
Matted blue-green: Patchy, moderate		Other:			
General water type:					
<u>Riffle</u> Run Pool		Warm <u>Cold</u> Mixed		Width 4-8'	
Depth 4-8"		Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec			
Channelized: Y / <u>N</u>		Upstream dam: Y / <u>N</u>		Other Modifications:	
Note: A lot of sand, some areas 100% embedded. Poor bank stability due to bedload. Black rocks, very silty, very hard to kick due to sealed substrate.					

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-08
Stream West Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, Approximately 200 linear feet upstream of culvert at Killington Access Road
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				
				KN-1	KN-2	Old BI	New BI	FFG
01.03.006.00	COLEOPTERA	OULIMNIUS	sp	100	92	2	3	SCR
01.03.008.00	COLEOPTERA	STENELMIS	sp	18	12	3	5	SCR
02.03.003.00	DIPTERA	BEZZIA	sp	6		3	6	PRD
02.05.065.00	DIPTERA	ORTHOCLADIUS	sp		2	3	7	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	6	8	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCLADIUS	sp		2	2	4	CG
02.05.085.05	DIPTERA	POLYPEDILUM	aviceps		4	3	5	CG
02.05.098.00	DIPTERA	RHEOTANYTARSUS	sp		4	3	6	CF
02.05.114.02	DIPTERA	TVETENIA	bavarica	6	10	2	4	CG
02.05.121.00	DIPTERA	MICROPSECTRA	sp		2	3	6	CG
02.06.001.00	DIPTERA	DIXA	sp	2	10	2	1	CG
02.08.000.00	DIPTERA	EMPIDIDAE	unid	2		3	6	PRD
02.19.003.00	DIPTERA	DICRANOTA	sp	14	22	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	10	4	2	2	PRD
03.01.001.09	EPHEMEROPTERA	BAETIS	tricaudatus	6		3	6	CG
03.01.001.91	EPHEMEROPTERA	BAETIS	sp a	12	2	3	6	CG
03.01.007.00	EPHEMEROPTERA	PLAUDITUS	sp	4		2	5	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	4		2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	6	10	2	4	CG
03.06.003.00	EPHEMEROPTERA	EPEORUS	sp	6	4	0	0	CG
03.07.005.00	EPHEMEROPTERA	PARALEPTOPHLEBIA	sp	4	4	2	1	CG
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp	10	4	1	0	SCR
04.05.003.00	TRICHOPTERA	DIPLECTRONA	sp	4	14	0	0	CF
04.05.006.00	TRICHOPTERA	PARAPSYCHE	sp	10	24	0	0	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	24	36	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp	4		1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	4	6	1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	114	118	0	0	CF
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	2	6	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	12	2	0	0	PRD
04.16.001.09	TRICHOPTERA	RHYACOPHILA	minora	2	2	0	0	PRD
04.16.001.12	TRICHOPTERA	RHYACOPHILA	invaria		2	1	1	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp	4		2	3	SCR
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	54	78	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	104	96	0	0	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid	8	70	1	0	SRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	10	24	1	2	PRD
05.07.007.00	PLECOPTERA	MALIREKUS	sp		2	1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus	16	18	1	0	SRD
06.04.001.00	ODONATA	CORDULEGASTER	sp	2		1	3	PRD
06.06.007.00	ODONATA	LANTHUS	sp	2		2	5	PRD
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	98	16	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAETIDAE	unid		4	0	0	CG

TOTAL 690 714

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-08
Stream West Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, Approximately 200 linear feet upstream of culvert at Killington Access Road
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	690	714	702
Species Richness	35	34	34.5
EPT Richness	23	20	21.5
Bio Index (0 to 5)	0.96	0.88	0.92
Bio Index (0 to 10)	1.51	1.24	1.37
% dominant taxa	16.5	16.5	16.5
EPT/EPT+C	0.97	0.94	0.96
EPT/Richness	0.66	0.59	0.62
% Model Affinity (orders)	70.3	69.8	70.1
PPCS - functional groups	0.63	0.55	0.59
Major Groups:			
Coleoptera (%)	17.1	14.6	15.8
Diptera (%)	6.7	9.5	8.1
Ephemeroptera (%)	6.1	2.8	4.4
Trichoptera (%)	27.5	30.0	28.8
Plecoptera (%)	27.8	40.3	34.1
Oligochaeta (%)	14.2	2.8	8.5
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.6	0.0	0.3
Other (%)	0.0	0.0	0.0
Total (%)	100	100	100
Feeding Groups:			
Collector Gatherer (%)	21.7	10.9	16.3
Collector Filterer (%)	22.0	27.5	24.7
Predator (%)	16.8	19.9	18.3
Shredder - Detritus (%)	19.1	25.8	22.5
Shredder - Herbivore (%)	0.0	0.0	0.0
Scraper (%)	20.3	16.0	18.1
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-08
Stream West Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, Approximately 200 linear feet upstream of culvert at Killington Access Road
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	702.0	≥300	Pass	≥400	Pass	≥500	Pass
Richness	34.5	≥27	Pass	≥31	Pass	≥35	Fail
EPT	21.5	≥16	Pass	≥19	Pass	≥21	Pass
PMA-O	70.1	≥45	Pass	≥55	Pass	≥65	Pass
BI	1.37	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	8.5	≤12	Pass	≤5	Fail	≤2	Fail
EPT/EPT+C	0.96	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-FG	0.59	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Meets Class B2-3					
Metrics not in compliance with Class B2-3 thresholds							

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET									
River: W. Roaring Bk RM 0.2			Project: Killington			Station: KP-8			
Collection Date: September 23, 2005			Time: 1145			Personnel: C. Szal			
Gear: 560 um kicknet						Effort Time: 2 min.			
Collection flow: H - <u>M</u> - L			Weather: Cloudy			Water temp: 14 C			
Substrate composition (%):									
Bedrock:			Coarse gravel (>.0.5-2.5"): 15			Silt:			
Boulder (>10"): 20			Gravel (>0.05-0.5"): 10			Clay:			
Cobble (2.5-10"): 40			Sand (0.002-0.05"): 15			CPOM:			
Embeddedness (%): (0-5) Excellent			(5-25) Very good			(25-50) <u>Good</u>			
			(50-75) Fair			(>75) Poor			
Canopy (%): 100 90 <u>80</u> 70 60 50			40 30 20 10 0			Overhead: Open / <u>Closed</u>			
Bank stability (%): <u>Excellent</u> (>80)			Good (50-79)			Fair (25-49)		Poor(<25)	
Bank vegetation (%):									
Softwood		Hardwood	<u>Mixed</u>		Brush	Grass			
Predominant surrounding land use: Forest and ski area									
Periphyton (%):									
Diatom: Light			Filamentous green:			Moss: Light			
Matted blue-green:			Other:						
General water type:									
<u>Riffle</u>	Run	Pool	Warm	<u>Cold</u>	Mixed	Width 6-10'			
Depth 4-8"			Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec						
Channelized: Y / <u>N</u>			Upstream dam: Y / <u>N</u>			Other Modifications:			
Note: Very light iron staining, no black rocks.									

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-10
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Roaring Brook
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				
				KN-1	KN-2	Old BI	New BI	FFG
02.03.003.00	DIPTERA	BEZZIA	sp	1		3	6	PRD
02.05.018.00	DIPTERA	CRICOTOPUS	sp		1	4	7	SHR
02.05.029.00	DIPTERA	EUKIEFFERIELLA	sp	10	9	2	6	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	5	2	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCLADIUS	sp	1	1	2	4	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	1	2	2	6	CG
02.05.098.00	DIPTERA	RHEOTANYTARSUS	sp	5		3	6	CF
02.05.114.02	DIPTERA	TVETENIA	bavarica	1	5	2	4	CG
02.05.121.00	DIPTERA	MICROPSECTRA	sp		1	3	6	CG
02.06.001.00	DIPTERA	DIXA	sp		1	2	1	CG
02.19.001.00	DIPTERA	ANTOCHA	sp		1	3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	4	4	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	6	2	2	2	PRD
03.01.001.09	EPHEMEROPTERA	BAETIS	tricaudatus	12	4	3	6	CG
03.01.001.91	EPHEMEROPTERA	BAETIS	sp a	14	15	3	6	CG
03.01.001.92	EPHEMEROPTERA	BAETIS	sp b	2		3	6	CG
03.01.007.00	EPHEMEROPTERA	PLAUDITUS	sp		8	2	5	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	1	2	2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	2	7	2	4	CG
03.04.005.02	EPHEMEROPTERA	EURYLOPHELLA	funeralis	1		1	0	SHR
03.06.003.00	EPHEMEROPTERA	EPEORUS	sp	4	1	0	0	CG
03.06.007.00	EPHEMEROPTERA	STENONEMA	sp	2	1	2	3	SCR
03.07.005.00	EPHEMEROPTERA	PARALEPTOPHLEBIA	sp		2	2	1	CG
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp	2		1	0	SCR
04.05.006.00	TRICHOPTERA	PARAPSYCHE	sp	4	10	0	0	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alhedra	4	5	2	3	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	11	2	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp	2	1	1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	4	4	1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	54	28	0	0	CF
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	8	11	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	2	1	0	0	PRD
04.16.001.09	TRICHOPTERA	RHYACOPHILA	minora	1		0	0	PRD
04.16.001.12	TRICHOPTERA	RHYACOPHILA	invaria			1	1	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp	2		2	3	SCR
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	58	22	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	155	134	0	0	SRD
05.04.000.01	PLECOPTERA	NEMOURIDAE	imm		1	0	2	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid	1	6	1	0	SRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	2	7	1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus	1		1	0	SRD
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	23	12	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid		4	0	0	CG

TOTAL 406 317

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-10
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	406	317	361.5
Species Richness	34	34	34
EPT Richness	24	20	22
Bio Index (0 to 5)	0.60	0.68	0.64
Bio Index (0 to 10)	1.15	1.34	1.24
% dominant taxa	38.2	42.3	40.2
EPT/EPT+C	0.94	0.93	0.93
EPT/Richness	0.71	0.59	0.65
% Model Affinity (orders)	62.4	62.8	62.6
PPCS - functional groups	0.55	0.54	0.55
Major Groups:			
Coleoptera (%)	0.0	0.0	0.0
Diptera (%)	8.4	9.1	8.8
Ephemeroptera (%)	9.4	12.6	11.0
Trichoptera (%)	23.2	19.6	21.4
Plecoptera (%)	53.4	53.6	53.5
Oligochaeta (%)	5.7	5.0	5.4
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.0	0.0	0.0
Other (%)	0.0	0.0	0.0
Total (%)	100	100	100
Feeding Groups:			
Collector Gatherer (%)	18.7	21.8	20.2
Collector Filterer (%)	19.2	14.2	16.7
Predator (%)	20.2	14.8	17.5
Shredder - Detritus (%)	39.2	44.8	42.0
Shredder - Herbivore (%)	0.2	0.3	0.3
Scraper (%)	2.5	4.1	3.3
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-10
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	361.5	≥300	Pass	≥400	Fail	≥500	Fail
Richness	34	≥27	Pass	≥31	Pass	≥35	Fail
EPT	22	≥16	Pass	≥19	Pass	≥21	Pass
PMA-O	62.6	≥45	Pass	≥55	Pass	≥65	Fail
BI	1.24	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	5.4	≤12	Pass	≤5	Fail	≤2	Fail
EPT/EPT+C	0.93	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-FG	0.55	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Meets Class B2-3					
Metrics not in compliance with Class B2-3 thresholds							

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET

River: Roaring Bk RM 4.3 Below base lodge	Project: Killington	Station: KP-10
Collection Date: September 23, 2005	Time: 1600	Personnel: C. Szal
Gear: 560 um kicknet		Effort Time: 2 min.
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 25	Silt:
Boulder (>10"): 40	Gravel (>0.05-0.5"): 5	Clay:
Cobble (2.5-10"): 25	Sand (0.002-0.05"): 5	CPOM:
Embeddedness (%): (0-5) Excellent	(5-25) <u>Very good</u>	(25-50) Good
	(50-75) Fair	(>75) Poor
Canopy (%): 100 90 80 70 <u>60</u> 50	40 30 20 10 0	Overhead: Open / <u>Closed</u>
Bank stability (%): <u>Excellent</u> (>80)	Good (50-79)	Fair (25-49) Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass
Predominant surrounding land use: Forest and ski area		
Periphyton (%): Diatom: Light	Filamentous green:	Moss: Moderate
Matted blue-green: Patchy	Other:	
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 8-14'
Depth 6-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec	
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications: Culvert
Note: Banks very armored, high gradient, gravel in pools, iron stains, silty, no black rocks, kick nets varied.		

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-11
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 3.8, below confluence with Ram's Head Brook
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				FFG
				KN-1	KN-2	Old BI	New BI	
02.03.003.00	DIPTERA	BEZZIA	sp	1		3	6	PRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp	1		3	5	PRD
02.05.017.00	DIPTERA	CORYNONEURA	sp	1		2	4	CG
02.05.029.00	DIPTERA	EUKIEFFERIELLA	sp			2	6	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	2	2	3	5	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	1		2	6	CG
02.05.110.00	DIPTERA	THIENEMANNEMYIA	sp	1		3	6	PRD
02.05.114.02	DIPTERA	TVETENIA	bavarica	5	1	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp	4	1	2	1	CG
02.14.005.00	DIPTERA	SIMULIUM	sp	8	1	2	5	CF
02.19.001.00	DIPTERA	ANTOCHA	sp		1	3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp		1	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	3	2	2	2	PRD
03.01.001.09	EPHEMEROPTERA	BAETIS	tricaudatus	11	6	3	6	CG
03.01.001.91	EPHEMEROPTERA	BAETIS	sp a	7	3	3	6	CG
03.01.001.92	EPHEMEROPTERA	BAETIS	sp b			3	6	CG
03.01.007.00	EPHEMEROPTERA	PLAUDITUS	sp	7		2	5	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	4	2	2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	4	2	2	4	CG
03.04.005.02	EPHEMEROPTERA	EURYLOPHELLA	funeralis			1	0	SHR
03.06.003.00	EPHEMEROPTERA	EPEORUS	sp	4	2	0	0	CG
03.07.005.00	EPHEMEROPTERA	PARALEPTOPHLEBIA	sp			2	1	CG
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp			1	0	SCR
04.05.006.00	TRICHOPTERA	PARAPSYCHE	sp	1	1	0	0	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alheda	3		2	3	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	5	2	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp		1	1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	3		1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	42	39	0	0	CF
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscata	4	6	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1	1	0	0	PRD
04.16.001.09	TRICHOPTERA	RHYACOPHILA	minora		1	0	0	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp	1	2	2	3	SCR
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	39	24	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	32	27	0	0	SRD
05.04.000.01	PLECOPTERA	NEMOURIDAE	imm	1		0	2	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid			1	0	SRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	7	7	1	2	PRD
05.07.007.00	PLECOPTERA	MALIREKUS	sp		2	1	2	PRD
09.01.001.00	AMPHIPODA	GAMMARUS	sp	1		2	6	CG
13.02.002.00	BIVALVIA	PISIDIUM	sp	1		4	8	CF
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	46	40	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid	12	12	0	0	CG

TOTAL 263 189

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-11
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 3.8, below confluence with Ram's Head Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	263	189	226
Species Richness	32	26	29
EPT Richness	18	17	17.5
Bio Index (0 to 5)	0.88	0.58	0.73
Bio Index (0 to 10)	1.76	1.06	1.41
% dominant taxa	17.5	21.2	19.3
EPT/EPT+C	0.94	0.98	0.96
EPT/Richness	0.56	0.65	0.60
% Model Affinity (orders)	69.1	62.2	65.7
PPCS - functional groups	0.61	0.58	0.60
Major Groups:			
Coleoptera (%)	0.0	0.0	0.0
Diptera (%)	10.3	4.8	7.5
Ephemeroptera (%)	14.1	7.9	11.0
Trichoptera (%)	22.8	28.0	25.4
Plecoptera (%)	30.0	31.7	30.9
Oligochaeta (%)	22.1	27.5	24.8
Bivalvia (%)	0.4	0.0	0.2
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.0	0.0	0.0
Other (%)	0.00	0.00	0.00
Total (%)	99.6	100.0	99.8
Feeding Groups:			
Collector Gatherer (%)	38.8	38.1	38.4
Collector Filterer (%)	22.8	22.8	22.8
Predator (%)	21.7	23.3	22.5
Shredder - Detritus (%)	12.5	14.8	13.7
Shredder - Herbivore (%)	0.0	0.0	0.0
Scraper (%)	4.2	1.1	2.6
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-11
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 3.8, below confluence with Ram's Head Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	226.0	≥300	Fail	≥400	Fail	≥500	Fail
Richness	29	≥27	Pass	≥31	Fail	≥35	Fail
EPT	17.5	≥16	Pass	≥19	Fail	≥21	Fail
PMA-O	65.7	≥45	Pass	≥55	Pass	≥65	Pass
BI	1.41	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	24.8	≤12	Fail	≤5	Fail	≤2	Fail
EPT/EPT+C	0.96	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-FG	0.60	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Does Not Meet Class B2-3					
Metrics not in compliance with Class B2-3 thresholds		Density and % Oligochaeta					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET

River: Roaring Bk below Ram's Head	Project: Killington	Station: KP-11
Collection Date: September 23, 2005	Time: 1500	Personnel: C. Szal
Gear: 560 um kicknet		Effort Time: 2 min.
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 15	Silt:
Boulder (>10"): 30	Gravel (>0.05-0.5"): 10	Clay:
Cobble (2.5-10"): 30	Sand (0.002-0.05"): 15	CPOM:
Embeddedness (%): (0-5) Excellent	(5-25) Very good	(25-50) <u>Good</u>
	(50-75) Fair	(>75) Poor
Canopy (%): 100 90 80 70 <u>60</u> 50	40 30 20 10 0	Overhead: Open / <u>Closed</u>
Bank stability (%): Excellent(> 80%)	Good (50-79)	<u>Fair</u> (25-49) Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass
Predominant surrounding land use: Forest and ski area		
Periphyton (%): Diatom: Light	Filamentous green:	Moss: Light
Matted blue-green: Patchy	Other:	
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 8-14'
Depth 6-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec	
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications: Culvert
Note: Bank widening, very silty, moderate iron stain, a few black rocks, very embedded in pools.		

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-15
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.7, below East Roaring Brook Road and above the Killington Golf Course
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				
				KN-1	KN-2	Old BI	New BI	FFG
01.03.006.00	COLEOPTERA	OULIMNIUS	sp	6	9	2	3	SCR
01.03.007.00	COLEOPTERA	PROMORESIA	sp		4	2	2	SCR
01.03.008.00	COLEOPTERA	STENELMIS	sp	4	2	3	5	SCR
02.03.003.00	DIPTERA	BEZZIA	sp	1	2	3	6	PRD
02.05.005.00	DIPTERA	BRILLIA	sp	1	1	3	5	SRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp		1	3	5	PRD
02.05.017.00	DIPTERA	CORYNONEURA	sp	1	1	2	4	CG
02.05.068.00	DIPTERA	PARACHAETOCLADIUS	sp		2	2	2	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	8	6	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCLADIUS	sp		6	2	4	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	3	2	2	6	CG
02.05.098.00	DIPTERA	RHEOTANYTARSUS	sp	4		3	6	CF
02.05.110.00	DIPTERA	THIENEMANNEMYIA	sp	1		3	6	PRD
02.05.114.01	DIPTERA	TVETENIA	discoloripes		3	3	6	CG
02.05.114.02	DIPTERA	TVETENIA	bavarica	4	21	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp	4	7	2	1	CG
02.14.005.00	DIPTERA	SIMULIUM	sp	2		2	5	CF
02.19.001.00	DIPTERA	ANTOCHA	sp	1		3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	3	6	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp		6	2	2	PRD
02.19.016.00	DIPTERA	TIPULA	sp	6	12	3	6	SRD
02.19.019.00	DIPTERA	MOLOPHILUS	sp	1	2	3	4	CG
03.06.003.00	EPEHEMEROPTERA	EPEORUS	sp	9	1	0	0	CG
03.07.005.00	EPEHEMEROPTERA	PARALEPTOPHLEBIA	sp	4		2	1	CG
04.01.003.00	TRICHOPTERA	MICRASEMA	sp		1	1	2	SHR
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp		4	1	0	SCR
04.05.003.00	TRICHOPTERA	DIPLECTRONA	sp	1	1	0	0	CF
04.05.008.06	TRICHOPTERA	SYMPHITOPSYCHE	slossonae	2		2	4	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	7	2	2	4	CF
04.09.002.00	TRICHOPTERA	APATANIA	sp		4	1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	77	14	0	0	CF
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	1	3	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1	1	0	0	PRD
04.16.001.12	TRICHOPTERA	RHYACOPHILA	invaria	1		1	1	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp		1	2	3	SCR
05.01.000.01	PLECOPTERA	CAPNIIDAE	imm		1	1	3	SRD
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	31	56	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	9	6	0	0	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid	14	37	1	0	SRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	3	16	1	2	PRD
06.06.007.00	ODONATA	LANTHUS	sp		2	2	5	PRD
12.08.002.00	GASTROPODA	PHYSA	sp		1	4	8	CG
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	5	9	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAETIDAE	unid	4	2	0	0	CG

TOTAL 219 255

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-15
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.7, below East Roaring Brook Road and above the Killington Golf Course
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	219	255	237
Species Richness	31	37	34
EPT Richness	13	15	14
Bio Index (0 to 5)	0.82	1.21	1.01
Bio Index (0 to 10)	1.30	1.82	1.56
% dominant taxa	35.2	22.0	28.6
EPT/EPT+C	0.88	0.77	0.83
EPT/Richness	0.42	0.41	0.41
% Model Affinity (orders)	78.3	59.4	68.8
PPCS - functional groups	0.56	0.59	0.57
Major Groups:			
Coleoptera (%)	4.6	5.9	5.2
Diptera (%)	18.3	30.6	24.4
Ephemeroptera (%)	5.9	0.4	3.2
Trichoptera (%)	41.1	12.2	26.6
Plecoptera (%)	26.0	45.5	35.8
Oligochaeta (%)	4.1	4.3	4.2
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.0	0.8	0.4
Other (%)	0.0	0.0	0.0
Total (%)	100	100	100
Feeding Groups:			
Collector Gatherer (%)	20.1	24.7	22.4
Collector Filterer (%)	42.5	6.7	24.6
Predator (%)	19.2	36.5	27.8
Shredder - Detritus (%)	13.7	22.4	18.0
Shredder - Herbivore (%)	0.0	0.4	0.2
Scraper (%)	4.6	9.4	7.0
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-15
Stream East Branch Roaring Brook Background **Class** Small, High Gradient, B2-3
Location RM 0.7, below East Roaring Brook Road and above the Killington Golf Course
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	237.0	≥300	Fail	≥400	Fail	≥500	Fail
Richness	34	≥27	Pass	≥31	Pass	≥35	Fail
EPT	14	≥16	Fail	≥19	Fail	≥21	Fail
PMA-O	68.8	≥45	Pass	≥55	Pass	≥65	Pass
BI	1.56	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	4.2	≤12	Pass	≤5	Pass	≤2	Fail
EPT/EPT+C	0.83	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-F	0.57	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Does Not Meet Class B2/3					
Metrics not in compliance with Class B2-3 thresholds		Density and EPT					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET

River: East Br. Of Roaring Bk RM 0.7	Project: Killington	Station: KP-15
Collection Date: September 23, 2005	Time: 0900	Personnel: C. Szal
Gear: 560 um kicknet		Effort Time: 2 min.
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 15	Silt:
Boulder (>10"): 40	Gravel (>0.05-0.5"): 5	Clay:
Cobble (2.5-10"): 30	Sand (0.002-0.05"): 10	CPOM:
Embeddedness (%): (0-5) Excellent	(5-25) <u>Very good</u>	(25-50) Good
	(50-75) Fair	(>75) Poor
Canopy (%): 100 90 80 <u>70</u> 60 50	40 30 20 10 0	Overhead: Open / <u>Closed</u>
Bank stability (%): Excellent(> 80%)	<u>Good</u> (50-79)	Fair (25-49) Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass
Predominant surrounding land use: Forest, residential development and ski area		
Periphyton (%): Diatom:	Filamentous green:	Moss: Light
Matted blue-green:	Other:	
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 3-10'
Depth 6-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec	
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications: Culvert
Note: Light iron staining, FPOM, black rocks, bank widening, high gradient		

Project Centex Destination Properties and Killington, Ltd
Background Water Quality Monitoring 2005

Station KP-17

Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3

Location RM 0.5, mid-area of Killington Golf Course and below sprayfield

Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				
				KN-1	KN-2	Old BI	New BI	FFG
01.03.006.00	COLEOPTERA	OULIMNIUS	sp	5	7	2	3	SCR
01.03.008.00	COLEOPTERA	STENELMIS	sp	18	2	3	5	SCR
02.03.003.00	DIPTERA	BEZZIA	sp	7	5	3	6	PRD
02.05.005.00	DIPTERA	BRILLIA	sp			3	5	SRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp	20	11	3	5	PRD
02.05.018.00	DIPTERA	CRICOTOPUS	sp	28	5	4	7	SHR
02.05.068.00	DIPTERA	PARACHAETOCLADIUS	sp	2		2	2	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	5	16	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCLADIUS	sp	14	2	2	4	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	2	22	2	6	CG
02.05.098.00	DIPTERA	RHEOTANYTARSUS	sp			3	6	CF
02.05.108.00	DIPTERA	TANYTARSUS	sp		1	3	6	CF
02.05.110.00	DIPTERA	THIENEMANNEMYIA	sp	1	1	3	6	PRD
02.05.114.01	DIPTERA	TVETENIA	discoloripes	5	26	3	6	CG
02.05.114.02	DIPTERA	TVETENIA	bavarica	38	74	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp		2	2	1	CG
02.19.001.00	DIPTERA	ANTOCHA	sp	20	14	3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	10	16	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	14	6	2	2	PRD
02.19.016.00	DIPTERA	TIPULA	sp	4	8	3	6	SRD
02.19.019.00	DIPTERA	MOLOPHILUS	sp			3	4	CG
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	17	18	2	4	CG
04.01.002.00	TRICHOPTERA	BRACHYCENTRUS	sp	6		1	1	CF
04.05.003.00	TRICHOPTERA	DIPLECTRONA	sp	6	8	0	0	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alhedra	4	28	2	3	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	50	36	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp	2		1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp			1	3	SCR
04.11.001.00	TRICHOPTERA	PSILOTRETA	sp		1	0	0	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	14	65	0	0	CF
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1		0	0	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp			2	3	SCR
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	29	32	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	6	2	0	0	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid			1	0	SRD
05.06.007.00	PLECOPTERA	AGNETINA	sp	1	1	0	2	PRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	1	4	1	2	PRD
06.01.004.00	ODONATA	BOYERIA	sp	1		2	2	PRD
06.04.001.00	ODONATA	CORDULEGASTER	sp	1		1	3	PRD
12.06.001.00	GASTROPODA	FERRISSIA	sp	1	1	3	6	SCR
12.08.002.00	GASTROPODA	PHYSA	sp	20	8	4	8	CG
16.01.001.00	GORDIIDA	GORDIUS	sp	1		0	0	0
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	8	11	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid			0	0	CG

TOTAL 362 433

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-17
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.5, mid-area of Killington Golf Course and below sprayfield
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	362	433	397.5
Species Richness	34	30	32
EPT Richness	12	10	11
Bio Index (0 to 5)	2.14	1.74	1.94
Bio Index (0 to 10)	3.77	3.24	3.50
% dominant taxa	13.8	17.1	15.5
EPT/EPT+C	0.54	0.55	0.55
EPT/Richness	0.35	0.33	0.34
% Model Affinity (orders)	64.2	63.2	63.7
PPCS - functional groups	0.56	0.57	0.57
Major Groups:			
Coleoptera (%)	6.4	2.1	4.2
Diptera (%)	47.0	48.3	47.6
Ephemeroptera (%)	4.7	4.2	4.4
Trichoptera (%)	22.9	31.9	27.4
Plecoptera (%)	10.2	9.0	9.6
Oligochaeta (%)	2.2	2.5	2.4
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.6	0.0	0.3
Other (%)	0.0	0.0	0.0
Total (%)	93.9	97.9	95.9
Feeding Groups:			
Collector Gatherer (%)	36.2	44.6	40.4
Collector Filterer (%)	22.1	31.9	27.0
Predator (%)	23.8	17.6	20.7
Shredder - Detritus (%)	3.3	2.3	2.8
Shredder - Herbivore (%)	7.7	1.2	4.4
Scraper (%)	6.6	2.5	4.6
Total (%)	99.7	100.0	99.9

