CENTRAL VERMONT REGIONAL PLANNING COMMISSION

FRIENDS OF THE MAD RIVER

WATERSHED CONSULTING

CENTRAL VERMONT – STORMWATER MASTER PLAN

DUXBURY, FAYSTON, MORETOWN, WAITSFIELD, AND WARREN, VERMONT

FINAL REPORT

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Prepared for:
Central Vermont Regional Planning Commission
29 Main St #4, Montpelier, VT 05602
P: 802.229.0389
cvrpc@cvregion.com

In Partnership with:
Friends of the Mad River
4061 Main Street
PO Box 255
Waitsfield, VT 05673
P: 802.496.9127
info@friendsofthemadriver.org

Prepared by:
Watershed Consulting Associates, LLC
208 Flynn Ave P.O. Box 4413
Burlington, VT 05406
P: 802.497.2367
info@watershedca.com

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I. Disclaimer

The intent of this report is to present the data collected, evaluations, analyses, designs, and cost estimates for subwatersheds in Duxbury, Fayston, Moretown, Waitsfield, and Warren under a contract between the Central Vermont Regional Planning Commission and Watershed Consulting Associates, LLC. Funding for the project was provided by the Vermont Department of Environmental Conservation's Clean Water Fund Grant. The plan presented is intended to provide the watershed's stakeholders a means by which to identify and prioritize future stormwater management efforts. This planning study presents a recommended collection of Best Management Practices (BMPs) that would address specific concerns that have been raised for these areas. There is great need to reduce stormwater impacts including phosphorus and sediment from stormwater runoff to receiving waters within the municipalities and the greater Lake Champlain Basin considering current and future regulation under the Lake Champlain Total Maximum Daily Load requirements. Although there are other BMP strategies that could be implemented in the watershed, those presented in this document are the sites and practices that project stakeholders believe will have the greatest impact and probability of implementation. These practices do not represent a regulatory obligation at this time, nor is any property owner within the watershed obligated to implement them. However, it should be noted that for properties with three or more acres of impervious cover without a current State stormwater permit, forthcoming regulations will require management of existing impervious areas. This stormwater master plan, and therefore its resultant strategies, is one of the actions in the Winooski Tactical Basin Plan. This will put the BMP strategies in queue for state funding for implementation.

II. Glossary of Terms

Best Management Practice (BMP)- BMPs are practices that manage stormwater runoff to improve water quality and reduce stormwater volume and velocity. Examples of BMPs include detention ponds, gravel wetlands, infiltration trenches, and bioretention practices.

Buffers- Protective vegetated areas (variable width) along stream banks that stabilize stream banks, filter sediment, slow stormwater runoff velocity, and shade streams to keep waters cool in the summer months.

Channel Protection Volume (CPv)- The stormwater volume generated from the one-year, 24-hour rainfall event. Management of this event targets preventing stream channel erosion.

Check Dam- A small dam, often constructed in a swale, that decreases the velocity of stormwater and encourages the settling and deposition of sediment. They are often constructed from wood, stone, or earth.

Detention BMP- A BMP that stores stormwater for a defined length of time before it eventually drains to the receiving water body. Stormwater is not retained in the practice. The objective of a detention BMP is to reduce the peak discharge from the BMP to reduce channel erosion and settle out pollutants from the stormwater. Some of these practices also include additional water quality benefits. Examples include gravel wetlands, detention ponds, and non-infiltration-dependent bioretention practices.

Drainage Area- The area contributing runoff to a specific point. Generally, this term is used for the area that drains to a BMP or other feature like a stormwater pipe.

Hydrologic Soil Group- A Natural Resource Conservation Service classification system for soils. They are categorized into four groups (A, B, C, and D) with “A” having the highest permeability and “D” having the lowest.

Infiltration/Infiltration Rate- Stormwater percolating into the ground surface. The rate at which this occurs (infiltration rate) is generally presented as inches per hour.

Infiltration BMP- A BMP that allows for the infiltration of stormwater into the subsurface soil as groundwater, which returns to the stream as baseflow. Mapped soils of Hydrologic Group A or B (sandy, well-drained soils) are an indicator of infiltration potential. Infiltration reduces the amount of surface storage required. Typical Infiltration BMP practices include infiltration trenches, bioretention practices, subsurface infiltration chambers, infiltration basins, and others.

Outfall- The point where stormwater discharges from a system like a pipe.

Sheet Flow- Stormwater runoff flowing over the ground surface in a thin layer.

Stabilization- Vegetated or structural practices that prevent erosion from occurring.

Stormwater/Stormwater Runoff- Precipitation and snowmelt that runs off the ground surface.

Stormwater Master Plan (SWMP)- A comprehensive plan to identify and prioritize stormwater management opportunities to address current, and prevent future, stormwater related problems.

Stormwater Permit- A permit issued by the State for the regulated discharge of stormwater.

Swale- An open vegetated channel used to convey runoff and to provide pre-treatment by filtering out pollutants and sediments.

Total Maximum Daily Load (TMDL)- A TMDL is a calculation of the maximum pollutant loading that a water body can accommodate and still meet Vermont Water Quality Standards. The term TMDL also refers to the regulated management plan, which defines how the water body will be regulated and returned to its acceptable condition. This includes the maximum loading, sources of pollution, and criteria for determining if the TMDL is met.

Total Phosphorus (TP)- The total phosphorus present in stormwater. This value is the sum of particulate and dissolved phosphorus. It includes both organic and inorganic forms.
Total Suspended Solids (TSS)- The total soil particulate matter suspended in the water column.

Watershed- The area contributing runoff to a specific point. For watersheds like the Mad River, this includes the entire area draining to the point where the river discharges to the Winooski River.

Water Quality Volume (WQv)- The stormwater volume generated from the first inch of runoff. This runoff is known as the 90th percentile rainfall event and contains the majority of pollutants.

1 Introduction

1.1 The Problem with Stormwater

Stormwater runoff is any precipitation including melting snow and ice that runs off the land. In undeveloped areas, much of the precipitation is soaked into the ground, taken up by plants, or evaporated back into the atmosphere. However, when human development limits or completely prevents this natural sponge-like effect of the land, generally through the introduction of impervious areas such as roads, parking lots, or buildings, the volume of stormwater runoff increases, sometimes dramatically. In addition to the increased volume of stormwater runoff, the runoff is also frequently laden with pollutants such as sediment, nutrients, oils, and pathogens. These stormwater runoff related issues decrease aquatic habitat health, increase flooding and erosion, threaten infrastructure, and prevent use and enjoyment of our water resources. Traditionally, stormwater management techniques have relied heavily upon gray infrastructure, where stormwater is collected and conveyed in a network of catchbasins and pipes, prior to discharging to surface waters (i.e. streams, rivers, ponds, lakes, and coastal waters). Although this approach is effective in removing stormwater from developed areas, it does not eliminate the problem and has proved to worsen negative stormwater effects such as erosion, flooding, and nutrient pollution. It is clear that something must change. This is where stormwater master planning comes into play. Funding is limited to implement projects that will improve water quality and reduce the negative impacts of uncontrolled stormwater runoff. As such, creating a plan of where and how to best use these funds to provide the greatest benefit to our water resources is key.

1.2 What is Stormwater Master Planning?

In the wake of rapid urban development and increasing rainfall intensity, stormwater management that seeks to mimic the undeveloped environment and treat stormwater runoff as close to the source as possible has become the focus of efforts to mitigate flooding and maintain the health of our waterways. Given the complexity of current stormwater issues, the development of the Stormwater Master Planning process provides communities with a range of possibilities for stormwater mitigation from small-scale (i.e. individual parcels), to large-scale (i.e.

community-wide). Stormwater rarely follows political or parcel boundaries and tackling this problem from a strategic perspective is key to preventing future problems and addressing current sources of water quality degradation. This process was developed because many of the developed areas within the State of Vermont predate regulatory requirements for stormwater management, but these distributed and unmanaged areas are contributing to the impairments of our surface waters including Lake Champlain. These unmanaged stormwater discharges can be identified and addressed through this Stormwater Master Planning process. The process allows for assessment and prioritization of the areas most in need of mitigation while acknowledging that, for many areas, these types of stormwater retrofits are voluntary. Public awareness of both stormwater problems and stormwater management practices are critical to the Stormwater Master Planning process. As such, working with municipal officials, project stakeholders, and community members is key to implementation of and support for these plans. Stormwater Master Planning involves analysis of current and anticipated future conditions, and seeks to prioritize stormwater solutions, maximizing the potential for water quality improvement, flood mitigation, erosion reduction, and pollution prevention using a variety of best management practices (BMPs) and allocating limited funds in a planned and methodical way.

2 Project Overview

In May 2013, the State of Vermont Department of Environmental Conservation (VT DEC) issued a document titled *Vermont Stormwater Master Planning Guidelines*, designed to provide VT communities with a standardized guideline and series of templates. The document assists communities in planning for future stormwater management practices and programs. Our Plan is a combination of Templates 2A: Hybrid site & community retrofit approach with green stormwater infrastructure (GSI) stormwater management, and 3A: Large watershed or regional approach with planned build out analysis and traditional (end of pipe or centralized) stormwater management.

Vermont has had stormwater regulations in place since 1978, with updates concerning unified sizing criteria made in 2002 and again in 2017. Recognizing that stormwater management can be a costly endeavor, the new guidelines are written to help identify the appropriate practices for each watershed, community, and site, in order to maximize the use of limited funds.

The guidelines encourage each stormwater master plan (SWMP) to follow the same procedures, and include:

- Problem Definition
- Collection of Existing Data
- Development of New Data
- Existing and Proposed Program, Procedure, or Practice Evaluation
- Summary and Recommendations

In keeping with these guidelines, we have prepared the following report. The report is broken up into five chapters, one for each municipality covered by this plan. The chapters are titled with the municipality name: Duxbury, Fayston, Moretown, Waitsfield, and Warren (Figure 1).

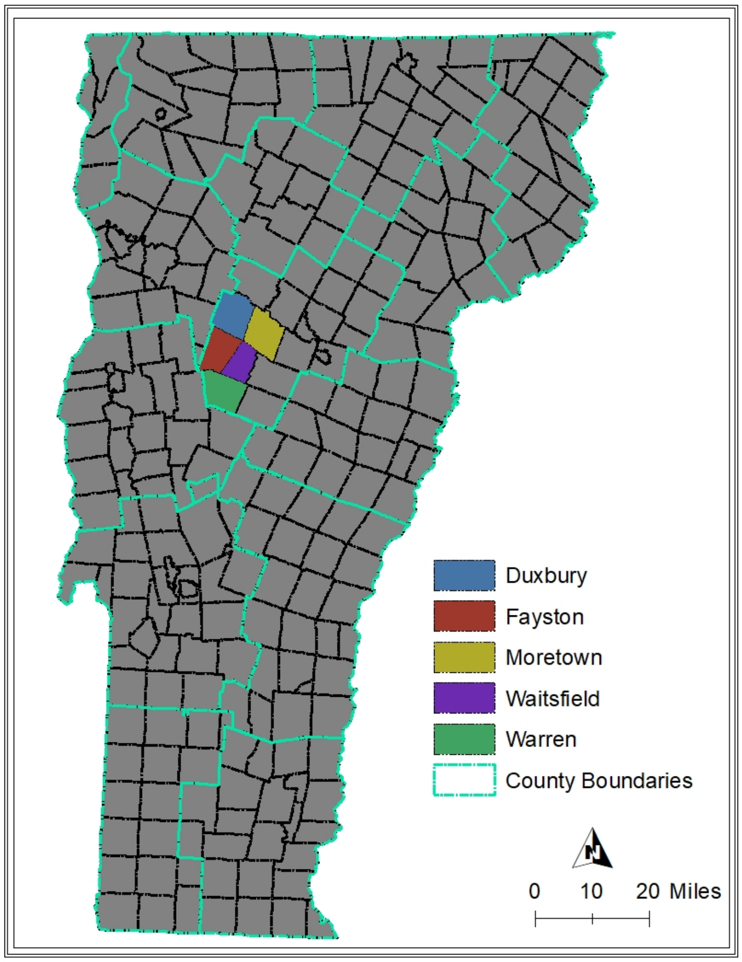


Figure 1. Duxbury, Fayston, Moretown, Waitsfield, and Warren are located in central Vermont within Washington County.

A. Chapter 1: Duxbury

1 Background

1.1 Problem Definition

The Town of Duxbury is located in Washington County primarily within the Mad River watershed, though small portions fall within four other watersheds including the Joiner Brook-Winooski River and Graves Brook-Winooski River (Figure A1). Each of these watersheds is within the larger Winooski River watershed, which drains to Lake Champlain. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

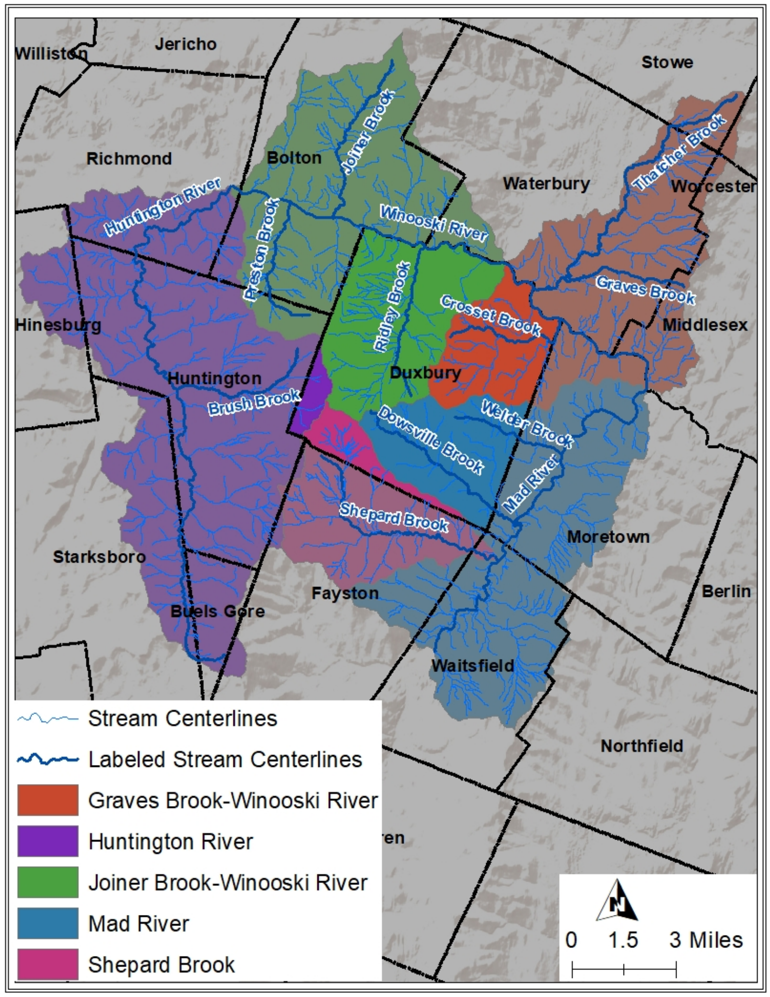


Figure A1. Duxbury is located primarily within the Kingsbury Branch watershed.

Duxbury has large areas of undeveloped forest in mountainous terrain. The development that exists is primarily located in the Route 100 corridor near the eastern boundary of the town. Other minor developed areas were historically in river valleys, however more recently residential development has been located at higher elevations with limited access.

Floodplains are limited to the Winooski River on the northern border of the town and a portion of Crossett Brook where Route 100 is located. Building regulations have been implemented in these areas to prevent property damage in the case of a flood.

An inventory of municipal roads has been created for the Town of Duxbury and a capital plan has been developed for 2016-2020 (2016, Town of Duxbury). The capital plan highlights three priority road erosion sites: Crossett Hill, Pleasant Street, and Camels Hump Road. Each of these roads has multiple erosion points impacting Crossett Brook and Ridley Brook. Treatment recommendations from the Capital Plan vary depending on site conditions, but include stone-lined ditch installation, gravel resurfacing, shoulder stabilization, and culvert additions.

1.2 Existing Conditions

The Town of Duxbury spans approximately 27,531 acres in Washington County, VT (Figure A2) and is primarily forested (93%) with 3% agricultural and 3% urban land use. Of that area, there are 253 acres (1%) of impervious cover.

Much of the Town of Duxbury is rural and residential, and this area contains roads that are generally unpaved with open roadside ditches. Many of these roads have steep slopes and traverse large areas. This predisposes these areas to erosion and sediment transport. Much of the older development within the Town was constructed before current stormwater standards were developed and were constructed without any or with only minimal stormwater management. This has resulted in untreated stormwater draining from developed lands directly to surface waters.

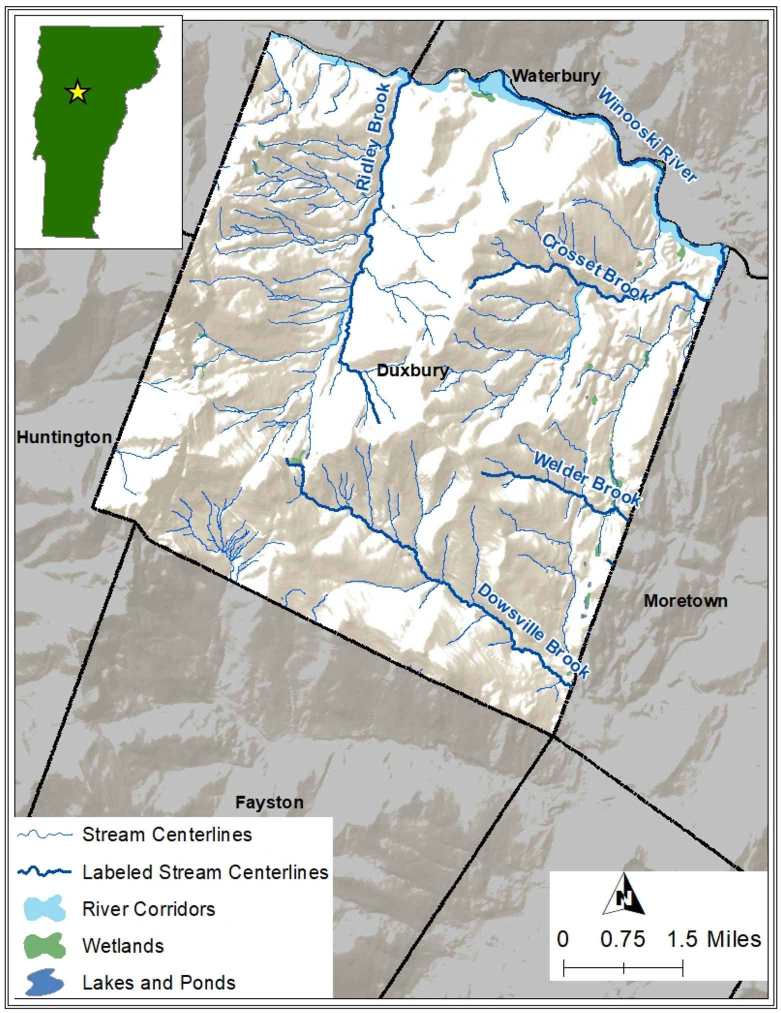


Figure A2. Duxbury is located in Washington County, VT.

Soils analyses indicate that of the 27,531 total acres in the Town, 97% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the Town, the majority of areas belong to either Hydrologic Soil Group C (46%) or D (38%), while only 4% are in group A, and 12% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix A1 – Map Atlas. Maps include:

- river corridors, wetlands, and hydric soils;
- impervious cover;
- soil infiltration potential;
- soil erodibility;
- land cover;
- slope;
- stormwater infrastructure and stormwater permits;
- and parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2018). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix A2 – Data Review.

The project team met with Town of Duxbury stakeholders, Friends of the Mad River (Friends), and the Central Vermont Regional Planning Commission (CVRPC) on December 7, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Meeting minutes from this meeting are included in Appendix A3. A second town-specific meeting was held on January 29, 2018 to identify a list of problem areas including specific parcels and general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed in order to identify additional potential sites for stormwater BMP implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. A point location was created for each identified site or area for assessment in the field.

A ‘green streets’ assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the “Promoting Green Streets” report published by the River Network (July 2016; included as Appendix A4).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.
Prerequisites:

1. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
    - ≥ 50 ft = Ideal (Score: 2 points)
    - 46-50 ft = Potential (Score: 1 point)
    - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

1. Hydrologic Soil Group (indication of infiltration potential)
   - A/B (highest infiltration potential) = Ideal (Score: 2 points)
   - B/C (moderate infiltration potential) = Potential (Score: 1 point)
   - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 2 sites with potential were noted for assessment in the field (Figure A3).

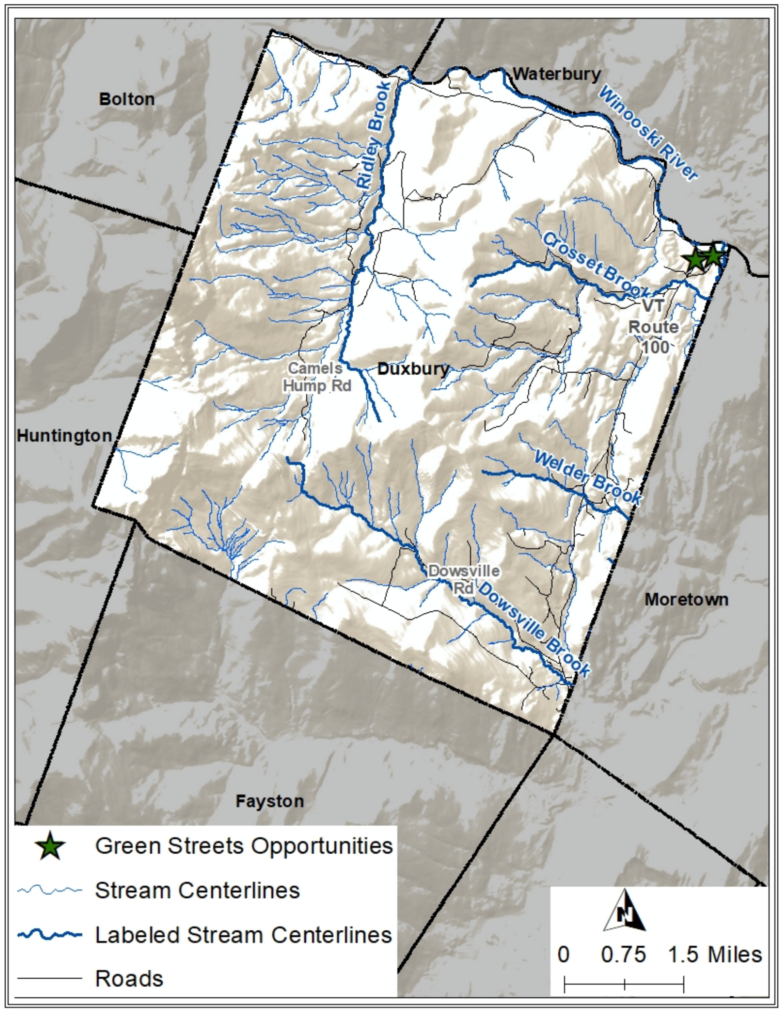


Figure A3. The 2 locations identified as potential green streets opportunities are shown with green stars.

A total of 54 locations, including the Green Streets sites, were identified for stormwater retrofit potential.

2.1.2.2 *Basemap and Mobile App Creation*

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

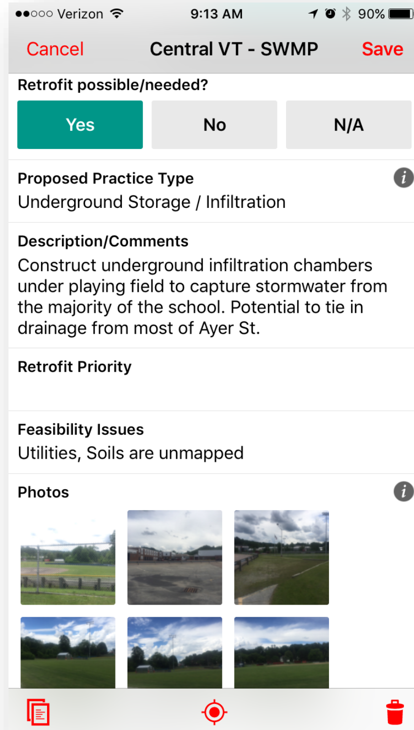


Figure A4. Example screen from data collection app.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 54-point locations for the potential BMP sites, which included both general Town-wide sites and green streets locations. These points allowed for easy site location and data collection in the field (Figure A4).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

2.1.3 Field Data Collection:

Each of the 54 previously identified potential BMP locations were evaluated in the field during the Summer of 2018 (Figure A5). Data was collected about each site in the mobile app. A large map of these sites with associated site names, and a list of these sites including potential BMP options and site notes can be found in Appendix A5 - Initial Site Identification.

Through the course of these field visits, additional stormwater retrofit sites were identified that had not been included in the initial assessment. A total of 56 sites in Duxbury were assessed as part of this plan. Some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific, prohibitive site conditions. Following this process, a total of 51 sites in Duxbury remained as potential BMP opportunities (Figure A6).

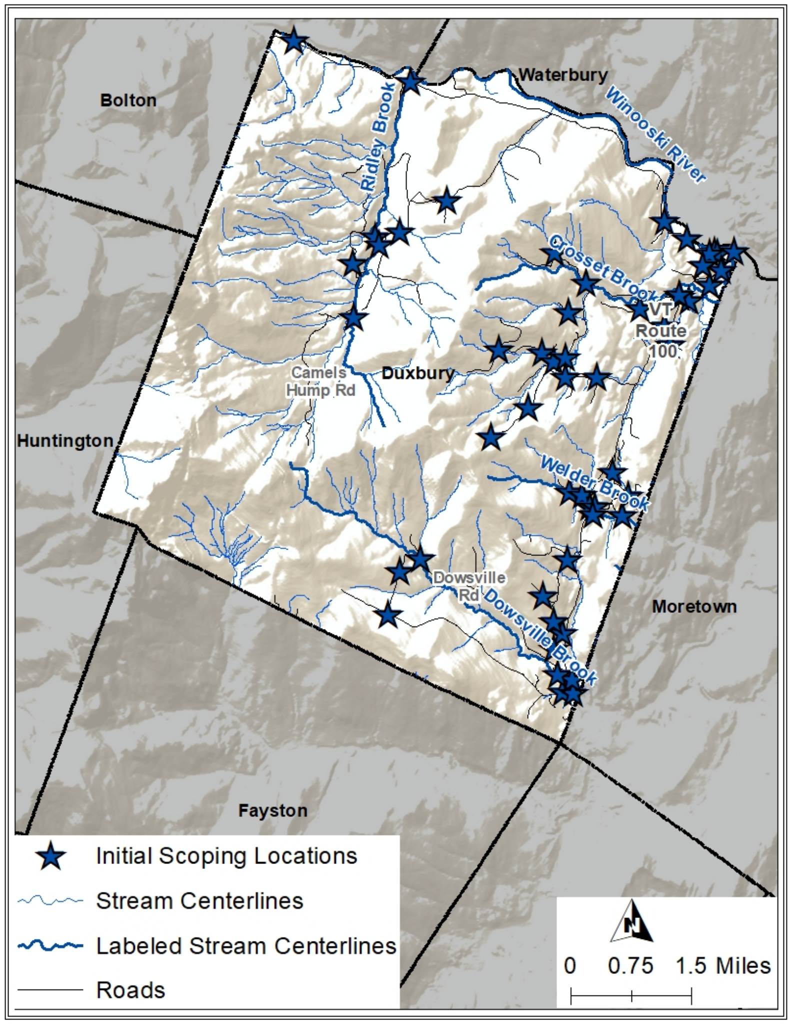


Figure A5. 54 potential sites for BMP implementation were identified for field investigation.

2.2 *Preliminary BMP Ranking*

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 51 projects (Figure A6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix A6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix A6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

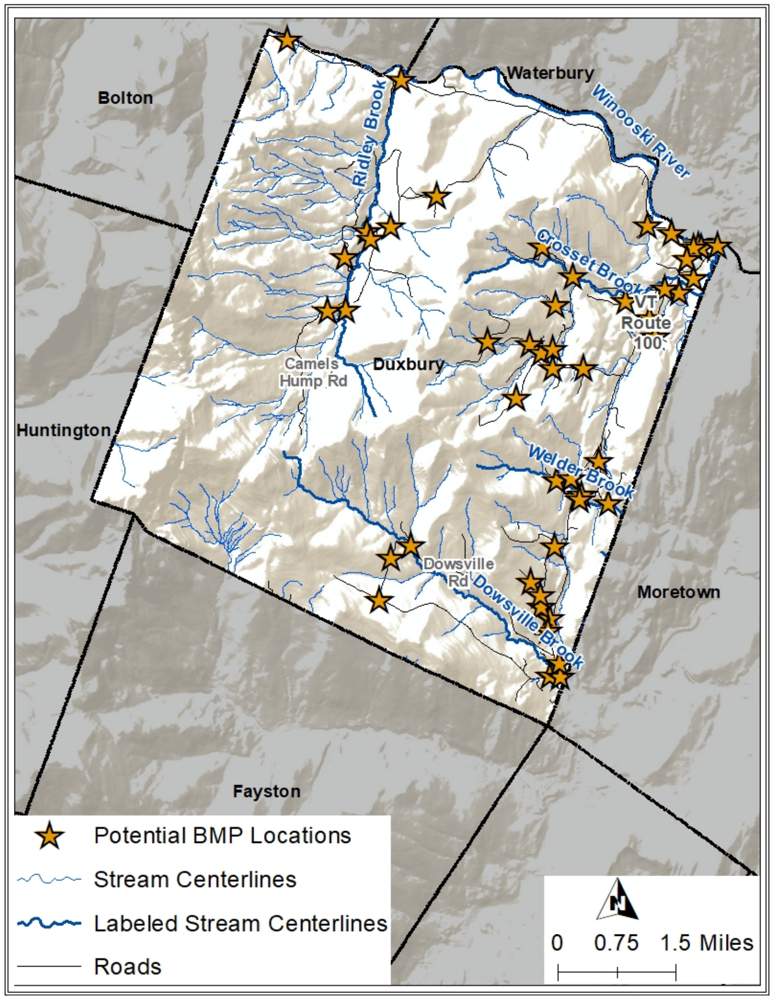


Figure A6. Following field investigations, the list of potential BMP sites was refined to 51. Point locations are shown for each site.

The draft Top 20 list was distributed to Duxbury stakeholders, the CVRPC, and Friends. As part of this process, the project team met with the stakeholders on August 21, 2018 to discuss the proposed Top 20 project sites. Following feedback from the stakeholders, the list was refined to reflect the Town's knowledge of potentially unwilling landowners and the Town's priorities. The number of BMP opportunities was reduced from 51 to 48 and the Top 20 sites were confirmed. These projects are listed in Table A1. Point locations are shown in Figure A7.

Table A1. Top 20 BMPs selected for the Duxbury SWMP.

Site ID	Proposed Practice Type
Ward Hill Rd and Route 100	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
Richardson Rd Lower	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
Turner Hill Rd South	Sediment Trap, Check Dams, Ditch / Swale Improvements, Turnouts
Dowsville Rd and Vigilante Rd	Ditch / Swale Improvements, Sediment Trap
Duxbury Town Garage	Stone-lined Swale, Bioretention
Duxbury Gravel Pit Access Drive	Ditch / Swale Improvements, Dry Wells, Infiltration Basin
Ward Hill Rd (2)	Check Dams, Ditch / Swale Improvements, Turnouts
Morse Rd	Check Dams, Ditch / Swale Improvements, Dry Wells
Hart Rd	Check Dams, Ditch / Swale Improvements, Turnouts, Dry Wells
River Rd	Check Dams, Ditch / Swale Improvements, Turnouts
Camels Hump Rd and Trail Access	Ditch / Swale Improvements, Check Dams, Turnouts, Filter Strip / Buffer Enhancement
Hayes Rd	Ditch / Swale Improvements, Check Dams, Turnouts
Westcott Rd and Crossett Hill	Ditch / Swale Improvements, Check Dams, Turnouts
Ryan Rd	Check Dams, Ditch / Swale Improvements
Ward Hill Rd (3)	Ditch / Swale Improvements, Check Dams, Turnouts
Crossett Brook Middle School	Filter Strip / Buffer Enhancement
River Rd Pull Off	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
Route 2 Winooski River Access	Filter Strip / Buffer Enhancement
Camels Hump Parking	Filter Strip / Buffer Enhancement
Pollander Rd	Ditch / Swale Improvements, Check Dams, Turnouts

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites (Figure A7). This modeling allowed for accurate sizing of the proposed practices as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and land use/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations. Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix A8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration-based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table A2. Complete modeling results are provided in Appendix A8 - Top 20 Sites Modeling.

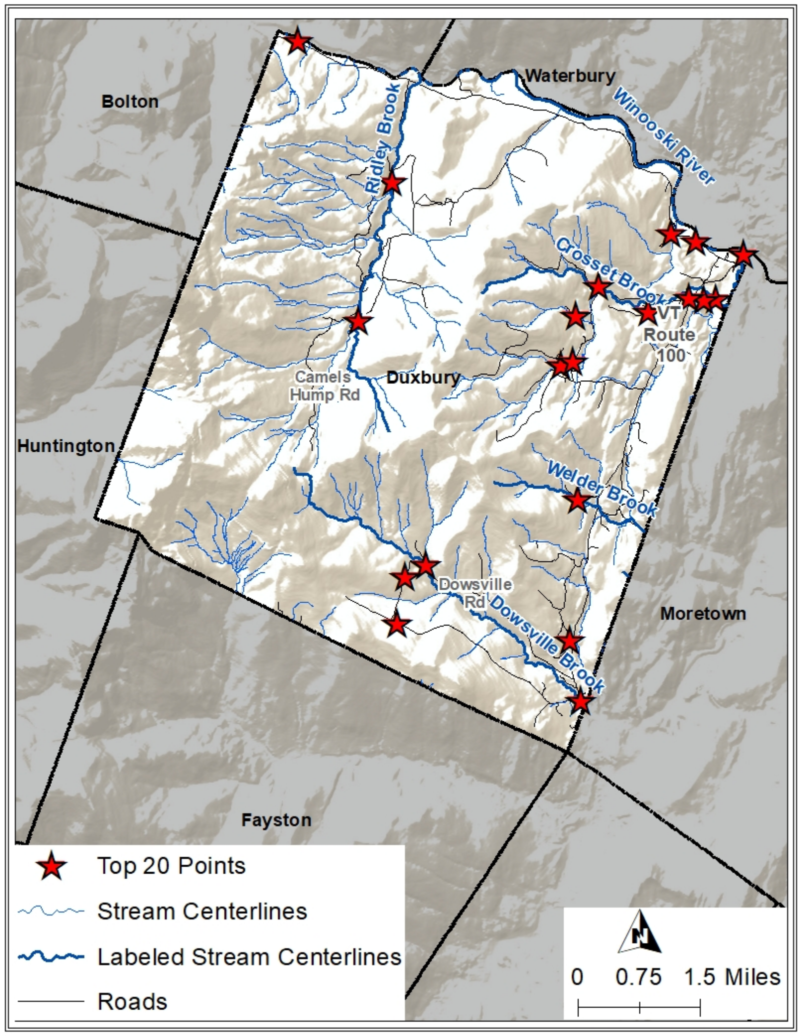


Figure A7. The Top 20 project locations are shown.

Table A2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Ward Hill Rd and Route 100	0.277	0.277	9153	94.64% (eastern section); 40.07% (western section)	6.43	96.09% (eastern section); 42.41% (western section)
Richardson Rd Lower	0.145	0.145	3785	56.79%	3.35	60.45%
Turner Hill Rd South	0.064	0.064	1625	61.15%	1.34	65.66%
Dowsville Rd and Vigilante Rd	0.031	0.031	428	65.97%	0.42	64.47%
Duxbury Town Garage	0.029	0.029	361	55.63%	0.35	54.14%
Duxbury Gravel Pit Access Drive	0.128	0.128	2029	73.13%	1.64	73.87%
Ward Hill Rd (2)	0.960	0	43360	60.00%	8.61	20.00%
Morse Rd	0.795	0	24199	60.00%	5.37	20.00%
Hart Rd	0.220	0	6077	60.00%	1.45	20.00%
River Rd	0.122	0	2868	60.00%	0.64	20.00%
Camels Hump Rd and Trail Access	0.080	0	1155	60.00%	0.35	20.00%
Hayes Rd	0.090	0	1582	60.00%	0.44	20.00%
Westcott Rd and Crossett Hill	0.089	0	1049	60.00%	0.32	20.00%
Ryan Rd	0.043	0	1381	60.00%	0.35	20.00%
Ward Hill Rd (3)	0.058	0	1558	60.00%	0.32	20.00%
Crossett Brook Middle School	0.012	0	71	65.00%	0.09	20.00%
River Rd Pull Off	0.012	0	146	60.00%	0.04	20.00%
Route 2 Winooski River Access	0.020	0	182	65.00%	0.06	20.00%
Camels Hump Parking	0.024	0	623	65.00%	0.06	20.00%
Peck Hill Rd S	0.043	0	686	60.00%	0.20	20.00%

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix A9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix A10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix A9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[1] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table A3 below.

Table A3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large above-ground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Used either 20% for large above-ground projects, or 35% for smaller or complex projects.

[1] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix A9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and their assigned rank are shown in Table A4. The comprehensive matrix used to rank the proposed BMP projects is provided in Appendix A9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table A4. Top 20 potential BMP sites for Duxbury.

Rank	Site ID	Address	Proposed Practice Type
1	Ward Hill Rd and Route 100	Ward Hill Rd, Duxbury, VT	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
2	Richardson Rd Lower	131 Richardson Rd, Duxbury, VT	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
3	Turner Hill Rd South	Turner Hill Rd and VT Route 100, Duxbury, VT	Sediment Trap, Check Dams, Ditch / Swale Improvements, Turnouts
4	Dowsville Rd and Vigilante Rd	Dowsville Rd and Vigilante Rd, Duxbury, VT	Ditch / Swale Improvements, Sediment Trap
5	Duxbury Town Garage	5421 VT Route 100, Duxbury, VT	Stone-lined Swale, Bioretention
6	Duxbury Gravel Pit Access Drive	5536 VT Route 100, Duxbury, VT	Ditch / Swale Improvements, Dry Wells, Infiltration Basin
7	Ward Hill Rd (2)	2727 Ward Hill Rd, Duxbury, VT	Check Dams, Ditch / Swale Improvements, Turnouts
8	Morse Rd	300–552 Morse Rd, Duxbury, VT	Check Dams, Ditch / Swale Improvements, Dry Wells
9	Hart Rd	Hart Rd, Duxbury, VT	Check Dams, Ditch / Swale Improvements, Turnouts, Dry Wells
10	River Rd	6182–6198 River Rd, Duxbury, VT	Check Dams, Ditch / Swale Improvements, Turnouts
11	Camels Hump Rd and Trail Access	Camels Hump Rd, Duxbury, VT	Ditch / Swale Improvements, Check Dams, Turnouts, Filter Strip / Buffer Enhancement
12	Hayes Rd	55 Hayes Rd, Duxbury, VT	Ditch / Swale Improvements, Check Dams, Turnouts
13	Westcott Rd and Crossett Hill	1267 Crossett Hl, Duxbury, VT	Ditch / Swale Improvements, Check Dams, Turnouts
14	Ryan Rd	384 Ryan Rd, Duxbury, VT	Check Dams, Ditch / Swale Improvements
15	Ward Hill Rd (3)	Ward Hill Rd, Duxbury, VT	Ditch / Swale Improvements, Check Dams, Turnouts
16	Crossett Brook Middle School	5672 VT Route 100, Duxbury, VT	Filter Strip / Buffer Enhancement
17	River Rd Pull Off	4–490 River Rd, Duxbury, VT	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
18	Route 2 Winooski River Access	563 Main St, Duxbury, VT	Filter Strip / Buffer Enhancement
19	Camels Hump Parking	Lt 3, Duxbury, VT	Filter Strip / Buffer Enhancement
20	Pollander Rd	1–499 Pollander Rd, Duxbury, VT	Ditch / Swale Improvements, Check Dams, Turnouts

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking as well as input from municipal officials concerning project priorities. The location of the sites within the Town are shown in Figure A8. In the final ranking, these 5 sites were awarded additional points in the site scoring to reflect the Town's priorities and the high probability for implementation. The Top 5 sites are listed in Table A5 in order of rank.

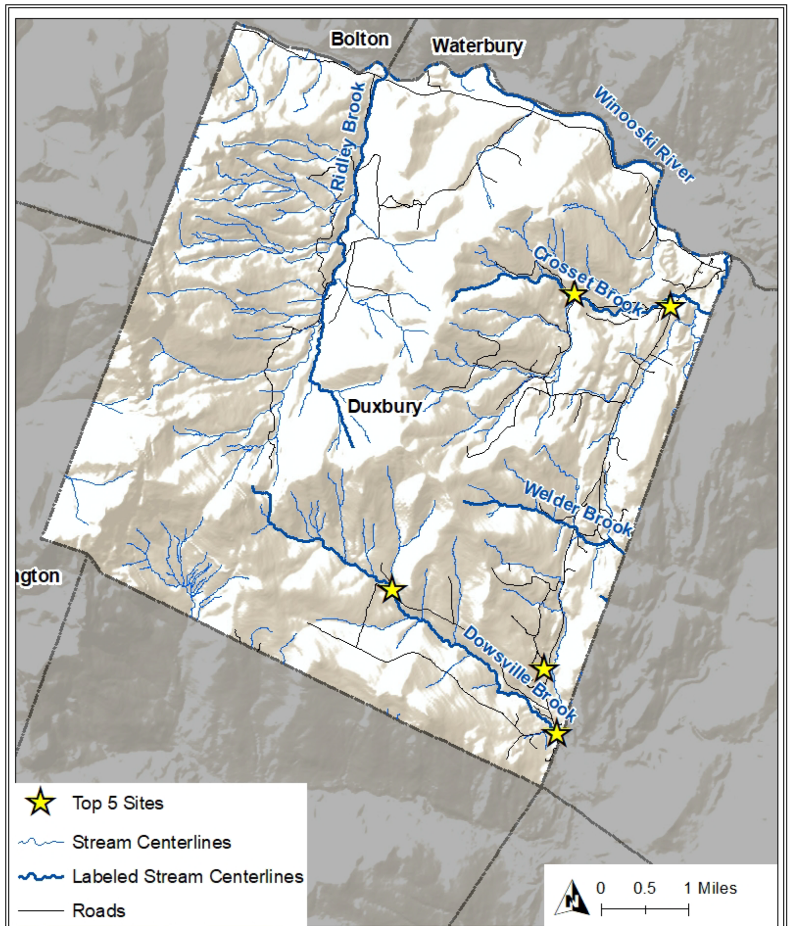


Figure A8. Top 5 sites for the Duxbury SWMP.

Table A5. Top 5 BMP sites for Duxbury.

Rank	Site ID	Address	Proposed Practice Type
1	Ward Hill Rd and Route 100	Ward Hill Rd, Duxbury, VT	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
2	Richardson Rd Lower	131 Richardson Rd, Duxbury, VT	Dry Wells, Ditch / Swale Improvements, Check Dams, Turnouts, Sediment Trap
3	Turner Hill Rd South	Turner Hill Rd and VT Route 100, Duxbury, VT	Sediment Trap, Check Dams, Ditch / Swale Improvements, Turnouts
4	Dowsville Rd and Vigilante Rd	Dowsville Rd and Vigilante Rd, Duxbury, VT	Ditch / Swale Improvements, Sediment Trap
5	Duxbury Town Garage	5421 VT Route 100, Duxbury, VT	Stone-lined Swale, Bioretention

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on Town property. A memo describing these sites and updated field data sheets are provided in Appendix A11.

Site: 1
Project Name: Ward Hill Rd and Route 100
Description: The site includes Ward Hill Rd between VT-100 and Hillcrest Ave. Stormwater is currently collected in roadside ditching and drains to Dowsville Brook. The concept for this site includes installing dry wells in roadside ditching, road regrading, stabilization of existing erosion, removal of grader berms, and expanding the existing sediment trap by the intersection with VT-100 (see Figure A9). Soils are mapped as being very good at this site (Hydrologic Group A), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed and found to be generally sandy and gravelly.
Outreach: This site is owned by the Town. However, additional outreach was conducted for the owners of 55 Ward Hill Rd. They expressed their willingness to further design.

Figure A9. General road and ditch improvements are proposed for the Ward Hill Rd and Route 100 site.

Site: 2
Project Name: Richardson Rd Lower
Description: The site includes a half-mile segment of Richardson Rd starting from the intersection with Crossett Hill Rd. Stormwater is currently collected in roadside ditching and drains to Crossett Brook. The concept for this site includes general road and ditch improvements such as dry well installations, road regrading, reducing road width, stabilization of existing erosion, and expanding the existing sediment trap at the end of Richardson Rd (see Figure A10). Soils are mapped as being good and poor at this site (Hydrologic Group B and C), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed and found to be generally loamy with a high percentage of silt and many coarse fragments.
Outreach: This site is owned by the Town, and as such, no additional outreach was carried out.

Figure A10. General road and ditch improvements are proposed for the Richardson Rd Lower site.

