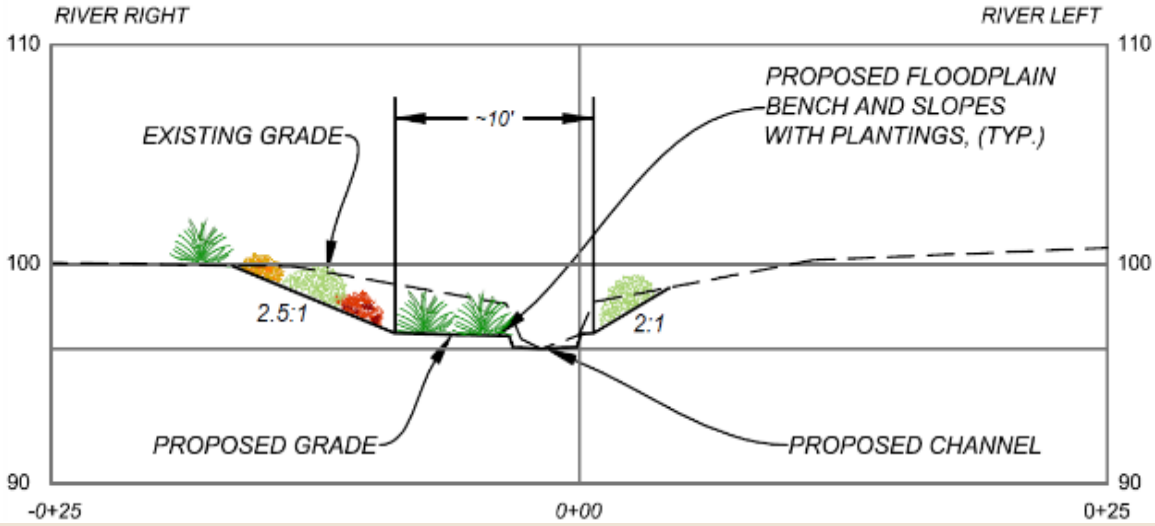
Stormwater Master Plan
Town of Hardwick, Vermont

STONE ENVIRONMENTAL



PROJECT NO.

16-138

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Cover: Present condition of a roadside channel adjacent to Buffalo Storage and VT Rte. 14 (top), and concept plan for a natural channel design to address the site's erosion and sediment transport issues (bottom).

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Acknowledgements

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1. Introduction

Water knows no political boundaries, and thus evaluations of water quality tend to be undertaken within watershed boundaries and involve land areas in multiple towns. From a water quality perspective, it would be ideal to manage water resources along watershed lines—but the reality is that many decisions, particularly those about land use, are made at the level of towns or individual sites.

A Stormwater Master Plan is responsive to existing landscape characteristics across all watersheds within local political bounds. It connects land use, stormwater management, floodplain management, river management, and public infrastructure needs to more effectively address all of the issues which contribute to water quality impairment or improvement. Within this Plan, localized stormwater problems are examined at a larger scale (e.g., throughout the town core) to determine their relative contributions and aid in setting priorities for addressing challenges related to stormwater runoff. As adjoining municipalities also take increasingly comprehensive views of stormwater management issues and planning, these plans are one-stop resources that can improve coordination and increase opportunities for collaboration in meeting watershed-related needs across political boundaries.

1.1. Project Background

As precipitation falls on an undisturbed, natural landscape and moves through the hydrologic cycle, it flows through a complex system of vegetation, soil, groundwater, and surface water. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, transpiration, infiltration, and runoff. Alterations to the landscape change the way it responds to precipitation events. Management of land use, rainfall, storm runoff, and surface water (streams and lakes) are interrelated, and the management practices chosen all influence water quality and stream health.

Watersheds are interconnected networks in which a change at any location can carry throughout the system. There are many factors that influence exactly how stormwater runoff from a particular site will affect other areas of the watershed. The degree and type of impact varies from location to location, but it can be significant relative to other sources of pollution. Stormwater runoff affects water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of the receiving water. Stormwater controls, in contrast, are typically conceived and implemented on a project-by-project basis. These projects are analyzed for their individual stormwater impacts, not in the context of their impact on an interconnected hydrologic and hydraulic system. It is well documented, however, that the cumulative effects of individual land surface changes dramatically influence flooding conditions and contribute to water quality degradation (NRC 2009).

What is a watershed? A watershed is any area of land in which all water runoff from its surface flows to the same drainage point. Watersheds are sometimes referred to as drainage areas. Watersheds are important because they are the basic unit of analysis for all surface water management. They come in all shapes and sizes, and are defined based on the intended study area.

Watershed management practices have direct impacts on water quality in local creeks and streams (such as Cooper Brook), as well as downstream waterbodies (the Lamoille River and, ultimately, Lake Champlain). Any decisions that affect land use have stormwater management ramifications and, in turn, impact all downstream water resources.

Vermont's streams, rivers and lakes are vital economic resources. The quality of local receiving waters affects both economic interests and quality of life in the surrounding areas. Throughout the Lamoille River basin, the local economy depends, in part, on the revenue gained from outdoor activities enjoyed in and on the water. Protecting the quality of surface waters is one of the most important commitments communities can make to protect the economic interests of residents.

Taken together, these elements emphasize the need for a holistic planning effort that considers the interconnected nature of land use, stormwater management, and river management in order to achieve overall watershed goals.

1.2. Project Goals

The ultimate objective of this stormwater master planning project is to support the Town in improving stormwater management, by providing a list of high priority water resource concerns and conceptual solutions that will support the development and implementation of future restoration projects in an efficient and targeted manner.

This Stormwater Master Plan first incorporates information from existing plans and datasets to create a single, town-specific resource to guide future stormwater management activities. The resulting stormwater management planning information and resources are included in Section 2 of this report.

This Stormwater Master Plan also:

- Provides a means for comparing anticipated benefits of individual stormwater improvement projects;
- Provides recommendations to address stormwater problems, including a prioritized list of problem areas that can assist the Town in directing resources to high priority projects; and
- Presents conceptual solutions for stormwater management measures in select high priority problem areas.

1.3. General Descriptions – Planning Area and the Lamoille River

The Town of Hardwick is located in Caledonia County in the Northeast Kingdom of Vermont. The Town has a total area of 38.6 square miles and as of the 2010 census, the population of Hardwick was 3,010 (US Census Bureau 2017). The Lamoille River flows into town from the northeast, and flows out of town into neighboring Wolcott. The areas of interest for this plan include Hardwick's village center in the vicinity of State Routes 14 and 15 and the Lamoille River, and the East Hardwick village area (Figure 1).

The Lamoille River watershed encompasses a watershed area of 706 square miles, and drains portions of Caledonia, Chittenden, Franklin, Lamoille, Orleans, and Washington counties in northern Vermont. The river begins in its headwaters located in Glover, and flows approximately 84 miles through 34 towns to Mallets Bay in Lake Champlain (VTDEC, 2017). The Lamoille River flows southeast from Greensboro and enters Hardwick from the northeast, before flowing west northwest into Wolcott. Within Hardwick, the Lamoille River is considered to be 'altered' as water level fluctuations occur due to the Hardwick Lake Dam (VTDEC, 2016).

2. Existing Plans and Data

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Hardwick's water, wastewater, and stormwater infrastructure; water resources; and the important interface between water resources and local land use decisions. At times these evaluations followed watershed boundaries, and at other times they have followed political boundaries. The following sections identify these evaluations and highlight information most relevant to Hardwick and most relevant to developing a list of strategic, prioritized projects that could be undertaken to improve water quality and increase resilience to future flooding.

2.1. Watershed-Based Assessments

The ongoing assessments described below are generally led by the State of Vermont's Agency of Natural Resources (ANR). These include basin planning efforts, stream geomorphic assessment and in-stream water quality assessment work, and TMDL development, each of which are briefly described below where applicable information is available for Hardwick.

2.1.1. Tactical Basin Planning

The main goal of tactical basin planning is to guide ANR in its own work and in collaborative projects with the public, municipalities, and other state and federal agencies. The basin plans have a five-year scope. The Town of Hardwick is located in the Lamoille River Basin (Basin #7), where a plan was adopted in December 2016 by the Agency of Natural Resources. The central component of this Tactical Basin Plan is an implementation table with targeted actions to protect high quality waters and to address identified water quality issues identified. One of the top priority actions stated in the plan was to 'develop a stormwater master plan for the Village of Hardwick and identify priority projects for mitigating runoff' (Item B4, Table 26 of the plan) (VTDEC, 2016).

2.1.2. Other Vermont ANR-Sponsored Programs

Additional ANR-based data sources reviewed prior to the start of field visits for the purpose of locating potential stormwater problem areas (Section 3) included:

- Stream Geomorphic Assessments: Recorded in the Vermont ANR Natural Resources Atlas Geomorphic Assessment Viewer (http://anrmaps.vermont.gov/websites/anra5/?LayerTheme=1)
- Water Quality Monitoring Data: Available through the Vermont Integrated Watershed Information System (IWIS), the VTDEC-Watershed Management Division's online data portal for water quality information, at https://anrweb.vt.gov/DEC/IWIS/.

2.2. Town-Wide Assessments and Programs

In addition to the watershed-based assessments, a number of assessments and datasets are developed on a municipality-by-municipality basis. These are important to fold into any effort to develop a list of strategic, prioritized projects that could be undertaken to improve water quality in and around Hardwick. These

include direct feedback from the Town, work by the Vermont Agency of Transportation and Vermont Department of Environmental Conservation, and past and current planning initiatives.

- Direct Input from Town Staff: Meetings with Town staff resulted in the identification of several areas of concern and priority project opportunities that were further assessed in the field and included in the stormwater opportunity prioritization and implementation matrix (Table 2).
- Vermont Agency of Transportation-Sponsored Programs: The agency's online bridge and culvert inventory (available at https://www.vtculverts.org/) was reviewed prior to field screening and evaluation of potential stormwater problem areas (Section 3). Much of the planning area is served by closed-system stormwater infrastructure, which was mapped by Vermont DEC (see below).
- Vermont DEC-Sponsored Programs: Detailed stormwater infrastructure mapping and state-issued post-construction stormwater permitting records were examined in order to identify additional stormwater management opportunities. The infrastructure mapping data represent an important supplement to VTrans' online bridge and culvert inventories and were invaluable during evaluations of existing problem areas and retrofit opportunities (Section 3 and as further described below).

A stormwater infrastructure mapping project completed by the VTDEC Ecosystem Restoration Program for the Hardwick (VTDEC, 2012) and East Hardwick (VTDEC, 2017) village areas identified potential locations for stormwater retrofit sites among priority drainage areas. The identified potential retrofits included:

- Two bioretention areas and an extended detention basin were proposed to treat a portion of the runoff from Hazen Union High School parking lot and upland drainage area.
- In East Hardwick, a swirl separator and outfall stabilization were proposed to treat runoff from Main Street and Brickhouse Road.

In addition, the age, style, size, and upkeep of existing facilities permitted by DEC – particularly facilities constructed prior to 2002 – may make them candidates for improvement to enhance stormwater management capabilities. Post-construction stormwater management permits for the planning area (as available from the ANR Atlas at http://anrmaps.vermont.gov/websites/anra5/, "Stormwater Permits – Issued" data layer) were reviewed during field screening of potential stormwater problem areas (Section 3) and development of potential implementation projects (Section 4).

3. Stormwater Problem Areas

One of the goals of this plan is to "develop a prioritized list of stormwater problem areas that can assist the Town in directing resources to high priority projects." To achieve this goal, a thorough effort was made to identify existing problem areas, and then to evaluate existing conditions and potential solutions.

3.1. Identification and Initial Evaluation of Problem Areas

The first task was to identify the location and nature of existing drainage problems and stormwater management concerns, and to gather field data for further analysis where appropriate. The approach to identifying potential problem areas included the following elements:

- Reviewing existing plans and data, as described in Section 2, and noting the location of any concerns related to stormwater
- Engagement with Town, CCNRCD, and State of Vermont staff
- Targeted site visits to verify problem areas during the fall of 2016
- Documentation (with photos) of existing problem areas

A "problem area data sheet" was developed and used as a guide to ensure that consistent information was collected as site visits were completed. A total of 21 potential problem areas were identified and geo-located (Figure 2, Appendix A). The data sheets for all of the problem areas identified in Hardwick are provided in Appendix B of this report.

3.2. Initial Screening Evaluation of Problem Areas

Working from the list of potential problem areas, Stone staff visited each potential problem area to directly observe the site. Where an unresolved problem was found, photos were taken of any areas of active erosion or observable impact, and observations were recorded regarding the source or cause.

Each problem area was given an initial score with the intent of: 1) generally assessing the severity of existing problems, 2) removing low priority problem areas from the dataset, and 3) providing general guidance on the relative order in which the problems should be addressed when considered across the project area. Scores were assigned as described in Table 1.

The problem areas identified during this initial evaluation were carried forward through a more detailed examination and prioritization process as described in Section 4.

Table 1. Scoring Criteria for Preliminary Evaluation of Stormwater Problem Areas.

Level	Classification
1	Outside of project scope, or infeasible to remedy due to project size.
2	Stable, but problem could escalate with future change in surrounding land use.
3	Limited erosion and/or drainage problems are present; issues may be readily addressed.
4	Moderate erosion and/or drainage problems are present; issues may be readily addressed.
5	Significant erosion and/or drainage problems are present; issues may be readily addressed.
6	Strategic retrofit opportunity.

4. Prioritization of Stormwater Management Opportunities and Implementation Matrix

Stone completed a field screening that identified 21 stormwater management opportunities in Hardwick during the fall of 2016, with additional field confirmation in 2017 (Section 3). The locations of the opportunities are shown on Figure 2 (Appendix A), and the nature of each identified problem and potential opportunity is summarized in Table 2.

During and following the field screening, Stone recorded observations about each site which were used in the implementation matrix (Table 2) to develop a score for each opportunity relative to several criteria:

- **Existing environmental concerns** – a score was assigned based on the type(s) of problems present, with 1 point added for each of the following concerns presented by the site's current condition: water quality concerns; infrastructure vulnerability; localized drainage issues/flooding; streambank or in-stream erosion; and overbank flooding. Although sites were generally anticipated to receive between 1 and 3 points, the maximum score a site could receive was 5.
- **Environmental priority –** relative environmental impact on nearest receiving water (e.g., proximity, location) and how "active" the problem area was during the site visit, with 1 being the smallest impact and 5 being the greatest impact.
- **Constructability –** relative ease with which a project could be implemented, including whether the recommended practice(s) could be constructed on publicly-owned land or with a willing landowner-partner, existing access to the site, and the amount of additional assessment and engineering design work that would be required to move the project to implementation. The maximum score a site could receive was 3, indicating a project that should move quickly and easily to implementation.
- **Ease of operation –** including the amount and frequency of maintenance likely to be required and whether maintenance activities would be straightforward to complete. The maximum score a site can receive is 3, indicating a project with infrequent maintenance needs that are easily completed.

The type of ownership of each project location, an initial indication of project cost, and the amount of additional engineering likely needed for implementation are also presented in the matrix (Table 2). These measures are not included in the score tabulated for each potential project, but are provided to give additional context for project prioritization.

Estimated annual phosphorus loads to be removed by the proposed improvements on an annual basis (lbs/year) are also included in the table for problem areas that were ultimately advanced to restoration plan, design-build, or concept (30%) design, where applicable. Estimated total phosphorus base loads (lbs/year) were calculated using the Simple Method approach, based on phosphorus loading rates for developed lands and transportation developed by Vermont DEC in 2015 as an interim procedure to guide applicants in meeting phosphorus "Net Zero" requirements for projects that would potentially discharge phosphorus to

Lake Champlain before the P TMDL was in place (VT DEC, 2015). The average annual pollutant (phosphorus) concentrations provided in the guidance are 0.441 mg/L for developed lands, 0.237 mg/L for paved roads, and 0.618 mg/L for unpaved roads. The developed lands concentration of 0.441 mg/L was applied for most systems in the project area, consistent with DEC guidance for systems that include driveways, access drives, and other transportation surfaces within larger development projects (e.g., residential and commercial developments). The estimated total phosphorus load to be removed by proposed improvements on an annual basis (lbs/year) was calculated based on the estimated total phosphorus base load, annual runoff volume anticipated to be captured by proposed BMPs, and percent pollutant removal efficiencies for the proposed BMP types, as included in the Lake Champlain BMP Scenario Tool (VT DEC, 2017).

Finally, in the three right-most columns, the matrix indicates the projects selected for development of a restoration plan, as well as sites that were advanced to preliminary design or design-build. These projects were selected in consultation with the Town, CCNRCD, and representatives from VT DEC.