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-17
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.5, mid-area of Killington Golf Course and below sprayfield
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	397.5	≥300	Pass	≥400	Fail	≥500	Fail
Richness	32.0	≥27	Pass	≥31	Pass	≥35	Fail
EPT	11.0	≥16	Fail	≥19	Fail	≥21	Fail
PMA-O	63.7	≥45	Pass	≥55	Pass	≥65	Fail
BI	3.50	≤4.50	Pass	≤3.50	Fail	≤3.00	Fail
%Oligo	2.4	≤12	Pass	≤5	Pass	≤2	Fail
EPT/EPT+C	0.55	≥0.45	Pass	≥0.55	Fail	≥0.65	Fail
PPCS-FG	0.57	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Does Not Meet Class B2/3					
Metrics not in compliance with Class B2-3 thresholds		EPT					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET

River: East Br. Roaring Bk mid golf course	Project: Killington	Station: KP-17
Collection Date: September 23, 2005	Time: 0800	Personnel: C. Szal
Gear: 560 um kicknet		Effort Time: 2 min.
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C
Substrate composition (%): Bedrock:	Coarse gravel (>.05-2.5"): 10	Silt:
Boulder (>10"): 35	Gravel (>0.05-0.5"): 5	Clay:
Cobble (2.5-10"): 35	Sand (0.002-0.05"): 15	CPOM:
Embeddedness (%): (0-5) Excellent	(5-25) <u>Very good</u>	(25-50) Good
	(50-75) Fair	(>75) Poor
Canopy (%): 100 90 80 70 60 <u>50</u>	40 30 20 10 0	Overhead: <u>Open</u> / Closed
Bank stability (%): <u>Excellent</u> (> 80%)	Good(50-79)	Fair (25-49) Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass
Predominant surrounding land use: Golf course		
Periphyton (%): Diatom:	Filamentous green:	Moss: Light
Matted blue-green: Heavy	Other:	
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 2-4'
Depth 4-8"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec	
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications:
Note: Heavy iron staining with some iron seeps, black rocks		

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-18
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, upstream of confluence with Roaring Brook
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				
				KN-1	KN-2	Old BI	New BI	FFG
01.03.006.00	COLEOPTERA	OULIMNIUS	sp	11	9	2	3	SCR
01.03.008.00	COLEOPTERA	STENELMIS	sp	3	5	3	5	SCR
02.03.003.00	DIPTERA	BEZZIA	sp	7	8	3	6	PRD
02.05.005.00	DIPTERA	BRILLIA	sp			3	5	SRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp	2		3	5	PRD
02.05.018.00	DIPTERA	CRICOTOPUS	sp	2		4	7	SHR
02.05.068.00	DIPTERA	PARACHAETOCLADIUS	sp	22	14	2	2	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	4	14	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCLADIUS	sp	4	3	2	4	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	2	2	2	6	CG
02.05.114.01	DIPTERA	TVETENIA	discoloripes			3	6	CG
02.05.114.02	DIPTERA	TVETENIA	bavarica	22	32	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp		1	2	1	CG
02.14.005.00	DIPTERA	SIMULIUM	sp		1	2	5	CF
02.19.001.00	DIPTERA	ANTOCHA	sp	23	8	3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	6	5	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	6	11	2	2	PRD
02.19.016.00	DIPTERA	TIPULA	sp	1	4	3	6	SRD
03.01.006.00	EPHEMEROPTERA	ACENTRELLA	sp	1		2	4	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gi	28	19	2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	2		2	4	CG
03.06.003.00	EPHEMEROPTERA	EPEORUS	sp	3		0	0	CG
03.07.005.00	EPHEMEROPTERA	PARALEPTOPHLEBIA	sp	2		2	1	CG
04.01.002.00	TRICHOPTERA	BRACHYCENTRUS	sp	23	9	1	1	CF
04.03.002.00	TRICHOPTERA	GLOSSOSOMA	sp	8	2	1	0	SCR
04.05.003.00	TRICHOPTERA	DIPLECTRONA	sp	1	4	0	0	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alhedra	22	6	2	3	CF
04.05.008.06	TRICHOPTERA	SYMPHITOPSYCHE	slossonae	20	22	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp		2	1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	1		1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	5	14	0	0	CF
04.14.005.00	TRICHOPTERA	POLYCENTROPUS	sp	1		3	6	PRD
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	37	28	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	3	2	0	0	SRD
05.04.000.01	PLECOPTERA	NEMOURIDAE	imm	1		0	2	SRD
05.06.007.00	PLECOPTERA	AGNETINA	sp		2	0	2	PRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	2		1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus		1	1	0	SRD
06.06.007.00	ODONATA	LANTHUS	sp	1		2	5	PRD
07.02.001.00	MEGALOPTERA	SIALIS	sp	1		3	6	PRD
12.06.001.00	GASTROPODA	FERRISSIA	sp	1	1	3	6	SCR
12.08.002.00	GASTROPODA	PHYSA	sp	7	3	4	8	CG
13.02.002.00	BIVALVIA	PISIDIUM	sp		1	4	8	CF
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	15	19	0	0	CG

TOTAL 300 252

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-18
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, upstream of confluence with Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	300	252	276
Species Richness	36	30	33
EPT Richness	17	12	14.5
Bio Index (0 to 5)	1.74	1.72	1.73
Bio Index (0 to 10)	2.74	2.90	2.82
% dominant taxa	12.3	12.7	12.5
EPT/EPT+C	0.73	0.63	0.68
EPT/Richness	0.47	0.40	0.44
% Model Affinity (orders)	78.0	69.6	73.8
PPCS - functional groups	0.64	0.53	0.58
Major Groups:			
Coleoptera (%)	4.7	5.6	5.1
Diptera (%)	33.7	40.9	37.3
Ephemeroptera (%)	12.0	7.5	9.8
Trichoptera (%)	27.0	23.4	25.2
Plecoptera (%)	14.3	13.1	13.7
Oligochaeta (%)	5.0	7.5	6.3
Bivalvia (%)	0.0	0.4	0.2
Megaloptera (%)	0.3	0.0	0.2
Odonata (%)	0.3	0.0	0.2
Other (%)	0.0	0.0	0.0
Total (%)	97.3	98.4	97.9
Feeding Groups:			
Collector Gatherer (%)	44.7	45.6	45.2
Collector Filterer (%)	23.7	22.6	23.1
Predator (%)	21.0	21.4	21.2
Shredder - Detritus (%)	1.7	3.6	2.6
Shredder - Herbivore (%)	0.7	0.0	0.3
Scraper (%)	8.3	6.7	7.5
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-18
Stream East Branch Roaring Brook **Class** Small, High Gradient, B2-3
Location RM 0.1, upstream of confluence with Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	276.0	≥300	Fail	≥400	Fail	≥500	Fail
Richness	33.0	≥27	Pass	≥31	Pass	≥35	Fail
EPT	14.5	≥16	Fail	≥19	Fail	≥21	Fail
PMA-O	73.8	≥45	Pass	≥55	Pass	≥65	Pass
BI	2.82	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	6.3	≤12	Pass	≤5	Fail	≤2	Fail
EPT/EPT+C	0.68	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-F	0.58	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Does Not Meet Class B2/3					
Metrics not in compliance with Class B2-3 thresholds		Density and EPT					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	≥22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET			
River: East Br. Roaring Bk at mouth	Project: Killington	Station: KP-18	
Collection Date: September 23, 2005	Time: 1000	Personnel: C. Szal	
Gear: 560 um kicknet		Effort Time: 2 min.	
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C	
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 15	Silt:	
Boulder (>10"): 20	Gravel (>0.05-0.5"): 5	Clay:	
Cobble (2.5-10"): 40	Sand (0.002-0.05"): 15	CPOM:	
Embeddedness (%): (0-5) Excellent	(5-25) Very good	(25-50) <u>Good</u>	
	(50-75) Fair	(>75) Poor	
Canopy (%): 100 90 80 70 <u>60</u> 50	40 30 20 10 0	Overhead: Open / <u>Closed</u>	
Bank stability (%): <u>Excellent</u> (> 80%)	Good(50-79)	Fair (25-49)	Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass	
Predominant surrounding land use: Golf course			
Periphyton (%): Diatom: Light	Filamentous green:	Moss: Light	
Matted blue-green: Light	Other:		
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 8-12'	
Depth 4-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec		
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications:	
Note: Iron staining, FPOM, black rocks, silty			

Project: Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-26
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Main stem Roaring Brook above confluence with East Branch Roaring Brook
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				FFG
				KN-1	KN-2	Old BI	New BI	
01.03.006.00	COLEOPTERA	OULIMNIUS	sp	6	5	2	3	SCR
02.03.003.00	DIPTERA	BEZZIA	sp		1	3	6	PRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp	5		3	5	PRD
02.05.018.00	DIPTERA	CRICOTOPUS	sp	1		4	7	SHR
02.05.068.00	DIPTERA	PARACHAETOCCLADIUS	sp	1		2	2	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp	10	11	3	5	CG
02.05.076.00	DIPTERA	PARAPHAENOCCLADIUS	sp	1		2	4	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp	2	1	2	6	CG
02.05.114.01	DIPTERA	TVETENIA	discoloripes	2	4	3	6	CG
02.05.114.02	DIPTERA	TVETENIA	bavarica	10		2	4	CG
02.08.000.00	DIPTERA	EMPIDIDAE	unid		1	3	6	PRD
02.19.001.00	DIPTERA	ANTOCHA	sp	1		3	3	CG
02.19.003.00	DIPTERA	DICRANOTA	sp	1	1	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	12	7	2	2	PRD
02.19.016.00	DIPTERA	TIPULA	sp	6		3	6	SRD
03.01.001.09	EPEMEROPTERA	BAETIS	tricaudatus		4	3	6	CG
03.01.001.91	EPEMEROPTERA	BAETIS	sp a	16	2	3	6	CG
03.01.006.00	EPEMEROPTERA	ACENTRELLA	sp	1	1	2	4	SCR
03.04.004.09	EPEMEROPTERA	EPEMERELLA	sub/inv/rot/gi	5	2	2	4	CG
03.04.004.91	EPEMEROPTERA	EPEMERELLA	sp a	18	7	2	4	CG
03.06.003.00	EPEMEROPTERA	EPEORUS	sp		4	0	0	CG
04.01.002.00	TRICHOPTERA	BRACHYCENTRUS	sp	10	6	1	1	CF
04.01.003.00	TRICHOPTERA	MICRASEMA	sp	2	2	1	2	SHR
04.05.008.02	TRICHOPTERA	SYMPHITOPSYCHE	bronta	1		3	5	CF
04.05.008.04	TRICHOPTERA	SYMPHITOPSYCHE	alhedra	5	24	2	3	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna	31	19	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp	6	2	1	1	SRD
04.09.002.00	TRICHOPTERA	APATANIA	sp	1		1	3	SCR
04.12.002.00	TRICHOPTERA	DOLOPHIODES	sp	120	110	0	0	CF
04.14.005.00	TRICHOPTERA	POLYCENTROPUS	sp	1	5	3	6	PRD
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	4	7	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1	1	0	0	PRD
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	65	52	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	12	10	0	0	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid	10		1	0	SRD
05.06.007.00	PLECOPTERA	AGNETINA	sp		1	0	2	PRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	24	12	1	2	PRD
05.07.007.00	PLECOPTERA	MALIREKUS	sp	1		1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus	6	7	1	0	SRD
06.04.001.00	ODONATA	CORDULEGASTER	sp			1	3	PRD
06.06.007.00	ODONATA	LANTHUS	sp		1	2	5	PRD
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	6	8	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid			0	0	CG
TOTAL				404	318			

Project: Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-26
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Main stem Roaring Brook above confluence with East Branch Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	404	318	361
Species Richness	35	30	32.5
EPT Richness	21	20	20.5
Bio Index (0 to 5)	0.95	0.83	0.89
Bio Index (0 to 10)	1.66	1.42	1.54
% dominant taxa	29.7	34.6	32.1
EPT/EPT+C	0.91	0.95	0.93
EPT/Richness	0.60	0.67	0.63
% Model Affinity (orders)	73.8	65.9	69.8
PPCS - functional groups	0.54	0.44	0.49
Major Groups:			
Coleoptera (%)	1.5	1.6	1.5
Diptera (%)	12.9	8.2	10.5
Ephemeroptera (%)	9.9	6.3	8.1
Trichoptera (%)	45.0	55.3	50.2
Plecoptera (%)	29.2	25.8	27.5
Oligochaeta (%)	1.5	2.5	2.0
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.0	0.3	0.2
Other (%)	0.0	0.0	0.0
Total (%)	100	100	100
Feeding Groups:			
Collector Gatherer (%)	17.8	13.5	15.7
Collector Filterer (%)	41.3	50.0	45.7
Predator (%)	28.2	28.0	28.1
Shredder - Detritus (%)	9.9	6.0	7.9
Shredder - Herbivore (%)	0.7	0.6	0.7
Scraper (%)	2.0	1.9	1.9
Total (%)	100	100	100

Project: Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-26
Stream Roaring Brook **Class** Small, High Gradient, B2-3
Location Main stem Roaring Brook downstream of confluence with East Branch Roaring Brook
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	361.0	≥300	Pass	≥400	Fail	≥500	Fail
Richness	32.5	≥27	Pass	≥31	Pass	≥35	Fail
EPT	20.5	≥16	Pass	≥19	Pass	≥21	Fail
PMA-O	69.8	≥45	Pass	≥55	Pass	≥65	Pass
BI	1.54	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	2.0	≤12	Pass	≤5	Pass	≤2	Fail
EPT/EPT+C	0.93	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-F	0.49	≥0.40	Pass	≥0.45	Pass	≥0.50	Fail
Outcome		Meets Class B2-3					
Metrics not in compliance with Class B2-3 thresholds							

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	>22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET			
River: Roaring Bk below E. Br.	Project: Killington	Station: KP-26	
Collection Date: September 23, 2005	Time: 1100	Personnel: C. Szal	
Gear: 560 um kicknet		Effort Time: 2 min.	
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C	
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 20	Silt:	
Boulder (>10"): 30	Gravel (>0.05-0.5"): 5	Clay:	
Cobble (2.5-10"): 40	Sand (0.002-0.05"): 5	CPOM:	
Embeddedness (%): (0-5) Excellent	(5-25) Very good	(25-50) <u>Good</u>	
	(50-75) Fair	(>75) Poor	
Canopy (%): 100 90 80 70 60 <u>50</u>	40 30 20 10 0	Overhead: Open / <u>Closed</u>	
Bank stability (%): Excellent (>80)	<u>Good</u> (50-79)	Fair (25-49)	Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass	
Predominant surrounding land use: Golf course, residential development, and ski area			
Periphyton (%): Diatom: Light	Filamentous green:	Moss: Light	
Matted blue-green: Light	Other:		
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 10-20'	
Depth 6-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec		
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications:	
Note: Iron staining, some black rocks, silty			

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-27
Stream KP-27 **Class** Small, High Gradient
Location Main stem Roaring Brook approximately 50 linear feet below confluence with W-4
Sample Date 09/23/05 **Sampler:** Cathy Szal, VHB

Key	Order	Genera	Species	ORGANISMS/KICKNET				FFG
				KN-1	KN-2	Old BI	New BI	
02.03.003.00	DIPTERA	BEZZIA	sp	1		3	6	PRD
02.05.005.00	DIPTERA	BRILLIA	sp			3	5	SRD
02.05.008.00	DIPTERA	CARDIOCLADIUS	sp	2	1	3	5	PRD
02.05.017.00	DIPTERA	CORYNONEURA	sp			2	4	CG
02.05.075.00	DIPTERA	PARAMETRIOCNEMUS	sp		1	3	5	CG
02.05.096.00	DIPTERA	RHEOCRICOTOPUS	sp			2	6	CG
02.05.108.00	DIPTERA	TANYTARSUS	sp			3	6	CF
02.05.114.02	DIPTERA	TVETENIA	bavarica	3	4	2	4	CG
02.06.001.00	DIPTERA	DIXA	sp		1	2	1	CG
02.14.005.00	DIPTERA	SIMULIUM	sp	2		2	5	CF
02.19.003.00	DIPTERA	DICRANOTA	sp	1	1	2	3	PRD
02.19.006.00	DIPTERA	HEXATOMA	sp	4	3	2	2	PRD
03.01.001.09	EPHEMEROPTERA	BAETIS	tricaudatus	7	7	3	6	CG
03.01.001.91	EPHEMEROPTERA	BAETIS	sp a	33	10	3	6	CG
03.01.006.00	EPHEMEROPTERA	ACENTRELLA	sp	2	1	2	4	SCR
03.04.004.09	EPHEMEROPTERA	EPHEMERELLA	sub/inv/rot/gr	8		2	4	CG
03.04.004.91	EPHEMEROPTERA	EPHEMERELLA	sp a	3		2	4	CG
03.06.003.00	EPHEMEROPTERA	EPEORUS	sp	5	3	0	0	CG
03.07.005.00	EPHEMEROPTERA	PARALEPTOPHLEBIA	sp	1		2	1	CG
04.01.003.00	TRICHOPTERA	MICRASEMA	sp	1		1	2	SHR
04.05.006.00	TRICHOPTERA	PARAPSYCHE	sp	1	1	0	0	CF
04.05.008.07	TRICHOPTERA	SYMPHITOPSYCHE	sparna		1	2	4	CF
04.07.001.00	TRICHOPTERA	LEPIDOSTOMA	sp		1	1	1	SRD
04.12.002.00	TRICHOPTERA	DOLOPHILODES	sp	19	43	0	0	CF
04.14.005.00	TRICHOPTERA	POLYCENTROPUS	sp			3	6	PRD
04.16.001.01	TRICHOPTERA	RHYACOPHILA	fuscula	3	9	1	2	PRD
04.16.001.03	TRICHOPTERA	RHYACOPHILA	carolina	1	1	0	0	PRD
04.16.001.12	TRICHOPTERA	RHYACOPHILA	invaria	1	1	1	1	PRD
04.18.013.00	TRICHOPTERA	NEOPHYLAX	sp	1		2	3	SCR
05.02.000.01	PLECOPTERA	CHLOROPERLIDAE	imm	22	39	0	0	PRD
05.03.000.01	PLECOPTERA	LEUCTRIDAE	imm	13	32	0	0	SRD
05.05.000.00	PLECOPTERA	PELTOPERLIDAE	unid		2	1	0	SRD
05.06.007.00	PLECOPTERA	AGNETINA	sp			0	2	PRD
05.07.006.00	PLECOPTERA	ISOPERLA	sp	6	13	1	2	PRD
05.07.007.00	PLECOPTERA	MALIREKUS	sp			1	2	PRD
05.08.001.02	PLECOPTERA	PTERONARCYS	proteus	3	5	1	0	SRD
18.04.000.00	OLIGOCHAETA	LUMBRICULIDAE	unid	36	23	0	0	CG
18.05.000.00	OLIGOCHAETA	ENCHYTRAEIDAE	unid		2	0	0	CG

TOTAL 179 205

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-27
Stream KP-27 **Class** Small, High Gradient
Location Main stem Roaring Brook approximately 50 linear feet below confluence with W-4
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

Replicate #	1	2	Average
Sampling Method	KN	KN	KN
Biometrics:			
Density/Unit	179	205	192
Species Richness	25	24	24.5
EPT Richness	18	16	17
Bio Index (0 to 5)	0.60	0.29	0.44
Bio Index (0 to 10)	1.14	0.50	0.82
% dominant taxa	100.0	100.0	100.0
EPT/EPT+C	0.96	0.97	0.96
EPT/Richness	0.72	0.67	0.69
% Model Affinity (orders)	66.8	64.9	65.9
PPCS - functional groups	0.56	0.50	0.53
Major Groups:			
Coleoptera (%)	0.0	0.0	0.0
Diptera (%)	7.3	5.4	6.3
Ephemeroptera (%)	33.0	10.2	21.6
Trichoptera (%)	15.1	27.8	21.4
Plecoptera (%)	24.6	44.4	34.5
Oligochaeta (%)	20.1	12.2	16.2
Bivalvia (%)	0.0	0.0	0.0
Megaloptera (%)	0.0	0.0	0.0
Odonata (%)	0.0	0.0	0.0
Other (%)	0.0	0.0	0.0
Total (%)	100	100	100
Feeding Groups:			
Collector Gatherer (%)	53.6	24.9	39.3
Collector Filterer (%)	12.3	22.0	17.1
Predator (%)	22.9	33.2	28.0
Shredder - Detritus (%)	8.9	19.5	14.2
Shredder - Herbivore (%)	0.6	0.0	0.3
Scraper (%)	1.7	0.5	1.1
Total (%)	100	100	100

Project Centex Destination Properties and Killington, Ltd
 Background Water Quality Monitoring 2005
Station KP-27
Stream KP-27 **Class** Small, High Gradient, B2-3
Location Main stem Roaring Brook approximately 50 linear feet below confluence with W-4
Sample Date 09/23/05 **Sampler** Cathy Szal, VHB

APPLICATION OF STATE OF VERMONT BIOCRITERIA (2/10/03)

Metric	Value	Metric Scoring Results Based on ANR Thresholds for SHG					
		Class B2-3		Class B1		Class A	
		Threshold	Outcome	Threshold	Outcome	Threshold	Outcome
Density	384.0	≥300	Pass	≥400	Fail	≥500	Fail
Richness	24.5	≥27	Fail	≥31	Fail	≥35	Fail
EPT	17	≥16	Pass	≥19	Fail	≥21	Fail
PMA-O	65.9	≥45	Pass	≥55	Pass	≥65	Pass
BI	0.82	≤4.50	Pass	≤3.50	Pass	≤3.00	Pass
%Oligo	16.2	≤12	Fail	≤5	Fail	≤2	Fail
EPT/EPT+C	0.96	≥0.45	Pass	≥0.55	Pass	≥0.65	Pass
PPCS-FG	0.53	≥0.40	Pass	≥0.45	Pass	≥0.50	Pass
Outcome		Does Not Meet Class B2/3					
Metrics not in compliance with Class B2-3 thresholds		Richness & PMA-O					

Scoring Guidelines - Wadeable Stream Category SHG

WQ Class	Score	Density	Richness	EPT	PMA-O	BI	% Oligo	EPT/ EPT+C	PPCS-F
A-1	Full Support	≥605	≥36	>22	≥70	≤2.70	≤1	≥0.67	≥0.55
	Threshold	≥500	≥35	≥21	≥65	≤3	≤2	≥0.65	≥0.5
	Non-Support	≤450	≤34	≤20	<60	≥3.30	≥3	≤0.63	≤0.45
B1	Full Support	≥450	≥32	≥20	≥60	≤3.35	≤3.5	≥0.57	≥0.50
	Threshold	≥400	≥31	≥19	≥55	≤3.5	≤5	≥0.55	≥0.45
	Non-Support	≤350	≤30	≤18	≤50	≥3.65	≥6.5	≤0.53	≤0.40
B2-3	Full Support	≥350	≥28	≥17	≥50	≤4.35	≤9.5	≥0.47	≥0.45
	Threshold	≥300	≥27	≥16	≥45	≤4.5	≤12	≥0.45	≥0.4
	Non-Support	≥250	≤26	≤15	≤40	≥4.65	≥14.5	≤0.43	≤0.35

LOTIC BENTHOS FIELD SHEET			
River: Roaring Bk below W4	Project: Killington	Station: KP-27	
Collection Date: September 23, 2005	Time: 1245	Personnel: C. Szal	
Gear: 560 um kicknet		Effort Time: 2 min.	
Collection flow: H - <u>M</u> - L	Weather: Cloudy	Water temp: 14 C	
Substrate composition (%): Bedrock:	Coarse gravel (>.0.5-2.5"): 10	Silt:	
Boulder (>10"): 35	Gravel (>0.05-0.5"): 10	Clay:	
Cobble (2.5-10"): 35	Sand (0.002-0.05"): 10	CPOM:	
Embeddedness (%): (0-5) Excellent	(5-25) <u>Very good</u>	(25-50) Good	
	(50-75) Fair	(>75) Poor	
Canopy (%): 100 90 80 70 <u>60</u> 50	40 30 20 10 0	Overhead: Open / <u>Closed</u>	
Bank stability (%): Excellent (>80)	<u>Good</u> (50-79)	Fair (25-49)	Poor(<25)
Bank vegetation (%): Softwood Hardwood	<u>Mixed</u> Brush	Grass	
Predominant surrounding land use: Forest and ski area			
Periphyton (%): Diatom: Light	Filamentous green:	Moss: Light	
Matted blue-green: Light	Other:		
General water type: <u>Riffle</u> Run Pool	Warm <u>Cold</u> Mixed	Width 10-14'	
Depth 6-12"	Velocity: <0.4ft./sec <u>0.5-2 ft./sec.</u> >2 ft/sec		
Channelized: Y / <u>N</u>	Upstream dam: Y / <u>N</u>	Other Modifications:	
Note: More embedded in slower moving areas, silty, very light iron stain			

APPENDIX 4

Biological and Aquatic Life Use Attainment Assessment Of Roaring Brook and Tributaries

April 26 2008



prepared by

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Biological Assessment Fact Sheet- Roaring Brook and Tribs

Description of impaired water body

Roaring Brook, **Figure 1**, and its Tributary's are managed as a Class B, Cold water fish habitat stream. The Roaring Brook and small tribs are located in the Town of Killington, Vt. Portions of Roaring Brook and East trib, are listed as "Impaired for ALS". Roaring Brook is listed as "impaired for ALS" from River Mile (RM) 3.5 to RM 4.2, and E.Brch Roaring Brook from RM 0.1 to 0.6. It is biologically assessed as a Small High Gradient (SHG) type stream for macroinvertebrate community assessments based on stream size, gradient and elevation. The Cold water IBI is used for fish community assessments. Based on the fingerprint of the aquatic communities, and site habitat observations the stressors responsible for the impaired ALS support are sediment from stormwater runoff, and construction related erosion.

Description of data used to characterize the water body

Roaring Brook and Tribs

Table 1 lists all 16 site locations sampled for macroinvertebrates since 1989. Recent assessments since 2002 have occurred at 11 sites. Fourteen macroinvertebrate assessments, and two fish community assessments one each on the tributary streams E.Branch and W.Branch Roaring Brook in 2007. These more recent assessments, have been made, to better define the trophic extent, length and more current condition of stream reaches listed as impaired.

The fish community Cold Water IBI scored 45 or *Excellent* **Table 2**, on both the East Branch Roaring Brook at RM 0.3 and on the West Branch Roaring Brook at RM 0.2.

The macroinvertebrate community has been sampled at 15 locations over the past 16 years; at 10 locations since 2002 in the upper watersheds of Roaring Brook **Table 3**.

On Roaring Brook main stem the community has scored *Very Good* at RM 2.7 in 2005, *G-fair* at RM 3.0 in 2007, *Poor and Fair* at RM 4.0 in 2004 and 2005 respectively, *Poor* at RM 4.1 in 2005, and *Good* at RM 4.3 in 2005.

On the East Trib Roaring Brook since 2002 the macroinvertebrate community scored *G-fair* at RM 0.1 in 2005, *Fair* and *G-fair* at RM 0.3 in 2004 and 2005 respectively, *F-poor* at RM 0.4 in 2005, and *Fair* at RM 0.7 in 2005.

On the West Trib roaring Brook since 2002 the macroinvertebrate community has scored *Excellent*, *Vg-good*, and *G-fair* respectively for the years 2002, 2005, and 2007. A site at RM 1.0, has not been sampled since 1999 when it also scored excellent for the third straight year.

Rams Head Tributary was sampled once since 2002, in 2005 and scored *F-poor* at RM 0.1. This small tributary was sampled in the late 1990's for three consecutive years and scored *Vgood*, *Vgood*, and *Good* from 1997-1999 respectively.