Site: 3
Project Name: Turner Hill Rd South
Description: The site includes a half-mile segment of Turner Hill Rd starting from the intersection with VT-100 north of Sunrise Ave. Stormwater is collected in roadside ditching and drains to a tributary of Dowsville Brook. The concept for this site includes general road and ditch improvements such as road regrading, removal of grader berms, addition of check dams, and construction of a sediment trap (see Figure A11). Soils are mapped as being poor at this site (Hydrologic Group C), so an analysis was not conducted to evaluate the potential for an infiltration practice.
Outreach: This site is owned by the Town, and as such, no additional outreach was carried out.

Figure A11. General road and ditch improvements are proposed for the Turner Hill Rd South site.

Site: 4
Project Name: Dowsville Rd and Vigilante Rd
Description: The site includes the intersection of Dowsville Rd and Vigilante Rd where Dowsville Brook passes under the road. Stormwater is currently unmanaged in this area and travels via overland flow to Dowsville Brook. The concept for this site includes construction of a sediment trap prior to the stream and stabilizing existing erosion (see Figure A12). Soils are mapped as being very good at this site (Hydrologic Group A) however, the proposed practice is not infiltration-based therefore an analysis was not conducted to evaluate the site's potential for infiltration.
Outreach: This site is owned by the Town, and as such, no additional outreach was carried out.

Figure A12. A sediment trap is proposed for the Dowsville Rd and Vigilante Rd site.

Site: 5
Project Name: Duxbury Town Garage
Description: The site includes the Duxbury Town Garage and Town Offices buildings, as well as associated driveways and parking areas. Stormwater currently sheet flows through this area and eventually drains to Crossett Brook. The concept for this site includes construction of a swale and bioretention by the lower Town Offices parking area (see Figure A13). Soils are mapped as being very poor at this site (Hydrologic Group D), so an analysis was not conducted to evaluate the site's potential for infiltration.
Outreach: This site is owned by the Town, and as such, no additional outreach was carried out.

Figure A13. A bioretention feature is proposed for the Duxbury Town Garage site.

When implemented, these five BMPs would treat approximately 66.5 acres, 4.9 acres (7%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table A6, indicate that these BMPs will prevent more than 15,000 lbs of total suspended solids and 11. lbs of total phosphorus from reaching receiving waters annually.

Table A6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Ward Hill Rd and Route 100	0.277	0.277	9153	94.64% (eastern section); 40.07% (western section)	6.43	96.09% (eastern section); 42.41% (western section)
Richardson Rd Lower	0.145	0.145	3785	56.79%	3.35	60.45%
Turner Hill Rd South	0.064	0.064	1625	61.15%	1.34	65.66%
Dowsville Rd and Vigilante Rd	0.031	0.031	428	65.97%	0.42	64.47%
Duxbury Town Garage	0.029	0.029	361	55.63%	0.35	54.14%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix A12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix A13 - 30% Designs.

Soils conditions were assessed at 2 of the top 5 sites where infiltration-based practices are proposed. Pits were manually excavated using a shovel and hand auger. Analysis at these sites included documentation of depth to water table (if applicable), horizon breaks, soil structure, type, moisture, color, presence or absence of redoximorphic features, and size and quantity of roots and coarse fragments. Any other notes considered to be important were recorded during this time. The soil profiles with photos can be found in Appendix A14.

4.1 Ward Hill Rd and Route 100

4.1.1 30% Concept Design Description

Ward Hill Rd runs east-west and connects with Route 100 at its eastern end. The unpaved road accesses residential properties, and significant erosion was noted along the road. The Town has indicated that this road has been a chronic problem area. Ward Hill Rd parallels a tributary of Dowsville Brook and is contributing significant sediment loads to the brook. Erosion and sediment deposits were noted down the bank along the side of the road nearest the stream. There is little opportunity for disconnection as the area is quite constrained. There is currently a sediment trap at the bottom of the hill on the south side of the road prior to Route 100. However, this sediment trap has filled with sediment and is overflowing along the road. There was not a controlled outlet found at the time of field investigations.

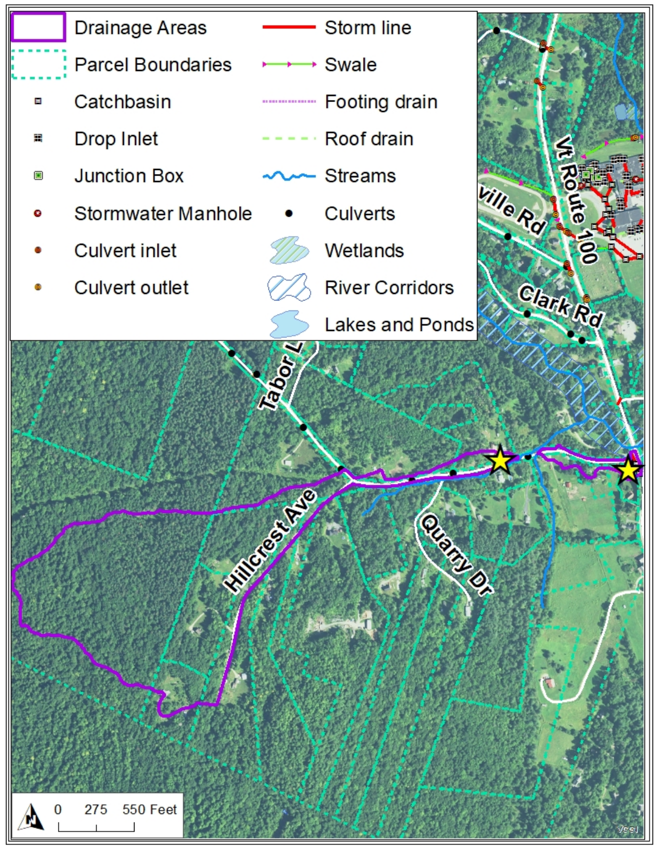


Figure A14. The proposed BMP drainage area is shown in purple. The recommended BMP locations are shown with stars.

The proposed retrofit for this site is to install dry wells in roadside ditching along Ward Hill Rd. A driveway culvert should be added at #55 Ward Hill Rd as drainage is flowing over the driveway and into the road from the ditch upstream of the driveway. The road should be recrowned to direct water towards stable ditch along road to prevent continued erosion over bank. The area by the Route 100 bridge where erosion is actively occurring should be stabilized and sediment trapped before it enters Dowsville Brook along Rte 100 (runoff from Rte 100 is contributing to this erosion). Also noted as part of this retrofit is to stabilize eroding ditches and remove any remaining grader berms. The existing sediment trap at the end of Ward Hill Rd (south side of road) would be expanded and an overflow created via grass swale to the existing catchbasin (see easternmost starred location in Figure A14). It should also be noted that there is a fairly high, steep bank that slopes up from the road above the existing catch basin. A resident along the road has noted that this bank is somewhat unstable, and final design should address the stability of the bank. See the photos and associated descriptions in Figure A16.

Stormwater is running over the road and depositing sediment where a driveway culvert is not present.

Drainage from Ward Hill Rd and Route 100 is eroding the area above Dowsville Brook at the bottom of Ward Hill Rd (north side of road).

The existing sediment trap at the bottom of Ward Hill Rd is overwhelmed by sediment and does not have a proper outlet so water runs over parking area and road (south side of Ward Hill Rd).

Significant ditch erosion is occurring along the steep Ward Hill Rd.

Figure A16. The Ward Hill Rd and Route 100 retrofit is described in the above photos.

Soils are mapped as being very good at this site (Hydrologic Group A), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger (Figure A15) and were found to be generally sandy and gravelly and appropriate for infiltration (Figure A17). The soil profile with photos can be found in Appendix A14.

Figure A15. Soils were assessed in the roadside ditch area.

Figure A17. Soils were generally sandy and gravelly.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix A16 - Site Renderings.

The design standard used for this retrofit was management of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 12,066 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent more than 9,000 lbs of total suspended solids (TSS) and 6.4 lbs of total phosphorus (TP) from entering receiving waters (Table A7). This project will provide a significant benefit to water quality.

Table A7. Ward Hill Rd and Route 100 benefit summary table.

TSS Removed	9,153 lbs
TP Removed	6.43 lbs
Impervious Treated	2.9 acres
Total Drainage Area	50.6 acres

4.1.3 Cost Estimates

The total estimated cost for this project is $39,000. These preliminary costs can be found in Table A8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $6,065.
- The cost per impervious acre treated is $13,448.
- The cost per cubic foot of runoff treated is $3.23.

Table A8. Ward Hill Rd and Route 100 project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.20	TEMPORARY EROSION MATTING	SY	280	$ 2.20	$ 616.00
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,616.00
Ditching					
	DITCH RE-SHAPING				
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	200	$ 13.59	$ 2,718.00
	MATERIALS				
	DITCH ARMORING				
613.10	STONE FILL, TYPE I	CY	90	$ 43.91	$ 3,951.90
613.11	STONE FILL, TYPE II	CY	30	$ 42.49	$ 1,274.70
613.12	STONE FILL, TYPE III	CY	20	$45.26	$ 905.20
616.35	TREATED TIMBER CURB (Timber Check Dam)	LF	60	$12.80	$ 768.00
	PIPING (CULVERTS)				
601.0915	18" CPEP (driveway culvert)	LF	20	$ 64.04	$ 1,280.80
	DRY WELLS OR OTHER STRUCTURES				
N/A	DRY WELL STRUCTURE	EACH	3	$ 2,300.00	$ 6,900.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	13.5	$ 34.04	$ 459.54
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	10	$ 43.91	$ 439.10
	DITCH BACKSLOPE EROSION CONTROL				
				Subtotal:	$ 18,697.24
Road Re-Shaping					
	RE-SHAPING				
203.40	SHOULDER BERM REMOVAL	LF	870	$ 0.38	$ 330.60
401.10	AGGREGATE SURFACE COURSE	CY	200	$ 43.60	$ 8,720.00
				Subtotal:	$ 9,050.60
Subtotal:					$ 29,363.84
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 2,936.38
	Final Design	HR	45	$ 125.00	$ 5,625.00
				Total (Rounded to nearest $1,000)	**$ 39,000.00**

4.1.4 Next Steps

As this site is owned and operated by the Town of Duxbury, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project's proximity to the river corridor. This project should be reviewed by a wetland ecologist prior to final design due to the project's proximity to hydric soils. No Act 250 permitting concerns are anticipated for this project.

4.2 Richardson Rd Lower

4.2.1 30% Concept Design Description

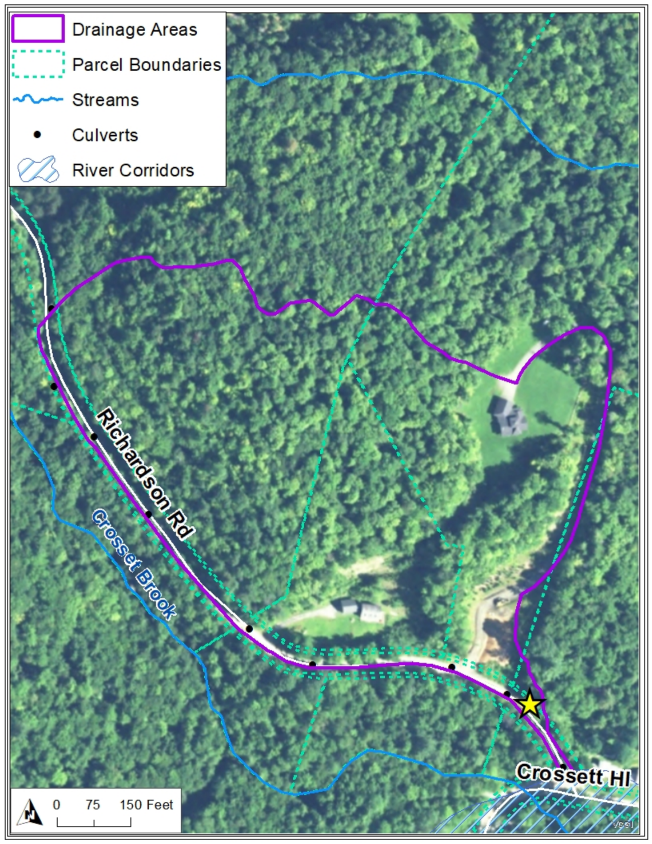


Figure A18. The drainage area for the proposed BMP is shown in purple.

Similar to Ward Hill Rd, Richardson Rd is a steep road with significant erosion issues that has been a chronic problem area for the Town. The road runs roughly north-south, paralleling Crossett Brook, and is contributing significant sediment loads to the brook. Erosion and sediment deposits were noted down the bank along the stream side of the road. There is little opportunity for disconnection as the area is quite constrained and very steep. Richardson Rd meets with Crossett Hill Rd at its southern end and dead ends at a residential property to the north. The road is an unpaved and accesses residential properties. There is currently a sediment trap at the bottom of the hill on the west side of the road prior to Crossett Hill Rd. However, this sediment trap has filled with sediment and is overflowing to the brook, transporting sediment to the stream.

The main concept for this site includes installing dry wells in roadside ditching along Richardson Rd (see site map in Figure A18). The retrofit will also involve recrowning the road to drain towards the stabilized ditch along road to prevent continued erosion over the bank. The road width can be reduced where road is over-widened, and this area should be revegetated. The existing eroding ditches should be stabilized with stone. The existing sediment trap at the south end of Richardson Rd (west side of road) should be expanded, and there should be a stable grass swale to direct the outflow from the practice to the stream. See the photos and associated descriptions in Figure A19.

The existing sediment trap at the bottom of Richardson Rd is overwhelmed by sediment and overflowing to Crossett Brook.

Drainage from Richardson Rd is eroding the road surface and forming eroded channels towards Crossett Brook.

Both Richardson Rd and residential driveways are steep and eroding.

Significant ditch erosion is occurring along the steep Richardson Rd.

Figure A19. The proposed retrofits are described in the above photos.

Figure A21. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Figure A20. Soils were generally loamy.

Soils are mapped as being good to poor at this site (Hydrologic Group B/C), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure A21) and were found to be generally loamy with a high percentage of silt and many coarse fragments (Figure A20). It should be noted that it was not possible to reach ideal depths during soil investigations due to the abundance of coarse fragments. It is recommended that further soil analysis be carried out at this site with an excavator. Soils conditions observed during analysis did not require altering the design for the proposed infiltration-based practice. The soil profile with photos can be found in Appendix A14.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix A16 - Site Renderings.

The design standard used for the infiltration basin retrofit was infiltration of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 6,316 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 3,700 lbs of total suspended solids (TSS) and 3.35 lbs of total phosphorus (TP) from entering receiving waters (Table A9).

Table A9. Richardson Rd Lower benefit summary table.

TSS Removed	3,785 lbs
TP Removed	3.35 lbs
Impervious Treated	0.9 acres
Total Drainage Area	10 acres

4.2.3 Cost Estimates

The total estimated cost for this project is $35,000. Note that these costs are very preliminary. Cost projections can be found in Table A10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $10,448.
- The cost per impervious acre treated is $38,889.
- The cost per cubic foot of runoff treated is $5.54.

Table A10. Richardson Rd Lower project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.11	CLEARING AND GRUBBING, INCLUDING INDIVIDUAL TREES AND STUMPS	ACRE	0.05	$ 33,805.52	$ 1,690.28
649.51	GEOTEXTILE FOR SILT FENCE	SY	45	$ 4.13	$ 185.85
653.20	TEMPORARY EROSION MATTING	SY	220	$ 2.20	$ 484.00
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
Subtotal:					$ 3,360.13
Sediment Trap					
203.15	COMMON EXCAVATION	CY	33	$ 9.86	$ 325.38
613.10	STONE FILL, TYPE I	CY	13	$ 43.91	$ 570.83
613.10	STONE FILL, TYPE I (OUTLET)	CY	8	$ 43.91	$ 351.28
				Subtotal:	$ 1,247.49
DRY WELLS OR OTHER STRUCTURES					
N/A	DRY WELL STRUCTURE	EACH	4	$ 2,300.00	$ 9,200.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	18	$ 34.04	$ 612.72
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	13	$ 43.91	$ 570.83
				Subtotal:	$ 10,383.55
DITCH BACKSLOPE EROSION CONTROL					
651.25	HAY MULCH	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 10,682.13
				Subtotal:	$ 25,673.29
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 2,567.33
	Final Design	HR	45	$ 125.00	$ 5,625.00
Total (Rounded to nearest $1,000)					**$ 35,000.00**

4.2.4 Next Steps

As this site is owned and operated by Duxbury, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, design, and routing to ensure that WQv can be completely managed and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.3 Turner Hill Rd South

4.3.1 30% Concept Design Description

Turner Hill Road is a steep unpaved road accessing residential properties. It meets with Route 100 at its southwestern end north of Sunrise Ave. This road is steep and has significant erosion issues that have been a chronic problem for the Town. Erosion along the road and within ditching was noted. Additionally, some areas, particularly near the intersection with Route 100, are lacking ditches, which results in erosion along the roadside. There is little opportunity for disconnection along most of the road as the area is quite constrained and steep.

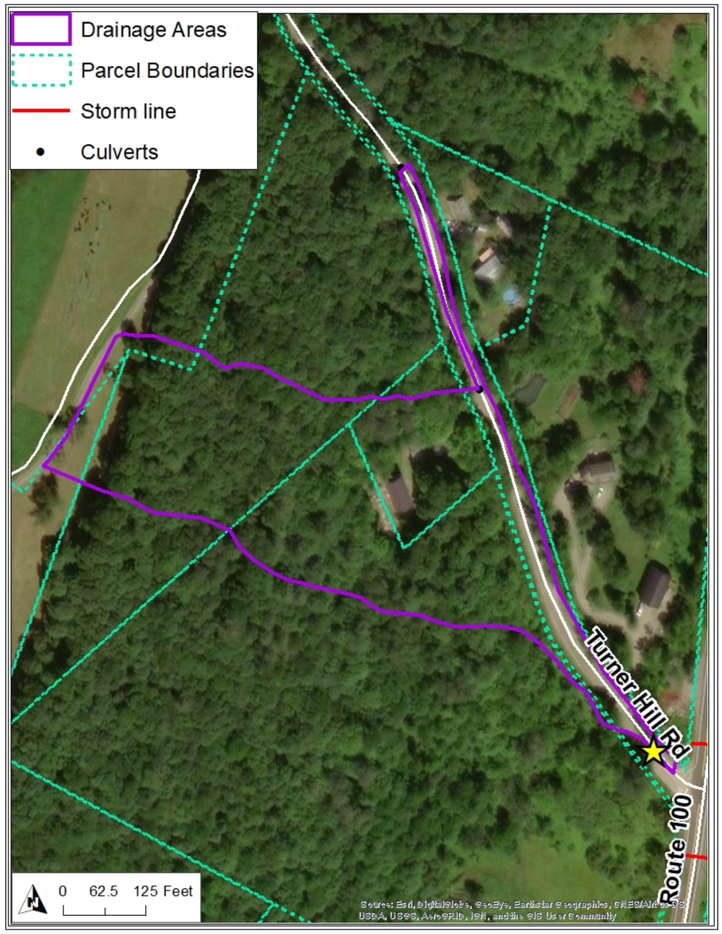


Figure A22. The drainage area is shown outlined in purple.

The proposed retrofit includes regrading and recrowning the road to better direct water off the road, ensuring that no grader berms remain, and stabilizing existing ditching and formalizing ditching where lacking (southern section of road). Also, adding timber check dams and cutting back slope in lower steep section is recommended. A sediment trap is proposed that will overflow to a turnout to the wooded area before large boulder (see starred location in Figure A22). See the photos and associated descriptions in Figure A23.

Some areas along road do not have formal ditching and erosion is occurring along roadside.

Erosion is occurring in existing ditches along road and eroded road material is collecting in ditching.

Area after large boulder where a sediment trap is proposed.

Figure A23. The proposed retrofits are described in the above photos

Soils are mapped as being poor at this site (Hydrologic Group C), so an analysis was not conducted to evaluate the potential for an infiltration practice.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town and the CVRPC to help advance designs toward implementation. This rendering can be found in Appendix A16 - Site Renderings.

This practice will provide a significant water quality benefit (see Table A11). The design standard used for this retrofit was detention and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 2,788 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 1,600 lbs of total suspended solids (TSS) and 1.34 lbs of total phosphorus (TP) from entering receiving waters annually (Table A11).

Table A11. Turner Hill Rd South benefit summary table.

TSS Removed	1,625 lbs
TP Removed	1.34 lbs
Impervious Treated	0.5 acres
Total Drainage Area	5 acres

4.3.3 Cost Estimates

The estimated cost for implementation of this project is $25,000. Note that these costs are very preliminary. Cost projections can be found in Table A12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $18,657.
- The cost per impervious acre treated is $50,000.
- The cost per cubic foot of runoff treated is $8.97.

Table A12. Turner Hill Rd South initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,000.00
Ditching					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	200	$ 13.59	$ 2,718.00
653.30	PREFABRICATED CHECK DAM	EACH	12	$ 295.79	$ 3,549.48
649.51	GEOTEXTILE FOR SILT FENCE	SY	25	$ 4.13	$ 103.25
651.25	HAY MULCH	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	450	$ 2.20	$ 990.00
613.10	STONE FILL, TYPE I	CY	150	$ 43.91	$ 6,586.50
				Subtotal:	$ 14,322.41
Level Spreader					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	5	$ 13.59	$ 67.95
616.25	PRECAST REINFORCED CONCRETE CURB, TYPE A (Level Spreader)	LF	15	$ 50.00	$ 750.00
613.10	STONE FILL, TYPE I	CY	28	$ 43.91	$ 1,229.48
				Subtotal:	$ 2,047.43
Road Re-Shaping					
401.10	AGGREGATE SURFACE COURSE	CY	125	$ 43.60	$ 5,450.00
				Subtotal:	$ 5,450.00
				Subtotal:	$ 22,819.84
	Construction Contingency - 10%**				$ 2,281.98
	Final Design	HR	10	$ 125.00	$ 1,250.00
				Total (Rounded to nearest $1,000)	**$ 25,000.00**

4.3.4 Next Steps

As this site is owned and operated by Duxbury, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, design, and routing to ensure that the WQv can be completely managed and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.4 Dowsville Rd and Vigilante Rd

4.4.1 30% Concept Design Description

This site is located near the intersection of Downsville Rd and Vigilante Rd where Dowsville Brook passes under Dowsville Rd. The unpaved road is steep in sections and is used to access residential properties. The road is very constrained, and, in many areas, even roadside ditching is not possible. At the stream crossing there is a direct connection from the drainage along the road to the brook. Evidence of significant sediment transport to the stream was noted. Additionally, sand was piled near the stream crossing on the north side of Dowsville Rd.

It is recommended that drainage is directed to a sediment trap prior to Dowsville Brook (see starred location in Figure A24). Additionally, the area before stream should be stabilized and revegetated to reduce erosion and sediment transport to the stream. There is potential to add formalized ditching along road uphill from stream crossing. Also, sand should be stored away from stream or stored in a sand shed. See the photos and associated descriptions in Figure A25.

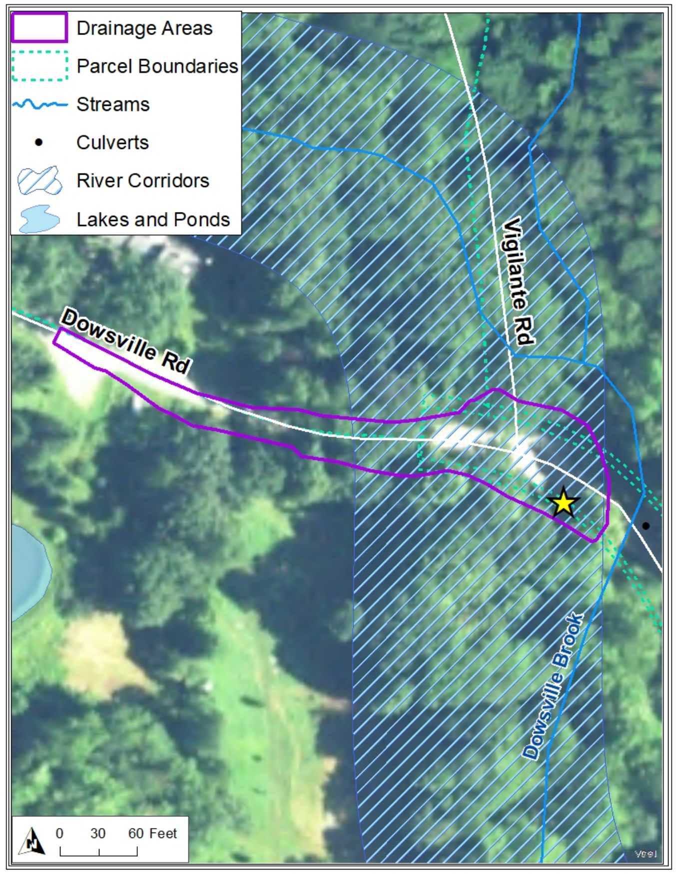
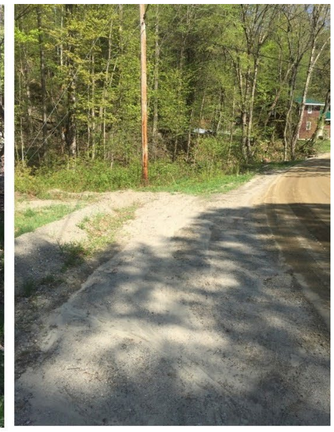


Figure A24. The proposed sediment trap is located prior to Dowsville Brook (see starred location). The area that would drain to this practice is shown with a purple outline.

Road drainage is directly connected to Dowsville Brook.

Sand is piled in pull-off by stream.

The ditch along Dowsville Rd is transporting significant sediment directly to the stream.



Evidence of water flowing down the road was noted.

Figure A25. The proposed retrofits are described in the above photos

Soils are mapped as being very good at this site (Hydrologic Group A), but the proposed practice is not infiltration-based due to the location of the stormwater-related issues to the stream. Thus, an analysis of this site's soil was not conducted to evaluate the site's potential for infiltration.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix A16 - Site Renderings.

The drainage area for this proposed BMP is 0.4 acres, approximately 50% of which is classified as impervious. This practice will provide a significant water quality benefit (Table A13) and manage a direct connection of drainage from road to stream. The design standard used for this retrofit was management of the CPv (or 2.02 inches of rain in a 24-hour period), equal to 1,350 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 428 lbs of total suspended solids (TSS) and 0.42 lbs of total phosphorus (TP) from entering receiving waters annually (Table A13).

Table A13. Dowsville Rd and Vigilante Rd benefit summary table.

TSS Removed	428 lbs
TP Removed	0.42 lbs
Impervious Treated	0.2 acre
Total Drainage Area	0.4 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $9,000. Note that these costs are very preliminary. Cost projections can be found in Table A14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $21,429.
- The cost per impervious acre treated is $45,000.
- The cost per cubic foot of runoff treated is $6.67.

Table A14. Dowsville Rd and Vigilante Rd project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
Subtotal:					$ 1,000.00
Ditching					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	45	$ 13.59	$ 611.55
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	53	$ 43.91	$ 2,327.23
601.0915	18" CPEP	LF	30	$ 64.04	$ 1,921.20
Subtotal:					$ 2,938.78
Sediment Trap					
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	11	$ 43.91	$ 483.01
203.15	COMMON EXCAVATION	CY	85	$ 9.86	$ 838.10
Subtotal:					$ 1,321.11
EROSION CONTROL					
649.51	GEOTEXTILE FOR SILT FENCE	SY	15	$ 4.13	$ 61.95
651.25	HAY MULCH	TON	0.4	$ 597.15	$ 238.86
651.15	SEED	LB	6	$ 7.66	$ 45.96
653.20	TEMPORARY EROSION MATTING	SY	100	$ 2.20	$ 220.00
Subtotal:					$ 566.77
Subtotal:					$ 5,826.66
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 582.67
	Incidentals to Construction - 5%**				$ 291.33
	Minor Additional Design Items - 5%**				$ 291.33
	Final Design	HR	16	$ 125.00	$ 2,000.00
Total (Rounded to nearest $1,000)					**$ 9,000.00**

4.4.4 Next Steps

As this site is owned and operated by the Town of Duxbury, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor. However, it should be noted that this project will not result in any net fill within the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.5 Duxbury Town Garage

4.5.1 30% Concept Design Description

The Duxbury Town Garage and Town Offices are located along Route 100 just south of the intersection with Crossett Hill Rd and Crossett Brook Middle School. This is a high visibility and high traffic area for the Town of Duxbury. Currently, much of the drainage from the site runs along the edge of the parking lot towards the Town Offices. This drainage has formed an eroding channel. Additionally, a berm has formed over time that has cut off drainage from the site from entering the roadside ditch. The water is thus running along the driveway and causing sediment deposition and erosion (see third photo from left in Figure A27 below).

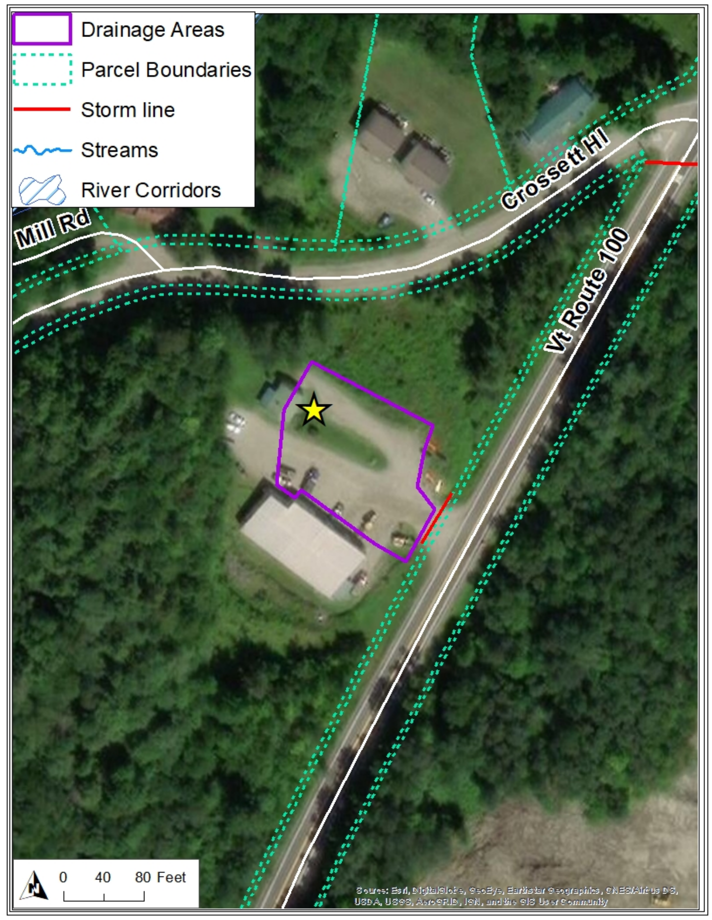


Figure A26. It is proposed that runoff from the western half of the school property, shown in red, is directed to a sand filter, and the eastern half, shown in orange, is directed to a bioretention.

The proposed stormwater improvements for this site include stabilizing the existing erosional channel into a vegetated or stone lined swale. This water should be directed around the existing greenspace to the lower Town Offices parking area (see starred location in Figure A26). It is proposed that drainage is directed to a bioretention feature. Additionally, the accumulated berm by the road should be removed to allow water to access the existing ditch. See the photos and associated descriptions in Figure A27. It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign.


Eroded swale along the parking lot edge.


Area by Town Office where practice is proposed.


A berm has formed by the entrance to the site, causing drainage to bypass the ditch and erode the driveway.


The Town Garage / Town Offices is a high visibility and high traffic site in Duxbury.

Figure A27. The proposed retrofits are described in the above photos.

Soils are mapped as being very poor at this site (Hydrologic Group D), so an analysis was not conducted to evaluate the potential for an infiltration practice.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix A16 - Site Renderings.

The drainage area for the proposed BMP is 0.4 acres, approximately 78% of which is classified as impervious. This practice will provide a significant water quality benefit (Table A15) but is also a high visibility site within the Town. This practice could spur additional retrofits and awareness of stormwater issues in the area. It is recommended that an educational sign be installed in conjunction with the retrofit.

The design standard used for this retrofit was filtration and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 1,263 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 361 lbs of total suspended solids (TSS) and 0.35 lbs of total phosphorus (TP) from entering receiving waters annually (Table A15).

Table A15. Duxbury Town Garage benefit summary table.

TSS Removed	361 lbs
TP Removed	0.35 lbs
Impervious Treated	0.3 acre
Total Drainage Area	0.4 acres

4.5.3 Cost Estimates

The total estimated cost for this project is $30,000. Note that these costs are very preliminary. Cost projections can be found in Table A16. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $85,714.
- The cost per impervious acre treated is $100,000.
- The cost per cubic foot of runoff treated is $23.75.

Table A16. Duxbury Town Garage project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	300	$ 1.17	$ 351.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	60	$ 4.13	$ 247.80
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,598.80
Bioretention - Excavation and Materials					
203.15	COMMON EXCAVATION	CY	362	$ 9.86	$ 3,569.32
651.35	TOPSOIL (BIORETENTION MEDIA)	CY	50	$ 30.96	$ 1,548.00
604.55	CAST IRON COVER WITH FRAME (RISER/OUTLET COVERS)	EACH	1	$ 762.78	$ 762.78
NA	GENERAL PLANTING PLAN	LS	1	$ 2,000.00	$ 2,000.00
New Infrastructure For Conveyance of Runoff to Practice					
613.11	STONE FILL, TYPE II	CY	18	$ 42.49	$ 764.82
601.0905	12" CPEP	LF	40	$ 39.24	$ 1,569.60
				Subtotal:	$ 10,214.52
GRASS REPLACEMENT					
651.25	HAY MULCH	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	5	$ 7.66	$ 38.30
				Subtotal:	$ 336.88
Road Re-Shaping					
203.40	SHOULDER BERM REMOVAL	LF	180	$ 0.38	$ 68.40
401.10	AGGREGATE SURFACE COURSE	CY	200	$ 43.60	$ 8,720.00
203.28	EXCAVATION OF SURFACES AND PAVEMENTS (re-grading driveway)	CY	150	$ 21.94	$ 3,291.00
				Subtotal:	$ 12,079.40
				Subtotal:	$ 24,229.60
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 2,422.96
	Final Design	HR	20	$ 125.00	$ 2,500.00
				Total (Rounded to nearest $1,000)	**$ 30,000.00**

4.5.4 Next Steps

As this site is owned and operated by the Town of Duxbury, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

B. Chapter 2: Fayston

1 Background

1.1 Problem Definition

The Town of Fayston is located in Washington County, within the Mad River watershed, including tributaries to the Mad River: Shepard Brook and Mill Brook (Figure B1). The Mad River flows into the Winooski River, which drains to Lake Champlain. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

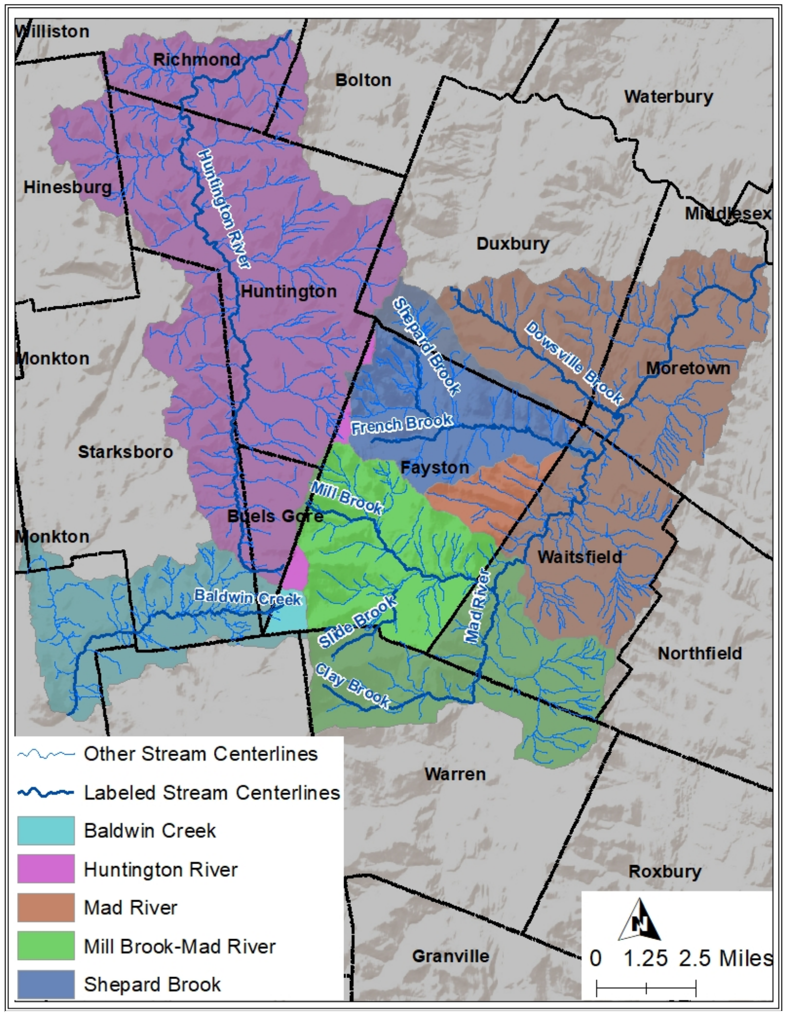


Figure B1. Fayston is located in the Mad River watershed, including Shepard Brook and Mill Brook tributaries.

Much of Fayston is comprised of steep terrain with narrow valley bottoms. Much of the land is not suitable for development or septic systems due to these limitations. Explicit plans for development, forestry, agriculture, recreation, and transportation will be needed to adequately manage for soil erosion and stormwater (2014 Fayston Town Plan).

The rural and scenic nature of Fayston is an asset the community has identified as a priority to maintain, limiting possible development. Land use is primarily forested with most development consisting of individual residences. The town has a history of agricultural land use; however, the mountainous terrain and shallow soil depths are not ideal conditions for agriculture and most agriculture is now limited to the valley floors.

Two ski resorts are also present in the town. Additional recreational use in the town is available on conserved land, which comprises 21% of the total land area, including both private and public conservation land. Further development in the town is possible in the southwest corner of the town near these ski resorts and other recreational lands.

Shepard Brook and Mill Brook are two of the largest tributaries of the Mad River. These tributaries are medium size streams in largely forested areas. Each of these tributaries can be subject to flooding following heavy rain events, causing erosion, damaging infrastructure, and transporting sediment, rocks, and tree branches. Sediment is also a threat to the town roads, bridges and culverts.

1.2 Existing Conditions

The Town of Fayston spans approximately 23,369 acres in Washington County, VT (Figure B2) and is primarily forested (90%) with 3% of the Town classified as agricultural and 3% of the Town is classified as urban. Of that area, there are 276 acres (1%) of impervious cover.

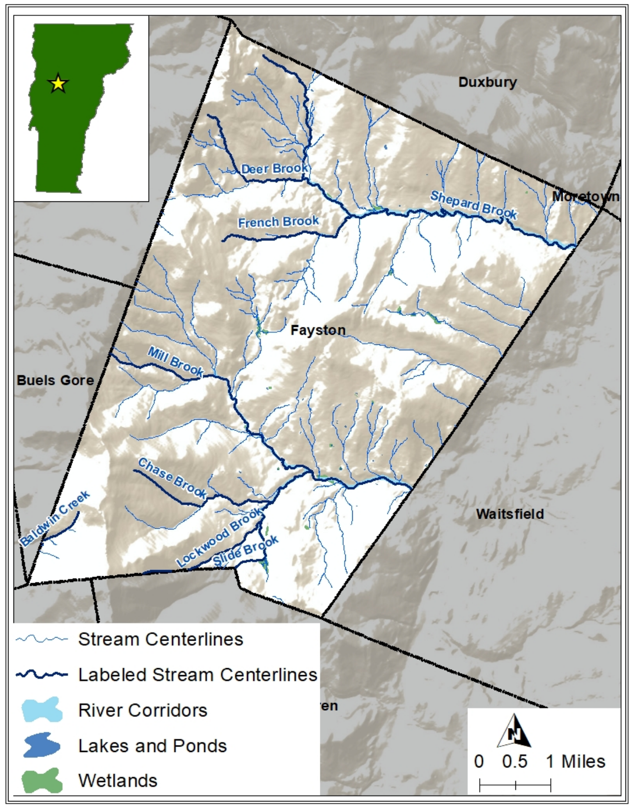


Figure B2. The Town of Fayston is located in Washington County, VT.

Many of the older developments within the Town were constructed before current stormwater standards were developed, and they were constructed without any or with only minimal stormwater management. This has resulted in untreated stormwater draining from developed lands discharging to surface waters.

Surrounding the developed lands, areas are more residential and rural. The area contains roads that are generally unpaved with open roadside ditches. Many of these roads have steep slopes and traverse large areas. This predisposes these areas to erosion and sediment transport.

Soils analyses indicate that of the 23,369 total acres in the Town, 99% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the Town, the majority of areas belong to either Hydrologic Soil Group C (40%) or D (39%), while only 3% are in group A, and 18% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly-erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix B1 – Map Atlas. Maps include:

- river corridors, wetlands, and hydric soils;
- impervious cover;
- soil infiltration potential;
- soil erodibility;
- land cover;
- slope;
- stormwater infrastructure and stormwater permits;
- and parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2018). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix B2 – Data Review.

The project team met with Town of Fayston stakeholders, Friends of the Mad River (Friends), and the Central Vermont Regional Planning Commission (CVRPC) on December 7, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Meeting minutes from this meeting are included in Appendix B3. A second town-specific meeting was held on January 10, 2018 to identify a list of problem areas including specific parcels and general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed to identify additional potential sites for stormwater best management practice (BMP) implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix B4).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.

Prerequisites:

1. Road Slope
   - 1-5% Slope = Ideal (Score: 2 points)
   - 5-7.5% Slope = Potential (Score: 1 point)
   - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
   - ≥ 50 ft = Ideal (Score: 2 points)
   - 46-50 ft = Potential (Score: 1 point)
   - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

3. Hydrologic Soil Group (indication of infiltration potential)
    - A/B (highest infiltration potential) = Ideal (Score: 2 points)
    - B/C (moderate infiltration potential) = Potential (Score: 1 point)
    - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

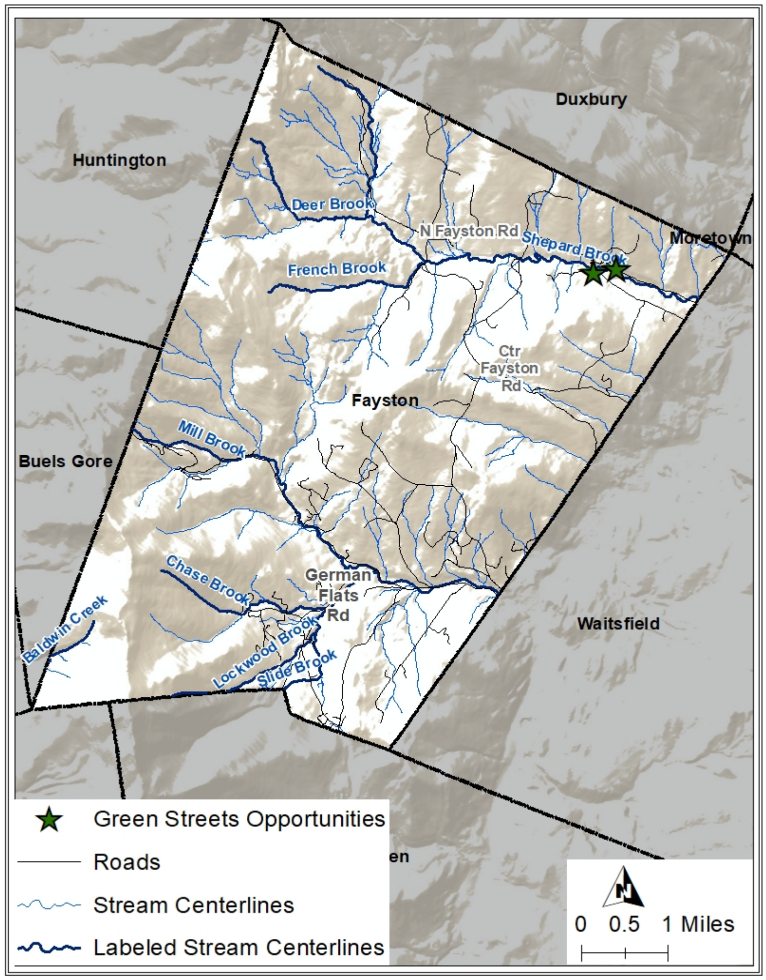


Figure B3. The 2 locations identified as potential green streets opportunities are shown with green stars.

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 2 sites with potential were noted for assessment in the field (Figure B3).

A total of 51 locations, including the Green Streets sites, were identified for stormwater retrofit potential. Note that there is a separate SWMP being completed for Chase Brook, so this area was excluded from the analysis. A map of this area is included in Appendix B5 – Initial Site Identification.

