Appendix 5. East Hardwick Stormwater Plan

Clean Water Project Plan for

EAST HARDWICK STORMWATER TREATMENT

HARDWICK, VERMONT

April 30, 2025

Submitted to:
Town of Hardwick
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1 SUMMARY

1.1 OBJECTIVE

The Town of Hardwick experienced significant flooding in the 2023 and 2024 storm events which exacerbated the existing inadequate stormwater collection and treatment systems. In East Hardwick in particular, there have been several studies, summarized below, addressing the inadequate stormwater collection and treatment but projects have not come to fruition.

The objective of this work is to take the projects identified in those previous studies, along with any additional projects that are identified through this work and develop preliminary designs and cost estimates so the Town can pursue funding to bring these projects to completion to help prevent further property damage and protect water quality.

A map of the project area is included as Figure 1-1.

1.2 SCOPE OF WORK

The scope of work for this project is focused on East Hardwick and includes:

- Summary of stormwater problem areas and impacts.
- Stormwater management site identification.
- Main Street Bridge and management site stormwater alternatives.
- Cost Estimates.
- Evaluation of treatment alternatives.
- Alternatives presentation and selection.
- Determination of recommended alternative.
- Stormwater Plan and 30% Design.
- Presentation of stormwater plan to the Community.

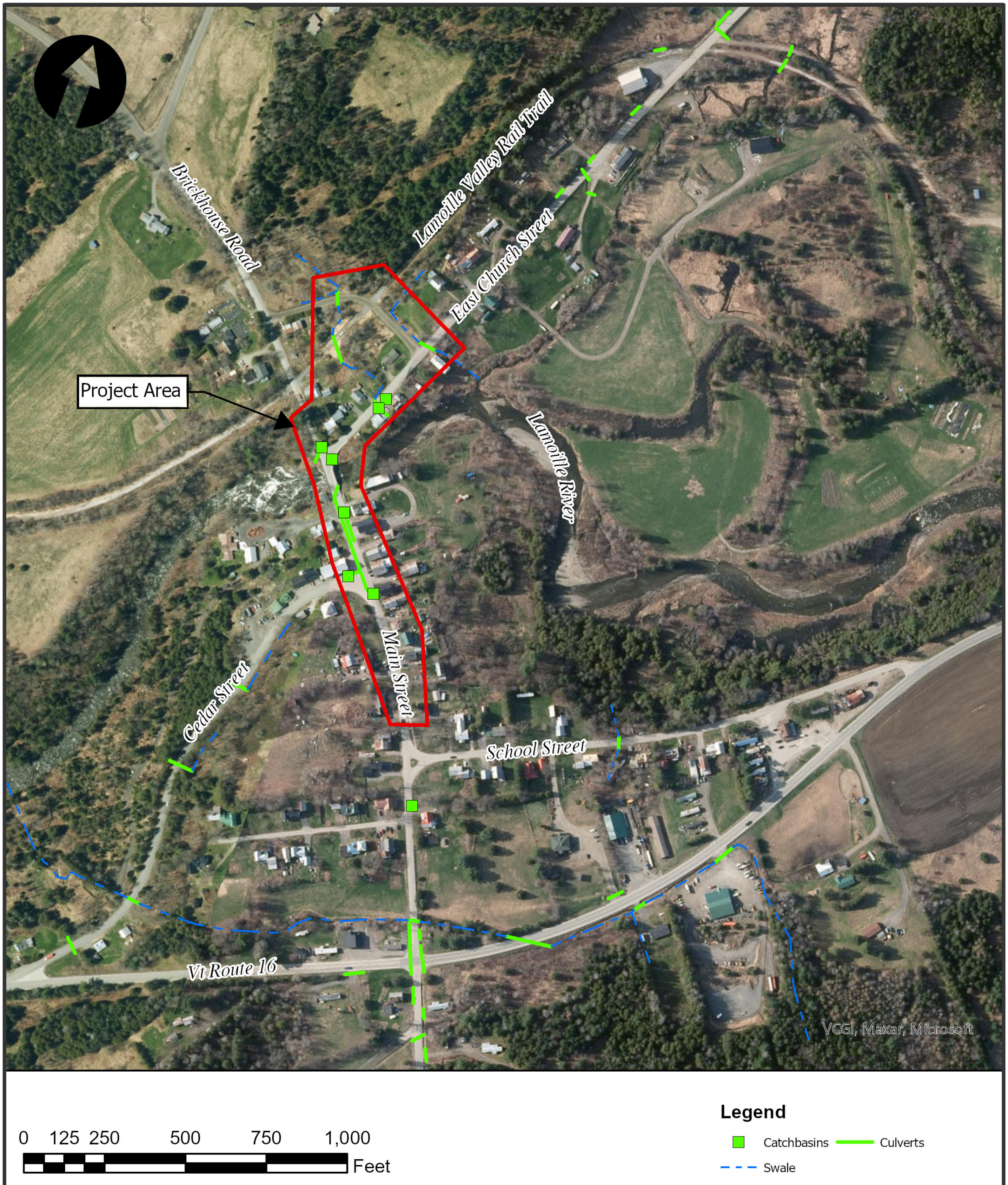

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FIGURE NO. 1-1

PROJECT AREA

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	MARCH 1, 2025
DRAWING NO.	Existing Stormwater

2 SUMMARY OF EXISTING CONDITIONS

2.1 COLLECTION SYSTEM

The existing stormwater system is limited and in poor condition. It consists of catch basins, storm drain pipe, ditches and culverts. Several locations of the collection system are exposed and have failed, the catch basins are not adequately capturing stormwater and discharge points do not have adequate erosion control. This results in sheet flow at the Main Street Bridge causing erosion as the stormwater flows over the ends of the abutments down the banks to the river. These issues are shown in the images below and in images from the Town's storm damage documentation from June 2024 in Section 2.2 below.

A map of the existing collection system is included as Figure 2-1 below.

Image 2-1: Main Street Exposed Storm Drain

0 125 250 500 750 1,000

Feet

Legend

Catchbasins

Culverts

Swale

DG

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FIGURE NO. 2-1

EXISTING STORMWATER INFRASTRUCTURE

HARDWICK, VERMONT

PROJECT NO. 7124009

PROJECT MJR. AJD

SCALE AS SHOWN

DATE MARCH 1, 2025

DRAWING NO. Existing Stormwater