Table 2. Stormwater Opportunity Prioritization and Implementation Matrix

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	Implementation Score	Potential Phosphorus Load Reduction (lbs./year)	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Develop Restoration Plan?	Prepare Preliminary Design?
CB-01	Fire Station	Retrofit opportunity	Capture and reuse roof runoff from the fire station with a cistern.	NR (Urban) Adams / Nicholville	2	1	3	3	9		C	L	N	L		
CB-02	North of 582 Mackville Rd.	Over-steepened embankment leading to the stream comprised of very small stone, shows signs of rill erosion.	The embankments should be stabilized using large stone at the toe of slope. If possible, the slopes should be constructed to be more gently sloping. This issue is also present at the intersection of Mackville Road and Carey Road – the same approach is applicable at that location.	A	3	2	2	3	10		D	L	N	L		
CB-03, CB-04	Spruce Drive at Mackville Road	A ditch draining building lots on Spruce Drive is in need of erosion prevention. The fire hydrant access on Mackville Road shows evidence of slumping and is eroding into the roadside ditch.	Install erosion prevention measures and/or water quality BMPs (bioswale) in the exisitng ditch following completion of construction activities for expansion of the mobile home park, At the hydrant, add stone to the toe of slope to stabilize the bank, and level the area used to access the hydrant.	NR (Urban) Adams / Nicholville	2	3	3	2	10	7.1 (CB-03), N/A (CB-04)	D	L	Y (partial)	L	Yes	
CB-05	Buffalo Storage	A ditch that conveys runoff and stream flow from roughly 111 acres of drainage is actively eroding and transporting large sediment loads directly to the Copper Brook.	Construct a revised stream channel sized to accommodate the 1.5 year storm event, and floodplain benches to accommodate flows for larger storm events. Side slopes will be graded between 2:1 and 3:1 up to existing grade and benches and slopes will be planted with native vegetation. Additional construction includes a pool and step on the upstream end to serve as a sediment forebay and upsizing the downstream exit culvert.	NR (Urban) Adams / Nicholville	4	5	2	1	12	47.1	B/C	M	N	H		Yes
CB-06	Poulin Lumber	Retrofit opportunity	It appears that roughly 3 acres of impervious surface is currently unmanaged and primarily drains to a single catch basin near the corner of Union Street and Wolcott Street. If the soils prove permeable, installing an infiltration basin with sediment forebay would reduce sediment transport and runoff currently directed to the confluence of the Copper Brook and the Lamoille River. There are site constraints caused by the close proximity of the railroad right-of-way.	NR (Urban) Adams / Nicholville	3	3	2	2	10		A	MH	Y (partial)	H		
CB-07	Corner of Spring and Granite Streets	Retrofit opportunity – A drainage system conveying runoff from an 8.6-acre area (Spring, Summer, and Dewey Streets) outfalls into Cooper Brook just northwest of the intersection of Spring and Granite Streets.	Existing green space east of the intersection could be utilized for stormwater volume capture and water quality treatment. Any stormwater treatment retrofit practices would be located in the brook's 100-year floodplain – so sub-surface chambers would likely be required for volume retention.	Sheepscot gravelly very fine sandy loam	4	3	1	1	9		D	MH	Y (partial)	H		
LR-01	Corner of Wolcott St. and W. Church St.	Retrofit Opportunity – The existing "trash can" style outlet cover does not protect against backwater when the river rises, causing the closed drainage system to back up.	Replace the existing "trash can" style outlet cover with a "duck bill" outlet structure or similar device. This location could be used as a demonstration, as there are many similar situations along the river.	NR (Urban) Adams / Nicholville	3	4	3	3	13	N/A	C	L	N	L	Yes (design-build)	
LR-02	Elm Street	Retrofit opportunity	There is opportunity to utilize green space between sidewalks and the roadway for treatment should the Town wish to implement further treatment in the neighborhood. However, this area already drains to the bioretention system at LR-03.	NR (Urban) Adams / Nicholville	2	2	2	2	8		D	M	Y (partial)	M		
LR-03	Bioretention	Existing bioretention area has not been maintained.	Complete practice maintenance, including sediment and weed removal. Consider replacement of original plantings with vegetation more easily maintained by Town staff. Create simple operations and maintenance plan and train local staff to ensure sustainable maintenance. Consider practice restoration only if maintenance and inspection uncover performance issues.	NR (Urban) Adams / Nicholville	3	3	2	2	10	14.8	C	L	Y – Existing	M	Yes	
LR-04	Tops/Rite Aid	Much of, if not all of the stormwater from the site appears to drain to the south edge of the paved area, transporting sediment and creating ponding.	A section of pavement at south edge appears to be unused. If soils are suitable for infiltration, excavating existing paved surface and installing infiltration basin with sediment forebay would reduce runoff from the site and provide treatment. Infiltration is not allowed if practice is within Zone I WHPA.	NR (Urban) Adams / Nicholville	3	4	3	2	12	2.6	A	MH	Y (partial)– no infiltration in Zone I	H	Yes	

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	Implementation Score	Potential Phosphorus Load Reduction (lbs./year)	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Develop Restoration Plan?	Prepare Preliminary Design?
LR-05	Lower Prospect Street at Wolcott Street	Roof runoff from the barn and surface runoff from Lower Prospect Street and Hillside Street is causing Lower Prospect Street to actively erode into the intersection of Hillside Street, Lower Prospect Street, and Wolcott Street.	Roof runoff could be captured with gutters and carried to ditches, an infiltration basin, a bioretention area, a cistern, etc. Ditches could also be established on Hillside Street to assist in reducing the amount of runoff that may be contributing to the erosion issue at the intersection.	NR (Urban) Adams / Nicholville	3	3	1	2	9		D	MH	N	H		
LR-06	Hazen Union School (Hardwick Trails)	Retrofit opportunity	Route runoff from the parking lot and uphill area to existing green space to allow for filtration. Install a small sediment basin outside wetland buffer to reduce sediment transport from paved parking and gravel access road/parking. Improve existing gravel parking with underdrained permeable paver/grass-pave system with daylight to buffer area.	A/D	2	2	3	3	10	0.2	C	L	Y (partial)	L	Yes (design-build)	
LR-07	Hazen Union School (Parking and Tennis Courts)	Retrofit opportunity	There is an existing stormwater retrofit present at this location that prevents clogging of the catch-basin. A paved swale along the driveway conveys runoff from the parking lot to a grass swale and the catch basin riser. The paved swale may be converted to a gravel wetland to treat runoff from the parking lot without substantially impacting adjacent recreational uses.	NR (Urban) Adams / Nicholville	3	3	3	2	11	2.3	C	M	N	H		Yes
LR-08	Wright Farm Road	Retrofit opportunity	Route runoff from VT Route 15 to the existing green space and install an infiltration basin with sediment bay that can be easily cleaned/maintained (pending soil investigations).	B/D	3	4	2	2	11		C	M	Y (partial)	M		
LR-09	GRACE	Retrofit opportunities	Two green strips exist between the buildings of Hardwick Village Market, GRACE, and Brochu Auto Service. These strips can be used for linear bioretention areas to capture, treat, and infiltrate runoff from Mill Street, parking areas, and roofs.	NR (Urban) Adams / Nicholville	4	4	2	2	12	0.5	A	M	Y (partial)	M	Yes	
LR-10	Positive Pie and Yummy Wok park	Retrofit opportunity	Promote infiltration and reestablish plantings within the existing park.	NR (Urban) Adams / Nicholville	1	4	2	2	9		A	L	Y (partial)	L		
LR-11	Hardwick Elementary School	Retrofit opportunity	There is a vegetated green strip between Hardwick Elementary School and Saint Norbert's Catholic Church. Install a linear bioretention area at that location. This could be implemented in conjunction with a repaving/regrading project. Parking lot reconstruction was completed in summer/fall 2017; parking is now graded to the closed drainage system and treatment in the green space is no longer feasible.	NR (Urban) Adams / Nicholville	3	4	3	3	13		A	MH	Y (partial)	M		
LR-12	VT 14/15	Retrofit opportunity	A substantial amount of sediment collects at the northern portion of an existing parking area. Installation of a swirl separator is planned in this area in conjunction with sidewalk project on South Main St. in 2017 (the practice was installed in the summer of 2017). Regular maintenance of this practice will be critical to its ongoing performance and success.	NR (Urban) Adams / Nicholville	4	5	3	2	14		C	H	N	H		
LR-13	Hardwick Veterinary Clinic	Retrofit opportunity	Vegetated green strip between the southern clinic parking lot and the Lamoille River north bank could be enhanced with additional plantings to slow down and evapotranspire runoff.	NR (Urban) Adams / Nicholville	1	3	2	3	9		A	L	Y (plantings only)	L		
LR-14	East Hardwick	Moderate erosion exists at the Main Street bridge over the Lamoille River, as well as the east edge of church street. The most significant erosion is present at the southeast and northwest corners of the bridge. Erosion is caused by high velocity over-land flow and active outlet scour at storm drains.	A variety of practices could be established at the northwest corner to alleviate ongoing erosion. Installation of a step-pool conveyance system, stone lined swale, swirl separator, or a combination of practices are all potentially viable options. At the southeast corner, the bank should be stabilized using large stone that will hold against high velocity flows. Even larger stone may be used at the toe of slope to help weight down and anchor the bank. Stone splash pads should be established at storm drain outlets. Proper embankment stabilization may require adjusting or removing the existing concrete retaining wall at the top of the embankment.	NR (Urban) Adams / Nicholville	4	5	1	2	12	8.2	D	MH	N	L	Yes	

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	Implementation Score	Potential Phosphorus Load Reduction (lbs./year)	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Develop Restoration Plan?	Prepare Preliminary Design?
NB-01	Carey Road at Dix Road	Moderate erosion along the north edge of Dix Road caused by steep roadway grading, a shoulder berm, turnouts, and cross culverts with elevated outlets.	Regrade the roadway to promote sheet flow and stabilize culvert outlets by installing stone splash pads.	A	1	2	3	3	9		C	L	Y – A Soils	L		

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

Need for Additional Engineering "key":

L	Project can be implemented without formal engineering
M	Project requires some amount of engineering design to ensure proper sizing
H	Project requires full engineering

Potential Phosphorus Load Reduction (lbs./year) was calculated only for projects advanced to restoration plan, design-build, or concept design, and as applicable to the specific retrofit or improvement proposed.

5. Conceptual Solutions for High Priority Stormwater Problems and Opportunities

Initially, the prioritization of all of the identified problem areas and opportunities (Section 4) resulted in 14 of the identified problem areas being assigned an implementation score of 10 or higher. In consultation with CCNRCD, Town staff, and Vermont DEC staff, this list was further narrowed to five projects for development of restoration plans. Two additional sites were chosen for design build, due to their relative ease of implementation, lower need for additional engineering, and lower cost. Finally, two sites were advanced to concept design, with selection based largely on size of the treatment opportunity, as well as property owner/stakeholder interest and concurrence of State agencies' staff that the concepts were worthy of advancement.

The five opportunities advanced to restoration plan development (Appendix C) were:

- CB-03, CB-04, Mackville Road
- LR-03, Community Recreation Park (Corner of Cottage Street and Cherry Street)
- LR-04, Tops/Rite-Aid Parking lot
- LR-09, Hardwick Village Market / GRACE / Brochu Auto Service Parking Areas
- LR-14, Main Street Bridge, East Hardwick

The two locations chosen for design build (Appendix D) were:

- LR-01, West Church Street Bridge
- LR-06, Hazen Union School / Hardwick Trails Access

The two opportunities advanced to concept design (Appendix E) were:

- CB-05, Buffalo Storage
- LR-07, Hazen Union School (Parking and Tennis Courts)

5.1. Concept Designs

5.1.1. CB-05, Buffalo Storage

The Buffalo Storage site includes a first order unnamed tributary to Cooper Brook that runs generally north to south, parallel to Route 14, and directly adjacent to the Buffalo Storage facility (see CB-05 PADS in Appendix B, and conceptual design plans in Appendix D). The existing channel is essentially serving as a drainage ditch that conveys roughly 111 acres of drainage from lands that have been steadily developed over time. The channel is actively transporting large sediment loads directly to Cooper Brook. This portion of the channel is

also subject to regular ditching and re-shaping by either the Town or VTrans, roughly once every 2-4 years. It is suspected that the channel is in adjustment due to the increased impervious area upstream, meaning that the channel is adjusting its cross sectional area to accommodate the increase in flows and stream power conveyed during storm events. The severity of sediment transport and active erosion can be observed in the photo below.

For conceptual design at this site, Stone considered Schumm's Channel Evolution Model (CEM; USDA 2012). The CEM provides a predictable sequence of changes a stream can undergo after disturbances such as channel straightening, increase in peak discharges, or decrease in sediment load (see figure in Appendix D). The changes can include increases or decreases in the width/depth ratio of the channel and alterations in the floodplain (USDA 2012). Field investigations performed by Stone indicate that the channel is currently in stage II, where the channel is incising and not reaching its floodplains during large storm events. Stream power is being expended on erosion of the channel bed and banks during these events.

The proposed restoration is based on accelerating the channel evolution process and bringing the channel to stage V of the CEM, where a new 'inset' floodplain exists and channel bed and banks have re-stabilized. Restoration includes a revised stream channel sized to accommodate the 1.5 year storm event, floodplain benches to accommodate flows for larger storm events (i.e. the 2 through 100 year events), side slopes graded between 2:1 and 3:1 up to existing grade, and planting of native vegetation along benches and slopes. Also proposed is a pool and step on the upstream end to serve as a sediment forebay, and upsizing of the downstream existing culvert. The end result is lower channel velocities, higher channel roughness, less

sediment transport, a significant increase in channel conveyance and increased storm resiliency during storm events. It is estimated that restoration will contribute to a total suspended solids load reduction of 47,130 lbs./year and a phosphorus load reduction of 47.1 lbs/yr.

A site visit and meeting to review priority projects across the planning area with the VTDEC Watershed Planner, VTDEC Rivers Program, and VTDEC Wetlands Program staff, and Stone was arranged by CCNRCD staff on September 8, 2017. The Buffalo Storage site and its constraints were discussed, as well as the potential application of a step pool storm conveyance or "regenerative stream conveyance" as a treatment solution. Following the meeting, Stone staff provided additional information regarding the regenerative stream conveyance concept. Rivers Program staff indicated on October 2, 2017 that they were willing to explore a "regenerative step-pool project" at this location as a demonstration, provided that Program staff concerns regarding floodplain connection, stream dredging, upstream stormwater inputs, maintenance, and potential Flood Hazard Area and River Corridor impacts could be addressed during later design phases. On November 7, 2017, representatives from Stone, CCNRCD, and VTDEC Watershed Management, Rivers Program, and Wetlands Program staff met with the Buffalo Storage ownership to consider site issues and the evolving retrofit concept. Existing conditions and maintenance of the current channel were discussed, as were potential implementation options. Concerns and constraints discussed included the sediment load conveyed to Cooper Brook, the potential for implementation practices to increase surface water elevations during flood events, coordination with VTrans regarding activity in the highway right-of-way, and encroachment of construction towards Buffalo Storage property and landscaping. Finally, on November 14, 2017, Stone and CCNRCD staff met with representatives from VTrans (District Office and MOB), DEC Rivers Program, and the property owner to discuss the site, potential solutions, and VTrans's specific concerns regarding work in the right-of-way, maintenance, and other relevant design aspects. As of the end of the November 14 site meeting, all parties agreed to move forward with development of the concept design.

An opinion of probable cost for implementation of the proposed restoration design at the Buffalo Storage site is provided in Table 3 below. The estimate assumes re-use of any on-site suitable rock material found during excavation for step and pool construction. Unit costs are based on Vermont Agency of Transportation (VTrans) 5 year average unit prices, ranging from July 2012 to June 2017 (http://vtrans.vermont.gov/sites/aot/files/estimating/documents/5YearEnglishAveragedPriceList11.pdf), and adjusted based on recent stream restoration construction projects implemented in 2017 and managed by Stone staff.

Table 3. Buffalo Storage – Opinion of Probable Cost – 30% Design

	Item	Unit Price	Unit	Design Quantity	Total Cost
1	Clearing and Grubbing	$2,000	LS	1	$2,000
2	Excavation, Including Haul Away	$50	CY	211	$10,550
3	Construct Step & Pool (Sediment Forebay)	$6,000	EA	1	$6,000
4	Fine Grading	$3,000	LS	1	$3,000
5	Culvert Pipe	$8,000	LS	1	$8,000
6	Plantings	$6,000	LS	1	$6,000
7	Erosion Control Matting	$10	SY	800	$8,000
8	Seed	$100	Lb	10	$1,000
9	Erosion Controls	$5,000	LS	1	$5,000
				Total Construction Cost	***$49,550***
				Mobilization - 10% of Construction Cost	*$4,955*
				Survey Stake Out - 5% of Construction Cost	*$2,478*
				Final Design – 30% of Construction Cost	*$14,865*
				Construction Oversight – 5% of Construction Cost	*$2,478*
				Contingency - 25 % of Construction Cost	*$12,388*
				Total Estimated Project Implementation Cost:	***$86,635***

5.1.2. LR-07, Hazen Union School (Parking Lot and Tennis Court)

The Hazen Union campus includes a large school building with approximately 2 acres of rooftop area, tennis courts, parking lot and associated access roads and driveways, and a large athletic field. The school building rooftops are largely connected to drywells and thus effectively disconnected. The tennis court drains to grass swales or to the parking lot. The total drainage area associated with the parking lot and tennis court is 3.44 acres, with 1.64 acres of impervious cover. The paved parking lot drains to two catch-basins that are connected by closed drainage to a paved swale that runs along the driveway entrance to the school, which conveys runoff from the parking lot to another grass swale and eventually to a catch basin and riser (see LR-07 PADS in Appendix B, and conceptual design plans in Appendix D). Due to poorly draining soils, presence of bedrock, and a shallow seasonal high groundwater table, this area of the recreational fields is wet throughout the entire year. The existing paved swale provides conveyance but no water quality treatment or peak flow control of stormwater runoff.

The proposed design for this site includes conversion of the paved swale to a gravel wetland that will treat runoff from the parking lot and a small portion of the tennis courts, and allow flow through to the downstream grass swale. The wetland will consist of a treatment cell approximately 7' wide by 80' long, with substrate comprised of a 2' layer of ¾" double washed crushed stone on the bottom, followed by a 4" choker course of pea gravel, and finally an 8" layer of wetland soils at the top of the substrate (see plans in Appendix D). Water will be stored in the pore spaces of the gravel in the treatment cell, and will be conveyed to a manhole outlet structure via a perforated PVC piping system buried in the bottom gravel layer. Freeboard above the wetland soil layer provides for approximately 18-24" of storage during high flow events, which is defined by side berms at slopes of 1 vertical to 2 horizontal. The design also includes a forebay to trap incoming sediment, and the outlet manhole structure has a trash rack to contain larger debris, in addition to a standard outlet and an overflow outlet to allow bypass during high flow events.

The proposed design will accommodate 100% of the water quality volume for a 1" storm event (approximately 3,500 cubic feet), will provide water quality treatment including sediment and phosphorous removal and provide for storage and velocity reduction of runoff during storm events. It is estimated that gravel wetland

BMP installation will contribute to a phosphorus load reduction of 2.25 lbs/yr from the existing impervious cover.