Figure 1: Map showing locations of Biomonitoring, and WQ locations for the **Roaring Brook and Tribs**

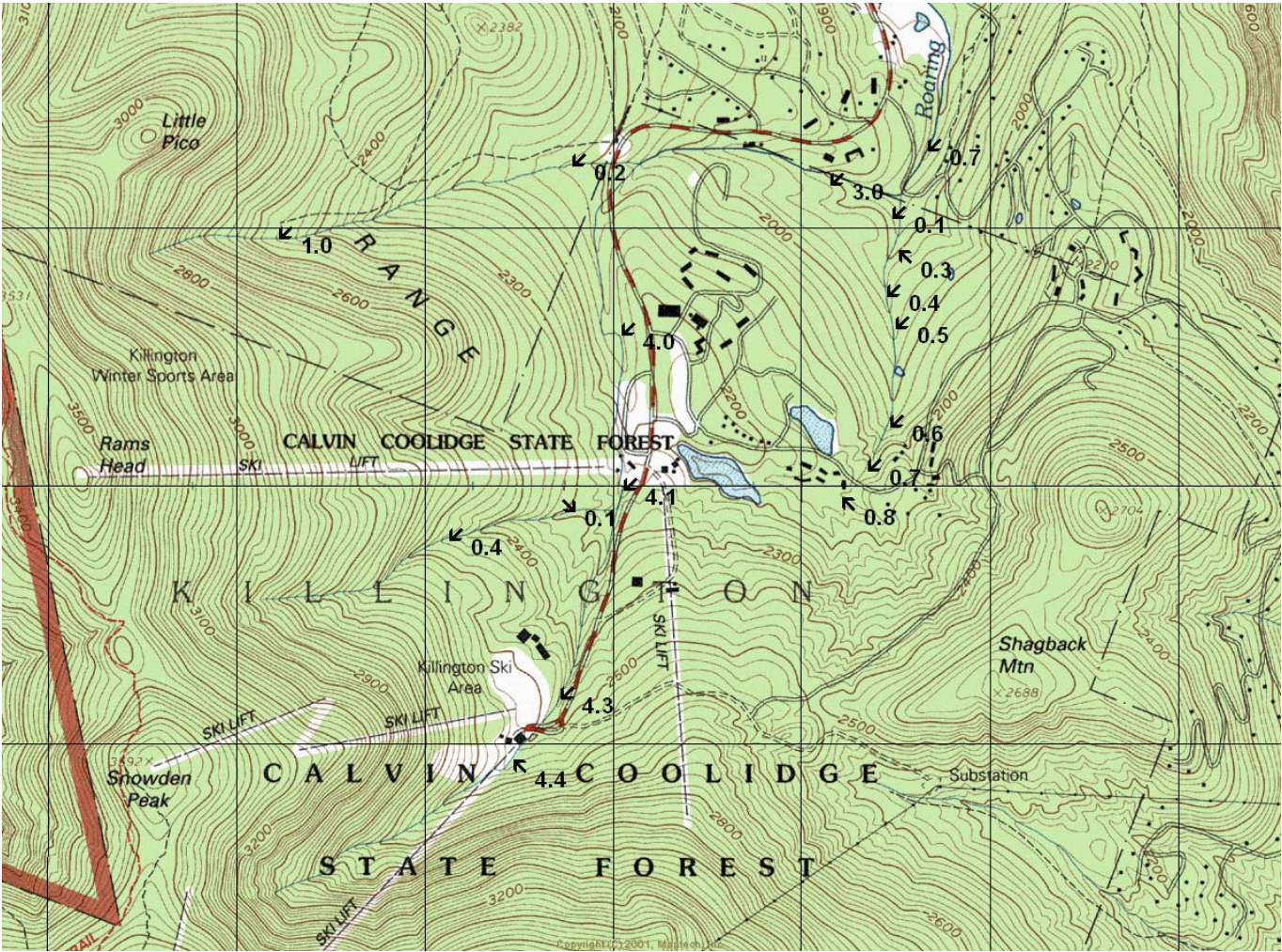


Table 1: Biomonitoring sites on Roaring Brook and Tribs . "RM" is river mile form mouth. M-Macroinvertebrate, F-Fish, WQ-water quality

Location	Site	Latitude	Longitude	Elevation	DA	Description
Roaring Brook						Located below Ravine Road 75m. Into wooded area.
	2.7	43.6355556	72.7863889	1825	11.1	
	3.0	43.6348600	72.7894000	1900	8.2	Above confluence with East Branch, above golf cart bridge into forested section
	4.0	43.6297222	72.7994444	2150	4.3	Located 75 m below first Killington parking lot.
	4.1	43.6261111	72.7997222	2240	4.1	Located above large parking lot, below Rams Head Trib.
	4.3	43.6177778	72.8025000	2460	3.3	Located below Killington Road, below base lodge.
	4.4	43.6166667	72.8041667	2520	3.2	Located near end of Killington Access Rd, above road, and baselodge.
East Trib Roaring Brook	0.1	43.6338889	72.7872222	1860	2.6	Located immediately above Roaring Brook confluence above Ravine Road
	0.3	43.6322222	72.7877778	1910	2.4	Located in lower area of Killington golf course, just above 1st foot/cart bridge.
	0.4	43.6305556	72.7877778	1950	2.2	Located below influnece of sprayfield, and Small GC Pond drainage.
	0.5	43.6280556	72.7877778	1990	2.0	Located in mid area of Killington golf course immediately below Killington spray disposal.
	0.6	43.6269444	72.7880556	2040	1.8	Located in upper Killington golf course immediately above Killington spray disposal area.
	0.7	43.6255556	72.7886111	2110	1.7	Located below Roaring Brk. Rd 20m, above Killington golf course fairway
	0.8	43.6250000	72.7911111	2145	1.6	Located above Roaring Brk. Rd 25m .
West Trib Roaring Brook	0.2	43.6355556	72.8011111	2120	2.0	Located immediatly above Killington Access Rd 20m.
	1.0	43.6327778	72.8144444	2460	0.6	Located immediatly below lift line of new Killington interconnect
Rams Head Brook	0.1	43.6241667	72.8002778	2260	1.0	Located just up from confluence of the Roaring Branch.
	0.4	43.6227778	72.8069444	2460	0.9	Located to the west of Killington access road, south of Rams head lift.

Table 2: Fish metrics and Cold Water Index of Biotic Integrity from Roaring Brook and Tribs: CW IBIs have a range of 9-45 (poor - excellent). Assessments of Excellent-Good indicate support Class B; assessments of Fair-Poor indicate non-support of Class B water management Classification.

Location	Sit	Date	Assessment	IBI	Total/ 100m2	Intol Sp	CW Spp%	GenFeed %	TopCarn %	BrkTrout Density	BrkTrout AgCl
East Trib Roaring Brook	0.3	9/2007	Excellent	45	18.3	2	100.0	0.0	93.2	17.1	2
West Trib Roaring Brook	0.2	9/2007	Excellent	45	21.8	2	100.0	0.0	73.2	16.0	3

Table 3: Macroinvertebrate SHG community assessments and metrics from sites in Roaring Brook and Tribs:. Assessments of Exellent-Good support Class B, Fair-Poor non-support of Class B water management Classification. **Bolded** metrics are at or below Class B biocriteria thresholds.

Location	Site	Date	Assessment	Density	Richness	Ept	PMA-O	BI	Oligoc%	Ept/EptC	PPCS-F
Roaring Brook	2.7	9/23/2005	VGood	361.0	32.5	20.5	70.1	1.54	2.0	0.93	0.49
	3	9/27/2007	G-Fair	732.0	37.0	22.0	60.5	1.62	14.1	0.98	0.44
	4	10/6/2004	Poor	319.0	30.0	21.0	61.6	2.12	26.5	0.98	0.49
		9/23/2005	Fair	192.0	22.5	17.0	66.4	1.81	16.2	0.97	0.53
	4.1	9/23/2005	Poor	226.0	29.5	17.5	65.9	1.41	24.8	0.96	0.60
	4.3	9/23/2005	Good	361.5	34.0	22.5	63.1	1.25	5.4	0.93	0.55
East Trib Roaring Brook	0.1	9/23/2005	G-Fair	276.0	33.0	14.5	73.8	2.82	6.3	0.68	0.58
	0.3	8/31/1989	Good	1050.9	36.5	17.0	79.9	3.28	3.4	0.79	0.43
		10/6/2004	Fair	346.0	43.5	21.5	79.2	2.94	14.6	0.83	0.59
		9/27/2007	G-Fair	311.5	41.0	20.0	79.4	2.74	14.2	0.81	0.61
	0.4	9/23/2005	F-Poor	397.5	32.0	11.0	63.7	3.51	2.4	0.55	0.57
	0.5	8/31/1989	Fair	3310.7	45.5	15.5	58.1	4.76	0.5	0.40	0.35
		8/29/1995	Fair	2856.0	46.0	14.0	57.5	4.94	4.3	0.44	0.33
	0.6	8/31/1989	Good	1488.0	38.0	17.5	77.7	2.87	0.0	0.74	0.52
	0.7	8/31/1989	G-Fair	246.0	38.0	19.5	77.9	3.02	3.8	0.79	0.71
		9/23/2005	Fair	237.0	34.0	14.0	69.1	1.56	4.2	0.83	0.57
	0.8	8/31/1989	G-Fair	706.1	31.0	15.0	79.8	2.40	0.0	0.76	0.71
West Trib Roaring Brook	0.2	9/1/1989	Vg-Good	1290.0	31.0	17.5	90.5	2.66	0.0	0.83	0.71
		10/2/1997	Exc	1408.0	37.0	23.0	75.0	1.55	0.0	0.88	0.54
		9/11/2002	Exc	1024.0	43.0	21.0	92.3	2.71	0.0	0.78	0.87
		9/23/2005	Vg-Good	702.0	34.5	24.0	70.3	1.37	8.5	0.96	0.59
		9/27/2007	G-Fair	1195.2	45.0	29.0	60.3	1.38	12.2	0.99	0.48
	1	10/6/1997	Exc	336.0	35.0	24.5	74.8	1.11	0.0	0.93	0.48
		10/17/1997	Exc	343.6	38.0	24.0	81.4	1.15	0.0	0.92	0.47
		10/16/1998	Exc	610.5	41.0	25.0	74.1	1.36	0.3	0.83	0.54
		10/11/1999	Exc	495.0	33.5	23.0	69.6	1.02	0.0	0.83	0.59
Rams Head Brook	0.1	9/23/2005	F-Poor	133.0	23.5	14.0	60.3	1.13	2.4	0.95	0.31
	0.4	10/6/1997	Vgood	418.5	30.5	19.0	67.9	1.48	4.0	0.84	0.40
		10/6/1998	Vgood	366.0	32.0	20.5	67.0	1.30	2.7	0.91	0.49
		10/1/1999	Good	1132.0	29.0	18.5	65.6	1.02	4.3	0.94	0.36
Class B Threshold			Threshold	>300	>27	>16	>45	<4.50	<12.0	>0.45	>0.40

Discussion of Biological Assessments Used to Characterize Impairments

The macroinvertebrate community was in an impaired condition in the main stem of Roaring Brook from RM 3.0 to RM 4.1, **Table 3**. The biometrics that were found to be below their biocriteria thresholds were Density and percent Oligochaeta. The number of taxa and EPT taxa present while meeting their minimum biocriteria thresholds were also negatively effected, compared to a local control site W.Branch Roaring Brook. This macroinvertebrate community fingerprint indicates that sediment is the likely stressor.

The other stream reach listed as consistently impaired is the E.Branch Roaring Brook from RM 0.1 to RM 0.5. Above this location the stream is inconsistently Good-Fair, from year to year and most often on the threshold. From RM 0.1 to RM 0.4 the biological fingerprint is similar to the main branch, low in density, and a high percentage of Oligochaeta; and depressed numbers of EPT taxa when compared to the local reference stream W.Branch Roaring Brook.

Rams Head Brook at RM 0.1, was sampled once in 2005, and scored F-poor. The community was found to be very low in density, and low in richness, and EPT taxa. The percentage of Oligochaeta; however were not elevated. The community was overwhelmingly dominated by collector filtering Trichoptera *Dolophilodes sp* and *Parapsyche sp*. These are both very water quality sensitive taxa typical of small cold water streams. This stream should be reassessed to determine if the impaired condition is present consistently over time or was possibly due to a scour event.

While both tributary's W.Branch RM 0.2 and E.Branch RM 0.3 scored a CW IBI of 45, an Excellent fish community score, overall greater number of slimy sculpin, and larger sized brook trout were collected from the "local control" W.Branch Tributary RM 0.2 site. This generally indicates better habitat conditions, especially deeper holding pools for larger brook trout. In East Branch the largest Brook trout was 115mm, and only 5 measured over 100mm. In the West Branch the largest brook trout measured 145 mm, and 8 measured over 120 mm; additionally it was noted on the field sheets that a number of large brook trout were missed in the West Branch because of the excellent pool depth and crevice space habitat within the pools.

Stressor Identification

Physical habitat observations, and Water Quality samples collected at the time of biomonitoring support the identification of sediment as a primary stressor. **Table 4** shows that the amount of sand, embeddedness and silt at sites on the Roaring Brook main stem listed as impaired are all at levels known to cause stress on the community.

Figure 2: Ortho map showing locations of Biomonitoring sites that have been scored below the Class B narrative biocriteria of Good, relative to land uses, in the upper Roaring Brook and Tribs



Table 4 : Habitat observation taken at time of macroinvertebrate sampling from sites in Roaring Brook and Tribs VT. Bolded values indicate moderate to high level of stress from particular habitat measure.

Location	Site	Date	Embeddedness	Silt Rating	Canopy %	Sand %	Gravel %	Filamentous %	BlueGr	Moss %
Roaring Brook	2.7	9/23/2005	3	3	50	5	5			
	3	9/27/2007	3	3	90	13	24		5	
	4	10/6/2004	1	4	90	17	31	0	0	5
		9/23/2005	3	3	60	10	10			
	4.1	9/23/2005	2	4	60	15	10			
	4.3	9/23/2005	4	3	60	5	5			
East Trib Roaring Brook	0.1	9/23/2005	3		60	15	10			
	0.3	8/31/1989	2	1	90	15	15	80	0	0
		10/6/2004	2	3	100	15	14	0	0	5
		9/27/2007	2	4	100	13	33	1		1
	0.4	9/23/2005	4		50	15	5			
	0.5	8/31/1989	2	1	0	10	20	25	0	25
		8/29/1995	3	1	0	15	10	15	25	5
	0.6	8/31/1989	3	1	0	5	15	1	10	0
	0.7	8/31/1989	1		99	50	10	0	0	10
9/23/2005		4		70	10	5				
0.8	8/31/1989	4	1	80	0	10	0	0	50	
West Trib Roaring Brook	0.2	9/1/1989	5		90	0	10	0	0	20
		10/2/1997	4	1	90	5	5	0	0	35
		9/11/2002	4		70	5	19	1	0	15
		9/23/2005	3		80	15	10			
		9/27/2007	5	2	95	1	10			20
	1	10/6/1997	5		10					
		10/16/1998	5		10					
	10/11/1999	4		10	8	11				
Rams Head Brook	0.1	9/23/2005	3		80	20	15			
	0.4	10/6/1997	3		80					
		10/6/1998	5		40					
		10/1/1999	3		70	10	16			

Table 5a: Water Quality measures from sites in the upper Roaring Brook and Tribs.

Location	Site	Date	Temp C	pH stu	Alk mg/l	Cond uhoms	TCl mg/l	Na mg/l	DFe ug/l	DMn ug/l
Roaring Brook	3	9/27/2007	15.5		38.9	290	54.2	22.8	50	
	4	10/6/2004	6.7	7.54	22.5	170	34.6	17.6	50.6	23.3
East Trib Roaring Brook	0.3	8/31/1989	14	7.84	41	247				
	0.3	10/6/2004	7.35	7.48	42.2	182	35.6	18.5	376	41.8
	0.3	9/27/2007	16.5		72.5	351	55.9	24.5	222	
	0.5	8/31/1989	17	7.97	36	248				
	0.5	8/29/1995	17	7.74	62	220				
	0.6	8/31/1989	15	8.03	36.5	154				
	0.7	8/31/1989	14	7.85	35	173				
	0.8	8/31/1989	14.5	7.47	27	153				
West Trib Roaring Brook	0.2	9/1/1989	14	7.98	21.6	68				
	0.2	10/2/1997	5	7.25	22.7	64				
	0.2	9/11/2002	15	7.39	29	78.5				
	0.2	9/27/2007	15.5		28.5	75.7	2	0.63	50	
	1	10/6/1997	7.9		8.68	33.5				
	1	10/16/1998	14.2	7.58	19.9	64.3				
	1	10/11/1999	9	6.55	17	53.3				
Rams Head Brook	0.4	10/6/1997	7.5	7.31	12.6	51.9				
	0.4	10/6/1998	10.6	7.53	7.31	54.2				
	0.4	10/1/1999	10.1	6.99	9.34	55.5				

5b: Water Quality measures from sites in the upper Roaring Brook and Tribs.

Location	Site	Date	Flow	Flow	Turb NTU	TP ug/l	DP ug/l	TN mg/l	NOX mg/l
Roaring Brook	3	9/27/2007	Moderate	Base	0.2	6.79	5	0.45	0.39
	4	10/6/2004	Moderate	Base	0.4	4	5	0.45	0.47
East Trib Roaring Brook	0.3	10/6/2004	Moderate	Base	1.97	10	7	0.23	0.13
	0.3	9/27/2007	Low	Base	0.29	6.14	5.32	0.42	0.22
West Trib Roaring Brook	0.2	9/27/2007	Moderate	Base	0.2	5	5	0.31	0.28

Table 6. Macroinvertebrate community composition by major orders for Roaring Brook and Tribs, and the Model expectation for Small High Gradient streams.

Location	Site	Date	Coleoptera %	Diptera %	Ephemeroptera %	Plecoptera %	Trichoptera %	Oligochaeta %	Other %
Roaring Brook	2.7	9/23/2005	1.5	10.5	8.1	27.5	50.2	2.0	0.2
	4	10/6/2004	0.1	5.6	35.6	17.5	14.3	26.5	0.3
		9/23/2005	0.0	6.3	21.6	34.5	21.4	16.2	0.0
	4.1	9/23/2005	0.0	7.5	11.0	30.9	25.4	24.8	0.4
	4.3	9/23/2005	0.0	8.8	11.0	53.5	21.4	5.4	0.0
East Trib Roaring Brook	0.1	9/23/2005	5.1	37.3	9.8	13.7	25.2	6.3	2.7
	0.3	8/31/1989	7.5	26.9	22.5	4.4	34.9	3.4	0.3
		10/6/2004	12.1	21.5	11.1	13.4	26.7	14.6	0.6
		9/27/2007	11.8	18.6	17.1	12.1	25.2	14.2	0.8
	0.4	9/23/2005	4.2	47.6	4.4	9.6	27.4	2.4	4.4
	0.5	8/31/1989	3.8	60.9	22.9	2.2	9.7	0.5	0.1
		8/29/1995	1.4	57.6	20.4	1.4	14.3	4.3	0.6
	0.6	8/31/1989	3.5	29.0	35.7	8.2	23.5	0.0	0.1
	0.7	8/31/1989	17.5	24.6	17.9	21.3	14.2	3.8	0.6
		9/23/2005	5.2	24.4	3.2	35.8	26.6	4.2	0.6
	0.8	8/31/1989	17.2	24.6	15.5	25.1	15.8	0.0	1.8
West Trib Roaring Brook	0.2	9/1/1989	13.5	17.3	25.8	21.5	21.6	0.0	0.3
		10/2/1997	16.2	13.4	17.3	38.1	14.8	0.0	0.3
		9/11/2002	9.6	24.7	22.1	20.8	21.9	0.0	0.8
		9/23/2005	15.8	8.1	4.4	34.1	28.8	8.5	0.3
		9/27/2007	21.3	2.8	37.3	10.6	14.9	12.2	0.8
	1	10/6/1997	1.2	10.1	15.8	46.7	26.2	0.0	0.0
		10/17/1997	1.8	11.4	19.9	40.1	26.8	0.0	0.0
		10/16/1998	0.1	21.5	9.7	39.4	29.1	0.3	0.0
		10/11/1999	0.3	21.2	2.6	45.4	30.5	0.0	0.1
Rams Head Brook	0.1	9/23/2005	0.0	12.9	3.2	15.4	65.0	2.4	1.1
	0.4	10/6/1997	0.0	20.7	3.2	40.1	32.0	4.0	0.0
		10/6/1998	0.0	17.2	3.2	52.3	24.6	2.7	0.0
		10/1/1999	0.0	15.5	1.5	40.8	38.0	4.3	0.0
SHG Model			8.0	19.0	23.0	21.0	28.0	0.5	0.5

Table 7. Macroinvertebrate community functional group composition for Roaring Brook and Tribs and the Model expectation for Small High Gradient streams (SHG).

Location	Site	Date	ColGath %	CollFilter %	Predator %	ShredrDetri %	ShredHerb %	Scraper %
Roaring Brook	2.7	9/23/2005	15.7	45.7	28.1	7.9	0.7	1.9
	4	10/6/2004	64.4	6.3	17.7	9.0	0.4	2.1
		9/23/2005	39.3	17.1	28.0	14.2	0.3	1.1
	4.1	9/23/2005	38.4	22.8	22.5	13.7	0.0	2.6
	4.3	9/23/2005	20.2	16.7	17.5	42.0	0.3	3.3
East Trib Roaring Brook	0.1	9/23/2005	45.2	23.1	21.2	2.6	0.3	7.5
	0.3	8/31/1989	36.4	39.6	8.8	0.7	0.0	8.0
		10/6/2004	32.2	21.3	24.1	3.8	0.0	14.8
		9/27/2007	41.7	23.2	16.1	3.1	0.3	15.1
	0.4	9/23/2005	40.4	27.0	20.7	2.8	4.4	4.6
	0.5	8/31/1989	55.3	11.7	4.7	1.1	21.7	4.3
		8/29/1995	55.7	13.7	8.0	0.3	20.3	1.5
	0.6	8/31/1989	52.9	21.8	9.5	3.0	3.1	7.8
	0.7	8/31/1989	34.1	9.8	27.6	7.8	0.8	19.3
		9/23/2005	22.4	24.6	27.8	18.0	0.2	7.0
0.8	8/31/1989	30.9	18.7	13.9	16.1	0.2	18.9	
West Trib Roaring Brook	0.2	9/1/1989	37.4	10.4	12.1	15.0	1.7	21.5
		10/2/1997	13.9	8.8	15.1	31.8	0.3	17.6
		9/11/2002	33.1	16.4	17.2	11.7	1.6	11.7
		9/23/2005	16.3	24.7	18.4	22.5	0.0	18.1
		9/27/2007	50.2	8.4	9.0	6.2	0.4	25.3
	1	10/6/1997	22.8	10.3	14.4	46.1	0.0	5.8
		10/17/1997	27.9	9.6	12.9	43.8	0.0	4.8
		10/16/1998	23.0	17.1	17.7	37.7	3.2	0.6
		10/11/1999	17.7	19.4	17.6	42.9	1.1	1.2
Rams Head Brook	0.1	9/23/2005	9.8	63.5	21.2	4.0	0.0	1.2
	0.4	10/6/1997	19.2	10.4	24.4	45.2	0.0	0.7
		10/6/1998	14.8	12.5	30.2	39.5	1.5	0.5
		10/1/1999	10.6	21.8	37.6	29.6	0.0	0.4
SHG model			31.0	18.0	19.0	1.0	15.0	12.0

Roaring Brook and Tributaries



APPENDIX 5

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
 Simple Method for Pollutant Loadings
 VHB
 September 16, 2010

$$\text{Annual Load} = P * P_j * C * A * R_v * 0.226$$

Where:

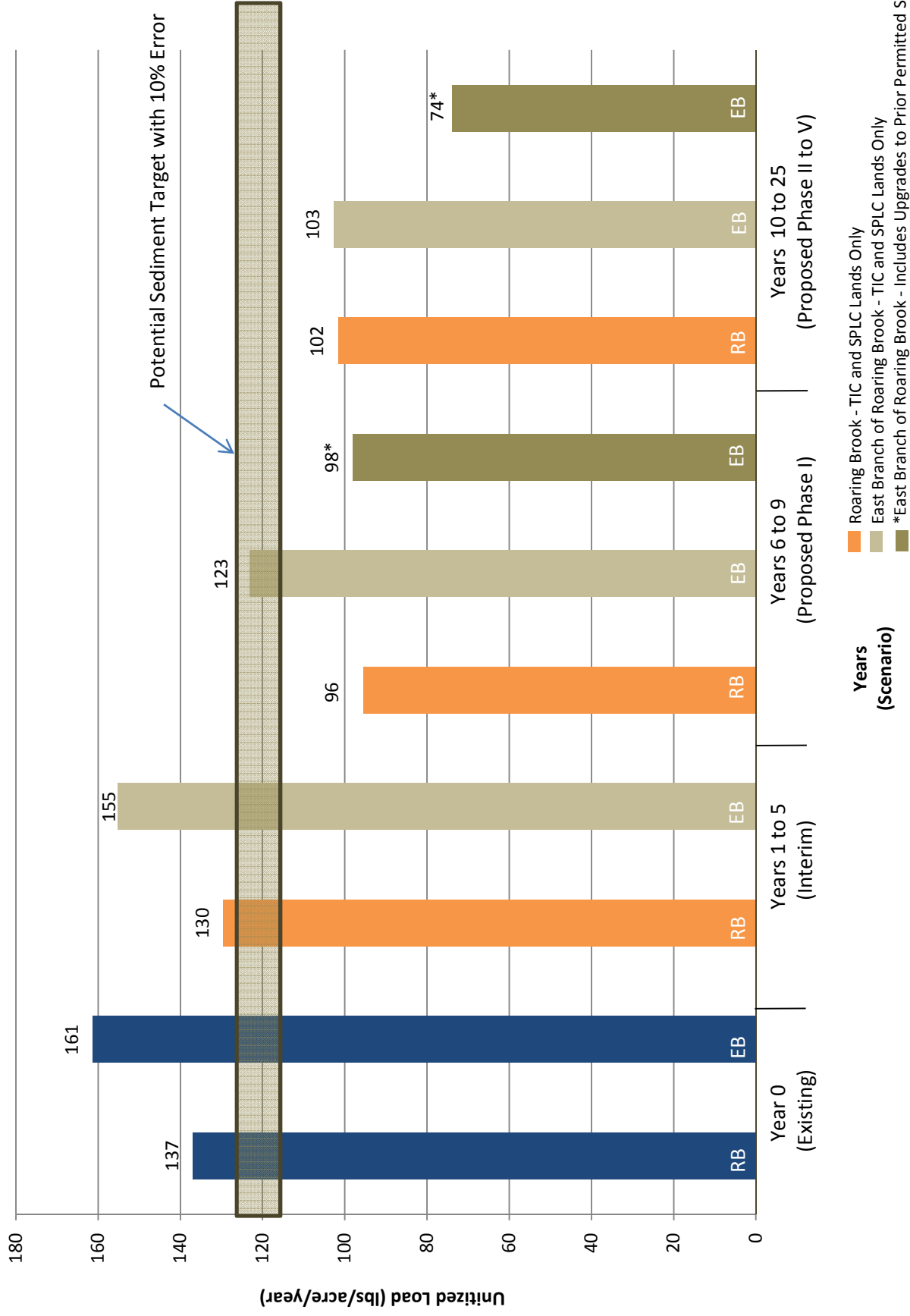
P = Yearly rainfall depth
 P_j = Fraction of rainfall events producing runoff (0.90)
 C = Flow weighted mean concentration of pollutant
 A = Area of contributing watershed
 R_v = 0.05 + 0.009 * (site imperviousness) or accepted value
 0.226 = Simple Method Coefficient

P = 55.4 (PRISM climatological data, downloaded from VCGI)
 P_j = 0.9
 Coefficient = 0.226

Table 1: Sediment Concentration Values

Land Use	TSS (mg/L)	Sources
Commercial	77	NYS DEC Draft Manual (2001)
Commercial Lodging	97	" "
Forest	51	" "
Golf Course	70	EPA NURP Results for Forest/Rural Open (1993)
Open	51	NYS DEC Draft Manual (2001)
Residential	70	" "
Ski Trail	100	VHB Judgement (2006)
Transportation Gravel	374	Clinton & Vose - WQ Report (2003)
Transportation Paved	142	NYS SMDM (2001)
Water	0	VHB Judgement (2006)

Unitized Sediment Loading Summary



Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Simple Method for Pollutant Loading - Existing Conditions
VHB
August 10, 2010

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Existing Conditions		
				Existing Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	60%	5,420	816
	Vale Parking Lot Lower	RB-A08	1.2	0%	692	558
	Killington Mountain Road 4	RB-A10	7.0	0%	1,327	189
	Killington Mountain Road 3	RB-A13	17.7	0%	2,680	151
	K-1 Parking Lot	RB-A15	12.0	1%	33,601	2,789
	Killington Mountain Road 2	RB-A16	71.1	0%	10,451	147
	Killington Mountain Road 1	RB-A17	6.3	0%	2,361	372
	Killington Peak	RB-A18	426.9	0%	27,531	64
	Bear Mtn 1	RB-A19	67.9	0%	8,247	121
	Snowdon 2	RB-A21	52.6	0%	10,486	199
	Cat Yard	RB-A22	5.2	14%	4,925	943
	Vale Parking West	RB-A24	6.2	0%	2,211	355
	Total	---	681.0	---	109,930	161
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	0%	20,109	74
	Total	---	273.5	---	20,109	74
Upper West Branch Roaring Brook (C)	Unnamed Tributary	RB-A04	205.2	0%	7,965	39
	Upper Snowshed	RB-A07	38.0	0%	10,578	278
	Ram's Head Parking Lot	RB-A09	9.6	4%	22,307	2,313
	Snowdon 3	RB-A11	6.5	0%	372	58
	Lower Killington Road 1	RB-A12	85.4	0%	5,762	67
West Branch Roaring Brook (D)	Total	---	344.7	---	46,984	136
	Upper West Branch	RB-A02	198.3	0%	5,854	30
	Lower West Branch	RB-A05	241.8	0%	7,832	32
Lower Roaring Brook 1 (E)	Total	---	440.1	---	13,686	31
	Pinnacle Condos	RB-A14	31.6	0%	10,865	344
	Glazer Brook Rd	RB-A20	44.8	0%	13,875	310
	Wastewater Treatment Plant	RB-A27	29.1	0%	4,596	158
	Lower Killington Road 2	RB-A28	15.3	0%	11,921	780
	Killington Golf Course 5	RB-A29	62.8	0%	29,444	469
	Total	---	183.5	---	70,700	385