2.2 Stormwater Problem Areas

Several stormwater problem areas have been identified in East Hardwick within the study area of Main Street, East Church Street and Brickhouse Road. A summary of those areas is included below. A separate stormwater project is underway at the end of School Street near VT Route 16. As that project is already underway, and outside the project area, it is not included in this plan.

1. Main Street

The most problematic area is on each side of the Main Street Bridge. The Main Street bridge is at the low point in the Village. Stormwater comes down Main Street and discharges along the eastern side of the bridge causing erosion. The existing stormwater collection system on Main Street has failed in several locations and is therefore not adequately collecting stormwater. This results in stormwater sheeting down Main Street and discharging over the bank on each side of the bridge. On the western side of the bridge, stormwater from Brickhouse Road and East Church Street sheets across the road and causes erosion on the western side of the bridge.

Image 2-2: Southeast Embankment of Main Street Bridge

Image 2-3: Erosion on Northwest Side of Main Street Bridge

2. East Church Street

The hillsides northwest of East Church Street have several areas of high groundwater and groundwater seeps that limit infiltration and increase runoff during periods of the year when groundwater is elevated or when frequent rain events occur. This groundwater, combined with stormwater runoff contributes to roadside ditches along Stevens Lane and East Church Street which are eventually carried in a culvert under East Church Street and discharged to the river. Erosion occurs at that culvert discharge.

Image 2-4: East Church Street Culvert Discharge

3. Brickhouse Road

Brickhouse Road lacks stormwater infrastructure which results in stormwater sheet flowing off the steep hill at the end of Brickhouse Road and running across the Brickhouse Road and East Church Street intersection. This contributes to the erosion on the west side of the Main Street bridge.

4. Main Street and Cedar Street

The intersection of Main and Cedar Street has excessive impervious area, beyond what is necessary for the flow of traffic. Opportunity exists to reduce stormwater runoff through the reduction of impervious area at the Main and Cedar Street intersection. The reduction of impervious area would decrease runoff.

Image 2-5: Main and Cedar Street Intersection

2.3 PROJECT NEED

Based on the assessment of the existing infrastructure and problem areas identified during recent flooding events, the following issues need to be addressed to improve stormwater runoff in East Hardwick:

- Inadequate and deteriorated existing stormwater collection system.
- Excessive impervious area.
- Lack of erosion control at discharge points.