Stone and CCNRCD staff met with the VTDEC Watershed Planner, as well as representatives from VT DEC Wetlands and Rivers Program staff, on September 8, 2017, and with the DEC Watershed Planner. Stone and CCNRCD staff met separately with the Hazen Union School facilities manager on November 7, 2017 to consider the proposed concept and to discuss potential constraints. All parties agreed to move forward with development of the conceptual design.

An opinion of probable cost for implementation of the gravel wetland is included in Table 4. Similar to Buffalo Storage, this estimate assumes re-use of any on-site suitable rock material found during excavation to be used for berm construction, and also references VTrans 5-year average unit prices.

Table 4. Hazen Union School (Rec. Fields) – Opinion of Probable Cost – 30% Design

	Item	Unit Price	Unit	Design Quantity	Total Cost
1	Clearing and Grubbing	$2,000	LS	1	$2,000
2	Excavation, Including Haul Away	$50	CY	125	$6,250
3	3/4" Dense Graded Double Washed Crushed Stone	$35	CY	42	$1,470
4	3/8" Double Washed Pea Stone	$40	CY	7	$280
5	Wetland Soil	$35	CY	14	$490
6	Stone Fill, Type II	$45	CY	7	$315
7	Precast Reinforced Concrete Manhole with Cast Iron Grate and Trash Rack	$10,000	EA	1	$10,000
8	6" Perforated PVC Pipe	$25	LF	100	$2,500
9	Erosion Control Matting	$10	SY	200	$2,000
10	Seed	$100	LB	5	$500
11	Erosion Controls	$2,500	LS	1	$2,500
				Total Construction Cost	***$28,305***
				Mobilization - 10% of Construction Cost	*$2,831*
				Survey Stake Out - 5% of Construction Cost	*$1,415*
				Final Design – 20% of Construction Cost	*$5,661*
				Construction Oversite – 5% of Construction Cost	*$1,415*
				Contingency - 25 % of Construction Cost	*$7,076*
				Total Estimated Project Implementation Cost:	***$46,703***

6. Next Steps

This document represents an extensive effort to identify and evaluate potential stormwater problem areas throughout the more densely developed areas of Hardwick. Several high priority potential stormwater improvement projects, including conceptual solutions, were identified in Section 5 that CCNRCD or the Town could pursue directly, or could work with partners to pursue funding to address.

Beyond addressing the specific problem areas identified in this plan, there are often opportunities to improve management of stormwater runoff that arise as part of routine municipal projects, such as the substantial reconstruction of a road surface or intersection. Grant funds may be available to cover the incremental cost of addressing stormwater runoff as part of such projects, if stormwater management is considered early enough in the design process and does not exceed regulatory thresholds for state stormwater permits. Any party choosing to advance one of these priority projects will likely need to consult on a case-by-case basis with the VT DEC Stormwater Program to determine whether or not a specific project will be subject to state jurisdiction.

Regardless, it is often significantly more cost-effective and efficient to incorporate stormwater management measures into a planned municipal project as compared to the construction of a "stand alone" stormwater management retrofit. The swirl separator installed near the corner of VT Routes 14 and 15 in the summer and fall of 2017 during construction of the Hardwick Village Sidewalks improvements is a prime example of how to take strategic advantage of such opportunities.

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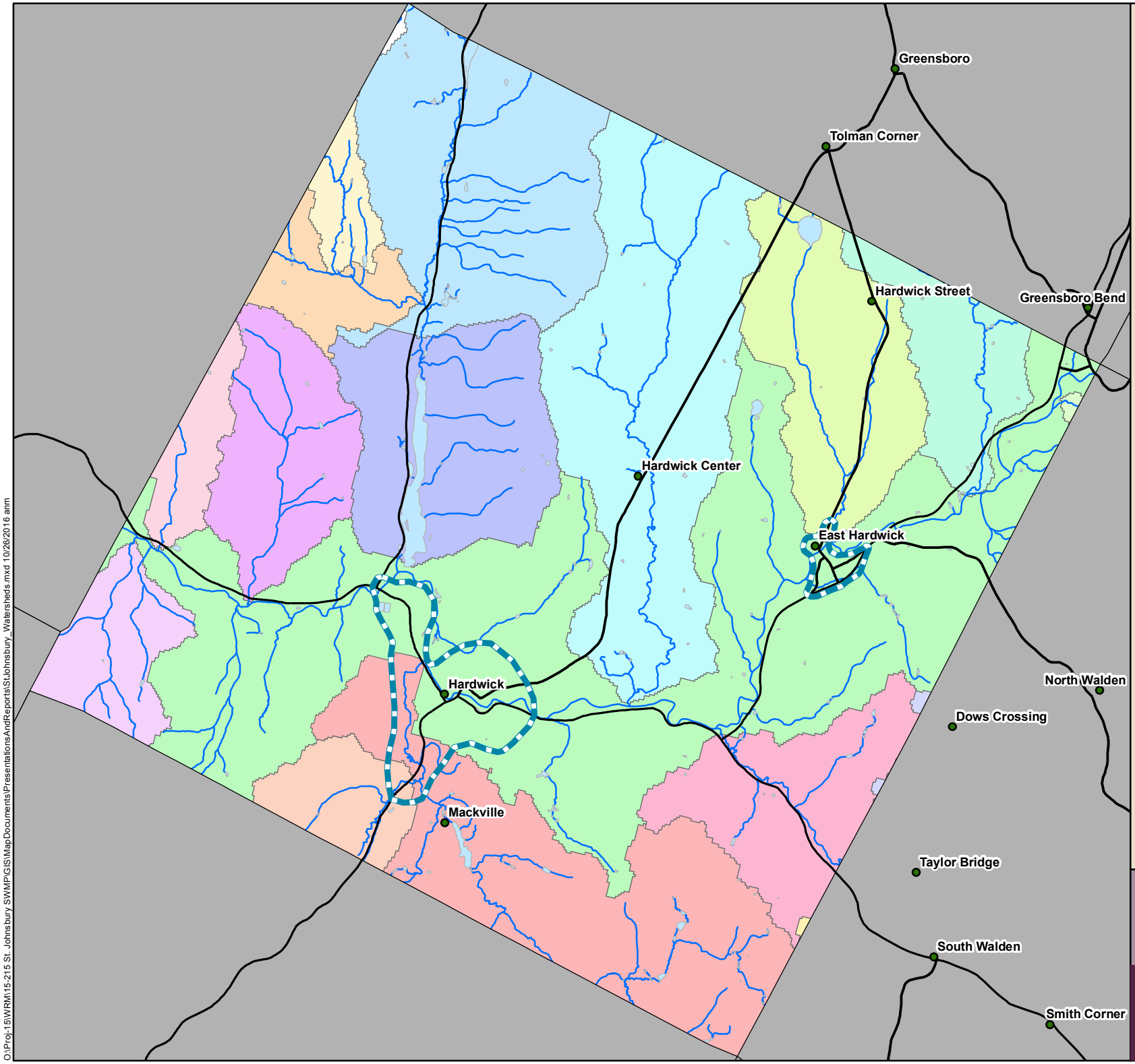
Appendix A. Maps


Greensboro
Tolman Corner
Hardwick Street
Greensboro Bend
Hardwick Center
East Hardwick
Hardwick
North Walden
Dows Crossing
Mackville
Taylor Bridge
South Walden
Smith Corner
N
0
0.55
1.1 Miles
Stormwater Master Plan Area
River or Stream
Hardwick Watersheds
Alder Brook
Bailey Brook
Bunker Brook
Cooper Brook
Greensboro Brook
Hardwick Lake
Haynesville Brook
Kate Brook
Keeler Brook
Lamoille River
Millard Brook
Morrill Brook
Nichols Brook
Perkins Meadow Brook
Porter Brook
Stevens Brook
Tucker Brook
Sources: Watershed Boundaries: NHD Plus 2;
Administrative Boundaries, Roads: VCGI.
STONE ENVIRONMENTAL
Watershed Boundaries
Figure 1
Hardwick
Stormwater Master
Planning
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East Hardwick

LR-14

LR-08

LR-04

LR-05

CB-06

LR-06

CB-01

LR-07

LR-01

LR-03

LR-02

CB-07

LR-12

LR-13

LR-09

LR-10

LR-11

CB-04

CB-03

CB-05

NB-01

CB-02

Problem Areas

- 2
- 3
- 4
- 6
- Stormwater Master Plan Area

Hardwick Watersheds

- Cooper Brook
- Bailey Brook
- Hardwick Lake
- Lamoille River
- Nichols Brook

Sources: Watershed Boundaries, Soils, Hydrography, NHD, Administrative Boundaries: VCGI. Culverts: www.vtculverts.org/

0 0.075 0.15 0.3 Miles

Level	Classification
1	Infeasible to remedy issue/ outside of project scope
2	Stable, but problem could escalate with future change in surrounding landuse
3	Limited erosion and/or drainage problems are present
4	Moderate erosion and/or drainage problems are present
5	Significant erosion and/or drainage problems are present
6	Strategic retrofit opportunity

N

Hardwick and East Hardwick Problem Areas

Figure 2

Hardwick Stormwater Master Planning

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Appendix B. Problem Area Data Sheets

January 17, 2017

MEMO

To: Kerry O'Brien
CCNRCD

STONE ENVIRONMENTAL INC

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From: Amy Macrellis
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SEI No. 16-138
Re: Stormwater Problem Area Data Sheets for the Town of Hardwick

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Stone Environmental has combed through existing reports, including the stormwater infrastructure mapping completed by VT DEC, and also worked directly with Town staff to identify current problem areas (e.g., actively eroding sites, areas impacted during past high flow events) that are a direct, or indirect, result of stormwater runoff.

A "problem area data sheet" was developed and used as a guide to ensure consistent information was collected as site visits were completed. The data sheets for all of the problem areas identified in Hardwick are attached to this memo. Each problem area was given a preliminary classification according to the following system:

Level	Classification
1	Infeasible to remedy issue/outside of project scope.
2	Stable, but problem could escalate with future change in surrounding land use.
3	Limited erosion and/or drainage problems are present; issues could be readily addressed.
4	Moderate erosion and/or drainage problems are present; issues may be readily addressed.
5	Significant erosion and/or drainage problems are present; issues may be readily addressed.
6	Strategic retrofit opportunity

Ultimately, the information collected during this phase of the project will be incorporated in an evaluation that considers both the Town's priorities and anticipated water quality benefits of addressing each problem area to develop a refined list of high priority projects.

Problem Area Data Sheet

Problem Area ID: NB-01	Latitude: 44.493161	Longitude: -72.373644

Watershed:	Nichols Brook
Location:	Carey Road at Dix Road
Problem Type:	Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick
Classification:	4

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is moderate erosion along the north edge of Dix Road. A significant berm exists along the edge of road and a moderate gully created by stormwater breaking through the berm is actively eroding. It appears that the roadway is graded steeply towards to the north – the problem may be alleviated by regrading along the north edge to promote sheet flow. A culvert crossing from Dix Road under Carey Road has an elevated outlet that is creating scour and gully erosion on the embankment. Stabilizing the outfall (e.g., installing a stone splash pad) would substantially slow erosion processes. It should be noted that the water draining over the north edge does not appear to conveyed to any further point – it looks as if the water infiltrates at the toe of slope.

Field Photos

Photo 1. Shoulder berm/erosion and gully formation

Photo 2. Elevated and eroding culvert outlet

Problem Area Data Sheet

Problem Area ID: CB-01	Latitude: 44.507909	Longitude: --72.371803°

Watershed:	Cooper Brook
Location:	Fire Station (Wolcott Street)
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is an opportunity to capture and reuse roof runoff from the fire station in a cistern to slow the rate of discharge to Copper Brook.

Field Photos

Photo 1. Catch basin appears to capture all site drainage

Photo 2. Example of a cistern used to collect roof runoff

Problem Area Data Sheet

Problem Area ID: CB-02	Latitude: 44.492981	Longitude: -72.367500

Watershed:	Cooper Brook
Location:	North of 582 Mackville Road
Problem Type:	Erosion
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project
Ownership:	Town of Hardwick
Classification:	2

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

The embankment leading to the stream below is over steepened and comprised of very small stone, and shows signs of minor rill erosion. Larger stone should be installed, especially at the toe of the slope, to stabilize the embankment and road shoulder.

Field Photos

Photo 1. West edge of Mackville Road

Photo 2. East edge of Mackville Road

Problem Area Data Sheet

Problem Area ID: CB-03, CB-04	Latitude: 44.499297	Longitude: -72.370600

Watershed:	Cooper Brook
Location:	Spruce Drive at Mackville Road
Problem Type:	Erosion
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project and SWMP Field Assessments
Ownership:	Town of Hardwick / Lamoille Housing Partnership
Classification:	4, 3

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

CB-03: It appears that new lots are being constructed on Spruce Drive and the ditch draining the area has been reshaped, but is currently destabilized. Erosion matting as well as other necessary erosion prevention measures should be installed as soon as possible and left in place until adequately stabilized.

CB-04: The fire hydrant access is slumping and eroding into the ditch line plugging up the stone and contributing to sediment transport. The slope could be stabilized by installing stone and leveling the access.

Field Photos

Photo 1. Destabilized open ditch lacking erosion control

Photo 2. Slumping fire hydrant access and concrete headwall

Problem Area Data Sheet

Problem Area ID: CB-05	Latitude: 44.497594	Longitude: -72.371869

Watershed:	Cooper Brook
Location:	Buffalo Storage
Problem Type:	Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick / State
Classification:	4

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

A large area (approximately 73 acres) is directed to this swale via stormwater infrastructure from the north and northeast, as well as a seasonal stream originating from the east. The existing channel should be cleaned, the sideslopes laid back to a 1:3 if space is available. The channel could also incorporate check dams to facilitate slowing of flow and promote sediment deposition, or it could be converted to a bioswale promoting infiltration, depending on soil type and groundwater conditions.

Field Photos

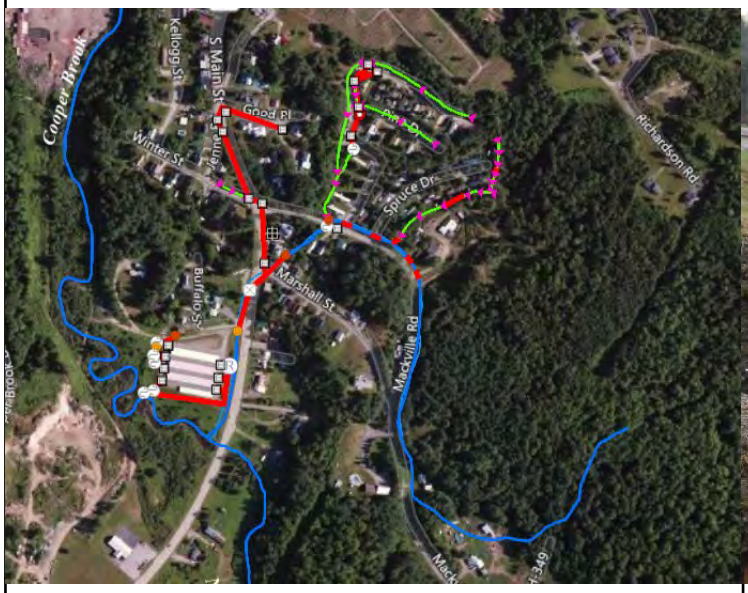


Photo 1. Conveyance feeding the eroded drainage channel

Photo 2. Erosion within drainage channel

Problem Area Data Sheet

Problem Area ID: CB-06	Latitude: 44.509483	Longitude: -72.372950

Watershed:	Cooper Brook
Location:	Poulin Lumber (Wolcott Street)
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick / Private
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

The site appears to drain to a single catch basin near the northernmost corner of the lot. The existing green space between Union Street and the Poulin Lumber fence could be utilized for stormwater capture and treatment. Further investigation regarding elevations in the area is needed to assess the viability of conveying runoff to this location.

Field Photos

Photo 1. Catch basin appears to capture all site drainage

Photo 2. Green space available for capture and treatment between fence and Union Street

Problem Area Data Sheet

Problem Area ID: CB-07	Latitude: 44.505045	Longitude: -72.373941

Watershed:	Cooper Brook
Location:	Granite Street, west of Brook St. intersection
Problem Type:	Unmanaged Impervious
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project
Ownership:	Town of Hardwick / Private
Classification:	6

Date of Field Data Collection: January 25, 2017

Description of Observed Conditions:

The closed drainage system that drains Spring, Summer, and Dewey Streets outfalls into Cooper Brook just north-west of the Spring Street-Granite Street intersection. The existing green space east of that intersection could be utilized for stormwater volume capture and water quality treatment. Any stormwater treatment retrofit practices here, however, would be located in the brook's 100-year floodplain.

Field Photos

Photo 1. Potential treatment area, looking southeast from Granite Street. (Photo from Google Street View, Aug. 2014)

Photo 2. Potential treatment area, looking north from Spring Street. Last manhole in the closed drainage system can be seen in the foreground. (Photo from Google Street View, Aug. 2014)

Problem Area Data Sheet

Problem Area ID: LR-01	Latitude: 44.506477	Longitude: -72.370098

Watershed:	Lamoille River
Location:	Corner of Wolcott Street and West Church Street
Problem Type:	Infrastructure/Maintenance
Identification Source:	Town of Hardwick
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

The Town has indicated that the current "trash can" style outlet cover does not adequately protect against backwater. This culvert, and ultimately the pipe system connected to it backs up during seasonal high water. This outlet structure could be replaced with a "duck bill" outlet structure, or similar device, as shown in Photo 2 below.

Field Photos

Photo 1. Existing culvert outlet with trash can style outlet structure

Photo 2. Example of a duck bill outlet structure

Problem Area Data Sheet

Problem Area ID: LR-02	Latitude: 44.505069	Longitude: -72.370919

Watershed:	Lamoille River
Location:	Elm Street
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is green space available between Elm Street and the sidewalk along the north edge of the road that could be utilized to capture and treat roadway runoff. There may also be available green space along the south edge between Elm Street and private fences that could be utilized for capture and treatment as well.