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Existing Conditions		
				Existing Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0%	8,558	124
	Tributary 1	RB-A06	404.7	0%	20,710	51
	Big Boulder Road	RB-A25	19.7	0%	2,707	137
	Links East Upper	RB-A26	37.9	0%	6,247	165
	Ravine Road	RB-A30	59.8	0%	17,820	298
	Access Road 1	RB-A31	72.4	0%	15,193	210
	Access Road 3	RB-A32	66.0	0%	22,901	347
	Access Road 4	RB-A33	31.6	0%	13,292	420
	Links East Lower	RB-A34	1.4	0%	43	31
	Links East	RB-A35	27.6	0%	2,733	99
	Total	---	790.4	---	110,203	139
Lower East Branch Roaring Brook (F)	Fall Line/Edgemont	EB-A01	55.4	0%	8,946	161
	Killington Golf Course 4	EB-A02	21.6	0%	2,246	104
	Mirror Lake	EB-A04	6.3	0%	399	63
	Killington Golf Course 3	EB-A05	59.6	0%	3,849	65
	Killington Club House	EB-A09	9.8	18%	7,801	795
	Wiffletree	EB-A10	3.3	0%	3,409	1,018
	East Mountain Road	EB-A11	4.4	0%	3,665	829
	Shagback Mtn	EB-A13	69.4	0%	4,156	60
	Edgemont	EB-A15	6.7	0%	4,232	635
	Fall Line	EB-A16	48.0	0%	4,704	98
	Killington Golf Course 1	EB-A17	5.5	0%	521	95
Upper East Branch Roaring Brook (G)	Killington Golf Course 2	EB-A18	22.6	0%	1,005	44
	Trail Creek Parking	EB-A19	1.0	0%	2,888	2,949
	Total	---	313.7	---	47,821	152
	Snowshed Parking Lot	EB-A03	10.8	40%	15,546	1,445
	Snowshed Pond 1	EB-A06	8.3	40%	93	11
	Grand Summit Hotel	EB-A07	7.4	40%	6,847	920
	Snowshed Pond 2	EB-A08	74.5	40%	4,298	58
	Snowshed	EB-A12	61.8	0%	2,405	39
	Trail Creek	EB-A14	23.3	0%	3,642	156
	Total	---	186.1	---	32,831	176
	Roaring Brook Total		2,713.21		371,613	137
	East Branch Roaring Brook Total		499.84		80,653	161

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
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Table 2A: Subwatershed Areas for Upper Roaring Brook (acres)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.00	0.12	0.26	0.76	1.16	0.00	0.00	2.18	1.70	3.14	1.73	0.04	11.1
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.40	0.44	1.52	10.8	0.00	49.0	3.13	306	42.8	26.2	0.76	3.59	445
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	2.81	0.39	2.80	1.55	2.32	5.29	1.75	0.28	0.45	3.14	1.36	2.09	24.2
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.00	1.88	3.99	0.00	14.0	0.20	117	21.2	18.1	0.00	0.00	176
Transportation Gravel	3.36	0.09	0.11	0.39	8.27	1.17	0.12	1.66	1.03	2.01	1.38	0.51	20.1
Transportation Paved	0.00	0.20	0.43	0.28	0.30	1.66	1.12	0.03	0.71	0.03	0.00	0.00	4.77
Water	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Total	6.64	1.24	7.00	17.7	12.0	71.1	6.34	427	67.9	52.6	5.22	6.23	681

Table 2B: Subwatershed Areas for Ram's Head Brook (acres)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.11	0.11
Commercial Lodging	0.00	0.00
Forest	219	219
Golf Course	0.00	0.00
Open	6.40	6.40
Residential	0.00	0.00
Ski Trail	45.3	45.3
Transportation Gravel	2.37	2.37
Transportation Paved	0.00	0.00
Water	0.00	0.00
Total	273	273

Table 2C: Subwatershed Areas for Upper West Branch Roaring Brook (acres)

Land Use	Major Subwatershed C					Total
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.00	0.20	1.63	0.38	0.00	2.21
Commercial Lodging	0.00	0.02	0.00	0.00	0.00	0.02
Forest	166	17.9	0.03	3.10	75.5	262
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.31	2.03	1.55	0.45	2.16	6.51
Residential	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	39.0	14.7	0.26	2.49	5.67	62.2
Transportation Gravel	0.00	1.77	5.35	0.03	0.00	7.15
Transportation Paved	0.00	1.34	0.81	0.00	2.11	4.26
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	205	38.0	9.64	6.45	85.4	345

Table 2D: Subwatershed Areas for West Branch Roaring Brook (acres)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	193	238	430
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	5.65	3.57	9.22
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.53	0.53
Water	0.00	0.00	0.00
Total	198	242	440

Table 2E: Subwatershed Areas for Lower Roaring Brook (acres)

Land Use	Major Subwatershed E					Total
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	
Commercial	3.90	0.10	1.96	1.14	2.19	9.29
Commercial Lodging	6.62	0.00	0.00	0.00	8.57	15.2
Forest	12.8	37.7	24.2	8.04	26.1	109
Golf Course	1.97	0.00	0.00	0.00	14.4	16.4
Open	1.57	0.09	0.56	0.55	3.13	5.90
Residential	0.00	2.17	0.00	0.84	0.00	3.00
Ski Trail	0.00	0.00	0.97	0.00	0.00	0.97
Transportation Gravel	0.03	1.90	0.60	1.48	4.71	8.72
Transportation Paved	4.67	2.80	0.80	3.24	3.72	15.2
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	31.6	44.8	29.1	15.3	62.8	184

Table 2H: Subwatershed Areas for Lower Roaring Brook 2 (acres)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	1.34	1.72	0.00	0.00	0.74	1.53	0.76	1.05	0.00	0.00	7.14
Commercial Lodging	0.00	0.79	0.00	0.00	2.07	0.00	1.68	0.02	0.00	0.00	4.57
Forest	64.0	397	17.1	31.0	42.4	56.0	42.4	22.5	1.13	25.0	699
Golf Course	0.00	0.00	1.15	0.05	2.30	0.00	4.80	2.68	0.26	0.34	11.6
Open	0.19	0.00	0.00	0.06	1.35	1.96	3.28	0.31	0.00	0.36	7.51
Residential	0.49	0.91	0.11	3.99	1.47	5.22	4.43	0.38	0.00	0.96	18.0
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Gravel	0.58	0.64	0.00	0.00	0.30	0.21	2.76	2.26	0.00	0.00	6.76
Transportation Paved	2.65	3.44	1.37	2.85	9.13	7.28	5.84	1.95	0.00	0.97	35.5
Water	0.00	0.00	0.00	0.00	0.00	0.18	0.01	0.51	0.00	0.00	0.69
Total	69.2	405	19.7	37.9	59.8	72.4	66.0	31.6	1.39	27.6	790

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Table 2F: Subwatershed Areas for Lower East Branch Roaring Brook (acres)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0.00	0.00	0.11	0.00	1.80	2.21	0.07	0.02	0.00	0.00	0.00	0.02	0.00	4.24
Commercial Lodging	3.30	0.00	0.00	0.05	0.82	0.00	1.85	1.85	1.50	1.11	0.00	0.00	0.31	10.8
Forest	48.2	12.3	0.97	26.4	1.40	0.15	0.16	65.8	2.97	37.2	1.25	16.2	0.00	213
Golf Course	0.50	8.52	1.20	31.7	1.57	0.02	0.00	0.02	0.70	5.68	4.10	6.20	0.00	60.2
Open	1.47	0.00	0.56	0.17	1.54	0.10	0.96	1.10	0.41	1.32	0.00	0.00	0.00	7.64
Residential	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Ski Trail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	1.31
Transportation Gravel	1.52	0.16	0.00	0.05	1.99	0.73	0.49	0.23	0.83	0.33	0.04	0.00	0.67	7.05
Transportation Paved	0.33	0.60	0.20	1.07	0.62	0.13	0.88	0.38	0.24	1.11	0.10	0.19	0.00	5.87
Water	0.00	0.00	3.28	0.12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46
Total	55.4	21.6	6.33	59.6	9.81	3.35	4.42	69.4	6.66	48.0	5.50	22.6	0.98	314

Table 2G: Subwatershed Areas for Upper East Branch Roaring Brook (acres)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.49	0.48	0.58	1.62	0.00	2.15	5.33
Commercial Lodging	0.00	0.02	2.93	0.00	0.00	3.62	6.57
Forest	0.00	0.10	0.00	35.8	60.7	15.0	112
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	3.13	0.09	1.19	1.11	0.59	2.02	8.12
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.02	0.00	35.0	0.36	0.00	35.4
Transportation Gravel	6.01	0.00	2.18	0.65	0.15	0.28	9.28
Transportation Paved	1.12	0.04	0.58	0.23	0.00	0.29	2.26
Water	0.00	7.50	0.00	0.08	0.00	0.00	7.59
Total	10.8	8.26	7.45	74.5	61.8	23.3	186

Table 2I: Watershed Areas Subtotal (acres)

Land Use	EB	RB
Commercial	9.56	29.9
Commercial Lodging	17.4	19.8
Forest	325	2164
Golf Course	60.2	27.9
Open	15.8	50.6
Residential	0.09	21.0
Ski Trail	36.7	293
Transportation Gravel	16.3	45.1
Transportation Paved	8.14	60.3
Water	11.0	0.76
Total	500	2713

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Table 2A: Subwatershed Areas for Upper Roaring Brook (acres)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.00	0.12	0.26	0.76	1.16	0.00	0.00	2.18	1.70	3.14	1.73	0.04	11.1
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.40	0.44	1.52	10.8	0.00	49.0	3.13	306	42.8	26.2	0.76	3.59	445
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	2.81	0.39	2.80	1.55	2.32	5.29	1.75	0.28	0.45	3.14	1.36	2.09	24.2
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.00	1.88	3.99	0.00	14.0	0.20	117	21.2	18.1	0.00	0.00	176
Transportation Gravel	3.36	0.09	0.11	0.39	8.27	1.17	0.12	1.66	1.03	2.01	1.38	0.51	20.1
Transportation Paved	0.00	0.20	0.43	0.28	0.30	1.66	1.12	0.03	0.71	0.03	0.00	0.00	4.77
Water	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Total	6.64	1.24	7.00	17.7	12.0	71.1	6.34	427	67.9	52.6	5.22	6.23	681

Table 2B: Subwatershed Areas for Ram's Head Brook (acres)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.11	0.11
Commercial Lodging	0.00	0.00
Forest	219	219
Golf Course	0.00	0.00
Open	6.40	6.40
Residential	0.00	0.00
Ski Trail	45.3	45.3
Transportation Gravel	2.37	2.37
Transportation Paved	0.00	0.00
Water	0.00	0.00
Total	273	273

Table 2C: Subwatershed Areas for Upper West Branch Roaring Brook (acres)

Land Use	Major Subwatershed C					Total
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.00	0.20	1.63	0.38	0.00	2.21
Commercial Lodging	0.00	0.02	0.00	0.00	0.00	0.02
Forest	166	17.9	0.03	3.10	75.5	262
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.31	2.03	1.55	0.45	2.16	6.51
Residential	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	39.0	14.7	0.26	2.49	5.67	62.2
Transportation Gravel	0.00	1.77	5.35	0.03	0.00	7.15
Transportation Paved	0.00	1.34	0.81	0.00	2.11	4.26
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	205	38.0	9.64	6.45	85.4	345

Table 2D: Subwatershed Areas for West Branch Roaring Brook (acres)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	193	238	430
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	5.65	3.57	9.22
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.53	0.53
Water	0.00	0.00	0.00
Total	198	242	440

Table 2E: Subwatershed Areas for Lower Roaring Brook (acres)

Land Use	Major Subwatershed E					Total
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	
Commercial	3.90	0.10	1.96	1.14	2.19	9.29
Commercial Lodging	6.62	0.00	0.00	0.00	8.57	15.2
Forest	12.8	37.7	24.2	8.04	26.1	109
Golf Course	1.97	0.00	0.00	0.00	14.4	16.4
Open	1.57	0.09	0.56	0.55	3.13	5.90
Residential	0.00	2.17	0.00	0.84	0.00	3.00
Ski Trail	0.00	0.00	0.97	0.00	0.00	0.97
Transportation Gravel	0.03	1.90	0.60	1.48	4.71	8.72
Transportation Paved	4.67	2.80	0.80	3.24	3.72	15.2
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	31.6	44.8	29.1	15.3	62.8	184

Table 2H: Subwatershed Areas for Lower Roaring Brook 2 (acres)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	1.34	1.72	0.00	0.00	0.74	1.53	0.76	1.05	0.00	0.00	7.14
Commercial Lodging	0.00	0.79	0.00	0.00	2.07	0.00	1.68	0.02	0.00	0.00	4.57
Forest	64.0	397	17.1	31.0	42.4	56.0	42.4	22.5	1.13	25.0	699
Golf Course	0.00	0.00	1.15	0.05	2.30	0.00	4.80	2.68	0.26	0.34	11.6
Open	0.19	0.00	0.00	0.06	1.35	1.96	3.28	0.31	0.00	0.36	7.51
Residential	0.49	0.91	0.11	3.99	1.47	5.22	4.43	0.38	0.00	0.96	18.0
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Gravel	0.58	0.64	0.00	0.00	0.30	0.21	2.76	2.26	0.00	0.00	6.76
Transportation Paved	2.65	3.44	1.37	2.85	9.13	7.28	5.84	1.95	0.00	0.97	35.5
Water	0.00	0.00	0.00	0.00	0.00	0.18	0.01	0.51	0.00	0.00	0.69
Total	69.2	405	19.7	37.9	59.8	72.4	66.0	31.6	1.39	27.6	790

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Table 2F: Subwatershed Areas for Lower East Branch Roaring Brook (acres)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0.00	0.00	0.11	0.00	1.80	2.21	0.07	0.02	0.00	0.00	0.00	0.02	0.00	4.24
Commercial Lodging	3.30	0.00	0.00	0.05	0.82	0.00	1.85	1.85	1.50	1.11	0.00	0.00	0.31	10.8
Forest	48.2	12.3	0.97	26.4	1.40	0.15	0.16	65.8	2.97	37.2	1.25	16.2	0.00	213
Golf Course	0.50	8.52	1.20	31.7	1.57	0.02	0.00	0.02	0.70	5.68	4.10	6.20	0.00	60.2
Open	1.47	0.00	0.56	0.17	1.54	0.10	0.96	1.10	0.41	1.32	0.00	0.00	0.00	7.64
Residential	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Ski Trail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	1.31
Transportation Gravel	1.52	0.16	0.00	0.05	1.99	0.73	0.49	0.23	0.83	0.33	0.04	0.00	0.67	7.05
Transportation Paved	0.33	0.60	0.20	1.07	0.62	0.13	0.88	0.38	0.24	1.11	0.10	0.19	0.00	5.87
Water	0.00	0.00	3.28	0.12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46
Total	55.4	21.6	6.33	59.6	9.81	3.35	4.42	69.4	6.66	48.0	5.50	22.6	0.98	314

Table 2G: Subwatershed Areas for Upper East Branch Roaring Brook (acres)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.49	0.48	0.58	1.62	0.00	2.15	5.33
Commercial Lodging	0.00	0.02	2.93	0.00	0.00	3.62	6.57
Forest	0.00	0.10	0.00	35.8	60.7	15.0	112
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	3.13	0.09	1.19	1.11	0.59	2.02	8.12
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.02	0.00	35.0	0.36	0.00	35.4
Transportation Gravel	6.01	0.00	2.18	0.65	0.15	0.28	9.28
Transportation Paved	1.12	0.04	0.58	0.23	0.00	0.29	2.26
Water	0.00	7.50	0.00	0.08	0.00	0.00	7.59
Total	10.8	8.26	7.45	74.5	61.8	23.3	186

Table 2I: Watershed Areas Subtotal (acres)

Land Use	EB	RB
Commercial	9.56	29.9
Commercial Lodging	17.4	19.8
Forest	325	2164
Golf Course	60.2	27.9
Open	15.8	50.6
Residential	0.09	21.0
Ski Trail	36.7	293
Transportation Gravel	16.3	45.1
Transportation Paved	8.14	60.3
Water	11.0	0.76
Total	500	2713

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Table 5A: Subwatershed Annual Loads for Upper Roaring Brook (lbs/year)

Land Use	Major Subwatershed A												
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	Total
Commercial	0	5	11	35	304	0	0	857	115	518	114	2	1,962
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	5	13	44	309	0	1,407	90	8,801	1,231	751	19	103	12,772
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	32	11	80	44	66	152	50	8	13	90	34	60	642
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Ski Trail	0	0	106	315	0	1,675	12	11,183	1,679	1,019	0	0	15,989
Transportation Gravel	5,383	358	430	1,549	32,783	4,697	500	6,633	4,128	8,057	4,758	2,046	71,322
Transportation Paved	0	305	655	427	448	2,520	1,709	50	1,081	50	0	0	7,244
Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	5,420	692	1,327	2,680	33,601	10,451	2,361	27,531	8,247	10,486	4,925	2,211	109,930
Unitized (lbs/ac/yr)	816	558	189	151	2,789	147	372	64	121	199	943	355	161

Table 5B: Subwatershed Annual Loads for Ram's Head Brook (lbs/year)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	75	75
Commercial Lodging	0	0
Forest	6,302	6,302
Golf Course	0	0
Open	184	184
Residential	0	0
Ski Trail	4,058	4,058
Transportation Gravel	9,490	9,490
Transportation Paved	0	0
Water	0	0
Total	20,109	20,109
Unitized (lbs/ac/yr)	74	74

Table 5C: Subwatershed Annual Loads for Upper West Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0	51	501	16	0	568
Commercial Lodging	0	1	0	0	0	1
Forest	4,765	515	1	89	2,169	7,539
Golf Course	0	0	0	0	0	0
Open	9	58	43	13	62	185
Residential	0	0	0	0	0	0
Ski Trail	3,191	830	14	141	319	4,495
Transportation Gravel	0	7,092	20,561	113	0	27,766
Transportation Paved	0	2,031	1,187	0	3,213	6,431
Water	0	0	0	0	0	0
Total	7,965	10,578	22,307	372	5,762	46,984
Unitized (lbs/ac/yr)	39	278	2,313	58	67	136

Table 5D: Subwatershed Annual Loads for West Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0	0	0
Commercial Lodging	0	0	0
Forest	5,536	6,831	12,367
Golf Course	0	0	0
Open	0	0	0
Residential	0	0	0
Ski Trail	318	201	519
Transportation Gravel	0	0	0
Transportation Paved	0	800	800
Water	0	0	0
Total	5854	7832	13686
Unitized (lbs/ac/yr)	30	32	31

Table 5E: Subwatershed Annual Loads for Lower Roaring Brook (lbs/year)

Land Use	Major Subwatershed E					
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	Total
Commercial	505	80	207	368	991	2,151
Commercial Lodging	2,630	0	0	0	2,522	5,152
Forest	368	1,084	695	231	750	3,128
Golf Course	78	0	0	0	567	645
Open	45	3	16	16	90	170
Residential	0	859	0	479	0	1,339
Ski Trail	0	0	55	0	0	55
Transportation Gravel	134	7,588	2,407	5,906	18,866	34,901
Transportation Paved	7,106	4,261	1,216	4,921	5,657	23,160
Water	0	0	0	0	0	0
Total	10,865	13,875	4,596	11,921	29,444	70,700
Unitized (lbs/ac/yr)	344	310	8,985	23,473	469	33,581

Table 5H: Subwatershed Annual Loads for Lower Roaring Brook 2 (lbs/year)

Land Use	Major Subwatershed H										
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	Total
Commercial	136	690	0	0	358	420	157	310	0	0	2,072
Commercial Lodging	0	371	0	0	517	0	433	1	0	0	1,322
Forest	1,838	11,414	491	891	1,219	1,610	1,218	645	32	718	20,078
Golf Course	0	0	45	2	91	0	189	106	10	13	457
Open	5	0	0	2	39	56	94	9	0	10	216
Residential	222	446	85	1,026	505	1,198	875	213	0	519	5,088
Ski Trail	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	2,333	2,555	5	0	1,217	836	11,061	9,039	0	0	27,047
Transportation Paved	4,023	5,234	2,081	4,326	13,874	11,074	8,873	2,967	0	1,472	53,924
Water	0	0	0	0	0	0	0	0	0	0	0
Total	8,558	20,710	2,707	6,247	17,820	15,193	22,901	13,292	43	2,733	110,203
Unitized (lbs/ac/yr)	16,980	51	137	165	298	210	347	420	31	99	18,739

Table 5F: Subwatershed Annual Loads for Lower East Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0	0	5	0	330	271	46	14	0	0	0	1	0	667
Commercial Lodging	849	0	0	3	37	0	275	716	407	283	0	0	194	2,763
Forest	1,385	353	28	760	33	4	5	1,891	85	1,068	36	466	0	6,114
Golf Course	20	336	47	1,249	51	1	0	1	28	224	162	244	0	2,363
Open	42	0	16	5	36	3	28	32	12	38	0	0	0	212
Residential	66	0	0	0	0	0	0	0	0	0	0	0	0	66
Ski Trail	1	0	0	0	0	0	0	0	0	73	0	0	0	74
Transportation Gravel	6,074	648	0	200	6,537	2,926	1,973	923	3,328	1,328	172	0	2,695	26,804
Transportation Paved	509	909	303	1,633	777	204	1,338	579	372	1,690	151	293	0	8,758
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8,946	2,246	399	3,849	7,801	3,409	3,665	4,156	4,232	4,704	521	1,005	2,888	47,821
Unitized (lbs/ac/yr)	161	104	63	65	795	1,018	829	60	635	98	95	44	2,949	152

Table 5G: Subwatershed Annual Loads for Upper East Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	19	50	22	596	0	93	779
Commercial Lodging	0	2	1,046	0	0	1,488	2,537
Forest	0	2	0	617	1,745	430	2,794
Golf Course	0	0	0	0	0	0	0
Open	54	2	20	19	17	58	170
Residential	0	0	0	0	0	0	0
Ski Trail	0	1	0	1,302	24	0	1,326
Transportation Gravel	14,447	0	5,235	1,555	619	1,127	22,984
Transportation Paved	1,026	37	525	209	0	445	2,241
Water	0	0	0	0	0	0	0
Total	15,546	93	6,847	4,298	2,405	3,642	32,831
Unitized (lbs/ac/yr)	1,445	11	920	58	39	156	176

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Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Interim Conditions (1-5)		
				Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	70%	4,065	612
	Vale Parking Lot Lower	RB-A08	1.2	0%	692	558
	Killington Mountain Road 4	RB-A10	7.0	0%	1,327	189
	Killington Mountain Road 3	RB-A13	17.7	0%	2,680	151
	K-1 Parking Lot	RB-A15	12.0	50%	16,970	1,408
	Killington Mountain Road 2	RB-A16	71.1	0%	10,451	147
	Killington Mountain Road 1	RB-A17	6.3	0%	2,361	372
	Killington Peak	RB-A18	426.9	0%	27,531	64
	Bear Mtn 1	RB-A19	67.9	0%	8,247	121
	Snowdon 2	RB-A21	52.6	0%	10,486	199
	Cat Yard	RB-A22	5.2	50%	2,863	548
	Vale Parking West	RB-A24	6.2	0%	2,211	355
	Total	---	681.0	---	89,883	132
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	0%	20,109	74
	Total	---	273.5	---	20,109	74
Upper West Branch Roaring Brook (C)	Unnamed Tributary	RB-A04	205.2	0%	7,965	39
	Upper Snowshed	RB-A07	38.0	0%	10,578	278
	Ram's Head Parking Lot	RB-A09	9.6	4%	22,307	2,313
	Snowdon 3	RB-A11	6.5	0%	372	58
	Lower Killington Road 1	RB-A12	85.4	0%	5,762	67
	Total	---	344.7	---	46,984	136
West Branch Roaring Brook (D)	Upper West Branch	RB-A02	198.3	0%	5,854	30
	Lower West Branch	RB-A05	241.8	0%	7,832	32
	Total	---	440.1	---	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	0%	10,865	344
	Glazer Brook Rd	RB-A20	44.8	0%	13,875	310
	Lower Killington Road 2	RB-A28	15.3	0%	11,921	780
	Wastewater Treatment Plant	RB-A27	29.1	0%	4,596	158
	Killington Golf Course 5	RB-A29	62.8	0%	29,444	469
	Total	---	183.5	0%	70,700	385

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Interim Conditions (1-5)		
				Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0%	8,558	124
	Tributary 1	RB-A06	404.7	0%	20,710	51
	Big Boulder Road	RB-A25	19.7	0%	2,707	137
	Links East Upper	RB-A26	37.9	0%	6,247	165
	Ravine Road	RB-A30	59.8	0%	17,820	298
	Access Road 1	RB-A31	72.4	0%	15,193	210
	Access Road 3	RB-A32	66.0	0%	22,901	347
	Access Road 4	RB-A33	31.6	0%	13,292	420
	Links East Lower	RB-A34	1.4	0%	43	31
	Links East	RB-A35	27.6	0%	2,733	99
	Total	---	790.4	---	110,203	139
	Fall Line/Edgemont	EB-A01	55.4	0%	8,946	161
	Killington Golf Course 4	EB-A02	21.6	0%	2,246	104
Lower East Branch Roaring Brook (F)	Mirror Lake	EB-A04	6.3	0%	399	63
	Killington Golf Course 3	EB-A05	59.6	0%	3,849	65
	Killington Club House	EB-A09	9.8	50%	4,757	485
	Wiffletree	EB-A10	3.3	0%	3,409	1,018
	East Mountain Road	EB-A11	4.4	0%	3,665	829
	Shagback Mtn	EB-A13	69.4	0%	4,156	60
	Edgemont	EB-A15	6.7	0%	4,232	635
	Fall Line	EB-A16	48.0	0%	4,704	98
	Killington Golf Course 1	EB-A17	5.5	0%	521	95
	Killington Golf Course 2	EB-A18	22.6	0%	1,005	44
	Trail Creek Parking	EB-A19	1.0	0%	2,888	2,949
	Total	---	313.7	---	44,777	143
	Snowshed Parking Lot	EB-A03	10.8	40%	15,546	1,439
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	40%	93	11
	Grand Summit Hotel	EB-A07	7.4	40%	6,847	920
	Snowshed Pond 2	EB-A08	74.5	40%	4,298	58
	Snowshed	EB-A12	61.8	0%	2,405	39
	Trail Creek	EB-A14	23.3	0%	3,642	156
	Total	---	186.2	---	32,831	176
Roaring Brook Total			2,713.21		351,566	130
East Branch Roaring Brook Total			499.88		77,608	155

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
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Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Interim Conditions (1-5)		
				Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	70%	4,065	612
	Vale Parking Lot Lower	RB-A08	1.2	0%	692	558
	Killington Mountain Road 4	RB-A10	7.0	0%	1,327	189
	Killington Mountain Road 3	RB-A13	17.7	0%	2,680	151
	K-1 Parking Lot	RB-A15	12.0	50%	16,970	1,408
	Killington Mountain Road 2	RB-A16	71.1	0%	10,451	147
	Killington Mountain Road 1	RB-A17	6.3	0%	2,361	372
	Killington Peak	RB-A18	426.9	0%	27,531	64
	Bear Mtn 1	RB-A19	67.9	0%	8,247	121
	Snowdon 2	RB-A21	52.6	0%	10,486	199
	Cat Yard	RB-A22	5.2	50%	2,863	548
	Vale Parking West	RB-A24	6.2	0%	2,211	355
	Total	---	681.0	---	89,883	132
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	0%	20,109	74
	Total	---	273.5	---	20,109	74
Upper West Branch Roaring Brook (C)	Unnamed Tributary	RB-A04	205.2	0%	7,965	39
	Upper Snowshed	RB-A07	38.0	0%	10,578	278
	Ram's Head Parking Lot	RB-A09	9.6	4%	22,307	2,313
	Snowdon 3	RB-A11	6.5	0%	372	58
	Lower Killington Road 1	RB-A12	85.4	0%	5,762	67
	Total	---	344.7	---	46,984	136
West Branch Roaring Brook (D)	Upper West Branch	RB-A02	198.3	0%	5,854	30
	Lower West Branch	RB-A05	241.8	0%	7,832	32
	Total	---	440.1	---	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	0%	10,865	344
	Glazer Brook Rd	RB-A20	44.8	0%	13,875	310
	Lower Killington Road 2	RB-A28	15.3	0%	11,921	780
	Wastewater Treatment Plant	RB-A27	29.1	0%	4,596	158
	Killington Golf Course 5	RB-A29	62.8	0%	29,444	469
	Total	---	183.5	0%	70,700	385

