FLOWER BROOK STORMWATER MASTER PLAN

Completed by,

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Introduction

Stormwater Master Planning (SWMP) in the Flower Brook Watershed was designed to identify headwater and village sources of fecal contamination, nutrient enrichment, sedimentation, and thermal modification to Flower Brook that originate through stormwater flow, and initiate steps to address these pollutants through various corrective actions. Flower Brook is impaired by elevated levels of fecal bacteria (from the confluence of the Mettowee River to the Mill Pond), affected by high water temperatures during low flow months (VDEC, 2012, and ENSR, 2002), and transports high levels of nutrients and sediment from the headwater tributaries (SMRC, 2006; PMNRCD, 2014). In addition, phosphorus concentrations in Beaver Brook, a significant Flower Brook Tributary, are twice that of other area streams (PMRCD, 2013 and 2014).

The SWMP scope of work involved multiple steps to address water quality concerns in Flower Brook. They included determining viable locations to infiltrate stormwater in the village area, surveying the steep headwaters roads for potential backroads projects, determining the mechanisms of sediment transport related to severe gullying in the headwater tributaries, and investigating the chronically-high *E. coli* levels in the village. The purpose of these investigations was to identify projects that would reduce the amount of stormwater runoff and sediment flowing to the brook during storm events and determine through modeling and community outreach the highest-priority projects to implement in the watershed.

The Flower Brook SWMP is a hybrid 1c (small urban area with existing pervious areas to infiltrate, use of LID principles and Green SW measures) and 3b (rural road focus in the headwaters) (VDEC, SWMP Guidelines, 2013) and included the following tasks:

- Compilation of Existing Data, including Planning and Assessment Resources
- Identification and design of stormwater mitigation projects in Pawlet Village
- River Corridor Planning to identify sediment attenuation and flood resiliency projects
- Repeat (post-Irene) stream geomorphic assessment of Flower Brook, reach 04
- Gully Evaluation Flower Brook (reach 04)
- Limited Septic Needs Assessment in Pawlet Village
- Preparation of Grant Applications, including a Better backroads project in Danby

Existing Data Analysis with Data Gap Identification

Each of the three towns that make up the Flower Brook watershed, Tinmouth, Danby, and Pawlet, have thoughtful and relatively complete town planning documents. Each has an approved town plan and is working with the Rutland RPC to complete Hazard Mitigation Plans; Tinouth and Pawlet have extensive and protective zoning. The Poultney Mettowee Conservation District, Rutland Regional Planning Commission, and Vermont DEC's Basin Planner, Ethan Swift, have worked in these towns (PNRCD mainly in Pawlet) to gather data, complete assessments, and incorporate this information into planning and zoning documents. In addition, within each town, there are citizens who are interested in and promote environmentally-friendly planning and zoning.

With the Town Plans and Assessments largely complete, these three towns can focus on project implementation to minimize the concentrations of nutrients and other pollution that reach their waterbodies. The implementation of Green Stormwater practices decreases the volume of stormwater runoff, which has the appealing co-benefit of protecting downstream areas against future flooding.

The biggest data gap identified through the process of compiling and reviewing these documents is the lack of tax maps and parcel data in Danby, making identification of landowners along the streams and subsequent outreach more difficult. Also noted was the need to look more closely at existing data, such as the geomorphic assessment data, in conjunction with town officials. The Town of Pawlet has a River Corridor Overlay District, to help protect the village from further development in potentially flood and erosion-prone areas near streams and to protect vital riparian and floodplain areas from development. Similar corridor protection zoning is recommended for Tinmouth and Danby, and while the lack of zoning is noted in the data review, the Rutland RPC is currently working with these towns to initiate corridor overlay districts.

Finally, the most important activity available to local conservation and planning groups that support towns, includes sharing all assessment findings and zoning needs with the town governing bodies. An important component of the education and outreach needed to promote community adoption of planning measures or community support of conservation projects should include reaching out to a diverse cross-section of the town and gaining audience with those not normally part of the conversation about flood preparedness and green stormwater management.

For the entire Flower Brook Data Library, please see Attachment A.

Previously-Identified Projects

Mettowee River Corridor Plan (RCP), PMNRCD, 2014

The January, 2014, Mettowee Watershed Project Prioritization RCP Grant listed eight sediment attenuation projects that are applicable to this SWMP and are briefly listed here with project updates:

- Water Quality Monitoring, continued in 2015, data available in February, 2016.
- Pawlet Village Stormwater Master Planning and Septic Assessment (completed in this report).
- Exclusion fencing at a beef farm located along a tributary to Flower Brook (in progress).
- Corridor Easement for Flower Brook/Beaver Brook confluence on Flower Brook, reach 02. To date no State funding is available for an easement at this location due to existing protections in place through class 2 mapped wetlands and VLT buffer requirements. The District continues landowner outreach about best land management practices, given importance of this attenuation area.
- Flower Brook headwaters, additional geomorphic and back roads assessment and gully stabilization study underway (results in this report).

- Lilly Hill Road, the Town of Danby would like to proceed with a grant through Better Back Roads, but wanted to wait one year, since they are working currently on a grant to make similar repairs to another road in town. The next grant round will be spring, 2016, but another project was selected due to the steep terrain at this site.
- Farm on Beaver Brook, exclusion fencing completed on the brook and a tributary from a pond to the road. Farm is being sold and is currently working with ANR through the State RCPP funds to create a management plan.
- Farm on Beaver Brook tributary, some exclusion fencing finished, more planned for summer, 2016. Farm is working with PMNRCD and VAAFM currently. PMNRCD holds an ERP grant for this farm that is scheduled to move forward in 2016 and which will alleviate a water quality concern.

Flower Brook Stream Geomorphic Assessment, SMRC, 2005 and 2007

Recommendations from the 2005 report:

6.1 Restoration

M05T03.01-B: If any changes in the height of the dam occur, re-evaluate the sediment trapping functions of the dam for resultant changes in flow and sediment regime in Flower Brook, upstream and downstream of this location.

M05T03.01-C: **Limit future development and floodplain filling** within the corridor of this segment. Continued channel management, such as armoring or channelization, should be considered in the broader context for channel adjustments such practices will set in motion up and downstream.

All Reaches: In general a passive geomorphic approach based on long-term management and **preservation of a belt-width derived river corridor** is appropriate for all of the reaches. Reduction of streambank erosion, improved floodplain access, and enhanced sediment attenuation in Flower Brook will reduce sediment production and delivery to downstream segment M05T03.01-C. This segment is constrained and unable to adjust to excess sediment loads delivered from upstream.

MT0305.02: Preserve this reach for its **sediment attenuation capabilities**. There is no landuse conflict. Continue outreach and education with the landowners.

Within the belt-width-defined corridor use passive geomorphic restoration, **enhancement of forested riparian buffer areas** along the channel margins should be pursued.

6.2 Water Quality

Mill dam and gorge: The high concentration of stormwater inputs and the diversion for power generation should be monitored for nutrient, bacteria, and thermal inputs. There is

a high concentration of paved road surfaces and roof tops immediately contiguous to this segment and in the catchment areas for observed stormwater drainage structures.

All reaches: restore and enhance buffers to provide shading to reduce instream temperatures. Buffer plantings should be prioritized for widened, shallow segments of the brook.

6.3 Community Planning

At present the degree of development along the Brook is low in many of the reaches. This presents the residents of Pawlet with a strategic opportunity to engage in a proactive planning process that supports the rivers ability to seek a post-disturbance equilibrium. Planning strategies can ensure that new development does not encroach on the corridor, reduce the flow and sediment attenuation abilities of the floodplain area, and place infrastructure at risk of fluvial erosion losses. (Specific recommendations on page 40 of the SGA).

Recommendations from the 2007 report:

Excerpted from Table 12: High Priority River Corridor Protection Sites

Flower Brook reach 04: Protect this reach, which is upstream of constrained/altered reaches.

Flower Brook reach 01: Inform residents of existing FEH hazards in densely populated areas.

Flower Brook reach 01C: reduce future fluvial erosion hazards along areas where there is a major departure from equilibrium conditions and threats from encroachment.

Flower Brook reach 01A: Reduce future fluvial erosion hazards along reaches at alluvial fans or points of marked valley slope reduction that contribute to increased sediment aggradation and adjustment. Carefully manage landuse changes upstream to reduce potential for increased sediment flows.

6.9.1 Controlling sources of Sediment

FLOWER BROOK REACH 04. There are significant sources of fine sediment along the valley margins of this reach from gullies that have developed in ephemeral tributaries. Conduct landowner outreach and site reconnaissance to evaluate the driving forces for gully formation on the tributaries and reduce sediment mobilization to Flower Brook. Preserve sinuosity and floodplain access along the brook, enhance sediment/flow attenuation functions, though passive geomorphic measures.

7.1 Corridor Planning. Recommended for Flower Brook, and in progress.
Please refer to Appendix 1 for a map of Flower Brook SGA recommendations.

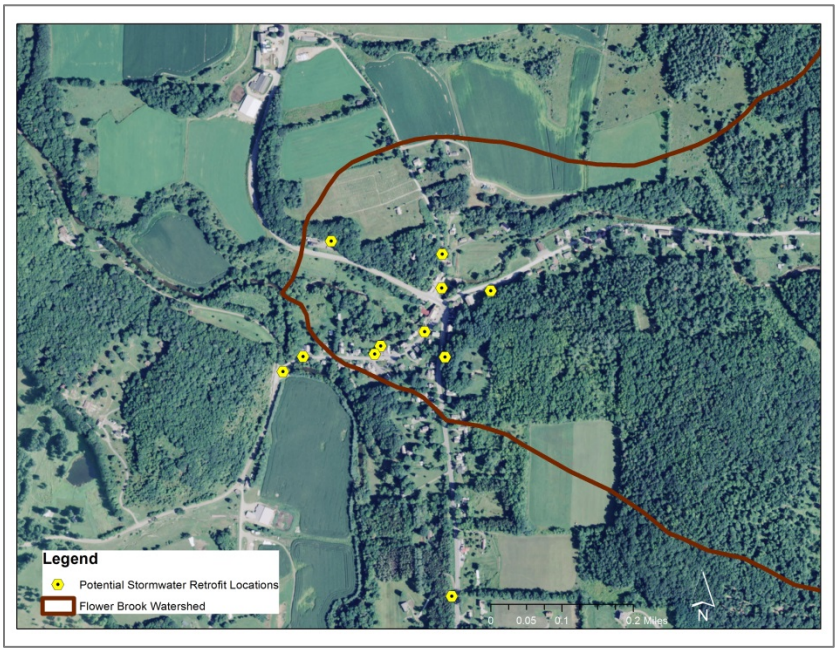
2016 STORMWATER MASTER PLANNING EFFORTS

Village Stormwater Projects

Pawlet Village is located between steep valley walls along a narrow strip of land on the banks of Flower Brook. The village center has a high incidence of impervious surfaces, causing stormwater to flow quickly to the Brook, while potentially carrying a heavy contaminant load.