2.1.2.2 *Basemap and Mobile App Creation*

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 51-point locations for the potential BMP sites, which included Town problem areas, general Town-wide sites, and green streets locations. These points allowed for easy site location and data collection in the field (Figure B4).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

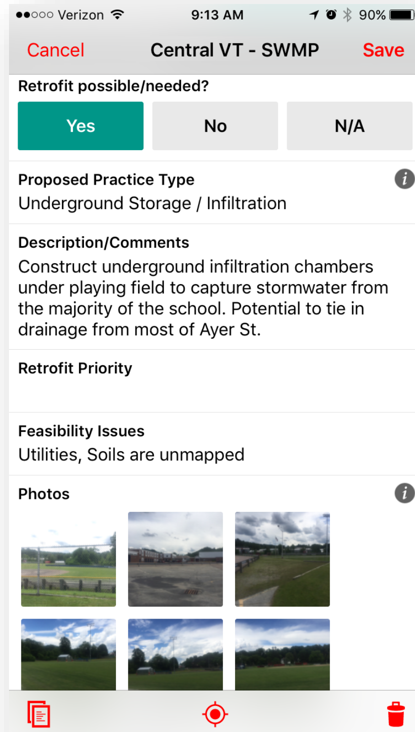


Figure B4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 51 previously identified potential BMP locations were evaluated in the field during the Summer of 2018 (Figure B5). Data was collected for each site in the mobile app. A large map of these sites with associated site names and a list of these sites including potential BMP options and site notes can be found in Appendix B5 - Initial Site Identification.

Through the course of these field visits, additional stormwater retrofit sites were identified that had not been included in the initial assessment. Some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific, prohibitive site conditions. Following this process, a total of 40 sites in Fayston remained as potential BMP opportunities.

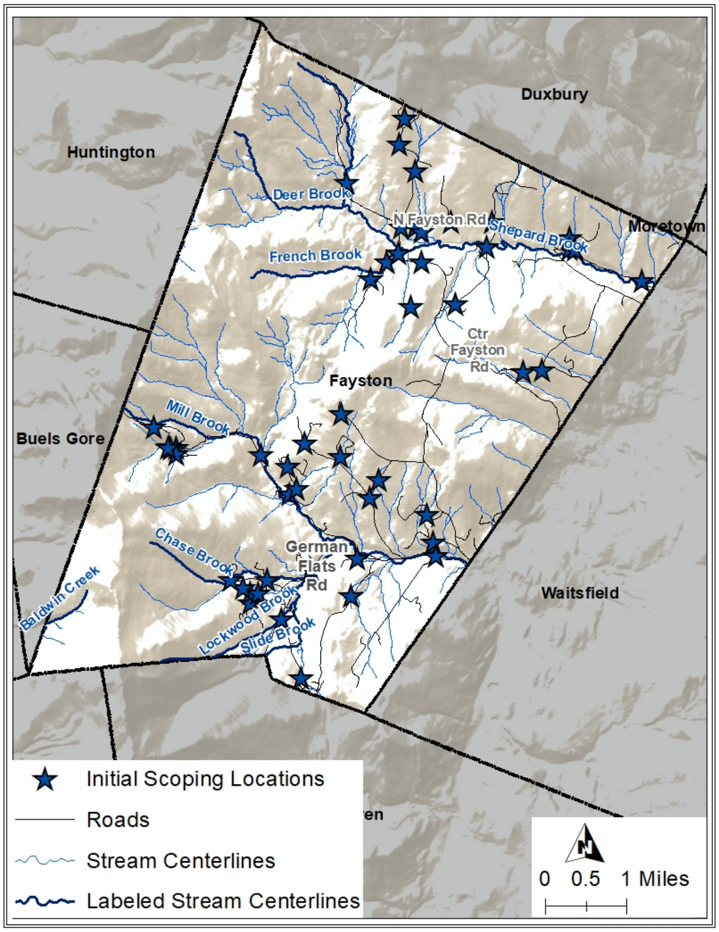


Figure B5. 51 potential sites for BMP implementation were identified for field investigation.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 40 projects (Figure B6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix B6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix B6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

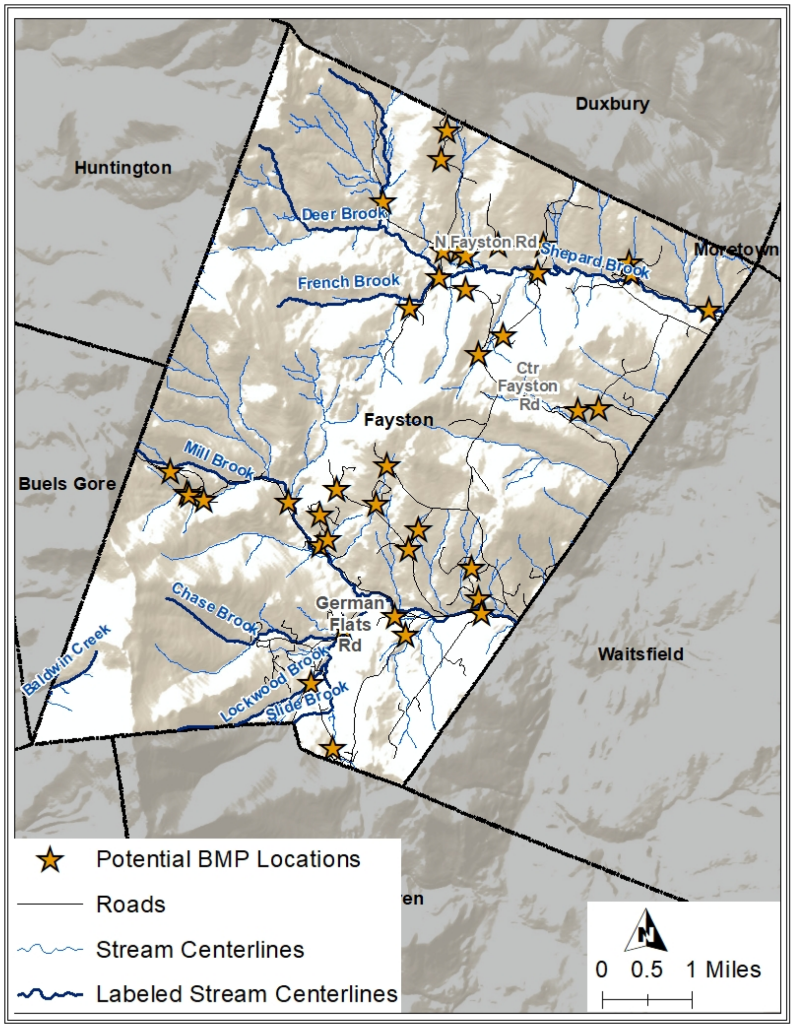


Figure B6. Following field investigations and stakeholder feedback, the list of potential BMP sites was revised to include 40 projects. Point locations are shown for each site.

The draft Top 20 list was distributed to Fayston stakeholders, the CVRPC, and Friends. As part of this process, the project team met with Fayston's stakeholders, the CVRPC, and Friends on August 24, 2018 to discuss the proposed Top 20 project sites. Following feedback from the Town, the order of the list was refined to reflect the Town's knowledge of these sites and the Town's priorities. These Top 20 sites are listed in Table B1. Point locations within the Town are shown in Figure B7.

Table B1. Top 20 BMPs selected for the Fayston SWMP.

Site ID	Proposed Practice Type
Green Mountain Valley School	Cistern / Rain Barrel, Dry Wells, Pavement Shim
Murphy Rd and Ctr Fayston Rd	Filter Strip / Buffer Enhancement, Check Dams, Turnouts, Ditch / Swale Improvements, Sediment Trap
Mansfield Rd and Stark Mtn View Rd	Sediment Trap, Ditch / Swale Improvements, Outfall Stabilization
N Fayston & Ctr Fayston Rd	Sand Filter, Sediment Trap, Ditch / Swale Improvements
Fayston Town Offices	Infiltration Basin
Fayston Town Garage & Sand Pile	Ditch / Swale Improvements, Filter Strip / Buffer Enhancement, Infiltration Basin
Center Fayston Road Upper	Ditch / Swale Improvements, Check Dams, Turnouts
Stagecoach Rd	Ditch / Swale Improvements, Check Dams, Turnouts
Smith Rd	Ditch / Swale Improvements, Turnouts, Cross Culverts
Fayston Gravel Pit	Filter Strip / Buffer Enhancement
Farm Rd	Ditch / Swale Improvements, Check Dams, Turnouts, Regrade Road
MRG - Cricket Club Building	Filter Strip / Buffer Enhancement, Sediment Trap
N Fayston Rd Stream Crossing	Ditch / Swale Improvements, Check Dams, Dry Wells
MRG - Base Area	Bioretention, Filter Strip / Buffer Enhancement, Vegetated Swale, Check Dams
Beaver Pond Rd and Randell Rd	Check Dams, Ditch / Swale Improvements
Randell Rd Stream Crossing	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts
Big Basin Rd Parking Lot	Filter Strip / Buffer Enhancement, Turnouts
N Fayston Rd Buffer	Filter Strip / Buffer Enhancement
MRG - Schuss Pass	Check Dams, Ditch / Swale Improvements, Dry Wells
Sugaring Operation Access Drive	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and land use/land cover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations. Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix B8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration-based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table B2. Complete modeling results are provided in Appendix B8 - Top 20 Sites Modeling.

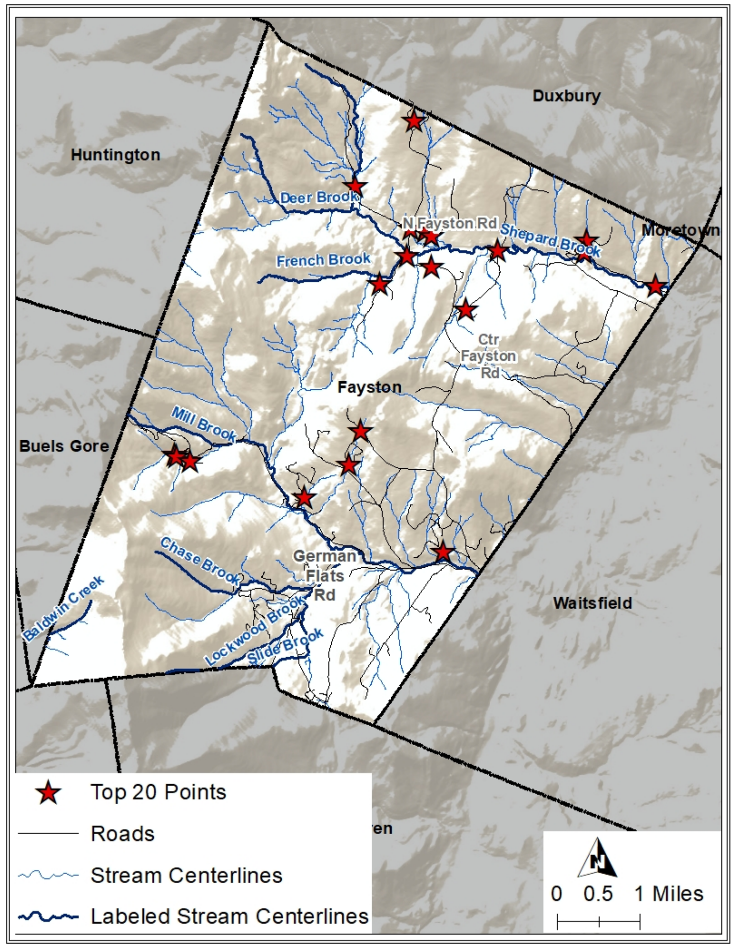


Figure B7. The Top 20 project locations are shown.

Table B2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Green Mountain Valley School	0.147	0.142	3058	70.09% (west); 100% (east); 60% (rain barrels)	2.31	72.94% (west); 100% (east); 20% (rain barrels)
Murphy Rd and Ctr Fayston Rd	0.092	0.009	3709	65% (Buffer); 49.2% (sed trap)	1.924	20% (Buffer); 40.6% (sed trap)
Mansfield Rd and Stark Mtn View Rd	0.012	0.006	5328	49.2% (sediment trap); 68.9% (stabilization)	1.66	40.6% (sediment trap); 67.3% (stabilization)
N Fayston & Ctr Fayston Rd	0.027	0.006	977	49.20%	0.85	40.60%
Fayston Town Offices	0.029	0.029	299	100.00%	0.214	100.00%
Fayston Town Garage & Sand Pile	0.227	0.227	2516	100%	1.98	100%
Center Fayston Road Upper	0.250	0	11364	60.00%	4.46	20.00%
Stagecoach Rd	0.162	0	6349	60.00%	1.60	20.00%
Smith Rd	0.250	0	5252	60.00%	1.21	20.00%
Fayston Gravel Pit	0.503	0	4209	65.00%	0.42	20.00%
Farm Rd	0.139	0	2444	60.00%	0.77	20.00%
MRG - Cricket Club Building	0.031	0.006	1492	49.20%	2.03	40.60%
N Fayston Rd Stream Crossing	0.120	0	4630	60.00%	1.06	20.00%
MRG - Base Area	0.040	0.037	2606	50.99% (west); 54.77% (east)	1.81	46.71% (west); 43.17% (east)
Beaver Pond Rd and Randell Rd	0.031	0	1096	60.00%	0.29	20.00%
Randell Rd Stream Crossing	0.027	0	274	60.00%	0.09	20.00%
Big Basin Rd Parking Lot	0.020	0	167	60.00%	0.05	20.00%
N Fayston Rd Buffer	0.022	0	594	65.00%	0.18	20.00%
MRG - Schuss Pass	0.050	0.05	517	31.86% (west); 20.92% (east)	0.44	42.03% (west); 24.16% (east)
Sugaring Operation Access Drive	0.025	0	1728	60.00%	0.46	20.00%

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix B9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix B10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix B9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[2] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table B3 below.

Table B3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large aboveground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

[2] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Permits and Engineering Costs: Used either 20% for large aboveground projects or 35% for smaller or complex projects.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix B9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices with their assigned rank are shown below in Table B4. The comprehensive ranking matrix used to rank the proposed BMP projects is provided in Appendix B9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table B4. Top 20 potential BMP sites for the Town of Fayston.

Rank	Site ID	Address	Proposed Practice Type
1	Green Mountain Valley School	311 Moulton Rd, Fayston, VT	Cistern / Rain Barrel, Dry Wells, Pavement Shim
2	Murphy Rd and Ctr Fayston Rd	Center Fayston Rd and Murphy Rd, Fayston, VT	Filter Strip / Buffer Enhancement, Check Dams, Turnouts, Ditch / Swale Improvements, Sediment Trap
3	Mansfield Rd and Stark Mtn View Rd	1–43 Stark Mountain View Rd, Fayston, VT	Sediment Trap, Ditch / Swale Improvements, Outfall Stabilization
4	N Fayston & Ctr Fayston Rd	Center Fayston Rd and N Fayston Rd, Fayston, VT	Sand Filter, Sediment Trap, Ditch / Swale Improvements
5	Fayston Town Offices	866 N Fayston Rd, Fayston, VT	Infiltration Basin
6	Fayston Town Garage & Sand Pile	41 Town Garage Rd, Fayston, VT	Ditch / Swale Improvements, Filter Strip / Buffer Enhancement, Infiltration Basin
7	Center Fayston Road Upper	3561-4083 Center Fayston Rd, Fayston, VT	Ditch / Swale Improvements, Check Dams, Turnouts
8	Stagecoach Rd	530–1030 Stagecoach Rd, Fayston, VT	Ditch / Swale Improvements, Check Dams, Turnouts
9	Smith Rd	Smith Rd, Fayston, VT	Ditch / Swale Improvements, Turnouts, Cross Culverts
10	Fayston Gravel Pit	1482 Sharpshooters Rd, Fayston, VT	Filter Strip / Buffer Enhancement
11	Farm Rd	129 Farm Rd, Fayston, VT	Ditch / Swale Improvements, Check Dams, Turnouts, Regrade Road
12	MRG - Cricket Club Building	57 Schuss Pass, Fayston, VT	Filter Strip / Buffer Enhancement, Sediment Trap
13	N Fayston Rd Stream Crossing	4008-3984 N Fayston Rd, Fayston, VT	Ditch / Swale Improvements, Check Dams, Dry Wells
14	MRG - Base Area	Mad River Resort Rd, Fayston, VT	Bioretention, Filter Strip / Buffer Enhancement, Vegetated Swale, Check Dams
15	Beaver Pond Rd and Randell Rd	1031–1223 Randell Rd, Fayston, VT	Check Dams, Ditch / Swale Improvements
16	Randell Rd Stream Crossing	343-297 Randell Rd, Fayston, VT	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts
17	Big Basin Rd Parking Lot	862-2059 Big Basin Rd, Fayston, VT	Filter Strip / Buffer Enhancement, Turnouts
18	N Fayston Rd Buffer	2380-2850 N Fayston Rd, Fayston, VT	Filter Strip / Buffer Enhancement
19	MRG - Schuss Pass	Schuss Pass, Fayston, VT	Check Dams, Ditch / Swale Improvements, Dry Wells
20	Sugaring Operation Access Drive	551-23 Murphy Rd, Fayston, VT	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking, input from municipal officials concerning project priorities, and the willingness of select private landowners to voluntarily participate in this plan. The location of the sites within the Town are shown in Figure B8. In the final ranking, these 5 sites were awarded additional points in the scoring to reflect the Town's priorities and high probability for implementation. The Top 5 sites are listed in Table B5.

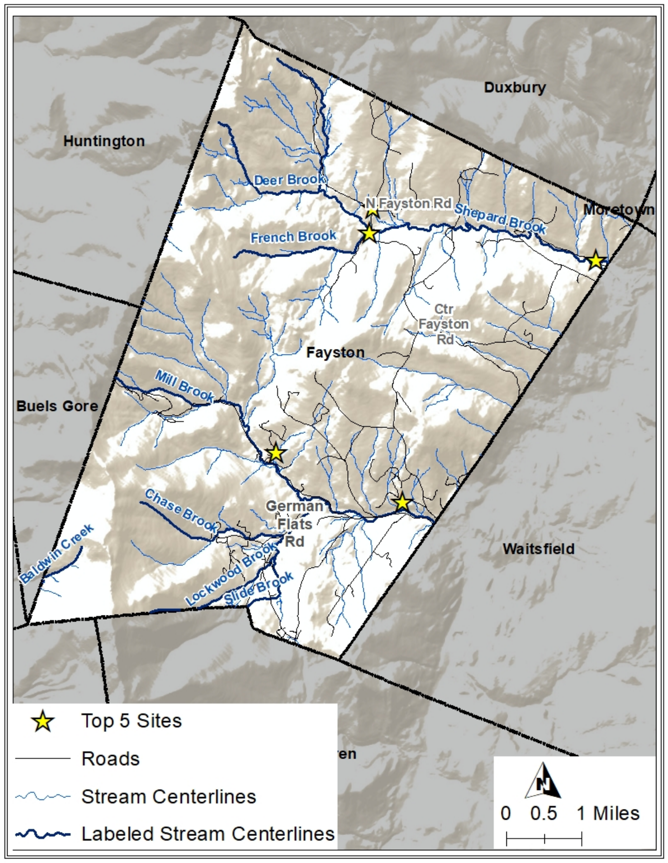


Figure B8. Top 5 sites for the Fayston SWMP.

Table B5. Top 5 BMP sites for the Town of Fayston.

Rank	Site ID	Address	Proposed Practice Type
1	Green Mountain Valley School	311 Moulton Rd, Fayston, VT	Cistern / Rain Barrel, Dry Wells, Pavement Shim
2	Murphy Rd and Ctr Fayston Rd	Center Fayston Rd and Murphy Rd, Fayston, VT	Filter Strip / Buffer Enhancement, Check Dams, Turnouts, Ditch / Swale Improvements, Sediment Trap
3	Mansfield Rd and Stark Mtn View Rd	1–43 Stark Mountain View Rd, Fayston, VT	Sediment Trap, Ditch / Swale Improvements, Outfall Stabilization
4	N Fayston & Ctr Fayston Rd	Center Fayston Rd and N Fayston Rd, Fayston, VT	Sand Filter, Sediment Trap, Ditch / Swale Improvements
5	Fayston Town Offices	866 N Fayston Rd, Fayston, VT	Infiltration Basin

3 Priority BMPs

The selected Top 5 BMP sites are briefly described below. These opportunities are located on Town property and private property. Brief descriptions of each site are provided below. A memo describing these sites and updated field data sheets are provided in Appendix B11.

Site: 1

Project Name: Green Mountain Valley School

Description: The site includes a both road drainage and the Green Mountain Valley School (GMVS) on Moulton Rd. Drainage from town road is running down westernmost parking lot edge and eroding a channel (Figure B9). The majority of runoff is coming from the Town's road, and there is potential to eliminate runoff from the road at the intersection with a dry well installation. Proposed BMPs include the following: add a pavement shim at edge of lower parking lot to direct surface flow into last bioretention prior to outlet/level spreader; alter curbing around inlet of middle bioretention to capture surface flow; install dry wells in ditching along road and direct overflow to existing stormline; excavate out area between Moulton Rd and Glen View Rd to trap sediment then direct to dry well; direct downspouts by the garden to rain barrels for watering; add dry wells to existing roadside swale along Moulton Rd to provide increased infiltration.

Figure B9. Stormwater is running over Moulton Rd and causing erosion onto GMVS property.

Outreach: The areas where the proposed retrofits are located are owned by the Town of Fayston and GMVS. Tim Harris (Assistant Head of School/COO) confirmed that GMVS is willing to move forward with further design.

Site: 2

Project Name: Murphy Rd and Ctr Fayston Rd

Description: The site includes unpaved roads accessing residential properties. The river is noticeably turbid from road drainage (Figure B10). It is partially in river corridor, and some hydric soils are mapped. Proposed BMPs included as follows: improve ditches and stabilize; direct drainage from Ctr Fayston Rd to low spot along Murphy Rd via culvert under hiking trail. Construct a sediment trap with controlled outlet in the depressed area. Redirect drainage from the east side of Ctr Fayston Rd to this practice via a new culvert. Install check dams in ditching along both sides of Ctr Fayston Rd. Potential to narrow intersection to traditional "T" intersection and revegetate area that was formerly road to provide additional filtration. As part of road narrowing, move road back from stream and plant vegetated buffer.

Outreach: The area where the proposed retrofits are located is owned by the Town of Fayston and as such no additional outreach was conducted.

Figure B10. Stormwater is running over road directly to stream and transporting sediment.

Site: 3

Project Name: Mansfield Rd and Stark Mtn View Rd

Description: The site includes an unpaved road accessing residential properties off Old Mansfield Rd. There is evidence of drainage issues, erosion, and sediment transport (Figure B11). The edge of the road is also eroding, and it is suspected that the river culvert is undersized. Erosion was noted to stream at the outlet of the existing cross culvert. Proposed BMPs for this site include as follows: regrade road to better direct water off the road surface; add check dams and turn outs along road. Ditches should be stabilized. Shave back bank that is nearly vertical and eroding into ditch; stabilize with vegetation. Stabilize erosion at culvert outlet by stream. Redirect drainage in swale around the curve in road to a sediment trap in low spot.

Outreach: The proposed sediment trap is located partially on private property owned by Thomas Studley, who has agreed to allow design to move forward. The remainder of the retrofits are on land owned by the Town of Fayston.

Figure B11. Erosion was noted within roadside ditch and at culvert outlet.

Site: 4
Project Name: N Fayston & Ctr Fayston Rd
Description: The site includes a four-way road intersection of unpaved roads near a stream crossing. The Town has noted that there have been significant drainage issues at this intersection in this past (Figure B12). Proposed BMPs for this site include as follows: Amend existing ditching to further detain and filter stormwater in existing ditching; ditch can be widened and deepened to provide additional storage. Install an outlet structure and create a sediment trap in the ditch west of the triangle intersection. It is recommended that the culvert passing under Center Fayston Rd from the triangle of greenspace should be cleaned out as it is currently clogged.
Outreach: The area where the proposed retrofits are located is owned by the Town of Fayston and as such no additional outreach was conducted.


Figure B12. Stormwater within roadside ditch is actively transporting sediment to stream.

Site: 5
Project Name: Fayston Town Offices
Description: The site includes the municipal offices and associated parking lot for the Town of Fayston off N Fayston Rd (Figure B13). This site is partially within the river corridor. Proposed BMPs for this site include as follows: construct a shallow infiltration basin in low spot between eastern edge of parking lot and Shepard Brook; regrade eastern half of driveway and parking to better direct runoff to feature.
Outreach: The area where the proposed retrofits are located is owned by the Town of Fayston and as such no additional outreach was conducted.


Figure B13. Drainage from the Town Office parking lot is currently unmanaged.

When implemented, these five BMPs would treat approximately 27.4 acres, 3.8 acres (14%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table B6, indicate that these BMPs will prevent more than 13,000 lbs of TSS and 6.8 lbs of TP from reaching receiving waters annually.

Table B6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Green Mountain Valley School	0.147	0.142	3058	70.09% (west); 100% (east); 60% (rain barrels)	2.31	72.94% (west); 100% (east); 20% (rain barrels)
Murphy Rd and Ctr Fayston Rd	0.092	0.009	3709	65% (Buffer); 49.2% (sediment trap)	1.924	20% (Buffer); 40.6% (sediment trap)
Mansfield Rd and Stark Mtn View Rd	0.012	0.006	5328	49.2% (sediment trap); 68.9% (stabilization)	1.66	40.6% (sediment trap); 67.3% (stabilization)
N Fayston & Ctr Fayston Rd	0.027	0.006	977	49.20%	0.85	40.60%
Fayston Town Offices	0.029	0.029	299	100.00%	0.214	100.00%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix B12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix B13 - 30% Designs.

Soils conditions were assessed at 2 of the top 5 sites where infiltration-based practices are proposed. Pits were manually excavated using a shovel and hand auger. Analysis at these sites included documentation of depth to water table (if applicable), horizon breaks, soil structure, type, moisture, color, presence or absence of redoximorphic features, and size and quantity of roots and coarse fragments. Any other notes considered to be important were recorded during this time. The soil profiles with photos can be found in Appendix B14.

4.1 Green Mountain Valley School

4.1.1 30% Concept Design Description

Currently, drainage is running down Glen View Rd and Moulton Rd, passing over the road, and draining down the Green Mountain Valley School access drive and over the School's parking area. Sediment deposited from this drainage was noted along the access drive, in the parking area, and in a bioretention area on the School's property. Additionally, drainage running east down Moulton Rd past the school property drains to a tributary of Mill Brook. The majority of the School's drainage is managed on their property in several distributed bioretention practices.

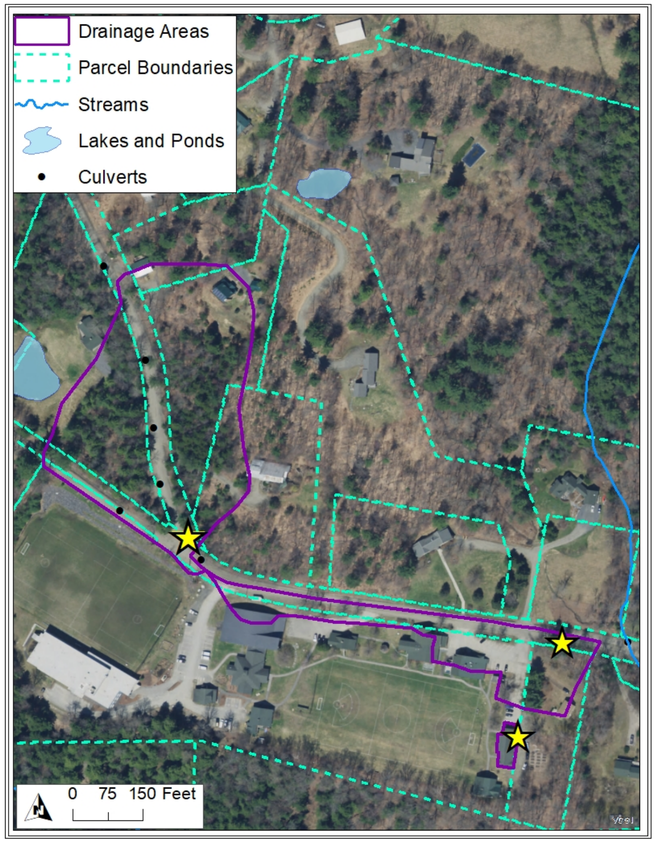


Figure B14. The proposed BMP drainage area is shown in purple. The dry well and rain barrel locations are shown with stars.

The proposed BMP for this site would be to install dry wells in ditching along road and direct overflow to existing stormline. Also, the area between Moulton Rd and Glen View Rd should be excavated to create a sediment trap then drainage directed to dry wells. Additionally, downspouts by the garden should be directed to rain barrels for watering (see southernmost starred location in Figure B14). Dry wells should also be added in the existing roadside swale along Moulton Rd to provide increased infiltration (see easternmost starred location in Figure B14). A pavement shim should be added at the edge of the lower parking lot to direct surface flow into the existing bioretention prior to outlet/level spreader. Overland flow is currently bypassing the existing bioretention area near the western side of the GMVS property (south of westernmost starred location in Figure B14), and curbing should be altered around the inlet of this bioretention to capture surface flow that is bypassing practice. See the photos and associated descriptions in Figure B15.

Drainage from the road is causing erosion along the GMVS driveway and in unpaved parking area.

Drainage from road is depositing sediment along the GMVS driveway and parking area.

Drainage from Moulton Rd and Glen View Rd is flowing over the road surface to the School's property.

A pavement shim is recommended where water is flowing over bank (see sand bags) instead of designed flow path to bioretention area.

Figure B15. The proposed retrofits are described in the above photos.

Figure B16. Soils were generally sandy and loamy.

Soils are mapped as being poor at this site (Hydrologic Group C) but were observed to be sandy during initial site visits so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed with a hand auger (Figure B17) and were found to be generally sandy and loamy (Figure B16). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. The soil profile with photos can be found in Appendix B14.

Figure B17. Soils were assessed in the roadside ditch area.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Renderings.

The design standard used for this retrofit was management of the Water Quality volume (WQv, or 1 inches of rain in a 24-hour period), equal to 6,403 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent more than 3,000 lbs of total suspended solids (TSS) and nearly 2.5 lbs of total phosphorus (TP) from entering receiving waters (Table B7).

Table B7. Green Mountain Valley School benefit summary table.

TSS Removed	3,058 lbs
TP Removed	2.31 lbs
Impervious Treated	1.7 acres
Total Drainage Area	6.2 acres

4.1.3 Cost Estimates

The total estimate cost for this project is $69,000. Note that these costs are very preliminary. Cost projections can be found in Table B8.

- The cost per pound of phosphorus treated is $29,870.
- The cost per impervious acre treated is $40,588.
- The cost per cubic foot of runoff treated is $10.78.

Table B8. Green Mountain Valley School project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.30	THINNING AND TRIMMING	ACRE	0.07	$ 11,670.04	$ 816.90
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,816.90
Erosion Control					
653.20	TEMPORARY EROSION MATTING	SY	700	$ 2.20	$ 1,540.00
651.29	STRAW MULCH	TON	1	$ 455.33	$ 455.33
649.51	GEOTEXTILE FOR SILT FENCE	SY	120	$ 4.13	$ 495.60
651.15	SEED	LB	2	$ 7.66	$ 15.32
				Subtotal:	$ 2,506.25
Dry Wells					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	235	$ 13.59	$ 3,193.65
N/A	DRY WELL STRUCTURE	EACH	12	$ 2,300.00	$ 27,600.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	36	$ 34.04	$ 1,225.44
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	27	$ 43.91	$ 1,185.57
				Subtotal:	$ 33,204.66
Paving of Parking Lot					
401.10	AGGREGATE SURFACE COURSE	CY	115	$ 43.60	$ 5,014.00
406.25	BITUMINOUS CONCRETE PAVEMENT (PAVED ROADS ONLY)	TON	105	$ 127.86	$ 13,425.30
				Subtotal:	$ 18,439.30
Rain Barrels					
NA	Rain Barrel	LS	4	$ 250.00	$ 1,000.00
				Subtotal:	$ 1,000.00
				Subtotal:	$ 56,967.11
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 5,696.71
	Final Design	HR	40	$ 125.00	$ 5,000.00
				Total (Rounded to nearest $1,000):	**$ 69,000.00**

4.1.4 Next Steps

As this site is owned and operated by GMVS and the Town of Fayston, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the school. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.2 Murphy Rd and Ctr Fayston Rd

4.2.1 30% Concept Design Description

Center Fayston Rd is a steep road that intersects with Murphy Rd to the north. Murphy Rd closely parallels French Brook, which meets with Shepard Brook close to the intersection of Center Fayston Rd and Murphy Rd. As the surface of the road is unstable, runoff from the road is very turbid and is resulting in an easily observable and significant sediment plume in the brook (pictured below in Figure B19). Both roads are used to access residential properties. Drainage along Center Fayston Rd is collected in ditches on either side of the road. The ditch on the west side of the road drains to a culvert that passes under Murphy Rd and drains directly to French Brook.

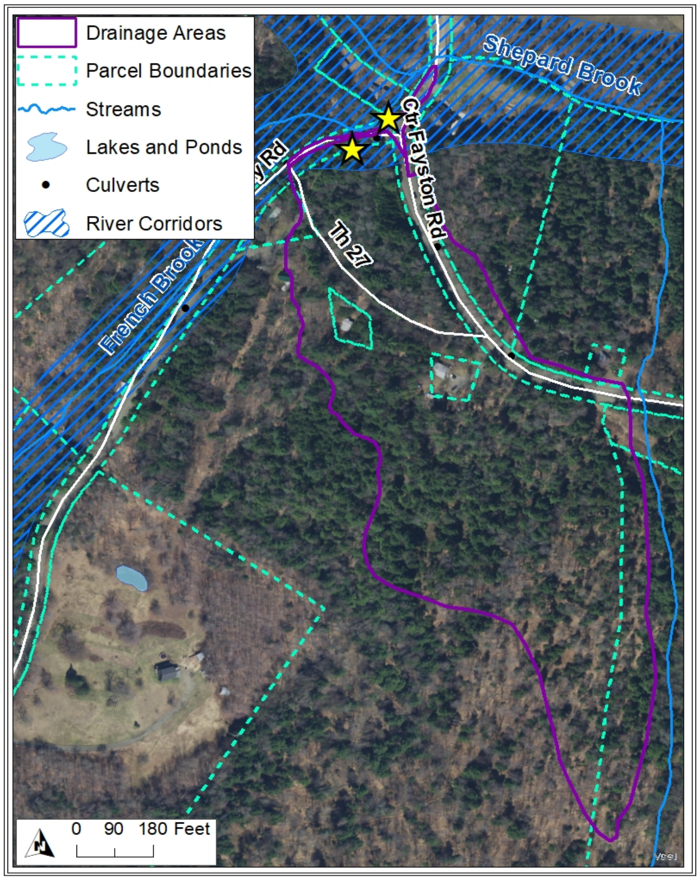


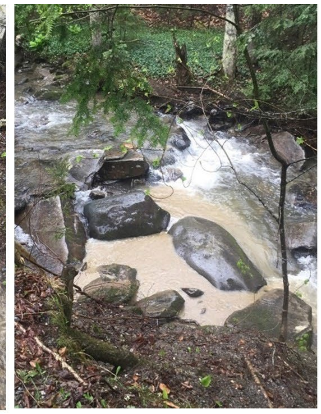
Figure B18. The proposed BMP drainage area is shown in purple. The BMP locations are shown with stars.

The retrofit for this site includes improving roadside ditching, stabilizing, and adding check dams on both sides of the road. Drainage should be redirected from Center Fayston Rd to the low spot along Murphy Rd via a new culvert under the existing hiking trail where a sediment trap with controlled outlet is proposed in this depressed area (see westernmost starred location in Figure B18). Drainage from the eastern side of Center Fayston Rd would be redirected to this practice via a new culvert. There is potential to narrow intersection to a traditional "T" intersection and revegetate area to provide additional filtration (see easternmost starred location in Figure B18). When narrowing intersection, consider moving road back from brook and planting a vegetated buffer. See the photos and associated descriptions in Figure B19.

Very turbid drainage from the road entering a culvert under Murphy Rd and discharging to French Brook.

Overland flow from road is also contributing turbid water directly to the stream.

Road drainage is causing an easily observable sediment plume in French Brook.



Drainage from the culvert under Murphy Rd (outlet is in center of photo) is causing an easily observable change in turbidity in the stream.

Figure B19. The proposed retrofits are described in the above photos.

Although soils are mapped as being good at this site (Hydrologic Group B), pooled water and field investigations suggested low infiltration potential. The proposed practice is not infiltration-based and therefore an analysis was not conducted to evaluate the site's potential for infiltration.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Renderings.

The design standard used for this retrofit was detention and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 4,008 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13- 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 3,500 lbs of total suspended solids (TSS) and more than 1.9 lbs of total phosphorus (TP) from entering receiving waters (Table B9).

Table B9. Murphy Rd and Ctr Fayston Rd benefit summary table.

TSS Removed	3,709 lbs
TP Removed	1.92 lbs
Impervious Treated	1.1 acres
Total Drainage Area	16.7 acres

4.2.3 Cost Estimates

The total estimated cost for this retrofit is $34,000. Note that these costs are very preliminary. Cost projections can be found in Table B10.

- The cost per pound of phosphorus treated is $17,708.
- The cost per impervious acre treated is $30,909.
- The cost per cubic foot of runoff treated is $8.48.

Table B10. Murphy Rd and Ctr Fayston Rd project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.11	CLEARING AND GRUBBING, INCLUDING INDIVIDUAL TREES AND STUMPS	ACRE	0.06	$ 33,805.52	$ 2,028.33
653.55	PROJECT DEMARCATION FENCE	LF	300	$ 1.17	$ 351.00
653.20	TEMPORARY EROSION MATTING	SY	275	$ 2.20	$ 605.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	20	$ 4.13	$ 82.60
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 4,066.93
Sediment Trap - Excavation and Materials					
	EXCAVATION				
203.15	COMMON EXCAVATION	CY	175	$ 9.86	$ 1,725.50
	MATERIALS				
613.10	STONE FILL, TYPE I	CY	105	$ 43.91	$ 4,610.55
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	55	$ 34.04	$ 1,872.20
649.31	GEOTEXTILE UNDER STONE FILL	SY	320	$ 2.51	$ 803.20
	PIPING				
601.0915	18" CPEP	LF	110	$ 64.04	$ 7,044.40
	INLET / OUTLET PROTECTION				
613.10	STONE FILL, TYPE II	CY	10	$ 42.49	$ 424.90
	SIDE SLOPE EROSION CONTROL				
651.25	HAY MULCH	TON	1	$597.15	$ 597.15
653.20	TEMPORARY EROSION MATTING	SY	350	$ 2.20	$ 770.00
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 17,924.50
Ditching					
	DITCH RE-SHAPING				
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	165	$ 13.59	$ 2,242.35
	CHECK DAMS				
613.10	STONE FILL, TYPE I	CY	15	$ 43.91	$ 658.65
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	5	$ 34.04	$ 170.20
				Subtotal:	$ 3,071.20
Subtotal:					$ 25,062.63
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 2,506.26
	Final Design	HR	40	$ 125.00	$ 5,000.00
Total (Rounded to nearest $1,000)					**$ 34,000.00**

4.2.4 Next Steps

As this site is owned and operated by the Town of Fayston, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor. However, it should be noted that this project will not result in any net fill within the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.3 Mansfield Rd and Stark Mtn View Rd

4.3.1 30% Concept Design Description

Mansfield Rd is a steep unpaved road used to access residential properties. The majority of the road runs north-south, but the road turns approximately 90 degrees by the intersection with Stark Mountain View Rd and runs east-west from that point until it meets with Old Mansfield Rd. At the intersection with Stark Mountain View Rd, a culvert passes under the road and discharges near a tributary of Mill Brook. This road is steep and has significant erosion issues that have caused continuous problems for the Town. Erosion along road and within roadside ditching was noted. In some areas along Mansfield Rd, the upslope banks of the ditches are nearly vertical and are eroding into the ditching.

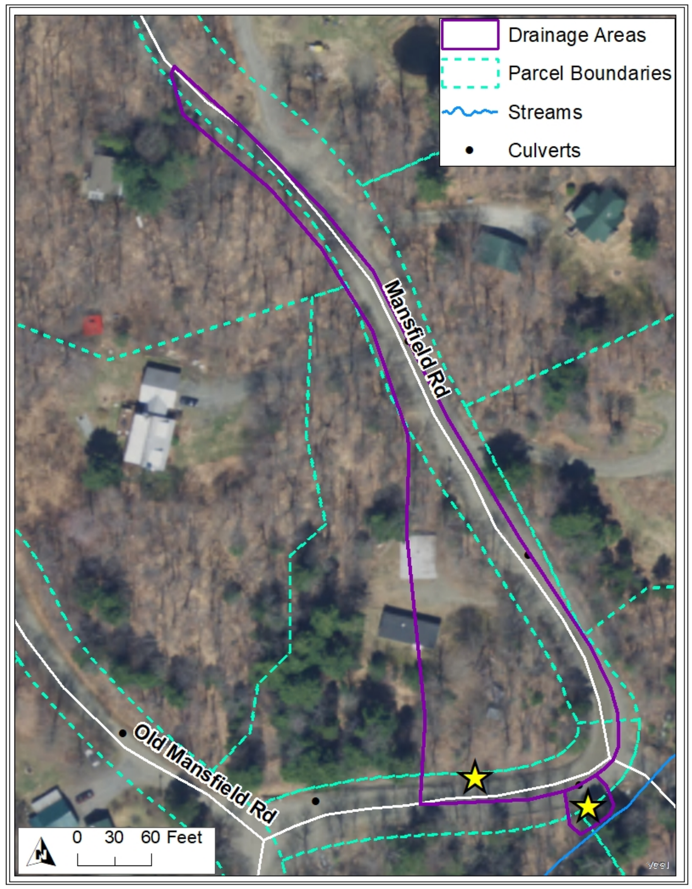
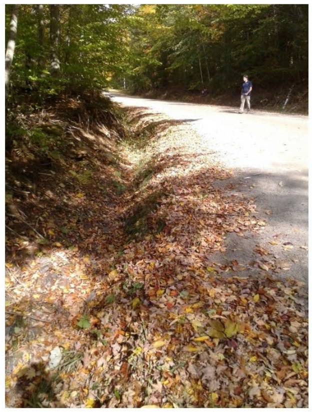


Figure B20. The drainage area for the proposed BMP is outlined in purple. The proposed BMP location is shown with a star.

The proposed retrofit for this site includes regrading the road to better direct water off the road surface, stabilizing ditching, and adding check dams and turnouts along the road where feasible. It is further recommended that bank that is nearly vertical and eroding into ditch be shaved back to reduce the slope and stabilize with vegetation. Erosion at the culvert outlet by stream should also be stabilized and the grader berm by guard rail removed. It is proposed that drainage in swale be redirected around the sharp curve in the road to a new sediment trap in an existing low spot (see westernmost starred location in Figure B20). This area is partially in the road right-of-way and partially on private property. The property owner has been contacted and is amenable to design and construction of this practice. See the photos and associated descriptions in Figure B21.

A culvert passes under Mansfield Rd towards a tributary of Mill Brook and an eroded channel has formed at the culvert outlet.



Ditching along Mansfield Rd is unstable.

In some areas along Mansfield Rd, the banks are eroding into ditches.

A significant grader berm has formed, concentrating drainage along the roadside.

Figure B21. The proposed retrofits are described in the above photos.

Soils are mapped as being poor at this site (Hydrologic Group C), so an analysis was not conducted to evaluate the potential for an infiltration practice.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Renderings.

This practice will provide a significant water quality benefit (see Table B11). The design standard used for this retrofit was filtration and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 523 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent nearly 5,500 lbs of total suspended solids (TSS) and 1.7 lbs of total phosphorus (TP) from entering receiving waters annually (Table B11).

Table B11. Mansfield Rd and Stark Mtn View Rd benefit summary table.

TSS Removed	5,328 lbs
TP Removed	1.66 lbs
Impervious Treated	0.3 acres
Total Drainage Area	1.0 acres

4.3.3 Cost Estimates

The total estimated cost for this project is $28,000. Note that these costs are very preliminary. Cost projections can be found in Table B12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $16,867.
- The cost per impervious acre treated is $93,333.
- The cost per cubic foot of runoff treated is $53.54.