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Interim Conditions (1-5)		
				Treatment (% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0%	8,558	124
	Tributary 1	RB-A06	404.7	0%	20,710	51
	Big Boulder Road	RB-A25	19.7	0%	2,707	137
	Links East Upper	RB-A26	37.9	0%	6,247	165
	Ravine Road	RB-A30	59.8	0%	17,820	298
	Access Road 1	RB-A31	72.4	0%	15,193	210
	Access Road 3	RB-A32	66.0	0%	22,901	347
	Access Road 4	RB-A33	31.6	0%	13,292	420
	Links East Lower	RB-A34	1.4	0%	43	31
	Links East	RB-A35	27.6	0%	2,733	99
	Total	---	790.4	---	110,203	139
	Fall Line/Edgemont	EB-A01	55.4	0%	2,948	53
	Killington Golf Course 4	EB-A02	21.6	0%	2,246	104
Lower East Branch Roaring Brook (F)	Mirror Lake	EB-A04	6.3	0%	399	63
	Killington Golf Course 3	EB-A05	59.6	0%	3,849	65
	Killington Club House	EB-A09	9.8	50%	4,757	485
	Wiffletree	EB-A10	3.3	0%	3,409	1,018
	East Mountain Road	EB-A11	4.4	0%	3,665	829
	Shagback Mtn	EB-A13	69.4	0%	4,156	60
	Edgemont	EB-A15	6.7	0%	946	142
	Fall Line	EB-A16	48.0	0%	4,704	98
	Killington Golf Course 1	EB-A17	5.5	0%	521	95
	Killington Golf Course 2	EB-A18	22.6	0%	1,005	44
	Trail Creek Parking	EB-A19	1.0	0%	578	590
	Total	---	313.7	---	33,181	106
	Snowshed Parking Lot	EB-A03	10.8	40%	15,546	1,439
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	40%	93	11
	Grand Summit Hotel	EB-A07	7.4	40%	6,847	920
	Snowshed Pond 2	EB-A08	74.5	40%	4,298	58
	Snowshed	EB-A12	61.8	0%	2,405	39
	Trail Creek	EB-A14	23.3	0%	1,119	48
	Total	---	186.2	---	30,308	163
Roaring Brook Total			2,713.21		351,566	130
East Branch Roaring Brook Total			499.88		63,489	127

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Simple Method Pollutant Loadings - Interim Conditions (Years 1-5) - Area Summary
Prepared by VHB
September 16, 2010

Table 2A: Subwatershed Area for Upper Roaring Brook (acres)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.00	0.12	0.26	0.76	1.16	0.00	0.00	2.18	1.70	3.14	1.73	0.04	11.1
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.40	0.44	1.52	10.8	0.00	49.0	3.13	306	42.8	26.2	0.76	3.59	445
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	2.81	0.39	2.80	1.55	2.32	5.29	1.75	0.28	0.45	3.14	1.36	2.09	24.2
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.00	1.88	3.99	0.00	14.0	0.20	117	21.2	18.1	0.00	0.00	176
Transportation Gravel	3.36	0.09	0.11	0.39	8.27	1.17	0.12	1.66	1.03	2.01	1.38	0.51	20.1
Transportation Paved	0.00	0.20	0.43	0.28	0.30	1.66	1.12	0.03	0.71	0.03	0.00	0.00	4.77
Water	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Total	6.64	1.24	7.00	17.7	12.0	71.1	6.34	427	67.9	52.6	5.22	6.23	681

Table 2B: Subwatershed Area for Ram's Head Brook (acres)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.11	0.11
Commercial Lodging	0.00	0.00
Forest	219	219
Golf Course	0.00	0.00
Open	6.40	6.40
Residential	0.00	0.00
Ski Trail	45.3	45.3
Transportation Gravel	2.37	2.37
Transportation Paved	0.00	0.00
Water	0.00	0.00
Total	273	273

Table 2C: Subwatershed Area for Upper West Branch Roaring Brook (acres)

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0.00	0.20	1.63	0.38	0.00	2.21
Commercial Lodging	0.00	0.02	0.00	0.00	0.00	0.02
Forest	166	17.9	0.03	3.10	75.5	262
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.31	2.03	1.55	0.45	2.16	6.51
Residential	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	39.0	14.7	0.26	2.49	5.67	62.2
Transportation Gravel	0.00	1.77	5.35	0.03	0.00	7.15
Transportation Paved	0.00	1.34	0.81	0.00	2.11	4.26
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	205	38.0	9.64	6.45	85.4	345

Table 2D: Subwatershed Area for West Branch Roaring Brook (acres)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	193	238	430
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	5.65	3.57	9.22
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.53	0.53
Water	0.00	0.00	0.00
Total	198.30	241.83	440.13

Table 2E: Subwatershed Area for Lower Roaring Brook (acres)

Land Use	Major Subwatershed E					
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	Total
Commercial	3.90	0.10	1.96	1.14	2.19	9.29
Commercial Lodging	6.62	0.00	0.00	0.00	8.57	15.2
Forest	12.8	37.7	24.2	8.04	26.1	109
Golf Course	1.97	0.00	0.00	0.00	14.39	16.4
Open	1.57	0.09	0.56	0.55	3.13	5.90
Residential	0.00	2.17	0.00	0.84	0.00	3.00
Ski Trail	0.00	0.00	0.97	0.00	0.00	0.97
Transportation Gravel	0.03	1.90	0.60	1.48	4.71	8.72
Transportation Paved	4.67	2.80	0.80	3.24	3.72	15.2
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	31.6	44.8	29.1	15.3	62.8	184

Table 2F: Subwatershed Area for Lower East Branch Roaring Brook (acres)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0.00	0.00	0.11	0.00	1.80	2.21	0.07	0.02	0.00	0.00	0.00	0.02	0.00	4.24
Commercial Lodging	3.30	0.00	0.00	0.05	0.82	0.00	1.85	1.85	1.50	1.11	0.00	0.00	0.31	10.8
Forest	48.2	12.3	0.97	26.4	1.40	0.15	0.16	65.8	2.97	37.2	1.25	16.2	0.00	213
Golf Course	0.50	8.52	1.20	31.7	1.57	0.02	0.00	0.02	0.70	5.68	4.10	6.20	0.00	60.2
Open	1.47	0.00	0.56	0.17	1.54	0.10	0.96	1.10	0.41	1.32	0.00	0.00	0.00	7.64
Residential	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Ski Trail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	1.31
Transportation Gravel	1.52	0.16	0.00	0.05	1.99	0.73	0.49	0.23	0.83	0.33	0.04	0.00	0.67	7.05
Transportation Paved	0.33	0.60	0.20	1.07	0.62	0.13	0.88	0.38	0.24	1.11	0.10	0.19	0.00	5.87
Water	0.00	0.00	3.28	0.12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46
Total	55.4	21.6	6.33	59.6	9.81	3.35	4.42	69.4	6.66	48.0	5.50	22.6	0.98	314

Table 2G: Subwatershed Area for Upper East Branch Roaring Brook (acres)

Land Use	Group G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.49	0.48	0.58	1.62	0.00	2.15	5.33
Commercial Lodging	0.00	0.02	2.93	0.00	0.00	3.62	6.57
Forest	0.00	0.10	0.00	35.8	60.7	15.0	112
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	3.13	0.09	1.19	1.11	0.59	2.02	8.12
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.02	0.00	35.0	0.36	0.00	35.4
Transportation Gravel	6.01	0.00	2.18	0.65	0.15	0.28	9.28
Transportation Paved	1.12	0.04	0.58	0.23	0.00	0.29	2.26
Water	0.00	7.50	0.00	0.08	0.00	0.00	7.59
Total	10.8	8.26	7.45	74.5	61.8	23.3	186

Table 2H: Subwatershed Area for Lower Roaring Brook 2 (acres)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	1.34	1.72	0.00	0.00	0.74	1.53	0.76	1.05	0.00	0.00	7.14
Commercial Lodging	0.00	0.79	0.00	0.00	2.07	0.00	1.68	0.02	0.00	0.00	4.57
Forest	64.0	397	17.1	31.0	42.4	56.0	42.4	22.5	1.13	25.0	699
Golf Course	0.00	0.00	1.15	0.05	2.30	0.00	4.80	2.68	0.26	0.34	11.6
Open	0.19	0.00	0.00	0.06	1.35	1.96	3.28	0.31	0.00	0.36	7.51
Residential	0.49	0.91	0.11	3.99	1.47	5.22	4.43	0.38	0.00	0.96	18.0
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Gravel	0.58	0.64	0.00	0.00	0.30	0.21	2.76	2.26	0.00	0.00	6.76
Transportation Paved	2.65	3.44	1.37	2.85	9.13	7.28	5.84	1.95	0.00	0.97	35.5
Water	0.00	0.00	0.00	0.00	0.00	0.18	0.01	0.51	0.00	0.00	0.69
Total	69.2	405	19.7	37.9	59.8	72.4	66.0	31.6	1.39	27.6	790

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
 Simple Method Pollutant Loadings - Interim Conditions (Years 1-5) - Rv Summary
 Prepared by VHB
 September 16, 2010

Table 4A: Subwatershed Runoff Coefficients for Upper Roaring Brook (Rv)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.05	0.05	0.05	0.05	0.30	0.05	0.05	0.45	0.08	0.19	0.09	0.05	---
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.05	0.05	0.05	0.07	0.05	0.11	0.05	0.09	0.07	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 4B: Subwatershed Runoff Coefficients for Ram's Head Brook (Rv)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.76	---
Commercial Lodging	0.05	---
Forest	0.05	---
Golf Course	0.05	---
Open	0.05	---
Residential	0.05	---
Ski Trail	0.08	---
Transportation Gravel	0.95	---
Transportation Paved	0.95	---
Water	0.05	---
Total	---	---

Table 4C: Subwatershed Runoff Coefficients for Upper West Branch Roaring Brook (Rv)

Land Use	Major Subwatershed C					Total
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.05	0.29	0.37	0.05	0.05	---
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.07	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---

Table 4D: Subwatershed Runoff Coefficients for West Branch Roaring Brook (Rv)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.05	0.05	---
Commercial Lodging	0.05	0.05	---
Forest	0.05	0.05	---
Golf Course	0.05	0.05	---
Open	0.05	0.05	---
Residential	0.05	0.05	---
Ski Trail	0.05	0.05	---
Transportation Gravel	0.95	0.95	---
Transportation Paved	0.95	0.95	---
Water	0.05	0.05	---
Total	---	---	---

Table 4E: Subwatershed Runoff Coefficients for Lower Roaring Brook (Rv)

Land Use	Group E					Total
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	
Commercial	0.15	0.95	0.12	0.37	0.52	---
Commercial Lodging	0.36	0.05	0.05	0.05	0.27	---
Forest	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.50	0.05	0.72	0.05	---
Ski Trail	0.05	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---

Table 4F: Subwatershed Runoff Coefficients for Lower East Branch Roaring Brook (Rv)

Land Use	Group F														Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19		
Commercial	0.05	0.05	0.05	0.05	0.26	0.14	0.75	0.95	0.05	0.05	0.05	0.05	0.05	---	
Commercial Lodging	0.24	0.05	0.05	0.05	0.05	0.05	0.14	0.35	0.25	0.23	0.05	0.05	0.58	---	
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Residential	0.95	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---	
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---	
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---	
Total	---	---	---	---	---	---	---	---	---	---	---	---	---	---	

Table 4G: Subwatershed Runoff Coefficients for Upper East Branch Roaring Brook (Rv)

Land Use	Group G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.07	0.20	0.07	0.71	0.05	0.05	---
Commercial Lodging	0.05	0.14	0.55	0.05	0.05	0.38	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.05	0.05	0.05	0.05	0.06	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---

Table 4H: Subwatershed Runoff Coefficients for Lower Roaring Brook 2 (Rv)

Land Use	Group H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	0.12	0.46	0.05	0.05	0.55	0.32	0.24	0.34	0.05	0.05	---
Commercial Lodging	0.05	0.43	0.05	0.05	0.23	0.05	0.24	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.57	0.62	0.95	0.33	0.43	0.29	0.25	0.71	0.05	0.68	---
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---	---	---	---	---

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Simple Method Pollutant Loadings - Interim Conditions (Years 1-5) - Loading Summary
Prepared by VHB
September 16, 2010

Table 4A: Subwatershed Annual Loads for Upper Roaring Brook (lbs/year)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0	5	11	35	154	0	0	857	115	518	67	2	1,763
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	3	13	44	309	0	1,407	90	8,801	1,231	751	11	103	12,763
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	24	11	80	44	33	152	50	8	13	90	19	60	587
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Ski Trail	0	0	106	315	0	1,675	12	11,183	1,679	1,019	0	0	15,989
Transportation Gravel	4,037	358	430	1,549	16,557	4,697	500	6,633	4,128	8,057	2,767	2,046	51,758
Transportation Paved	0	305	655	427	226	2,520	1,709	50	1,081	50	0	0	7,022
Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4,065	692	1,327	2,680	16,970	10,451	2,361	27,531	8,247	10,486	2,863	2,211	89,883
Unitized (lbs/ac/yr)	612	558	189	151	1,408	147	372	64	121	199	548	355	132

Table 6B: Subwatershed Annual Loads for Ram's Head Brook (lbs/year)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	75	75
Commercial Lodging	0	0
Forest	6,302	6,302
Golf Course	0	0
Open	184	184
Residential	0	0
Ski Trail	4,058	4,058
Transportation Gravel	9,490	9,490
Transportation Paved	0	0
Water	0	0
Total	20,109	20,109
Unitized (lbs/ac/yr)	74	74

Table 6C: Subwatershed Annual Loads for Upper West Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0	51	501	16	0	568
Commercial Lodging	0	1	0	0	0	1
Forest	4,765	515	1	89	2,169	7,539
Golf Course	0	0	0	0	0	0
Open	9	58	43	13	62	185
Residential	0	0	0	0	0	0
Ski Trail	3,191	830	14	141	319	4,495
Transportation Gravel	0	7,092	20,561	113	0	27,766
Transportation Paved	0	2,031	1,187	0	3,213	6,431
Water	0	0	0	0	0	0
Total	7,965	10,578	22,307	372	5,762	46,984
Unitized (lbs/ac/yr)	39	278	2,313	58	67	136

Table 6D: Subwatershed Annual Loads for West Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0	0	0
Commercial Lodging	0	0	0
Forest	5,536	6,831	12,367
Golf Course	0	0	0
Open	0	0	0
Residential	0	0	0
Ski Trail	318	201	519
Transportation Gravel	0	0	0
Transportation Paved	0	800	800
Water	0	0	0
Total	5,854	7,832	13,686
Unitized (lbs/ac/yr)	30	32	31

Table 6E: Subwatershed Annual Loads for Lower Roaring Brook (lbs/year)

Land Use	Major Subwatershed E					
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	Total
Commercial	505	80	207	368	991	2,151
Commercial Lodging	2,630	0	0	0	2,522	5,152
Forest	368	1,084	695	231	750	3,128
Golf Course	78	0	0	0	567	645
Open	45	3	16	16	90	170
Residential	0	859	0	479	0	1,339
Ski Trail	0	0	55	0	0	55
Transportation Gravel	134	7,588	2,407	5,906	18,866	34,901
Transportation Paved	7,106	4,261	1,216	4,921	5,657	23,160
Water	0	0	0	0	0	0
Total	10,865	13,875	4,596	11,921	29,444	70,700
Unitized (lbs/ac/yr)	344	310	158	780	469	385

Table 6F: Subwatershed Annual Loads for Lower East Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0	0	5	0	201	271	46	14	0	0	0	1	0	538
Commercial Lodging	849	0	0	3	22	0	275	716	407	283	0	0	194	2,749
Forest	1,385	353	28	760	20	4	5	1,891	85	1,068	36	466	0	6,101
Golf Course	20	336	47	1,249	31	1	0	1	28	224	162	244	0	2,343
Open	42	0	16	5	22	3	28	32	12	38	0	0	0	197
Residential	66	0	0	0	0	0	0	0	0	0	0	0	0	66
Ski Trail	1	0	0	0	0	0	0	0	0	73	0	0	0	74
Transportation Gravel	6,074	648	0	200	3,986	2,926	1,973	923	3,328	1,328	172	0	2,695	24,253
Transportation Paved	509	909	303	1,633	474	204	1,338	579	372	1,690	151	293	0	8,455
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8,946	2,246	399	3,849	4,757	3,409	3,665	4,156	4,232	4,704	521	1,005	2,888	44,777
Unitized (lbs/ac/yr)	161	104	63	65	485	1,018	829	60	635	98	95	44	2,949	143

Table 6G: Subwatershed Annual Loads for Upper East Branch Roaring Brook (lbs/year)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	19	50	22	596	0	93	779
Commercial Lodging	0	2	1,046	0	0	1,488	2,537
Forest	0	2	0	617	1,745	430	2,794
Golf Course	0	0	0	0	0	0	0
Open	54	2	20	19	17	58	170
Residential	0	0	0	0	0	0	0
Ski Trail	0	1	0	1,302	24	0	1,326
Transportation Gravel	14,447	0	5,235	1,555	619	1,127	22,984
Transportation Paved	1,026	37	525	209	0	445	2,241
Water	0	0	0	0	0	0	0
Total	15,546	93	6,847	4,298	2,405	3,642	32,831
Unitized (lbs/ac/yr)	1,445	11	920	58	39	156	176

Table 5H: Subwatershed Annual Loads for Lower Roaring Brook 2 (lbs/year)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	136	690	0	0	358	420	157	310	0	0	2,072
Commercial Lodging	0	371	0	0	517	0	433	1	0	0	1,322
Forest	1,838	11,414	491	891	1,219	1,610	1,218	645	32	718	20,078
Golf Course	0	0	45	2	91	0	189	106	10	13	457
Open	5	0	0	2	39	56	94	9	0	10	216
Residential	222	446	85	1,026	505	1,198	875	213	0	519	5,088
Ski Trail	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	2,333	2,555	5	0	1,217	836	11,061	9,039	0	0	27,047
Transportation Paved	4,023	5,234	2,081	4,326	13,874	11,074	8,873	2,967	0	1,472	53,924
Water	0	0	0	0	0	0	0	0	0	0	0
Total	8,558	20,710	2,707	6,247	17,820	15,193	22,901	13,292	43	2,733	110,203
Unitized (lbs/ac/yr)	124	51	137	165	298	210	347	420	31	99	139

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Simple Method for Pollutant Loading - Proposed Phase I Conditions (Years 6 - 9)
VHB
September 16, 2010

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Post Phase I Conditions		
				Impervious Acres Treated	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	6.6	4,065	612
	Vale Parking Lot Lower	RB-A08	1.2	0.0	692	558
	Killington Mountain Road 4	RB-A10	7.0	0.0	1,327	189
	Killington Mountain Road 3	RB-A13	17.7	0.0	2,680	151
	K-1 Parking Lot	RB-A15	12.0	12.0	16,970	1,408
	Killington Mountain Road 2	RB-A16	71.1	0.0	10,451	147
	Killington Mountain Road 1	RB-A17	6.3	0.0	2,361	372
	Killington Peak	RB-A18	426.9	0.0	27,531	64
	Bear Mtn 1	RB-A19	67.9	0.0	8,247	121
	Snowdon 2	RB-A21	52.6	0.0	10,486	199
	Cat Yard	RB-A22	5.2	3.9	2,863	548
	Vale Parking West	RB-A24	6.2	0.0	2,211	355
	Total	---	681.0	22.5	89,883	132
	Snowdon 2	RB-A23	273.5	0.0	20,109	74
Ram's Head Brook (B)	Total	---	273.5	0.0	20,109	74
Upper West Branch Roaring Brook (C)	Snowshed Parking Lot	EB-A03	10.8	10.7	1,676	156
	Unnamed Tributary	RB-A04	205.2	9.8	10,837	34
	Upper Snowshed	RB-A07	38.0	6.0	2946	78
	Ram's Head Parking Lot	RB-A09	9.6	6.8	4,366	453
	Snowdon 3	RB-A11	6.5	0.0	372	58
	Lower Killington Road 1	RB-A12	85.4	17.7	6,377	75
	Total	---	355.4	51.0	26,575	75
	Upper West Branch	RB-A02	198.3	0.0	5,854	30
West Branch Roaring Brook (D)	Lower West Branch	RB-A05	241.8	0.0	7,832	32
	Total	---	440.1	0.0	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	5.4	10,895	345
	Glazer Brook Rd	RB-A20	44.8	0.0	13,865	310
	Wastewater Treatment Plant	RB-A27	29.1	15.6	8,118	279
	Lower Killington Road 2	RB-A28	15.3	0.0	11,921	780
	Killington Golf Course 5	RB-A29	62.8	2.1	28,041	446
	Total	---	183.5	23.1	72,840	397

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Post Phase I Conditions		
				Impervious Acres Treated	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0.0	8,558	124
	Tributary 1	RB-A06	404.7	0.0	20,710	51
	Big Boulder Road	RB-A25	19.7	0.0	2,707	137
	Links East Upper	RB-A26	37.9	0.0	6,247	165
	Ravine Road	RB-A30	59.8	0.0	17,820	298
	Access Road 1	RB-A31	72.4	0.0	15,193	210
	Access Road 3	RB-A32	66.0	0.0	22,901	347
	Access Road 4	RB-A33	31.6	0.0	13,292	420
	Links East Lower	RB-A34	1.4	0.0	43	31
	Links East	RB-A35	27.6	0.0	2,733	99
	Total	---	790.4	0.0	110,203	139
	Fall Line/Edgemont	EB-A01	55.4	0.0	8,946	161
Lower East Branch Roaring Brook	Killington Golf Course 4	EB-A02	21.6	0.0	2,246	104
	Mirror Lake	EB-A04	6.3	0.0	399	63
	Killington Golf Course 3	EB-A05	59.6	0.0	3,849	65
	Killington Club House	EB-A09	9.8	5.1	4,757	485
	Wiffletree	EB-A10	3.3	0.0	3,409	1,018
	East Mountain Road	EB-A11	4.4	0.0	3,665	829
	Shagback Mtn	EB-A13	69.4	0.0	4,156	60
	Edgemont	EB-A15	6.7	0.0	4,232	635
	Fall Line	EB-A16	48.0	0.0	4,704	98
	Killington Golf Course 1	EB-A17	5.5	0.0	521	95
	Killington Golf Course 2	EB-A18	22.6	0.0	1,005	44
	Trail Creek Parking	EB-A19	1.0	0.0	2,888	2,949
	Total	---	313.7	5.10	44,777	143
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	1.7 (50% Removal)	77	9
	Grand Summit Hotel	EB-A07	7.4	7.4 (50% Removal)	5,706	766
	Snowshed Pond 2	EB-A08	74.5	36.3 (50% Removal)	3,582	48
	Snowshed	EB-A12	61.8	0.0	2,418	39
	Trail Creek	EB-A14	23.3	0.0	3,642	156
	Total	---	175.4	45.4	15,425	88
Roaring Brook Total			2,724		260,456	96
East Branch Roaring Brook Total			489		60,202	123

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
Simple Method for Pollutant Loading - Proposed Phase I Conditions (Years 6-9) with Prior Permitted Systems Upgrades
VHB
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Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Post Phase I Conditions		
				Impervious Acres Treated	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	6.6	4,065	612
	Vale Parking Lot Lower	RB-A08	1.2	0.0	692	558
	Killington Mountain Road 4	RB-A10	7.0	0.0	1,327	189
	Killington Mountain Road 3	RB-A13	17.7	0.0	2,680	151
	K-1 Parking Lot	RB-A15	12.0	12.0	16,970	1,408
	Killington Mountain Road 2	RB-A16	71.1	0.0	10,451	147
	Killington Mountain Road 1	RB-A17	6.3	0.0	2,361	372
	Killington Peak	RB-A18	426.9	0.0	27,531	64
	Bear Mtn 1	RB-A19	67.9	0.0	8,247	121
	Snowdon 2	RB-A21	52.6	0.0	10,486	199
	Cat Yard	RB-A22	5.2	3.9	2,863	548
	Vale Parking West	RB-A24	6.2	0.0	2,211	355
	Total	---	681.0	22.5	89,883	132
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	0.0	20,109	74
	Total	---	273.5	0.0	20,109	74
Upper West Branch Roaring Brook (C)	Snowshed Parking Lot	EB-A03	10.8	10.7	1,676	156
	Unnamed Tributary	RB-A04	205.2	9.8	10,837	34
	Upper Snowshed	RB-A07	38.0	6.0	2946	78
	Ram's Head Parking Lot	RB-A09	9.6	6.8	4,366	453
	Snowdon 3	RB-A11	6.5	0.0	372	58
	Lower Killington Road 1	RB-A12	85.4	17.7	6,377	75
	Total	---	355.4	51.0	26,575	75
West Branch Roaring Brook (D)	Upper West Branch	RB-A02	198.3	0.0	5,854	30
	Lower West Branch	RB-A05	241.8	0.0	7,832	32
	Total	---	440.1	0.0	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	5.4	10,895	345
	Glazer Brook Rd	RB-A20	44.8	0.0	13,865	310
	Wastewater Treatment Plant	RB-A27	29.1	15.6	8,118	279
	Lower Killington Road 2	RB-A28	15.3	0.0	11,921	780
	Killington Golf Course 5	RB-A29	62.8	2.1	28,041	446
	Total	---	183.5	23.1	72,840	397

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Post Phase I Conditions		
				Impervious Acres Treated	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0.0	8,558	124
	Tributary 1	RB-A06	404.7	0.0	20,710	51
	Big Boulder Road	RB-A25	19.7	0.0	2,707	137
	Links East Upper	RB-A26	37.9	0.0	6,247	165
	Ravine Road	RB-A30	59.8	0.0	17,820	298
	Access Road 1	RB-A31	72.4	0.0	15,193	210
	Access Road 3	RB-A32	66.0	0.0	22,901	347
	Access Road 4	RB-A33	31.6	0.0	13,292	420
	Links East Lower	RB-A34	1.4	0.0	43	31
	Links East	RB-A35	27.6	0.0	2,733	99
	Total	---	790.4	0.0	110,203	139
	Fall Line/Edgemont	EB-A01	55.4	0.0	2,948	53
Lower East Branch Roaring Brook	Killington Golf Course 4	EB-A02	21.6	0.0	2,246	104
	Mirror Lake	EB-A04	6.3	0.0	399	63
	Killington Golf Course 3	EB-A05	59.6	0.0	3,849	65
	Killington Club House	EB-A09	9.8	5.1	4,757	485
	Wiffletree	EB-A10	3.3	0.0	3,409	1,018
	East Mountain Road	EB-A11	4.4	0.0	3,665	829
	Shagback Mtn	EB-A13	69.4	0.0	4,156	60
	Edgemont	EB-A15	6.7	0.0	946	142
	Fall Line	EB-A16	48.0	0.0	4,704	98
	Killington Golf Course 1	EB-A17	5.5	0.0	521	95
	Killington Golf Course 2	EB-A18	22.6	0.0	1,005	44
	Trail Creek Parking	EB-A19	1.0	0.0	578	590
	Total	---	313.7	5.10	33,181	106
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	1.7 (40% Removal)	93	11
	Grand Summit Hotel	EB-A07	7.4	7.4 (40% Removal)	6,847	920
	Snowshed Pond 2	EB-A08	74.5	36.3 (40% Removal)	4,298	58
	Snowshed	EB-A12	61.8	0.0	2,418	39
	Trail Creek	EB-A14	23.3	0.0	1,119	48
	Total	---	175.4	45.4	14,775	84
Roaring Brook Total			2,540		260,456	103
East Branch Roaring Brook Total			489		47,956	98

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
 Simple Method for Pollutant Loading - Proposed Phase I Conditions (Years 6-9) - Area Summary
 VHB
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Table 2A: Subwatershed Area for Upper Roaring Brook (acres)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.00	0.12	0.26	0.76	1.16	0.00	0.00	2.18	1.70	3.14	1.73	0.04	11.1
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.40	0.44	1.52	10.8	0.00	49.0	3.13	306	42.8	26.2	0.76	3.59	445
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	2.81	0.39	2.80	1.55	2.32	5.29	1.75	0.28	0.45	3.14	1.36	2.09	24.2
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.00	1.88	3.99	0.00	14.0	0.20	117	21.2	18.1	0.00	0.00	176
Transportation Gravel	3.36	0.09	0.11	0.39	8.27	1.17	0.12	1.66	1.03	2.01	1.38	0.51	20.1
Transportation Paved	0.00	0.20	0.43	0.28	0.30	1.66	1.12	0.03	0.71	0.03	0.00	0.00	4.77
Water	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Total	6.64	1.24	7.00	17.7	12.0	71.1	6.34	427	67.9	52.6	5.22	6.23	681