Contributing factors to these stormwater runoff issues include:

- Steep slopes along Main Street and Brickhouse Road.
- Lack of green space between houses and the edge of road.
- Limited space around the Main Street bridge.

Most of the project area has Hydrologically Connected Road Segments as defined in the Municipal Roads General Permit. The discharges at the Main Street Bridge were reviewed in October 2024 and the discharge on the northwest side is considered to partially meet the outlet scoring. A map of the project area segments and discharges is shown in Figure 2-2 below.

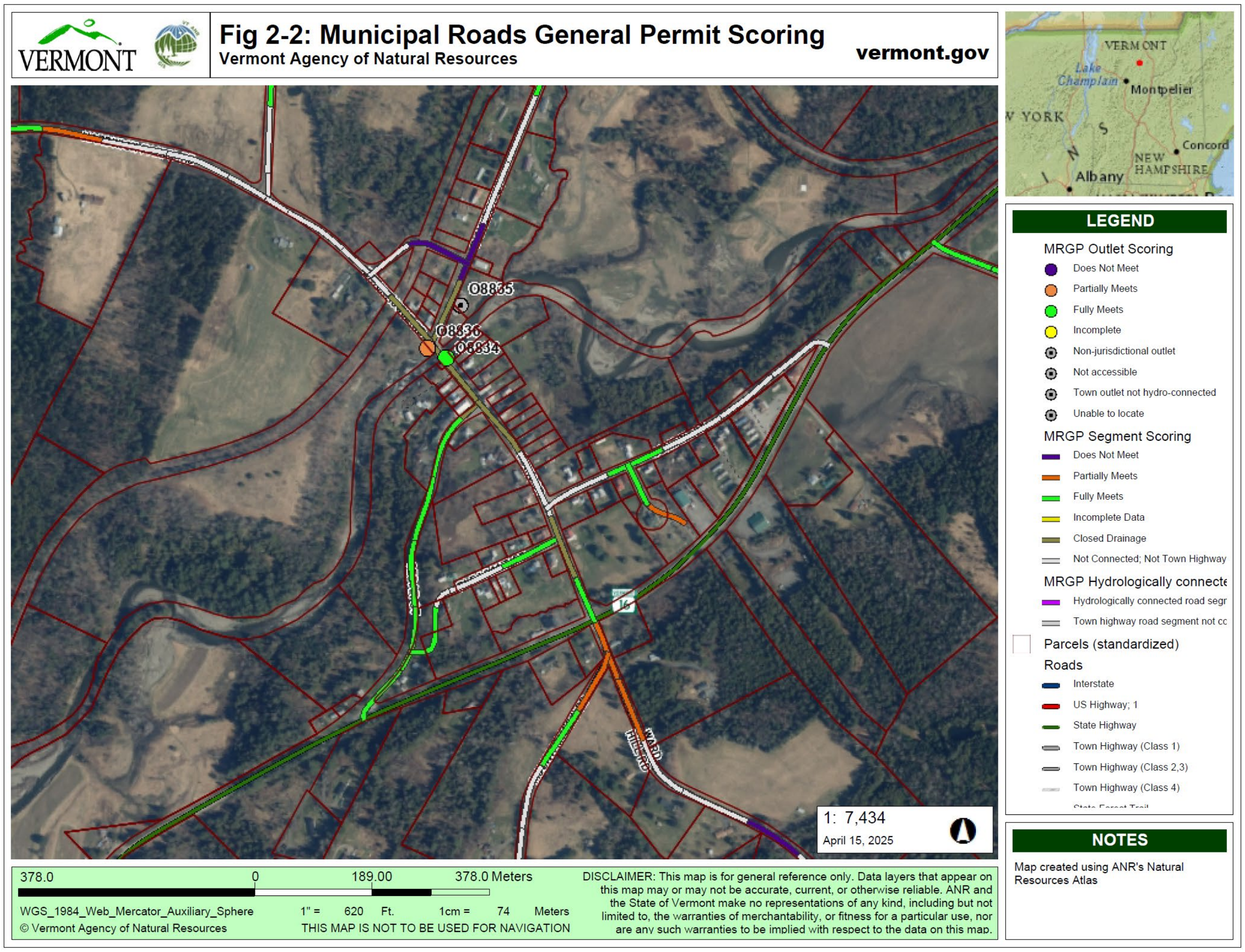


Fig 2-2: Municipal Roads General Permit Scoring

3 SUMMARY OF PREVIOUSLY COMPLETED STUDIES

Previously completed studies related to Stormwater in East Hardwick reviewed for this report include:

1. Stormwater Infrastructure Mapping Project - Jim Pease, David Ainley, VT DEC (January 2017)
2. Stormwater Master Plan, Town of Hardwick, VT, Stone Environmental (November 2017)
3. East Hardwick Existing Stormwater Infrastructure Map – ANR
4. Upper Lamoille River Stream Geomorphic Assessment Phase 2 Report – CCNRCD (February 2009)

See Appendix A for copies of the documents listed above.

In general, these documents are in broad concurrence on the need for stormwater collection and treatment improvements in the Village area. The findings of these studies are summarized below.

1. Stormwater Mapping Infrastructure Project (January 2017)

The Stormwater Mapping Infrastructure Project completed in 2017 by the Vermont Agency of Natural Resources Ecosystems Restoration program focused on updating stormwater mapping for use by municipalities and identifying potential locations for the installation of Best Management Practices (BMP) to reduce nutrient and contaminant loading in surface waters.

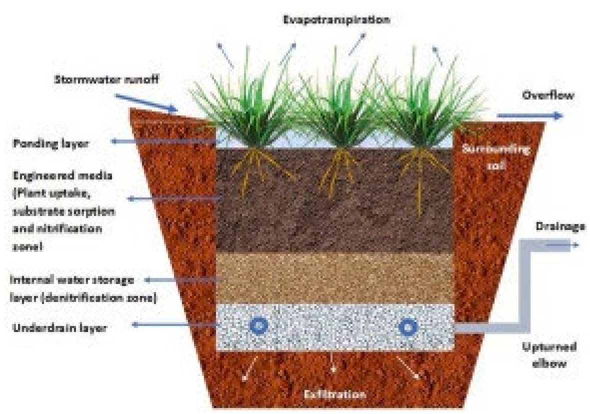


Image 3-1 Bioretention

The project identified two potential areas for improvements in East Hardwick, one near the intersection of VT Route 16 and School Street and another around the Main Street bridge. The recommended improvements include a bioretention treatment area like that shown in Image 3-1 along VT Route 16 and swirl separators with outfall stabilization where culverts discharge around the bridge on Main Street.

There are three discharge outfalls within 500 feet of the Lamoille River identified in the report that should be addressed and are within the project area, one on each side of the bridge and one just north of the bridge on E. Church Street. The recommendations in the report for this area are to utilize swirl separators for treatment prior to discharge and construct outfall stabilization at each discharge like that shown in Image 3-2.

Image 3-2: Outfall Stabilization

2. Stormwater Master Plan (November 2017)

Stone Environmental completed a Stormwater Master Plan for the Town of Hardwick in 2017 and identified one area of focus in East Hardwick. Areas of moderate erosion around the Main Street Bridge and on the east side of Church Street were identified in the plan. Recommendations were broken into three categories: Improve Site Drainage, Install BMPs, and Stabilize Overflow/Flow Path. The recommendations are listed below.

Improve Site Drainage:

- Re-establish the closed stormwater drainage network or create a more functional surface slow 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.
- Consider under drained 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.

Conceptual recommendations for addressing erosion at the northwest corner of the bridge include step-pool conveyance like shown in Image 3-3, a stone-lined swale like shown in Image 3-4 or a swirl separator like shown in Image 3-5.