Table B12. Mansfield Rd and Stark Mtn View Rd project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.11	CLEARING AND GRUBBING, INCLUDING INDIVIDUAL TREES AND STUMPS	ACRE	0.05	$ 33,805.52	$ 1,690.28
653.55	PROJECT DEMARCATION FENCE	LF	160	$ 1.17	$ 187.20
653.20	TEMPORARY EROSION MATTING	SY		$ 2.20	$ -
649.51	GEOTEXTILE FOR SILT FENCE	SY		$ 4.13	$ -
N/A	CONSTRUCTION STAKING	HR	6	$ 125.00	$ 750.00
				Subtotal:	$ 3,127.48
Sediment Trap - Excavation and Materials					
	EXCAVATION				
203.15	COMMON EXCAVATION	CY	60	$ 9.86	$ 591.60
	MATERIALS				
613.10	STONE FILL, TYPE I	CY	30	$ 43.91	$ 1,317.30
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	7	$ 34.04	$ 238.28
649.31	GEOTEXTILE UNDER STONE FILL	SY	60	$ 2.51	$ 150.60
	INLET / OUTLET PROTECTION				
613.10	STONE FILL, TYPE II	CY	14	$ 42.49	$ 594.86
	SIDE SLOPE EROSION CONTROL				
651.29	STRAW MULCH	TON	1	$ 455.33	$ 455.33
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	60	$ 2.20	$ 132.00
				Subtotal:	$ 3,556.57
Ditching					
	DITCH RE-SHAPING				
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	70	$ 13.59	$ 951.30
613.10	STONE FILL, TYPE I	CY	72	$ 43.91	$ 3,161.52
	CHECK DAMS				
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	3	$ 34.04	$ 102.12
613.10	STONE FILL, TYPE I	CY	10	$ 43.91	$ 439.10
	STRUCTURES AND APPURTENANCES				
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	1	$ 4,009.29	$ 4,009.29
	PIPING				
601.0915	18" CPEP	LF	40	$ 64.04	$ 2,561.60
	STABILIZATION OF OUTLET				
613.10	STONE FILL, TYPE II	CY	20	$ 42.49	$ 849.80
				Subtotal:	$ 12,074.73
Road Re-Shaping					
	RE-SHAPING				
203.40	SHOULDER BERM REMOVAL	LF	160	$ 0.38	$ 60.80
401.10	AGGREGATE SURFACE COURSE	CY	25	$ 43.60	$ 1,090.00
				Subtotal:	$ 1,150.80
	Subtotal:				$ 19,909.58
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 1,990.96
	Final Design	HR	40	$ 125.00	$ 5,000.00
				Total (Rounded to nearest $1,000)	**$ 28,000.00**

4.3.4 Next Steps

As this site is owned by Thomas Studley and the Town of Fayston, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This site should be reviewed by a State River Scientist prior to final design due to the project's proximity to surface waters. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.4 N Fayston & Ctr Fayston Rd

4.4.1 30% Concept Design Description

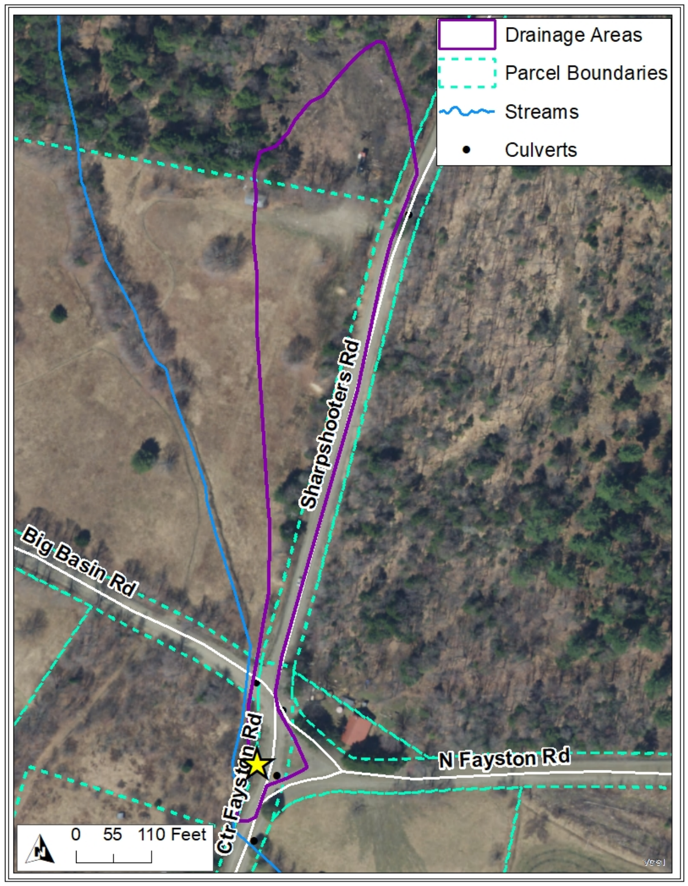


Figure B22. The two proposed sediment traps are shown with yellow stars. The drainage areas for these two practices are shown in orange (west) and red (east).

Drainage issues were noted at a 4-way intersection with a triangle of greenspace. The roads at this intersection are Sharpshooter Rd to the north, Big Basin Rd to the west, N Fayston Rd to the east, and Center Fayston Rd to the south. Each of these roads are unpaved and used to access residential areas, except for Sharpshooter Rd which accesses the Fayston Gravel Pit. Drainage from these roads is noticeably turbid. Drainage from the lower (southern) section of Sharpshooter Rd enters a roadside ditch and passes through a culvert under Big Basin Rd. Drainage from Center Fayston Rd runs along the road, into the triangle of greenspace to the low point in the southern corner, and then passes under Center Fayston Rd to an existing ditch. Currently, this culvert is clogged with sediment and causes ponding. The drainage discharges to a tributary of Shepard Brook across Center Fayston Rd. The water in this tributary is turbid during rain events as a result of this road drainage (see third photo from left below in Figure B23).

The proposed retrofit for this area includes amending existing ditching to further detain and filter stormwater in existing ditching. The ditch can be widened and deepened to provide additional storage (see starred locations in Figure B22). It is recommended that an outlet structure be installed and a sediment trap created in the ditch west of the triangle intersection. It is further recommended that the culvert passing under Center Fayston Rd from the triangle of greenspace should be cleaned out as it is currently clogged. See the photos and associated descriptions in Figure B23.

Turbid drainage from the road entering a culvert under Big Basin Rd.

Drainage from Center Fayston Rd runs along the triangle greenspace to a culvert near the wooden post.

Drainage from the swale along Center Fayston Rd is discharging turbid water to a tributary of Shepard Brook.

Runoff from Sharpshooters Rd is turbid as it runs south in the ditch.

Figure B23. The proposed retrofits are described in the above photos.

Soils are mapped as being poor (Hydrologic Group C), so an analysis was not conducted to evaluate the potential for an infiltration practice.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Renderings.

This practice will provide a significant water quality benefit (Table B13). The design standard used for this retrofit was filtration and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 1,176 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent nearly 1,000 lbs of total suspended solids (TSS) and 0.85 lbs of total phosphorus (TP) from entering receiving waters annually (Table B13).

Table B13. N Fayston & Ctr Fayston Rd benefit summary table.

TSS Removed	977 lbs
TP Removed	0.85 lbs
Impervious Treated	0.6 acres
Total Drainage Area	3 acres

4.4.3 Cost Estimates

The total estimated cost for this project is $20,000. Note that these costs are very preliminary. Cost projections can be found in Table B14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $23,529.
- The cost per impervious acre treated is $33,333.
- The cost per cubic foot of runoff treated is $17.01.

Table B14. N Fayston & Ctr Fayston Rd project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	350	$ 1.17	$ 409.50
653.20	TEMPORARY EROSION MATTING	SY	200	$ 2.20	$ 440.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	86	$ 4.13	$ 355.18
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 2,204.68
Sediment Trap - Excavation and Materials					
	EXCAVATION				
203.15	COMMON EXCAVATION	CY	370	$ 9.86	$ 3,648.20
	MATERIALS				
613.10	STONE FILL, TYPE I	CY	75	$ 43.91	$ 3,293.25
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	35	$ 34.04	$ 1,191.40
649.31	GEOTEXTILE UNDER STONE FILL	SY	225	$ 2.51	$ 564.75
	INLET / OUTLET PROTECTION				
613.10	STONE FILL, TYPE I	CY	8	$ 43.91	$ 351.28
	SIDE SLOPE EROSION CONTROL				
651.29	STRAW MULCH	TON	1	$ 455.33	$ 455.33
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	35	$ 2.20	$ 77.00
	STRUCTURES AND APPURTENANCES				
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	1	$ 4,009.29	$ 4,009.29
				Subtotal:	$ 9,504.21
STABILIZATION OF OUTLET					
NA	PRECAST CONCRETE HEADWALL	LS	1	$ 500.00	$ 500.00
613.10	STONE FILL, TYPE I	CY	17	$ 43.91	$ 746.47
				Subtotal:	$ 1,246.47
				Subtotal:	$ 12,955.36
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 1,295.54
	Final Design	HR	35	$ 125.00	$ 4,375.00
				Total (Rounded to nearest $1,000)	**$ 20,000.00**

4.4.4 Next Steps

As this site is owned and operated by the Town of Fayston, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by the River Scientist prior to final design due to its proximity to surface waters. No other permitting concerns are anticipated for this project.

4.5 Fayston Town Offices

4.5.1 30% Concept Design Description

The Fayston Town Offices are located on North Fayston Rd just northwest of where Shepard Brook passes under North Fayston Rd. This is a high visibility and high traffic area for the Town of Fayston. Currently, drainage from the southeastern section of the site runs over the parking lot and to an unvegetated channel in the southeasternmost corner of the parking lot (see leftmost photo in Figure B25). There is nuisance puddling in the parking area (see second photo from left in Figure B25).

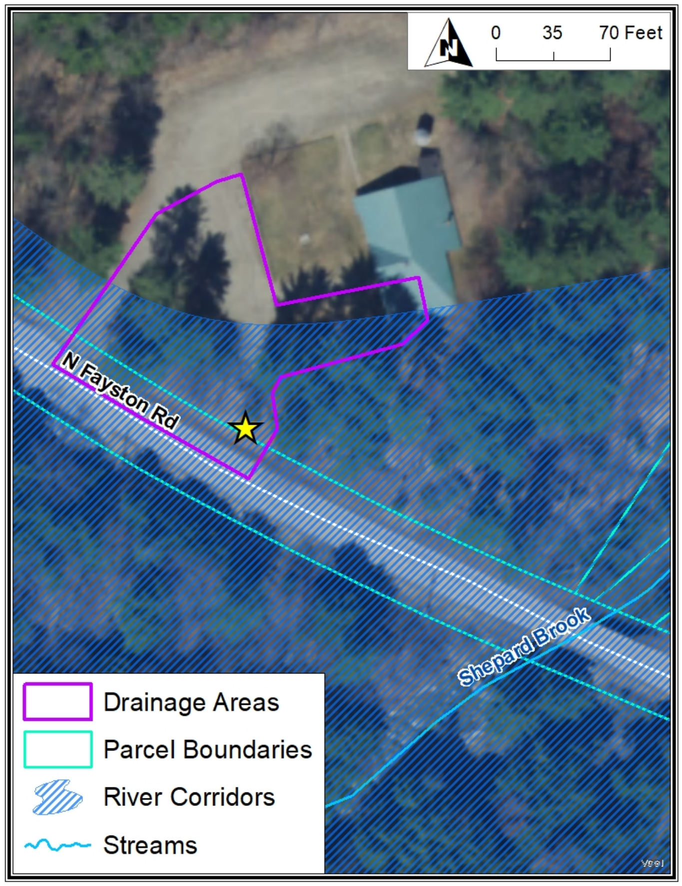


Figure B24. The proposed BMP drainage area is shown in purple. The BMP location is shown with a star.

To decrease drainage from this site to Shepard Brook, it is recommended that a shallow infiltration basin is implemented in the area of the existing unvegetated channel just beyond the edge of the parking lot (see starred location in Figure B24). The eastern portion of the driveway and parking lot should be regraded to direct drainage to this feature. See the photos and associated descriptions in Figure B25. It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign.

Drainage from the parking lot enters a bare soil channel and discharges to Shepard Brook along N Fayston Rd.

The parking lot experiences nuisance puddling.

Drainage from the entryway to the site is combined with parking lot runoff and drains to Shepard Brook.

The Town Offices site is a high visibility area for the Town.

Figure B25. The proposed retrofits are described in the above photos.

Figure B27. Soils were assessed using a hand auger and shovel.

Soils are mapped as being very good at this site (Hydrologic Group A), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure B27) and were found to be generally sandy and gravelly (Figure B26). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix B14 for this site's complete soil log.

Figure B26. Soils were generally sandy and gravelly.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Renderings.

The design standard used for this retrofit was infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 1,263 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 299 lbs of total suspended solids (TSS) and 0.21 lbs of total phosphorus (TP) from entering receiving waters annually (Table B15). However, importantly, the retrofits in this location also have the potential to raise awareness of stormwater issues in the Town, as the proposed location for the practice has high visibility. It is recommended that an educational sign be installed in conjunction with the retrofits.

Table B15. Fayston Town Offices benefit summary table.

TSS Removed	299 lbs
TP Removed	0.21 lbs
Impervious Treated	0.2 acres
Total Drainage Area	0.44 acres

4.5.3 Cost Estimates

The total estimated cost for this project is $7,000. Note that these costs are very preliminary. Cost projections can be found in Table B16. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $32,649.
- The cost per impervious acre treated is $35,000.
- The cost per cubic foot of runoff treated is $5.54.

Table B16. Fayston Town Offices project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	150	$ 1.17	$ 175.50
649.51	GEOTEXTILE FOR SILT FENCE	SY	60	$ 4.13	$ 247.80
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,423.30
Infiltration Basin					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	50	$ 9.86	$ 493.00
651.35	TOPSOIL	CY	10	$ 30.96	$ 309.60
612.10	STONE FILL, TYPE I	CY	3	$ 42.49	$ 127.47
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	5	$ 34.04	$ 170.20
649.31	GEOTEXTILE UNDER STONE FILL	SY	130	$ 2.51	$ 326.30
651.25	HAY MULCH	TON	0.4	$ 597.15	$ 238.86
651.15	SEED	LB	5	$ 7.66	$ 38.30
				Subtotal:	$ 1,426.57
Driveway Resurface					
401.10	AGGREGATE SURFACE COURSE	CY	40	$ 43.60	$ 1,744.00
				Subtotal:	$ 1,744.00
Swale					
CONVEYANCE					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	18	$ 13.59	$ 244.62
651.15	SEED	LB	2	$ 7.66	$ 15.32
				Subtotal:	$ 259.94
Subtotal:					$ 4,593.87
	Construction Oversight**	HR	6	$ 125.00	$ 750.00
	Construction Contingency - 10%**				$ 459.39
	Final Design	HR	12	$ 125.00	$ 1,500.00
Total (Rounded to nearest $1,000)					**$ 7,000.00**

4.5.4 Next Steps

As this site is owned and operated by the Town of Fayston, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B15 - Permit Review Sheets. In summary:

Stormwater Permit
This site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. The parcel, as a whole, contains more than 3 acres of impervious cover, so this site would necessitate a permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by the River Scientist prior to final design due to its location in the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

C. Chapter 3: Moretown

1 Background

1.1 Problem Definition

The Town of Moretown is located in Washington County primarily within the Mad River watershed, a tributary of the Winooski River (Figure C1). Portions of the town are also in the Great Brook-Winooski River and Dog River watersheds. All these watersheds are tributaries of the Winooski River, which forms the northern border of the town. The Winooski River ultimately drains into Lake Champlain. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

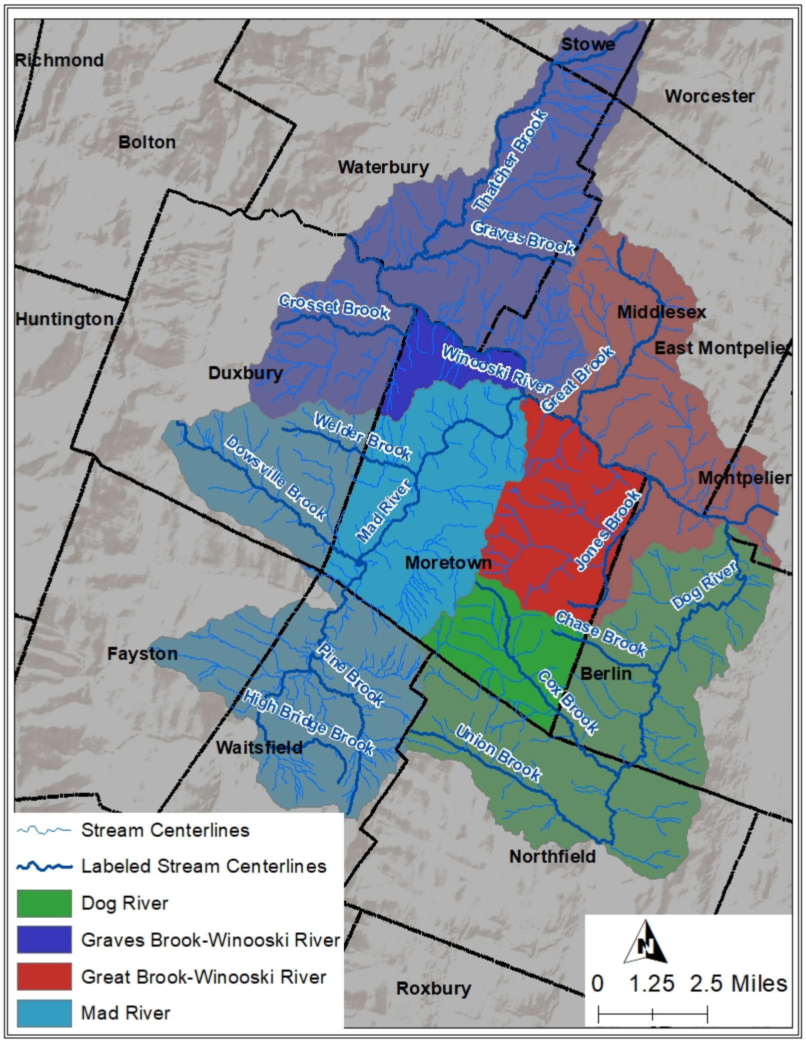


Figure C1. The Town of Moretown is primarily located in the Mad River watershed, a tributary of the Winooski River.

Much of the Winooski River has been straightened and banks armored to control the river to accommodate transportation infrastructure built in the valley floor. The Mad River valley also contains structural development, including the historic village and major roads. It is evident that these engineered controls are at risk of failure following flood events that cause inundation and fluvial erosion. Moving transportation infrastructure out of the valley floor is not possible, so better stormwater management is necessary to improve flood resiliency in the town.

According to the 2014 Moretown Town Plan, flood mitigation actions have been taken in Moretown following Tropical Storm Irene in 2011. There is recognition that the town is vulnerable to future flood events. Steps are being taken to upsize culverts and design plans have been produced to mitigate erosion through improved stormwater management. Road washouts and structural damages to buildings in the river corridor will likely continue unless stormwater management actions are taken to reduce fluvial erosion and minimize inundation flooding.

1.2 Existing Conditions

The Town of Moretown spans approximately 25,741 acres in Washington County, VT and is primarily forested (88%) with smaller areas of agricultural (5%) and urban land cover (4%). Of that area, there are 323 acres (1%) of impervious cover. Moretown lies east of Duxbury and southeast and south respectively of more highly developed Waterbury and Montpelier (Figure C2). This area of the state is primarily rural with small commercial developments and rural residential areas.

Many of the older developments within the Town were constructed before current stormwater standards were developed, and they were constructed without any or with only minimal stormwater management. This has resulted in untreated stormwater draining from large portions of developed lands discharging directly to surface waters.

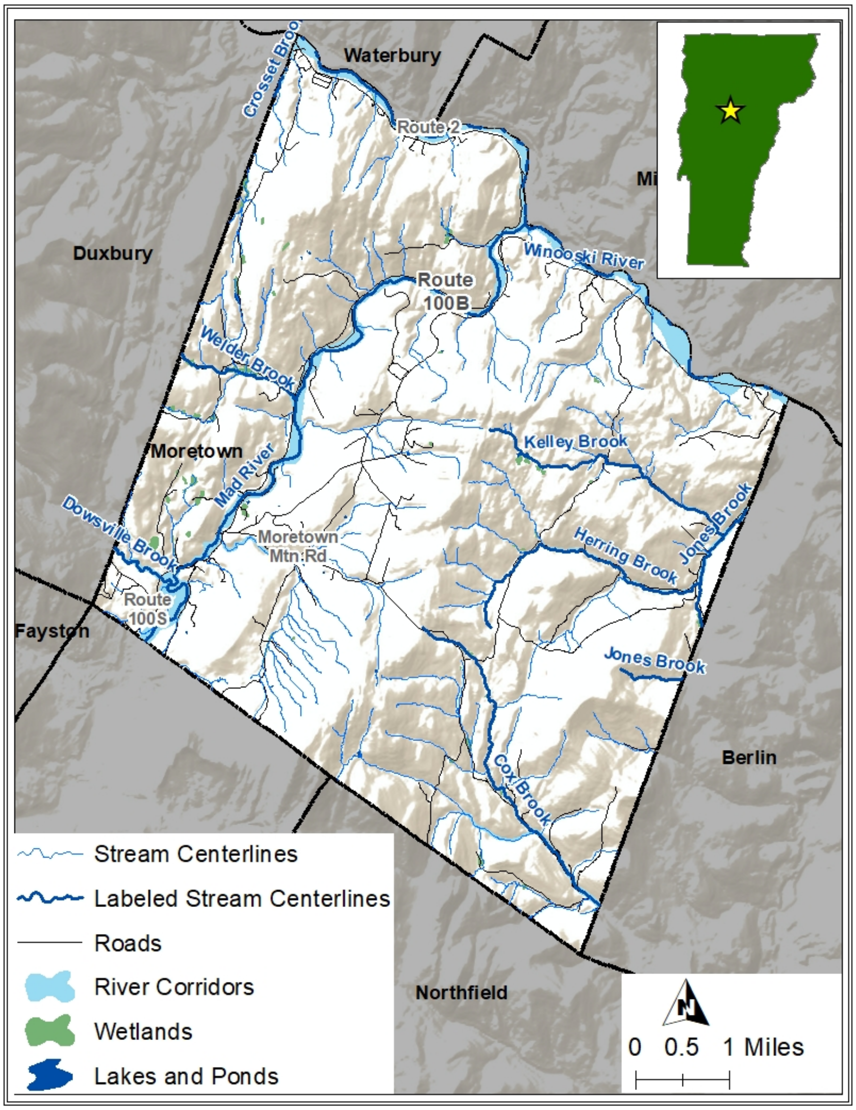


Figure C2. The Town of Moretown is located in Washington County, VT.

Surrounding the developed lands, rural roads are generally unpaved, with open roadside ditches, and cross culverts. Many of these roads have steep slopes, and traverse large areas. Furthermore, the rural roads access residential driveways which often convey drainage into, and through the Town road drainage system. This is a problem because runoff from private lands is negatively impacting the Town's overall drainage system.

Soils analyses indicate that of the 25,741 total acres in the Town, 95% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the Town, the majority of areas belong to either Hydrologic Soil Group C (76%) or D (10%), while only 4% are in group A, and 9% are in group B. The remainder is not classified or comprised of water. This combination of limited infiltration capacity and a highly-erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix C1 – Map Atlas. Maps include:

- river corridors, wetlands, and hydric soils;
- impervious cover;
- soil infiltration potential;
- soil erodibility;
- land cover;
- slope;
- stormwater infrastructure and stormwater permits;
- and parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this stormwater master plan (SWMP) study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2017). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix C2 – Data Review.

The project team met with Town of Moretown stakeholders, Friends of the Mad River (Friends), and the Central Vermont Regional Planning Commission (CVRPC) on December 7, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Meeting minutes from this meeting are included in Appendix C3. A second town-specific meeting was held on January 23, 2018 to identify a list of problem areas including specific parcels and general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed to identify additional potential sites for stormwater best management practice (BMP) implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix B4).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.
Prerequisites:

1. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
    - ≥ 50 ft = Ideal (Score: 2 points)
    - 46-50 ft = Potential (Score: 1 point)
    - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

3. Hydrologic Soil Group (indication of infiltration potential)
   - A/B (highest infiltration potential) = Ideal (Score: 2 points)
   - B/C (moderate infiltration potential) = Potential (Score: 1 point)
   - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 2 sites with potential were noted for assessment in the field (Figure C3).

A total of 50 locations, including the Green Streets sites, were identified for stormwater retrofit potential

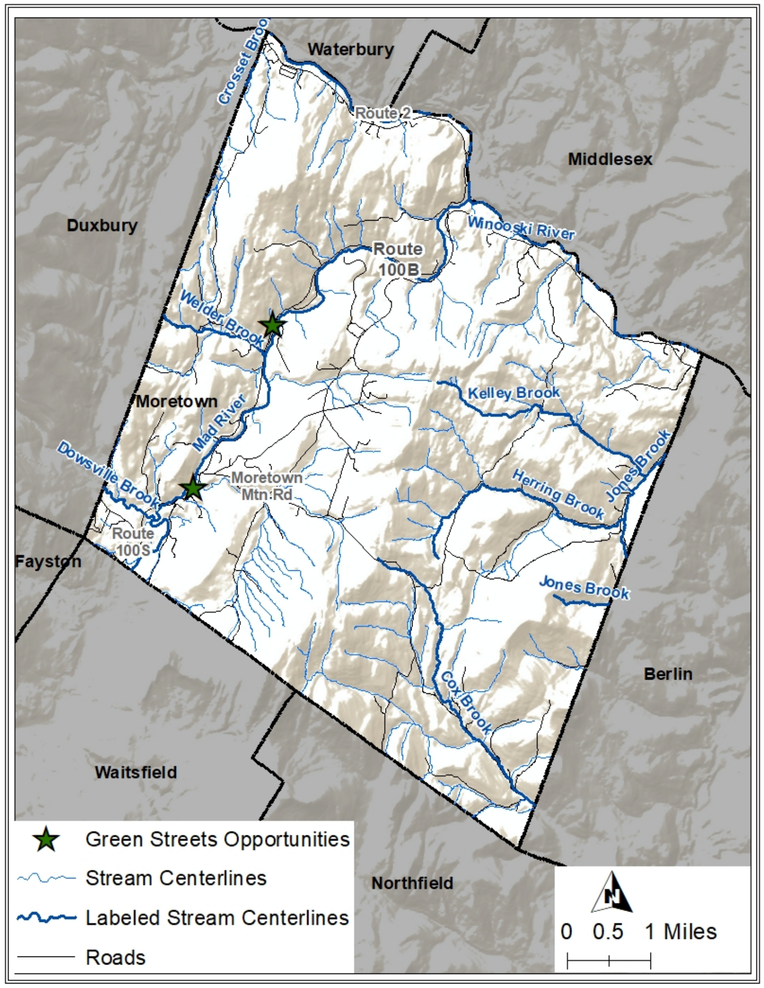


Figure C3. The 2 locations identified as potential green streets opportunities are shown with green stars.

2.1.2.2 *Basemap and Mobile App Creation*

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 50-point locations for the potential BMP sites. These points allowed for easy site location and data collection in the field (Figure C5).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data (Figure C4). All collected data was securely uploaded to the Cloud for later use.

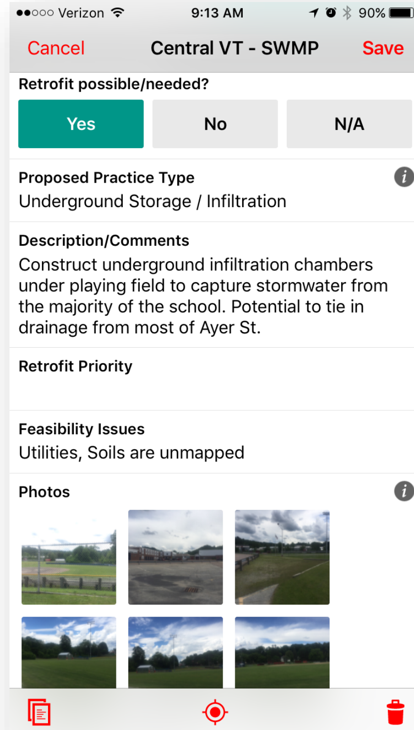


Figure C4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 50 previously identified potential BMP locations were evaluated in the field during the Summer of 2018 (Figure C5). Data was collected about each site in the mobile app. A large map of these sites with associated site names and a list of these sites including potential BMP options and site notes can be found in Appendix C5 - Initial Site Identification.

Through the course of these field visits, additional stormwater retrofit sites were identified that had not been included in the initial assessment. A total of 59 sites in Moretown were assessed as part of this plan. Some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific, prohibitive site conditions. Following this process, a total of 46 sites in Moretown sites remained as potential BMP opportunities.

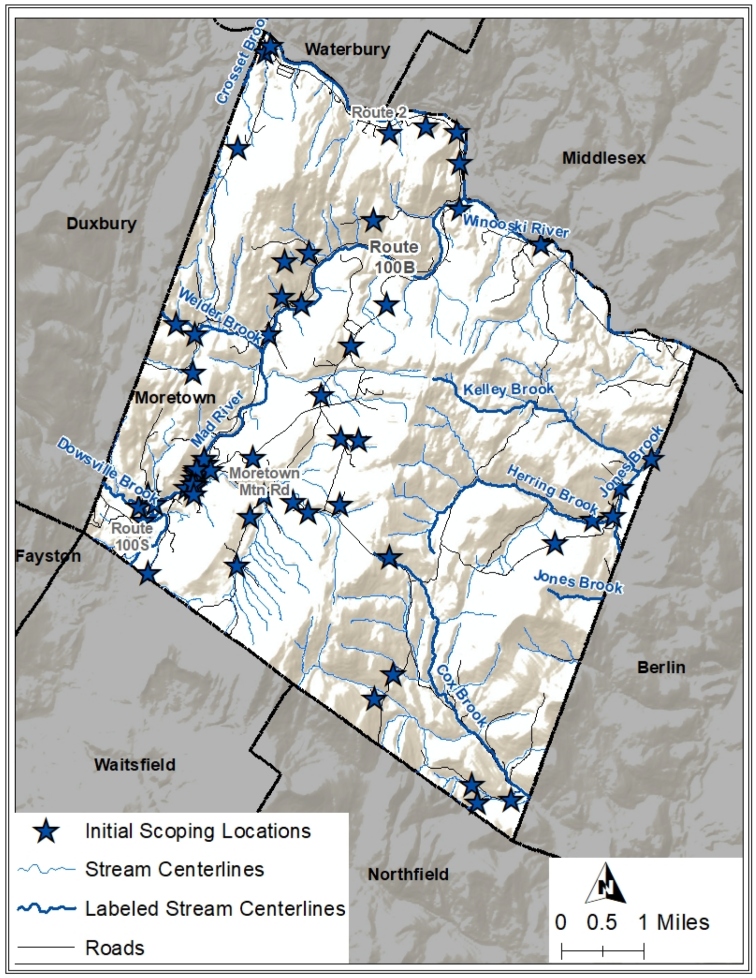


Figure C5. 50 potential sites for BMP implementation were identified for field investigation.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 46 projects (Figure C6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix C6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix C6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

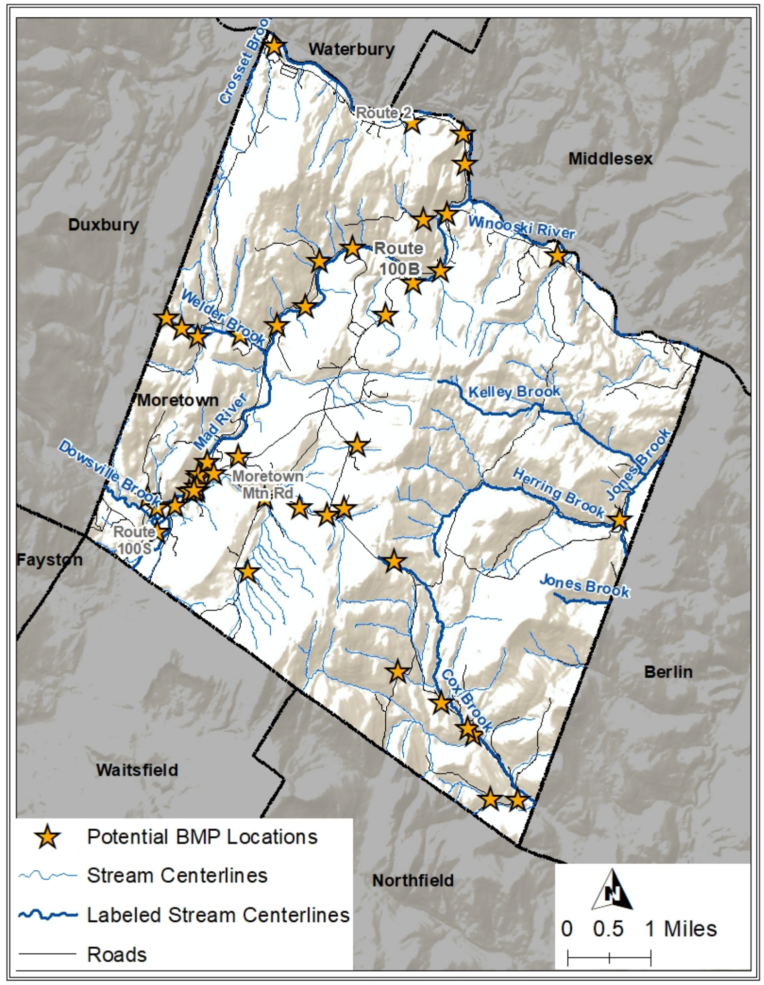


Figure C6. Following field investigations and stakeholder feedback, the list of potential BMP sites was refined to 45. Point locations are shown for each site.

The draft Top 20 list was distributed to Moretown stakeholders, the CVRPC, and Friends. As part of this process, the project team met with the stakeholders on August 23, 2018 to discuss the proposed Top 20 project sites. Following feedback from the Town, the list was refined from 46 to 45 to reflect the Town's knowledge of potentially unwilling landowners and the Town's priorities. These Top 20 sites are listed in Table C1. Point locations are shown in Figure C7

Table C1. Top 20 BMPs selected for the Moretown SWMP.

Site ID	Proposed Practice Type
Town Garage and Sand Storage	Underground Storage / Infiltration, Filter Strip / Buffer Enhancement, Sediment Trap
Moretown Elementary School	Gravel Wetland, Sand Filters, Infrastructure Addition
Moretown Library	Bioretention
Town Hall	Dry Well, Bioretention
Moretown Post Office	Underground Sand Filter
Moretown Mountain Road pull off	Check Dams, Ditch / Swale Improvements, Turnouts, Sediment Trap
Moretown Mountain Road Culvert	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement, Sediment Trap
McGibbons Rd	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement
Stevens Brook Rd Pull Off	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
Longley Rd	Check Dams, Turnouts, Ditch / Swale Improvements
S Hill Rd and Moretown Mountain Rd	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts, Impervious Cover Reduction
Stevens Brook Rd Upper	Check Dams, Ditch / Swale Improvements, Turnouts
Moretown Common Rd Check Dams	Check Dams, Turnouts, Ditch / Swale Improvements, Filter Strip / Buffer Enhancement
Stevens Brook Rd Lower	Check Dams, Ditch / Swale Improvements, Turnouts
Freeman Hill and Route 100B Cemetery	Filter Strip / Buffer Enhancement
Hooper Ln	Check Dams, Ditch / Swale Improvements, Sediment Trap
Moretown Common Rd Pull Off	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
Moretown United Methodist Church	Dry Well
Salaki Rd	Ditch / Swale Improvements, Check Dams, Turnouts
Congdon Rd	Ditch / Swale Improvements, Check Dams, Turnouts, Cross Culvert

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices, as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations. Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix C8 - Top 20 Sites Modeling for modeling reports).

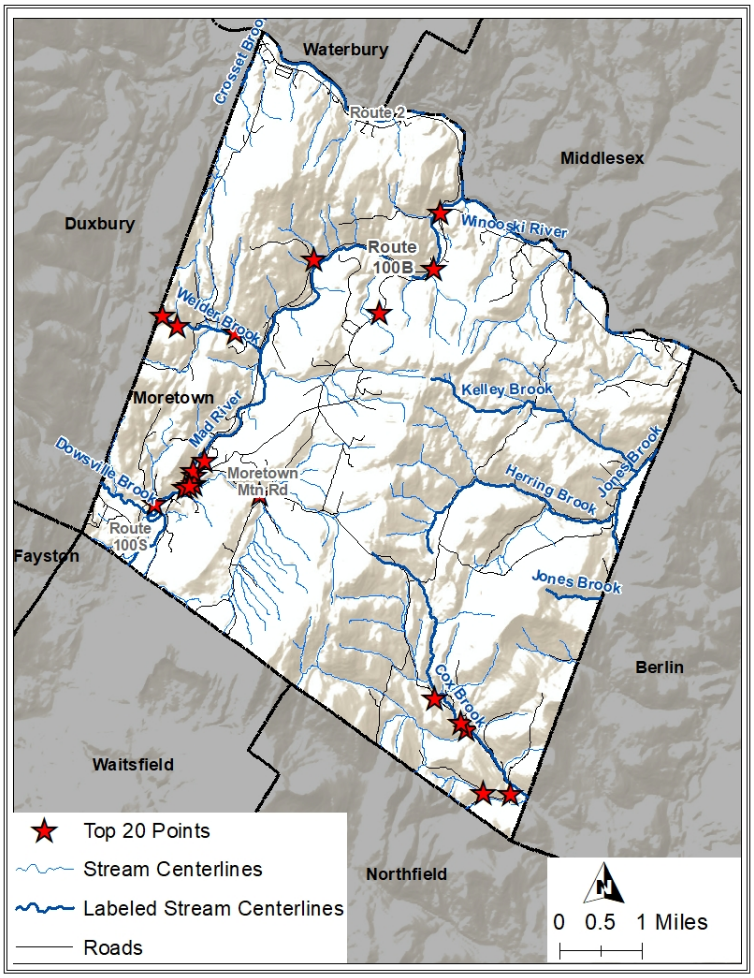


Figure C7. The Top 20 project locations are shown.

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration-based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site’s current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table C2. Complete modeling results are provided in Appendix C8 - Top 20 Sites Modeling.

Table C2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Town Garage and Sand Storage	0.340	0.340	10511	95.67% (infiltration); 98.73% (sediment trap 1); 99.2% (sediment trap 2)	6.13	91.28% (infiltration); 98.67% (sediment trap 1); 99.17% (sediment trap 2)
Moretown Elementary School	0.201	0	1302	96% (gravel wetland); 51% (sand filter)	1.98	58% (gravel wetland); 33% (sand filter)
Moretown Library	0.005	0.005	193	99.78%	0.17	99.31%
Town Hall	0.035	0.035	1038	100% (dry wells); 99.47% (Bioretention)	0.30	100% (dry wells); 99.47% (Bioretention)
Moretown Post Office	0.072	0	2277	51.00%	0.54	33.00%
Moretown Mountain Road pull off	0.131	0.131	2075	96%	1.66	96%
Moretown Mountain Road Culvert	0.173	0.173	2521	88.49%	1.62	89.94%
McGibbons Rd	0.111	0	3239	60.00%	1.05	20.00%
Stevens Brook Rd Pull Off	0.110	0	3840	60.00%	0.93	20.00%
Longley Rd	0.115	0	2660	60.00%	0.71	20.00%
S Hill Rd and Moretown Mountain Rd	0.096	0	3004	60.00%	0.78	20.00%
Stevens Brook Rd Upper	0.095	0	3698	60.00%	0.77	20.00%
Moretown Common Rd Check Dams	0.073	0	2490	60.00%	0.77	20.00%
Stevens Brook Rd Lower	0.078	0	1920	60.00%	0.48	20.00%
Freeman Hill and Route 100B Cemetery	0.027	0	952	65.00%	0.26	20.00%
Hooper Ln	0.014	0.014	460	61.72%	0.44	61.60%
Moretown Common Rd Pull Off	0.025	0	1457	60.00%	0.35	20.00%
Moretown United Methodist Church	0.010	0.010	11	100.00%	0.11	100.00%
Salaki Rd	0.026	0	903	60.00%	0.23	20.00%
Congdon Rd	0.013	0	562	60.00%	0.14	20.00%

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix C9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix C10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix C9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or green stormwater infrastructure (GSI)-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[3] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table C3 below.

Table C3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large aboveground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

[3] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Permits and Engineering Costs: Used either 20% for large aboveground projects or 35% for smaller or complex projects.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix C9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and ranks are shown below in Table C4. The comprehensive ranking matrix used to rank the proposed BMP projects is provided in Appendix C9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table C4. Top 20 potential BMP sites for the Town of Moretown.

Rank	Site ID	Address	Proposed Practice Type
1	Town Garage and Sand Storage	1305 Route 100 B, Moretown, VT	Underground Storage / Infiltration, Filter Strip / Buffer Enhancement, Sediment Trap
2	Moretown Elementary School	968 Route 100 B, Moretown, VT	Gravel Wetland, Sand Filters, Infrastructure Addition
3	Moretown Library	897 Route 100 B, Moretown, VT	Bioretention
4	Town Hall	21 Fletcher Rd, Moretown, VT	Dry Well, Bioretention
5	Moretown Post Office	1115 Route 100 B, Moretown, VT	Underground Sand Filter
6	Moretown Mountain Road pull off	4704–4934 Moretown Mountain Rd, Moretown, VT	Check Dams, Ditch / Swale Improvements, Turnouts, Sediment Trap
7	Moretown Mountain Road Culvert	5283–5349 Moretown Mountain Rd, Moretown, VT	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement, Sediment Trap
8	McGibbons Rd	82–426 McGibbons Rd, Moretown, VT	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement
9	Stevens Brook Rd Pull Off	1437 Stevens Brook Rd, Moretown, VT	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
10	Longley Rd	Longley Rd, Moretown, VT	Check Dams, Turnouts, Ditch / Swale Improvements
11	S Hill Rd and Moretown Mountain Rd	28 S Hill Rd, Moretown, VT	Filter Strip / Buffer Enhancement, Ditch / Swale Improvements, Check Dams, Turnouts, Impervious Cover Reduction
12	Stevens Brook Rd Upper	1191 Stevens Brook Rd, Moretown, VT	Check Dams, Ditch / Swale Improvements, Turnouts
13	Moretown Common Rd Check Dams	3051–3727 Moretown Common Rd, Moretown, VT	Check Dams, Turnouts, Ditch / Swale Improvements, Filter Strip / Buffer Enhancement
14	Stevens Brook Rd Lower	445 Stevens Brook Rd, Moretown, VT	Check Dams, Ditch / Swale Improvements, Turnouts
15	Freeman Hill and Route 100B Cemetery	146–148 Route 100 B, Moretown, VT	Filter Strip / Buffer Enhancement
16	Hooper Ln	Lovers Ln, Moretown, VT	Check Dams, Ditch / Swale Improvements, Sediment Trap
17	Moretown Common Rd Pull Off	5892–5930 VT Route 100B, Moretown, VT	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
18	Moretown United Methodist Church	962 Route 100 B, Moretown, VT	Dry Well
19	Salaki Rd	300–698 Salaki Rd, Moretown, VT	Ditch / Swale Improvements, Check Dams, Turnouts
20	Congdon Rd	Congdon Rd and Moretown Mountain Rd, Moretown, VT	Ditch / Swale Improvements, Check Dams, Turnouts, Cross Culvert

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking, input from municipal officials concerning project priorities, and the willingness of select private landowners to voluntarily participate in this plan. The location of these sites within the Town is shown in Figure C8. In the final ranking, these 5 sites were awarded additional points in the site scoring to reflect the Town's priorities and high-probability for implementation. The Top 5 sites are listed in Table C5.

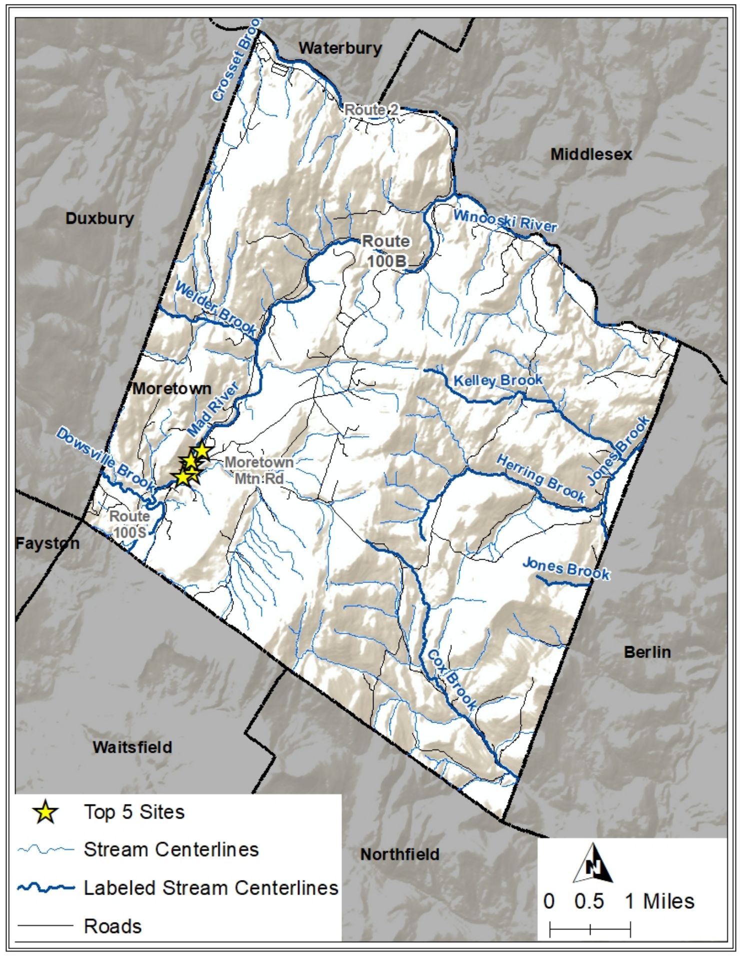


Figure C8. Top 5 sites for the Town of Moretown SWMP.

Table C5. Top 5 BMP sites for the Town of Moretown.