Field Photos

Photo 1. Green space available for stormwater capture and treatment

Photo 2. Green space available for stormwater capture and treatment

Problem Area Data Sheet

Problem Area ID: LR-03	Latitude: 44.505053	Longitude: -72.372303

Watershed:	Lamoille River (DEC Subwatershed 12)
Location:	Community Recreation Park (Corner of Cottage Street and Cherry Street)
Problem Type:	Infrastructure/Maintenance
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

A previously established bioretention area is in need of maintenance. The area should be cleaned of weeds, woody growth, and invasives, and reestablished to operate as designed. A simple Operations & Maintenance plan could be developed to ensure sustainable maintenance in the future.

Field Photos

Photo 1. Community Recreation Park

Photo 2. Bioretention area at Community Recreation Park in need of maintenance

Problem Area Data Sheet

Problem Area ID: LR-04	Latitude: 44.513236	Longitude: -72.372586

Watershed:	Lamoille River
Location:	Tops/Rite Aid
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Much, if not all, of the stormwater from the site appears to drain to the center of the parking lot and flow south where it enters a stone channel. The stone has become plugged and the banks are eroded. The parking lot also looks to have settled in locations causing ponding. The existing drainage pattern could be reestablished, and a portion of the parking lot to the south, that appears to be mostly unused, could be converted to a stormwater practice to capture and treat runoff from approximately 3 acres of impervious surface.

Field Photos

Photo 1. Ponding water due to settling and/or plugged or damaged drainage infrastructure

Photo 2. Parking lot drainage pattern with ponding water and potential stormwater practice location

Problem Area Data Sheet

Problem Area ID: LR-05	Latitude: 44.510628	Longitude: -72.373289

Watershed:	Lamoille River
Location:	Lower Prospect Street at Wolcott Street
Problem Type:	Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	3

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Lower Prospect Street is eroding into intersection of Hillside Street, Lower Prospect Street, and Wolcott Street. It appears that the cause of the erosion is primarily runoff from the barn roof to the southwest.

Field Photos

Photo 1. Driveway erosion at the home on the south corner of Hillside Street and Wolcott Street

Photo 2. Sediment transport, deposition, and erosion at the intersection of Hillside Street and Wolcott Street

Problem Area Data Sheet

Problem Area ID: LR-06	Latitude: 44.509158	Longitude: -72.363758

Watershed:	Lamoille River
Location:	Hazen Union School (Hardwick Trails)
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessment
Ownership:	Orleans Southwest Supervisory Union
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Runoff from the parking lot and uphill area to the east gravel area near Hardwick Trails. The runoff could be routed to the existing green space where it could be captured and treated. Ideally the existing green space could be used to infiltrate, pending soil investigations.

Field Photos

Photo 1. Existing drainage and green space with retrofit potential

Photo 2. Uphill area that drains towards Hardwick Trails

Problem Area Data Sheet

Problem Area ID: LR-07	Latitude: 44.507350	Longitude: -72.363567

Watershed:	Lamoille River (VT DEC Subwatershed 47)
Location:	Hazen Union School (Rec. Fields)
Problem Type:	Unmanaged Impervious
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project
Ownership:	Orleans Southwest Supervisory Union
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Runoff from virtually all of the paved surfaces on campus flows to the south via pavement, swales, and culverts before ultimately discharging over the bank in the area highlighted in red above. The runoff is then conveyed by a paved swale to a detention basin southwest of the school entrance. The detention basin and its outlet structure could be rehabilitated and extended to use the area shown below.

Field Photos

Photo 1. Potential retrofit location south east of school

Photo 2. Existing detention basin outlet structure

Problem Area Data Sheet

Problem Area ID: LR-08	Latitude: 44.516106	Longitude: -72.379189

Watershed:	Lamoille River
Location:	Wright Farm Road
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Road runoff as well as runoff from the CATT/VASA trail deposits large amounts of sediment in a small tributary immediately above its confluence with the Lamoille River. A stormwater retrofit could be installed within the green space to the south of the parking area. Ideally the treatment practice would incorporate a sediment basin that could be easily cleaned and maintained. *Wright Farm Road is a Class IV road maintained by Greensboro Garage.*

Field Photos

Photo 1. Sediment transport from VT Route 15 onto Wright Farm Road

Photo 2. Green space available for stormwater retrofit

Problem Area Data Sheet

Problem Area ID: LR-09	Latitude: 44.504292	Longitude: -72.365131

Watershed:	Lamoille River
Location:	Hardwick Village Market / GRACE / Brochu Auto Service
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is available green space between the parking lots of Hardwick Village Market, GRACE, and Brochu Auto Service that could be utilized for roadway, parking lot, and rooftop runoff capture and treatment. Narrow linear bioretention swales could be developed in these areas.

Field Photos

Photo 1. Available green space between Hardwick Village Market and GRACE

Photo 2. Available green space between GRACE and Brochu Auto Service

Problem Area Data Sheet

Problem Area ID: LR-10	Latitude: 44.504292	Longitude: -72.365131

Watershed:	Lamoille River
Location:	Park between Positive Pie and Yummy Wok
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

A brick park between Positive Pie and Yummy Wok offers available space to implement a stormwater retrofit. The treatment practice could incorporate roof water collection systems as well as the addition of recessed planters to help absorb stormwater. There are already plantings present in the park at this time.

Field Photos

Photo 1. East edge of the park

Photo 2. West edge of the park

Problem Area Data Sheet

Problem Area ID: LR-11	Latitude: 44.503122	Longitude: -72.368592

Watershed:	Lamoille River
Location:	Green Space between Hardwick Elementary School and St. Norbert's Church
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Orleans Southwest Supervisory Union / Private
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is a vegetated green strip between Hardwick Elementary School and St. Norbert's Catholic Church available to implement a linear stormwater retrofit to capture and treat stormwater from parking area and rooftops. Further investigation into current site drainage would be required to assess how much of an impact such a retrofit would have.

Field Photos

Photo 1. Green space available for linear stormwater retrofit

Photo 2. Green space available for linear stormwater retrofit

Problem Area Data Sheet

Problem Area ID: LR-12	Latitude: 44.504569	Longitude: -72.368472

Watershed:	Lamoille River
Location:	Intersection of Vermont Rt. 14 and Vermont Rt. 15
Problem Type:	Unmanaged Impervious
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick
Classification:	6

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

There is a large area of impervious surface north of Wolcott Street between the roadway and the river that is currently intended as parking. This area receives considerable stormwater from Wolcott Street and collects substantial sediment. A sedimentation basin could be installed in this area to help reduce sediment loading to the river. Depending on required size, this retrofit could require the elimination of one or more parking spaces. *A swirl separator is anticipated to be installed here in conjunction with a sidewalk project on South Main Street in 2017.*

Field Photos

Photo 1. Existing conditions in the location of a potential sedimentation basin

Photo 2. Existing conditions in the location of a potential sedimentation basin

Problem Area Data Sheet

Problem Area ID: LR-13	Latitude: 44.504937	Longitude: -72.365410

Watershed:	Lamoille River
Location:	Green space between Hardwick Veterinary Clinic and Lamoille River
Problem Type:	Unmanaged Impervious
Identification Source:	Town of Hardwick Stormwater Infrastructure Mapping Project
Ownership:	Private
Classification:	6

Date of Field Data Collection: January 24, 2017

Description of Observed Conditions:

There is a vegetated green strip between the veterinary clinic's southern gravel parking lot and the north bank of the Lamoille River. The strip is narrow and adjacent to a retaining wall at the river's north bank, so there is not sufficient space for a bioswale between the parking lot and the river, but the mowed lawn area could be enhanced with perennials or shrubs to slow down and/or evapotranspire runoff form the gravel lot and nearby up-slope structures.

Field Photos

Photo 1. Green space available for additional vegetative buffer plantings (photo from Google Street View, Aug. 2014)

Problem Area Data Sheet

Problem Area ID: LR-14	Latitude: 44.521125	Longitude: -72.307869

Watershed:	Lamoille River
Location:	Main Street Bridge, East Hardwick
Problem Type:	Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Town of Hardwick / Fire District
Classification:	4

Date of Field Data Collection: October 25, 2016

Description of Observed Conditions:

Overland stormwater runoff from Main Street is causing significant erosion at the southeast corner of the bridge. Marginal erosion created by overland runoff from Brickhouse Road is also present at the northwest corner of the bridge. Both areas would benefit from the installation of step-pools and/or large stone to slow water and reduce erosion. A retaining wall on private property on the southeast corner may need to be relocated to achieve proper conveyance.

Field Photos

Photo 1. Marginal erosion on the northwest corner of the bridge

Photo 2. Substantial erosion on the southeast corner of the bridge

Appendix C. Restoration Plans

Project: CB-03, CB-04	Hardwick VT SWMP, Site Restoration Plan

Location:	Mackville Road
Latitude: **Longitude:**	**44.499297 N** **-72.369078 W**
Land Ownership:	Private (Lamoille Valley Housing Trust)
Drainage Area (acres)	CB-03: 28.8 CB-04: 11.1
Impervious (acres)	CB-03: 0.83 CB-04: 0.93

Site Description:

- CB-03: The swale draining an area adjacent to Spruce Drive was reshaped during construction of new lots in the mobile home park. Construction phase erosion was stabilized, but opportunities remain for stabilization of the park's open drainage channels, as well as for BMP retrofits to improve water quality treatment.
- CB-04: The fire hydrant access is slumping and eroding into the ditch line, plugging the stone and contributing to sediment transport. The slope should be stabilized by installing stone and leveling the access.

Proposed Scope of Work

Install BMPs	• Establish erosion prevention measures within the channel (stone lining, stone check dams, or both depending upon channel slope). • Investigate construction of a sedimentation basin within the flow path to further reduce sediment transport, or bioswale retrofits in the existing channels.
Stabilize Overflow / Flow Path	• Strategically place stone in areas more prone to erosion (where existing channels turn sharply or drop in elevation). • Vegetate the swale as well as possible. • Consider installing check dams to slow flow velocity and promote sediment deposition. • At the fire hydrant access, place concrete waste blocks or large stones at the toe of slope and level the access to discourage slumping. • If snow is plowed to this location, take care to not add too much weight at the top of slope as doing so can increase the risk of saturating the soil at the access and creating a failure plane causing the slope to slip or slump into the roadside ditch.

Additional Design/Permitting Requirements:

- Conduct soil characterization to determine whether stormwater can be infiltrated. For bioswale design, this will determine whether or not the swale should be underdrained.
- Site survey and hydrologic modeling is required to correctly design a BMP. Additional engineering support is estimated to include one and a half weeks for survey and design, two days of technical field oversight during construction to assist with BMP stakeout, grading, and outlet structure configuration, and one half-day for final construction inspection (~15-20% of total project cost).

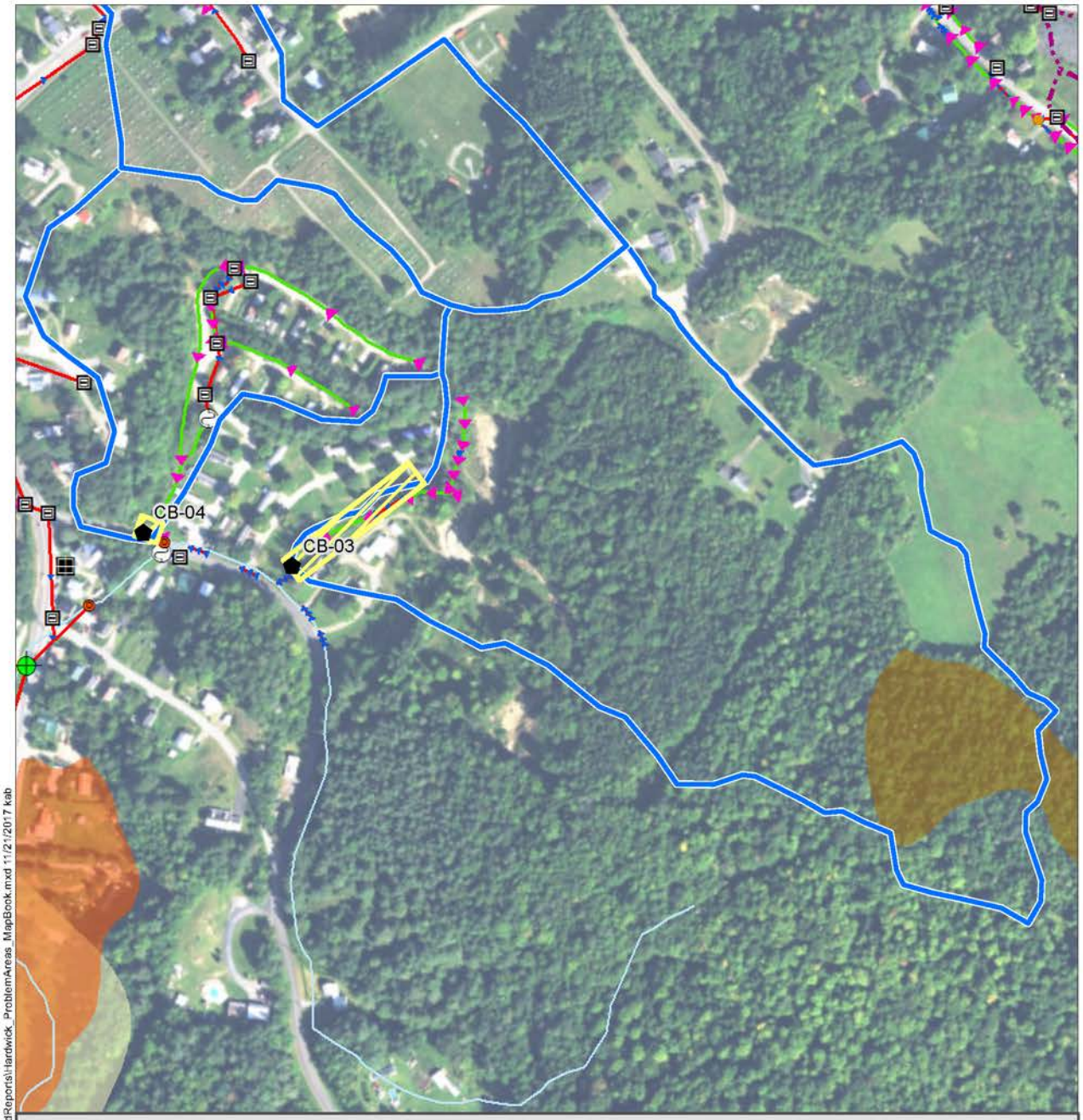
Next Steps:

- Confirm project support from property owners, the Town of Hardwick, other project stakeholders.
- Apply for funding to support final design.

Project Benefits:

- This project would mitigate source of sediment in relative proximity to Cooper Brook. Installation of erosion prevention measures or bioswales will reduce sediment transport, while reducing the volume and velocity of flow within the downstream open and closed stormwater drainage network during storm events.
- Stabilizing the hydrant access allows continued use of the fire hydrant, and improves stability of the roadway.

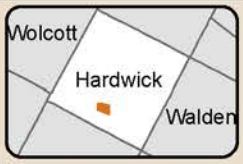
Estimated Total Project Cost: < $20,000 for stabilization only;
$20,000 - $50,000 for stabilization and bioswales or other water quality treatment



Proposed BMP Location (Point)
Propoed BMP Location
BMP Drainage Area
River or Stream
AE (1% ann flood chance w/ elev)
River Corridor
Hydric Soil

Existing, Catchbasin
Existing, Culvert inlet
Existing, Culvert outlet
Existing, Drop Inlet
Existing, Grate/Curb Inlet
Existing, Outfall

Existing, Storm line
Existing, Swale
Existing, Under drain



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Sources: Problem Areas and Drainage Areas: Stone, Streams and Water Bodies: VCGI, Wetlands (VSWI): VT ANR, River Corridors: VT ANR, Hydric Soils (SSURGO): VCGI, FEMA Floodplain: VCGI, Stormwater Infrastructure: VT ANR, Imagery: Esri

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Mackville Road
CB-03, CB-04

Hardwick
Stormwater Master
Planning

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Project: LR-03	Hardwick VT SWMP, Site Restoration Plan
Location:	Community Recreation Park (Corner of Cottage Street and Cherry Street)
Latitude: **Longitude:**	**44.505053 N** **-72.372303 W**
Land Ownership:	Town of Hardwick
Drainage Area (acres)	24.5
Impervious (acres)	7.8

Site Description:

- A previously established bioretention area is in need of maintenance. The forebay should be cleaned of sediment. Small trees, invasive species, and dead vegetation should be removed. Creation of a simple Operations & Maintenance plan will ensure sustainable maintenance in the future.

Proposed Scope of Work

Improve Site Drainage	• The site appears to drain adequately.
Restore BMP	• The forebay should be cleaned of sediment. • Small trees, invasive species, and dead vegetation should be removed. • Creation of a simple Operations & Maintenance plan will ensure sustainable maintenance in the future.
Future Maintenance	• Follow an Operations and Maintenance plan that includes should include bi-annual cleaning of the bioretention area. • Bi-annual cleaning should include removing sediment, and mowing or trimming vegetation as necessary.
Improve Winter Maintenance	• The Town may use the bioretention area for snow storage in winter months. Doing so will allow snow melt to infiltrate and capture sediment. • If the bioretention area is used for winter snow storage, sediment must be removed every spring after all the snow has melted. This will ensure adequate permeability is maintained within the bioretention area.

Additional Design/Permitting Requirements:

- Additional engineering support includes one day to create an Operations and Maintenance Plan, and one half-day to perform inspection and offer suggestions after initial maintenance has taken place.

Next Steps:

- Confirm project support from the Town of Hardwick.
- Conduct project.

Project Benefits:

- The existing bioretention area significantly reduces sediment and pollutant transport, while attenuating the volume and velocity of flow within the closed stormwater drainage network during storm events. Providing regular maintenance and a simple O&M plan will sustain the long-term functionality of the practice.