Stone Environmental, Inc. completed a field screening that identified approximately 20 potential stormwater retrofit projects in the Village of Pawlet. Stone then completed a basic physical feasibility assessment for each project area, defining the contributing drainage area and the area available for treatment, and reviewed soil condition information presented in the NRCS Soil Survey. Based on this evaluation, and feedback received by PMNRCD during committee meetings and a door-to-door survey of Pawlet residents, several projects were eliminated from further consideration.

Each of the 13 remaining potential projects received a score relative to the following criteria: **Environmental priority –** relative environmental impact caused by this source on the nearest receiving water; **Constructability –** relative ease with which a project could be implemented, including whether the recommended practice(s) could be constructed on town-owned land or with a willing landowner partner, existing access to the site, and the amount of engineering design work that would be required to move the project to implementation; **Ease of operation –** including the amount and frequency of maintenance likely to be required and whether maintenance activities will be straightforward to complete, and **Anticipated pollutant abatement –** including the ability of the recommended practice to reduce runoff volumes and/or address sediment and nutrient pollution.



While each of the top 13 projects were seen as high-priority, six of the top-scoring projects received conceptual designs (please refer to Attachments C and D for more information on the initial projects identified and to see the concept designs for the highest-ranking projects).

Figure 1: The final 13 stormwater projects selected in Pawlet Village (one of the sites has three associated projects).

Headwater Projects

The headwaters of Flower Brook are located in a steep, mountainous area of the Taconic Range. Both Pawlet and Danby contain miles of roads that are potentially highly erodible, based on their driving surface slope or their location on steep side slopes. The Town of Danby maintains a road network including Kelly Hill, Lilly Hill, Green Hill, and Little Village Road that contain areas of steep slope and, in stretches, parallel the larger Flower Brook tributaries, including the Flower Brook headwaters and Purchase Brook. Sections of Lilly Hill and Green Hill Roads near the Flower Brook crossing were identified in 2013 as a potential backroad project when road sediments were observed flowing to Flower Brook at the District's uppermost water quality monitoring site, Flower03. Additional field assessments through the SWMP have yielded three more backroad projects, each of which received a concept design through this study.

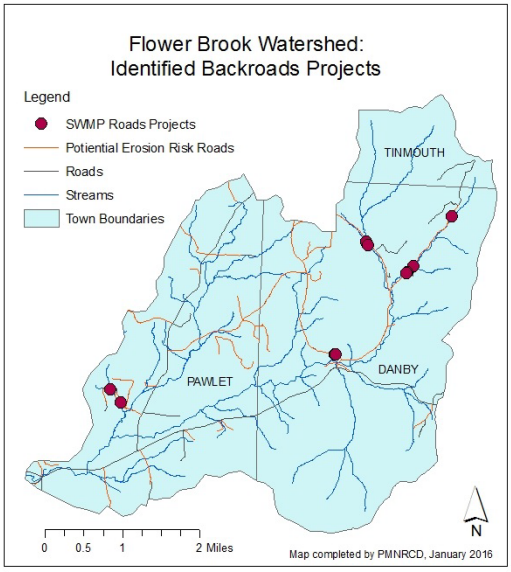


Figure 2: Backroads projects in the Flower Brook headwaters.

As part of the backroads survey, culverts suspected as good candidates for replacement to improve future flood resiliency or aquatic organism passage were revisited. One culvert was determined to be a candidate for additional studies, which will be conducted by the Poultney Mettowee and Bennington Conservation Districts. Additionally, the District received the results of a Nature Conservancy project, which ranked culverts based on their potential as high-priority AOP barriers. Of the culverts in the top tiers for consideration, nine are located in the Flower Brook watershed. Most of these are on smaller, very steep headwater ephemeral streams, not suited for fish. One culvert, located on Purchase Brook is a possibly-viable candidate and is located downstream from the culvert that was identified during the backroads surveys as needing additional assessment. The culvert identified through the SWMP is a tier 5 culvert and ranks 48th out of the 348 Mettowee watershed culverts analyzed by The Nature Conservancy. The tier one through four culverts are shown on Figure 3 and the culverts on Purchase Book are circled in red.

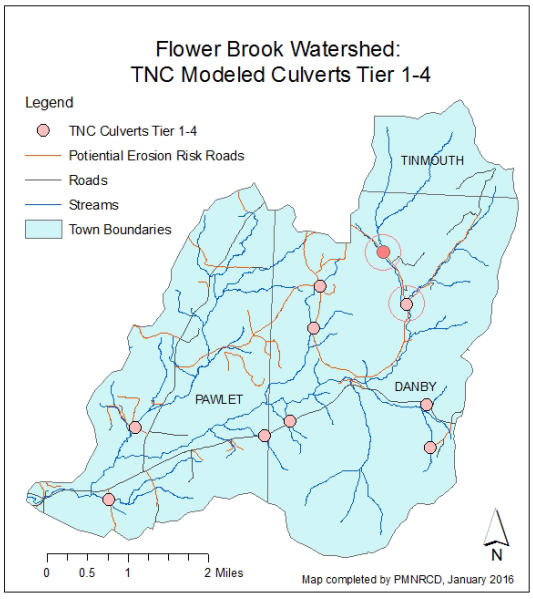


Figure 3: Tier 1-4 culverts in the Flower Brook watershed and a SWMP culvert.

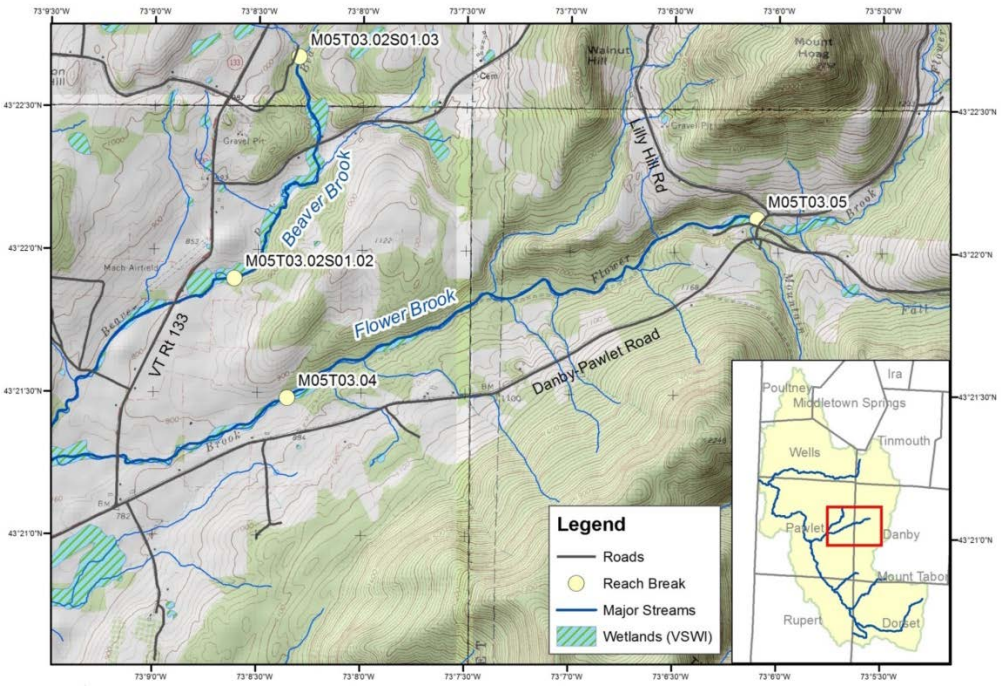
Stream Reach Reassessment (Reach 04)

A stream geomorphic assessment was completed in May 2015 for a 2.2-mile reach (M05T03.04) of the Flower Brook (see Figure 1). This reach was previously assessed during the summer of 2006. A repeat assessment was conducted: (1) to document potential changes in reach condition and sensitivity following impacts of Tropical Storm Irene (August 2011); and (2) to characterize the fluvial geomorphic context for the evaluation of gullies identified within the reach that are serving as a source of coarse and fine sediments to the Flower Brook and downstream reaches (see separate task description). Results of the assessment are detailed in Attachment F.

Considerable lateral channel adjustments and aggradation have occurred in reach M05T03.04 since it was originally assessed in 2006, which appear to be associated with channel responses from Tropical Storm Irene (August 2011). Still, the overall classification of reach condition (Fair) and sensitivity (High) did not change. The reach is in the latter stages of channel evolution, and represents a sediment and flood attenuation asset worthy of protection, particularly in light of ongoing sediment contributions from gullies.

The recommendations from the 2006 assessment remain applicable for this reach. The District will continue working with landowners to identify highly eroding areas and gullies in the headwater tributaries, reduce sediment mobilization to Flower Brook, preserve sinuosity and floodplain access, and protect the riparian buffers. The landowners along this reach are interesting in participating in cost-share and other programs to remediate erosion, as appropriate, and protect the brook's riparian functions.

Figure 4: Reach 04 Stream Geomorphic Reassessment Study Area.