Table 2B: Subwatershed Area for Ram's Head Brook (acres)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.11	0.11
Commercial Lodging	0.00	0.00
Forest	219	219
Golf Course	0.00	0.00
Open	6.40	6.40
Residential	0.00	0.00
Ski Trail	45.3	45.3
Transportation Gravel	2.37	2.37
Transportation Paved	0.00	0.00
Water	0.00	0.00
Total	273	273

Table 2C: Subwatershed Area for Upper West Branch Roaring Brook (acres)

Land Use	Major Subwatershed C					Total
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.00	0.20	1.63	0.38	0.00	2.21
Commercial Lodging	0.00	0.02	0.00	0.00	0.00	0.02
Forest	165.8	17.9	0.03	3.10	75.5	262
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.31	2.03	1.55	0.45	2.16	6.51
Residential	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	39.0	14.7	0.26	2.49	5.67	62.2
Transportation Gravel	0.00	1.77	5.35	0.03	0.00	7.15
Transportation Paved	0.00	1.34	0.81	0.00	2.11	4.26
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	205	38.0	9.64	6.45	85.4	345

Table 2D: Subwatershed Area for West Branch Roaring Brook (acres)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	193	238	430
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	5.65	3.57	9.22
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.53	0.53
Water	0.00	0.00	0.00
Total	198	242	440

Table 2E: Subwatershed Area for Lower Roaring Brook (acres)

Land Use	Major Subwatershed E					Total
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	
Commercial	3.90	0.10	1.96	1.14	2.19	9.29
Commercial Lodging	6.62	0.00	0.00	0.00	8.57	15.2
Forest	12.8	37.7	24.2	8.04	26.1	109
Golf Course	1.97	0.00	0.00	0.00	14.4	16.4
Open	1.57	0.09	0.56	0.55	3.13	5.90
Residential	0.00	2.15	0.00	0.84	0.00	2.99
Ski Trail	0.00	0.00	0.97	0.00	0.00	0.97
Transportation Gravel	0.03	1.90	0.60	1.48	4.71	8.72
Transportation Paved	4.67	2.80	0.80	3.24	3.72	15.2
Water	0.00	0.00	0.00	0.00	0.00	0.00
Total	31.6	44.8	29.1	15.3	62.8	184

Table 2F: Subwatershed Area for Lower East Branch Roaring Brook (acres)

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0.00	0.00	0.11	0.00	1.80	2.21	0.07	0.02	0.00	0.00	0.00	0.02	0.00	4.24
Commercial Lodging	3.30	0.00	0.00	0.05	0.82	0.00	1.85	1.85	1.50	1.11	0.00	0.00	0.31	10.8
Forest	48.2	12.3	0.97	26.4	1.40	0.15	0.16	65.8	2.97	37.2	1.25	16.2	0.00	213
Golf Course	0.50	8.52	1.20	31.7	1.57	0.02	0.00	0.02	0.70	5.68	4.10	6.20	0.00	60.2
Open	1.47	0.00	0.56	0.17	1.54	0.10	0.96	1.10	0.41	1.32	0.00	0.00	0.00	7.64
Residential	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
Ski Trail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	1.31
Transportation Gravel	1.52	0.16	0.00	0.05	1.99	0.73	0.49	0.23	0.83	0.33	0.04	0.00	0.67	7.05
Transportation Paved	0.33	0.60	0.20	1.07	0.62	0.13	0.88	0.38	0.24	1.11	0.10	0.19	0.00	5.87
Water	0.00	0.00	3.28	0.12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.46
Total	55.4	21.6	6.33	59.6	9.81	3.35	4.42	69.41	6.66	48.0	5.50	22.6	0.98	314

Table 2G: Subwatershed Area for Upper East Branch Roaring Brook (acres)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.49	0.48	0.58	1.62	0.00	2.15	5.33
Commercial Lodging	0.00	0.02	2.93	0.00	0.00	3.62	6.57
Forest	0.00	0.10	0.00	35.8	60.7	15.0	112
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	3.13	0.09	1.19	1.11	0.59	2.02	8.12
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.02	0.00	35.0	0.36	0.00	35.4
Transportation Gravel	6.01	0.00	2.18	0.65	0.16	0.28	9.28
Transportation Paved	1.12	0.04	0.58	0.23	0.00	0.29	2.26
Water	0.00	7.50	0.00	0.08	0.00	0.00	7.59
Total	10.8	8.26	7.45	74.5	61.8	23.3	186

Table 2H: Subwatershed Area for Lower Roaring Brook 2 (acres)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	1.34	1.72	0.00	0.00	0.74	1.53	0.76	1.05	0.00	0.00	7.14
Commercial Lodging	0.00	0.79	0.00	0.00	2.07	0.00	1.68	0.02	0.00	0.00	4.57
Forest	64.0	397	17.1	31.0	42.4	56.0	42.4	22.5	1.13	25.0	699
Golf Course	0.00	0.00	1.15	0.05	2.30	0.00	4.80	2.68	0.26	0.34	11.6
Open	0.19	0.00	0.00	0.06	1.35	1.96	3.28	0.31	0.00	0.36	7.51
Residential	0.49	0.91	0.11	3.99	1.47	5.22	4.43	0.38	0.00	0.96	18.0
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Gravel	0.58	0.64	0.00	0.00	0.30	0.21	2.76	2.26	0.00	0.00	6.76
Transportation Paved	2.65	3.44	1.37	2.85	9.13	7.28	5.84	1.95	0.00	0.97	35.5
Water	0.00	0.00	0.00	0.00	0.00	0.18	0.01	0.51	0.00	0.00	0.69
Total	69.2	405	19.7	37.9	59.8	72.4	66.0	31.6	1.39	27.6	790

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Table 2A: Subwatershed Runoff Coefficient for Upper Roaring Brook (Rv)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0.05	0.05	0.05	0.05	0.30	0.05	0.05	0.45	0.08	0.19	0.09	0.05	---
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.05	0.05	0.05	0.07	0.05	0.11	0.05	0.09	0.07	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 2B: Subwatershed Runoff Coefficient
for Ram's Head Brook (Rv)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.76	---
Commercial Lodging	0.05	---
Forest	0.05	---
Golf Course	0.05	---
Open	0.05	---
Residential	0.05	---
Ski Trail	0.08	---
Transportation Gravel	0.95	---
Transportation Paved	0.95	---
Water	0.05	---
Total	---	---

Table 2C: Subwatershed Runoff Coefficient for Upper West Branch Roaring Brook (Rv)

Land Use	Major Subwatershed C					Total
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.05	0.29	0.37	0.05	0.05	---
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.07	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---

Table 2D: Subwatershed Runoff Coefficient for West
Branch Roaring Brook (Rv)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.05	0.05	---
Commercial Lodging	0.05	0.05	---
Forest	0.05	0.05	---
Golf Course	0.05	0.05	---
Open	0.05	0.05	---
Residential	0.05	0.05	---
Ski Trail	0.05	0.05	---
Transportation Gravel	0.95	0.95	---
Transportation Paved	0.95	0.95	---
Water	0.05	0.05	---
Total	---	---	---

Table 2E: Subwatershed Runoff Coefficient for Lower Roaring Brook (Rv)

Land Use	Major Subwatershed E					Total
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	
Commercial	0.15	0.95	0.12	0.37	0.52	---
Commercial Lodging	0.36	0.05	0.05	0.05	0.27	---
Forest	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.50	0.05	0.72	0.05	---
Ski Trail	0.05	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---

Table 2F: Subwatershed Runoff Coefficient for Lower East Branch Roaring Brook (Rv)

Land Use	Major Subwatershed F													
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	Total
Commercial	0.05	0.05	0.05	0.05	0.26	0.14	0.75	0.95	0.05	0.05	0.05	0.05	0.05	---
Commercial Lodging	0.24	0.05	0.05	0.05	0.05	0.05	0.14	0.35	0.25	0.23	0.05	0.05	0.58	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.95	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 2G: Subwatershed Runoff Coefficient for Upper East Branch Roaring Brook (Rv)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.07	0.20	0.07	0.71	0.05	0.05	---
Commercial Lodging	0.05	0.14	0.55	0.05	0.05	0.38	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.05	0.05	0.05	0.05	0.05	0.05	---
Ski Trail	0.05	0.05	0.05	0.05	0.06	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---

Table 2H: Subwatershed Runoff Coefficient for Lower Roaring Brook 2 (Rv)

Land Use	Major Subwatershed H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	0.12	0.46	0.05	0.05	0.55	0.32	0.24	0.34	0.05	0.05	---
Commercial Lodging	0.05	0.43	0.05	0.05	0.23	0.05	0.24	0.05	0.05	0.05	---
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Residential	0.57	0.62	0.95	0.33	0.43	0.29	0.25	0.71	0.05	0.68	---
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	---
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	---
Total	---	---	---	---	---	---	---	---	---	---	---

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Table 6A: Subwatershed Load for Upper Roaring Brook (lbs/acre)

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0	5	11	35	154	0	0	857	115	518	67	2	1,763
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	3	13	44	309	0	1,407	90	8,801	1,231	751	11	103	12,763
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	24	11	80	44	33	152	50	8	13	90	19	60	587
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Ski Trail	0	0	106	315	0	1,675	12	11,183	1,679	1,019	0	0	15,989
Transportation Gravel	4,037	358	430	1,549	16,557	4,697	500	6,633	4,128	8,057	2,767	2,046	51,758
Transportation Paved	0	305	655	427	226	2,520	1,709	50	1,081	50	0	0	7,022
Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4,065	692	1,327	2,680	16,970	10,451	2,361	27,531	8,247	10,486	2,863	2,211	89,883
Unitized (lbs/ac/yr)	612	558	189	151	1,408	147	372	64	121	199	548	355	132

Table 6B: Subwatershed Loading for Ram's Head Brook (lbs/acre)

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	75	75
Commercial Lodging	0	0
Forest	6,302	6,302
Golf Course	0	0
Open	184	184
Residential	0	0
Ski Trail	4,058	4,058
Transportation Gravel	9,490	9,490
Transportation Paved	0	0
Water	0	0
Total	20,109	20,109
Unitized (lbs/ac/yr)	74	74

Table 6C: Subwatershed Loading for Upper West Branch Roaring Brook (lbs/acre)

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0	51	501	16	0	568
Commercial Lodging	0	1	0	0	0	1
Forest	4,765	515	1	89	2,169	7,539
Golf Course	0	0	0	0	0	0
Open	9	58	43	13	62	185
Residential	0	0	0	0	0	0
Ski Trail	3,191	830	14	141	319	4,495
Transportation Gravel	0	7,092	20,561	113	0	27,766
Transportation Paved	0	2,031	1,187	0	3,213	6,431
Water	0	0	0	0	0	0
Total	7,965	10,578	22,307	372	5,762	46,984
Unitized (lbs/ac/yr)	39	278	2,313	58	67	136

Table 6D: Subwatershed Loading for West Branch Roaring Brook (lbs/acre)

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0	0	0
Commercial Lodging	0	0	0
Forest	5,536	6,831	12,367
Golf Course	0	0	0
Open	0	0	0
Residential	0	0	0
Ski Trail	318	201	519
Transportation Gravel	0	0	0
Transportation Paved	0	800	800
Water	0	0	0
Total	5,854.0	7,832.4	13,686.3
Unitized (lbs/ac/yr)	29.5	32.4	31.1

Table 6E: Subwatershed Loading for Lower Roaring Brook (lbs/acre)

Land Use	Group E					
	RB-A14	RB-A20	RB-A27	RB-A28	RB-A29	Total
Commercial	505	80	207	368	991	2,151
Commercial Lodging	2,630	0	0	0	2,522	5,152
Forest	368	1,084	695	231	750	3,128
Golf Course	78	0	0	0	567	645
Open	45	3	16	16	90	170
Residential	0	850	0	479	0	1,329
Ski Trail	0	0	55	0	0	55
Transportation Gravel	134	7,588	2,407	5,906	18,866	34,901
Transportation Paved	7,106	4,261	1,216	4,921	5,657	23,160
Water	0	0	0	0	0	0
Total	10,865	13,865	4,596	11,921	29,444	70,690
Unitized (lbs/ac/yr)	344	310	158	780	469	385

Table 6F: Subwatershed Loading for Lower East Branch Roaring Brook (lbs/acre)

Land Use	Major Subwatershed F													
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	Total
Commercial	0	0	5	0	201	271	46	14	0	0	0	1	0	538
Commercial Lodging	849	0	0	3	22	0	275	716	407	283	0	0	194	2,749
Forest	1,385	353	28	760	20	4	5	1,891	85	1,068	36	466	0	6,101
Golf Course	20	336	47	1,249	31	1	0	1	28	224	162	244	0	2,343
Open	42	0	16	5	22	3	28	32	12	38	0	0	0	197
Residential	66	0	0	0	0	0	0	0	0	0	0	0	0	66
Ski Trail	1	0	0	0	0	0	0	0	0	73	0	0	0	74
Transportation Gravel	6,074	648	0	200	3,986	2,926	1,973	923	3,328	1,328	172	0	2,695	24,253
Transportation Paved	509	909	303	1,633	474	204	1,338	579	372	1,690	151	293	0	8,455
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8,946	2,246	399	3,849	4,757	3,409	3,665	4,156	4,232	4,704	521	1,005	2,888	44,777
Unitized (lbs/ac/yr)	161	104	63	65	485	1,018	829	60	635	98	95	44	2,949	143

Table 6G: Subwatershed Loading for Upper East Branch Roaring Brook (lbs/acre)

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	19	41	18	496	0	93	668
Commercial Lodging	0	2	872	0	0	1,488	2,362
Forest	0	1	0	514	1,745	430	2,691
Golf Course	0	0	0	0	0	0	0
Open	54	1	17	16	17	58	163
Residential	0	0	0	0	0	0	0
Ski Trail	0	1	0	1,085	24	0	1,109
Transportation Gravel	14,447	0	4,362	1,296	632	1,127	21,865
Transportation Paved	1,026	31	437	174	0	445	2,113
Water	0	0	0	0	0	0	0
Total	15,546	77	5,706	3,582	2,418	3,642	30,971
Unitized (lbs/ac/yr)	1,445	9	766	48	39	156	166

Table 5H: Subwatershed Loading for Lower Roaring Brook 2 (lbs/acre)

Land Use	Group H										Total
	RB-A01	RB-A06	RB-A25	RB-A26	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	136	690	0	0	358	420	157	310	0	0	2,072
Commercial Lodging	0	371	0	0	517	0	433	1	0	0	1,322
Forest	1,838	11,414	491	891	1,219	1,610	1,218	645	32	718	20,078
Golf Course	0	0	45	2	91	0	189	106	10	13	457
Open	5	0	0	2	39	56	94	9	0	10	216
Residential	222	446	85	1,026	505	1,198	875	213	0	519	5,088
Ski Trail	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	2,333	2,555	5	0	1,217	836	11,061	9,039	0	0	27,047
Transportation Paved	4,023	5,234	2,081	4,326	13,874	11,074	8,873	2,967	0	1,472	53,924
Water	0	0	0	0	0	0	0	0	0	0	0
Total	8,558	20,710	2,707	6,247	17,820	15,193	22,901	13,292	43	2,733	110,203
Unitized (lbs/ac/yr)	124	51	137	165	298	210	347	420	31	99	139

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
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Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Proposed Conditions		
				Acres Treated (80% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	6.6	390	59
	Vale Parking Lot Lower	RB-A08	1.2	0.4	353	284
	Killington Mountain Road 4	RB-A10	7.0	3.9	831	119
	Killington Mountain Road 3	RB-A13	17.7	10.2	850	48
	K-1 Parking Lot	RB-A15	12.0	12.0	2,384	198
	Killington Mountain Road 2	RB-A16	71.1	21.1	4,542	64
	Killington Mountain Road 1	RB-A17	6.3	2.6	242	38
	Killington Peak	RB-A18	426.9	0.13	22,593	53
	Bear Mtn 1	RB-A19	67.9	0.7	6,074	89
	Snowdon 2	RB-A21	52.6	4.1	7,347	140
	Cat Yard	RB-A22	5.2	3.9	658	126
	Vale Parking West	RB-A24	6.2	5.5	261	42
	Total	---	681.0	71.3	46,526	68
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	43.4	14,981	55
	Total	---	273.5	43.4	14,981	55
Upper West Branch Roaring Brook (C)	Snowshed Parking Lot	EB-A03	10.8	10.7	1,676	156
	Unnamed Tributary	RB-A04	205.2	9.8	7,066	34
	Upper Snowshed	RB-A07	38.0	8.6	3,097	81
	Ram's Head Parking Lot	RB-A09	9.6	6.8	4,366	453
	Snowdon 3	RB-A11	6.5	5.5	452	70
	Lower Killington Road 1	RB-A12	85.4	17.7	6,377	75
	Total	---	355.4	48.3	21,358	60
West Branch Roaring Brook (D)	Upper West Branch	RB-A02	198.3	0.0	5,854	30
	Lower West Branch	RB-A05	241.8	0.0	7,832	32
	Total	---	440.1	0.0	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	5.4	10,895	345
	Glazer Brook Rd	RB-A20	44.8	0.0	13,875	310
	Wastewater Treatment Plant	RB-A27	29.1	15.6	8,118	279
	Lower Killington Road 2	RB-A28	15.3	0.0	11,921	780
	Killington Golf Course 5	RB-A29	62.8	2.1	28,041	446
	Total	---	183.5	23.1	72,849	397

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Proposed Conditions		
				Acres Treated (80% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0.0	8,558	124
	Tributary 1	RB-A06	404.7	0.0	20,710	51
	Big Boulder Road	RB-A25	19.7	0.0	2,531	128
	Links East Upper	RB-A26	37.9	3.8	6,255	165
	Ravine Road	RB-A30	59.8	0.0	17,105	286
	Access Road 1	RB-A31	72.4	0.0	15,193	210
	Access Road 3	RB-A32	66.0	0.0	21,683	329
	Access Road 4	RB-A33	31.6	0.0	12,884	407
	Links East Lower	RB-A34	1.4	1.1	32	23
	Links East	RB-A35	27.6	7.0	2,658	96
	Total	---	790.4	11.9	107,607	136
Lower East Branch Roaring Brook (F)	Fall Line/Edgemont	EB-A01	55.4	0.0	8,946	161
	Killington Golf Course 4	EB-A02	21.6	0.0	1,337	62
	Mirror Lake	EB-A04	6.3	4.6	490	77
	Killington Golf Course 3	EB-A05	59.6	13.4	2,108	35
	Killington Club House	EB-A09	9.8	5.1	3,253	332
	Wiffletree	EB-A10	3.3	2.2	1,237	369
	East Mountain Road	EB-A11	4.4	0.0	3,665	829
	Shagback Mtn	EB-A13	69.4	3.4	4,127	59
	Edgemont	EB-A15	6.7	0.0	4,152	623
	Fall Line	EB-A16	48.0	0.6	4,166	87
	Killington Golf Course 1	EB-A17	5.5	0.9	326	59
	Killington Golf Course 2	EB-A18	22.6	0.0	712	31
	Trail Creek Parking	EB-A19	1.0	0.0	2,888	2949
	Total	---	313.7	30.2	37,407	119
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	7.1	257	31
	Grand Summit Hotel	EB-A07	7.4	7.4	1,785	240
	Snowshed Pond 2	EB-A08	74.5	36.3	4,666	63
	Snowshed	EB-A12	61.8	23.0	2,258	37
	Trail Creek	EB-A14	23.3	13.3	3,842	165
	Total	---	175.4	87.2	12,808	73
Roaring Brook Total			2,724		277,008	102
East Branch Roaring Brook Total			489		50,214	103

Roaring Brook and East Branch of Roaring Brook - Water Quality Remediation Plan
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Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Proposed Conditions		
				Acres Treated (80% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Upper Roaring Brook (A)	Vale Parking Lot	RB-A03	6.6	6.6	390	59
	Vale Parking Lot Lower	RB-A08	1.2	0.4	353	284
	Killington Mountain Road 4	RB-A10	7.0	3.9	831	119
	Killington Mountain Road 3	RB-A13	17.7	10.2	850	48
	K-1 Parking Lot	RB-A15	12.0	12.0	2,384	198
	Killington Mountain Road 2	RB-A16	71.1	21.1	4,542	64
	Killington Mountain Road 1	RB-A17	6.3	2.6	242	38
	Killington Peak	RB-A18	426.9	0.13	22,593	53
	Bear Mtn 1	RB-A19	67.9	0.7	6,074	89
	Snowdon 2	RB-A21	52.6	4.1	7,347	140
	Cat Yard	RB-A22	5.2	3.9	658	126
	Vale Parking West	RB-A24	6.2	5.5	261	42
	Total	---	681.0	71.3	46,526	68
Ram's Head Brook (B)	Snowdon 2	RB-A23	273.5	43.4	14,981	55
	Total	---	273.5	43.4	14,981	55
Upper West Branch Roaring Brook (C)	Snowshed Parking Lot	EB-A03	10.8	10.7	1,676	156
	Unnamed Tributary	RB-A04	205.2	9.8	7,066	34
	Upper Snowshed	RB-A07	38.0	8.6	3,097	81
	Ram's Head Parking Lot	RB-A09	9.6	6.8	4,366	453
	Snowdon 3	RB-A11	6.5	5.5	452	70
	Lower Killington Road 1	RB-A12	85.4	17.7	6,377	75
	Total	---	355.4	48.3	21,358	60
West Branch Roaring Brook (D)	Upper West Branch	RB-A02	198.3	0.0	5,854	30
	Lower West Branch	RB-A05	241.8	0.0	7,832	32
	Total	---	440.1	0.0	13,686	31
Lower Roaring Brook 1 (E)	Pinnacle Condos	RB-A14	31.6	5.4	10,895	345
	Glazer Brook Rd	RB-A20	44.8	0.0	13,875	310
	Wastewater Treatment Plant	RB-A27	29.1	15.6	8,118	279
	Lower Killington Road 2	RB-A28	15.3	0.0	11,921	780
	Killington Golf Course 5	RB-A29	62.8	2.1	28,041	446
	Total	---	183.5	23.1	72,849	397

Major Subwatershed	Subwatershed Name	Subwatershed ID	Total Area (ac)	Proposed Conditions		
				Acres Treated (80% Removal)	Total Load (lbs/yr)	Unitized Load (lbs/ac/yr)
Lower Roaring Brook 2 (H)	Access Road 2	RB-A01	69.2	0.0	8,558	124
	Tributary 1	RB-A06	404.7	0.0	20,710	51
	Big Boulder Road	RB-A25	19.7	0.0	2,531	128
	Links East Upper	RB-A26	37.9	3.8	6,255	165
	Ravine Road	RB-A30	59.8	0.0	17,105	286
	Access Road 1	RB-A31	72.4	0.0	15,193	210
	Access Road 3	RB-A32	66.0	0.0	21,683	329
	Access Road 4	RB-A33	31.6	0.0	12,884	407
	Links East Lower	RB-A34	1.4	1.1	32	23
	Links East	RB-A35	27.6	7.0	2,658	96
	Total	---	790.4	11.9	107,607	136
Lower East Branch Roaring Brook (F)	Fall Line/Edgemont	EB-A01	55.4	0.0	2,948	53
	Killington Golf Course 4	EB-A02	21.6	0.0	1,337	62
	Mirror Lake	EB-A04	6.3	4.6	490	77
	Killington Golf Course 3	EB-A05	59.6	13.4	2,108	35
	Killington Club House	EB-A09	9.8	5.1	3,253	332
	Wiffletree	EB-A10	3.3	2.2	1,237	369
	East Mountain Road	EB-A11	4.4	0.0	3,665	829
	Shagback Mtn	EB-A13	69.4	3.4	4,127	59
	Edgemont	EB-A15	6.7	0.0	930	140
	Fall Line	EB-A16	48.0	0.6	4,166	87
	Killington Golf Course 1	EB-A17	5.5	0.9	326	59
	Killington Golf Course 2	EB-A18	22.6	0.0	712	31
	Trail Creek Parking	EB-A19	1.0	0.0	578	590
	Total	---	313.7	30.2	25,875	82
Upper East Branch Roaring Brook (G)	Snowshed Pond 1	EB-A06	8.3	7.1	257	31
	Grand Summit Hotel	EB-A07	7.4	7.4	1,785	240
	Snowshed Pond 2	EB-A08	74.5	36.3	4,666	63
	Snowshed	EB-A12	61.8	23.0	2,258	37
	Trail Creek	EB-A14	23.3	13.3	1,318	56
	Total	---	175.4	87.2	10,284	59
Roaring Brook Total			2,724		277,008	102
East Branch Roaring Brook Total			489		36,159	74

Table 2A: Subwatershed Areas for Upper Roaring Brook (acres) - Not Receiving Treatment

Land Use	Major Subwatershed A											
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	Total
Commercial	0.00	0.11	0.18	0.00	0.00	0.00	0.00	2.13	1.70	1.65	0.14	5.92
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.00	0.41	0.67	3.89	0.00	37.2	3.11	306	42.7	25.0	0.35	420
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.04	0.24	0.79	0.17	0.00	1.15	0.59	0.28	0.29	2.48	0.79	7.12
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.00	1.31	3.39	0.00	11.16	0.00	117	21.6	18.1	0.00	172
Transportation Gravel	0.00	0.07	0.10	0.02	0.00	0.49	0.00	1.58	0.87	1.19	0.04	4.37
Transportation Paved	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.03
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.04	0.83	3.05	7.49	0.00	50.0	3.71	427	67.2	48.4	1.33	610

Table 2B: Subwatershed Areas for Upper Roaring Brook (acres) - Receiving Treatment

Land Use	Major Subwatershed A											
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	Total
Commercial	0.00	0.00	0.69	0.00	3.55	0.00	0.00	0.00	0.00	2.67	2.62	9.54
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.42	0.19	0.20	0.19	0.38	3.57	0.03	0.00	0.20	0.02	0.02	7.31
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.00	0.00	0.11	0.00	1.19	0.00	0.00	0.00	0.00	0.32	0.30	1.92
Residential	5.68	0.03	0.46	7.74	0.00	13.6	0.72	0.00	0.00	0.00	0.44	31.8
Ski Trail	0.00	0.00	1.95	2.04	0.02	3.20	1.61	0.00	0.41	0.47	0.27	9.99
Transportation Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Paved	0.51	0.19	0.53	0.27	6.90	0.66	0.27	0.13	0.05	0.65	0.24	10.7
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	6.61	0.41	3.95	10.2	12.0	21.1	2.64	0.13	0.66	4.13	3.90	71.3

Table 2C: Subwatershed Areas for Ram's Head Brook
(acres) - Not Receiving Treatment

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	0.11	0.11
Commercial Lodging	0.00	0.00
Forest	183.6	183.6
Golf Course	0.00	0.00
Open	1.47	1.47
Residential	0.00	0.00
Ski Trail	43.6	43.6
Transportation Gravel	1.31	1.31
Transportation Paved	0.00	0.00
Water	0.00	0.00
Total	230.1	230.1

Table 2D: Subwatershed Areas for Ram's Head Brook
(acres) - Receiving Treatment

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	3.82	3.82
Commercial Lodging	0.00	0.00
Forest	14.1	14.1
Golf Course	0.00	0.00
Open	0.00	0.00
Residential	20.6	20.6
Ski Trail	3.46	3.46
Transportation Gravel	0.00	0.00
Transportation Paved	1.32	1.32
Water	0.00	0.00
Total	43.4	43.4

Table 2E: Subwatershed Areas for Upper West Branch Roaring Brook (acres) - Not Receiving Treatment

Land Use	Major Subwatershed C							
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total		
Commercial	0.00	0.11	1.34	0.38	0.00	1.83		
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00		
Forest	156	14.0	0.01	0.44	59.1	230		
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00		
Open	0.31	0.89	0.57	0.02	1.44	3.23		
Residential	0.00	0.00	0.00	0.00	0.00	0.00		
Ski Trail	39.0	14.3	0.26	0.14	5.30	59.0		
Transportation Gravel	0.00	0.08	0.68	0.03	0.00	0.79		
Transportation Paved	0.00	0.00	0.02	0.00	1.85	1.87		
Water	0.00	0.00	0.00	0.00	0.00	0.00		
Total	195	29.4	2.88	1.00	67.7	296		

Table 2F: Subwatershed Areas for Upper West Branch Roaring Brook
(acres) - Receiving Treatment