Rank	Site ID	Address	Proposed Practice Type
1	Town Garage and Sand Storage	1305 Route 100 B, Moretown, VT	Underground Storage / Infiltration, Filter Strip / Buffer Enhancement, Sediment Trap
2	Moretown Elementary School	968 Route 100 B, Moretown, VT	Gravel Wetland, Sand Filters, Infrastructure Addition
3	Moretown Library	897 Route 100 B, Moretown, VT	Bioretention
4	Town Hall	21 Fletcher Rd, Moretown, VT	Dry Well, Bioretention
5	Moretown Post Office	1115 Route 100 B, Moretown, VT	Underground Sand Filter

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on Town property and private property. A memo describing these sites and updated field data sheets are provided in Appendix C11.

Site: 1
Project Name: Town Garage and Sand Storage
Description: The site includes management of the stormline runs north along Route 100B including drainage from a portion of Moretown Mountain Rd. There is currently significant sediment transport to river, and it was noted that drainage and sediment accumulates at southern corner of site. The site is located partially in the river corridor and was a State-identified retrofit location. Proposed BMPs for this site include as follows: intercept the stormline running north down Main St and route to a subsurface infiltration practice in the greenspace between the Town's sand storage and the road (Figure C9). Enhance the riparian buffer along the Mad River where snow is currently plowed over banks (northwest and southwest corners). Implement a sediment trap between fuel tank and tree in southwest corner and another by the entrance of site to collect, filter, and infiltrate drainage from this area. Improve snow removal and management practices by plowing into basins instead of over riverbank.

Figure C9. A subsurface infiltration practice is proposed in the greenspace pictured above along Route 100B.

Outreach: This site is owned by the Town of Moretown and as such, no additional outreach was conducted.

Site: 2
Project Name: Moretown Elementary School
Description: The site, the Moretown Elementary School complex, is a top-priority for the Town. There is run-on from the hill behind the school that accumulates at the building and floods the basement. There are two catchbasins by the school that will be replaced as part of a VTrans project along Route 100. Significant drainage issues in the parking lot were noted. Proposed BMPs for this site include as follows: Parking lot drainage should be combined in a gravel wetland with the Town Clerk's Office drainage (Figure C10). Parking lot should be paved and sloped to ensure that pavement directs runoff to (new) catchbasins. New catchbasins will be required in the parking lot in addition to the catchbasins installed during the VTrans project. It is recommended that the staff discontinue mowing the fields above the recreational fields and that the swale perpendicular to the hill slope should be excavated to better direct drainage away from fields. The buried culvert by the playing fields should be cleaned out. There is potential to implement a sand filter in the existing wide swales running along the sports fields to Doctors Brook. Install sand filter in swale along west side of school before drainage enters catchbasin. Note that there was a previously developed plan for this site, and most of the retrofits proposed here are shown in this plan.

Figure C10. It is proposed that the drainage from the Moretown Elementary parking lot be managed in a gravel wetland.

Outreach: This site is owned by the Town of Moretown and as such, no additional outreach was conducted.

Site: 3
Project Name: Moretown Library
Description: The site includes the Moretown Library building and unpaved parking area (Figure C11). It is located within the river corridor. The proposed BMP for this site includes directing roof runoff to a rain garden in the greenspace prior to drop off to river. As this site is a public location within the Town, it is also recommended that an educational sign be installed for visitors to the site to learn about stormwater management within the Town.
Outreach: This site is owned by the Town of Moretown and as such, no additional outreach was conducted.

Figure C11. Drainage from the site would be managed in a proposed bioretention to the left of photo.

Site: 4
Project Name: Town Hall
Description: The site includes the Moretown Town Hall parking lot and the area along Fletcher Rd by Ward Clapboard Mills. Proposed BMPs for this site include as follows: Install a rain garden behind the Town Hall building to capture parking lot runoff (Figure C12); install a dry well in existing catchbasin across road from Town Hall (by Ward Clapboard Mills). It is also recommended that snow should not be plowed over bank to river.
Outreach: This site is owned by the Town of Moretown and as such, no additional outreach was conducted.

Figure C12. Drainage would be managed in a proposed bioretention.

Site: 5
Project Name: Moretown Post Office
Description: The site includes the Moretown Post Office located along Route 100B. The elevation drops off steeply to the west of the parking lot. Proposed BMPs for this site include as follows: Redirect stormline from 100B to a lined subsurface filtration system under the Post Office parking lot and greenspace (Figure C13). Add a swale to direct parking lot runoff to the practice. Redirect drainage from Mobile Gas Station to this line of catchbasins along Route 100B.
Outreach: The Post Office parcel is privately owned by Wilcox and Barton, Inc. The owners of the site have expressed their wiliness to proceed with further design.

Figure C13. Proposed subsurface sand filter is located under the Post Office parking lot.

When implemented, these five BMPs would treat approximately 34.7 acres, 7.1 acres (20%) of which are impervious. Modeled pollutant reductions for each of the projects, shown below in Table C6, indicate that these BMPs will prevent nearly 15,000 lbs of TSS and more than 9 lbs of TP from reaching receiving waters annually.

Table C6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Town Garage and Sand Storage	0.340	0.340	10511	95.67% (infiltration); 98.73% (sediment trap 1); 99.2% (sediment trap 2)	6.13	91.28% (infiltration); 98.67% (sediment trap 1); 99.17% (sediment trap 2)
Moretown Elementary School	0.201	0	1302	96% (gravel wetland); 51% (sand filter)	1.98	58% (gravel wetland); 33% (sand filter)
Moretown Library	0.005	0.005	193	99.78%	0.17	99.31%
Town Hall	0.035	0.035	1038	100% (dry wells); 99.47% (Bioretention)	0.30	100% (dry wells); 99.47% (Bioretention)
Moretown Post Office	0.072	0	2277	51.00%	0.54	33.00%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were developed for each site. See Appendix C12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix C13 - 30% Designs.

Soils conditions were assessed at 1 of the top 5 sites where an infiltration-based practice is proposed. The pit was manually excavated using a shovel and hand auger. Analysis at this site included documentation of horizon breaks, soil structure, type, moisture, color, presence or absence of redoximorphic features, and size and quantity of roots and coarse fragments. Any other notes considered to be important were recorded during this time. The soil profile and photos can be found in Appendix C14.

4.1 Town Garage and Sand Storage

4.1.1 30% Concept Design Description

The Town of Moretown's sand storage area is located along Route 100B (west side of road), north of the intersection of Moretown Mountain Rd. This site abuts the Mad River. For the Town's sand storage area, the northern half of the site drains to the river via two drainage channels and the southern half drains to a low point located in the southwest corner of the site. The Town's salt shed is adjacent to the sand storage area. It is anticipated that the Town will be updating this structure in the future. The riparian buffer along the river has been removed in one location and sediment is being transported to the river via drainage channels as well as current snow removal practices. The Town Garage is located just south of this site on the eastern side of Route 200B. A stormline currently runs north down Route 100B and discharges to the Mad River just north of the Town's sand storage area.

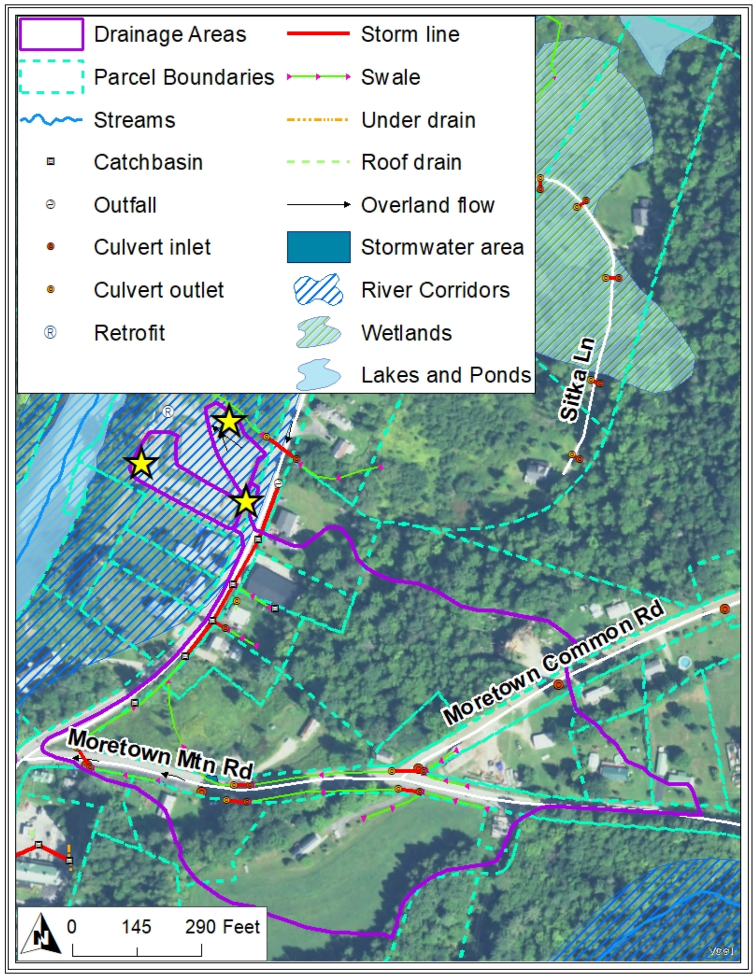


Figure C14. The drainage areas for the proposed BMPs are shown in purple and the practice locations are shown with stars.

The proposed retrofit for this site includes intercepting the stormline running north down Main St and routing to a subsurface infiltration practice in the greenspace between the Town's sand storage and the road (see easternmost starred location in Figure C14). Also included in the design is the enhancement of the riparian buffer along the Mad River where snow is currently plowed over banks (northwest and southwest corners). Two sediment traps are proposed. One is located between fuel tank and tree in southwest corner, and another is located by the entrance of site. These practices will collect, filter, and infiltrate drainage from this area. Also recommended is an improvement in snow removal and management procedures by plowing into basins instead of over riverbank. See the photos and associated descriptions in Figure C15.

Snow is plowed over the bank to the Mad River in this location.

Drainage from the sand storage facility by the entrance is entering a swale that drains to the Mad River.

Drainage from the sand storage facility is draining to the Mad River.

The greenspace by the sand storage facility along Route 100B is the proposed location for infiltrating drainage from the Town Garage and surrounding areas.

Figure C15. The proposed retrofits are described in the above photos.

Figure C17. A hand auger was used to assess soil conditions and infiltration potential.

Soils are mapped as being very good at this site (Hydrologic Group A), and an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger (Figure C16) and were found to be generally sandy and loamy with a thin clay layer (Figure C17). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix C14 for this site's complete soil log.

Figure C16. Soils were generally sandy and loamy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix C16 - Site Renderings.

The design standard used for this retrofit was management of the Water Quality Volume (WQv, or 1.00 inch of rain in a 24-hour period), equal to 14,810 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C11 - Top 5 Sites. A 30% design plan is provided in Appendix C13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent more than 10,500 lbs of total suspended solids (TSS) and 6.1 lbs of total phosphorus (TP) from entering receiving waters (Table C7).

Table C7. Town Garage and Sand Storage benefit summary table.

TSS Removed	10,511 lbs
TP Removed	6.1 lbs
Impervious Treated	3.6 acres
Total Drainage Area	16.6 acres

4.1.3 Cost Estimates

The estimated cost for this project is $51,000. Note that these costs are very preliminary. Costs are shown in Table C8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $8,361.
- The cost per impervious acre treated is $14,167.
- The cost per cubic foot of runoff treated is $3.44.

Table C8. Town Garage and Sand Storage project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	300	$ 1.17	$ 351.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	340	$ 4.13	$ 1,404.20
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 2,755.20
Sedimentation Basin					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	345	$ 9.86	$ 3,401.70
MATERIALS					
613.11	STONE FILL, TYPE I	CY	228	$ 42.49	$ 9,687.72
INLET / OUTLET PROTECTION					
613.11	STONE FILL, TYPE II	CY	57	$ 42.49	$ 2,421.93
				Subtotal:	$ 15,511.35
CHAMBERS					
203.15	COMMON EXCAVATION	CY	365	$ 9.86	$ 3,598.90
	MC3500	EACH	24	$ 400.20	$ 9,604.80
	MC3500 PLAIN END CAP	EACH	3	$ 300.15	$ 900.45
	MC3500 24B END CAP	EACH	1	$ 404.23	$ 404.23
	12" 90 BEND	EACH	1	$ 57.10	$ 57.10
	12" COUPLER	EACH	2	$ 8.29	$ 16.58
	12" N12 AASHTO FOR MANIFOLD	LF	20	$ 7.75	$ 155.02
	24" N12 AASHTO FOR ISOLATOR ROW	LF	20	$ 22.54	$ 450.80
	315WTM FOR SCOUR PROTECTION	SY	500	$ 0.74	$ 370.00
	601TG TO WRAP SYSTEM	SY	2000	$ 0.82	$ 1,633.00
	12X6 INSPECTION PORT KIT	EACH	1	$ 430.10	$ 430.10
	6" RED HOLE SAW	EACH	1	$ 172.17	$ 172.17
				Subtotal:	$ 17,793.15
Subtotal:					$ 36,059.70
	Construction Oversight**	HR	8	$ 125.00	$ 1,000.00
	Construction Contingency - 10%**				$ 3,605.97
	Incidentals to Construction - 5%**				$ 1,802.99
	Minor Additional Design Items - 5%**				$ 1,802.99
	Final Design	HR	40	$ 125.00	$ 5,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	10	$ 125.00	$ 1,250.00
				Total (Rounded to nearest $1,000)	**$ 51,000.00**

4.1.4 Next Steps

As this site is owned and operated by the Town of Moretown, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and the floodplain. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.2 Moretown Elementary School

4.2.1 30% Concept Design Description

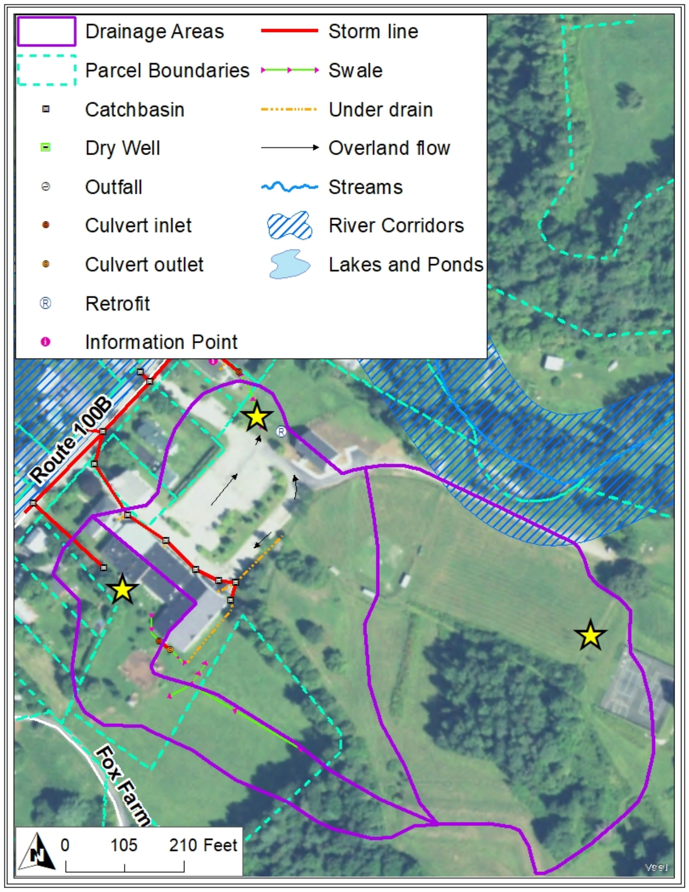


Figure C18. The drainage areas for the proposed BMPs are shown in purple and the practice locations are shown with stars.

The Moretown Elementary School is located along Route 100B on the southeast side of the road. The site is also shared by the Town Clerk's Office (north side of the site). This is a high visibility site as well as a highly trafficked area within the Town. The School is located at the bottom of a large hill that lies to the east of the School. The School experiences significant run-on from the hill behind the building, which accumulates along the foundation and floods parts of the building as well as the adjacent grounds. There are also significant drainage issues in the School's parking lot including ponding, puddling, rutting, erosion, and frequent loss of parking lot surface material. Drainage from the School's site is collected in a stormline that runs down Route 100B and is discharged to the Mad River without treatment. Note that the Vermont Agency of Transportation (VTrans) is currently working on a sidewalk project along Route 100B which involves stormlines within this area.

It is proposed that the parking lot drainage be combined in a gravel wetland with the Town Clerk's Office drainage (see northernmost starred location in Figure C18). It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. The parking lot should be paved and sloped to ensure that pavement directs runoff to (new) catchbasins. New catchbasins will be required in the parking lot in addition to the catchbasins installed during the VTrans project. It is recommended that the staff discontinue mowing the fields above the recreational fields, and that the swale perpendicular to the hill slope should be excavated to better direct drainage away from fields. The buried culvert should be dug out, and there is potential to implement a sand filter in the existing wide swales running along the sports fields to Doctors Brook. Also recommended is the installation of a sand filter in the swale along west side of school before drainage enters the catchbasin. Note that there was a previously developed plan for this site, and most of the retrofits proposed here are shown in this plan. See the photos and associated descriptions in Figure C19. School and municipal officials have expressed their willingness to proceed with further design for this project.

Run-on from hill behind school accumulates at building.

The parking lot and access drives are in disrepair and stormwater ponds in several areas.

Drainage from the parking lot is eroding a channel into the greenspace near the Town Clerk's Office; this is the location of the proposed gravel wetland.

Drainage from the large parking area travels over the parking lot surface prior to entering the VTrans stormline along Route 100B and discharging to the Mad River.

Figure C19. The proposed retrofits are described in the above photos.

Soils are mapped as being good at this site (Hydrologic Group B), however there is evidence of high groundwater in the area. As such, the proposed practice is not infiltration-based so an analysis was not conducted to evaluate the site's potential for infiltration.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix C16 - Site Renderings.

The design standard used for this retrofit was the management and treatment of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period) for the gravel wetland and filtration of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period) for the sand filters. This equals 8,756 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C11 - Top 5 Sites. A 30% design plan is provided in Appendix C13 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent nearly 1,302 lbs of total suspended solids (TSS) and 1.98 lbs of total phosphorus (TP) from entering receiving waters (Table C9). The retrofits in this location also have the potential to raise awareness of stormwater issues in the Town, as the proposed location for the practice has high visibility. It is recommended that an educational sign be installed in conjunction with the retrofits.

Table C9. Moretown Elementary School benefit summary table.

TSS Removed	1,302 lbs
TP Removed	1.98 lbs
Impervious Treated	1.8 acres
Total Drainage Area	13.1 acres

4.2.3 Cost Estimates

The estimated cost for this project is $112,000. Note that these costs are very preliminary. Costs are shown in Table C10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $56,566.
- The cost per impervious acre treated is $62,222.
- The cost per cubic foot of runoff treated is $12.79.

Table C10. Moretown Elementary School initial construction cost projection

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	475	$ 1.17	$ 555.75
653.20	TEMPORARY EROSION MATTING	SY	500	$ 2.20	$ 1,100.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	35	$ 4.13	$ 144.55
N/A	CONSTRUCTION STAKING	HR	6	$ 125.00	$ 750.00
				Subtotal:	$ 3,050.30
Gravel Wetland - Excavation and Materials					
	EXCAVATION				
203.15	COMMON EXCAVATION	CY	785	$ 9.86	$ 7,740.10
	MATERIALS				
	GRAVEL LAYERING				
651.35	TOPSOIL (MUCK SOIL)	CY	80	$ 30.96	$ 2,476.80
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	300	$ 34.04	$ 10,212.00
301.26	SUBBASE OF CRUSHED GRAVEL, FINE GRADED	CY	78	$ 40.03	$ 3,122.34
649.31	GEOTEXTILE UNDER STONE FILL	SY	470	$ 2.51	$ 1,179.70
	PIPING				
605.10	6 INCH UNDERDRAIN PIPE	LF	100	$ 21.86	$ 2,186.00
605.20	6 INCH UNDERDRAIN CARRIER PIPE	LF	50	$ 24.43	$ 1,221.50
649.41	GEOTEXTILE FOR UNDERDRAIN TRENCH LINING	SY	40	$ 4.04	$ 161.60
	STRUCTURES AND APPURTENANCES				
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	6	$ 4,009.29	$ 24,055.74
N/A	18' ANTI-SEEP COLLAR	EACH	1	$ 250.00	$ 250.00
N/A	18" BEEHIVE GRATE	EACH	1	$ 615.00	$ 615.00
N/A	30 MM PVC LINER	SY	500	$ 5.40	$ 2,700.00
	OVERFLOWS AND TRANSFER WEIRS				
613.10	STONE FILL, TYPE I	CY	10	$ 43.91	$ 439.10
	PLANTING				
N/A	WETLAND PLANT SEEDS	LBS	5	$ 125.00	$ 625.00
656.41	PERENNIALS	EACH	350	$ 8.77	$ 3,069.50
	SIDE SLOPE EROSION CONTROL				
651.25	HAY MULCH	TON	0.75	$ 597.15	$ 447.86
				Subtotal:	$ 60,502.24
New Infrastructure For Conveyance of Runoff to Practice					
601.0910	15" CPEP	LF	575	$ 34.05	$ 19,578.75
				Subtotal:	$ 19,578.75
Subtotal:					$ 83,131.29
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 8,313.13
	Incidentals to Construction - 5%**				$ 4,156.56
	Minor Additional Design Items - 5%**				$ 4,156.56
	Final Design	HR	80	$ 125.00	$ 10,000.00
				Total (Rounded to nearest $1,000)	**$ 112,000.00**

4.2.4 Next Steps

As this site is owned and operated by the Town of Moretown, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s proximity to the river corridor and its location in the floodplain. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.3 Moretown Library

4.3.1 30% Concept Design Description

The Moretown Library is located along Route 100B just east of the Mad River. This is a high visibility and high traffic area for the Town of Moretown. The site consists of a library building and an unpaved parking area. The drainage from the site makes its way overland to the Mad River.

It is recommended that runoff from a section of the library's roof and parking lot be directed to a rain garden in the greenspace prior to drop off to river (see starred location in Figure C20). See the photos and associated descriptions in Figure C21. It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign.

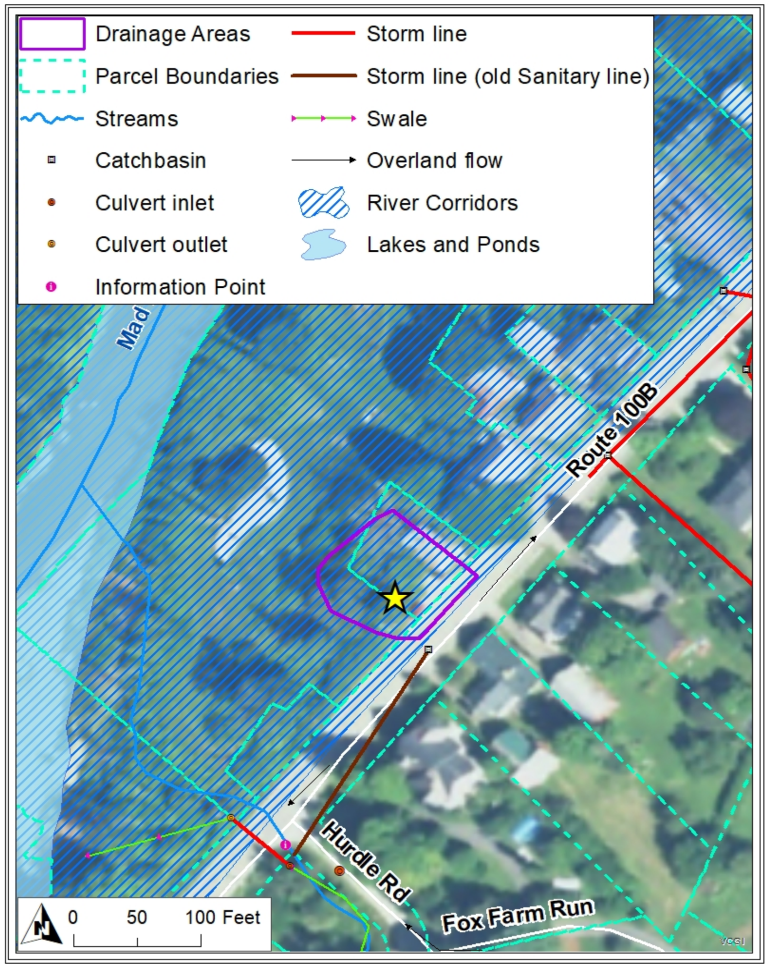


Figure C20. The location of the proposed BMP is shown with a star.

Town Garage building. This site was built up out of a wetland.

Salt residue around the front of the salt shed. Any spills should be cleaned immediately.

Eroded channels are forming due to drainage flowing over the steep bank.

Proposed location of a sedimentation basin to decrease sediment transport from the site.

Figure C21. The proposed retrofits are described in the above photos.

Soils are mapped as being good at this site (Hydrologic Group B), however the site did not appear to be well drained during field investigations. As such, the proposed practice is not infiltration-based so an analysis was not conducted to evaluate the site's potential for infiltration.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix C16 - Site Renderings.

The design standard used for this retrofit was detention and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 218 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C11 - Top 5 Sites. A 30% design plan is provided in Appendix C13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 193 lbs of total suspended solids (TSS) and .17 lbs of total phosphorus (TP) from entering receiving waters annually (Table C11).

Table C11. Moretown Library benefit summary table.

TSS Removed	193 lbs
TP Removed	0.17 lbs
Impervious Treated	0.1 acres
Total Drainage Area	0.2 acres

4.3.3 Cost Estimates

The estimated cost for this project is $4,000. Note that these costs are very preliminary. Costs are shown in Table C12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $23,529.
- The cost per impervious acre treated is $40,000.
- The cost per cubic foot of runoff treated is $18.35.

Table C12. Moretown Library project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	75	$ 1.17	$ 87.75
649.51	GEOTEXTILE FOR SILT FENCE	SY	35	$ 4.13	$ 144.55
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
Subtotal:					$ 1,232.30
Bioretention Area					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	15	$ 9.86	$ 147.90
MATERIALS					
651.35	TOPSOIL (Bioretention Media)	CY	8	$ 30.96	$ 247.68
N/A	GENERAL PLANTING PLAN	LS	1	$ 500.00	$ 500.00
651.25	STRAW	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	2	$ 7.66	$ 15.32
Subtotal:					$ 1,194.16
Subtotal:					$ 2,426.46
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 242.65
	Final Design	HR	4	$ 125.00	$ 500.00
Total (Rounded to nearest $1,000)					**$ 4,000.00**

4.3.4 Next Steps

As this site is owned and operated by the Town of Moretown, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project's location in the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.4 Town Hall

4.4.1 30% Concept Design Description

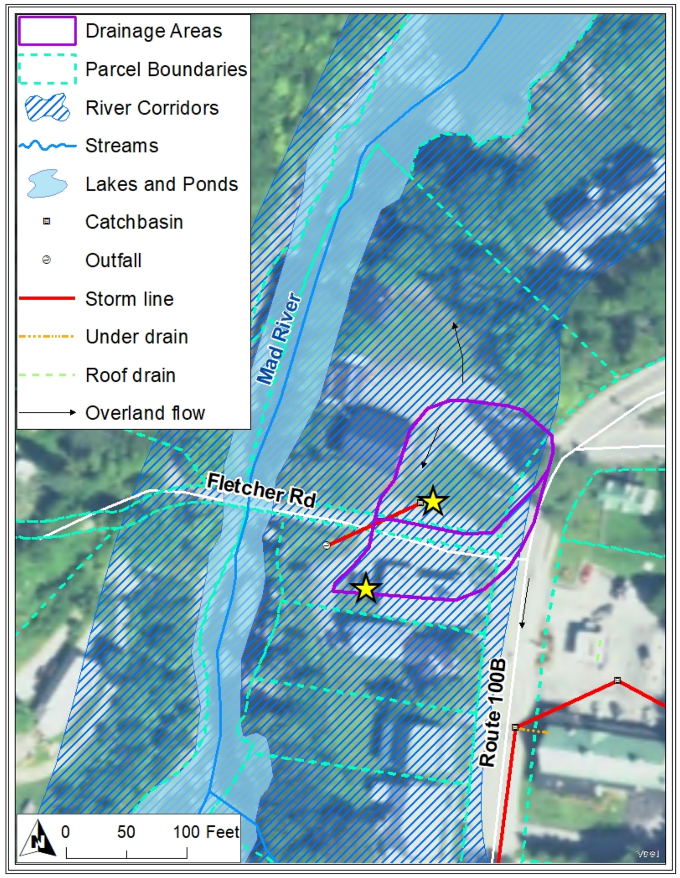


Figure C22. The drainage areas for the proposed BMPs are shown in purple and the practice locations are shown with stars.

The Moretown Town Hall is located at the intersection of Route 100B and Fletcher Rd. The drainage from the north side of the Town Hall and the parking area is forming an eroded channel down the residential driveway that runs along the Town Hall parking lot. To the north of Fletcher Rd, the Ward Clapboard Mills site is also contributing drainage to this area. Both sites are located just east of the Mad River. There is a steep drop off from these sites to the river.

It is recommended that a rain garden be installed behind the Town Hall building to capture runoff from the parking lot (see southernmost starred location in Figure C22). A dry well is also proposed in the existing catchbasin across road from Town Hall by Ward Clapboard Mills (see northernmost starred location in Figure C22). It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. It is further recommended that plowing of the road and parking lot over the bank to the river be discontinued. See the photos and associated descriptions in Figure C23.

Drainage from the Town Hall parking area and roof drainage is forming an eroded channel.

Much of the drainage from the Ward Clapboard Mills site is currently traveling overland to the parking area for the Town Hall.

Plowing over the bank into the Mad River should be discontinued.

A dry well is proposed to manage a section of drainage from the Ward Clapboard Mills site approximately where the truck is parked in this photo.

Figure C23. The proposed retrofits are described in the above photos.

Soils are mapped as being very good at this site (Hydrologic Group A). Though the proposed practice is infiltration-based, due to ice cover at this site, soil analyses were not possible at the time soils were assessed. It is recommended that an assessment of soils be carried out at this location as soon possible when the existing ice pack is melted.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix C16 - Site Renderings.

The design standard used for the dry wells was full infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), and the full management of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period) for the bioretention area. In total, this equals to 1,525 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C11 - Top 5 Sites. A 30% design plan is provided in Appendix C13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 1,038 lbs of total suspended solids (TSS) and 0.3 lbs of total phosphorus (TP) from entering receiving waters annually (Table C13).

Table C13. Town Hall benefit summary table.

TSS Removed	1,038 lbs
TP Removed	0.30 lbs
Impervious Treated	0.3 acres
Total Drainage Area	0.4 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $26,000. Note that these costs are very preliminary. Cost projections can be found in Table C14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $86,667.
- The cost per impervious acre treated is $86,667.
- The cost per cubic foot of runoff treated is $17.05.

Table C14. Town Hall project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	160	$ 1.17	$ 187.20
649.51	GEOTEXTILE FOR SILT FENCE	SY	55	$ 4.13	$ 227.15
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
Subtotal:					$ 1,414.35
Bioretention - Excavation and Materials					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	55	$ 9.86	$ 542.30
MATERIALS					
651.35	TOPSOIL (BIORETENTION MEDIA)	CY	17	$ 30.96	$ 526.32
601.0915	18" CPEP	LF	50	$ 64.04	$ 3,202.00
613.11	STONE FILL, TYPE II (Outlet Splash Pad)	CY	8	$ 42.49	$ 339.92
PLANTING					
N/A	GENERAL PLANTING PLAN	LS	1	$ 1,000.00	$ 1,000.00
651.15	SEED	LB	2	$ 7.66	$ 15.32
651.25	STRAW	TON	1	$ 597.15	$ 597.15
SIDE SLOPE EROSION CONTROL					
653.20	TEMPORARY EROSION MATTING	SY	23	$ 2.20	$ 50.60
651.25	HAY MULCH	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	5	$ 7.66	$ 38.30
Subtotal:					$ 6,572.19
Ditching					
	DRY WELLS OR OTHER STRUCTURES				
203.15	COMMON EXCAVATION	CY	30	$ 9.86	$ 295.80
N/A	DRY WELL STRUCTURE	EACH	2	$ 2,300.00	$ 4,600.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	9	$ 34.04	$ 306.36
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	7.5	$ 43.91	$ 329.33
Subtotal:					$ 5,531.49
Stabilization					
653.20	TEMPORARY EROSION MATTING	SY	35	$ 2.20	$ 77.00
651.25	HAY MULCH	TON	1	$ 597.15	$ 597.15
651.15	SEED	LB	2	$ 7.66	$ 15.32
Subtotal:					$ 689.47
	Parking Lot Re-Grading				
401.10	AGGREGATE SURFACE COURSE	CY	40	$ 43.60	$ 1,744.00
				Subtotal:	$ 1,744.00
Subtotal:					$ 15,951.49
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 1,595.15
	Incidentals to Construction - 5%**				$ 797.57
	Minor Additional Design Items - 5%**				$ 797.57
	Final Design	HR	40	$ 125.00	$ 5,000.00
Total (Rounded to nearest $1,000)					**$ 26,000.00**

4.4.4 Next Steps

As this site is owned and operated by the Town of Moretown, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and proximity to the floodplain. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.5 Moretown Post Office

4.5.1 30% Concept Design Description

Currently, stormwater drains south along Route 100B and discharges to the Mad River just south of the Moretown Post Office. The Moretown Post Office is located to the west of Route 100B south of the Moretown Town Hall.

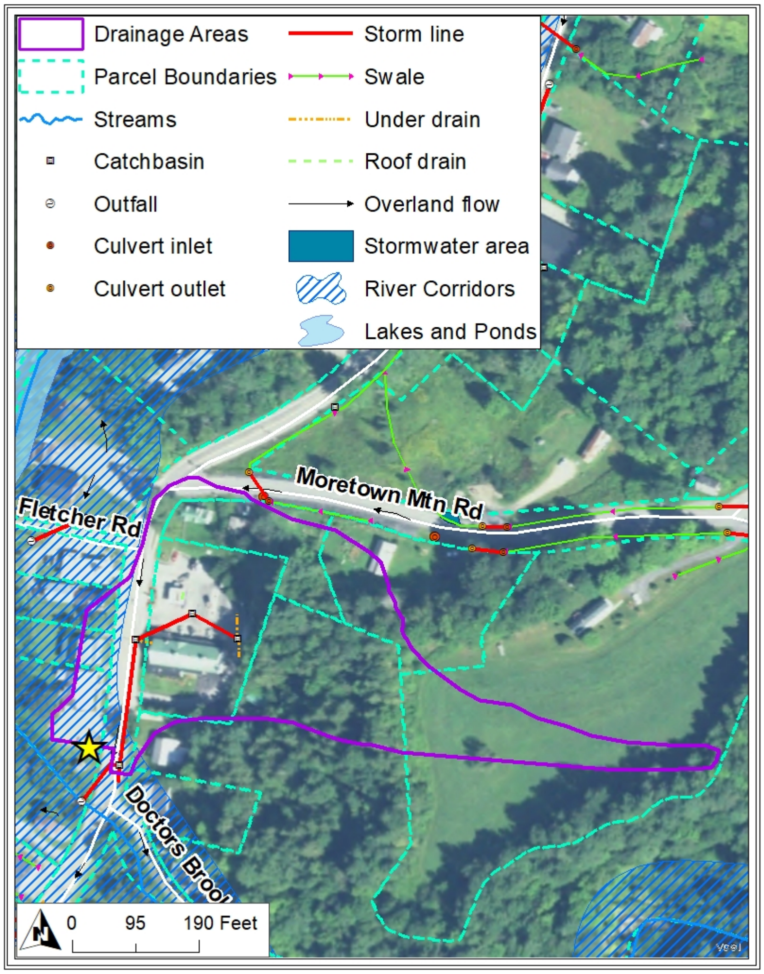


Figure C24. The location of the proposed BMP is shown with a star.

It is recommended that the stormline from 100B be redirected to a lined subsurface sand filter system under the Post Office parking lot and greenspace (see starred location in Figure C24). The drainage from the Mobile gas station and Moretown General Store, located on the east side of Route 100B across from Fletcher Rd, should be directed to this stormline for management. It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. A swale is proposed to direct parking lot runoff to the practice. See the photos and associated descriptions in Figure C25. The Moretown Post Office site is privately owned, and the owners of the site have given permission to proceed with design for this project.

Stormwater runoff from the Mobile gas station and Moretown General Store enters a series of catchbains along Route 100B.

The Moretown Post Office parking lot is proposed to be collected and managed in a subsurface filtration system.

The proposed subsurface filtration feature would be located under the greenspace and partially under the parking area of the Moretown Post Office.

Drainage from this section of Route 100B will also be directed to the proposed stormwater treatment feature.

Figure C25. The proposed retrofits are described in the above photos.

Soils are mapped as being good at this site (Hydrologic Group B). However, the proposed practice is not infiltration-based due to potential contamination issues in the event of an accidental spill from the gas station. As such, an analysis was not conducted to evaluate the site's potential for infiltration.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix C16 - Site Renderings.

The design standard used for this retrofit was full management of the Water Quality volume (WQv, 1.00 inches of rain in a 24-hour period), equal to 3,136 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C11 - Top 5 Sites. A 30% design plan is provided in Appendix C13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 2,277 lbs of total suspended solids (TSS) and 0.49 lbs of total phosphorus (TP) from entering receiving waters annually (Table C15).

Table C15. Moretown Post Office benefit summary table.

TSS Removed	2,277 lbs
TP Removed	0.54 lbs
Impervious Treated	1.4 acres
Total Drainage Area	4.3 acres

4.5.3 Cost Estimates

Cost projections, which are detailed in Table C16, total $62,000. Note that these costs are very preliminary. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $114,630.
- The cost per impervious acre treated is $44,286.
- The cost per cubic foot of runoff treated is $19.77.

Table C16. Moretown Post Office project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	200	$ 1.17	$ 234.00
653.20	TEMPORARY EROSION MATTING	SY	185	$ 2.20	$ 407.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	107	$ 4.13	$ 441.91
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 2,082.91
Conveyance Structures - Piping and Ditching					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	22	$ 13.59	$ 298.98
613.10	STONE FILL, TYPE I	CY	14	$ 43.91	$ 614.74
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	2	$ 4,009.29	$ 8,018.58
601.0920	24" CPEP	LF	35	$ 61.37	$ 2,147.95
				Subtotal:	$ 11,080.25
Subsurface Sand Filter					
N/A	DC780	EACH	30	$ 234.60	$ 7,038.00
N/A	SC740 PLAIN END CAP	EACH	6	$ 48.30	$ 289.80
N/A	SC740 24B END CAP	EACH	2	$ 337.58	$ 675.17
N/A	12" 90 BEND	EACH	1	$ 57.10	$ 57.10
N/A	12" TEE	EACH	2	$ 109.70	$ 219.40
N/A	12" COUPLER	EACH	8	$ 8.29	$ 66.33
N/A	24" COUPLER	EACH	2	$ 33.20	$ 66.40
N/A	12" N12 AASHTO FOR MANIFOLD	LF	40	$ 7.75	$ 310.04
N/A	24" N12 AASHTO FOR ISOLATOR ROW	LF	20	$ 22.54	$ 450.80
N/A	315WTK FOR SCOUR PROTECTION	SY	1000	$ 0.72	$ 724.50
N/A	601TG TO WRAP SYSTEM	SY	2000	$ 0.82	$ 1,633.00
N/A	12X6 INSPECTION PORT KIT	EACH	1	$ 430.10	$ 430.10
N/A	6" RED HOLE SAW	EACH	1	$ 172.17	$ 172.17
N/A	8 INCH UNDERDRAIN PIPE	LF	275	$ 35.00	$ 9,625.00
N/A	8 INCH UNDERDRAIN CARRIER PIPE	LF	25	$ 40.00	$ 1,000.00
301.26	SUBBASE OF CRUSHED GRAVEL, FINE GRADED	CY	55	$ 40.03	$ 2,201.65
N/A	30 MM PVC LINER	SY	700	$ 8.00	$ 5,600.00
N/A	GEOTEXTILE FOR UNDERDRAIN TRENCH LINING	SY	140	$ 5.00	$ 700.00
				Subtotal:	$ 31,259.45
Erosion Control					
651.25	HAY MULCH	TON	1	$ 597.15	$ 597.15
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 673.75
				Subtotal:	$ 45,096.36
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 4,509.64
	Incidentals to Construction - 5%**				$ 2,254.82
	Minor Additional Design Items - 5%**				$ 2,254.82
	Final Design	HR	45	$ 125.00	$ 5,625.00
			Total (Rounded to nearest $1,000)		**$ 62,000.00**

4.5.4 Next Steps

As this site is owned by Wilcox and Barton, Inc. and will involve VTrans due to connections along Route 100B, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner and approval from VTrans. Wilcox and Barton are willing to proceed with further design. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project's location in the river corridor and proximity to the floodplain. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

D. Chapter 1: Waitsfield

1 Background

1.1 Problem Definition

The Town of Waitsfield is located in Washington County primarily within the Mad River watershed (Figure D1). The Mad River and major tributaries of the Mad river flow through Waitsfield, including Mill Brook and Shepard Brook. The headwaters of the Dog River originate in Waitsfield. Each of these watersheds is within the larger Winooski River watershed, which drains to Lake Champlain. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

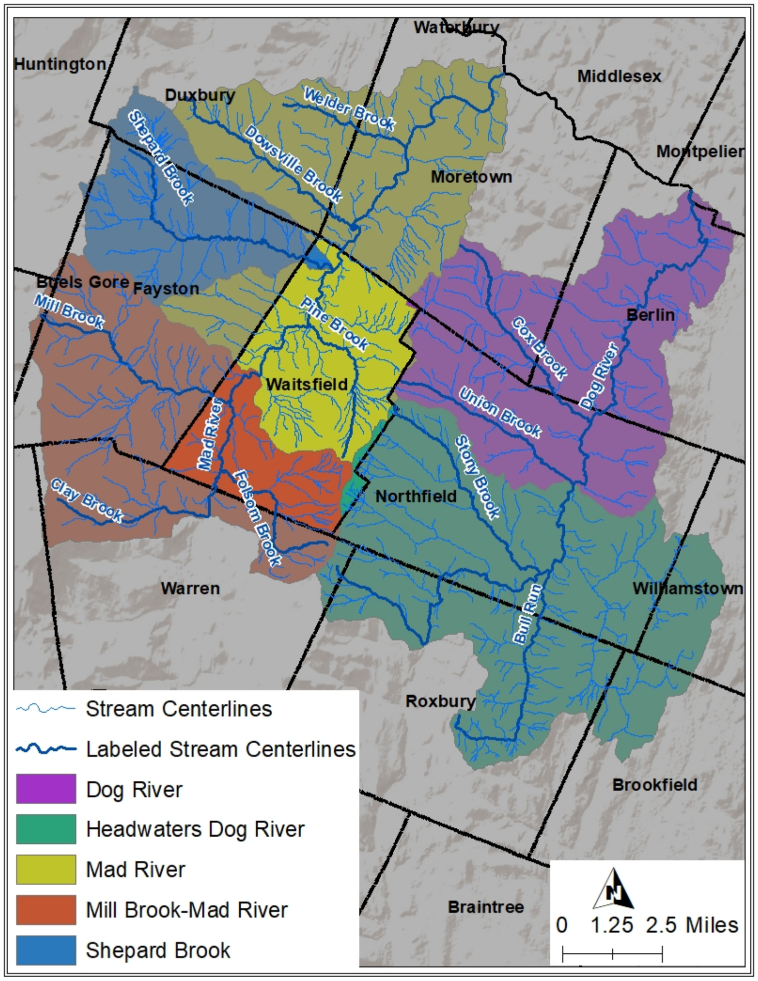


Figure D1. Waitsfield is located primarily within the Mad River watershed.

The Waitsfield Village Center is located within the river corridor of the Mad River, in a high flood hazard area. Waitsfield has experienced extensive flooding in this area, leading to property damage. New development in the town, primarily second homes and commercial development, has occurred. Residential building has occurred on steep slopes outside the village center, whereas commercial development has been located near the historic downtown.

Heavy flooding occurred as a result of Tropical Storm Irene, however, this was not the only occurrence of Waitsfield experiencing disastrous flood levels. Damage to roads, homes, and crops occurred, causing significant economic losses. To improve flood resiliency in Waitsfield, recommendations have been made to identify priority actions and policies that should be implemented. The Disaster Recovery and Long-Term Resilience Planning in Vermont (2013) outlines these recommendations. Since this report was produced, a new Town Plan has been adopted (2018). Flood Hazard Overlay and Fluvial Erosion Hazard Overlay Districts in the updated Town Plan identify policies that will help minimize losses due to floods and manage development in these areas.

1.2 Existing Conditions

The Town of Waitsfield spans approximately 16,591 acres in Washington County, VT (Figure D2) and is primarily forested (76%) with 17% agricultural and 5% urban land use. Of that area, there are 355 acres (2%) of impervious cover.

Much of the Town of Waitsfield is rural and residential, and this area contains roads that are generally unpaved with open roadside ditches. Many of these roads have steep slopes and traverse large areas. This predisposes these areas to erosion and sediment transport. Much of the older development within the Town was constructed before current stormwater standards were developed and were constructed without any or with only minimal stormwater management. This has resulted in untreated stormwater draining from developed lands directly to surface waters.