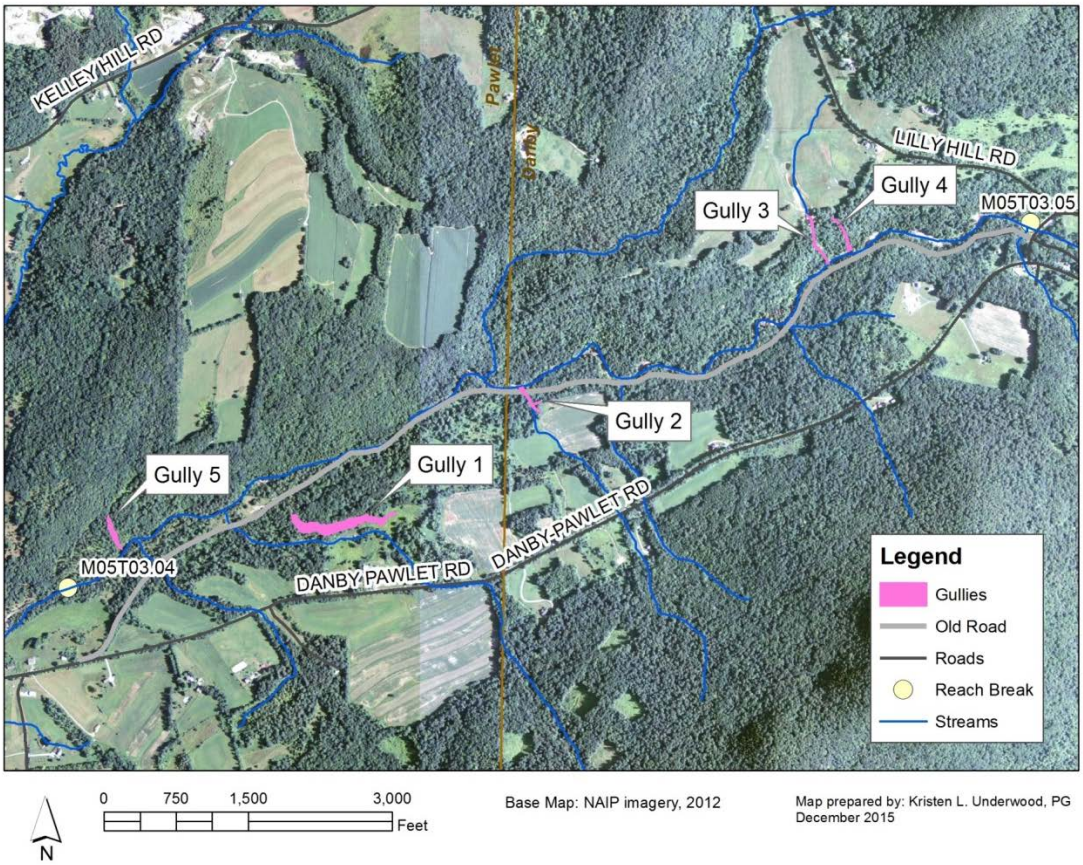


Gully Assessment

A limited field assessment was completed in 2015 to identify and characterize erosional gullies draining to a 2.2-mile reach (M05T03.04) of the Flower Brook. Five gullies were identified through a combination of remote-sensing and field reconnaissance (Figure 5). Evaluations are summarized in Appendix G.

The gullies ranged from 340 feet to over 1200 feet in length, and originate at edge-of-field settings where concentrated snowmelt and runoff in perennial or ephemeral channels have been directed to steeper, forested side slopes of the Flower Brook floodplain. These channel segments have cut down into erodible glacial sediments and become overwidened. Sediment produced from these gullies has entered the Flower Brook, particularly during extreme events, such as the floods of December 2000, January 2006, and August 2011. Other factors which may have contributed to formation of these gullies include: (1) increased imperviousness in the upstream catchment areas associated with residential development and logging activity; and (2) enhanced connectivity of surface runoff from logging access networks and road and driveway networks in the upstream catchments. Various restoration and conservation projects have been identified to address sediment production from these gullies, contingent on landowner willingness (Appendix 3).

Figure 5: Gully location map—aerial imagery base.



Septic Assessment

The District, with technical and financial assistance from its partners including Vermont DEC and the Center for Watershed Protection, conducted a door-to-door survey of 60 residences and recorded homeowner descriptions of the types and locations of septic tanks and treatment areas in the Village of Pawlet. The treatment types included holding tanks, leach fields, mound systems, and dry wells. The District assessed several parameters in relation to each system to determine the potential risk of each system leaking partially-treated sewage to groundwater. Roughly 30% of the lots in Pawlet scored in the potentially moderate to high risk categories, while the majority of properties, the remaining 70% of sites, had low or slight risk factors. The District presented the study results to Pawlet residents on November 3, 2015, at a public meeting.

Pawlet Septic Risk Assessment	
Low Risk	19
Slight Risk	19
Moderate Risk	9
Higher Risk	8

The results of the Septic risk analysis indicate that approximately 17 properties have moderate to high risk of causing groundwater contamination under certain conditions. The remaining 38 properties are evenly split within the low and slight risk categories.

The low risk categories include the holding tanks and should pose little to no threat to local water quality. The slight risk sites include leach fields that are on larger parcels, with enough room for an adequate treatment area, located at least 500 feet from the brook. The moderate risk category includes larger parcels with dry wells located at least 500 feet from the brook, or smaller parcels with leach fields. The Higher risk category includes smaller parcels on the brook without obvious land for sewage treatment, regardless of treatment type, dry wells located near the brook, and small parcels with unknown treatment systems in the immediate village area.

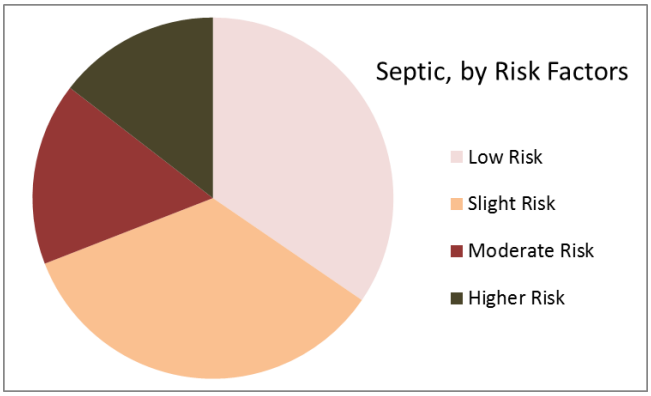


Figure 6: Results of the Septic survey indicating potential for septic systems to contribute fecal bacteria to Flower Brook.

Concurrent to the door-to-door septic assessment carried out by the District, Vermont DEC hired Watershed Consulting Associates to conduct an Illicit Discharge Detection and Elimination survey in the Pawlet Village. This survey focuses on identifying illegal sources of septic waste connected to the stormdrain system. Through smoke testing in a suspicious outfall, a home was found to be directly discharging sewage to an old, disconnected stormdrain that leads to Flower Brook. Vermont DEC, the Town of Pawlet, and the homeowner are following up to remediate this source of bacteria to the brook. The study found several additional outfalls with potential bacteria contamination, but the sources were inconclusive.

Grant Applications

The following grant applications either will be or were drafted and submitted through this project:

- Better Backroads: This grant is due in April, 2016, and the Danby Road crew has accepted an offer of assistance from the District, who will draft this application. The District, the Road Foreman, and Road Commissioner are meeting in February for planning purposes. Also involved is Susan Schreibman with the Rutland RPC, who is assisting Danby with a Category A Backroad Assessment application for April.
- ERP/Clean Water Fund: Also likely due in April, the District will apply for a grant to complete Green Stormwater Projects in Pawlet and/or to assist with the gully stabilization projects currently being engineered through VACD and NRCS.
- NRCS EQIP: Cost-share program to help alleviate the erosion in the agricultural fields uphill from Gully #2 (in progress).
- Lake Champlain Basin Program Pollution Prevention Grant: A landscape assessment to delineate forest sinks and sources of phosphorus reaching Flower Brook (application completed and grant received).

Copies of the applications are available upon request.

Conclusions

The towns in the Flower Brook watershed are seeing increased stream erosion and contain inherent challenges in their landscape, which includes mountain drainages with steep topography near Flower Brook and then fairly flat land above the steep valley walls that is employed in a number of land uses, including transportation, forestry, agriculture, and rural home sites. It seems that several key factors are leading to instability in lands with this topographic pattern. The higher elevations are managed as timber lands, possibly changing the hydrology in the area; the land along the terrace is slowly becoming more developed with homes; a road bisecting the terrace acts as a water bar, only letting water through at culverts; the soils are glacial gravel deposits, and the power and duration of rainfall events is increasing due to climate change. All of these factors together are leading to active incision of the steep downgradient sections of the headwater tributaries and the deposition of these sediments in Flower Brook, causing instability in the Brook and decreasing the available channel volume and the brook's ability to convey water during storm events.

The District has collected much information about the flooding and erosion trends in the Flower Brook watershed and would like to spend more time communicating this information and relevant project ideas to the townspeople in Tinmouth, Danby, and Pawlet.
Through the stormwater master plan, over 30 projects were initially identified as potential village green stormwater projects, backroad or culvert projects, gully stabilization projects, or corridor easement locations. Of the 20 stormwater projects identified in the village, 13 were considered viable and as a result of an additional ranking process, which considered the relative environmental impact of each project, six were provided with conceptual designs. The three backroads projects were considered high-priority and also received conceptual designs. Several culverts were identified and will receive additional field assessment to characterize their potential as replacement projects. The gullies identified in the 2006 Flower Brook Stream Geomorphic Assessment were

evaluated and stabilization techniques were identified to decrease the speed at which they are eroding into farmlands and other areas. Several additional gullies were identified and are undergoing additional assessment and characterization for stabilization techniques. Finally, talks are ongoing with Vermont DEC regarding the potential for offering a corridor easement on Reach 04 of Flower Brook.

The Flower Brook Stormwater Master Plan was successful in identifying and ranking high-priority sediment, nutrient, and bacteria-reducing projects in the watershed. Ongoing work through conservation partners including the Towns, the District, Vermont DEC, and the Rutland RPC will continue to ensure that these projects are implemented and that the brook is monitored to evaluate the effectiveness of the work.