Land Use	Major Subwatershed C							
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total		
Commercial	0.00	1.89	4.75	1.94	0.00	8.58		
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00		
Forest	1.33	0.77	0.13	0.38	3.50	6.11		
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00		
Open	0.00	1.07	0.29	0.00	2.20	3.57		
Residential	8.45	0.00	0.00	0.18	9.69	18.3		
Ski Trail	0.00	0.41	0.00	2.95	0.00	3.36		
Transportation Gravel	0.00	0.00	0.00	0.00	0.98	0.98		
Transportation Paved	0.00	4.46	1.59	0.00	1.30	7.35		
Water	0.00	0.00	0.00	0.00	0.00	0.00		
Total	9.78	8.60	6.76	5.45	17.7	48.3		

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Table 2G: Subwatershed Areas for West Branch Roaring Brook (acres) - - Not Receiving Treatment

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	193	238	430
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	5.65	3.57	9.22
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.53	0.53
Water	0.00	0.00	0.00
Total	198	242	440

Table 2H: Subwatershed Areas for West Branch Roaring Brook (acres) - Receiving Treatment

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0.00	0.00	0.00
Commercial Lodging	0.00	0.00	0.00
Forest	0.00	0.00	0.00
Golf Course	0.00	0.00	0.00
Open	0.00	0.00	0.00
Residential	0.00	0.00	0.00
Ski Trail	0.00	0.00	0.00
Transportation Gravel	0.00	0.00	0.00
Transportation Paved	0.00	0.00	0.00
Water	0.00	0.00	0.00
Total	0.00	0.00	0.00

Table 2I: Subwatershed Areas for Lower Roaring Brook (acres) - Not Receiving Treatment

Land Use		Major Subwatershed E and H															Total
		RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	1.34	1.72	2.76	0.10	0.00	0.00	1.96	1.14	2.12	0.74	1.53	0.76	1.05	0.00	0.00	15.2	
Commercial Lodging	0.00	0.79	6.62	0.00	0.00	0.00	0.00	0.00	8.11	2.07	0.00	1.68	0.02	0.00	0.00	19.3	
Forest	64.0	397.2	9.08	37.7	17.1	27.2	10.1	8.04	25.1	42.4	56.0	42.4	22.5	0.27	18.1	777	
Golf Course	0.00	0.00	1.97	0.00	1.15	0.05	0.00	0.00	14.39	2.30	0.00	4.80	2.68	0.02	0.28	27.6	
Open	0.19	0.00	1.51	0.09	0.00	0.06	0.26	0.55	3.06	1.35	1.96	3.28	0.31	0.00	0.36	13.0	
Residential	0.49	0.91	0.00	2.17	0.11	3.99	0.00	0.84	0.00	1.47	5.22	4.43	0.38	0.00	0.96	21.0	
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Transportation Gravel	0.58	0.64	0.02	1.90	0.00	0.00	0.60	1.48	4.71	0.30	0.21	2.76	2.26	0.00	0.00	15.5	
Transportation Paved	2.65	3.44	3.99	2.80	1.25	2.85	0.56	3.24	2.60	8.66	7.28	5.04	1.68	0.00	0.97	47.0	
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.01	0.51	0.00	0.00	0.69	
Total	69.2	405	25.9	44.8	19.6	34.2	13.4	15.3	60.1	59.3	72.4	65.2	31.4	0.29	20.7	936	

Table 2J: Subwatershed Areas for Lower Roaring Brook (acres) - Receiving Treatment

Land Use	Major Subwatershed E and H															Total
	RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.00	0.00	2.05	0.00	0.00	1.26	5.24	0.00	0.00	0.00	0.00	0.00	0.00	0.66	4.70	13.9
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.00	0.00	0.19	0.00	0.00	0.00	4.36	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	4.72
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.44	2.28	5.24
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Gravel	0.00	0.00	0.95	0.00	0.00	0.00	5.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.82
Transportation Paved	0.00	0.00	2.17	0.00	0.00	0.00	0.14	0.00	0.84	0.00	0.00	0.00	0.00	0.00	0.00	3.16
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.00	0.00	5.36	0.00	0.00	3.78	15.6	0.00	2.08	0.00	0.00	0.00	0.00	1.10	6.97	34.9

Table 2K: Subwatershed Areas for Lower East Branch Roaring Brook (acres) - Not Receiving Treatment

Land Use	Major Subwatershed F														Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19		
Commercial	0.00	0.00	0.04	0.00	0.37	0.80	0.07	0.02	0.00	0.00	0.00	0.02	0.00	1.32	
Commercial Lodging	3.30	0.00	0.00	0.05	0.82	0.00	1.85	1.85	1.50	1.11	0.00	0.00	0.31	10.8	
Forest	48.2	12.3	0.07	13.9	0.70	0.01	0.16	62.5	2.97	36.6	1.22	16.2	0.00	195	
Golf Course	0.50	8.52	1.00	30.90	1.09	0.02	0.00	0.02	0.70	5.67	3.25	6.20	0.00	57.9	
Open	1.47	0.00	0.30	0.15	0.72	0.00	0.96	1.01	0.41	1.32	0.00	0.00	0.00	6.36	
Residential	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	
Ski Trail	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	1.31	
Transportation Gravel	1.52	0.16	0.00	0.02	0.41	0.18	0.49	0.23	0.83	0.33	0.00	0.00	0.67	4.85	
Transportation Paved	0.33	0.00	0.18	0.00	0.58	0.12	0.88	0.38	0.19	0.76	0.03	0.00	0.00	3.45	
Water	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	
Total	55.4	21.0	1.72	45.1	4.69	1.14	4.42	66.0	6.61	47.1	4.50	22.4	0.98	281	

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Table 2L: Subwatershed Areas for Lower East Branch Roaring Brook (acres) - Receiving Treatment

Land Use	Major Subwatershed F														Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19		
Commercial	0.00	0.00	1.12	0.28	4.38	1.67	0.00	0.00	0.00	0.00	0.79	0.00	0.00	8.25	
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Forest	0.00	0.00	0.00	5.52	0.00	0.00	0.00	2.09	0.00	0.25	0.00	0.00	0.00	7.86	
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Open	0.00	0.00	3.47	0.02	0.68	0.54	0.00	0.00	0.00	0.00	0.14	0.00	0.00	4.86	
Residential	0.00	0.00	0.00	7.58	0.00	0.00	0.00	1.31	0.00	0.33	0.00	0.00	0.00	9.22	
Ski Trail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Transportation Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Transportation Paved	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total	0.00	0.00	4.59	13.4	5.08	2.21	0.00	3.40	0.00	0.58	0.93	0.00	0.00	30.2	

Table 2M: Subwatershed Areas for Upper East Branch Roaring Brook (acres) - Not Receiving Treatment

Land Use	Major Subwatershed G						Total
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	
Commercial	0.02	0.31	0.32	0.42	0.00	2.15	3.22
Commercial Lodging	0.00	0.02	2.85	0.00	0.00	3.62	6.50
Forest	0.00	0.10	0.00	8.45	36.4	2.75	47.7
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.00	0.04	0.41	0.00	0.00	0.93	1.37
Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ski Trail	0.00	0.02	0.00	29.1	2.24	0.00	31.4
Transportation Gravel	0.03	0.00	1.25	0.20	0.16	0.28	1.93
Transportation Paved	0.03	0.04	0.46	0.01	0.00	0.29	0.83
Water	0.00	0.60	0.00	0.02	0.00	0.00	0.62
Total	0.08	1.13	5.29	38.2	38.8	10.0	93.5

Table 2N: Subwatershed Areas for Upper East Branch Roaring Brook (acres) - Receiving Treatment

Land Use	Major Subwatershed G						
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	Total
Commercial	9.66	1.16	2.16	5.83	0.51	1.06	20.4
Commercial Lodging	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	0.00	0.09	0.00	16.4	12.9	6.08	35.5
Golf Course	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open	0.07	0.00	0.00	0.23	0.00	0.00	0.30
Residential	0.00	0.00	0.00	10.9	5.41	4.01	20.3
Ski Trail	0.17	0.00	0.00	1.83	4.09	1.37	7.46
Transportation Gravel	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transportation Paved	0.78	0.02	0.00	0.95	0.11	0.78	2.65
Water	0.00	5.86	0.00	0.16	0.00	0.00	6.02
Total	10.7	7.13	2.16	36.3	23.0	13.3	92.6

Table 4A: Runoff Coefficient for Upper Roaring Brook - Not Receiving Treatment

Land Use	Major Subwatershed A											
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24
Commercial	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.46	0.08	0.17	0.05	0.05
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 4B: Runoff Coefficient for Upper Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed A											
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24
Commercial	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Commercial Lodging	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Transportation Paved	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 4C: Runoff Coefficient for Ram's Head
Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed B
	RB-A23
Commercial	0.81
Commercial Lodging	0.05
Forest	0.05
Golf Course	0.05
Open	0.05
Residential	0.05
Ski Trail	0.05
Transportation Gravel	0.95
Transportation Paved	0.95
Water	0.05

Table 4D: Runoff Coefficient for Ram's Head
Brook (%) - Receiving Treatment

Land Use	Major Subwatershed B
	RB-A23
Commercial	0.77
Commercial Lodging	0.77
Forest	0.05
Golf Course	0.05
Open	0.05
Residential	0.28
Ski Trail	0.05
Transportation Gravel	0.86
Transportation Paved	0.86
Water	0.05

Table 4E: Runoff Coefficient for Upper West Branch
Roaring Brook (%) -Not Receiving Treatment

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.05	0.48	0.42	0.05	0.05	0.05
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	0.05
Forest	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.05	0.05	0.05	0.05	0.05	0.05
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95
Water	0.05	0.05	0.05	0.05	0.05	0.05

Table 4F: Runoff Coefficient for Upper West Branch
Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	
Commercial	0.77	0.77	0.77	0.77	0.77	0.77
Commercial Lodging	0.77	0.77	0.77	0.77	0.77	0.77
Forest	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.28	0.28	0.28	0.28	0.28	0.28
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.86	0.86	0.86	0.86	0.86	0.86
Transportation Paved	0.86	0.86	0.86	0.86	0.86	0.86
Water	0.05	0.05	0.05	0.05	0.05	0.05

Table 4G: Runoff Coefficient for West Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Watershed D	
	RB-A02	RB-A05
Commercial	0.05	0.05
Commercial Lodging	0.05	0.05
Forest	0.05	0.05
Golf Course	0.05	0.05
Open	0.05	0.05
Residential	0.05	0.05
Ski Trail	0.05	0.05
Transportation Gravel	0.95	0.95
Transportation Paved	0.95	0.95
Water	0.05	0.05

Table 4H: Runoff Coefficient for West Branch Roaring Brook (%) - Receiving Treatment

Land Use	Major Watershed D	
	RB-A02	RB-A05
Commercial	0.77	0.77
Commercial Lodging	0.77	0.77
Forest	0.05	0.05
Golf Course	0.05	0.05
Open	0.05	0.05
Residential	0.28	0.28
Ski Trail	0.05	0.05
Transportation Gravel	0.86	0.86
Transportation Paved	0.86	0.86
Water	0.05	0.05

Table 4I: Runoff Coefficient for Lower Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Watershed E and H														
	RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35
Commercial	0.12	0.46	0.19	0.95	0.05	0.05	0.12	0.37	0.54	0.55	0.32	0.24	0.34	0.05	0.05
	0.05	0.43	0.36	0.05	0.05	0.05	0.05	0.05	0.28	0.23	0.05	0.24	0.05	0.05	0.05
Commercial Lodging	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.57	0.62	0.05	0.50	0.95	0.33	0.05	0.72	0.05	0.43	0.29	0.25	0.71	0.05	0.68
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

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Table 4J: Runoff Coefficient for Lower Roaring Brook (%) - Receiving Treatment

Land Use	Major Watershed E and H														
	RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35
Commercial	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Commercial Lodging	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Transportation Paved	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 4K: Runoff Coefficient for Lower East Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Watershed F												
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19
Commercial	0.05	0.05	0.05	0.05	0.05	0.16	0.75	0.95	0.05	0.05	0.05	0.05	0.05
Commercial Lodging	0.24	0.05	0.05	0.05	0.05	0.05	0.14	0.35	0.25	0.23	0.05	0.05	0.58
Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Residential	0.95	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Transportation Paved	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 4L: Runoff Coefficient for Lower East Branch Roaring Brook (%) - Receiving Treatment

Land Use		Major Watershed F												
		EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19
Commercial	Commercial	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
	Commercial Lodging	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.77
Forest	Forest	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Golf Course	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Open	Open	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Residential	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Ski Trail	Ski Trail	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
	Transportation Gravel	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Transportation Paved	Transportation Paved	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
	Water	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

Table 4M: Runoff Coefficient for Upper East Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Group G				
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A14
Commercial	0.05	0.10	0.09	0.88	0.05
Commercial Lodging	0.05	0.14	0.56	0.05	0.38
Forest	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05
Residential	0.05	0.05	0.05	0.05	0.05
Ski Trail	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.95	0.95	0.95	0.95	0.95
Transportation Paved	0.95	0.95	0.95	0.95	0.95
Water	0.05	0.05	0.05	0.05	0.05

Table 4N: Runoff Coefficient for Upper East Branch Roaring Brook (%) - Receiving Treatment

Land Use	Group G				
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A14
Commercial	0.77	0.77	0.77	0.77	0.77
Commercial Lodging	0.77	0.77	0.77	0.77	0.77
Forest	0.05	0.05	0.05	0.05	0.05
Golf Course	0.05	0.05	0.05	0.05	0.05
Open	0.05	0.05	0.05	0.05	0.05
Residential	0.28	0.28	0.28	0.28	0.28
Ski Trail	0.05	0.05	0.05	0.05	0.05
Transportation Gravel	0.86	0.86	0.86	0.86	0.86
Transportation Paved	0.86	0.86	0.86	0.86	0.86
Water	0.05	0.05	0.05	0.05	0.05

Table 5A: Subwatershed Annual Loads for Upper Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0	5	8	0	0	0	0	855	115	245	6	0	1234
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	0	12	19	112	0	1070	89	8800	1228	719	10	13	12072
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	1	7	23	5	0	33	17	8	8	71	23	9	204
Residential	0	0	0	0	0	0	0	0	0	0	0	0	0
Ski Trail	0	0	74	191	0	629	0	6567	1219	1019	0	0	9699
Transportation Gravel	0	274	420	91	0	1979	0	6324	3483	4750	178	0	17499
Transportation Paved	0	0	5	17	0	0	13	4	2	0	0	0	40
Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	297	548	417	0	3711	119	22558	6055	6805	217	22	40748

Table 5B: Subwatershed Annual Loads for Upper Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed A												Total
	RB-A03	RB-A08	RB-A10	RB-A13	RB-A15	RB-A16	RB-A17	RB-A18	RB-A19	RB-A21	RB-A22	RB-A24	
Commercial	0	0	92	0	475	0	0	0	0	357	350	0	1275
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	2	1	1	1	2	21	0	0	1	0	0	12	42
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	0	0	1	0	7	0	0	0	0	2	2	0	11
Residential	246	1	20	336	0	592	31	0	0	0	19	133	1379
Ski Trail	0	0	22	23	0	36	18	0	5	5	3	0	113
Transportation Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Paved	141	53	147	73	1900	183	74	35	13	178	67	95	2958
Water	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	389	55	283	433	2384	832	123	35	19	542	441	239	5777
Combined Treated and Untreated	390	353	831	850	2384	4542	242	22593	6074	7347	658	261	46526
Unitized (lbs / acre / yr)	59	284	119	48	198	64	38	53	89	140	126	42	68

Table 5C: Subwatershed Annual Loads for Ram's Head Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	75	75
Commercial Lodging	0	0
Forest	5276	5276
Golf Course	0	0
Open	42	42
Residential	0	0
Ski Trail	2456	2456
Transportation Gravel	5244	5244
Transportation Paved	0	0
Water	0	0
Total	13093	13093

Table 5E: Subwatershed Annual Loads for Upper West Branch Roaring Brook (%) -Not Receiving Treatment

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0	47	493	16	0	556
Commercial Lodging	0	0	0	0	0	0
Forest	4484	403	0	13	1699	6600
Golf Course	0	0	0	0	0	0
Open	9	26	16	1	41	93
Residential	0	0	0	0	0	0
Ski Trail	2198	805	15	8	298	3324
Transportation Gravel	0	320	2738	113	0	3170
Transportation Paved	0	0	29	0	2814	2843
Water	0	0	0	0	0	0
Total	6692	1600	3290	150	4853	16585

Table 5D: Subwatershed Annual Loads for Ram's Head Brook (%) - Receiving Treatment

Land Use	Major Subwatershed B	
	RB-A23	Total
Commercial	510	510
Commercial Lodging	0	0
Forest	81	81
Golf Course	0	0
Open	0	0
Residential	896	896
Ski Trail	39	39
Transportation Gravel	0	0
Transportation Paved	362	362
Water	0	0
Total	1888	1888
Combined Treated and Untreated	14981	14981
Unitized (lbs / acre / yr)	55	55

Table 5F: Subwatershed Annual Loads for Upper West Branch Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed C					
	RB-A04	RB-A07	RB-A09	RB-A11	RB-A12	Total
Commercial	0	253	635	259	0	1147
Commercial Lodging	0	0	0	0	0	0
Forest	8	4	1	2	20	35
Golf Course	0	0	0	0	0	0
Open	0	6	2	0	13	21
Residential	366	0	0	8	421	795
Ski Trail	0	5	0	33	0	38
Transportation Gravel	0	0	0	0	713	713
Transportation Paved	0	1228	438	0	358	2024
Water	0	0	0	0	0	0
Total	374	1496	1076	302	1524	4772
Combined Treated and Untreated	7066	3097	4366	452	6377	21358
Unitized (lbs / acre / yr)	34	81	453	70	75	62

Table 5G: Subwatershed Annual Loads for West Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0	0	0
Commercial Lodging	0	0	0
Forest	5536	6831	12367
Golf Course	0	0	0
Open	0	0	0
Residential	0	0	0
Ski Trail	318	201	519
Transportation Gravel	0	0	0
Transportation Paved	0	800	800
Water	0	0	0
Total	5854	7832	13686

Table 5H: Subwatershed Annual Loads for West Branch Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed D		
	RB-A02	RB-A05	Total
Commercial	0	0	0
Commercial Lodging	0	0	0
Forest	0	0	0
Golf Course	0	0	0
Open	0	0	0
Residential	0	0	0
Ski Trail	0	0	0
Transportation Gravel	0	0	0
Transportation Paved	0	0	0
Water	0	0	0
Total	0	0	0
Combined Treated and Untreated	5854	7832	13686
Unitized (lbs / acre / yr)	30	32	31

Table 5I: Subwatershed Annual Loads for Lower Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed E and H															Total
	RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	136	690	456	80	0	0	0	0	142	358	420	157	310	0	0	2,751
Commercial Lodging	0	371	2,630	0	0	0	0	0	0	517	0	433	1	0	0	3,952
Forest	1,838	11,414	261	1,084	491	782	30	0	0	1,219	1,610	1,218	645	8	520	21,121
Golf Course	0	0	78	0	45	2	0	0	0	91	0	189	106	1	11	522
Open	5	0	43	3	0	2	25	0	1	39	56	94	9	0	10	288
Residential	222	446	0	859	85	1,026	0	0	0	505	1,198	875	213	0	519	5,947
Ski Trail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	2,333	2,555	64	7,588	5	0	4,257	0	0	1,217	836	11,061	9,039	0	0	38,955
Transportation Paved	4,023	5,234	6,064	4,261	1,905	4,326	40	0	232	13,159	11,074	7,655	2,559	0	1,472	62,003
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8,558	20,710	9,595	13,875	2,531	6,138	4,351	0	375	17,105	15,193	21,683	12,884	9	2,532	135,538

Table 5J: Subwatershed Annual Loads for Lower Roaring Brook (%) - Receiving Treatment

Land Use	Major Watershed E and H															Total
	RB-A01	RB-A06	RB-A14	RB-A20	RB-A25	RB-A26	RB-A27	RB-A28	RB-A29	RB-A30	RB-A31	RB-A32	RB-A33	RB-A34	RB-A35	
Commercial	0	0	0	0	0	0	207	368	988	0	0	0	0	0	0	1,562
Commercial Lodging	0	0	0	0	0	0	0	0	2,493	0	0	0	0	0	0	2,493
Forest	0	0	12	0	0	7	289	231	721	0	0	0	0	4	27	1,291
Golf Course	0	0	0	0	0	0	0	0	567	0	0	0	0	0	0	567
Open	0	0	1	0	0	0	7	16	88	0	0	0	0	0	0	112
Residential	0	0	0	0	0	109	0	479	0	0	0	0	0	19	99	706
Ski Trail	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	0	0	689	0	0	0	2,407	5,906	18,852	0	0	0	0	0	0	27,854
Transportation Paved	0	0	598	0	0	0	855	4,921	3,957	0	0	0	0	0	0	10,331
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1,300	0	0	117	3,766	11,921	27,666	0	0	0	0	23	126	44,918
Combined Treated and Untreated	8558	20710	10895	13875	2531	6255	8118	11921	28041	17105	15193	21683	12884	32	2658	180457
Unitized (lbs / acre / yr)	124	51	348	310	129	165	279	780	451	288	210	333	411	23	96	186

Table 5K: Subwatershed Annual Loads for Lower East Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0	0	2	0	16	111	46	14	0	0	0	1	0	190
Commercial Lodging	849	0	0	3	45	0	275	716	407	283	0	0	194	2771
Forest	1385	353	2	401	20	0	5	1796	85	1051	35	466	0	5600
Golf Course	20	336	39	1219	43	1	0	1	28	224	128	244	0	2282
Open	42	0	9	4	21	0	28	29	12	38	0	0	0	183
Residential	66	0	0	0	0	0	0	0	0	0	0	0	0	66
Ski Trail	1	0	0	0	0	0	0	0	0	73	0	0	0	74
Transportation Gravel	6074	648	0	74	1640	718	1973	923	3328	1328	11	0	2695	19411
Transportation Paved	509	0	269	0	874	181	1338	579	292	1153	46	0	0	5241
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8946	1337	320	1700	2659	1011	3665	4058	4152	4150	220	712	2888	35818

Table 5L: Subwatershed Annual Loads for Lower East Branch Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed F													Total
	EB-A01	EB-A02	EB-A04	EB-A05	EB-A09	EB-A10	EB-A11	EB-A13	EB-A15	EB-A16	EB-A17	EB-A18	EB-A19	
Commercial	0	0	150	38	586	223	0	0	0	0	106	0	0	1102
Commercial Lodging	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest	0	0	0	32	0	0	0	12	0	1	0	0	0	45
Golf Course	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Open	0	0	20	0	4	3	0	0	0	0	1	0	0	28
Residential	0	0	0	329	0	0	0	57	0	14	0	0	0	400
Ski Trail	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Gravel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Transportation Paved	0	0	0	9	4	0	0	0	0	0	0	0	0	14
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	170	408	594	226	0	69	0	16	106	0	0	1589
Combined Treated and Untreated	8946	1337	490	2108	3253	1237	3665	4127	4152	4166	326	712	2888	37407
Unitized (lbs / acre / yr)	161	64	78	36	333	369	829	59	628	87	60	32	2949	120

Table 5M: Subwatershed Annual Loads for Upper East Branch Roaring Brook (%) - Not Receiving Treatment

Land Use	Major Subwatershed G						
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	Total
Commercial	1	26	5	319	0	93	444
Commercial Lodging	0	4	348	0	0	1488	1840
Forest	0	3	0	243	1047	79	1371
Golf Course	0	0	0	0	0	0	0
Open	0	1	2	0	0	27	30
Residential	0	0	0	0	0	0	0
Ski Trail	0	1	0	1639	126	0	1767
Transportation Gravel	122	0	1003	821	632	1127	3705
Transportation Paved	45	61	138	13	0	445	703
Water	0	0	0	0	0	0	0
Total	167	96	1497	3035	1805	3260	9860

Table 5N: Subwatershed Annual Loads for Upper East Branch Roaring Brook (%) - Receiving Treatment

Land Use	Major Subwatershed G						
	EB-A03	EB-A06	EB-A07	EB-A08	EB-A12	EB-A14	Total
Commercial	1291	156	288	780	68	142	2725
Commercial Lodging	0	0	0	0	0	0	0
Forest	0	1	0	94	74	35	204
Golf Course	0	0	0	0	0	0	0
Open	0	0	0	1	0	0	2
Residential	0	0	0	473	235	174	881
Ski Trail	2	0	0	21	46	15	84
Transportation Gravel	0	0	0	0	0	0	0
Transportation Paved	216	5	0	262	29	216	728
Water	0	0	0	0	0	0	0
Total	1509	161	288	1631	453	582	4624
Combined Treated and Untreated	1676	257	1785	4666	2258	3842	14484
Unitized (lbs / acre / yr)	156	31	240	63	37	165	78

APPENDIX 6

VHB

SP Land Co./Killington WQ & SW

Date: 12/21/2005

Stormwater Treatment Sizing per VT Manual

Subwatershed Rams Head Lot

Description:

1) Water Quality Volume Calculation (WQv) - Section 1.1.1

Subwatershed	Area (acres)		% Impervious	Rv *	acre-ft	WQv		0.2" Minimum WQv	
	Impervious	Total				gal	cubic feet	acre-ft	gal
Rams Head Lot	5.62	6.92	81.3%	0.78	0.406	132,124	17,664	0.115	37,579
							Use Minimum?	No	

* $Rv = 0.05 + (I) * (0.009)$ ** $WQv = [(0.9) * (Rv) * (A)] / 12$

2) Channel Protection Volume (CPv) for 12 hrs. ED - Section 1.1.2

Harrington Volume Method (see page 1-12 of 2002 Manual):

Abbreviations for Calculations:

$Q_i =$	11.73	cfs	$Q_i =$ Known inflow for 1 year storm (from HydroCAD)
$Q_d =$	1.05	inches	$Q_d =$ Known runoff depth (from HydroCAD)
$V_r =$	0.61	acre-ft	$V_r =$ runoff volume
$I_a =$	0.30	$I_a = (200/CN) - 2$	$I_a =$ TR55 Initial Abstraction (unitless)
$P =$	2.10	inches	$P =$ 1 yr. storm rainfall depth (in)
$I_a/P =$	0.14		
$q_u =$	1033.2	$q_u = Q_i / (A * Q_d)$	$q_u =$ unit peak discharge (csm/in)
$A =$	0.0108	sq.mi.	$A =$ drainage area
Required $Q_o/Q_i =$	0.038	(2002 Manual figure 1.5)	$Q_o/Q_i =$ Ratio of Pond Peak Outflow/Inflow
$Q_o =$	0.446		$Q_i * (Q_o/Q_i)$
$V_s/V_r =$	0.63	(2002 Manual pg. 1-6)	$V_s/V_r = 0.682 - 1.43(Q_o/Q_i) + 1.64(Q_o/Q_i)^2 - 0.804(Q_o/Q_i)^3$
			where:
			$V_s =$ required storage volume (acre-ft)
			$V_r =$ design storm runoff volume (acre-ft)
Required $V_s =$	0.38	acre-ft	
	124,289	gal.	
	16616	cubic feet	
$WQv + CPv =$	256,414	gal	

VHB

SP Land Co./Killington WQ & SW

Date: 12/21/2005

Stormwater Treatment Sizing per VT Manual

Subwatershed Cat Yard Lot
Description:

1) Water Quality Volume Calculation (WQv) - Section 1.1.1

Subwatershed	Area (acres)		% Impervious:	Rv *	acre-ft	WQv		0.2" Minimum WQv	
	Impervious	Total				gal	cubic feet	acre-ft	gal
Cat Yard Lot	1.40	5.22	26.8%	0.29	0.114	37,169	4,969	0.087	28,347
								Use Minimum?	No

* $Rv = 0.05 + (I) * (0.009)$ ** $WQv = [(0.9) * (Rv) * (A)] / 12$

2) Channel Protection Volume (CPv) for 12 hrs. ED - Section 1.1.2

Harrington Volume Method (see page 1-12 of 2002 Manual):

Abbreviations for Calculations:

$Q_i =$	2.86	cfs	$Q_i =$ Known inflow for 1 year storm (from HydroCAD)
$Q_d =$	0.44	inches	$Q_d =$ Known runoff depth (from HydroCAD)
$V_r =$	0.19	acre-ft	$V_r =$ runoff volume
$I_a =$	0.70	$I_a = (200/CN) - 2$	$I_a =$ TR55 Initial Abstraction (unitless)
$P =$	2.10	inches	$P =$ 1 yr. storm rainfall depth (in)
$I_a/P =$	0.33		
$q_u =$	796.9	$q_u = Q_i / (A * Q_d)$	$q_u =$ unit peak discharge (csm/in)
$A =$	0.0082	sq.mi.	$A =$ drainage area
Required $Q_o/Q_i =$	0.045	(2002 Manual figure 1.5)	$Q_o/Q_i =$ Ratio of Pond Peak Outflow/Inflow
$Q_o =$	0.129		$Q_i * (Q_o/Q_i)$
$V_s/V_r =$	0.62	(2002 Manual pg. 1-6)	$V_s/V_r = 0.682 - 1.43(Q_o/Q_i) + 1.64(Q_o/Q_i)^2 - 0.804(Q_o/Q_i)^3$
			where:
			$V_s =$ required storage volume (acre-ft)
			$V_r =$ design storm runoff volume (acre-ft)
Required $V_s =$	0.12	acre-ft	
	38,721	gal.	
	5177	cubic feet	
$WQv + CPv =$	75,890	gal	

Stormwater Treatment Sizing per VT Manual
Killington Vale and K1 Basins
VHB

Date: 1/11/2006

Subwatershed K1 Lot
Description

1) Water Quality Volume Calculation (WQv) - Section 1.1.1

Subwatershed	Area (acres) Impervious	Total	% Impervious:	Rv *	acre-ft	WQv gal	cubic feet	0.2" Minimum WQv acre-ft	gal
K1 Lot	8.904	12.056	73.9%	0.71	0.646	210,560	28,150	0.201	65,470
Use Minimum?									No

* $Rv = 0.05 + (I) * (0.009)$

** $WQv = [(0.9") * (Rv) * (A)] / 12$

2) Channel Protection Volume (CPv) for 12 hrs. ED - Section 1.1.2

Harrington Volume Method (see page 1-12 of 2002 Manual):

Abbreviations for Calculations:

$Q_i =$	17.42	cfs
$Q_d =$	0.99	inches
$V_r =$	0.99	acre-ft
$I_a =$	0.33	$I_a = (200/CN) - 2$
$P =$	2.20	inches
$I_a/P =$	0.15	
$q_u =$	934	$q_u = Q_i / (A * Q_d)$
$A =$	0.0188	sq.mi.