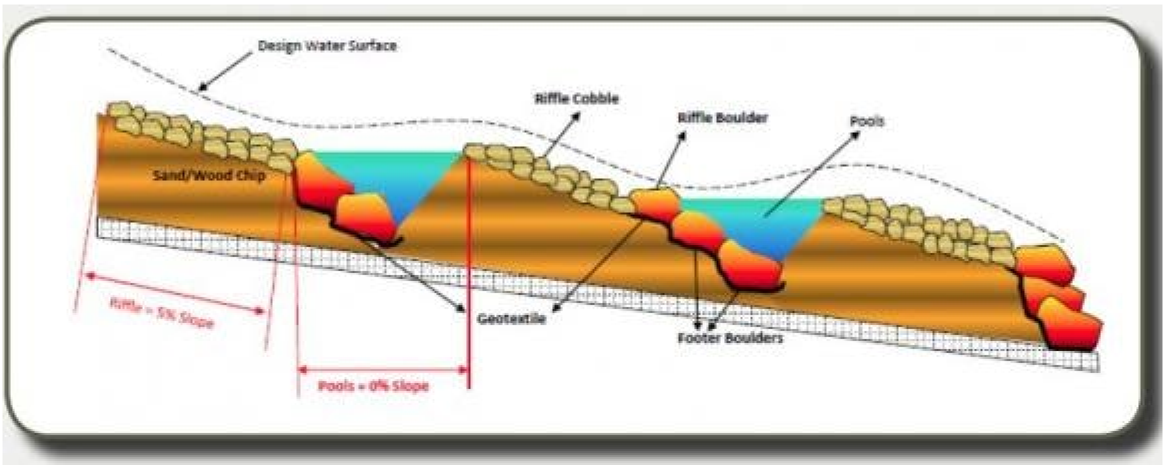


Image 3-3 Step-pool Conveyance

Image 3-4 Stone-lined Swale

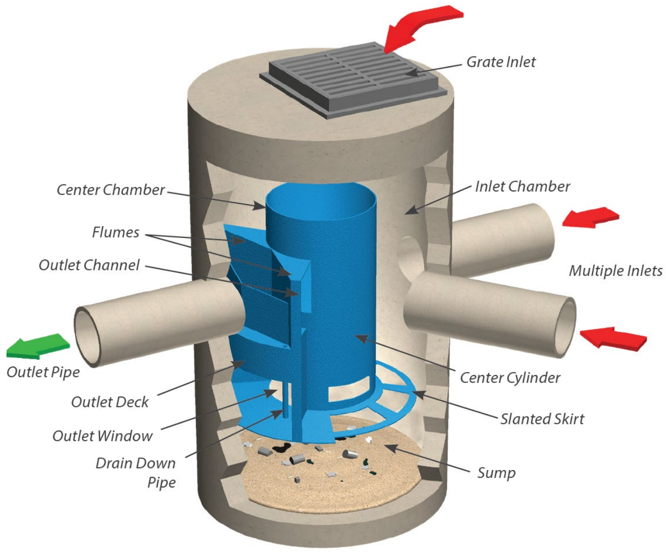


Image 3-5 Swirl Separator

At the southeast corner, a conceptual recommendation to address erosion at the storm drain outlet include stone splash pads with overall bank stabilization using large stone like that shown in Image 3-6.

Image 3-6 Stone Stabilization

3. East Hardwick Existing Stormwater Infrastructure Map

See previous Figure 2-1 of existing stormwater infrastructure.

4. Upper Lamoille River Stream Geomorphic Assessment Phase 2 Report – CCNRCD (February 2009)

The Upper Lamoille River Stream Geomorphic Assessment reviews current geomorphic conditions, meaning the form of the river, and summarizes recommendations for each reach.

East Hardwick Village is located along Reach 28B as identified in the report. This segment is described as a B-type stream and transport reach with grade control through a weir that channels the flow under the Main Street bridge. Preliminary management strategies recommended in the report include:

- The floodplain area along the right bank upstream from the village is currently undeveloped and is providing critical floodwater storage for East Hardwick. Consideration of a conservation easement on this floodplain is recommended, both to protect the floodplain and to allow channel planform adjustment to continue to take place. Long-term planning with the town to look at current and future zoning options may be another way to help protect this resource.
- Modification of the bridge is recommended when the opportunity arises. An assessment of the purpose and efficacy of the weir should be considered. Stormwater runoff from the bridge has eroded areas on and around the bridge and runoff is going directly from the road into the stream. Upgrades to the bridge should direct water towards vegetated areas.