FLOWER BROOK STORMWATER MASTER PLAN REPORT APPENDICES

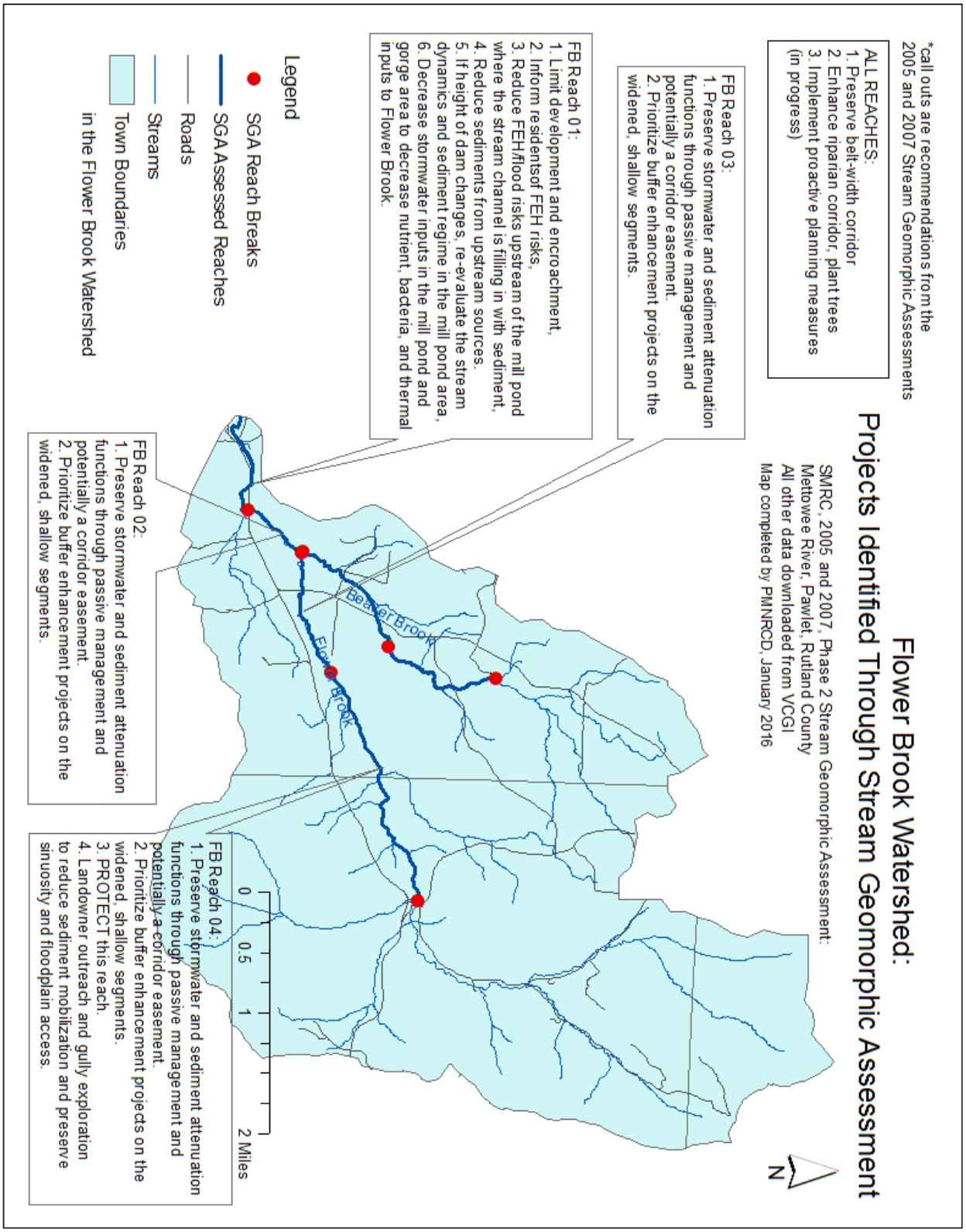
These maps and figures are found at the end of this report:

1) Flower Brook Stream Geomorphic Assessment Recommendations Map
2) SWMP Implementation Matrix
3) Headwaters Implementation Table
4) Reduced-size Conceptual Designs for High-Priority Projects

These documents are found as separate attachments and formed the basis of the SWMP recommendations. They include the background information, study data and in-depth conclusions.

A) Flower Brook Report Index and Data Library, PMNRCD 2016 update
B) Flower Brook 2014 River Corridor Project Sheets, PMNRD 2015
C) Village Stormwater Problem Area Data Sheets- Initial Project Identification 2015
D) Conceptual Designs of Village Stormwater Projects, Stone 2015
E) Conceptual Designs of Headwaters Roads Projects, Stone 2016
F) Flower Brook Reach 04 Post-Irene Assessment Memo, SMRC 2015 (worksheets and GIS data available upon request)
G) Gully Assessment Alternatives Analysis Memo, SMRC 2015
H) Septic Survey Report, PMNRCD 2015
I) Grant Applications, PMNRCD 2015 and 2016, (available upon request)

Appendix 1: Recommendations from the SMRC, 2005 and 2007, Stream Geomorphic Assessment.



Appendix 2: Matrix used to determine stormwater project rankings in Pawlet Village.

Site ID	Site Name	Recommended Practice(s)	Environmental Priority (scale 1-5)	Constructability (scale 1-5)	Ease of Operation (scale 1-5)	Anticipated Pollutant Abatement (scale 1-5)	Implementation Score	Project Type	Estimated Implementation Cost
2A	Town Green	Reshape catchbasin inlet	3	5	5	2	15	C	L
2B	Town Hall	Stabilize culvert outlet and provide conveyance to Flower Brook	2 (assumes 2A implemented)	4	5	3	14	C	M
2C	75 School St.	Bioretention/infiltration area	3	3	4	4	14	A	L
3	School St. at Rupert Hill Rd.	Detention/infiltration	1	2	4	2	9	C	L
5	Dry hydrant access road, off Rupert Rd.	Stone-lined swale, step pools	4	2	3	3	12	D	M
8	Pawlet Station	Bioretention / detention	2	3	4	4	13	A	L
12A	The Barn	Bioretention / infiltration	4	2	3	5	14	A	M
12B	The Barn	Gully stabilization south of Route 30	5	1	1	3	10	A	MH
13	Cemetery Hill dry hydrant	Regrade access and relocate inlet; install catch basin insert	3	3	2	3	11	C	L
14	Cemetery Hill Rd.	Regrade road, stone line ditch, add check dams; may require some work with private road intersection	4	4	3	4	15	D	M
15	Pawlet Community Church	Improve conveyance, add bioretention / infiltration area	4	3	3	5	15	A	M
17	Eastman parcel, Route 30	Bioretention / detention	3	2	4	5	14	A	M
19	Sheldon Store	Gully stabilization west of Route 30	5	1	2	3	11	D	H

Project Type "key":

- **A** Private property
- **B** State property or right-of-way
- **C** Public property (town-owned land or right-of-way)
- **D** Hybrid: part public land, part private land

Estimated Implementation Cost "key":

- L less than $20,000
- M $20-$50,000
- MH $50-$100,000
- H more than $100,000

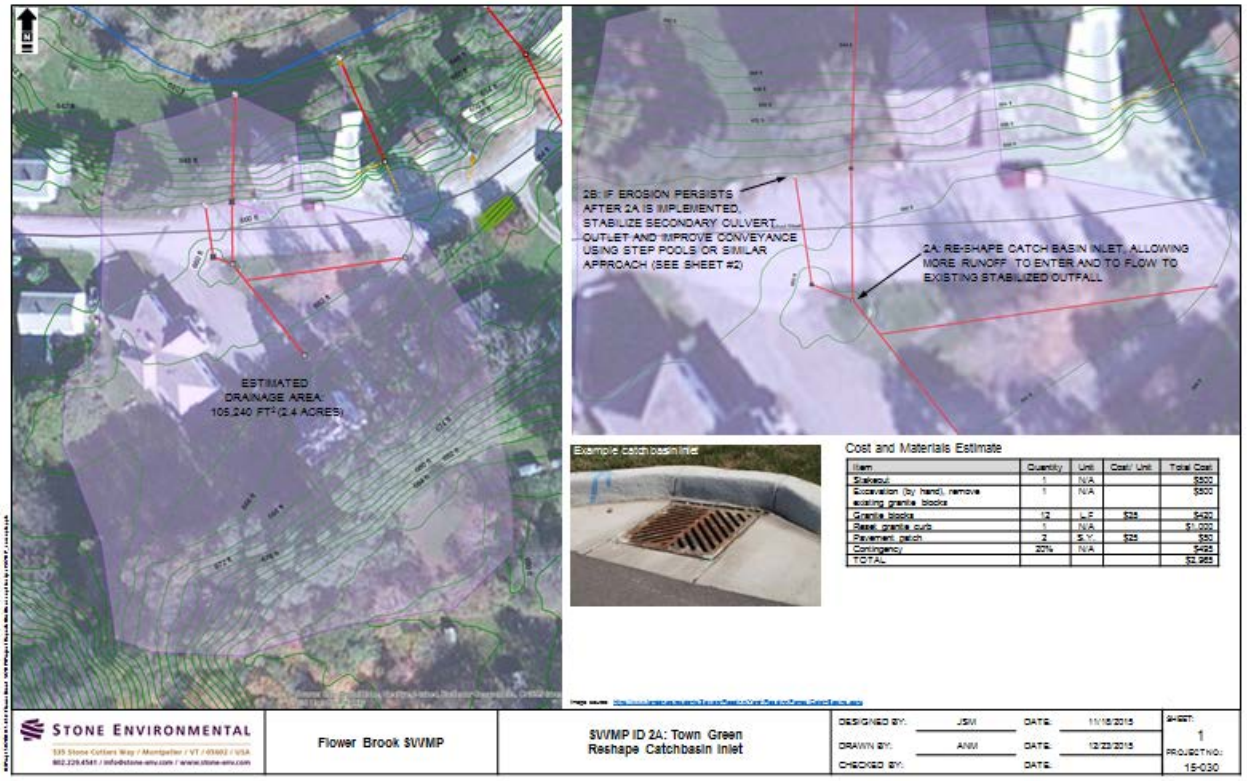
Appendix 3: Headwaters Project Implementation Table