Estimated Total Project Cost: < $10,000

Project: LR-04	Hardwick VT SWMP, Site Restoration Plan

Location:	Tops/Rite-Aid Parking lot
Latitude: **Longitude:**	**44.512336 N** **-72.372586 W**
Land Ownership:	Private (Tops/Rite-Aid)
Drainage Area (acres)	1.64
Impervious (acres)	1.64

Site Description:

Much of, if not all of, of the stormwater from the site appears to drain to the center of the parking lot and flow south where it transports sediment, creates ponding, and enters a stone lined swale. The stone has become plugged and the banks are eroded. The parking lot has also settled, causing ponding. The likely original drainage pattern could be re-established, and a portion of the parking lot to the south, which appears unused, could be converted to a stormwater BMP to capture and treat runoff from up to 2.8 acres of impervious surface.

Proposed Scope of Work

Improve Site Drainage	• Regrade raised lawn area at curb inlet on the north side of the access drive to allow disconnection of ponded runoff towards existing grass swale. • Consider re-grading the parking lot to better direct stormwater to existing flow path and reduce ponding. If regraded, it would be possible to collect and treat drainage from the northern edge and eastern edge of the parking lot (behind Tops/Rite Aid) at a single location. If this was accomplished, the total drainage area captured and treated would increase to 2.75 acres.
Install BMPs	• Install sedimentation basin along edge of parking lot within the existing flow path. • Improve stone lined swale conveyance and install check dams to promote additional sediment capture and velocity reduction. • Consider installing a second stone lined swale with check dams or lined linear bioretention at the site discharge point at the southeast corner of the parking lot.
Stabilize Overflow / Flow Path	• Stabilize the overflow from the sedimentation basin with a stone lined swale and check dams extending to the adjacent wetland or stable location.
Improve Winter Maintenance	• Work with Tops/Rite Aid to create a snow plowing and snow stockpiling plan that will protect the drainage and BMP features while reducing sediment loading to the wetland and river.

Additional Design/Permitting Requirements:

- Site survey and hydrologic modeling required to design the BMPs. Additional engineering support includes approximately three weeks for survey and design, one day of technical field oversight during construction to assist with BMP sizing, location, layout, grading, and outlet structure configuration, and one half-day for final construction inspection (~15-20% of total project cost)
- Infiltrating BMPs are not allowed within the Zone I wellhead protection area for the Town's water system supply wells, and are discouraged in the wells' groundwater recharge area (which covers the entire site).

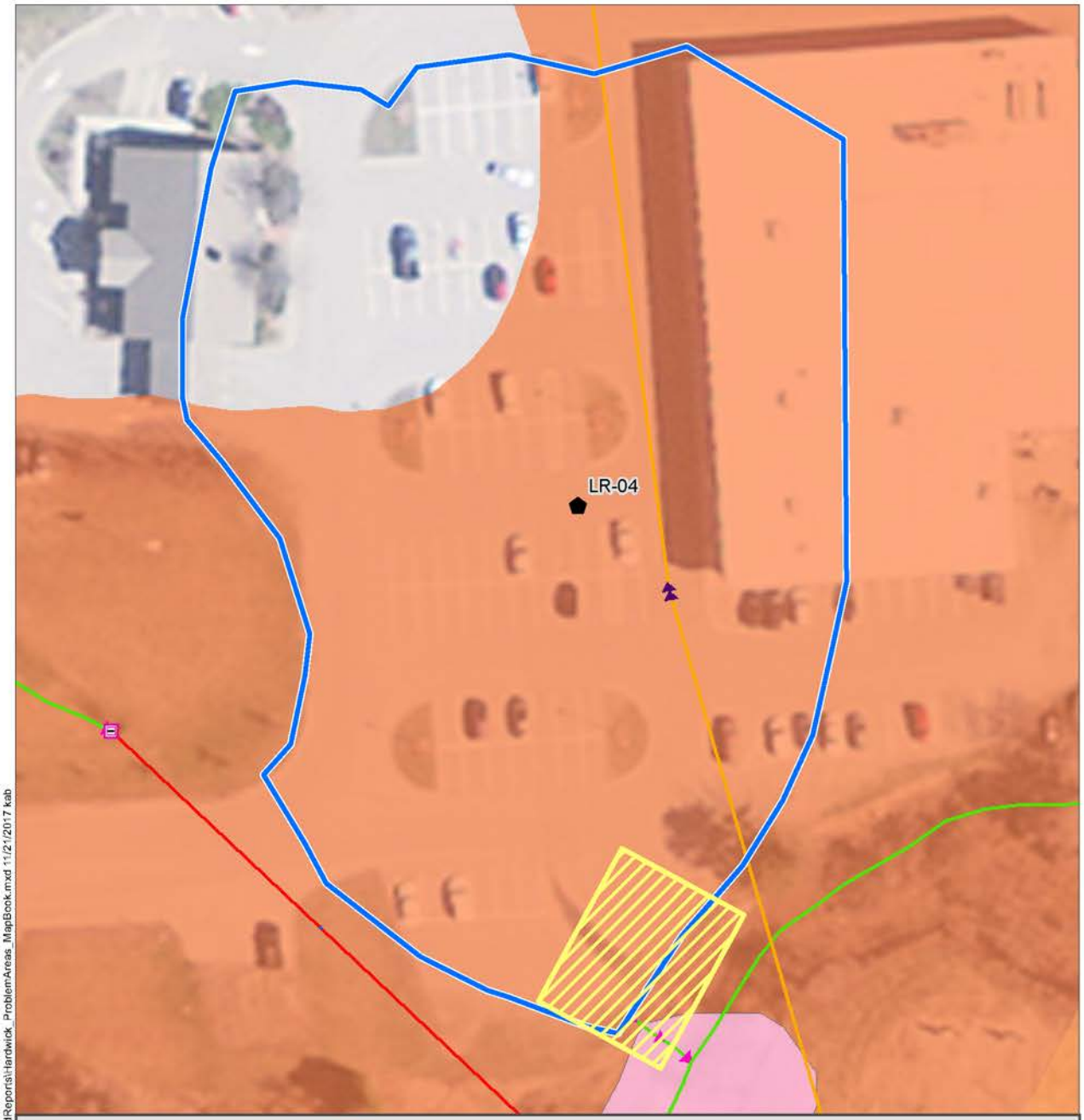
Next Steps:

- Confirm project support from Tops/Rite Aid, other project stakeholders.
- Apply for funding to support final design and construction.

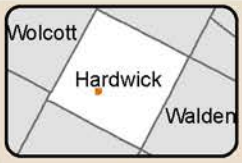
Project Benefits:

- Mitigates a source of pollutants to the adjacent wetland and river. Installation of a sedimentation basin and/or water quality BMP treating runoff from the parking lot up-slope from the stone lined swale will significantly reduce sediment transport from the parking lot.

Estimated Total Project Cost: $50,000 - $100,000



Proposed BMP Location (Point)
Propoed BMP Location
BMP Drainage Area
AE (1% ann flood chance w/ elev)
River Corridor
Existing, Outfall
Proposed, Catchbasin
Potential Stormwater Area
Existing, Storm line
Existing, Storm line (old Sanitary line)
Existing, Swale



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Sources: Problem Areas and Drainage Areas: Stone, Streams and Water Bodies: VCGI, Wetlands (VSWI): VT ANR, River Corridors: VT ANR, Hydric Soils (SSURGO): VCGI, FEMA Floodplain: VCGI, Stormwater Infrastructure: VT ANR, Imagery: Esri

STONE ENVIRONMENTAL INC

Tops / Rite-Aid Parking lot
LR-04

Hardwick
Stormwater Master
Planning

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Project: LR-09	Hardwick VT SWMP, Site Restoration Plan
Location:	Hardwick Village Market / GRACE / Brochu Auto Service Parking Areas
Latitude: **Longitude:**	**44.512336 N** **-72.372586 W**
Land Ownership:	Private (Hardwick Village Market / GRACE / Brochu Auto Service)
Drainage Area (acres)	0.40
Impervious (acres)	0.34

Site Description:

There is available green space between the parking lots of Hardwick Village Market, GRACE, and Brochu Auto Service that could be utilized for stormwater treatment. Bioswales could be developed in these areas to capture and treat runoff from Mill Street, parking areas, and roofs.

Proposed Scope of Work

Improve Site Drainage	• Regrade parking areas to direct stormwater to linear bioretention swales. • Consider adding gutters to all buildings that outlet to the bioswales, whether directly or via surface flow. Currently, most site runoff drains to the north and discharges directly to the river. The addition of gutters would reduce erosion and sediment transport from individual driveways/parking lots, and reduce volume and velocity of flow to the river.
Install BMPs	• Install bioswales in existing green strips. • There is a dumpster in the alley between Hardwick Village Market and G.R.A.C.E. that is leaking. It would be possible to either replace the dumpster, or position it to encourage the leak to flow into the bioswale and receive treatment. • Install stable overflow structure from bioswales to existing closed drainage system or to Lamoille River.
Improve Winter Maintenance	• Property owners may plow snow into the bioswales. This would provide snow storage and treatment during spring thaw, but may also cause compaction within the practices. • If the swales are used for winter snow storage, the maintenance plan must specify sediment removal following snowmelt each year to ensure adequate permeability is maintained within the bioretention swales.

Additional Design/Permitting Requirements:

- Soil characterization should be conducted to determine whether stormwater can be infiltrated, or if the bioswales should be underdrained.
- Site survey and hydrologic modeling is required to design the BMP. Additional engineering needed includes two weeks for any necessary survey, modeling, and design, two days of technical field oversight during construction to assist with BMP sizing, location, layout, grading, and outlet structure configuration, and one half-day for final construction inspection.

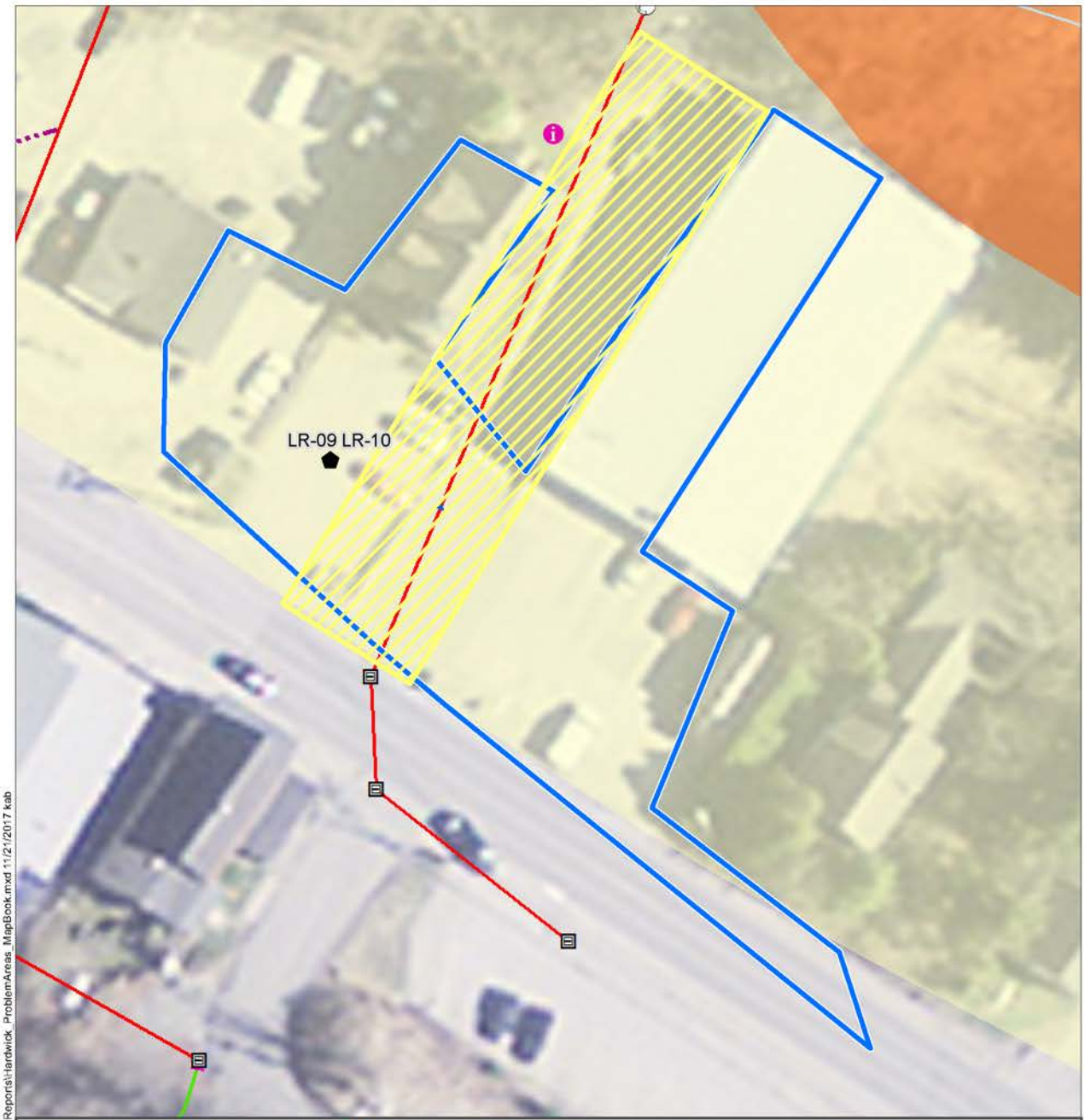
Next Steps:

- Confirm project support from all property owners, the Town of Hardwick if the design includes overflow to the Town's closed stormwater drainage network, and other project stakeholders.
- Apply for funding to support final design. Depending upon the number of committed property owners and size of the project, it may be preferred to apply for a LCBP Pollution Prevention grant (up to $25k) and complete design and construction in one phase.

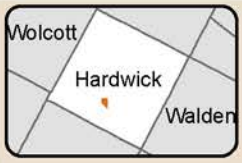
Project Benefits:

- This project would mitigate a source of sediment and phosphorus to the adjacent river. Bioswale installation would reduce sediment transport from the parking lots and roadway, while attenuating volume and velocity of flow within the closed stormwater drainage network during storm events.

Estimated Total Project Cost: $20,000 - $50,000



- Proposed BMP Location (Point)
- Propoed BMP Location
- BMP Drainage Area
- River or Stream
- AE (1% ann flood chance w/ elev)
- River Corridor
- Existing, Catchbasin
- Existing, Information Point
- Existing, Outfall
- Existing, Storm line
- Existing, Swale
- Existing, Under drain



0 15 30 60 Feet

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Sources: Problem Areas and Drainage Areas: Stone, Streams and Water Bodies: VCGI, Wetlands (VSWI): VT ANR, River Corridors: VT ANR, Hydric Soils (SSURGO): VCGI, FEMA Floodplain: VCGI, Stormwater Infrastructure: VT ANR, Imagery: Esri

STONE ENVIRONMENTAL INC

Village Mkt / GRACE / Brochu Auto

LR-09

Hardwick
Stormwater Master
Planning

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Project: LR-14	Hardwick VT SWMP, Site Restoration Plan

Location:	Main Street Bridge, East Hardwick
Latitude: **Longitude:**	**44.521125 N** **-72.307869 W**
Land Ownership:	Town of East Hardwick
Drainage Area (acres)	18.4
Impervious (acres)	3.7

Site Description:

Overland stormwater runoff from Main Street is causing significant erosion at the southeast corner of the bridge. Marginal erosion created by overland runoff from Brickhouse Road is also present at the northwest corner of the bridge. Both areas would benefit from the installation of step-pools and/or large stone to slow water and reduce erosion. A retaining wall on private property on the southeast corner may need to be relocated to achieve proper conveyance. Moderate erosion also exists at the east edge of Church Street, northeast of the bridge. Overall, erosion in this drainage area is caused by high velocity overland flow and by active outlet scour at storm drain outlets.

Proposed Scope of Work

Improve Site Drainage	• Catch basins are either not present or paved over on Main Street, and are not present on Brickhouse Road. Re-establish the closed stormwater drainage network, or create a more functional surface flow pattern. • Divert runoff in the drainage area, reducing flow volumes reaching the bridge if possible.
Install BMPs	• Limited green space exists to the southeast and northwest of the bridge that may be used to site BMPs that capture and treat runoff from Main Street and Brickhouse Road respectively. Available area is primarily on private property. • Consider underdrained bioretention or gravel wetlands areas with controlled stable outlets to the river. Infiltration in these areas is unlikely. Steep slopes, finely textured soils, right-of-way constraints, and utility conflicts limit BMP opportunities. If GSI practices are infeasible, consider installing swirl separators to reduce sediment transport.
Stabilize Overflow/ Flow Path	• Install stone splash pads at culvert outlets and stabilize flow paths to the river with appropriately sized stone, placed strategically to create step-pool conveyances and mitigate erosion on the riverbank.

Additional Design/Permitting Requirements:

- Conduct soil characterization to determine whether underdrains are required for any proposed green stormwater infrastructure practices.
- Site survey and hydrologic modeling is required for BMP and stable flow path design. Additional engineering support is estimated to include four to six weeks for survey and design, two days of technical field oversight during construction to assist with BMP stakeout, grading, and outlet structure configuration, and one half-day for final construction inspection (~15-20% of total project cost).
- Consult with DEC Rivers Program and ACOE as appropriate to determine permits required; portions of the area are within the mapped River Corridor, floodway, and/or Zone AE (the 100-year floodplain).