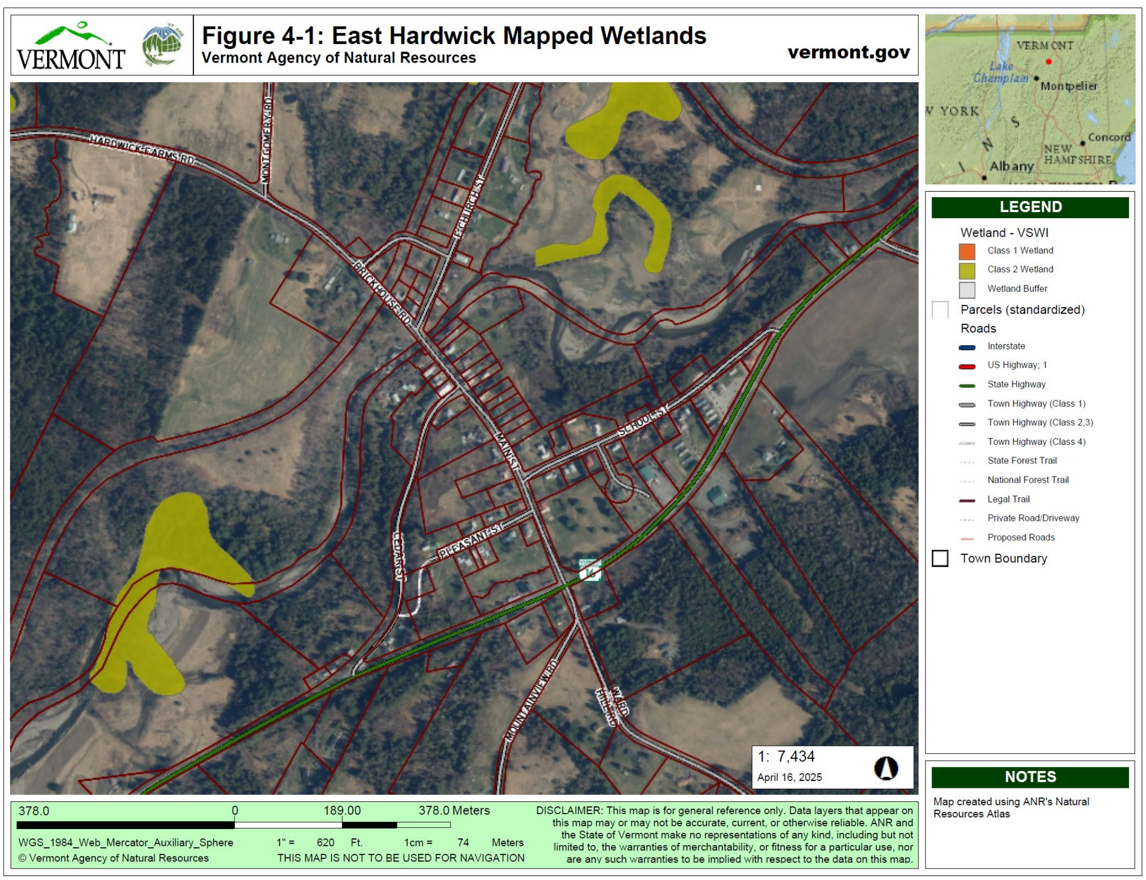
4 NATURAL AND CULTURAL RESOURCES

Impacts on natural and cultural resources were evaluated through on-site review and information compiled from the Agency of Natural Resources Natural Resources Atlas and the Vermont Center for Geographic Information in the project area. A summary of the impacts to natural and cultural resources is included below.

4.1 NATURAL RESOURCES

4.1.1 WETLANDS

There are no mapped wetlands in the area proposed for construction, however an on-site review during the design phase should be completed by a wetlands scientist to identify any wetlands that are not mapped on the ANR Atlas.