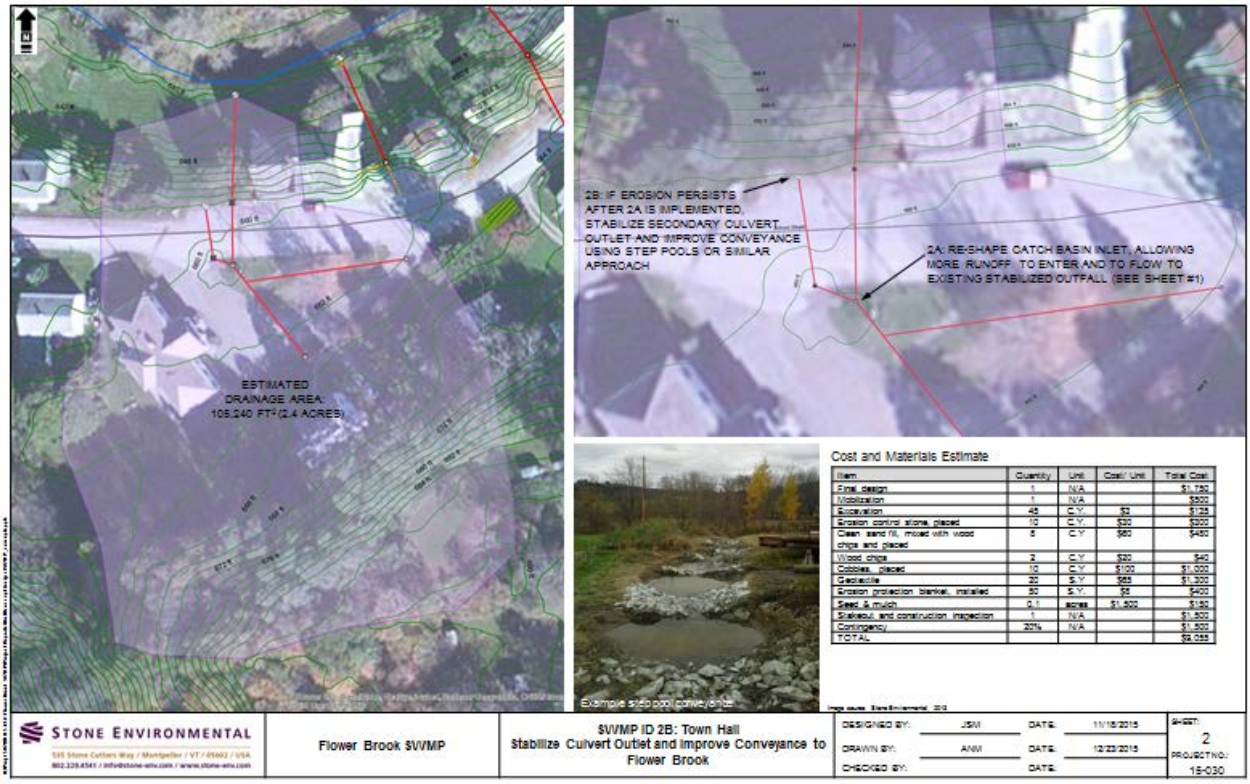
Site	Priority H	Priority M	Priority L	Reach/ Town	Project/Strategy Description	Stressors addressed	Technical Feasibility	Other Social Benefits	Costs	Landowner Commitment	Potential Partners/ Funding Program
1	X			M05T03.04 Pawlet Danby	**River Corridor Protection.** Corridor protection could be achieved through river corridor easement administered by the Vermont River Conservancy to protect floodplain and sediment attenuation functions in perpetuity. Alternatively, the vicinity could be conserved through Vermont Land Trust with corridor protections offered through designation of a Special Treatment Area.	Channel Erosion, Sediment Loading, Nutrient Loading, Thermal Stress	Very High, two landowners	Public access. Reduced erosion hazards in downstream reaches. Mammalian habitat corridor.	Medium	Unknown	VRC, VLT, VHCB, VTANR (ERP), PMNRCD
2	X			Gully 1 Pawlet	**Gully Entrance Stabilization**. Andrus Farm. Rock-lined entrance practice to arrest head-cutting.	Channel Erosion, Sediment Loading	High	Improved water quality	Low	Unknown	FSA (EQIP), VTANR (ERP, VWG), PMNRCD
2			X	Gully 1	Landslide stabilization - engineered structures	Sediment loading	Low to mod		High	Unknown	
2		X		Gully 1	Accelerate revegetation of landslides to stabilize ravine and reduce sediment erosion - as a project alongside measures to stabilize gully entrance and attenuate flows in upstream catchment.	Sediment loading	High	Improved water quality	Low to Med (depending on project specifications)	Unknown	FSA (EQIP), VTANR (ERP, VWG), PMNRCD, NRCS/USFS Landscape
2		X		Gully 1	Rock-lined Waterway to stabilize gully erosion, control grade, - as a project alongside measures to stabilize gully entrance and attenuate flows in upstream catchment. Possible Critical Area	Channel Erosion, Sediment Loading	Mod	Improved water quality	Med-High	Unknown	FSA (EQIP), VTANR (ERP, VWG), PMNRCD, NRCS/USFS Landscape
2	X			Gully 1	Actively **manage/harvest sediment** produced from gully to prevent/reduce loading to Flower Brook. Activities limited to Flower Brook floodplain above the bankfull elevation.	Sediment loading	Very High	Improved water quality	Low - gravel used or sold	Likely	
3	X			Gully 2 Danby	**Gully Stabilization.** Bioengineering techniques such as log check dams and log stacks, to arrest head-cutting, provide grade control, and stabilize gullies. Vegetate disturbed areas through NRCS Critical Area Planting practice, or equivalent.	Channel Erosion, Sediment Loading	High (minimizes forest disturbance)	Improved water quality	Low	Unknown	VTANR (ERP, VWG), PMNRCD, VYCC, NRCS/USFS Landscape Restoration Fund, VYCC
3		X		Gully 2 Danby	**Gully Stabilization.** Rock lined Waterway and Stone-lined Entrance, to arrest head-cutting, provide grade control, and stabilize gullies. Critical Area Seeding and Erosion Control Blankets on disturbed soils.	Channel Erosion, Sediment Loading	Mod-High (access limited; requires forest disturbance)	Improved water quality	Medium	Unknown	FSA (EQIP), VTANR (ERP, VWG), PMNRCD, VYCC, NRCS/USFS Landscape Restoration Fund

Appendix 3: Headwaters Project Implementation Table, page 2

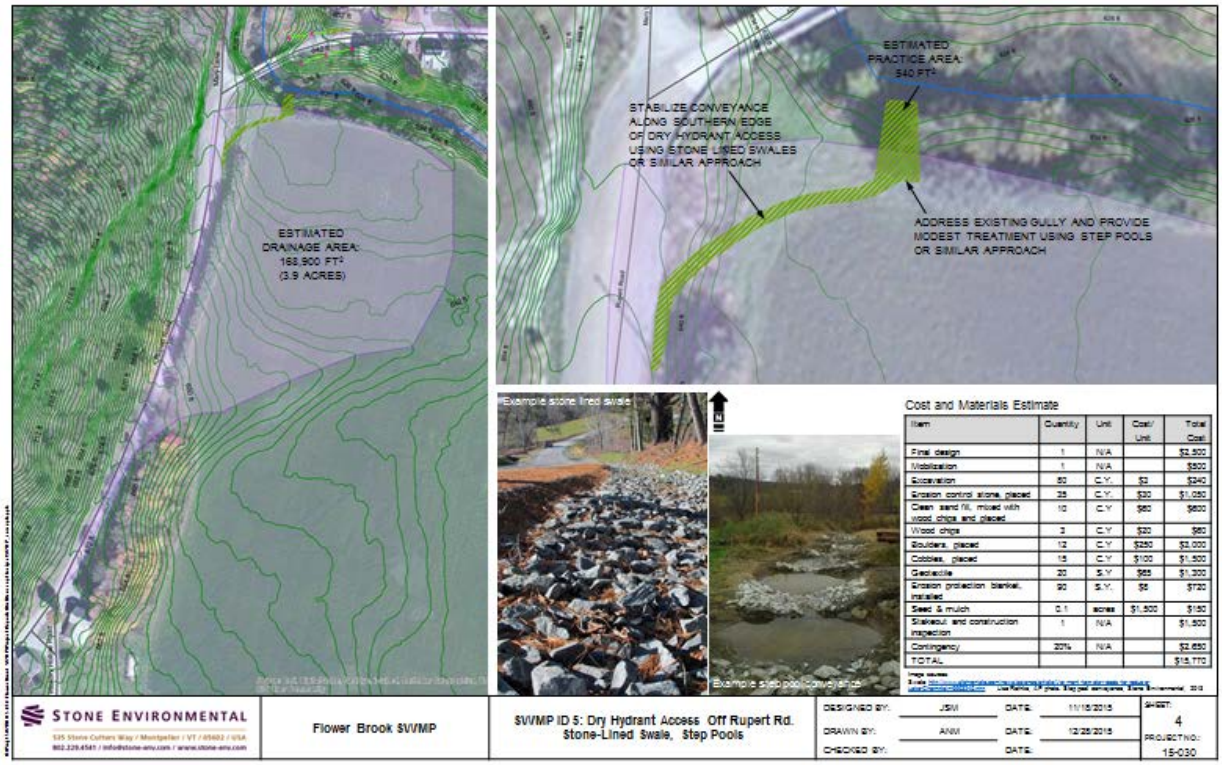
Site	Priority H	M	L	Reach/ Town	Project/Strategy Description	Stressors addressed	Technical Feasibility	Other Social Benefits	Costs	Landowner Commitment	Potential Partners/ Funding Program
4	X			Gullies 3&4	**Gully Stabilization.** Stone-lined entrance. Bioengineering techniques or NRCS standard stone-lined swales to treat two gullies draining the northern steep valley slopes along Flower Brook.	Channel Erosion, Sediment Loading, Nutrient Loading	Very High	Improved instream habitat,	Medium	Unknown, unlikely	FSA (EQIP), VTANR (ERP, VWG), PMNRCD, NRCS/USFS Landscape Restoration Fund
5	X			Channel upstream of Gully 5	**Stabilize Edge-of-Field Erosion.** Stone-lined entrance, Critical Area Seeding, Mulching	Channel Erosion, Sediment Loading, Nutrient Loading	Very High	Improved water quality	Low	Likely	FSA (EQIP), PMNRCD, NRCS/USFS Landscape Restoration Fund
6	X			head-waters Pawlet, Danby	**Forest Management Practices workshop**. Demonstration projects for Mettowee watershed forest land owners hosted by local forest owner. (e.g., road design, broad-based dips, forwarders)	Channel Erosion, Sediment Loading, Increased peak flows	Very High	Build capacity among forest land owners for more flood resilient practices	Low	Undetermined	VTANR (ERP), PMNRCD, Vermont Family Forests.
7	X			Ephemeral channels leading to gullies	**Improved Agricultural Practices**. Enhance riparian buffers along ephemeral channels, seed critical areas of field erosion, install grass or rock-lined waterways where warranted. Various landowners and agricultural operators.	Channel Erosion, Sediment Loading, Thermal Stresses	Very High	Improved shading, enhanced channel stability, improved water quality	Low	Undetermined	FSA (EQIP), PMNRCD, NRCS/USFS Landscape Restoration Fund