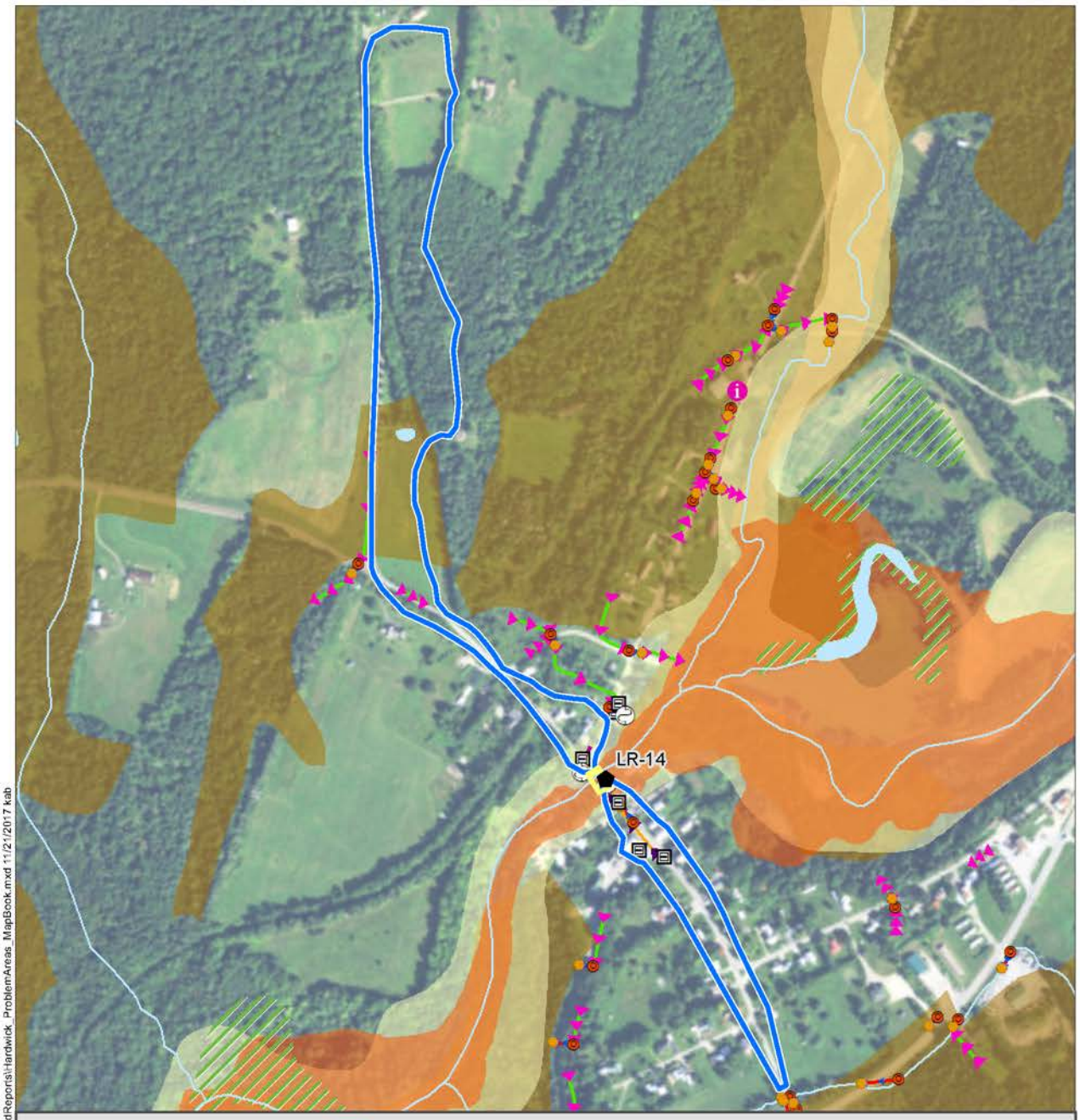
Next Steps:

- Confirm project support from the Town of Hardwick, all property owners, other project stakeholders.
- Apply for funding to support final design.

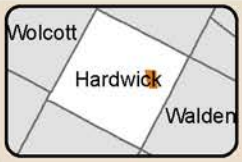
Project Benefits:

- This project would mitigate erosion and reduce infrastructure damage, as well as reduce pollutant loading to the river. Installation of drainage improvements and water quality treatment practices will reduce pollutant loading from Main Street and Brickhouse Road, while reducing runoff velocity.
- This project would lengthen the effective lifespan of the bridge by ensuring damaging stormwater flows do not continue to erode the bank and abutments.

Estimated Total Project Cost: $100,000+



Proposed BMP Location (Point)
Propoed BMP Location
BMP Drainage Area
River or Stream
Waterbody
Wetland
A (1% ann flood chance w/o elev)
AE (1% ann flood chance w/ elev)
River Corridor
Hydric Soil
Existing, Catchbasin
Existing, Culvert inlet
Existing, Culvert outlet
Existing, Information Point
Existing, Outfall
Existing, Storm line
Existing, Storm line (old Sanitary line)
Existing, Swale
Existing, Under drain



0 230 460 920 Feet

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Sources: Problem Areas and Drainage Areas: Stone, Streams and Water Bodies: VCGI, Wetlands (VSWI): VT ANR, River Corridors: VT ANR, Hydric Soils (SSURGO): VCGI, FEMA Floodplain: VCGI, Stormwater Infrastructure: VT ANR, Imagery: Esri

STONE ENVIRONMENTAL INC

Main Street Bridge, East Hardwick
LR-14

Hardwick
Stormwater Master
Planning

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Appendix D. Design Build Plans

Project: LR-01	Hardwick VT SWMP, Design Build Plan

Location:	West Church Street Bridge
Latitude: **Longitude:**	**44.50658 N** **-72.37008 W**
Land Ownership:	Town of Hardwick
Drainage Area (acres)	32.0
Impervious (acres)	9.43

Site Description:

The Town has indicated that the current "trash can" style outlet cover does not adequately protect against backwater. This culvert, and ultimately the pipe system connected to it, backs up during seasonal high water. This outlet structure could be replaced with a "duck bill" outlet structure, or similar device.

Proposed Scope of Work

Install BMPs	• Install a "duck bill" outlet structure or in-line backflow prevention valve installation to improve drainage through the closed stormwater drainage system by providing protection against backwater conditions within the system. • Tideflex TF-2 Curved Bill Check Valve or similar recommended for installation at the outfall (see attached cut sheet)
Stabilize Overflow / Flow Path	• The existing outfall is stable; no additional improvements are necessary.

Additional Design/Permitting Requirements:

- The check valves are individually manufactured based on line pressure, backpressure, and the outside diameter of the existing pipe, so hydrologic/hydraulic modeling is required for check valve design and sizing.
- Additional engineering support includes approximately one half-week for hydrologic modeling, and one half-day for final construction inspection (~15-20% of total project cost).

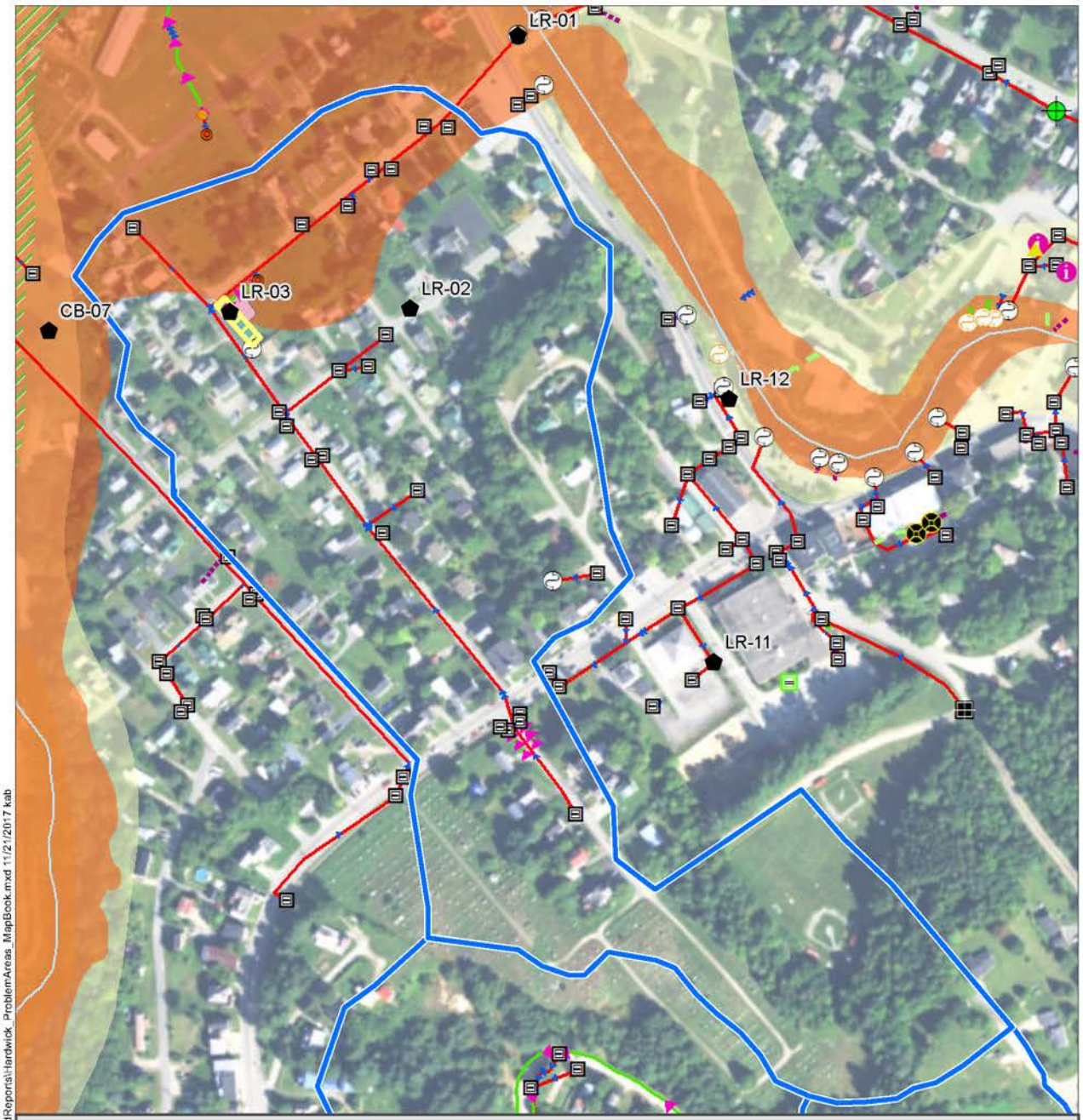
Next Steps:

- Confirm project support from the Town of Hardwick, other project stakeholders.
- Complete additional modeling with support from local distributor (New England Environmental Equipment, Bedford, MA (http://www.ne3inc.com).

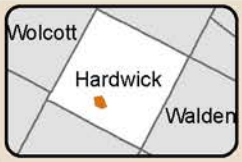
Project Benefits:

- "Duck bill" outlet structure installation will prevent backwater conditions when the river elevation is above the outlet.

Estimated Total Project Cost: < $10,000



- Proposed BMP Location (Point)
- Propoed BMP Location
- BMP Drainage Area
- River or Stream
- Wetland
- AE (1% ann flood chance w/ elev)
- River Corridor
- Hydric Soil
- Existing, Sewer PumpStation
- Abandoned, Outfall
- Existing, Area drain
- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Drop Inlet
- Existing, Dry Well
- Existing, Grate/Curb Inlet
- Existing, Information Point
- Existing, Outfall
- Existing Stormwater Area
- Potential Stormwater Area
- Abandoned, Storm line
- Existing, Footing drain
- Existing, Roof drain
- Existing, Storm line
- Existing, Swale
- Existing, Under drain



0 120 240 480 Feet

N

Sources: Problem Areas and Drainage Areas: Stone, Streams and Water Bodies: VCGI, Wetlands (VSWI): VT ANR, River Corridors: VT ANR, Hydric Soils (SSURGO): VCGI, FEMA Floodplain: VCGI, Stormwater Infrastructure: VT ANR, Imagery: Esri

STONE ENVIRONMENTAL INC

West Church Street Bridge

LR-01

Hardwick
Stormwater Master
Planning

O:\Proj-16\WRM\16-138 Hardwick SWMP\GIS\MapDocuments\Presentations\AndReports\Hardwick_ProblemAreas_MapBook.mxd 11/21/2017 kab

Series TF-2

- 100% elastomer construction
- Will not rust or corrode
- Will not warp or freeze open or shut
- Custom-built to customer specifications
- Low cracking pressure, low headloss
- Eliminates backflow

Materials of Construction

Neoprene, Hypalon®, Buna-N, EPDM, Viton®.

Mounting Bands

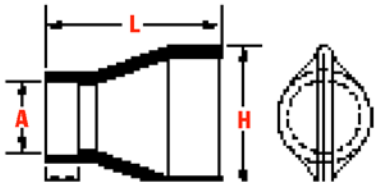
304 or 316 Stainless steel.

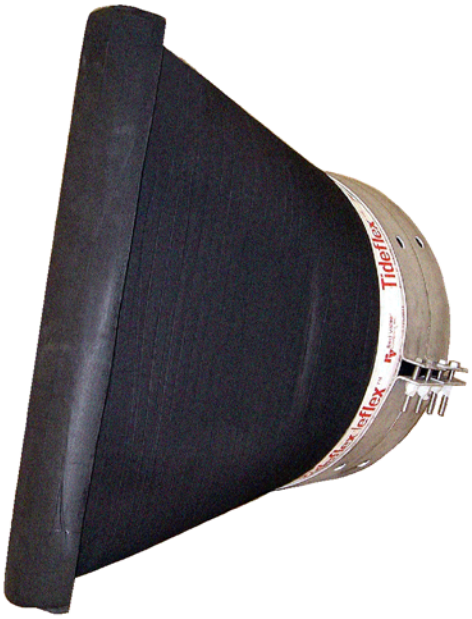
The Tideflex® Check Valve is a revolutionary design for backflow prevention. It offers low cracking pressure to eliminate standing water and very low headloss that is not affected by rust, corrosion or lack of lubrication. Tideflex® Check Valves are cost-effective because they require no maintenance or repairs and have a long operational life span. Tideflex® operate using line pressure and backpressure to open and close so no outside energy source is required.

Tideflex® valves are excellent replacements for ineffective metal flapgate valves because they will not warp or freeze and are virtually maintenance free.

The inside diameter of the TF-2's cuff is constructed to exactly match the outside diameter of the pipe.

The valve is slid onto the pipe and held in place with steel or stainless steel band clamps, eliminating flanging costs. Tideflex® TF-2 valves are constructed with a curved bill as standard.





Pipe O.D. (A)	Length (L)	Bill Height (H)	Cuff Length (C)
1/2	3	1 1/2	1/2
3/4	3	2	1
1	4	2	1
1 1/2	7	4	1
2	6	4	1
2 1/2	8	5	1
3	9	6	1 1/2
4	12	7	1 1/2
5	16	9	2
6	16	11	2
8	17	13	2
10	23	17	3
12	27	21	4
14	26	22	4
16	28	27	5
18	30	27	6
20	34	33	8 1/2
22	38	33	8
24	42	39	8
26	42	39	8
28	42	39	8
30	45	50	9
32	46	53	10
36	50	61	10
38	50	61	10
40	50	61	10
42	55	71	10
44	55	71	10
48	60	78	12
50	60	78	12
54	72	97	12
58	72	97	12
60	75	97	15
68	75	97	15
72	95	115	17
84	92	111	18
90	102	119	17
92	102	119	17
96	102	119	17

Project: LR-06	Hardwick VT SWMP, Design Build Plan

Location:	Hazen Union School / Hardwick Trails Access
Latitude: **Longitude:**	**44.50913 N** **-72.36337 W**
Land Ownership:	Town of Hardwick / Hazen Union School
Drainage Area (acres)	0.69
Impervious (acres)	0.55

Site Description:

Stormwater runoff from the paved parking lot, gravel parking area, and uphill area near the tennis courts is causing erosion and sediment transport to an unmapped wetland area and an unnamed tributary to the Lamoille River .

Proposed Scope of Work

Improve Site Drainage	• Vegetate the existing flow path adjacent to the parking area as well as possible.
Install BMPs	• Reduce the size of the gravel parking area slightly and direct flow to a hardened sediment basin with stabilized outlet to the existing flow path. • Excavate the gravel parking area and install permeable parking. This could be done by creating an underdrained gravel reservoir (12", with 4" perforated PVC set at the bottom, sloped to daylight towards the wetland/stream) and adding a 3" pea stone choker course, topped with a plastic grid system which can be filled with topsoil and seeded for the parking surface, or by installing permeable pavers. • If desired, install bollards or other measures to limit vehicle traffic within the wetland buffer.
Stabilize Overflow / Flow Path	• A controlled outlet from the sediment basin will reduce flow velocity, creating a stable flow path to the wetland that can be allowed to revegetate naturally.
Improve Winter Maintenance	• The sediment basin may be used for snow storage. When the snow melts, sediment will be trapped within the basin and allow for easy removal via skid steer and/or shovels.

Additional Design/Permitting Requirements:

- Additional engineering support includes approximately one half-week for hydrologic modeling, two days to provide design support and materials estimates, two days of technical field oversight during construction to assist with BMP sizing, location, layout, grading, and outlet structure configuration, and one half-day for final construction inspection (~15-20% of total project cost).
- Improvements cannot be constructed within 50 feet of the wet swale at the back of the parking area (assume that the mowing line is the edge of wetland). Soil restoration and amendments may be installed within the buffer, but BMP installation is discouraged. Further dialogue with Wetlands Program staff may be needed if permeable parking installation in the current parking area is desired.

Next Steps:

- Confirm project support from the Hazen Union School, the Town of Hardwick, other project stakeholders.
- Apply for funding to support design and construction.

Project Benefits:

- This project would mitigate a source of sediment and phosphorus that is currently entering the adjacent wetland and stream. Sediment basin installation would reduce sediment transport from the parking lot and uphill drainage area while providing attenuation to reduce the volume and velocity of flow as it enters the wetland. Installation of permeable parking would reduce the volume of stormwater entering the wetland via surface flows.