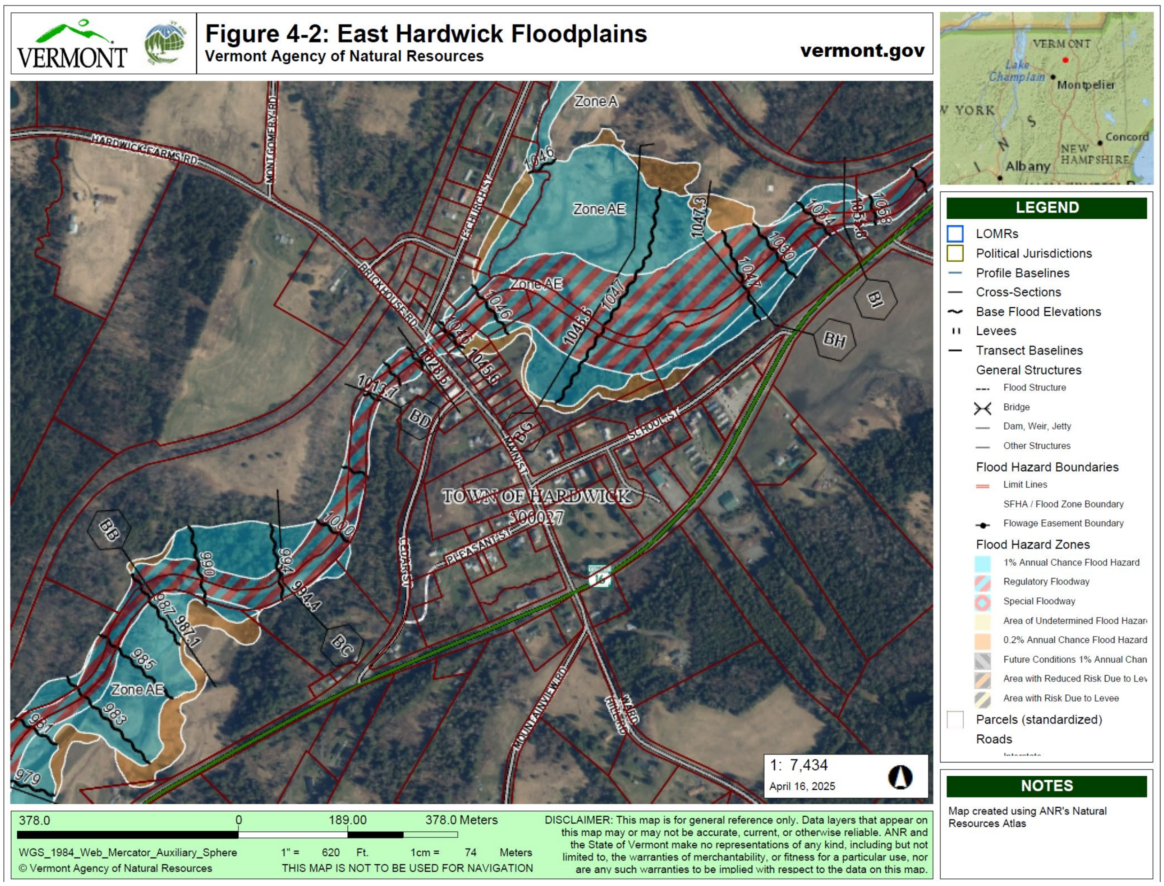


4.1.2 LAKES, PONDS, STREAMS, AND RIVERS

The Lamoille River runs through the center of the project area. The use of Best Management Practices will need to be employed to avoid erosion and runoff to the river during construction. Changes to the riverbank may need to be reviewed by the State Rivers Engineer.

4.1.3 Floodplains

Floodplains in the project area around the Lamoille River are shown in Figure 4-2. Permitting work within the floodplain will need to be coordinated with the Town of Hardwick during the design phase.



4.1.4 Endangered Species

No rare, threatened, or endangered species were identified in the project area.