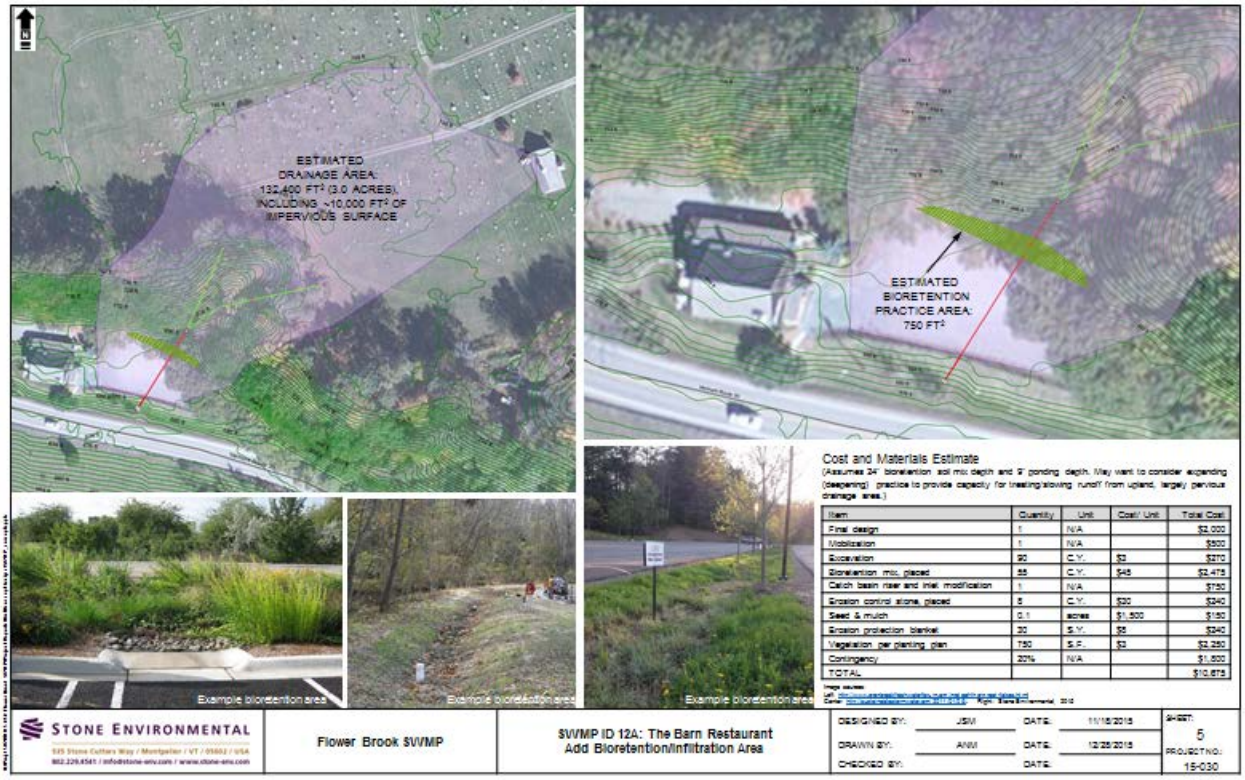
Appendix 4: Reduced-size Conceptual Designs for High-Priority Projects

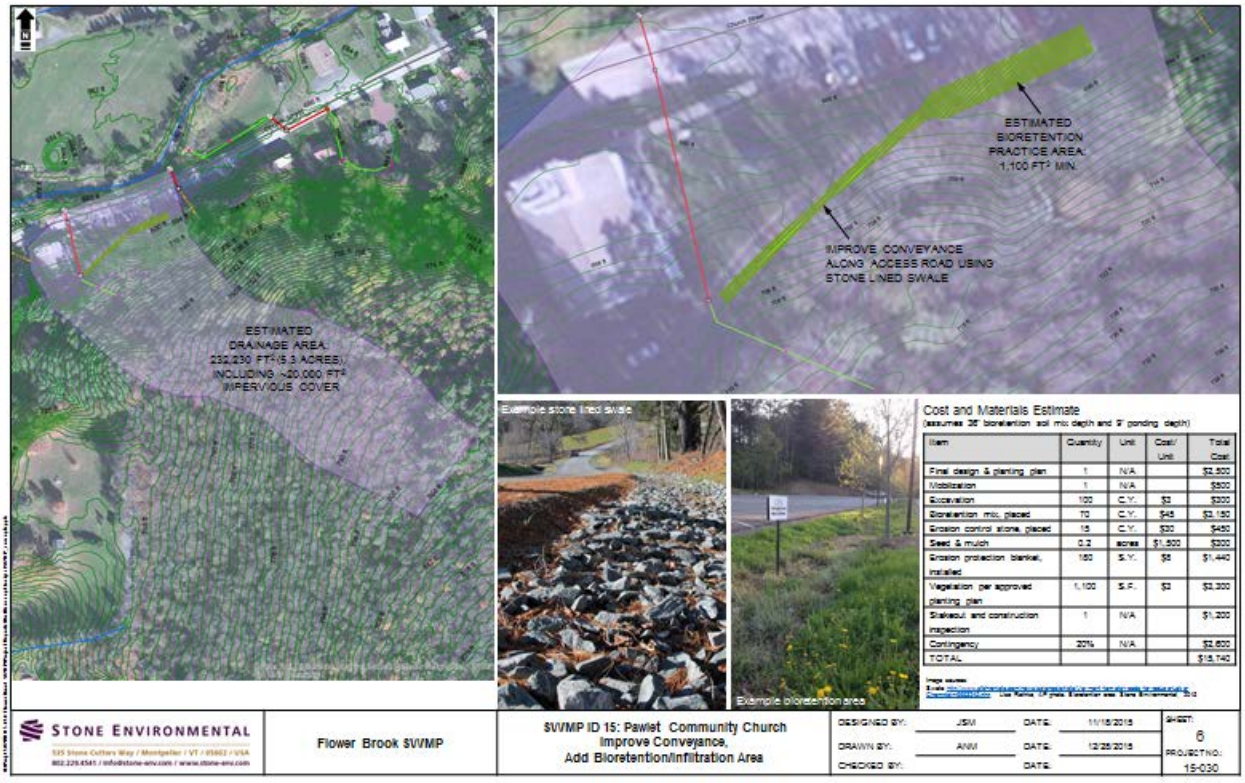


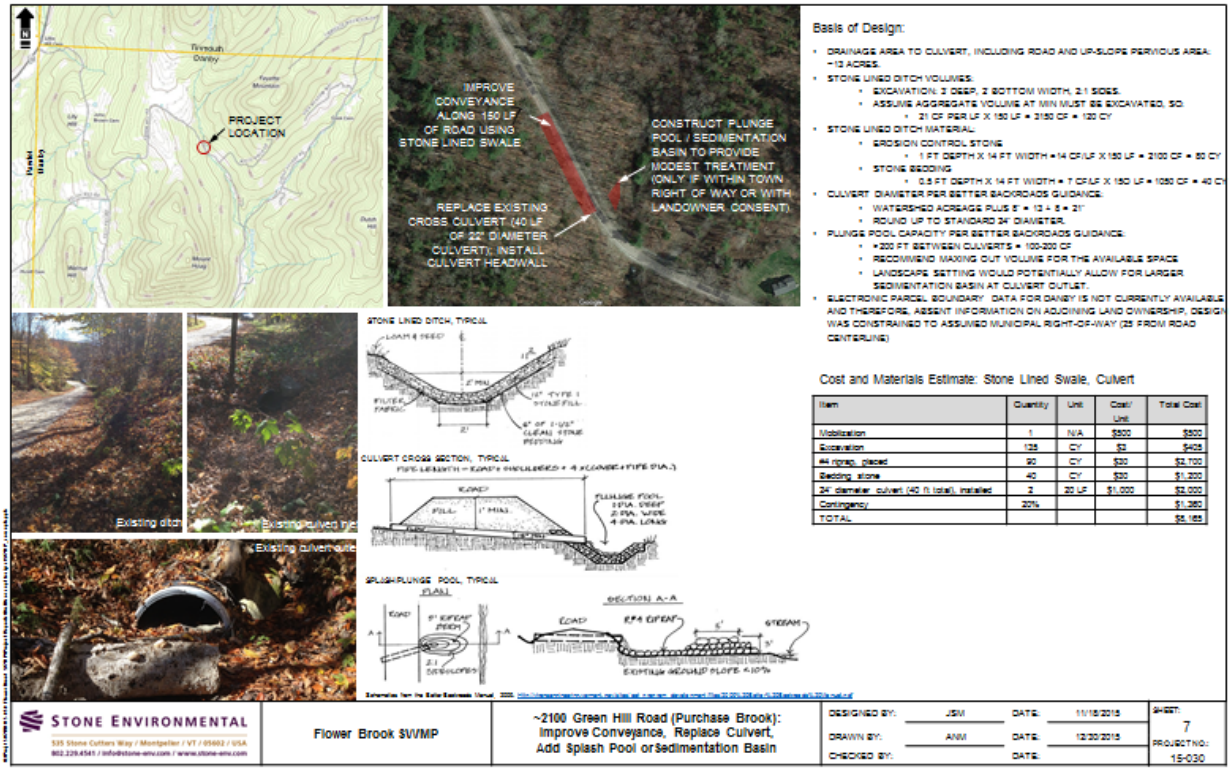



ESTIMATED
DRAINAGE AREA:
36,320 FT² (0.8 ACRES)
POTENTIAL
STORMWATER
PRACTICE:
200 FT²
Example residential bioretention area
Cost and Materials Estimate
(assumes 45' bioretention soil mix depth and 9" ponding depth)
Item | Quantity | Unit | Cost/Unit | Total Cost
Final design | 1 | N/A | | $500
Mobilization | 1 | N/A | | $500
Excavation | 30 | C.Y. | $3 | $90
Bioretention mix, placed | 15 | C.Y. | $45 | $675
Erosion control stone, placed | 3 | C.Y. | $30 | $90
Seed & mulch | 0.1 | acres | $1,500 | $150
Erosion protection blanket | 25 | S.Y. | $5 | $200
Vegetation per approved planting plan | 200 | S.F. | $3 | $600
Contingency | 20% | N/A | | $600
TOTAL | | | | $3,405
STONE ENVIRONMENTAL
Flower Brook SWMP
SWMP ID 2C: 75 School Street
Bioretention/Infiltration Area
DESIGNED BY: JSM DATE: 11/18/2015
DRAWN BY: ANM DATE: 12/23/2015
CHECKED BY: DATE:
SHEET: 3
PROJECT NO: 15-030