Soils analyses indicate that of the 16,591 total acres in the Town, 90% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the City, the majority of areas belong to either Hydrologic Soil Group C (51%) or D (28%), while only 8% are in group A, and 13% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed

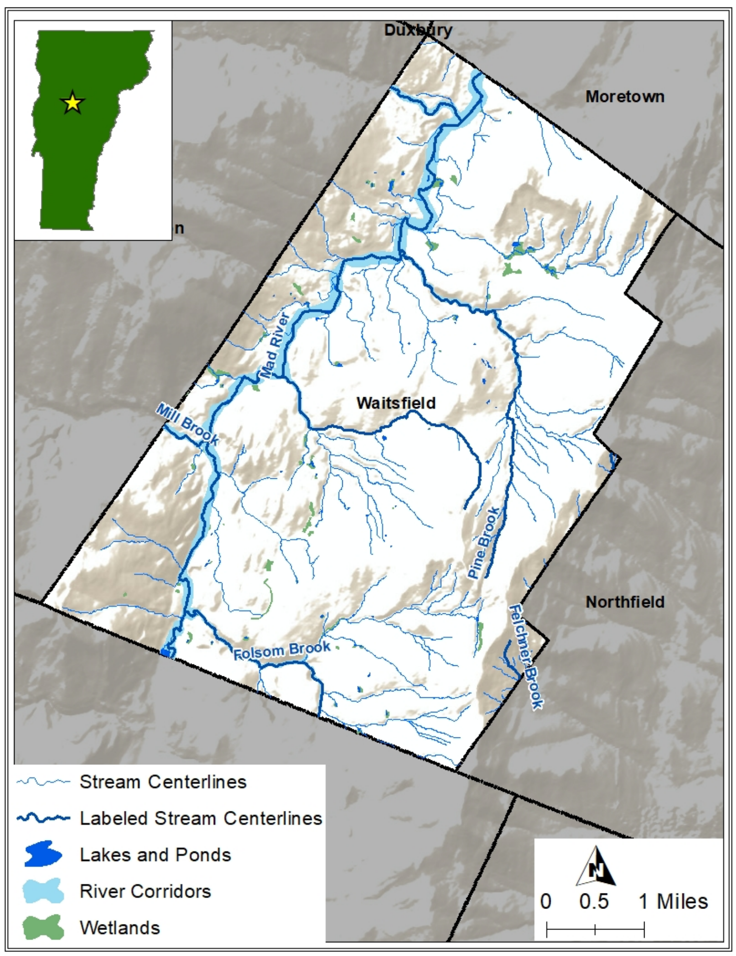


Figure D2. Waitsfield is located in Washington County, VT.

conditions can be found in Appendix D1 – Map Atlas. Maps include:

- river corridors, wetlands, and hydric soils;
- impervious cover;
- soil infiltration potential;
- soil erodibility;
- land cover;
- slope;
- stormwater infrastructure and stormwater permits;
- and parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2018). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix D2 – Data Review.

The project team met with Town of Waitsfield stakeholders, Friends of the Mad River (Friends), and the Central Vermont Regional Planning Commission (CVRPC) on December 7, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Meeting minutes from this meeting are included in Appendix D3. A second town-specific meeting was held on January 25, 2018 to identify a list of problem areas including specific parcels and general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed in order to identify additional potential sites for stormwater BMP implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix D4).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.
Prerequisites:

1. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
    - ≥ 50 ft = Ideal (Score: 2 points)
    - 46-50 ft = Potential (Score: 1 point)
    - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

3. Hydrologic Soil Group (indication of infiltration potential)
   - A/B (highest infiltration potential) = Ideal (Score: 2 points)
   - B/C (moderate infiltration potential) = Potential (Score: 1 point)
   - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 17 sites with potential were noted for assessment in the field (Figure D3).

A total of 54 locations, including the Green Streets sites, were identified for stormwater retrofit potential.

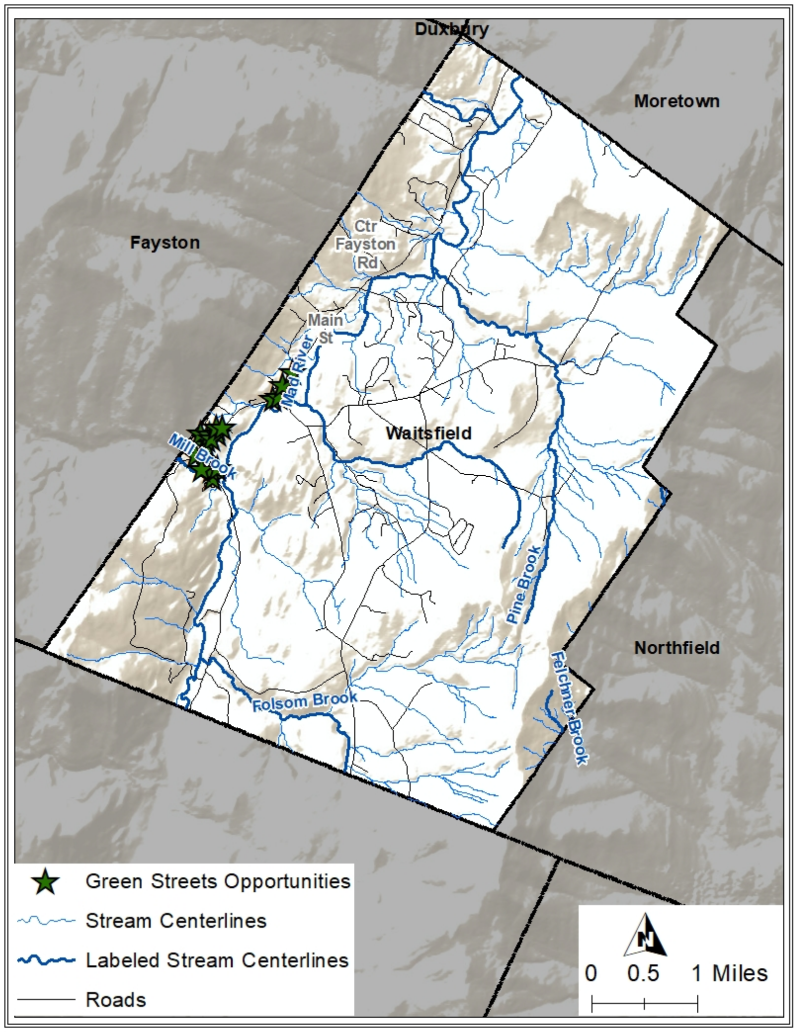


Figure D3. The 17 locations identified as potential green streets opportunities are shown with green stars.

2.1.2.2 *Basemap and Mobile App Creation*

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 54-point locations for the potential BMP sites, which included both general Town-wide sites and green streets locations. These points allowed for easy site location and data collection in the field (Figure D4).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

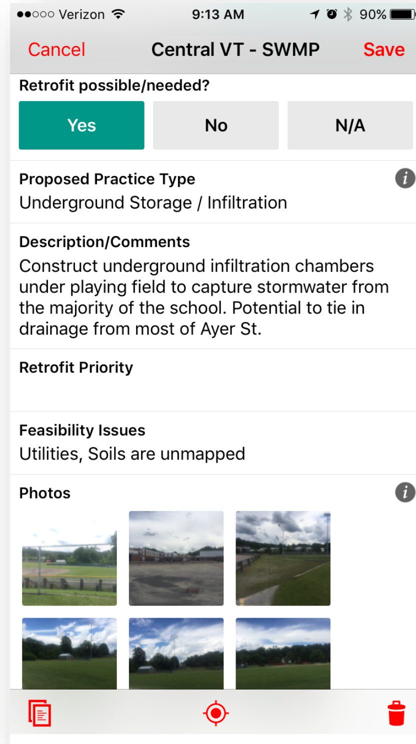


Figure D4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 54 previously identified potential BMP locations were evaluated in the field during the Summer of 2018 (Figure D5). Data was collected about each site in the mobile app. A large map of these sites with associated site names, and a list of these sites including potential BMP options and site notes can be found in Appendix D5 - Initial Site Identification.

Through the course of these field visits, additional stormwater retrofit sites were identified that had not been included in the initial assessment. Some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific, prohibitive site conditions. Following this process, a total of 39 sites in Waitsfield remained as potential BMP opportunities (Figure D6).

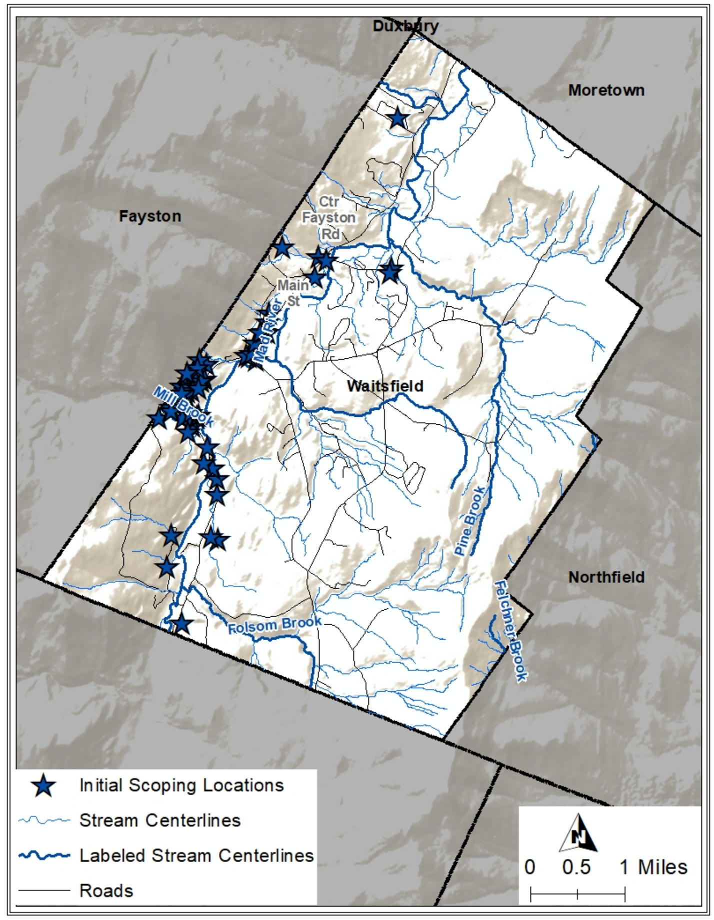


Figure D5. 54 potential sites for BMP implementation were identified for field investigation.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 39 projects (Figure D6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix D6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix D6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

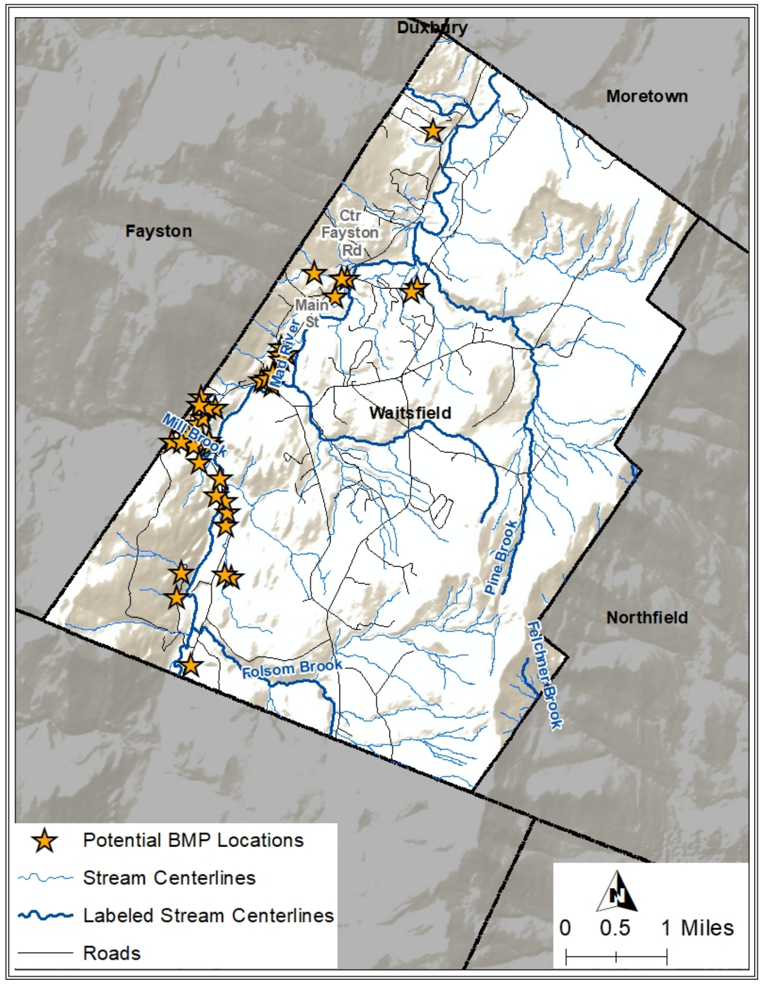


Figure D6. Following field investigations, the list of potential BMP sites was refined to 39. Point locations are shown for each site.

The draft Top 20 list was distributed to Waitsfield stakeholders, the CVRPC, and Friends. As part of this process, the project team met with the stakeholders on August 23, 2018 to discuss the proposed Top 20 project sites. Following feedback from the Town, the list was reordered to reflect the Town's knowledge of potentially unwilling landowners and the Town's priorities. These Top 20 sites are listed in Table D1. Point locations are shown in Figure D7.

Table D1. Top 20 BMPs selected for the Waitsfield SWMP.

Site ID	Proposed Practice Type
Town Garage	Subsurface Infiltration Chambers
Main St Infiltration	Underground Storage / Infiltration, Level Spreader
Mad River Green Field	Filter Strip / Buffer Enhancement, Infiltration trench, Bioretention
Bridge and Main Commercial	Filter Strip / Buffer Enhancement, Relocate Sand Pile
Lareau Park	Subsurface Infiltration Chambers
Slow Rd Infiltration	Infiltration Trench
Mad River Valley Ambulance	Infiltration Basin
Localfolk Smokehouse	Dry Well
Kenyon's Variety	Infiltration Basin
Town Sand Pull-off	Infiltration Basin, Impervious Cover Reduction
Mad River Health Center	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement
Waitsfield Fire Station	Dry Wells, Bioretention, Curb Bump Out, Stormwater Planter
Main St Step Pools	Bioretention, Infiltration Trench, Stormwater Planter, Curb Bump Out
Mad River Park	Bioretention, Filter Strip / Buffer Enhancement
Jamieson Insurance	Subsurface Infiltration Chambers
Church and Child Center	Underground Storage / Infiltration, Level Spreader
Dana Hill Rd and Rte 17	Filter Strip / Buffer Enhancement, Infiltration trench, Bioretention
Bridge St Green Streets NW	Filter Strip / Buffer Enhancement, Relocate Sand Pile
Main St by Bridge St Green Streets	Subsurface Infiltration Chambers
Tremblay Rd Parking Lot	Infiltration Trench

2.3 *Modeling and Concept Refinement for Top 20 BMPs*

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations. Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix D8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration-based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table D2. Complete modeling results are provided in Appendix D8 - Top 20 Sites Modeling.

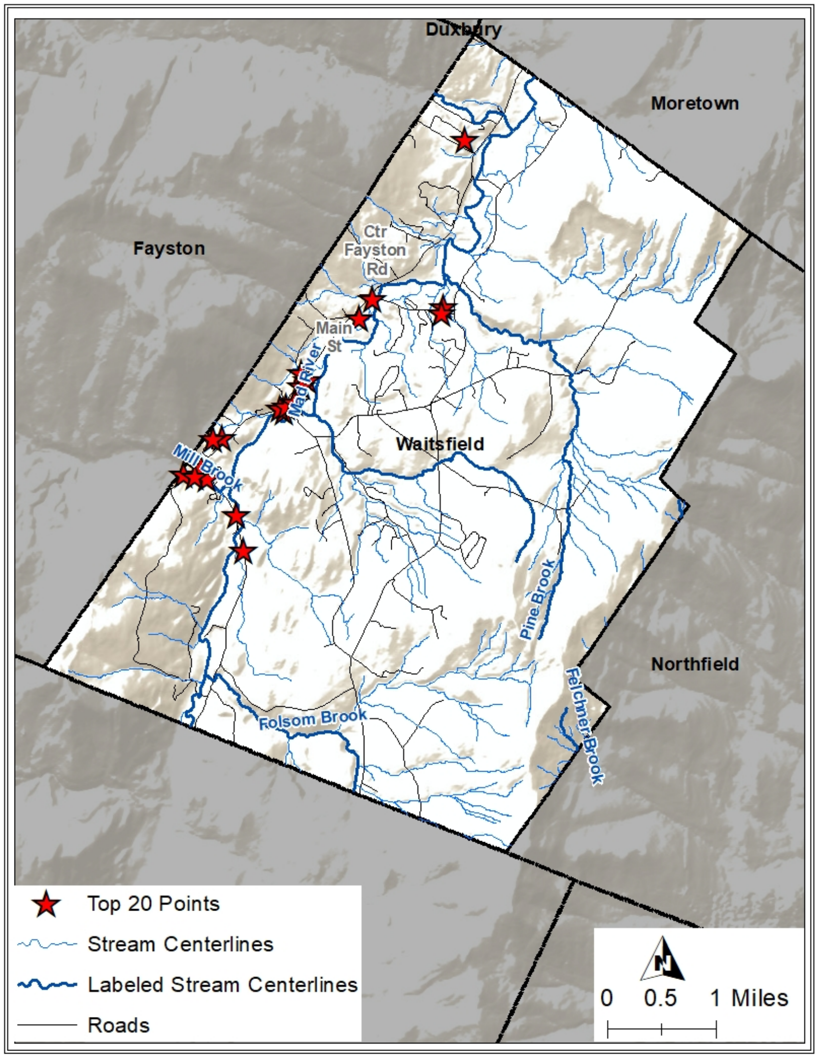


Figure D7. The Top 20 project locations are shown.

Table D2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Town Garage	0.227	0.227	2254	97.25%	1.94	97.76%
Main St Infiltration	0.463	0.463	8190	99.42%	3.20	99.05%
Mad River Green Field	0.635	0	28336	96.00%	10.19	58.00%
Bridge and Main Commercial	0.082	0.082	823	50.79%	0.52	49.55%
Lareau Park	0.038	0.038	892	96.88%	0.51	90.32%
Slow Rd Infiltration	0.198	0.198	5685	99.43%	1.71	99.08%
Mad River Valley Ambulance	0.649	0.649	6400	95.32%	5.54	95.64%
Localfolk Smokehouse	0.214	0.214	6542	100%	2.13	100%
Kenyon's Variety	0.004	0.004	6386	60% Buffer; 99.05% Bioretention 1; 79.66% Bioretention 2	2.88	20% Buffer; 99.33% Bioretention 1; 79.2% Bioretention 2
Town Sand Pull-off	0.007	0	4071	60% (filter strip); 100% (moving sand pile)	1.00	20% (filter strip); 100% (moving sand pile)
Mad River Health Center	0.137	0.137	2625	100.00%	1.25	100.00%
Waitsfield Fire Station	0.086	0.086	1623	100.00%	0.58	100.00%
Main St Step Pools	0.040	0.04	2627	96.20%	0.94	91.64%
Mad River Park	0.032	0.032	1008	60.70%	5.08	57.62%
Jamieson Insurance	0.064	0.064	1448	97.48%	1.18	98.57%
Church and Child Center	0.064	0.064	2044	96.82%	0.76	92.24%
Dana Hill Rd and Rte 17	0.087	0	1830	60.00%	0.50	20.00%
Bridge St Green Streets NW	0.051	0.051	640	63.09%	0.17	61.05%
Main St by Bridge St Green Streets	0.079	0	835	60.00%	0.20	20.00%
Tremblay Rd Parking Lot	0.010	0.01	796	96.92% (Bioretention); 60% (Buffer)	0.19	93.55% (Bioretention); 20% (Buffer)

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix D9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix D10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix D9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[4] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table A3 below.

Table D3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large above-ground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Used either 20% for large above-ground projects, or 35% for smaller or complex projects.

[4] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix D9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and their assigned rank are shown in Table D4. The comprehensive matrix used to rank the proposed BMP projects is provided in Appendix D9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table D4. Top 20 potential BMP sites for Waitsfield.

Rank	Site ID	Address	Proposed Practice Type
1	Town Garage	761 Tremblay Rd, Waitsfield, VT	Infiltration Basin, Chloride Management
2	Main St Infiltration	Main St and Bridge St, Waitsfield, VT	Underground Storage / Infiltration
3	Mad River Green Field	Mad River Canoe Rd, Waitsfield, VT	Gravel Wetland
4	Bridge and Main Commercial	4457 Main St, Waitsfield, VT	Dry Wells, Filter Strip / Buffer Enhancement
5	Lareau Park	5919 Main St, Waitsfield, VT	Bioretention, Filter Strip / Buffer Enhancement
6	Slow Rd Infiltration	129–199 Slow Rd, Waitsfield, VT	Infiltration Trench
7	Mad River Valley Ambulance	4124 Main St, Waitsfield, VT	Subsurface Infiltration Chambers
8	Localfolk Smokehouse	9 VT Route 17, Waitsfield, VT	Underground Storage / Infiltration, Level Spreader
9	Kenyon’s Variety	3337 Main St, Waitsfield, VT 05673	Filter Strip / Buffer Enhancement, Infiltration trench, Bioretention
10	Town Sand Pull-off	689 Tremblay Rd, Waitsfield, VT	Filter Strip / Buffer Enhancement, Relocate Sand Pile
11	Mad River Health Center	4036 Main St, Waitsfield, VT	Subsurface Infiltration Chambers
12	Waitsfield Fire Station	4103 Main St, Waitsfield, VT	Infiltration Trench
13	Main St Step Pools	5351 Main St, Waitsfield, VT	Infiltration Basin
14	Mad River Park	Home Farm Way, Waitsfield, VT	Dry Well
15	Jamieson Insurance	5730 Main St, Waitsfield, VT	Infiltration Basin
16	Church and Child Center	6305 Main St, Waitsfield, VT	Infiltration Basin, Impervious Cover Reduction
17	Dana Hill Rd and Rte 17	1–271 Dana Hill Rd, Waitsfield, VT	Ditch / Swale Improvements, Check Dams, Filter Strip / Buffer Enhancement
18	Bridge St Green Streets NW	20 Bridge St, Waitsfield, VT	Dry Wells, Bioretention, Curb Bump Out, Stormwater Planter
19	Main St by Bridge St Green Streets	4456 Main St, Waitsfield, VT	Bioretention, Infiltration Trench, Stormwater Planter, Curb Bump Out
20	Tremblay Rd Parking Lot	Tremblay Rd and Main St, Waitsfield, VT	Bioretention, Filter Strip / Buffer Enhancement

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking as well as input from municipal officials concerning project priorities. The location of the sites within the Town are shown in Figure A8. In the final ranking, these 5 sites were awarded additional points in the site scoring to reflect the Town's priorities and the high probability for implementation. The Top 5 sites are listed in Table D5 in order of rank.

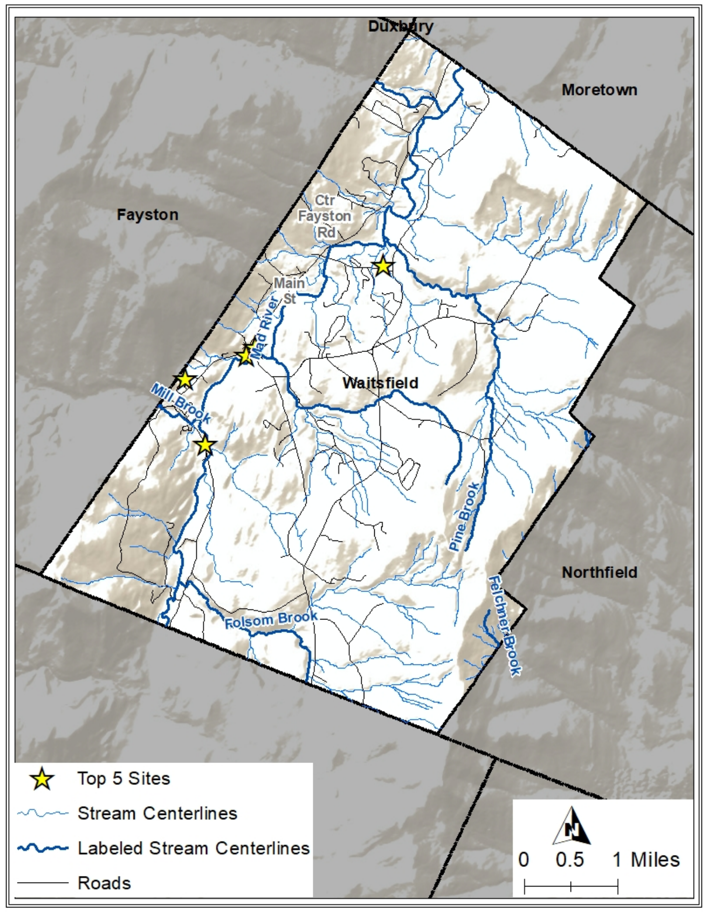


Figure D8. Top 5 sites for the Waitsfield SWMP.

Table D5. Top 5 BMP sites for Waitsfield.

Rank	Site ID	Address	Proposed Practice Type
1	Town Garage	761 Tremblay Rd, Waitsfield, VT	Infiltration Basin, Chloride Management
2	Main St Infiltration	Main St and Bridge St, Waitsfield, VT	Underground Storage / Infiltration
3	Mad River Green Field	Mad River Canoe Rd, Waitsfield, VT	Gravel Wetland
4	Bridge and Main Commercial	4457 Main St, Waitsfield, VT	Dry Wells, Filter Strip / Buffer Enhancement
5	Lareau Park	5919 Main St, Waitsfield, VT	Bioretention, Filter Strip / Buffer Enhancement

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on Town property and private property. A memo describing these sites and updated field data sheets are provided in Appendix D11.

Site: 1
Project Name: Town Garage
Description: The site includes the Waitsfield Town Garage facility. Included in the site is an unpaved access drive, the garage building, and sand and salt storage. Proposed BMPs for the site include as follows: Construct an infiltration basin in existing swale located south of solar panels (Figure D9). Create two inflow swales, one along the northwestern edge, and one around the southwestern corner, and direct to basin. Regrade parking area to improve drainage throughout site. Create a paved apron in front of salt shed to improve chloride management. Ensure that any spillage is cleaned up immediately.
Outreach: This site is owned by the Town of Waitsfield, and as such, no additional outreach was carried out.

Figure D9. The proposed infiltration basin is located to the left of photo.

Site: 2
Project Name: Main St Infiltration
Description: The site includes the mixed residential and commercial area drained by a series of catch basins and pipes along Main St and Bridge St. This area is a chronic problem area for the Town. Proposed BMPs for the site include as follows: Redirect the stormline running down Bridge St, via a connecting pipe by the Madsonian Museum's driveway, to a subsurface infiltration chamber system in the lawn east of the Waitsfield United Church of Christ's parking lot (Figure D10).
Outreach: The Waitsfield United Church of Christ has expressed interest in further design. Additionally, David Sellers, owner of the Madsonian, has expressed his willingness to allow further design to be completed.

Figure D10. The proposed location of subsurface infiltration chambers.

Site: 3
Project Name: Mad River Green Field
Description: The site includes the Business park that houses Shaw's Supermarket. The Shaw's parcel has more than 3 acres of impervious cover and does not have a current stormwater permit. Proposed BMPs for this site include as follows: Construct a gravel wetland in the greenspace northeast of the Shaw's plaza parking lot (Figure D11). This system would collect, slow, and filter stormwater runoff from the Mad River Green shopping center and overflow to the existing outlet. This practice would require the removal of some of the trees currently planted in the greenspace. Note that a number of these trees are already dead. Also, there is potential to reduce the width of the over-widened Mad River Canoe Rd which runs along the east of the greenspace.

Figure D11. The proposed gravel wetland is located in the greenspace next to Shaw's.

Outreach: Both Crosspoint Associates, Inc., the owners of the property, and the Shaw's Supermarket manager have expressed their willingness to proceed with further design.

Site: 4
Project Name: Bridge and Main Commercial
Description: The site includes the commercial complex along the Mad River (Figure D12). This site is a chronic problem area that is located partially within the river corridor. It was noted by State as a retrofit opportunity. Proposed BMPs for this site include as follows: add dry wells in low points in parking lot to infiltrate drainage from the site. Regrade the parking lot to better direct drainage to the dry wells. Enhance buffer along river bank.
Outreach: The owner of the commercial complex has expressed wiliness to proceed with further design.

Figure D12. Parking area where dry wells are proposed.

Site: 5
Project Name: Lareau Park
Description: The site includes Lareau Park, a public recreational area along the Mad River. The site is located within the river corridor. Proposed BMPs for the site include as follows: Enhance riparian buffer by implementing a low or no mow zone between the parking lot and the river. Create designated access points to river. Construct two bioretention areas along the edge of the parking lot to collect and filter the site's stormwater runoff (Figure D13).
Outreach: This site is owned by the Town of Waitsfield, and as such, no additional outreach was carried out.


Figure D13. The proposed bioretention areas would be located to the left of the photo.

When implemented, these five BMPs would treat approximately 51.8 acres, 14.8 acres (29%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table D6, indicate that these BMPs will prevent nearly 40,500 lbs of total suspended solids and 16.4 lbs of total phosphorus from reaching receiving waters annually.

Table D6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Town Garage	0.227	0.227	2254	97.25%	1.94	97.76%
Main St Infiltration	0.463	0.463	8190	99.42%	3.20	99.05%
Mad River Green Field	0.635	0	28336	96.00%	10.19	58.00%
Bridge and Main Commercial	0.082	0.082	823	50.79%	0.52	49.55%
Lareau Park	0.038	0.038	892	96.88%	0.51	90.32%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix D12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix D13 - 30% Designs.

Soils conditions were assessed at 3 of the top 5 sites where infiltration-based practices are proposed. Pits were manually excavated using a shovel and hand auger. Analysis at these sites included documentation of depth to water table (if applicable), horizon breaks, soil structure, type, moisture, color, presence or absence of redoximorphic features, and size and quantity of roots and coarse fragments. Any other notes considered to be important were recorded during this time. The soil profiles with photos can be found in Appendix D14.

4.1 Town Garage

4.1.1 30% Concept Design Description

The Town of Waitsfield's Town Garage is located on Tremblay Road near the intersection with North Rd. The majority of the site drains towards the west to an existing swale located south of the solar panels. Drainage from the swale flows down the bank into an unnamed tributary before discharging to the Mad River by the adjacent farm fields. Sand and salt are stored at this site.

Figure D14. The proposed BMP drainage area is shown in purple. The recommended BMP locations are shown with stars.

It is recommended that an infiltration basin is constructed in the existing swale located south of the solar panels (see starred location in Figure D14). Two inflow swales are proposed, one along the northwestern edge, and one around the southwestern corner, to direct drainage to basin. The parking area should be regraded to improve drainage throughout site. Additionally, a paved apron should be created in front of the salt shed to improve chloride management. Staff should ensure that any spills are cleaned up immediately. See the photos and associated descriptions in Figure D17.

Most of the site drains to this swale by the solar panels.

Salt storage at the Town Garage should be improved and any spills cleaned up immediately.

The majority of the Town Garage site drains to a swale northwest of the main building.

Figure D17. The retrofits are described in the above photos.

Soils are mapped as being very good at this site (Hydrologic Group A), and an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger (Figure D16) and were found to be generally sandy (Figure D15). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix D14 for this site's complete soil log.

Figure D15. Soils were generally sandy.

Figure D16. Soils were assessed in the roadside ditch area.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix D16 - Site Renderings.

The design standard used for this retrofit was management and infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 9,888 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix D11 - Top 5 Sites. A 30% design plan is provided in Appendix D13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent more than 2,254 lbs of total suspended solids (TSS) and 1.94 lbs of total phosphorus (TP) from entering receiving waters (Table D7). This project will provide a significant benefit to water quality.

Table D7. Town Garage benefit summary table.

TSS Removed	2,254 lbs
TP Removed	1.94 lbs
Impervious Treated	1.5 acres
Total Drainage Area	2 acres

4.1.3 Cost Estimates

The total estimated cost for this project is $39,000. These preliminary costs can be found in Figure D8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $20,103.
- The cost per impervious acre treated is $26,000.
- The cost per cubic foot of runoff treated is $3.94.

Table D8. Town Garage project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	310	$ 1.17	$ 362.70
649.51	GEOTEXTILE FOR SILT FENCE	SY	150	$ 4.13	$ 619.50
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,982.20
Infiltration Basin					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	300	$ 9.86	$ 2,958.00
MATERIALS					
613.11	STONE FILL, TYPE I	CY	140	$ 42.49	$ 5,948.60
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	50	$ 34.04	$ 1,702.00
601.0915	18" CPEP	LF	45	$ 64.04	$ 2,881.80
601.5814	18" CPEP ELBOW	EACH	1	$200.00	$ 200.00
INLET / OUTLET PROTECTION					
613.11	STONE FILL, TYPE I	CY	25	$ 42.49	$ 1,062.25
SIDE SLOPE EROSION CONTROL					
651.25	HAY MULCH	TON	1	$597.15	$ 597.15
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	550	$ 2.20	$ 1,210.00
				Subtotal:	$ 16,636.40
Conveyance Swales & Pavement Apron					
EXCAVATION					
203.27	UNCLASSIFIED CHANNEL EXCAVATION	CY	280	$ 13.65	$ 3,822.00
Check Dams					
613.11	STONE FILL, TYPE I	CY	15	$ 42.49	$ 637.35
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	5	$ 34.04	$ 170.20
PAVEMENT REPLACEMENT					
406.25	BITUMINOUS CONCRETE PAVEMENT	TON	40	$ 127.86	$ 5,114.40
GRASS REPLACEMENT					
653.20	TEMPORARY EROSION MATTING	SY	500	$ 2.20	$ 1,100.00
651.15	SEED	LB	40	$ 7.66	$ 306.40
				Subtotal:	$ 11,150.35
Subtotal:					$ 29,768.95
	Construction Oversight**	HR	8	$ 125.00	$ 1,000.00
	Construction Contingency - 10%**				$ 2,976.90
	Incidentals to Construction - 5%**				$ 1,488.45
	Minor Additional Design Items - 5%**				$ 1,488.45
	Final Design	HR	20	$ 125.00	$ 2,500.00
Total (Rounded to nearest $1,000)					**$ 39,000.00**

4.1.4 Next Steps

As this site is owned and operated by the Town of Waitsfield, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix D15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
An Act 250 permit for the gravel pit located at the Town Garage property (5W1230) exists, and as such this project should be reviewed to determine if an amendment to this permit would be required. Permits are not anticipated to meet River Corridor or Wetlands Rules requirments for this project.

4.2 Main St Infiltration

4.2.1 30% Concept Design Description

An area of mixed residential and commercial properties is drained by a series of catchbasins and pipes along Main St/ VT-100 and Bridge St. The Town of Waitsfield has noted that this is a problem area for stormwater. The stormline currently runs southwest down Main St and is directed southeast down Bridge St before discharging directly to the Mad River without treatment.

It is recommended that the stormline running down Bridge St be redirected via a connecting pipe by the Madsonian Museum's driveway to a subsurface infiltration chamber system in the lawn east of the Waitsfield United Church of Christ's parking lot (see site map in Figure D18). The owners of the Madsonian Museum and the Church have expressed willingness to proceed with further design. See the photos and associated descriptions in Figure D19.

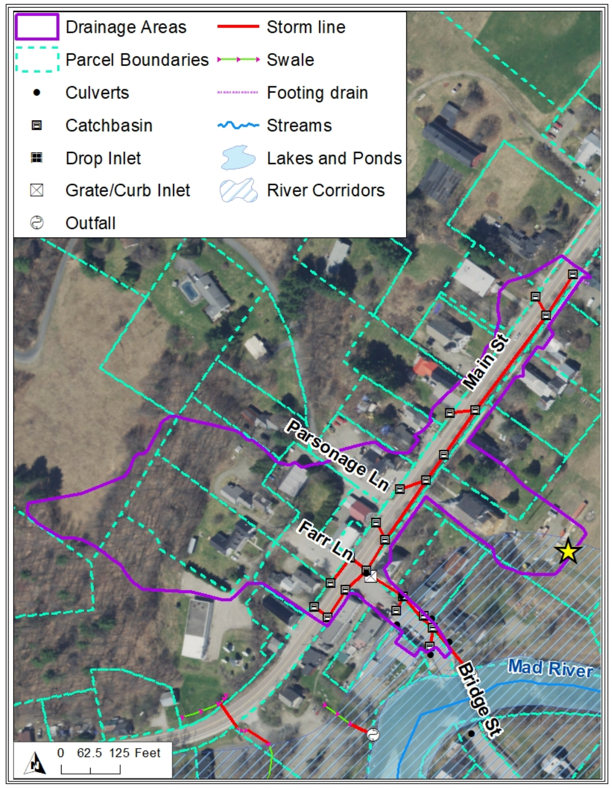


Figure D18. The drainage area for the proposed BMP is shown in purple.

Proposed subsurface infiltration chambers would be located in the greenspace to the right of the unpaved church parking lot.

The proposed practice would be located behind the main church.

Drainage from Bridge St and Route 100 are collected in a series of catchbasins that currently drain to the Mad River.

Figure D19. The proposed retrofits are described in the above photos

Figure D20. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils are mapped as being good at this site (Hydrologic Group B), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure D21) and were found to be generally sandy (Figure D20). Soils conditions observed during analysis were appropriate for an infiltration-based practice and did not prompt a need to alter the proposed retrofit design. The soil profile with photos can be found in Appendix D14.

Figure D21. Soils were generally sandy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix D16 - Site Renderings.

The design standard used for the infiltration chamber retrofit was infiltration of the Channel Protection Volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 20,169 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix D11 - Top 5 Sites. A 30% design plan is provided in Appendix D13 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 8,190 lbs of total suspended solids (TSS) and 3.2 lbs of total phosphorus (TP) from entering receiving waters (Table D9).

Table D9. Main St Infiltration benefit summary table.

TSS Removed	8,190 lbs
TP Removed	3.2 lbs
Impervious Treated	3 acres
Total Drainage Area	7.6 acres

4.2.3 Cost Estimates

The total estimated cost for this project is $87,000. Note that these costs are very preliminary. Cost projections can be found in Table D10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $27,188.
- The cost per impervious acre treated is $29,000.
- The cost per cubic foot of runoff treated is $4.31.

Table D10. Main St Infiltration project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	200	$ 1.17	$ 234.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	106	$ 4.13	$ 437.78
N/A	CONSTRUCTION STAKING	HR	8	$ 125.00	$ 1,000.00
Subtotal:					$ 2,171.78
Chambers - Excavation and Materials					
EXCAVATION					
203.28	EXCAVATION OF SURFACES AND PAVEMENTS	CY	23	$ 21.94	$ 504.62
203.15	COMMON EXCAVATION	CY	730	$ 9.86	$ 7,197.80
MATERIALS					
BASE / COVER / SURROUNDING STONE					
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	75	$ 34.04	$ 2,553.00
STRUCTURES AND APPURTENANCES					
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	2	$ 4,009.29	$ 8,018.58
601.09	12" CPEP	LF	300	$ 39.24	$ 11,772.00
PLANTING (ABOVE CHAMBERS IN GREENSPACE)					
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	485	$ 2.20	$ 1,067.00
651.25	HAY MULCH	TON	1	$ 597.15	$ 597.15
CHAMBERS - LUMP SUM COSTS					
	MC3500	EACH	50	$ 400.20	$ 20,010.00
	MC3500 PLAIN END CAP	EACH	5	$ 300.15	$ 1,500.75
	MC3500 18T END CAP	EACH	4	$ 404.23	$ 1,616.92
	MC3500 24B END CAP	EACH	1	$ 404.23	$ 404.23
	18" TEE	EACH	3	$ 230.01	$ 690.03
	18" 90 BEND	EACH	1	$ 144.80	$ 144.80
	18" COUPLER	EACH	11	$ 23.54	$ 258.95
	18" N12 AASHTO FOR MANIFOLD	LF	40	$ 14.94	$ 597.54
	24" N12 AASHTO FOR ISOLATOR ROW	LF	20	$ 22.54	$ 450.80
	315WTM FOR SCOUR PROTECTION	SY	500	$ 0.74	$ 370.00
	601TG TO WRAP SYSTEM	SY	2500	$ 0.82	$ 2,041.25
	12X6 INSPECTION PORT KIT	EACH	1	$ 430.10	$ 430.10
N/A	6" RED HOLE SAW	EACH	1	$ 172.17	$ 172.17
Subtotal:					$ 60,474.28
Road Replacement					
401.10	AGGREGATE SURFACE COURSE	CY	25	$ 43.60	$ 1,090.00
Subtotal:					$ 1,090.00
Subtotal:					$ 63,736.06
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 6,373.61
	Incidentals to Construction - 5%**				$ 3,186.80
	Minor Additional Design Items - 5%**				$ 3,186.80
	Final Design	HR	55	$ 125.00	$ 6,875.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$ 125.00	$ 2,000.00
Total (Rounded to nearest $1,000)					**$ 87,000.00**

4.2.4 Next Steps

As this site is owned by the Waitsfield United Church of Christ and will require a piped connection through property owned by David Sellers, it is recommended that the Town proceed with further design of this retrofit after obtaining formal memorandums of understanding with the landowners. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix D15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and floodplain. However, it should be noted that this project will not result in any net fill within the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.3 Mad River Green Field

4.3.1 30% Concept Design Description

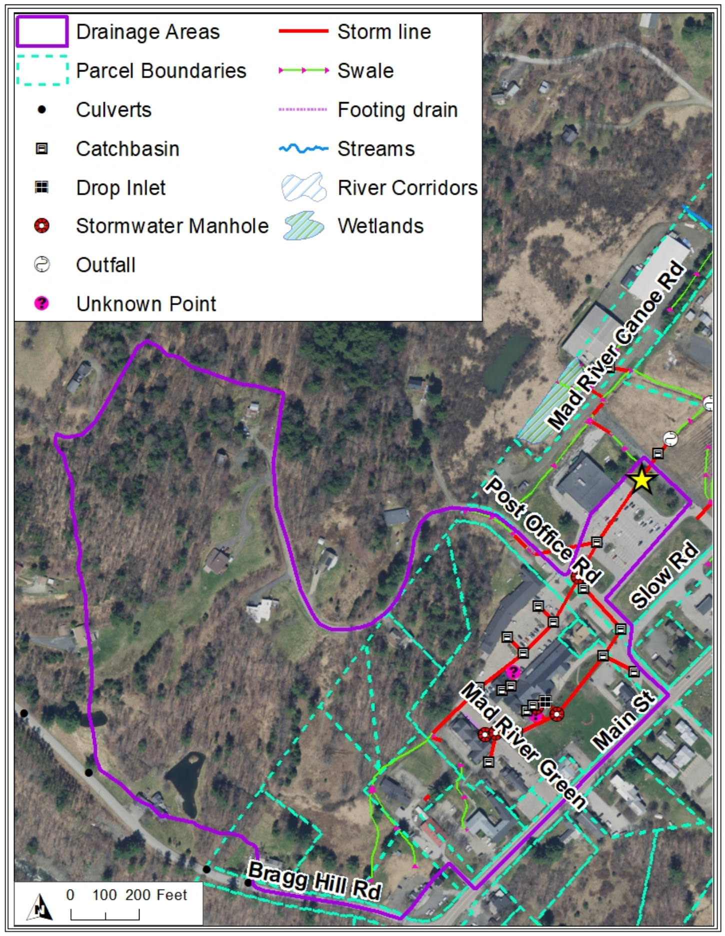


Figure D22. The drainage area is shown outlined in purple.

Shaw's Supermarket is a part of the Mad River Green shopping center located off Main St/VT-100 between the Mad River Green access drive, Post Office Rd, Slow Rd, and Mad River Canoe Rd. This shopping center is one of the largest commercial properties in the area, is situated on a parcel with greater than 3 acres of impervious cover and does not have a Vermont State stormwater permit. Drainage from this site is currently collected in a series of pipes and catchbasins that outlets to a field just northeast of the Shaw's plaza and Mad River Canoe Rd.

It is recommended that a gravel wetland is constructed in the greenspace northeast of the Shaw's plaza parking lot (see starred location in Figure D22). An educational sign should be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. This system would collect, slow, and filter stormwater runoff from the Mad River Green shopping center and overflow to the existing outlet. This practice would require the removal of some of the trees currently planted in the greenspace. Note that a number of these trees are already dead. Impervious reduction is also a possibility in this area as the parking lot is oversized and Mad River Canoe Rd (running east of the greenspace) has been over-widened. Shaw's Supermarket and owners of the Mad River Green shopping center, Crosspoint Associates, Inc., have expressed willingness to proceed with further design. See the photos and associated descriptions in Figure D23.

Potential to reduce the width of the access drive that runs along greenspace as it is overwidened.

The greenspace to the northeast of the Shaw's parking lot is the location for the proposed treatment.

The Shaw's property is collected in a stormline that drains north under the pictured greenspace.

The area where the retrofit is proposed currently has trees planted, but several have died.

Figure D23. The proposed retrofits are described in the above photos.

Soils are mapped as being poor to very poor at this site (Hydrologic Group C/D), so an analysis was not conducted to evaluate the potential for an infiltration practice.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix D16 - Site Renderings.