Q_i = Known inflow for 1 year storm (from HydroCAD)
 Q_d = Known runoff depth (from HydroCAD)
 V_r = runoff volume
 I_a = TR55 Initial Abstraction (unitless)
 P = 1 yr. storm rainfall depth (in)

Required $Q_o/Q_i =$	0.040	(2002 Manual figure 1.5)
$Q_o =$	0.697	
$V_s/V_r =$	0.63	(2002 Manual pg. 1-12)

q_u = unit peak discharge (csm/in)
 A = drainage area
 Q_i = Known TR20 pond inflow (cfs)
 Q_o/Q_i = Ratio of Pond Peak Outflow/Inflow
 $Q_i * (Q_o/Q_i)$
 $V_s/V_r = 0.682 - 1.43(Q_o/Q_i) + 1.64(Q_o/Q_i)^2 - 0.804(Q_o/Q_i)^3$
 where:
 V_s = required storage volume (acre-ft)
 V_r = design storm runoff volume (acre-ft)

Required $V_s =$	0.624	acre-ft
	203,316	gal.
	27181	cubic feet
$WQv + CP_v =$	413,877	gal

Stormwater Treatment Sizing per VT Manual
Killington WQRP
VHB

Date: 1/11/2006 (Revised 061809)

Subwatershed Description Vale Lot

1) Water Quality Volume Calculation (WQv) - Section 1.1.1

Subwatershed	Area (acres) Impervious	Total	% Impervious:	Rv *	acre-ft	WQv cubic feet	0.2" Minimum acre-ft	WQv gal
Vale Lot	3.361	6.640	50.6%	0.51	0.252	10,967	0.111	36,058

Use Minimum? Yes

* $Rv = 0.05 + (I) * (0.009)$

** $WQv = [(0.9") * (Rv) * (A)] / 12$

2) Channel Protection Volume (CPv) for 12 hrs. ED - Section 1.1.2

Harrington Volume Method (see page 1-12 of 2002 Manual):

Abbreviations for Calculations:

Qi =	7.86	cfs
Qd =	0.77	inches
Vr =	0.43	acre-ft
Ia =	0.44	Ia = (200/CN) - 2
P =	2.30	inches
Ia/P =	0.19	
qu =	984	qu = Qi/(A*Qd)
A =	0.0104	sq.mi.

Qi = Known inflow for 1 year storm (from HydroCAD)

Qd = Known runoff depth (from HydroCAD)

Vr = runoff volume

Ia = TR55 Initial Abstraction (unitless)

P = 1 yr. storm rainfall depth (in)

qu = unit peak discharge (csm/in)

A = drainage area

Qi = Known TR20 pond inflow (cfs)

Qo/Qi = Ratio of Pond Peak Outflow/Inflow

Qi * (Qo/Qi)

Vs/Vr = $0.682 - 1.43(Qo/Qi) + 1.64(Qo/Qi)^2 - 0.804(Qo/Qi)$

where:

Vs = required storage volume (acre-ft)

Vr = design storm runoff volume (acre-ft)

Required Qo/Qi =	0.040	(2002 Manual figure 1.5)
Qo =	0.314	
Vs/Vr =	0.63	(2002 Manual pg. 1-12)

Required Vs =	0.267	acre-ft
	11,644	cubic feet

WQv + CPv =	22,611	cubic feet
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Stormwater Treatment Sizing per VT Manual
Killington WQRP
VHB

Date: 1/11/2006 (Revised 061809)

Subwatershed Club House Basin
 Description

1) Water Quality Volume Calculation (WQv) - Section 1.1.1

Subwatershed	Area (acres) Impervious	Total	% Impervious:	Rv *	acre-ft	WQv cubic feet	0.2" Minimum acre-ft	WQv gal
Club House Basin	2.033	4.570	44.5%	0.45	0.154	6,724	0.076	24,817

Use Minimum? Yes

* $Rv = 0.05 + (I) * (0.009)$

** $WQv = [(0.9") * (Rv) * (A)] / 12$

2) Channel Protection Volume (CPv) for 12 hrs. ED - Section 1.1.2

Harrington Volume Method (see page 1-12 of 2002 Manual):

Abbreviations for Calculations:

$Q_i =$	6.33	cfs
$Q_d =$	0.93	inches
$V_r =$	0.35	acre-ft
$I_a =$	0.35	$I_a = (200/CN) - 2$
$P =$	2.30	inches
$I_a/P =$	0.15	
$q_u =$	953	$q_u = Q_i / (A * Q_d)$
$A =$	0.0071	sq.mi.

Q_i = Known inflow for 1 year storm (from HydroCAD)

Q_d = Known runoff depth (from HydroCAD)

V_r = runoff volume

I_a = TR55 Initial Abstraction (unitless)

P = 1 yr. storm rainfall depth (in)

q_u = unit peak discharge (csm/in)

A = drainage area

Q_i = Known TR20 pond inflow (cfs)

Q_o/Q_i = Ratio of Pond Peak Outflow/Inflow

$Q_i * (Q_o/Q_i)$

$V_s/V_r = 0.682 - 1.43(Q_o/Q_i) + 1.64(Q_o/Q_i)^2 - 0.804(Q_o/Q_i)^3$

where:

V_s = required storage volume (acre-ft)

V_r = design storm runoff volume (acre-ft)

Required $Q_o/Q_i =$	0.040	(2002 Manual figure 1.5)
$Q_o =$	0.253	
$V_s/V_r =$	0.63	(2002 Manual pg. 1-12)

Required $V_s =$ 0.222 acre-ft
9,679 cubic feet

$WQv + CPv =$ 16,403 cubic feet



Rams Head Predev



Cat Yard Predev



K1 Lot Predev



Vale Lot Predev



Club House Basin
Subw. Predev



Rams Head



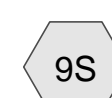
Cat Yard



K1 Lot



Vale Lot



Club House Basin
Subw.



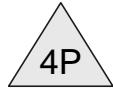
Rams Head Pond



Cat Yard Pond



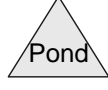
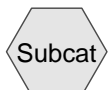
K1 Pond



Vale Pond



Club House Pond



Drainage Diagram for Existing Catyard, K1, RamsHead, Tenniscourt, and Clubhouse Basins_for2009WQRF

Prepared by VHB, Printed 11/29/2010

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Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

Prepared by VHB

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Summary for Subcatchment 1S: Rams Head

Runoff = 11.73 cfs @ 12.02 hrs, Volume= 0.607 af, Depth> 1.05"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
0.641	98	Paved parking & roofs
4.982	89	Gravel roads, HSG C
0.003	70	Woods, Good, HSG C
1.289	74	>75% Grass cover, Good, HSG C
6.915	87	Weighted Average
6.274		90.73% Pervious Area
0.641		9.27% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	100	0.0500	0.22		Sheet Flow, Grass: Short n= 0.150 P2= 2.50"
0.3	50	0.1200	2.42		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
1.1	190	0.0320	2.88		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
1.5	600	0.0300	6.76	21.22	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.024
10.6	940	Total			

Summary for Subcatchment 2S: Rams Head Predev

Runoff = 0.84 cfs @ 12.90 hrs, Volume= 0.174 af, Depth> 0.30"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
6.915	70	Woods, Good, HSG C
6.915		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
39.6	150	0.0530	0.06		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 2.50"
29.3	760	0.0300	0.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
68.9	910	Total			

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Summary for Subcatchment 3S: Cat Yard

Runoff = 2.86 cfs @ 12.10 hrs, Volume= 0.191 af, Depth> 0.44"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
0.053	55	Woods, Good, HSG B
0.501	85	Gravel roads, HSG B
1.216	61	>75% Grass cover, Good, HSG B
0.149	98	Paved parking & roofs
0.750	89	Gravel roads, HSG C
0.705	70	Woods, Good, HSG C
1.853	74	>75% Grass cover, Good, HSG C
5.227	74	Weighted Average
5.078		97.15% Pervious Area
0.149		2.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.7	100	0.2000	0.17		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 2.50"
1.5	140	0.1000	1.58		Shallow Concentrated Flow, Woodland Kv= 5.0 fps
2.3	270	0.0800	1.98		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.8	200	0.0600	3.94		Shallow Concentrated Flow, Unpaved Kv= 16.1 fps
0.6	80	0.1000	2.21		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.1	80	0.0800	11.03	34.66	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.024
0.2	110	0.1200	9.72	53.43	Trap/Vee/Rect Channel Flow, Bot.W=3.00' D=1.00' Z= 2.5 '/' Top.W=8.00' n= 0.040
0.1	50	0.0800	11.03	34.66	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.024
0.2	140	0.2800	14.84	81.62	Trap/Vee/Rect Channel Flow, Bot.W=3.00' D=1.00' Z= 2.5 '/' Top.W=8.00' n= 0.040
15.5	1,170	Total			

Summary for Subcatchment 4S: Cat Yard Predev

Runoff = 0.40 cfs @ 12.59 hrs, Volume= 0.080 af, Depth> 0.18"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Area (ac)	CN	Description
1.769	55	Woods, Good, HSG B
3.455	70	Woods, Good, HSG C
5.224	65	Weighted Average
5.224		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.9	150	0.1700	0.10		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 2.50"
18.1	940	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
43.0	1,090	Total			

Summary for Subcatchment 5S: K1 Lot

Runoff = 17.42 cfs @ 12.06 hrs, Volume= 0.995 af, Depth> 0.99"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
8.278	89	Gravel roads, HSG C
0.626	98	Paved parking & roofs
1.220	74	>75% Grass cover, Good, HSG C
1.932	74	>75% Grass cover, Good, HSG C
12.056	86	Weighted Average
11.430		94.81% Pervious Area
0.626		5.19% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.0	100	0.0450	0.21		Sheet Flow, Grass: Short n= 0.150 P2= 2.50"
3.5	315	0.0450	1.48		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.2	90	0.0480	6.25	7.67	Pipe Channel, 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.024
1.0	75	0.0300	1.21		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
0.4	90	0.0110	4.09	12.85	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.024
0.7	630	0.1000	14.31	70.26	Pipe Channel, 30.0" Round Area= 4.9 sf Perim= 7.9' r= 0.63' n= 0.024
13.8	1,300	Total			

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Summary for Subcatchment 6S: K1 Lot Predev

Runoff = 1.66 cfs @ 12.72 hrs, Volume= 0.306 af, Depth> 0.30"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
12.056	70	Woods, Good, HSG C
12.056		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
33.6	150	0.0800	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 2.50"
23.6	1,000	0.0800	0.71		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
57.2	1,150	Total			

Summary for Subcatchment 7S: Vale Lot

Runoff = 7.86 cfs @ 12.05 hrs, Volume= 0.428 af, Depth> 0.77"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
0.403	70	Woods, Good, HSG C
2.811	74	>75% Grass cover, Good, HSG C
3.361	89	Gravel roads, HSG C
* 0.065	100	water
6.640	82	Weighted Average
6.575		99.02% Pervious Area
0.065		0.98% Impervious Area

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.5	100	0.2100	0.18		Sheet Flow, Woods: Light underbrush n= 0.400 P2= 2.50"
0.6	85	0.2100	2.29		Shallow Concentrated Flow, Woodland Kv= 5.0 fps
0.4	235	0.1100	8.86	39.85	Trap/Vee/Rect Channel Flow, Bot.W=2.00' D=1.00' Z= 2.5 ' /' Top.W=7.00' n= 0.040 Earth, cobble bottom, clean sides
0.1	50	0.1000	10.18	17.99	Pipe Channel, 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.024
0.1	125	0.1300	23.22	41.03	Pipe Channel, 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.012
0.1	110	0.0900	19.32	34.14	Pipe Channel, 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.012
0.7	150	0.0600	3.67		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.1	120	0.0360	14.80	46.50	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012
0.2	65	0.1200	5.20		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.1	120	0.0400	15.60	49.02	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012
0.2	120	0.0150	9.55	30.02	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012
0.2	120	0.0150	9.55	30.02	Pipe Channel, 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.012
12.3	1,400	Total			

Summary for Subcatchment 8S: Vale Lot Predev

Runoff = 0.97 cfs @ 12.65 hrs, Volume= 0.169 af, Depth> 0.31"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
6.640	70	Woods, Good, HSG C
6.640		100.00% Pervious Area

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.7	150	0.1000	0.08		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 2.50"
22.1	1,050	0.1000	0.79		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
52.8	1,200	Total			

Summary for Subcatchment 9S: Club House Basin Subw.

Runoff = 6.33 cfs @ 12.06 hrs, Volume= 0.355 af, Depth> 0.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.30"

Area (ac)	CN	Description
* 0.041	98	Impervious Roof
* 1.992	98	Impervious Roads and Parking
2.483	74	>75% Grass cover, Good, HSG C
* 0.053	100	
4.569	85	Weighted Average
2.483		54.34% Pervious Area
2.086		45.66% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.4	100	0.0300	0.18		Sheet Flow, Grass: Short n= 0.150 P2= 2.50"
2.1	380	0.0400	3.00		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.1	50	0.0400	6.44	11.38	Pipe Channel, 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.024
1.6	380	0.0700	3.97		Shallow Concentrated Flow, Grassed Waterway Kv= 15.0 fps
0.1	40	0.0400	6.44	11.38	Pipe Channel, 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.024
13.3	950	Total			

Summary for Subcatchment 10S: Club House Basin Subw. Predev

Runoff = 0.55 cfs @ 12.92 hrs, Volume= 0.115 af, Depth> 0.30"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 1 year Rainfall=2.30"

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Area (ac)	CN	Description
4.570	70	Woods, Good, HSG C
4.570		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
49.7	150	0.0300	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 2.50"
20.7	760	0.0600	0.61		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
70.4	910	Total			

Summary for Pond 1P: Rams Head Pond

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
 Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Starting Elev= 2,152.50' Surf.Area= 1,300 sf Storage= 650 cf
 Peak Elev= 2,152.50' @ 5.00 hrs Surf.Area= 1,300 sf Storage= 650 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
 Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	2,152.00'	14,523 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
2,152.00	1,300	0	0
2,152.50	1,300	650	650
2,154.00	2,668	2,976	3,626
2,156.00	3,886	6,554	10,180
2,157.00	4,800	4,343	14,523

Device	Routing	Invert	Outlet Devices
#1	Device 3	2,152.50'	2.0" Vert. Orifice/Grate X 3.00 C= 0.600
#2	Device 3	2,156.60'	18.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Primary	2,153.00'	18.0" Round Culvert L= 30.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 2,153.00' / 2,152.00' S= 0.0333 '/' Cc= 0.900 n= 0.024
#4	Primary	2,156.60'	10.0' long x 10.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=2,152.50' (Free Discharge)

3=Culvert (Controls 0.00 cfs)
 1=Orifice/Grate (Controls 0.00 cfs)
 2=Orifice/Grate (Controls 0.00 cfs)
 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 2P: Cat Yard Pond

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
 Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Starting Elev= 2,359.60' Surf.Area= 1,345 sf Storage= 673 cf
 Peak Elev= 2,359.60' @ 5.00 hrs Surf.Area= 1,345 sf Storage= 673 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
 Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	2,359.10'	9,338 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
2,359.10	1,345	0	0
2,359.60	1,345	673	673
2,360.00	1,670	603	1,276
2,362.00	2,200	3,870	5,146
2,363.50	3,390	4,193	9,338

Device	Routing	Invert	Outlet Devices
#1	Device 3	2,359.60'	2.0" Vert. Orifice/Grate X 3.00 C= 0.600
#2	Device 3	2,362.20'	24.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Primary	2,356.20'	24.0" Round Culvert L= 45.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 2,356.20' / 2,353.80' S= 0.0533 '/' Cc= 0.900 n= 0.024
#4	Primary	2,363.10'	10.0' long x 20.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=2,359.60' (Free Discharge)

3=Culvert (Passes 0.00 cfs of 23.43 cfs potential flow)
 1=Orifice/Grate (Controls 0.00 cfs)
 2=Orifice/Grate (Controls 0.00 cfs)
 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Summary for Pond 3P: K1 Pond

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
 Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Starting Elev= 2,383.40' Surf.Area= 560 sf Storage= 280 cf

Peak Elev= 2,383.40' @ 5.00 hrs Surf.Area= 560 sf Storage= 280 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	2,382.90'	27,671 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
2,382.90	560	0	0
2,383.40	560	280	280
2,384.00	941	450	730
2,386.00	1,702	2,643	3,373
2,388.00	2,526	4,228	7,601
2,390.00	3,435	5,961	13,562
2,392.00	4,375	7,810	21,372
2,393.30	5,315	6,299	27,671

Device	Routing	Invert	Outlet Devices
#1	Device 3	2,383.40'	2.0" Vert. Orifice/Grate X 3.00 C= 0.600
#2	Device 3	2,389.20'	24.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Primary	2,383.10'	24.0" Round Culvert L= 75.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 2,383.10' / 2,379.30' S= 0.0507 '/' Cc= 0.900 n= 0.024
#4	Primary	2,391.00'	7.0' long x 25.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=2,383.40' (Free Discharge)

3=Culvert (Passes 0.00 cfs of 0.55 cfs potential flow)
 1=Orifice/Grate (Controls 0.00 cfs)
 2=Orifice/Grate (Controls 0.00 cfs)
 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 4P: Vale Pond

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
 Primary = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Starting Elev= 2,244.50' Surf.Area= 2,760 sf Storage= 2,760 cf
 Peak Elev= 2,244.50' @ 5.00 hrs Surf.Area= 2,760 sf Storage= 2,760 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	2,243.50'	34,899 cf	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
2,243.50	2,760	0	0
2,244.50	2,760	2,760	2,760
2,246.00	3,485	4,684	7,444
2,248.00	4,473	7,958	15,402
2,250.00	5,779	10,252	25,654
2,251.40	7,428	9,245	34,899

Device	Routing	Invert	Outlet Devices
#1	Device 3	2,244.50'	2.0" Vert. Orifice/Grate X 3.00 C= 0.600
#2	Device 3	2,249.10'	24.0" Horiz. Orifice/Grate C= 0.600 Limited to weir flow at low heads
#3	Primary	2,243.50'	24.0" Round Culvert L= 65.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 2,243.50' / 2,241.50' S= 0.0308 '/' Cc= 0.900 n= 0.024
#4	Primary	2,250.50'	6.0' long x 20.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.00 cfs @ 5.00 hrs HW=2,244.50' (Free Discharge)

3=Culvert (Passes 0.00 cfs of 5.35 cfs potential flow)
 1=Orifice/Grate (Controls 0.00 cfs)
 2=Orifice/Grate (Controls 0.00 cfs)
 4=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond 5P: Club House Pond

Inflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
 Starting Elev= 2,153.50' Surf.Area= 2,472 sf Storage= 1,187 cf
 Peak Elev= 2,153.50' @ 5.00 hrs Surf.Area= 2,472 sf Storage= 1,187 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	2,153.00'	15,283 cf	Custom Stage Data (Prismatic) Listed below (Recalc)

Existing Catyard, K1, RamsHead, Tenniscourt, and CluType II 24-hr 1 year Rainfall=2.30"

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Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
2,153.00	2,275	0	0
2,154.00	2,669	2,472	2,472
2,156.00	3,679	6,348	8,820
2,157.60	4,400	6,463	15,283

East Branch of Roaring Brook Watershed

Roaring Brook Watershed

Inset Map - 1" = 200'

Roaring Brook and East Branch of Roaring Brook Killington, Vermont Overall Watershed Map

January 25, 2011

- | | | |
|----------------------------------|----------------------------------|--------------|
| Sediment Source - Priority Level | Proposed Stormwater Pond | Land Cover |
| Low | Existing Stormwater Basin | Building |
| Mod/Low | Parcel Boundary | Forest |
| High | Stormwater Permits | Golf Course |
| Major Subwatershed Boundary | Stormwater Permit Coverage Areas | Parking/Road |
| Subwatershed Boundary | Areas of Proposed Development | Open |
| Water Quality Monitoring Station | Contour (10 Ft.) | Ski Trail |
| Turbidity Monitoring Station | Contour (100 Ft.) | Water |
| Stream | | |
| Culvert | | |

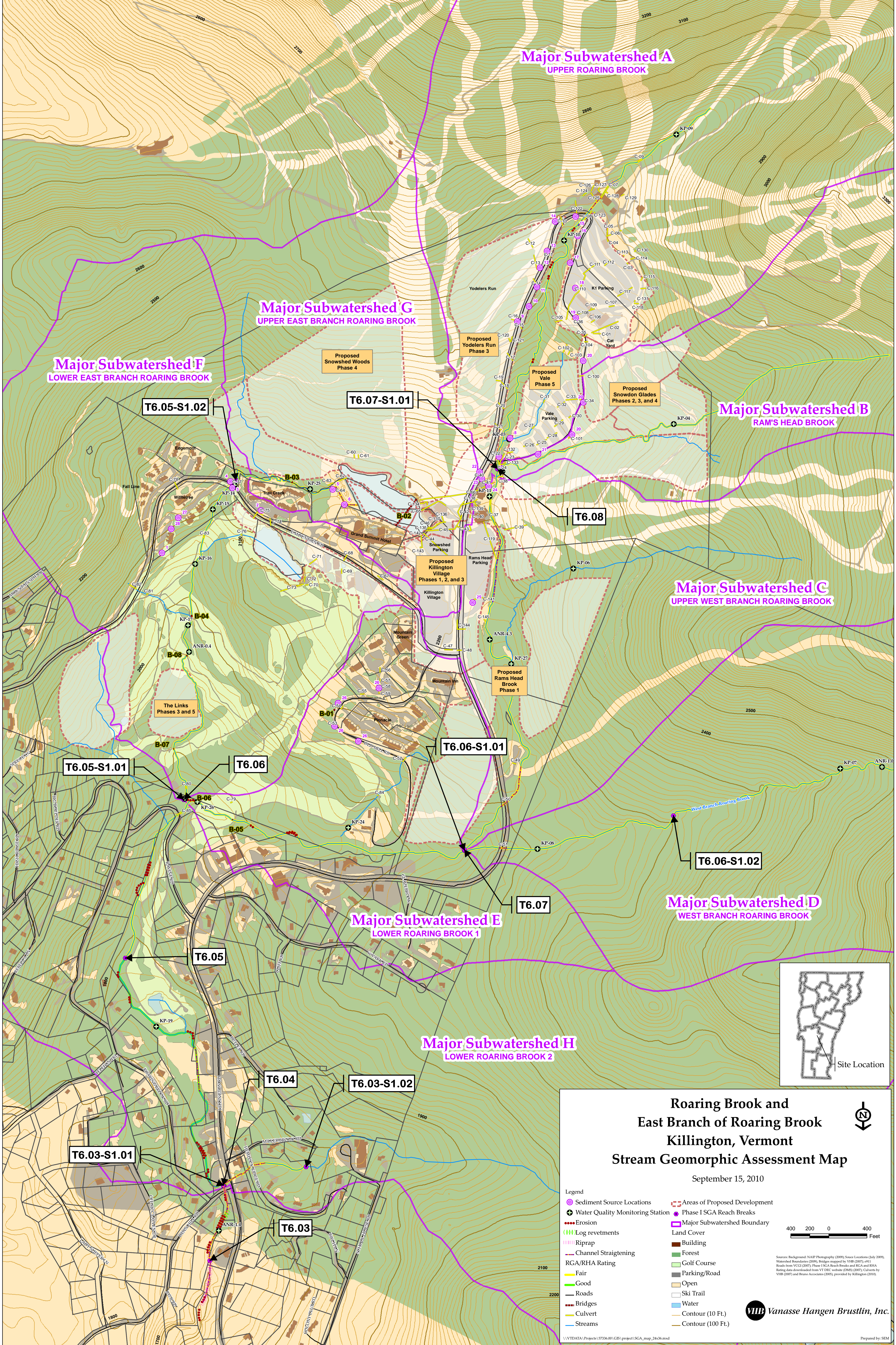
400 200 0 400 Feet

Sources: Land Cover created by VHB (2007) using Potomac Aerial Surveys linework (2004) and NAIP color orthophotos (2003); Watershed Boundaries, Areas of Proposed Development (2009); Turbidity Monitoring Stations, WQ Monitoring Stations, Basins & Streams by VHB (2005); Stormwater Permits (2005) by ANR; PUD Boundary from Hart Howerton (5/16/10).

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F:\57336.00\GIS\project\OverallWatershedMap_2011.mxd

Prepared by: SEM/JAT



Major Subwatershed A
UPPER ROARING BROOK

Major Subwatershed G
UPPER EAST BRANCH ROARING BROOK

Major Subwatershed F
LOWER EAST BRANCH ROARING BROOK

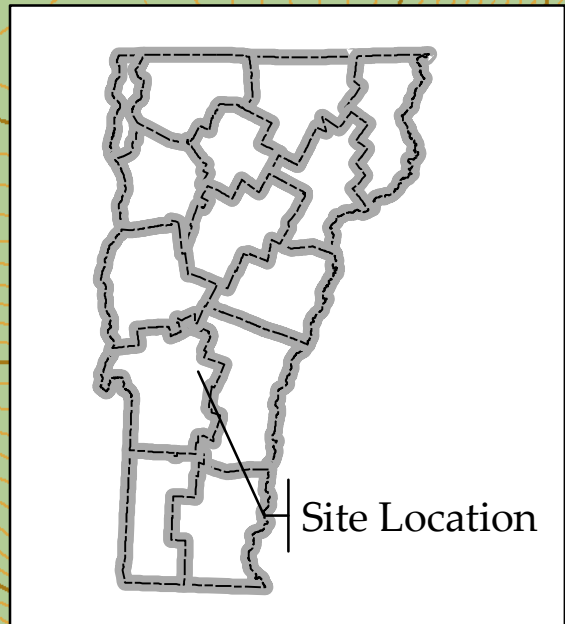
Major Subwatershed B
RAM'S HEAD BROOK

Major Subwatershed C
UPPER WEST BRANCH ROARING BROOK

Major Subwatershed D
WEST BRANCH ROARING BROOK

Major Subwatershed E
LOWER ROARING BROOK 1

Major Subwatershed H
LOWER ROARING BROOK 2



Site Location

Roaring Brook and
East Branch of Roaring Brook
Killington, Vermont
Stream Geomorphic Assessment Map

September 15, 2010

- Legend
- | | |
|------------------------------------|---------------------------------|
| ● Sediment Source Locations | ■ Areas of Proposed Development |
| ⊕ Water Quality Monitoring Station | ● Phase I SGA Reach Breaks |
| --- Erosion | --- Major Subwatershed Boundary |
| --- Log revetments | Land Cover |
| --- Riprap | ■ Building |
| --- Channel Straigthening | ■ Forest |
| RG/RHA Rating | ■ Golf Course |
| --- Fair | ■ Parking/Road |
| --- Good | ■ Open |
| --- Roads | ■ Ski Trail |
| --- Bridges | ■ Water |
| --- Culvert | --- Contour (10 Ft.) |
| --- Streams | --- Contour (100 Ft.) |

400 200 0 400 Feet

Sources: Background: NADP Photography (2009); Source Locations (July 2009); Watershed Boundaries (2009); Bridges mapped by VHB (2007); e911 Roads from VCGI (2007); Phase I SGA Reach Breaks and RGA and RHA Rating data downloaded from VT DEC website (DMS) (2007); Culverts by VHB (2007) and Bruno Associates (2005); provided by Killington (2010).

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