ESTIMATED
DRAINAGE AREA:
168,900 FT²
(3.9 ACRES)
ESTIMATED
PRACTICE AREA:
540 FT²
STABILIZE CONVEYANCE
ALONG SOUTHERN EDGE
OF DRY HYDRANT ACCESS
USING STONE LINED SWALES
OR SIMILAR APPROACH
ADDRESS EXISTING GULLY AND PROVIDE
MODEST TREATMENT USING STEP POOLS
OR SIMILAR APPROACH
Example stone lined swale
Example step pool conveyance
Cost and Materials Estimate
Item | Quantity | Unit | Cost/ Unit | Total Cost
Final design | 1 | N/A | | $2,500
Mobilization | 1 | N/A | | $500
Excavation | 80 | C.Y. | $3 | $240
Erosion control stone, placed | 35 | C.Y. | $30 | $1,050
Clean sand fill, mixed with wood chips and placed | 10 | C.Y. | $60 | $600
Wood chips | 3 | C.Y. | $30 | $90
Boulders, placed | 12 | C.Y. | $250 | $3,000
Cobbles, placed | 15 | C.Y. | $100 | $1,500
Geotextile | 20 | S.Y. | $65 | $1,300
Erosion protection blanket, installed | 90 | S.Y. | $5 | $720
Seed & mulch | 0.1 | acres | $1,500 | $150
Stakeout and construction inspection | 1 | N/A | | $1,500
Contingency | 20% | N/A | | $2,650
TOTAL | | | | $15,770
STONE ENVIRONMENTAL
Flower Brook SWMP
SWMP ID 5: Dry Hydrant Access Off Rupert Rd.
Stone-Lined Swale, Step Pools
DESIGNED BY: JSM DATE: 11/18/2015
DRAWN BY: ANM DATE: 12/28/2015
CHECKED BY: DATE:
SHEET: 4
PROJECT NO: 15-030


ESTIMATED
DRAINAGE AREA:
132,400 FT² (3.0 ACRES),
INCLUDING ~10,000 FT² OF
IMPERVIOUS SURFACE
ESTIMATED
BIORETENTION
PRACTICE AREA:
750 FT²
Example bioretention area
Example bioretention area
Example bioretention area
Cost and Materials Estimate
(Assumes 24" bioretention soil mix depth and 9" ponding depth. May want to consider expanding (deepening) practice to provide capacity for treating/slowing runoff from upland, largely pervious drainage area.)
Item | Quantity | Unit | Cost/ Unit | Total Cost
Final design | 1 | N/A | | $2,000
Mobilization | 1 | N/A | | $500
Excavation | 90 | C.Y. | $3 | $270
Bioretention mix, placed | 55 | C.Y. | $45 | $2,475
Catch basin riser and inlet modification | 1 | N/A | | $750
Erosion control stone, placed | 8 | C.Y. | $30 | $240
Seed & mulch | 0.1 | acres | $1,500 | $150
Erosion protection blanket | 30 | S.Y. | $8 | $240
Vegetation per planting plan | 750 | S.F. | $3 | $2,250
Contingency | 20% | N/A | | $1,500
TOTAL | | | | $10,675
STONE ENVIRONMENTAL
Flower Brook SWMP
SWMP ID 12A: The Barn Restaurant
Add Bioretention/Infiltration Area
DESIGNED BY: JSM DATE: 11/16/2015
DRAWN BY: ANM DATE: 12/28/2015
CHECKED BY: DATE:
SHEET: 5
PROJECT NO.: 15-030


ESTIMATED
DRAINAGE AREA:
232,230 FT² (5.3 ACRES),
INCLUDING ~20,000 FT²
IMPERVIOUS COVER
ESTIMATED
BIORETENTION
PRACTICE AREA:
1,100 FT² MIN.
IMPROVE CONVEYANCE
ALONG ACCESS ROAD USING
STONE LINED SWALE
Example stone lined swale
Example bioretention area
Cost and Materials Estimate
(assumes 36" bioretention soil mix depth and 9" ponding depth)
Item | Quantity | Unit | Cost/ Unit | Total Cost
Final design & planting plan | 1 | N/A | | $2,500
Mobilization | 1 | N/A | | $500
Excavation | 100 | C.Y. | $3 | $300
Bioretention mix, placed | 70 | C.Y. | $45 | $3,150
Erosion control stone, placed | 15 | C.Y. | $30 | $450
Seed & mulch | 0.2 | acres | $1,500 | $300
Erosion protection blanket, installed | 160 | S.Y. | $8 | $1,440
Vegetation per approved planting plan | 1,100 | S.F. | $3 | $3,300
Stakeout and construction inspection | 1 | N/A | | $1,200
Contingency | 20% | N/A | | $2,600
TOTAL | | | | $15,740
STONE ENVIRONMENTAL
Flower Brook SWMP
SWMP ID 15: Pawlet Community Church
Improve Conveyance,
Add Bioretention/Infiltration Area
DESIGNED BY: JSM DATE: 11/16/2015
DRAWN BY: ANM DATE: 12/28/2015
CHECKED BY: DATE:
SHEET: 6
PROJECT NO.: 15-030

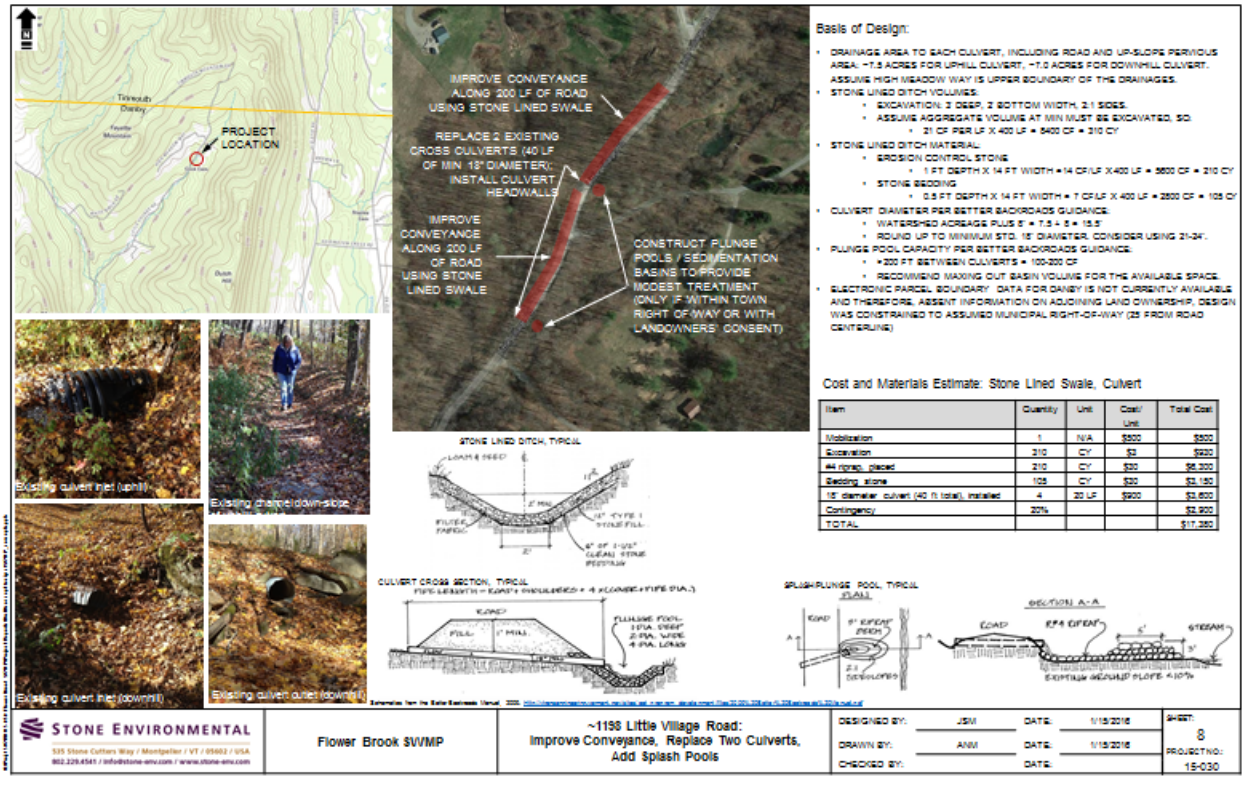


Basis of Design:

- DRAINAGE AREA TO CULVERT, INCLUDING ROAD AND UP-SLOPE PERVIOUS AREA: ~13 ACRES.
- STONE LINED DITCH VOLUMES:
  - EXCAVATION: 2 DEEP, 2 BOTTOM WIDTH, 2:1 SIDES.
  - ASSUME AGGREGATE VOLUME AT MIN MUST BE EXCAVATED, SO:
    - 21 CF PER LF X 150 LF = 3150 CF = 120 CY
- STONE LINED DITCH MATERIAL:
  - EROSION CONTROL STONE
    - 1 FT DEPTH X 14 FT WIDTH = 14 CF/LF X 150 LF = 2100 CF = 80 CY
  - STONE BEDDING
    - 0.5 FT DEPTH X 14 FT WIDTH = 7 CF/LF X 150 LF = 1050 CF = 40 CY
- CULVERT DIAMETER PER BETTER BACKROADS GUIDANCE:
  - WATERSHED ACREAGE PLUS 5' = 13 + 5 = 21'
  - ROUND UP TO STANDARD 24' DIAMETER.
- PLUNGE POOL CAPACITY PER BETTER BACKROADS GUIDANCE:
  - =200 FT BETWEEN CULVERTS = 100-200 CF
  - RECOMMEND MAXING OUT VOLUME FOR THE AVAILABLE SPACE
  - LANDSCAPE SETTING WOULD POTENTIALLY ALLOW FOR LARGER SEDIMENTATION BASIN AT CULVERT OUTLET.
- ELECTRONIC PARCEL BOUNDARY DATA FOR DANBY IS NOT CURRENTLY AVAILABLE AND THEREFORE, ABSENT INFORMATION ON ADJOINING LAND OWNERSHIP, DESIGN WAS CONSTRAINED TO ASSUMED MUNICIPAL RIGHT-OF-WAY (25 FROM ROAD CENTERLINE)