Estimated Total Project Cost: $20,000 - $50,000


50' Buffer
Stream
Permeable Parking
Sediment Basin
Drainage Area
Hazen Union Dr
Main St N

Appendix E. Concept Designs for Priority Stormwater Problem Areas

SITE PLAN
Scale: 1" = 50'

DESIGN NOTES

1. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE, DO NOT REPRESENT A BOUNDARY SURVEY AND SHOULD BE CONSIDERED APPROXIMATE.
2. EXISTING INVERT ELEVATIONS AND REPRESENTATION OF TOPOGRAPHY ARE FROM A TOTAL STATION SURVEY EXECUTED BY STONE ENVIRONMENTAL, INC. ON 11/17/2017 AND ARE FOR THE PURPOSES OF THIS CONCEPTUAL PLAN ONLY.
3. CHANNEL SIDE SLOPES TO EXISTING GRADE ARE CONCEPTUAL AND SHALL BE CONFIRMED AND VERIFIED DURING FUTURE DESIGN PHASES.
4. DETAILS OF EXISTING 24" X 36" CMP OUTFALL PIPE, INCLUDING ANY SUB-STRUCTURES SHALL BE VERIFIED IN FUTURE DESIGN PHASES.
5. ANNUAL PHOSPHORUS LOAD REDUCTION IN LBS. ESTIMATED FOR THIS PRACTICE OVER A 20 YEAR PLANNING HORIZON: 47.1 LBS./YR.

GENERAL NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORSEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. FLOODPLAIN BENCHES SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
10. FLOODPLAIN BENCHES SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.

LEGEND

- PARCELS
- PROPOSED CHANNEL
- PROPOSED FLOODPLAIN BENCH
- PROPOSED SLOPED BANK

CONCEPT
NOT FOR CONSTRUCTION

File: O:\Proj-16\WRM\16-138 Hardwick SWMP\CAD\Buffalo_Storage_Concept.dwg

DRAWING CREDITS

Drawn On:	11-21-17
Drawn By:	GMB
Checked On:	11-30-2017
Checked By:	BAM
Project No.:	16-138

REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

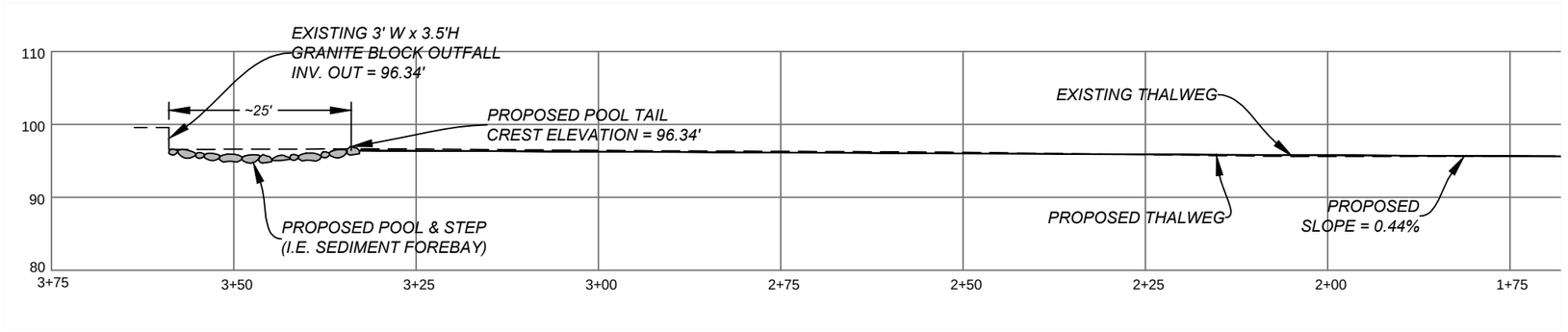
DRAWING SCALE

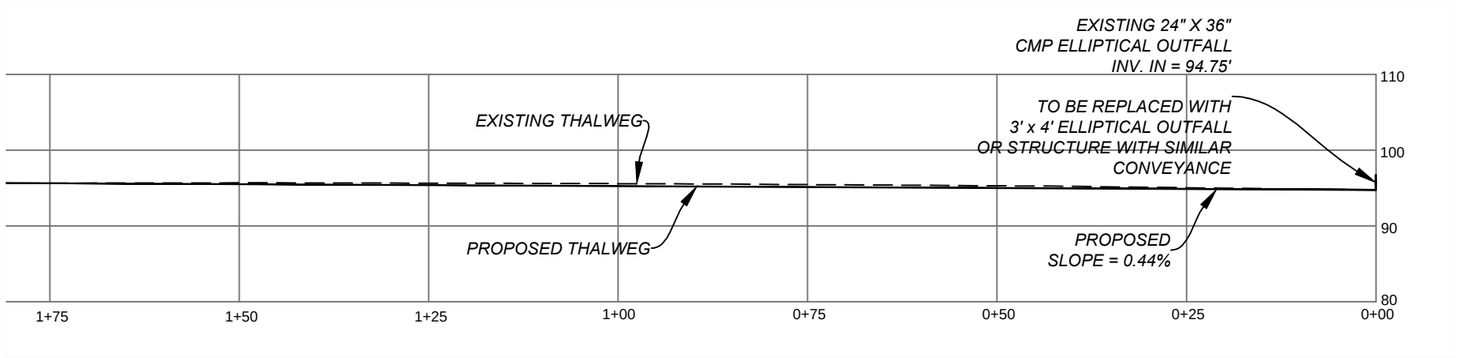
0 50 100 150
SCALE: 1" = 50'

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

Hardwick, VT Stormwater Master PLan
Concept Plan - Buffalo Storage
Site Plan
Hardwick Vermont

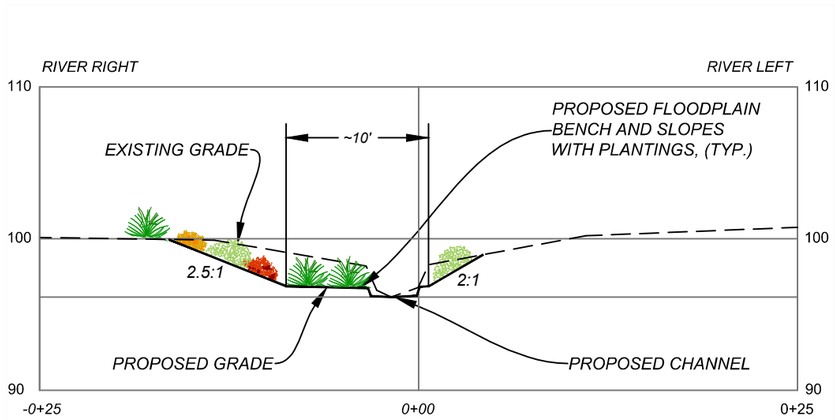
SHEET NUMBER 1





Profile

Horz. Scale: 1" = 20', Vertical Scale: 1" = 1'



CHANNEL CROSS SECTION A-A'

LOOKING UPSTREAM

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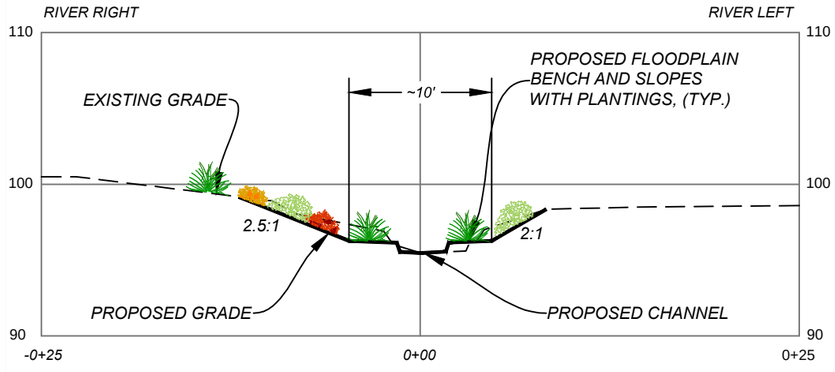

CHANNEL CROSS SECTION B-B'

LOOKING UPSTREAM

Horz. Scale: 1" = 10', Vertical Scale: 1" = 1'

CONCEPT
NOT FOR CONSTRUCTION

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Checked On:	Date
Checked By:	Initials
Project No.:	16-138

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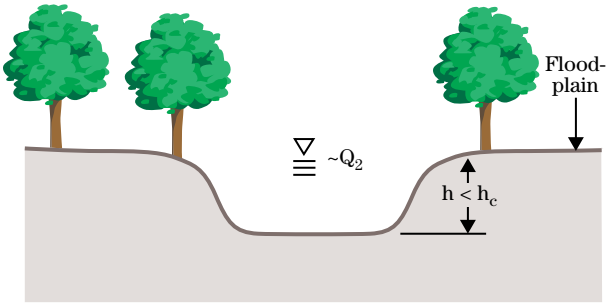
Hardwick, VT Stormwater Master Plan
Concept Plan - Buffalo Storage
Profile and Sections

Hardwick Vermont

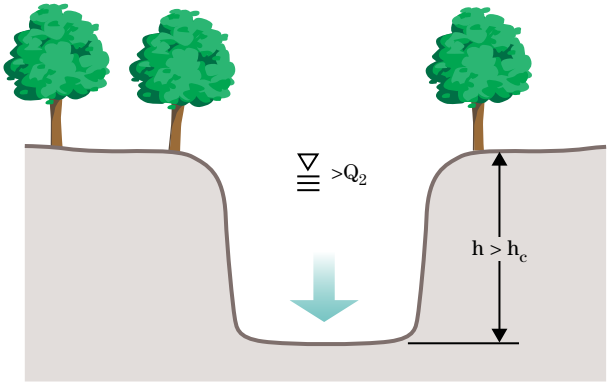
SHEET NUMBER 2

Figure 14 Schumm CEM

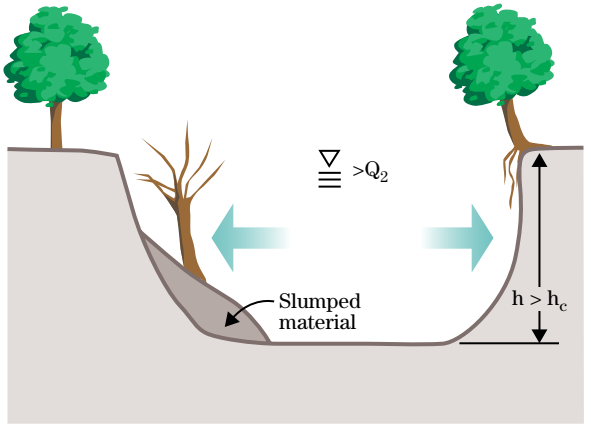
Type I–Stable



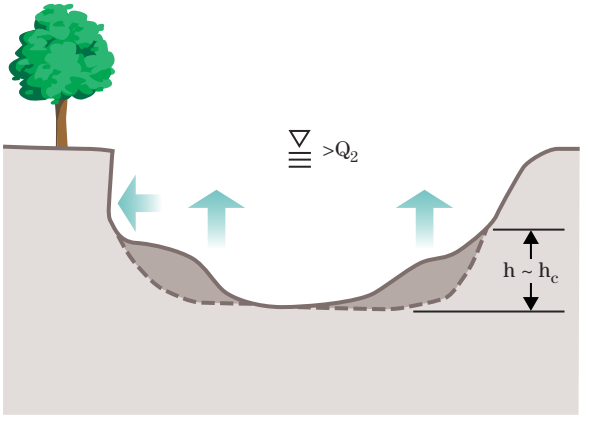
Type II–Incision



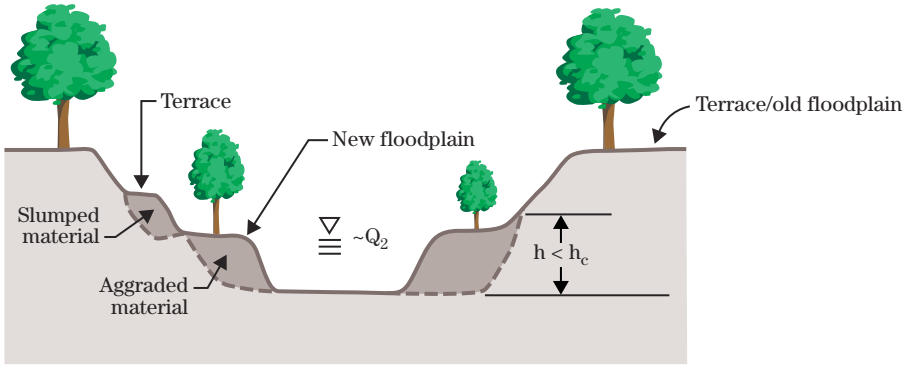
Type III–Widening

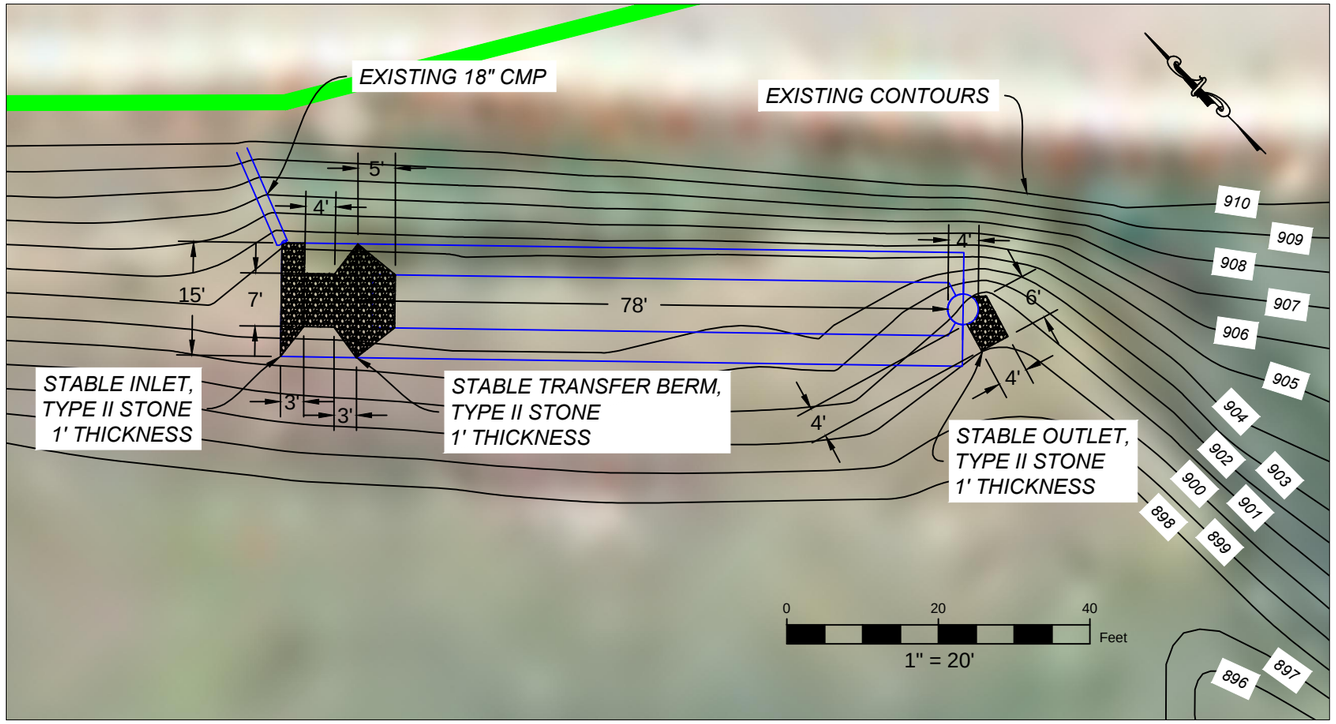


Type IV–Depostion/stabilizing



Type V–Quasi-equilibrium stable





GRAVEL WETLAND LAYOUT

PROJECT LOCATION
HAZEN UNION SCHOOL
HARDWICK, VERMONT

GENERAL NOTES:

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
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8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. GRAVEL WETLAND AREA SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS OTHERWISE NOTED.
10. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE GRAVEL WETLAND. EXCAVATING EQUIPMENT MUST HAVE BOOMS WITH ADEQUATE REACH SO THEY DO NOT HAVE TO SIT INSIDE THE FOOTPRINT OF THE GRAVEL WETLAND.
11. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
12. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.