This practice will provide a significant water quality benefit (see Table D11). The design standard used for this retrofit was detention and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 27,661 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix D11 - Top 5 Sites. A 30% design plan is provided in Appendix D13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 28,335 lbs of total suspended solids (TSS) and 10.19 lbs of total phosphorus (TP) from entering receiving waters annually (Table D11).

Table D11. Mad River Green Field benefit summary table.

TSS Removed	28,336 lbs
TP Removed	10.19 lbs
Impervious Treated	8.8 acres
Total Drainage Area	39.8 acres

4.3.3 Cost Estimates

The estimated cost for implementation of this project is $129,000. Note that these costs are very preliminary. Cost projections can be found in Table D12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $12,659.
- The cost per impervious acre treated is $14,659.
- The cost per cubic foot of runoff treated is $4.66.

Table D12. Mad River Green Field initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.11	CLEARING AND GRUBBING, INCLUDING INDIVIDUAL TREES AND STUMPS	ACRE	0.1	$ 33,805.52	$ 3,380.55
653.55	PROJECT DEMARCATION FENCE	LF	700	$ 1.17	$ 819.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	70	$ 4.13	$ 289.10
N/A	CONSTRUCTION STAKING	HR	8	$ 125.00	$ 1,000.00
				Subtotal:	$ 5,988.65
Gravel Wetland - Excavation and Materials					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	2200	$ 9.86	$ 21,692.00
MATERIALS					
GRAVEL LAYERING					
651.35	TOPSOIL (MUCK SOIL)	CY	150	$ 30.96	$ 4,644.00
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	70	$ 34.04	$ 2,382.80
301.26	SUBBASE OF CRUSHED GRAVEL, FINE GRADED	CY	415	$ 40.03	$ 16,612.45
PIPING					
605.13	12 INCH UNDERDRAIN PIPE	LF	200	$ 47.00	$ 9,400.00
649.41	GEOTEXTILE FOR UNDERDRAIN TRENCH LINING	SY	50	$ 4.04	$ 202.00
601.0905	12" CPEP	LF	60	$39.24	$ 2,354.40
601.0920	24" CPEP (stand pipe)	LF	55	$ 61.37	$ 3,375.35
N/A	12" BEEHIVE GRATE	EACH	10	$ 615.00	$ 6,150.00
STRUCTURES AND APPURTENANCES					
N/A	18' ANTI-SEEP COLLAR	EACH	2	$ 250.00	$ 500.00
N/A	30 MM PVC LINER	SY	2500	$ 5.40	$ 13,500.00
604.18	PRECAST REINFORCED CONCRETE DROP INLET WITH CAST IRON GRATE	EACH	2	$ 4,009.29	$ 8,018.58
OVERFLOWS AND TRANSFER WEIRS					
613.10	STONE FILL, TYPE I	CY	15	$ 43.91	$ 658.65
PLANTING					
N/A	WETLAND PLANT SEEDS	LBS	10	$ 125.00	$ 1,250.00
				Subtotal:	$ 90,740.23
GRASS REPLACEMENT					
653.20	TEMPORARY EROSION MATTING	SY	500	$ 2.20	$ 1,100.00
651.29	STRAW MULCH	TON	1	$ 455.33	$ 455.33
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 1,631.93
Subtotal:					$ 98,360.81
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 9,836.08
	Incidentals to Construction - 5%**				$ 4,918.04
	Minor Additional Design Items - 5%**				$ 4,918.04
	Final Design	HR	55	$ 125.00	$ 6,875.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$ 125.00	$ 2,000.00
Total (Rounded to nearest $1,000)					**$ 129,000.00**

4.3.4 Next Steps

As this site is owned by Crosspoint Associates, Inc, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix D15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
An Act 250 permit for The Village Square Company (5W0025) exists, and as such this project should be reviewed to determine if an amendment to this permit would be required. This project should be reviewed by a wetland ecologist prior to final design due to the presence of hydric soils. No River Corridor permitting concerns are anticipated for this project.

4.4 Bridge and Main Commercial

4.4.1 30% Concept Design Description

The Bridge St Marketplace, located south of the intersection of Main St/VT-100 and Bridge St, is comprised of several commercial properties and a large gravel parking lot with direct access to the Mad River. The Town of Waitsfield has noted that this is a problem area for stormwater. Drainage from this area is currently unmanaged and sheet flows through the parking lot into the river.

It is proposed that dry wells be installed in low points in parking lot to infiltrate drainage from the site (see starred location in Figure D24). The parking lot could be regraded to better direct drainage to the dry wells. Additionally, the buffer along river bank should be enhanced with low lying native woody plants. Owners of the marketplace, the Waitsfield Historic Village Association, are currently discussing the potential for this site to be included in the Town's stormwater master plan. See the photos and associated descriptions in Figure D25.

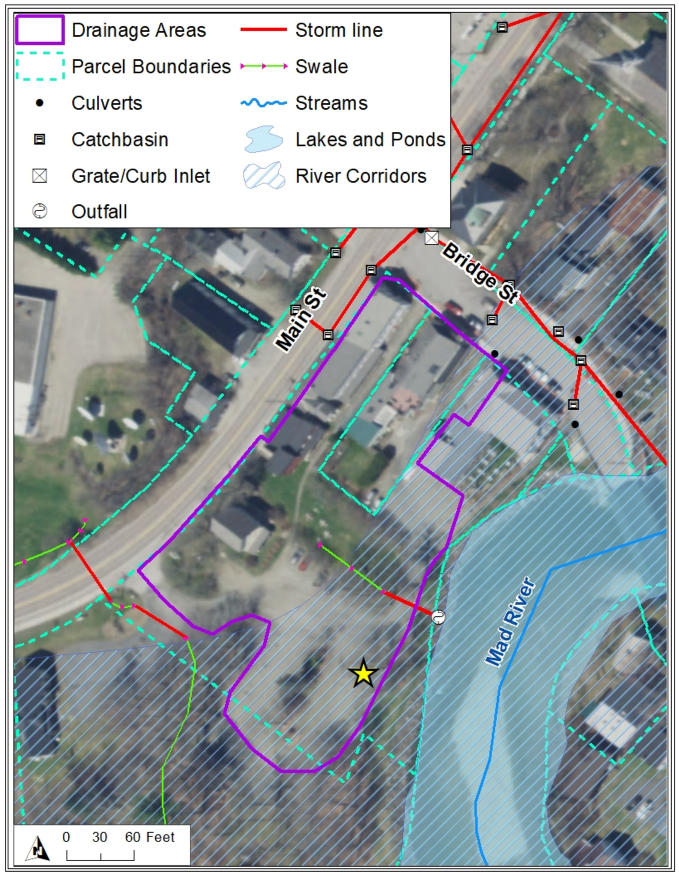


Figure D24. The drainage area for the proposed BMP is shown in purple.

Water causes puddling and ponding in the parking lot.

Drainage from the parking area drains directly to the Mad River.

There is little to no buffer along the Mad River in this area.

Dry wells are proposed in the parking lot to infiltrate drainage from the site.

Figure D25. The proposed retrofits are described in the above photos.

Figure D26. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils are mapped as being good at this site (Hydrologic Group B), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure D26) and were found to be generally sandy (Figure D27). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix D14 for this site's complete soil log.

Figure D27. Soils were generally sandy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix D16 - Site Renderings.

This practice will provide a significant water quality benefit (Table D13). The design standard used for this retrofit was management and infiltration of the Water Quality volume (WQv or 1 inch of rain in a 24-hour period), equal to 3,572 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix D11 - Top 5 Sites. A 30% design plan is provided in Appendix D13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 832 lbs of total suspended solids (TSS) and 0.52 lbs of total phosphorus (TP) from entering receiving waters annually (Table D13).

Table D13. Bridge and Main Commercial benefit summary table.

TSS Removed	823 lbs
TP Removed	0.52 lbs
Impervious Treated	1.1 acre
Total Drainage Area	1.6 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $23,000. Note that these costs are very preliminary. Cost projections can be found in Table D14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $44,231.
- The cost per impervious acre treated is $20,909.
- The cost per cubic foot of runoff treated is $6.44.

Table D14. Bridge and Main Commercial project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	60	$ 4.13	$ 247.80
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	500	$ 1.17	$ 585.00
				Subtotal:	$ 1,832.80
Dry Wells					
Excavation					
203.15	COMMON EXCAVATION	CY	90	$ 9.86	$ 887.40
MATERIALS					
N/A	DRY WELL STRUCTURE	EACH	3	$ 2,300.00	$ 6,900.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	13.5	$ 34.04	$ 459.54
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	12	$ 43.91	$ 526.92
DITCH BACKSLOPE EROSION CONTROL					
653.20	TEMPORARY EROSION MATTING	SY	450	$ 2.20	$ 990.00
651.29	HAY MULCH	TON	1	$ 455.33	$ 455.33
651.15	SEED	LB	12	$ 7.66	$ 91.92
				Subtotal:	$ 10,311.11
				Subtotal:	$ 12,143.91
	Construction Oversight**	HR	16	$ 125.00	$ 2,000.00
	Construction Contingency - 10%**				$ 1,214.39
	Incidentals to Construction - 5%**				$ 607.20
	Minor Additional Design Items - 5%**				$ 607.20
	Final Design	HR	50	$ 125.00	$ 6,250.00
Total (Rounded to nearest $1,000)					**$ 23,000.00**

4.4.4 Next Steps

As this site is owned by the Historic Waitsfield Village Association, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix D15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
Act 250 permits for P.J.S. Investments (5W0786, 5W0795) exist, and as such this project should be reviewed to determine if an amendment to these permits would be required. This project should be reviewed by a River Scientist prior to final design due to the project's location in the river corridor and the floodplain. However, it should be noted that this project will not result in any net fill within the river corridor. No Wetlands permitting concerns are anticipated for this project.

4.5 Lareau Park

4.5.1 30% Concept Design Description

Lareau Park is located on the banks of the Mad River, east of VT-100 between the Featherbed Inn and Lareau Rd. The park has a large gravel parking lot and provides access to the river and to trails running along the river. Stormwater from this site is unmanaged and currently sheetflows east across the parking lot and down to the river.

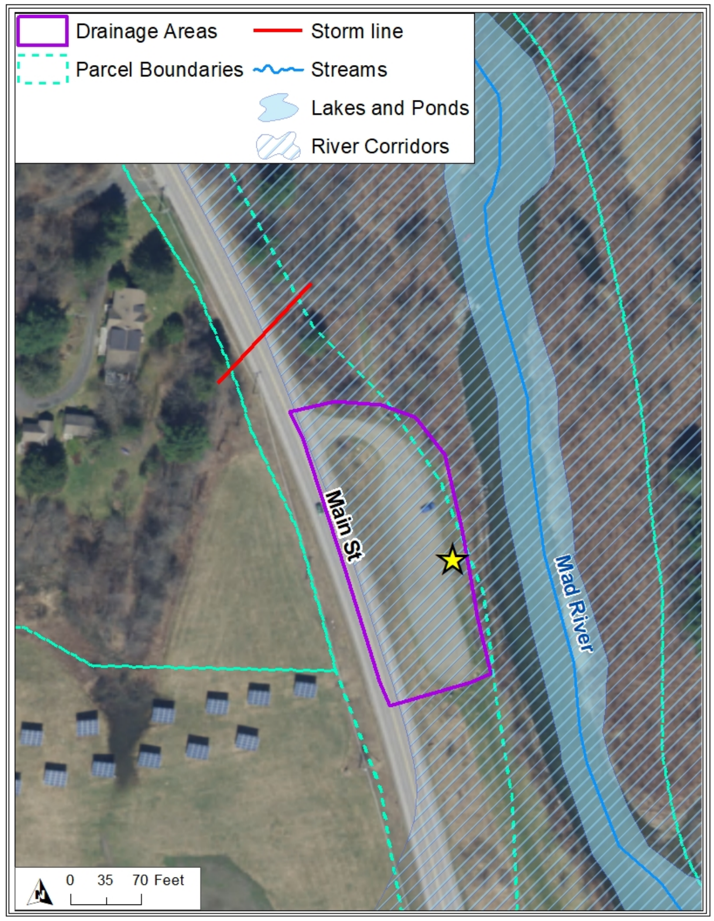
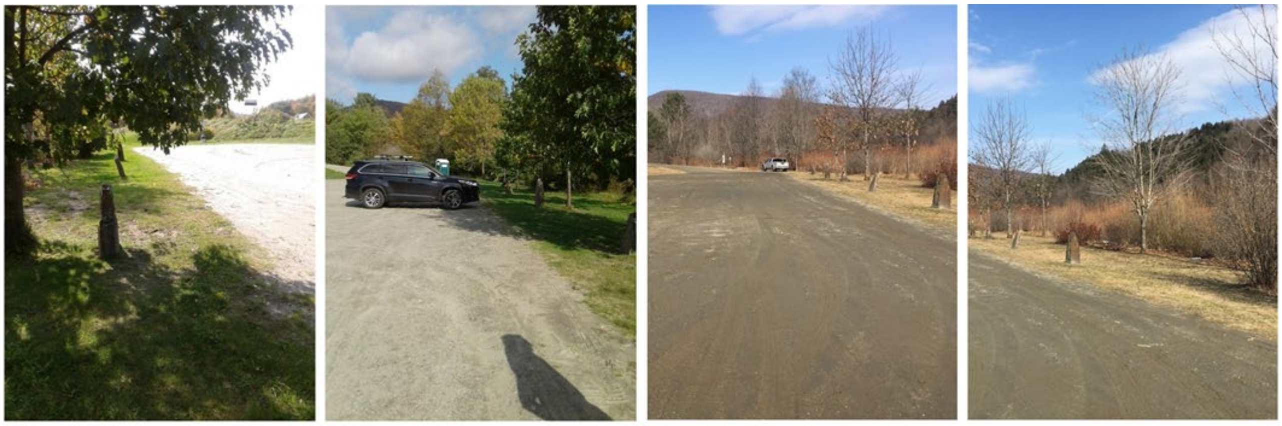


Figure D28. The drainage area for the proposed BMP is shown in purple.

It is proposed that the riparian buffer is enhanced by implementing a low or no mow zone between the parking lot and the river. Stabilized designated access points to river should be created. Two bioretention areas are proposed along the edge of the parking lot to collect and filter the site's stormwater runoff (see starred location in Figure D28). It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately, $500 should be budgeted for this sign. See the photos and associated descriptions in Figure D29.



Water is running to the Mad River from the parking area.

Drainage from the parking area drains to the Mad River with minimal filtration from short grass.

The large unpaved parking area for the park is located just west of the Mad River within the River Corridor.

Bioretention areas are proposed in the greenspace prior to the Mad River to manage parking lot drainage.

Figure D29. The proposed retrofits are described in the above photos.

Figure D30. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils are mapped as being good at this site (Hydrologic Group B), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure D30) and were found to be generally sandy (Figure D31). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix D14 for this site's complete soil log.

Figure D31. Soils were generally sandy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix D16 - Site Renderings.

This practice will provide a significant water quality benefit (Table D15) but is also a high visibility site within the Town. This practice could spur additional retrofits and awareness of stormwater issues in the area. It is recommended that an educational sign be installed in conjunction with the retrofit.

The design standard used for this retrofit was infiltration of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 1,655 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix D11 - Top 5 Sites. A 30% design plan is provided in Appendix D13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 892 lbs of total suspended solids (TSS) and 0.56 lbs of total phosphorus (TP) from entering receiving waters annually (Table D15).

Table D15. Lareau Park benefit summary table.

TSS Removed	892 lbs
TP Removed	0.56 lbs
Impervious Treated	0.5 acre
Total Drainage Area	0.8 acres

4.5.3 Cost Estimates

The total estimated cost for this project is $26,000. Note that these costs are very preliminary. Cost projections can be found in Table D16. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $46,429.
- The cost per impervious acre treated is $52,000.
- The cost per cubic foot of runoff treated is $15.71.

Table D16. Lareau Park project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
201.11	CLEARING AND GRUBBING, INCLUDING INDIVIDUAL TREES AND STUMPS	ACRE	0.04	$ 33,805.52	$ 1,352.22
653.55	PROJECT DEMARCATION FENCE	LF	275	$ 1.17	$ 321.75
653.20	TEMPORARY EROSION MATTING	SY	450	$ 2.20	$ 990.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	180	$ 4.13	$ 743.40
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
Subtotal:					$ 4,407.37
Bioretention - Excavation and Materials					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	225	$ 9.86	$ 2,218.50
MATERIALS					
BIORETENTION MEDIA					
651.35	TOPSOIL (BIORETENTION MEDIA)	CY	80	$ 30.96	$ 2,476.80
OVERFLOWS AND INLET PROTECTION					
613.10	STONE FILL, TYPE I	CY	10	$ 43.91	$ 439.10
PLANTING					
N/A	WILDFLOWER PLANT SEEDS	LBS	5	$ 125.00	$ 625.00
656.41	PERENNIALS	EACH	300	$ 8.77	$ 2,631.00
651.15	SEED	LB	10	$ 7.66	$ 76.60
Subtotal:					$ 8,467.00
Conveyance Swales					
EXCAVATION					
203.27	UNCLASSIFIED CHANNEL EXCAVATION	CY	70	$ 13.65	$ 955.50
653.30	*PREFABRICATED CHECK DAM*	*EACH*	*3*	*$ 295.79*	*$ 887.37*
GRASS REPLACEMENT					
651.29	*HAY MULCH*	*TON*	*1*	*$ 455.33*	*$ 455.33*
651.15	SEED	LB	10	$ 7.66	$ 76.60
Subtotal:					$ 2,374.80
Subtotal:					$ 15,249.17
	Construction Oversight**	HR	12	$ 125.00	$ 1,500.00
	Construction Contingency - 10%**				$ 1,524.92
	Incidentals to Construction - 5%**				$ 762.46
	Minor Additional Design Items - 5%**				$ 762.46
	Final Design	HR	30	$ 125.00	$ 3,750.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$ 125.00	$ 2,000.00
Total (Rounded to nearest $1,000)					**$ 26,000.00**

4.5.4 Next Steps

As this site is owned and operated by the Town of Waitsfield, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix D15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and the floodplain. However, it should be noted that this project will not result in any net fill within the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

E. Chapter 1: Warren

1 Background

1.1 Problem Definition

The Town of Warren is located in Washington County almost entirely within the Mad River watershed, including portions of the tributary Mill Brook watershed (Figure E1). The Mad River flows into the Winooski River, which drains to Lake Champlain. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

The Town of Warren is nearly 85% forested, with development located primarily near the historic downtown and at the Sugarbush ski resort. Residential development is distributed across the rural town. Development outside the resort area is limited due to steep slopes. Additional growth in the town center is limited by flood hazard areas.

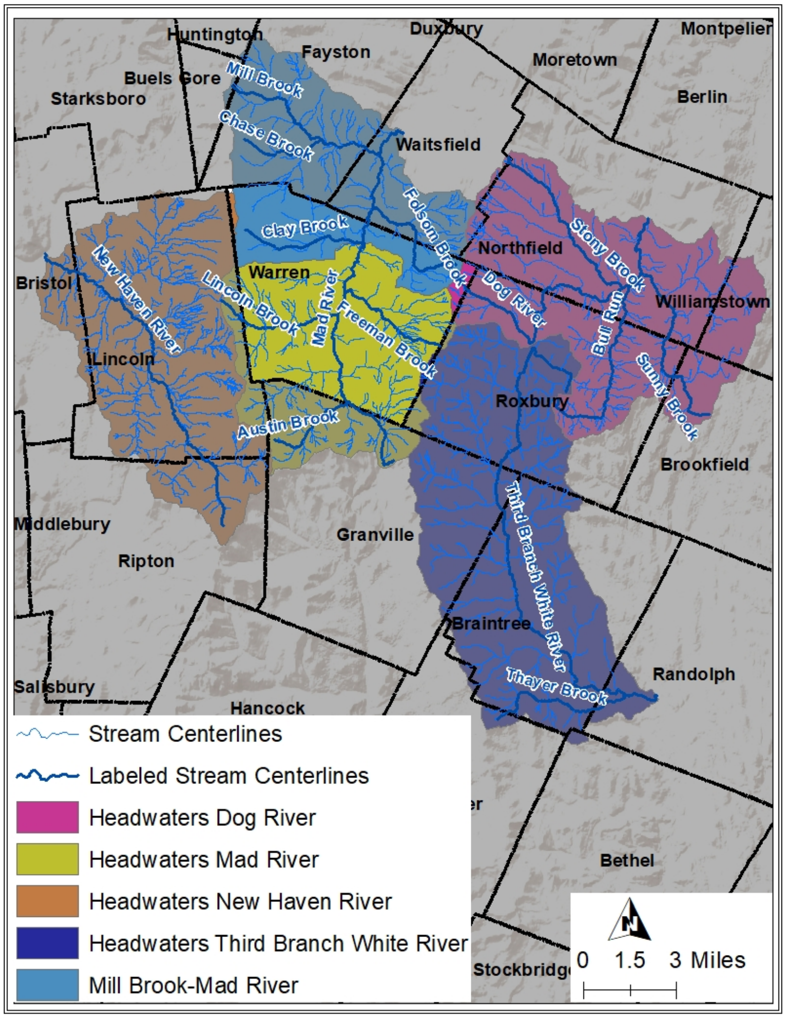


Figure E1. Warren is located primarily within the Mad River watershed.

The Town of Warren has recognized the need for flood resiliency by participating in the National Flood Insurance Program and implementing a Flood Hazard Overlay District to protect life and property. Flood threats in Warren are primarily fluvial erosion, rather than inundation flooding. A fluvial erosion hazard overlay district was adopted to restrict development in high risk areas.

1.2 Existing Conditions

The Town of Warren spans approximately 25,685 acres in Washington County, VT (Figure E2) and is primarily forested (84%) with 8% agricultural and 5% urban land use. Of that area, there are 436 acres (2%) of impervious cover.

Much of the Town of Warren is rural and residential, and this area contains roads that are generally unpaved with open roadside ditches. Many of these roads have steep slopes and traverse large areas. This predisposes these areas to erosion and sediment transport. Much of the older development within the Town was constructed before current stormwater standards were developed and were constructed without any or with only minimal stormwater management. This has resulted in untreated stormwater draining from developed lands directly to surface waters.

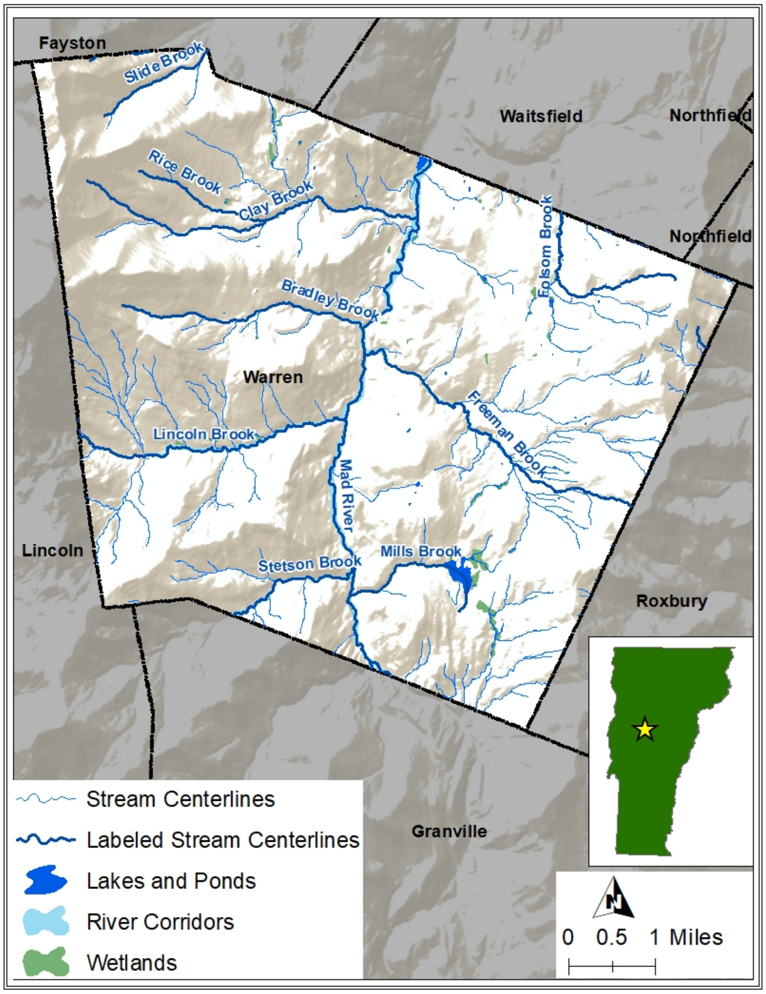


Figure E2. Warren is located in Washington County, VT.

Soils analyses indicate that of the 25,685 total acres in the Town, 84% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the City, the majority of areas belong to either Hydrologic Soil Group C (40%) or D (35%), while only 7% are in group A, and 18% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix E1 – Map Atlas. Maps include:

- river corridors, wetlands, and hydric soils;
- impervious cover;

- soil infiltration potential;
- soil erodibility;
- land cover;
- slope;
- stormwater infrastructure and stormwater permits;
- and parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2018). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix E2 – Data Review.

The project team met with Town of Warren stakeholders, Friends of the Mad River (Friends), and the Central Vermont Regional Planning Commission (CVRPC) on December 7, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Meeting minutes from this meeting are included in Appendix E3. A second town-specific meeting was held on January 29, 2018 to identify a list of problem areas including specific parcels and general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed in order to identify additional potential sites for stormwater BMP implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix E4).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.

Prerequisites:

1. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
    - ≥ 50 ft = Ideal (Score: 2 points)
    - 46-50 ft = Potential (Score: 1 point)
    - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

3. Hydrologic Soil Group (indication of infiltration potential)
    - A/B (highest infiltration potential) = Ideal (Score: 2 points)
    - B/C (moderate infiltration potential) = Potential (Score: 1 point)
    - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 2 sites with potential were noted for assessment in the field (Figure E3).

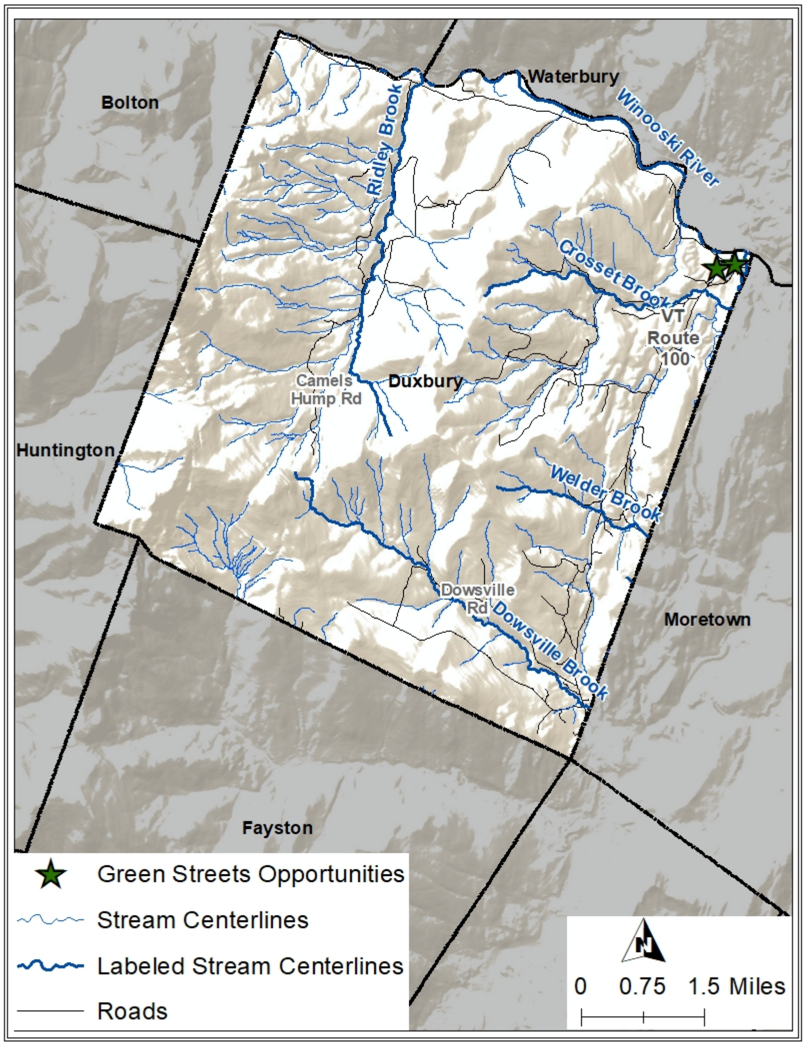


Figure E3. The 2 locations identified as potential green streets opportunities are shown with green stars.

A total of 63 locations, including the Green Streets sites, were identified for stormwater retrofit potential.

2.1.2.2 *Basemap and Mobile App Creation*

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 63-point locations for the potential BMP sites, which included both general Town-wide sites and green streets locations. These points allowed for easy site location and data collection in the field (Figure E4).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

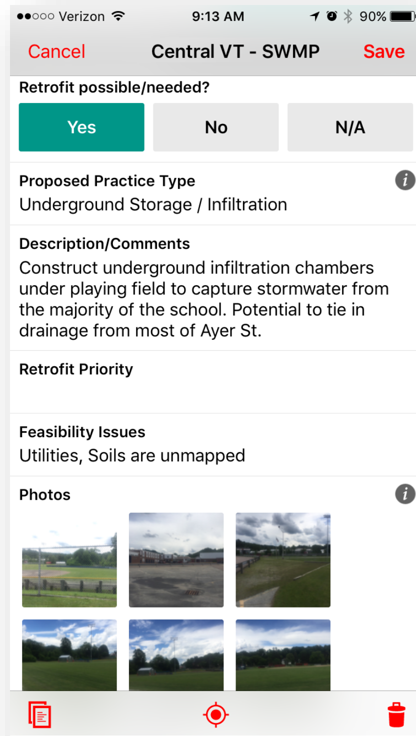


Figure E4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 63 previously identified potential BMP locations were evaluated in the field during the Summer of 2018 (Figure E5). Data was collected about each site in the mobile app. A large map of these sites with associated site names, and a list of these sites including potential BMP options and site notes can be found in Appendix E5 - Initial Site Identification.

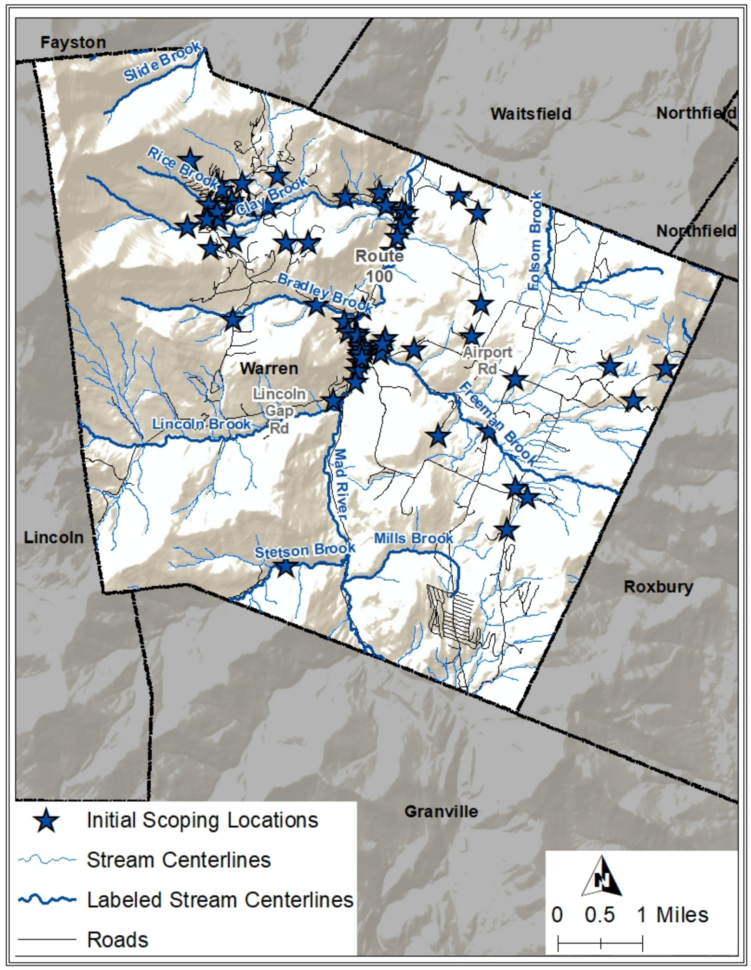


Figure E5. 63 potential sites for BMP implementation were identified for field investigation.

Through the course of these field visits, additional stormwater retrofit sites were identified that had not been included in the initial assessment. A total of 65 sites in Warren were assessed as part of this plan. Some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific, prohibitive site conditions. Following this process, a total of 46 sites in Warren remained as potential BMP opportunities (Figure E6).

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 46 projects (Figure E6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix E6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix E6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

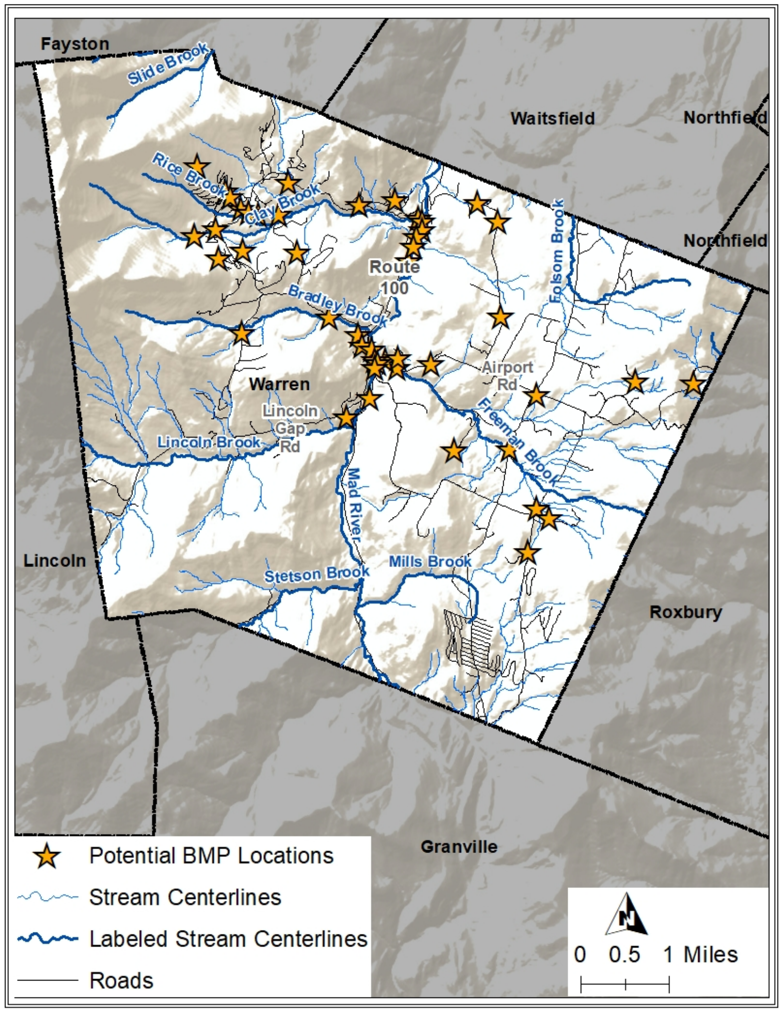


Figure E6. Following field investigations, the list of potential BMP sites was refined to 46. Point locations are shown for each site.

The draft Top 20 list was distributed to Warren stakeholders, the CVRPC, and Friends. As part of this process, the project team met with the stakeholders on August 22, 2018 to discuss the proposed Top 20 project sites. Following feedback from the Town, the list was refined from 46 to 45 to reflect the Town's knowledge of potentially unwilling landowners and the Town's priorities. These Top 20 sites are listed in Table E1. Point locations are shown in Figure E7.

Table E1. Top 20 BMPs selected for the Warren SWMP.

Site ID	Proposed Practice Type
Slopeside Developments	Ditch / Swale Improvements, Check Dams, Sediment Traps
Town Gravel Pit	Sediment Trap, Road Improvements, Infrastructure Addition
Flat Iron Rd	Step Pools, Dry Wells
Warren Lodge	Bioretention, Buffer Enhancement
Vaughn Brown Rd	Turnouts, Check Dams, Ditch / Swale Improvements, Dry Well, Infiltration Basin
The Bridges VT Resort & Tennis Club	Infiltration Basin, Outfall Stabilization
E Village Rd and Summit Rd Retrofit	Infiltration Basin
Town Garage	Infiltration Basin
Warren Post Office	Subsurface Infiltration Chambers
School Rd and Brook Rd	Infiltration Trench, Infiltration Basin
Sugarbush Resort - Lincoln Peak	Convert existing detention pond to gravel wetland; redirect culvert to treatment feature
Prickly Mountain Rd	Turnouts, Check Dams, Ditch / Swale Improvements
Sugarbush Service Station	Dry Wells, Filter Strip / Buffer Enhancement
Senor Rd Stream Crossing	Check Dams, Ditch / Swale Improvements
Main St Buffer	Filter Strip / Buffer Enhancement, Residential GSI
W Hill Rd Upper	Check Dams, Ditch / Swale Improvements
East Warren Community Market	Bioretention, Sand Filter, Stormwater Planters
Warren Park and Ride	Filter Strip / Buffer Enhancement
Travel Information Center	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
Warren Store	Stormwater Planter, Bioretention, Filter Strip / Buffer Enhancement

2.3 *Modeling and Concept Refinement for Top 20 BMPs*

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations. Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix E8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration-based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table E2. A Complete modeling results are provided in Appendix E8 - Top 20 Sites Modeling.

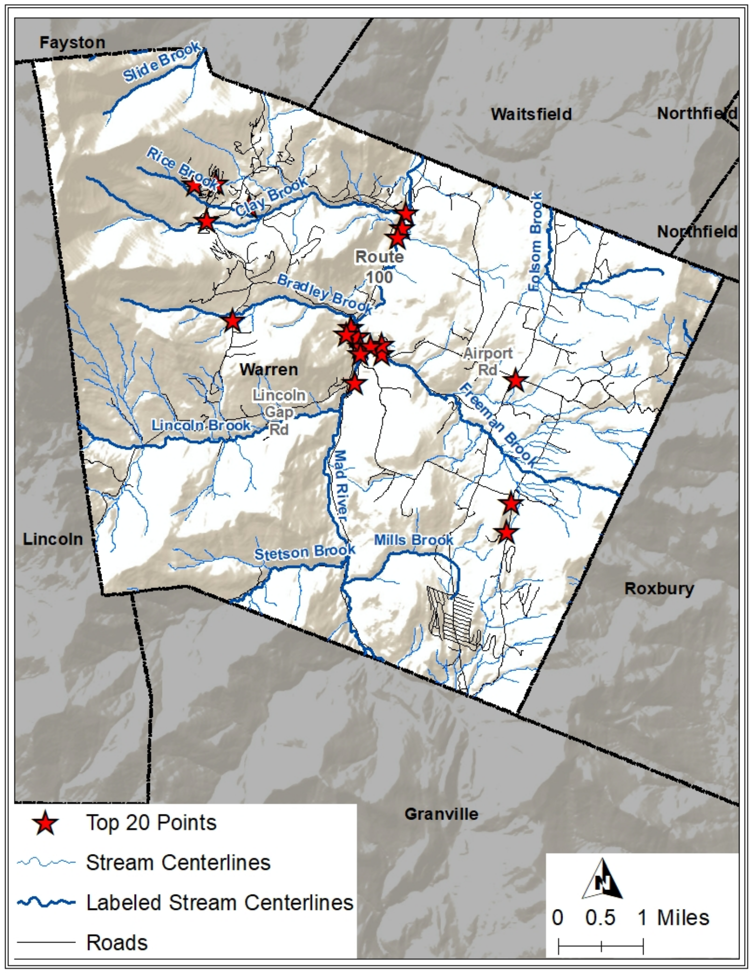


Figure E7. The Top 20 project locations are shown.

Table E2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Slopeside Developments	0.419	0.419	8962	76.21%	7.52	77.24%
Town Gravel Pit	0.068	0.068	2855	47.32%	2.47	47.64%
Flat Iron Rd	0.067	0.067	1367	98.7% (dry wells); 100% (step pools)	1.27	98.96% (dry wells); 100% (step pools)
Warren Lodge	0.059	0.059	2244	98.32%	0.89	97.79%
Vaughn Brown Rd	0.087	0.087	1002	97.74%	0.87	98.32%
The Bridges VT Resort & Tennis Club	0.279	0.279	4494	99.82%	13.277	99.76%
E Village Rd and Summit Rd Retrofit	0.214	0.214	5031	80.79%	4.68	83.33%
Town Garage	0.206	0.206	2431	98.66%	15.21	99.13%
Warren Post Office	0.166	0.166	3277	99.76%	2.07	99.46%
School Rd and Brook Rd	0.083	0.083	2476	95.08%	13.22	96.24%
Sugarbush Resort - Lincoln Peak	0.716	0	15814	96.00%	3.41	58.00%
Prickly Mountain Rd	0.115	0	2876	60.00%	0.77	20.00%
Sugarbush Service Station	0.059	0.059	2229	97.36%	1.09	97.77%
Senor Rd Stream Crossing	0.030	0	1082	60.00%	0.48	20.00%
Main St Buffer	0.051	0	863	60.00%	0.23	20.00%
W Hill Rd Upper	0.010	0	329	60.00%	0.11	20.00%
East Warren Community Market	0.023	0.023	699	57.85%	0.45	40.37%
Warren Park and Ride	0.011	0	194	60.00%	0.05	20.00%
Travel Information Center	0.021	0	313	60%	0.03	20%
Warren Store	0.029	0.029	1111	69.45%	0.20	64.07%

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix E9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix E10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix E9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[5] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table A3 below.

Table E3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	**Base Cost ($/ft^3)**
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large above-ground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

Permits and Engineering Costs: Used either 20% for large above-ground projects, or 35% for smaller or complex projects.

[5] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix E9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and their assigned rank are shown in Table A4. The comprehensive matrix used to rank the proposed BMP projects is provided in Appendix E9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table E4. Top 20 potential BMP sites for Warren.

Rank	Site ID	Address	Proposed Practice Type
1	Slopeside Developments	890 Upper Village Rd, Warren VT	Ditch / Swale Improvements, Check Dams, Sediment Traps
2	Town Gravel Pit	VT Route 100 and Vaughn Brown Rd, Warren VT	Sediment Trap, Road Improvements, Infrastructure Addition
3	Flat Iron Rd	Flat Iron Rd, Warren VT	Step Pools, Dry Wells
4	Warren Lodge	731 VT Route 100 Warren Washington VT 05674 US	Bioretention, Buffer Enhancement
5	Vaughn Brown Rd	105 Vaughn Brown Rd, Warren VT	Turnouts, Check Dams, Ditch / Swale Improvements, Dry Well, Infiltration Basin
6	The Bridges VT Resort & Tennis Club	202 Bridges Cir Warren Washington VT 05674 US	Infiltration Basin, Outfall Stabilization
7	E Village Rd and Summit Rd Retrofit	67 Shady Ln, Warren VT	Infiltration Basin
8	Town Garage	293 School Rd, Warren VT	Infiltration Basin
9	Warren Post Office	354 Main St Warren Washington VT 05674 US	Subsurface Infiltration Chambers
10	School Rd and Brook Rd	264 Brook Rd Warren Washington VT 05674 US	Infiltration Trench, Infiltration Basin
11	Sugarbush Resort - Lincoln Peak	1–123 Forest Dr, Warren VT	Convert existing detention pond to gravel wetland; redirect culvert to treatment feature
12	Prickly Mountain Rd	208–448 Prickly Mountain Rd, Warren VT	Turnouts, Check Dams, Ditch / Swale Improvements
13	Sugarbush Service Station	899 VT Route 100, Warren VT	Dry Wells, Filter Strip / Buffer Enhancement
14	Senor Rd Stream Crossing	951–1199 Senor Rd, Warren VT	Check Dams, Ditch / Swale Improvements
15	Main St Buffer	677 Main St, Warren VT	Filter Strip / Buffer Enhancement, Residential GSI
16	W Hill Rd Upper	1925 W Hill Rd, Warren VT	Check Dams, Ditch / Swale Improvements
17	East Warren Community Market	42 Roxbury Mountain Rd, Warren VT	Bioretention, Sand Filter, Stormwater Planters
18	Warren Park and Ride	104–228 Main St, Warren VT	Filter Strip / Buffer Enhancement
19	Travel Information Center	927–1257 VT Route 100, Warren VT	Filter Strip / Buffer Enhancement, Impervious Cover Reduction
20	Warren Store	284 Main St, Warren VT	Stormwater Planter, Bioretention, Filter Strip / Buffer Enhancement

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking as well as input from municipal officials concerning project priorities. The location of the sites within the Town are shown in Figure E8. In the final ranking, these 5 sites were awarded additional points in the site scoring to reflect the Town's priorities and the high probability for implementation. The Top 5 sites are listed in Table E5 in order of rank.