Cost and Materials Estimate: Stone Lined Swale, Culvert

Item	Quantity	Unit	Cost/ Unit	Total Cost
Mobilization	1	N/A	$500	$500
Excavation	135	CY	$3	$405
#4 riprap, placed	90	CY	$30	$2,700
Bedding, stone	40	CY	$30	$1,200
24" diameter culvert (40 ft total), installed	2	20 LF	$1,000	$2,000
Contingency	20%			$1,360
TOTAL				$8,165

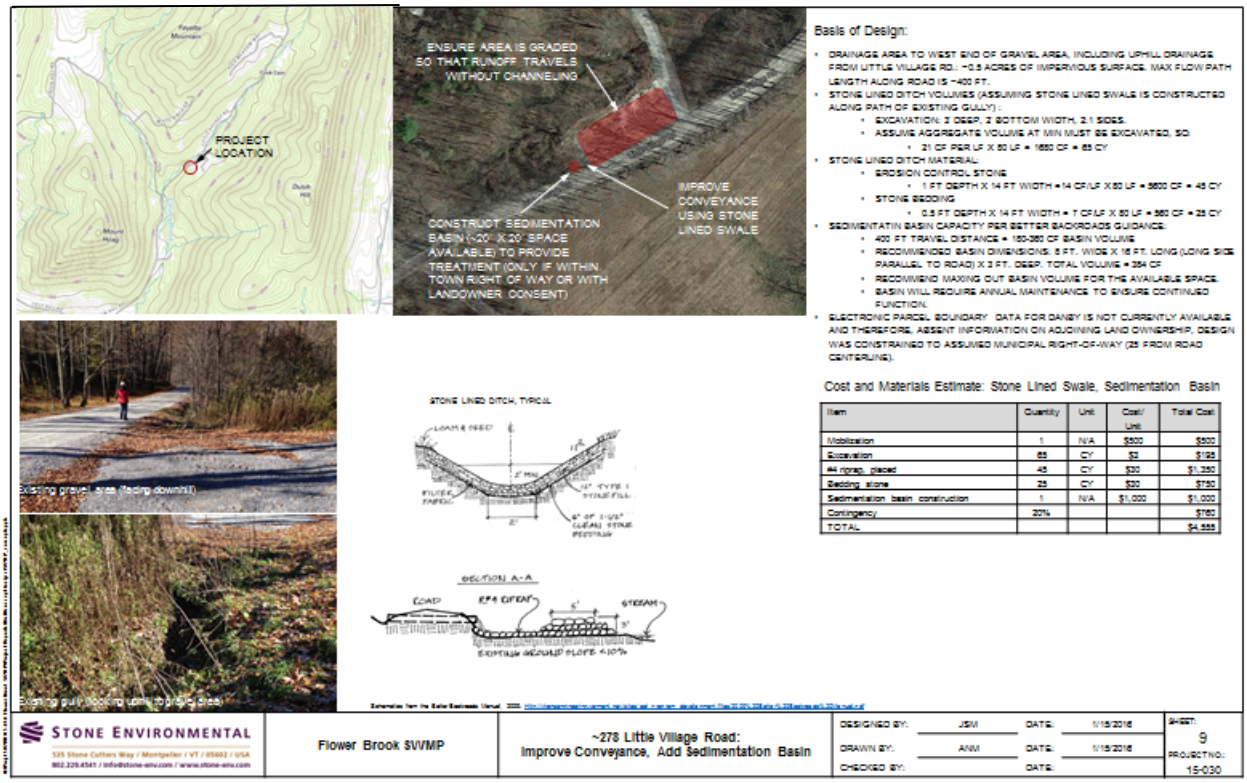


Basis of Design:

- DRAINAGE AREA TO EACH CULVERT, INCLUDING ROAD AND UP-SLOPE PERVIOUS AREA: ~7.5 ACRES FOR UPHILL CULVERT, ~7.0 ACRES FOR DOWNHILL CULVERT. ASSUME HIGH MEADOW WAY IS UPPER BOUNDARY OF THE DRAINAGES.
- STONE LINED DITCH VOLUMES:
  - EXCAVATION: 2 DEEP, 2 BOTTOM WIDTH, 2:1 SIDES.
  - ASSUME AGGREGATE VOLUME AT MIN MUST BE EXCAVATED, SO:
    - 21 CF PER LF X 400 LF = 8400 CF = 310 CY
- STONE LINED DITCH MATERIAL:
  - EROSION CONTROL STONE
    - 1 FT DEPTH X 14 FT WIDTH = 14 CF/LF X 400 LF = 5600 CF = 210 CY
  - STONE BEDDING
    - 0.5 FT DEPTH X 14 FT WIDTH = 7 CF/LF X 400 LF = 2800 CF = 105 CY
- CULVERT DIAMETER PER BETTER BACKROADS GUIDANCE:
  - WATERSHED ACREAGE PLUS 5' = 7.5 + 5 = 15.5'
  - ROUND UP TO MINIMUM STD. 18' DIAMETER. CONSIDER USING 21-24'.
- PLUNGE POOL CAPACITY PER BETTER BACKROADS GUIDANCE:
  - =200 FT BETWEEN CULVERTS = 100-200 CF
  - RECOMMEND MAXING OUT BASIN VOLUME FOR THE AVAILABLE SPACE.
- ELECTRONIC PARCEL BOUNDARY DATA FOR DANBY IS NOT CURRENTLY AVAILABLE AND THEREFORE, ABSENT INFORMATION ON ADJOINING LAND OWNERSHIP, DESIGN WAS CONSTRAINED TO ASSUMED MUNICIPAL RIGHT-OF-WAY (25 FROM ROAD CENTERLINE)

Cost and Materials Estimate: Stone Lined Swale, Culvert

Item	Quantity	Unit	Cost/ Unit	Total Cost
Mobilization	1	N/A	$500	$500
Excavation	310	CY	$3	$930
#4 riprap, placed	210	CY	$30	$6,300
Bedding, stone	105	CY	$30	$3,150
18" diameter culvert (40 ft total), installed	4	20 LF	$900	$3,600
Contingency	20%			$2,900
TOTAL				$17,380


PROJECT LOCATION
ENSURE AREA IS GRADED SO THAT RUNOFF TRAVELS WITHOUT CHANNELING
IMPROVE CONVEYANCE USING STONE LINED SWALE
CONSTRUCT SEDIMENTATION BASIN (~20' X 20' SPACE AVAILABLE) TO PROVIDE TREATMENT (ONLY IF WITHIN TOWN RIGHT OF WAY OR WITH LANDOWNER CONSENT)
Existing gravel area (facing downhill)
Existing gully looking uphill to gravel area
STONE LINED DITCH, TYPICAL
SECTION A-A
EXISTING GROUND SLOPE 4-10%
Basis of Design:
DRAINAGE AREA TO WEST END OF GRAVEL AREA, INCLUDING UPHILL DRAINAGE FROM LITTLE VILLAGE RD.: ~0.5 ACRES OF IMPERVIOUS SURFACE. MAX FLOW PATH LENGTH ALONG ROAD IS ~400 FT.
STONE LINED DITCH VOLUMES (ASSUMING STONE LINED SWALE IS CONSTRUCTED ALONG PATH OF EXISTING GULLY):
EXCAVATION: 3 DEEP, 2 BOTTOM WIDTH, 2:1 SIDES.
ASSUME AGGREGATE VOLUME AT MIN MUST BE EXCAVATED, SO:
21 CF PER LF X 80 LF = 1680 CF = 65 CY
STONE LINED DITCH MATERIAL:
EROSION CONTROL STONE
1 FT DEPTH X 14 FT WIDTH =14 CF/LF X 80 LF = 3600 CF = 45 CY
STONE BEDDING
0.5 FT DEPTH X 14 FT WIDTH = 7 CF/LF X 80 LF = 560 CF = 25 CY
SEDIMENTATION BASIN CAPACITY PER BETTER BACKROADS GUIDANCE:
400 FT TRAVEL DISTANCE = 150-360 CF BASIN VOLUME
RECOMMENDED BASIN DIMENSIONS: 5 FT. WIDE X 16 FT. LONG (LONG SIDE PARALLEL TO ROAD) X 3 FT. DEEP. TOTAL VOLUME = 254 CF
RECOMMEND MAXING OUT BASIN VOLUME FOR THE AVAILABLE SPACE.
BASIN WILL REQUIRE ANNUAL MAINTENANCE TO ENSURE CONTINUED FUNCTION.
ELECTRONIC PARCEL BOUNDARY DATA FOR DANBY IS NOT CURRENTLY AVAILABLE AND THEREFORE, ABSENT INFORMATION ON ADJOINING LAND OWNERSHIP, DESIGN WAS CONSTRAINED TO ASSUMED MUNICIPAL RIGHT-OF-WAY (25 FROM ROAD CENTERLINE).
Cost and Materials Estimate: Stone Lined Swale, Sedimentation Basin
Item | Quantity | Unit | Cost/ Unit | Total Cost
Mobilization | 1 | N/A | $500 | $500
Excavation | 65 | CY | $3 | $195
#4 riprap, placed | 45 | CY | $30 | $1,350
Bedding stone | 25 | CY | $30 | $750
Sedimentation basin construction | 1 | N/A | $1,000 | $1,000
Contingency | 20% | | | $760
TOTAL | | | | $4,555
STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com
Flower Brook SWMP
~278 Little Village Road:
Improve Conveyance, Add Sedimentation Basin
DESIGNED BY: JSW DATE: 1/15/2016
DRAWN BY: ANM DATE: 1/15/2016
CHECKED BY: DATE:
SHEET: 9
PROJECT NO: 15-030