CONCEPT
NOT FOR CONSTRUCTION

File: O:\Proj-16\WRM\16-138 Hardwick SWMP\CAD\Hazen Union\Hazen Union.dwg

DRAWING CREDITS
Drawn On: 11-29-17
Drawn By: BAM
Checked On: 11-30-17
Checked By: GMB
Project No.: 16-138

REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

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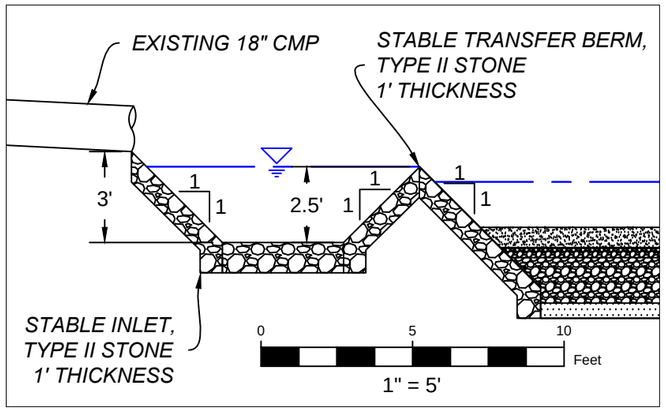
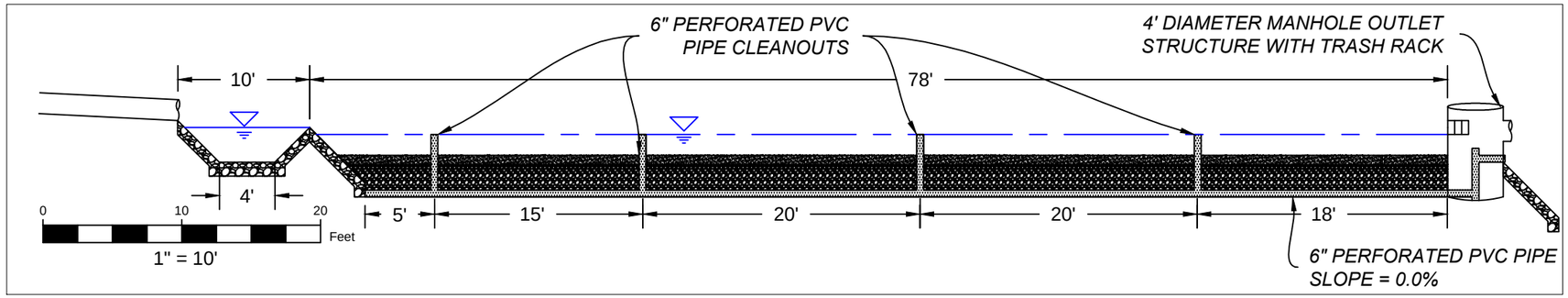
Hardwick, VT Stormwater Master Plan
Concept Plan - Hazen Union School
Layout & Notes
Hardwick Vermont

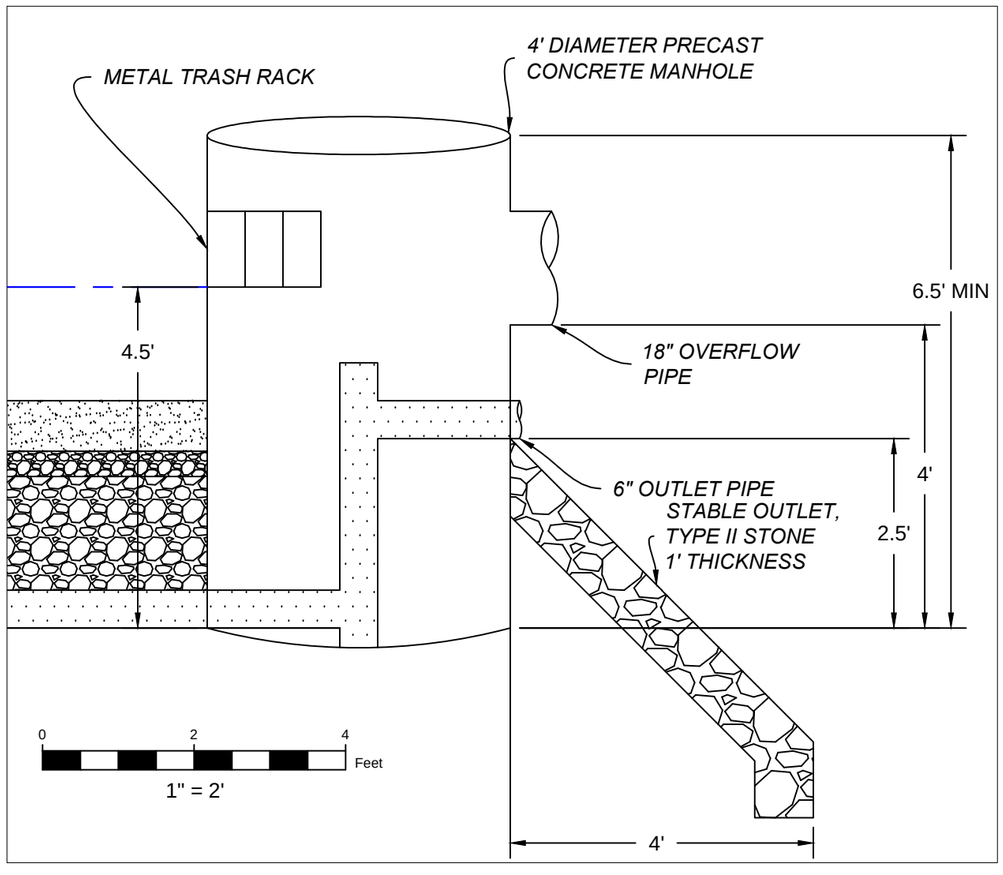
FIGURE NO. 1



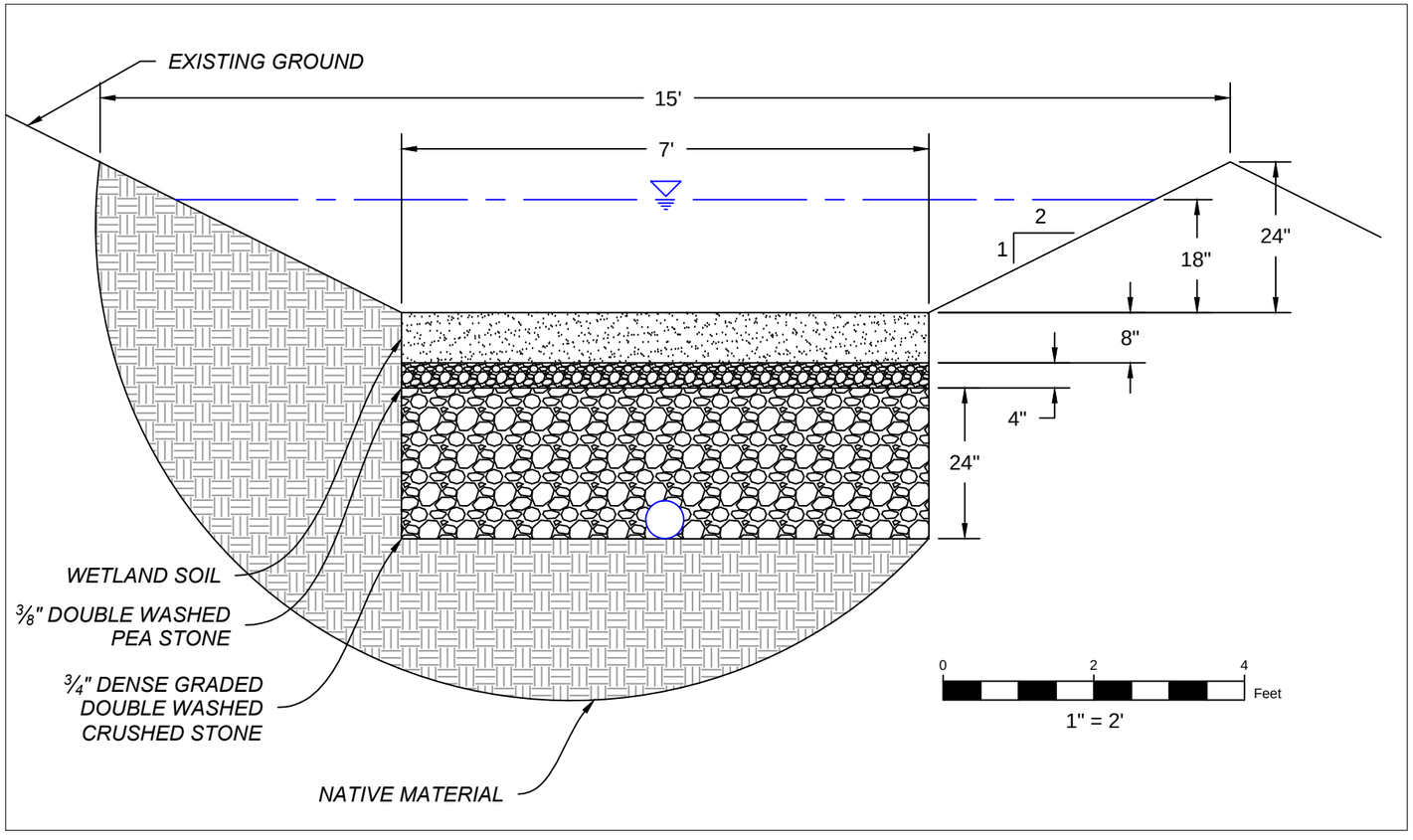
SEDIMENT FOREBAY DETAIL



GRAVEL WETLAND DETAIL
(LAYOUT)



OUTLET STRUCTURE DETAIL



GRAVEL WETLAND DETAIL
(CROSS SECTION)

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DRAWING CREDITS
Drawn On: 11-29-17
Drawn By: BAM
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535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

Hardwick, VT Stormwater Master Plan
Concept Plan - Hazen Union School
Details
Hardwick Vermont

FIGURE NO.
2

Appendix F. Batch Input File for VTDEC Tracking

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**ProjectName**	**ProjectDescription**	**ProjectType**	**ProjectTypeID**	**SGA reach**	**Latitude**	**Longitude**	**Notes**	**Towns**	**SubBasin**	**Partners**	**PotentialFundingSources**	**ParentProjecID**	**Priority Type**	**Rating**
2	Fire Station roof runoff capture and re-use (CB-01)	Capture and reuse roof runoff from the fire station with a cistern.	Stormwater Master Planning	1		44.509483	-72.371859		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
3	North of 582 Mackville Rd. Embankment Repair (CB-02)	The embankments should be stabilized using large stone at the toe of slope. If possible, the slopes should be constructed to be more gently sloping. This issue is also present at the intersection of Mackville Road and Carey Road – the same approach is applicable at that location.	Stormwater Master Planning	1		44.492981	-72.3675		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
4	Spruce Drive at Mackville Road, erosion prevention and water quality improvements (CB-03)	Install erosion prevention measures and/or water quality BMPs (bioswale) in the exisitng ditch following completion of construction activities for expansion of the mobile home park.	Stormwater Master Planning	1		44.498963	-72.369376		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
5	Mackville Road hydrant access repair (CB-04)	At the hydrant, add stone to the toe of slope to stabilize the bank, and level the area used to access the hydrant.	Stormwater Master Planning	1		44.499297	-72.3706		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
6	Buffalo Storage / Rte 14 drainage channel improvements (CB-05)	Construct a revised stream channel sized to accommodate the 1.5 year storm event, and floodplain benches to accommodate flows for larger storm events. Side slopes will be graded between 2:1 and 3:1 up to existing grade and benches and slopes will be planted with native vegetation. Additional construction includes a pool and step on the upstream end to serve as a sediment forebay and upsizing the downstream exit culvert.	Stormwater Master Planning	1		44.497594	-72.371869	Town, DEC Wetlands and Rivers programs, DEC basin planner, VTrans Ops and District Office, and landowner have been consulted and agreed to development of conceptual design	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	High
7	Poulin Lumber Retrofit opportunity (CB-06)	It appears that roughly 3 acres of impervious surface is currently unmanaged and primarily drains to a single catch basin near the corner of Union Street and Wolcott Street. If the soils prove permeable, installing an infiltration basin with sediment forebay would reduce sediment transport and runoff currently directed to the confluence of the Copper Brook and the Lamoille River. There are site constraints caused by the close proximity of the railroad right-of-way.	Stormwater Master Planning	1		44.509483	-72.37295	Likely to fall within the 3-acre/developed lands permit process and be challenging to fund through ERP	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
8	Corner of Spring and Granite Streets Retrofit opportunity (CB-07)	A drainage system conveying runoff from an 8.6-acre area (Spring, Summer, and Dewey Streets) outfalls into Cooper Brook just northwest of the intersection of Spring and Granite Streets. Existing green space east of the intersection could be utilized for stormwater volume capture and water quality treatment.	Stormwater Master Planning	1		44.505045	-72.373941	Any stormwater treatment retrofit practices would be located in the brook's 100-year floodplain – so sub-surface chambers would likely be required for volume retention.	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
9	Corner of Wolcott St. and W. Church St. Retrofit Opportunity (LR-01)	The existing "trash can" style outlet cover does not protect against backwater when the river rises, causing the closed drainage system to back up. Replace the cover with a "duck bill" outlet structure or similar device. This location could be used as a demonstration, as there are many similar situations along the river.	Stormwater Master Planning	1		44.506528	-72.375955	More infrastructure and property protection than water quality benefit, may not be easily advanced through ERP	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
10	Elm Street Retrofit opportunity (LR-02)	There is opportunity to utilize green space between sidewalks and the roadway for treatment should the Town wish to implement further treatment in the neighborhood.	Stormwater Master Planning	1		44.505069	-72.370919	Low priority, this area already drains to the bioretention system at LR-03.	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
11	Create O&M Plan for existing bioretention area (LR-03)	Complete practice maintenance, including sediment and weed removal. Consider replacement of original plantings with vegetation more easily maintained by Town staff. Create simple operations and maintenance plan and train local staff to ensure sustainable maintenance. Consider practice restoration only if maintenance and inspection uncover performance issues.	Stormwater Master Planning	1		44.505053	-72.372303		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
12	Tops/Rite Aid retrofit opportunity (LR-04)	Much of, if not all of the stormwater from the site appears to drain to the south edge of the paved area, transporting sediment and creating ponding. A section of pavement at south edge appears to be unused. If soils are suitable for infiltration, excavating existing paved surface and installing infiltration basin with sediment forebay would reduce runoff from the site and provide treatment.	Stormwater Master Planning	1		44.513236	-72.372586	Infiltration is not allowed if practice is within Zone I WHPA. Entire site is within town well field's gw recharge area. Most of site is within floodplain.	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
13	Lower Prospect Street at Wolcott Street retrofit opportunity (LR-05)	Roof runoff from the barn and surface runoff from Lower Prospect Street and Hillside Street is causing Lower Prospect Street to actively erode into the intersection of Hillside Street, Lower Prospect Street, and Wolcott Street. Roof runoff could be captured with gutters and carried to ditches, an infiltration basin, a bioretention area, a cistern, etc. Ditches could also be established on Hillside Street to assist in reducing the amount of runoff that may be contributing to the erosion issue at the intersection.	Stormwater Master Planning	1		44.510628	-72.373289		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
14	Hazen Union School (Hardwick Trails) Retrofit opportunity (LR-06)	Route runoff from the parking lot and uphill area to existing green space to allow for filtration. Install a small sediment basin outside wetland buffer to reduce sediment transport from paved parking and gravel access road/parking. Improve existing gravel parking with underdrained permeable paver/grass-pave system with daylight to buffer area.	Stormwater Master Planning	1		44.509158	-72.363758	Facilities director, DEC Wetlands and Rivers programs, DEC basin planner, have been consulted and agreed to development of design-build concept	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	High
15	Hazen Union School (Parking and Tennis Courts) Retrofit opportunity (LR-07)	There is an existing stormwater retrofit present at this location that prevents clogging of the catch-basin. A paved swale along the driveway conveys runoff from the parking lot to a grass swale and the catch basin riser. The paved swale may be converted to a gravel wetland to treat runoff from the parking lot without substantially impacting adjacent recreational uses.	Stormwater Master Planning	1		44.50735	-72.363567	Facilities director, DEC Wetlands and Rivers programs, DEC basin planner, have been consulted and agreed to development of conceptual design	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	High
16	Wright Farm Road Retrofit opportunity (LR-08)	Route runoff from VT Route 15 to the existing green space and install an infiltration basin with sediment bay that can be easily cleaned/maintained (pending soil investigations).	Stormwater Master Planning	1		44.516106	-72.379189		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
17	GRACE Retrofit opportunities (LR-09)	Two green strips exist between the buildings of Hardwick Village Market, GRACE, and Brochu Auto Service. These strips can be used for linear bioretention areas to capture, treat, and infiltrate runoff from Mill Street, parking areas, and roofs.	Stormwater Master Planning	1		44.504292	-72.365131		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
18	Positive Pie and Yummy Wok park Retrofit opportunity (LR-10)	Promote infiltration and reestablish plantings within the existing park.	Stormwater Master Planning	1		44.504292	-72.365131		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low

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1	**ProjectName**	**ProjectDescription**	**ProjectType**	**ProjectTypeID**	**SGA reach**	**Latitude**	**Longitude**	**Notes**	**Towns**	**SubBasin**	**Partners**	**PotentialFundingSources**	**ParentProjecID**	**Priority Type**	**Rating**
19	Hardwick Elementary School Retrofit opportunity (LR-11)	There is a vegetated green strip between Hardwick Elementary School and Saint Norbert's Catholic Church. Install a linear bioretention area at that location. This could be implemented in conjunction with a repaving/regrading project.	Stormwater Master Planning	1		44.503122	-72.368592	Parking lot reconstruction was completed in summer/fall 2017; parking is now graded to the closed drainage system and treatment in the green space is no longer feasible.	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
20	VT 14/15 Retrofit opportunity (LR-12)	A substantial amount of sediment collects at the northern portion of an existing parking area. Installation of a swirl separator is planned in this area in conjunction with sidewalk project on South Main St. in 2017.	Stormwater Master Planning	1		44.504569	-72.368472	The practice was installed in the summer of 2017. Regular maintenance will be critical to its ongoing performance and success.	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
21	Hardwick Veterinary Clinic Retrofit opportunity (LR-13)	Vegetated green strip between the southern clinic parking lot and the Lamoille River north bank could be enhanced with additional plantings to slow down and evapotranspire runoff.	Stormwater Master Planning	1		44.504928	-72.365347	Recent changes in ownership of this property have made implementation of existing retrofit designs impossible - moving forward with these plantings given current ownership extremely unlikely (as of November 2017).	Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low
22	East Hardwick Main Street Bridge Improvements (LR-14)	Moderate erosion exists at the Main Street bridge over the Lamoille River, as well as the east edge of church street. The most significant erosion is present at the southeast and northwest corners of the bridge. Erosion is caused by high velocity over-land flow and active outlet scour at storm drains. A variety of practices could be established at the northwest corner to alleviate ongoing erosion. Installation of a step-pool conveyance system, stone lined swale, swirl separator, or a combination of practices are all potentially viable options. At the southeast corner, the bank should be stabilized using large stone that will hold against high velocity flows. Even larger stone may be used at the toe of slope to help weight down and anchor the bank. Stone splash pads should be established at storm drain outlets. Proper embankment stabilization may require adjusting or removing the existing concrete retaining wall at the top of the embankment.	Stormwater Master Planning	1		44.521125	-72.307869		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Medium
23	Carey Road at Dix Road Stabilization Improvements (NB-01)	Moderate erosion along the north edge of Dix Road caused by steep roadway grading, a shoulder berm, turnouts, and cross culverts with elevated outlets. Regrade the roadway to promote sheet flow and stabilize culvert outlets by installing stone splash pads.	Stormwater Master Planning	1		44.493161	-72.373644		Hardwick	Lower Headwaters Lamoille River	Caledonia County NRCD	Ecosystem Restoration Program		Stormwater Master Plan	Low