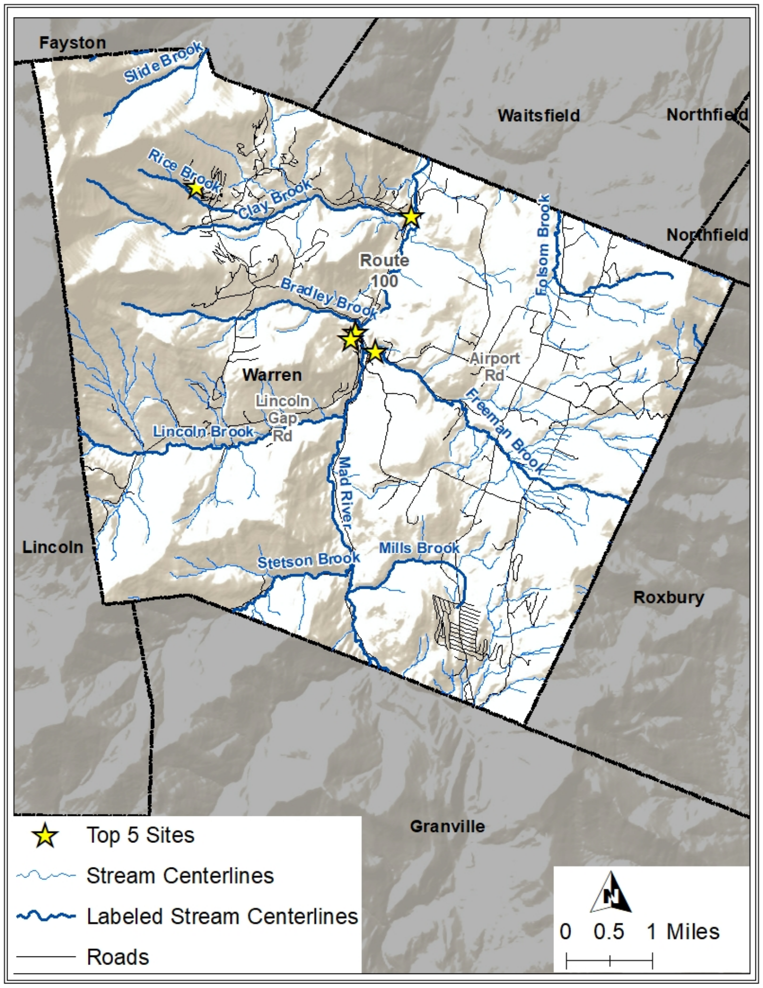


Figure E8. Top 5 sites for the Warren SWMP.

Table E5. Top 5 BMP sites for Warren.

Rank	Site ID	Address	Proposed Practice Type
1	Slopeside Developments	890 Upper Village Rd, Warren VT	Ditch / Swale Improvements, Check Dams, Sediment Traps
2	Town Gravel Pit	VT Route 100 and Vaughn Brown Rd, Warren VT	Sediment Trap, Road Improvements, Infrastructure Addition
3	Flat Iron Rd	Flat Iron Rd, Warren VT	Step Pools, Dry Wells
4	Warren Lodge	731 VT Route 100 Warren Washington VT 05674 US	Bioretention, Buffer Enhancement
5	Vaughn Brown Rd	105 Vaughn Brown Rd, Warren VT	Turnouts, Check Dams, Ditch / Swale Improvements, Dry Well, Infiltration Basin

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on Town property and private property. A memo describing these sites and updated field data sheets are provided in Appendix E11.

Site: 1
Project Name: Slopeside Developments
Description: The site includes unpaved roads accessing private properties next to Lincoln Peak. Several sediment traps are placed strategically throughout the road network, but there are still significant drainage issues (Figure E9). The roads in this development are generally quite steep. The proposed BMPs for this site include as follows: Clean out ditching and re-line with stone to stabilize. Remove sediment from existing check dams and sediment traps. Add additional timber check dams, with hard bottoms for reduced maintenance, sediment traps with controlled outlets, and a snow storage bowl to collect, filter, and slow drainage along the road. Potential for dry wells as soils allow. Regrade and recrown road as necessary to better direct drainage to ditching.
Outreach: This site is privately owned and managed the by Sugarbush Resort. Eric Hanson (Sugarbush Environmental Compliance Coordinator) has confirmed Sugarbush's willingness to proceed with further design.

Figure E9. There are issues with sediment transport along Slopeside Development's private roads.

Site: 2
Project Name: Town Gravel Pit
Description: The site includes the Town Gravel Pit's access drive. The gravel pit drains to stream along the driveway and eventually discharges to the Mad River across Route 100 (Figure E10). Proposed BMPs for this site include as follows: Regrade road to direct drainage away from stream. Formalize ditching along the access drive and remove any grader berm. Add a culvert with a level spreader in upper extent of access drive. Construct a sediment trap in vegetated area north of gravel pull off by intersection with Vaughn Brown Rd. Direct drainage from road to feature via a cross culvert.
Outreach: This site is owned by the Town of Warren, and as such, no additional outreach was carried out.

Figure E10. Drainage from the access drive currently drains to a stream.

Site: 3
Project Name: Flat Iron Rd
Description: The site includes Flat Iron Rd, which closely parallels Freeman Brook, a tributary of the Mad River. The road is within the river corridor and there have been noted drainage issues along this road. Proposed BMPs for this site include as follows: Add drywells in the existing stormline at the intersection of Flat Iron Rd and Brook Rd to infiltrate runoff from the road prior to discharge to brook. Construct a series of step pools below culvert outlet at intersection of Flat Iron Rd and Main St (Figure E11).
Outreach: This site is owned by the Town of Warren, and as such, no additional outreach was carried out.

Figure E11. Step pools are proposed between the culvert outlet pictured above and river.

Site: 4
Project Name: Warren Lodge
Description: The site includes a rental lodge across from the intersection of Sugarbush Access Rd and Route 100; located primarily within the river corridor. Proposed BMPs for this site include as follows: Construct a swale along the perimeter of the lower parking lot and regrade the parking lot, if necessary, to better direct runoff into the swale. Construct a bioretention in low point of existing greenspace east of tree line (Figure E12). Direct drainage from the swale to the bioretention. Improve the riparian buffer along the river with low-lying shrubby vegetation.
Outreach: This site is privately owned, and property owners Dana and Zan Franc have expressed their wiliness to proceed with further design.

Figure E12. A bioretention practice is proposed in the low spot pictured in the middle left side of photo.

Site: 5
Project Name: Vaughn Brown Rd
Description: The site includes an unpaved road accessing residential properties and adjacent to the Town Gravel Pit access drive. Proposed BMPs for this site include as follows: Regrade and recrown the road. Formalize roadside ditching, stabilize with stone, and direct drainage from upper extent of road to a turnout located in the field east of the road. Stabilize eroding culvert inlet and install a dry well at culvert outlet north of the field. Add timber check dams in ditching along west side of road towards intersection with VT-100 and construct an infiltration basin in the greenspace (privately owned) south of the intersection of Vaughn Brown Rd and VT-100 (Figure E13). Direct drainage to feature.

Figure E13. An infiltration basin is proposed in the area pictured above.

Outreach: Contact was made with the homeowners at the eastern end of Vaughn Brown Rd where the proposed infiltration basin would be located. They have expressed their willingness to proceed with further design. The remainder of retrofits are located on property owned by the Town of Warren.

When implemented, these five BMPs would treat approximately 35.3 acres, 6.4 acres (18%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table E6, indicate that these BMPs will prevent more than 16,400 lbs of total suspended solids and more than 13 lbs of total phosphorus from reaching receiving waters annually.

Table E6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Slopeside Developments	0.419	0.419	8962	76.21%	7.52	77.24%
Town Gravel Pit	0.068	0.068	2855	47.32%	2.47	47.64%
Flat Iron Rd	0.067	0.067	1367	98.7% (dry wells); 100% (step pools)	1.27	98.96% (dry wells); 100% (step pools)
Warren Lodge	0.059	0.059	2244	98.32%	0.89	97.79%
Vaughn Brown Rd	0.087	0.087	1002	97.74%	0.87	98.32%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix E12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix E13 - 30% Designs.

Soils conditions were assessed at each of the top 5 sites where infiltration-based practices are proposed. Pits were manually excavated using a shovel and hand auger. Analysis at these sites included documentation of depth to water table (if applicable), horizon breaks, soil structure, type, moisture, color, presence or absence of redoximorphic features, and size and quantity of roots and coarse fragments. Any other notes considered to be important were recorded during this time. The soil profiles with photos can be found in Appendix E14.

4.1 Slopeside Developments

4.1.1 30% Concept Design Description

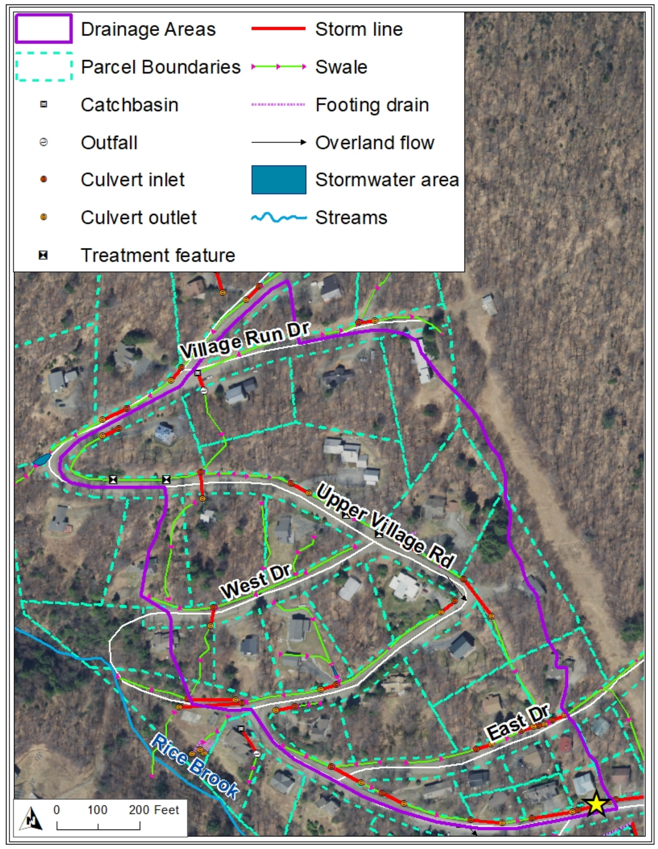


Figure E14. The proposed BMP drainage area is shown in purple.

Upper Village Rd is a steep, narrow, unpaved road accessing private residential properties east of Lincoln Peak. There are several existing sediment traps in the ditching throughout this road network. Stormwater is currently directed off the road surface into ditching and eventually drains to Rice Brook. Many of the ditches throughout this area require sediment removal and stabilization via stone lining.

It is recommended that ditching is cleaned of sediment and re-line with stone to stabilize erosion. Also recommended is removal of sediment from the existing check dams and sediment traps. Additional timber check dams with hard bottoms for reduced maintenance are proposed in conjunction with sediment traps with controlled outlets. A snow storage bowl could be excavated to store plowed snow. These practices will collect, filter, and slow drainage along the road (see drainage area in Figure E16). There is also potential for dry wells as soil conditions allow. It is recommended that further soils investigations are carried out in the upper sections of this development. The road should be regraded and recrowned as necessary to better direct drainage to ditching. Sugarbush Resort is willing to proceed with further design. See the photos and associated descriptions in Figure E17.

Ditching along Upper Village Rd is filled with sediment. Dry wells are proposed in the ditching throughout this area.

An old stonelined ditch with stone check dams in need of a cleanout.

Residential properties contribute runoff and sediment to the drainage network along Upper Village Rd.

The road is steep, narrow, and winding and is subject to use year-round.

Figure E17. The Ward Hill Rd and Route 100 retrofit is described in the above photos.

Soils are mapped as being good at this site (Hydrologic Group B), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger (Figure E16) and were found to be generally sandy (Figure E15). The presence of high groundwater observed during analysis prompted a need to alter the proposed retrofit design from dry wells to sediment traps. However, it is possible that areas along the road at higher elevations would not have this groundwater restriction. The soil profile with photos can be found in Appendix E14.

Figure E15. Soils were generally sandy.

Figure E16. Soils were assessed in the roadside ditch area.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix E16 - Site Renderings.

The design standard used for this retrofit was management of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 18,252 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix E11 - Top 5 Sites. A 30% design plan is provided in Appendix E13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent nearly 9,000 lbs of total suspended solids (TSS) and 7.5 lbs of total phosphorus (TP) from entering receiving waters (Table E7). This project will provide a significant benefit to water quality.

Table E7. Slopeside Developments benefit summary table.

TSS Removed	8,962 lbs
TP Removed	7.52 lbs
Impervious Treated	4.4 acres
Total Drainage Area	22.4 acres

4.1.3 Cost Estimates

The total estimated cost for this project is $82,000. These preliminary costs can be found in Table E8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $10,904.
- The cost per impervious acre treated is $18,636.
- The cost per cubic foot of runoff treated is $4.49.

Table E8. Slopeside Developments project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
N/A	CONSTRUCTION STAKING	HR	6	$ 125.00	$ 750.00
				Subtotal:	$ 1,250.00
Ditching					
DITCH RE-SHAPING					
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	900	$ 13.59	$ 12,231.00
DITCH ARMORING					
613.10	STONE FILL, TYPE I	CY	600	$ 43.91	$ 26,346.00
653.30	PREFABRICATED CHECK DAM	EACH	50	$ 295.79	$ 14,789.50
				Subtotal:	$ 53,366.50
DRY WELLS (3)					
203.15	COMMON EXCAVATION	CY	60	$ 9.86	$ 591.60
N/A	DRY WELL STRUCTURE	EACH	3	$ 2,300.00	$ 6,900.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	13.5	$ 34.04	$ 459.54
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	12	$ 43.91	$ 526.92
DITCH BACKSLOPE EROSION CONTROL					
651.25	HAY MULCH	TON	1.5	$ 597.15	$ 895.73
651.15	SEED	LB	10	$ 7.66	$ 76.60
653.20	TEMPORARY EROSION MATTING	SY	450	$ 2.20	$ 990.00
				Subtotal:	$ 9,373.79
Sediment Traps (3)					
203.15	COMMON EXCAVATION	CY	90	$ 9.86	$ 887.40
601.0915	18" CPEP	LF	45	$ 64.04	$ 2,881.80
N/A	18" BEEHIVE GRATE	EACH	3	$ 615.00	$ 1,845.00
613.10	STONE FILL, TYPE I	CY	28	$ 43.91	$ 1,229.48
				Subtotal:	$ 6,843.68
Subtotal:					$ 70,833.97
	Construction Oversight**	HR	6	$ 125.00	$ 750.00
	Construction Contingency - 10%**				$ 7,083.40
	Incidentals to Construction - 5%**				$ 3,541.70
	Final Design	HR	40	$ 125.00	$ 5,000.00
Total (Rounded to nearest $1,000)					**$ 82,000.00**

4.1.4 Next Steps

As this site is privately owned and maintained by Sugarbush Resort, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix E15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.2 Town Gravel Pit

4.2.1 30% Concept Design Description

Town of Warren's gravel pit and associated gravel access drive located off Vaughn Brown Rd just southwest of the intersection of Main St and VT-100. Stormwater from the site currently drains to a swale along the access drive and eventually to the Mad River across Main St. Lack of roadside ditching prompts water to run down the road and into stream. A portion of the gravel pit site is plowed into the stream.

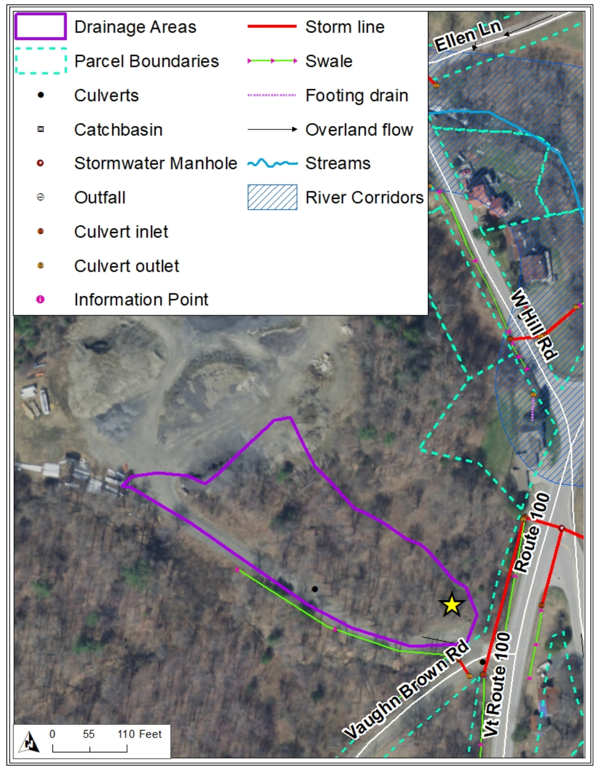
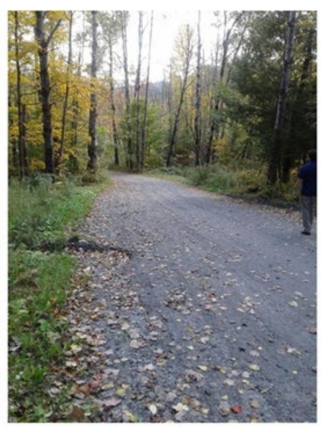


Figure E18. The drainage area for the proposed BMP is shown in purple.

It is recommended that the road be regraded to direct drainage away from stream. Ditching should be formalized along the access drive and any grader berms removed. It is proposed that a culvert is added with a level spreader in upper extent of access drive. A sediment trap in vegetated area north of gravel pull off by intersection with Vaughn Brown Rd is proposed (see site map in Figure E18). Drainage should be directed from the road to feature via a cross culvert. See the photos and associated descriptions in Figure E19.

Water currently runs down the Town gravel pit's access drive towards Vaughn Brown Rd and VT-100. An infiltration basin is proposed just northwest of the intersection of the access road and Vaughn Brown Rd to collect and infiltrate runoff from the road.

Some runoff drains directly to an unnamed tributary located south of the access drive.



Areas where runoff is eroding areas along the access road. The area (pictured left) is the proposed location of a new culvert and level spreader.

Figure E19. The proposed retrofits are described in the above photos

Figure E21. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Figure E20. Soils were generally sandy.

Soils are mapped as being very good at this site (Hydrologic Group A), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure E21) and were found to be generally sandy (Figure E20). However, the presence of high groundwater observed during analysis prompted a need to alter the proposed retrofit design from an infiltration basin to a sediment trap. The soil profile with photos can be found in Appendix E14.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix E16 - Site Renderings.

The design standard used for the infiltration basin retrofit was infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 2,962 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix E11 - Top 5 Sites. A 30% design plan is provided in Appendix E13 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent nearly 3,000 lbs of total suspended solids (TSS) and 2.47 lbs of total phosphorus (TP) from entering receiving waters (Table E9).

Table E9. Town Gravel Pit benefit summary table.

TSS Removed	2,855 lbs
TP Removed	2.47 lbs
Impervious Treated	0.4 acres
Total Drainage Area	1.7 acres

4.2.3 Cost Estimates

The total estimated cost for this project is $14,000. Note that these costs are very preliminary. Cost projections can be found in Table E10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $5,668.
- The cost per impervious acre treated is $35,000.
- The cost per cubic foot of runoff treated is $4.73.

Table E10. Town Gravel Pit project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Site Preparation				
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
649.51	GEOTEXTILE FOR SILT FENCE	SY	80	$ 4.13	$ 330.40
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,330.40
	Infiltration Basin				
	EXCAVATION				
203.15	COMMON EXCAVATION	CY	260	$ 9.86	$ 2,563.60
613.11	STONE FILL, TYPE I	CY	52	$ 42.49	$ 2,209.48
629.54	CRUSHED STONE BEDDING (3/4" - 1 1/2" STONE)	TON	25	$ 34.04	$ 851.00
	INLET / OUTLET PROTECTION				
613.11	STONE FILL, TYPE II	CY	14	$ 42.49	$ 594.86
				Subtotal:	$ 6,218.94
	Level Spreader				
203.15	COMMON EXCAVATION	CY	16	$ 9.86	$ 157.76
613.11	STONE FILL, TYPE II	CY	14	$ 42.49	$ 594.86
				Subtotal:	$ 752.62
	Road Re-grade				
401.10	AGGREGATE SURFACE COURSE	CY	37	$ 43.60	$ 1,613.20
				Subtotal:	$ 1,613.20
				Subtotal:	$ 9,915.16
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 991.52
	Final Design	HR	20	$ 125.00	$ 2,500.00
	Total (Rounded to nearest $1,000)				**$ 14,000.00**

4.2.4 Next Steps

As this site is owned and operated by the Town of Warren, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix E15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.3 Flat Iron Rd

4.3.1 30% Concept Design Description

Flat Iron Rd is a paved road accessing residential properties located between Brook Rd and Main St in downtown Warren. The eastern half of the road runs parallel to Freeman Brook, is highly constrained, and has no buffer. Stormwater from the eastern half of the road, as well as a portion of Brook Rd, is discharged directly to the brook via stormlines and culverts without treatment. The western half of the road drains to a culvert just east of the intersection of Flat Iron Rd and Main St. The culvert outlets to a greenspace, next to the gazebo, where stormwater travels via overland flow and over the bank to Freeman Brook.

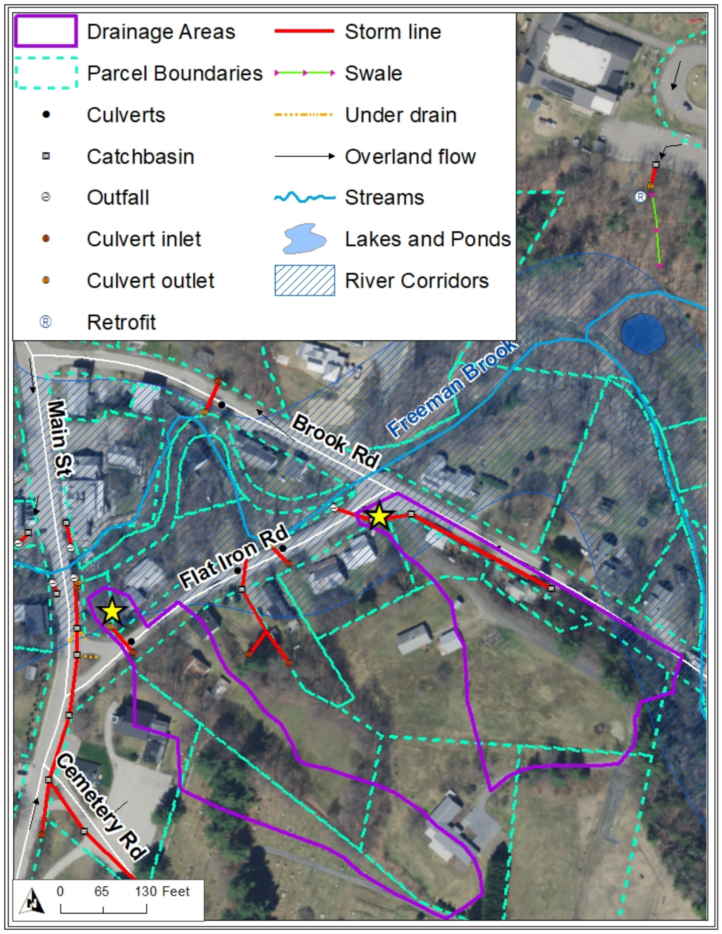


Figure E22. The drainage area is shown outlined in purple.

It is proposed that dry wells are installed prior to the catchbasins for the existing stormline at the intersection of Flat Iron Rd and Brook Rd to infiltrate runoff from the road prior to discharge to brook (see northernmost starred location in Figure E22). A series of step pools are recommended below culvert outlet at intersection of Flat Iron Rd and Main St (see southernmost starred location in Figure A24). It is recommended that an educational sign be installed at this site. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. It is also recommended that the section of Flat Iron Rd that is very constrained and armored with a retaining wall be investigated further. Though further assessment of this section of road was not possible given the scope of this project, it was noted as a problem area in the Town. See the photos and associated descriptions in Figure E23.

Culvert outlet located north of the intersection of Flat Iron Rd and Main St. A series of step pools are proposed for this location.

Drainage from Flat Iron Rd is directed to the culvert and travels via overland flow to Freeman Brook.

The eastern half of Flat Iron Rd is very constrained between residential properties and Freeman Brook.

A paved swale directs runoff to a stormline at the intersection of Brook Rd and Flat Iron Rd before being discharged to Freeman Brook. This is the proposed location for a dry well.

Figure E23. The proposed retrofits are described in the above photos

Figure E25. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils are mapped as being poor at this site (Hydrologic Group C), but the proposed dry wells are located very close to soils mapped as having very good infiltration potential (Hydrologic Group A). An analysis was conducted at the proposed dry well location to evaluate the potential for an infiltration practice. Soils were not assessed where the proposed step pools are located as infiltration is not proposed. For the dry well location, soils were assessed using a hand auger and shovel (Figure E25) and were found to be generally sandy and loamy (Figure E24). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design.

Figure E24. Soils were generally sandy and loamy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix E16 - Site Renderings.

This practice will provide a significant water quality benefit (see Table E11). The design standard used for this retrofit was detention and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 2,919 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix E11 - Top 5 Sites. A 30% design plan is provided in Appendix E13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 1,300 lbs of total suspended solids (TSS) and 1.27 lbs of total phosphorus (TP) from entering receiving waters annually (Table E11).

Table E11. Flat Iron Rd benefit summary table.

TSS Removed	1,367 lbs
TP Removed	1.27 lbs
Impervious Treated	0.6 acres
Total Drainage Area	4.2 acres

4.3.3 Cost Estimates

The estimated cost for implementation of this project is $21,000. Note that these costs are very preliminary. Cost projections can be found in Table E12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $16,535.
- The cost per impervious acre treated is $35,000.
- The cost per cubic foot of runoff treated is $7.19.

Table E12. Flat Iron Rd initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	215	$ 1.17	$ 251.55
649.51	GEOTEXTILE FOR SILT FENCE	SY	55	$ 4.13	$ 227.15
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,478.70
Infiltration Basin					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	100	$ 9.86	$ 986.00
MATERIALS					
613.11	STONE FILL, TYPE I	CY	45	$ 42.49	$ 1,912.05
INLET / OUTLET PROTECTION					
613.11	STONE FILL, TYPE I	CY	25	$ 42.49	$ 1,062.25
SIDE SLOPE EROSION CONTROL					
651.25	HAY MULCH	TON	1	$ 597.15	$ 597.15
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 4,634.05
Dry Wells					
EXCAVATION					
N/A	DRY WELL STRUCTURE	EACH	2	$ 2,300.00	$ 4,600.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	9	$ 34.04	$ 306.36
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	8	$ 43.91	$ 351.28
203.15	COMMON EXCAVATION	CY	45	$ 9.86	$ 443.70
				Subtotal:	$ 5,701.34
				Subtotal:	$ 11,814.09
	Construction Oversight**	HR	8	$ 125.00	$ 1,000.00
	Construction Contingency - 10%**				$ 1,181.41
	Incidentals to Construction - 5%**				$ 590.70
	Final Design	HR	50	$ 125.00	$ 6,250.00
				Total (Rounded to nearest $1,000)	**$ 21,000.00**

4.3.4 Next Steps

As this site is owned and operated by the Town of Warren, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix E15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and proximity to the floodplain. However, it should be noted that this project will not result in any net fill within the river corridor. Permits are not anticipated to meet Act 250 or Wetlands Rules requirments for this project.

4.4 Warren Lodge

4.4.1 30% Concept Design Description

Warren Lodge is a rental lodge located across from Sugarbush Access Rd on VT-100 and includes two buildings and two gravel parking lots. Clay Brook runs along the southern edge of the site and the Mad River runs along the eastern edge of the site. The Lodge offers direct access to the river and is located primarily within the mapped river corridor. The Town of Warren would like the riparian buffer restored in this area as recent clearing and landscaping removed vegetation along the river. Riverbank erosion was observed during the site assessment in the location of the clearing. Stormwater in this area currently flows from the upper parking lot to the lower parking lot and over the bank into Clay Brook. This includes drainage from a portion of VT-100.

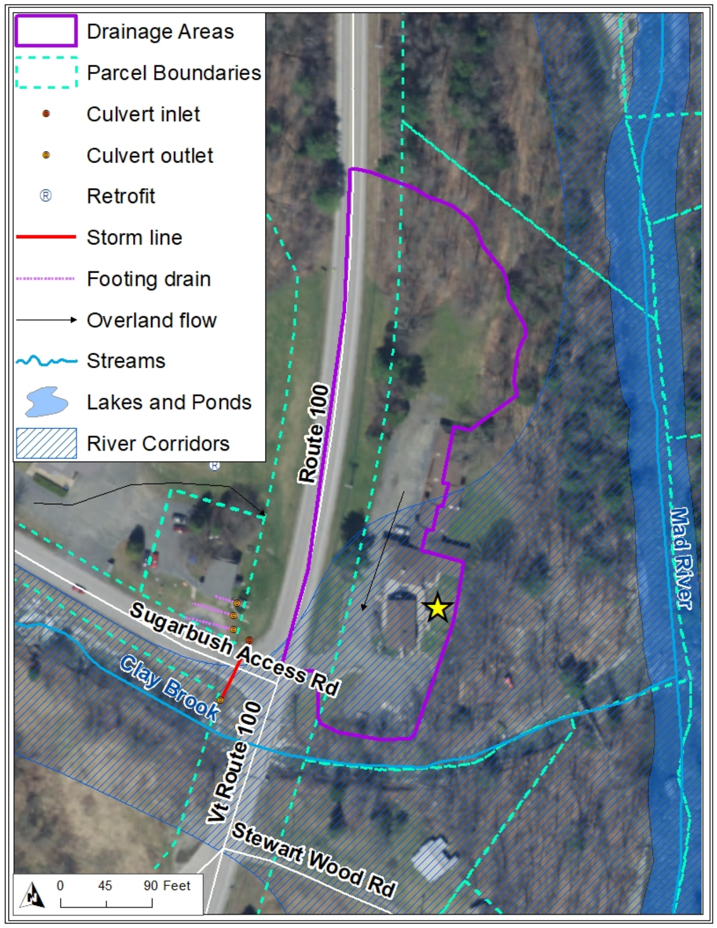


Figure E26. The proposed bioretention is located west of the Mad River (see starred location). The area that would drain to this practice is shown with a purple outline.

It is recommended that a swale be constructed along the perimeter of the lower parking lot and the parking lot be regraded as necessary to better direct runoff into the swale. Construction of a bioretention practice is proposed in low point of existing greenspace east of tree line (see starred location in Figure E26). Drainage should be directed from the swale to the bioretention. Additionally, the riparian buffer could be improved along the river with low-lying shrubby vegetation that would maintain the character of the site. It is recommended that an educational sign be installed at this site to educate guests at the Lodge and the public who utilize the hiking trail that passes by the property. This cost is not reflected in the estimated project cost itemized below. Approximately $500 should be budgeted for this sign. Owners of the Warren Lodge have expressed their willingness to proceed with further design at this site. See the photos and associated descriptions in Figure E27.

Upper parking lot of the Warren Lodge. Stormwater currently travels via overland flow through this area and down to the lower parking lot.

The proposed bioretention will be located in the existing low spot along the tree line. Drainage from the lower parking lot is to be directed to the bioretention.

Area below the building and parking lots where vegetation was cleared along the Mad River.

Erosion along the riverbank.

Figure E27. The proposed retrofits are described in the above photos

Figure E29. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils are mapped as being good to poor at this site (Hydrologic Group A/C), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure E29) and were found to be generally sandy (Figure E28). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design.

Figure E28. Soils were generally sandy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town, the CVRPC, and Friends to help advance designs toward implementation. This rendering can be found in Appendix E16 - Site Renderings.

This practice will provide a significant water quality benefit (Table E13). The design standard used for this retrofit was management of the WQv (or 1 inch of rain in a 24-hour period), equal to 2,570 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix E11 - Top 5 Sites. A 30% design plan is provided in Appendix E13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 2,244 lbs of total suspended solids (TSS) and 0.89 lbs of total phosphorus (TP) from entering receiving waters annually (Table E13).

Table E13. Warren Lodge benefit summary table.

TSS Removed	2,244 lbs
TP Removed	0.89 lbs
Impervious Treated	0.7 acre
Total Drainage Area	1.8 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $12,000. Note that these costs are very preliminary. Cost projections can be found in Table E14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $13,483.
- The cost per impervious acre treated is $17,143.
- The cost per cubic foot of runoff treated is $4.67.

Table E14. Warren Lodge project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
653.55	PROJECT DEMARCATION FENCE	LF	250	$ 1.17	$ 292.50
649.51	GEOTEXTILE FOR SILT FENCE	SY	124	$ 4.13	$ 512.12
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,804.62
Bioretention Area & Conveyance Swale					
EXCAVATION					
203.15	COMMON EXCAVATION	CY	260	$ 9.86	$ 2,563.60
203.25	CHANNEL EXCAVATION OF EARTH (Conveyance Swale)	CY	70	$ 13.59	$ 951.30
MATERIALS					
651.35	TOPSOIL (Bioretention Media)	CY	40	$ 30.96	$ 1,238.40
INLET / OUTLET PROTECTION					
613.11	STONE FILL, TYPE II	CY	10	$ 42.49	$ 424.90
PLANTING					
N/A	WILDFLOWER SEED MIX	LBS	2	$ 125.00	$ 250.00
651.15	SEED	LB	3	$ 7.66	$ 22.98
651.29	STRAW MULCH	TON	0.5	$ 455.33	$ 227.67
SIDE SLOPE EROSION CONTROL					
653.20	TEMPORARY EROSION MATTING	SY	117	$ 2.20	$ 257.40
651.25	HAY MULCH	TON	0.5	$ 597.15	$ 298.58
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 6,234.82
				Subtotal:	$ 8,039.44
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 803.94
	Final Design	HR	25	$ 125.00	$ 3,125.00
				Total (Rounded to nearest $1,000)	**$ 12,000.00**

4.4.4 Next Steps

As this site is owned by Dana and Zan Franc, it is recommended that the Town proceed with further design of this retrofit after obtaining a formal memorandum of understanding with the landowner. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix E15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
An Act 250 permit for the Warren Lodge (5W0379) exists, and as such this project should be reviewed to determine if an amendment to this permit would be required. This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor and proximity to the floodplain. However, it should be noted that this project will not result in any net fill within the river corridor. This project should be reviewed by a wetland ecologist prior to final design due to the presence of hydric soils.

4.5 Vaughn Brown Rd

4.5.1 30% Concept Design Description

Vaughn Brown Rd is a steep gravel road accessing residential properties located southwest of the intersection of Main St and VT-100. The Town of Warren's gravel pit driveway is accessed from Vaughn Brown Rd. Road is not properly crowned, and sediment is being transported from road surface to the intersection with VT-100. Drainage from this area currently runs down the road and to the culvert at the intersection with VT-100 before eventually being discharged to the Mad River without treatment.

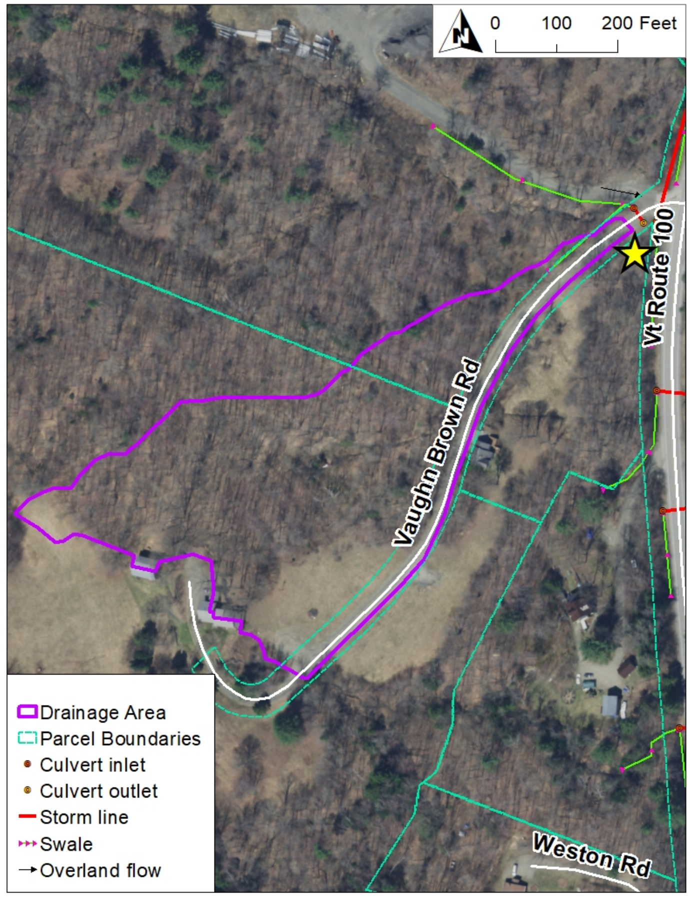


Figure E30. It is proposed that runoff from the western half of the school property, shown in red, is directed to a sand filter, and the eastern half, shown in orange, is directed to a bioretention.

It is recommended that Vaughn Brown Rd be regraded and recrowned. Roadside ditching should be formalized and stabilize with stone in steeper areas. It is proposed that drainage be directed from the upper extent of road to a turnout located in the field east of the road. The eroding culvert inlet should be stabilized and a dry well installed at the culvert outlet north of the field. It has also been noted by a landowner on this road that this culvert routinely fills with gravel perhaps due to inadequate slope. This should be assessed during final design. Timber check dams are proposed to be added in ditching along west side of road towards intersection with VT-100 and drainage directed to an infiltration basin in the greenspace (privately owned) south of the intersection of Vaughn Brown Rd and VT-100 (see starred location in Figure E30). Owners of this property have expressed their willingness to proceed with further design. See the photos and associated descriptions in Figure E31.


Upper extent of Vaughn Brown Rd where stonelined ditching is proposed with a turnout to the field.


A section along Vaughn Brown Rd has sunk over time. Ditching below the house should be lined with stone.


Vegetated area between the road and VT-100 where overland drainage has deposited sediment over time.

Intersection of Vaughn Brown Rd, the Town gravel pit access road, and VT-100 where sediment collects. Drainage throughout this area flows to a culvert and is eventually discharged directly to the Mad River.

Figure E31. The proposed retrofits are described in the above photos.


Figure E32. A hand auger and shovel were used to assess soil conditions and infiltration potential.

Soils were assessed in two locations for the Vaughn Brown Rd site. A dry well/sediment trap and general road and ditch improvements were proposed for the first site located in the roadside ditch north of the road. Soils were mapped as being very good to poor at this site (Hydrologic Group A/C), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed and were found to be generally sandy, although the presence of high groundwater observed during analysis precluded the placement of dry wells in this location.

Due to the presence of high groundwater, the proposed design was altered to include an infiltration basin in the privately-owned greenspace between Vaughn Brown Rd and VT-100. Soils were assessed at this additional location. Soils are mapped as being very good at this site (Hydrologic Group A), so an analysis was conducted to evaluate the potential for an infiltration practice. Soils were assessed using a hand auger and shovel (Figure E32) and were found to be generally loamy (Figure E33). Soils conditions observed during analysis did not prompt a need to alter the proposed retrofit design. See Appendix E14 for both complete soil logs from this site.


Figure E33. Soils were generally loamy.

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town and the CVRPC to help advance designs toward implementation. This rendering can be found in Appendix E16 - Site Renderings.

The design standard used for this retrofit was filtration and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 3,790 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix E11 - Top 5 Sites. A 30% design plan is provided in Appendix E13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 1,000 lbs of total suspended solids (TSS) and 0.87 lbs of total phosphorus (TP) from entering receiving waters annually (Table E15).

Table E15. Vaughn Brown Rd benefit summary table.

TSS Removed	1,002 lbs
TP Removed	0.87 lbs
Impervious Treated	0.2 acre
Total Drainage Area	5.3 acres

4.5.3 Cost Estimates

The total estimated cost for this project is $34,000. Note that these costs are very preliminary. Cost projections can be found in Table E16. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $39,080.
- The cost per impervious acre treated is $170,000.
- The cost per cubic foot of runoff treated is $8.97.

Table E16. Vaughn Brown Rd project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Site Preparation				
N/A	MOBILIZATION	LS	1	$ 500.00	$ 500.00
N/A	CONSTRUCTION STAKING	HR	4	$ 125.00	$ 500.00
				Subtotal:	$ 1,000.00
	Ditching, Drywells, Sedimentation Basins				
	DITCH RESHAPING				
203.25	CHANNEL EXCAVATION OF EARTH (DITCH RE-SHAPING)	CY	200	$ 13.59	$ 2,718.00
	MATERIALS				
613.10	STONE FILL, TYPE I	CY	193	$ 43.91	$ 8,474.63
653.30	PREFABRICATED CHECK DAM	EACH	6	$ 295.79	$ 1,774.74
	PIPING (CULVERTS)				
601.0905	12" CPEP	LF	40	$ 39.24	$ 1,569.60
	DRY WELLS OR OTHER STRUCTURES				
203.15	COMMON EXCAVATION	CY	30	$ 9.86	$ 295.80
N/A	DRY WELL STRUCTURE	EACH	2	$ 2,300.00	$ 4,600.00
629.54	CRUSHED STONE BEDDING (SMALLER BACKFILL AROUND DRY WELL)	TON	9	$ 34.04	$ 306.36
613.10	STONE FILL, TYPE I (BACKFILL AROUND STRUCTURE)	CY	7.5	$ 43.91	$ 329.33
	DITCH BACKSLOPE EROSION CONTROL				
649.51	GEOTEXTILE FOR SILT FENCE	SY	65	$ 4.13	$ 268.45
651.25	HAY MULCH	TON	1	$ 597.15	$ 597.15
651.15	SEED	LB	10	$ 7.66	$ 76.60
				Subtotal:	$ 20,934.06
	Road Re-Shaping				
	RE-SHAPING				
401.10	AGGREGATE SURFACE COURSE	CY	72	$ 43.60	$ 3,139.20
				Subtotal:	$ 3,139.20
				Subtotal:	$ 25,073.26
	Construction Oversight**	HR	4	$ 125.00	$ 500.00
	Construction Contingency - 10%**				$ 2,507.33
	Incidentals to Construction - 5%**				$ 1,253.66
	Final Design	HR	40	$ 125.00	$ 5,000.00
	Total (Rounded to nearest $1,000)				**$ 34,000.00**

4.5.4 Next Steps

As this site is owned and operated by the Town of Warren, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the target volume can be completely managed and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix E15 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

5 Final Recommendations

The results of this SWMP have identified several potential BMP concepts and locations that would have a positive impact on water quality in Duxbury, Fayston, Moretown, Waitsfield, and Warren and their receiving waters. Although designs were only advanced for the top 5 projects per municipality, this plan also serves to highlight other opportunities throughout the study areas. As such, the momentum developed during this study should be strengthened and continued.

The practices proposed in this study all stand to have a substantial impact on abating water pollution and setting a precedent for integrating GSI into the landscape. It is our recommendation that the municipalities, potentially in partnership with the CVRPC and/or Friends, move to implement the Top 5 practices, but also move forward with additional design and implementation of the other projects presented in this plan (see Appendices with Top 20 Site Final Rankings: A9, B9, C9, D9, and E9). As these practices are the result of a stormwater master planning effort under a Clean Water Fund grant, they are well-suited as candidates for an implementation grant from this same source. We recommend the following steps in proceeding with this:

- For priority projects already at the 30% concept level, consider grant request for final design and implementation.
- Following implementation of the priority projects, submit grant funding requests for higher-scoring projects that may include both preliminary and final design.

It is further recommended that each Town look into alternative road surface materials to increase stability and longevity of municipal unpaved roads. We encourage road crews to consider the use of crushed ledge product with a mix of small angular particles (as opposed to bank run gravel with rounded stones) and over 50% fine particles to encourage compaction and cohesion. This product goes by several names such as StayMat, SurePack, or 'plant mix.' This material should be placed on the surface of the road, above a gravel subbase compacted to 90-95 Proctor density. The road surface material should be rolled and compacted to 90-95 Proctor. Another acceptable material is crusher-run gravel which, while it contains fewer fine particles than the aforementioned material, does not have rounded stones like bank run gravel. Where StayMat (or similar) is not available or is prohibitively expensive, crusher run gravel can be used and is preferred to bank run. Compaction procedures should mimic the process outlined for StayMat.

One area that was highlighted through this study was Camels Hump Rd, located in Duxbury. Although this area was included as part of this study in a cursory was, a more comprehensive, stand-alone master planning assessment is highly recommended for this area, especially considering planned expansions to recreational opportunities and the anticipated increase in vehicular and foot traffic to access these resources.

Another area that was identified as a high priority that fell outside of the scope of this plan is Flat Iron Rd located in Warren. There are significant issues along this road including ongoing undermining of the road along the retaining wall that boarders Freeman Brook on the north side of Flat Iron Rd. It is recommended that a separate study of this road be completed to assess the potential solutions for this highly constrained area and the feasibility of these solutions.

The Vermont Agency of Transportation (VTrans), as part of their Transportation Separate Storm Sewer System (TS4) General Permit, will be completing their own retrofit assessment of VTrans-owned impervious surfaces throughout the region. Projects recommended throughout this plan that involve VTrans-owned infrastructure or drainage should be coordinated with VTrans.