4.1.5 Flora and Fauna

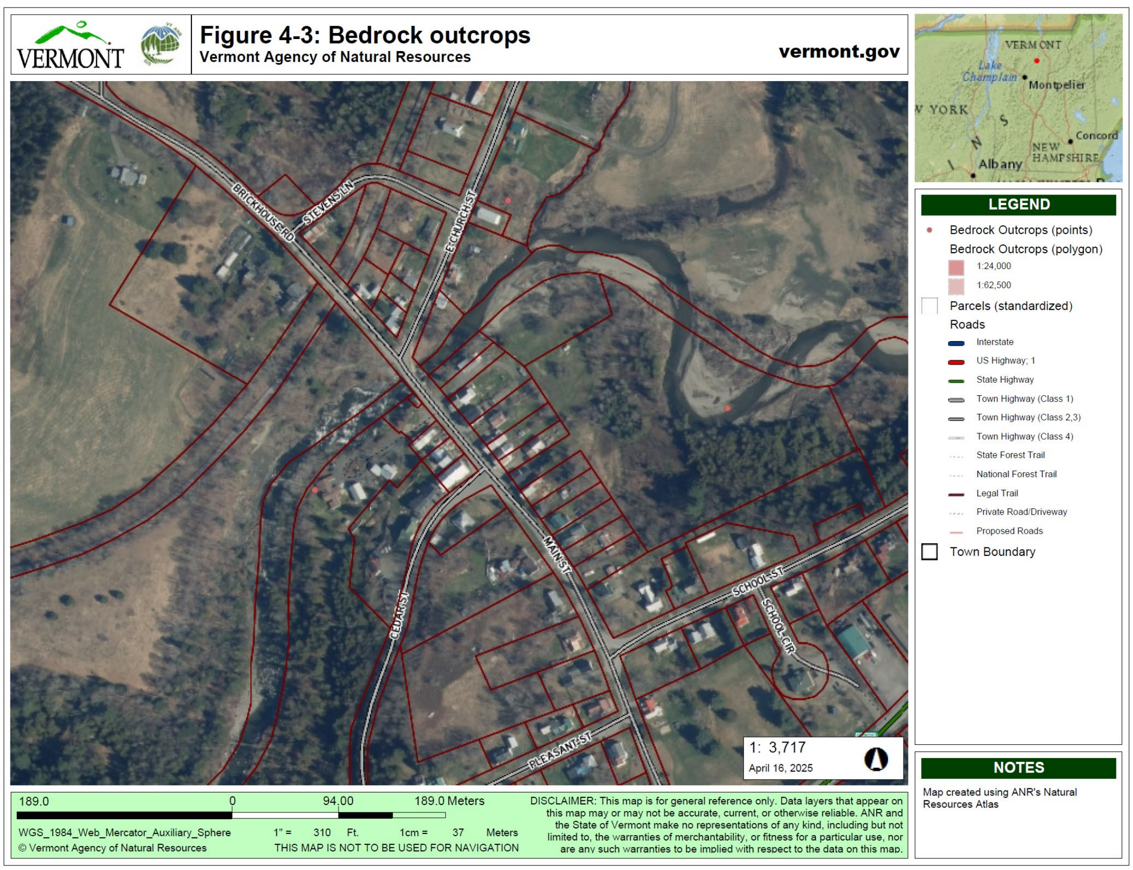
No endangered flora or fauna were identified in the project area.

4.1.6 Soils, Ledge, Groundwater

Soils in the project area have limited characterization due to the urban nature of the area. Data from on-site septic system permits provides soil infiltration rates adjacent to the Main Street and Cedar Street intersection and along East Church Street.

Groundwater seeps around and upslope of Stevens Lane have been described by residents. On the Main Street side of the project area, groundwater has not been observed. Any proposed infiltration practices will need to avoid areas of high groundwater.

The ANR Atlas shows three bedrock outcrops adjacent to the project area as shown in Figure 4-3 below. Any proposed infiltration practices will need to avoid bedrock.



4.1.7 Hazardous Wastes

One property in the project area, as shown in Figure 4-4 below. was previously identified as a hazardous site due to a heating oil leak. That leak was cleaned up and the site classified as "Sites Management Activities Complete" in 2003. No other hazardous waste sites were identified.

Figure 4-4: Hazardous Waste Sites

4.1.8 Forest Land

There was no forest land identified in the project area.

4.2 Cultural Resources

4.2.1 Historical and Archeological

A historic and archaeological resource assessment was not completed as part of this project.

The project area is within the East Hardwick Historic District and therefore will likely have some requirements for improvements. Coordination with the Vermont Department of Historic Preservation should occur during the design phase to ensure proposed improvements are consistent with the historic patterns in East Hardwick.

4.2.2 Public Lands

No impacts to public lands are anticipated.

4.2.3 Agricultural Lands

As the project is within a developed Village, no impacts to agricultural lands are anticipated.

5 STORMWATER ALTERNATIVES

5.1 MANAGEMENT AND TREATMENT ALTERNATIVES

There are many Best Management Practices (BMPs) available that will remove contaminants from stormwater but not all BMPs fit every application. Some BMPs require a large area, well-draining soil, and separation from the practice to groundwater and ledge. A summary of methods considered for East Hardwick to manage and treat stormwater is included below.

1. **Stone-lined Ditches and Check Dams**
   Stone-lined ditches stabilize ditches and prevent erosion. Check dams slow the flow of water, reduce channel erosion, and can trap sediments. Under low flow conditions, water ponds behind the check dams and either releases slowly or evaporates. Under high flow conditions, the check dams slow the velocity of water.

   Treatment:

   - Although some sediment likely settles out behind the check dams, their treatment capability is not quantifiable.
   - The primary benefit of stone-lined ditches and check dams is erosion prevention by slowing the velocity of runoff.

   Maintenance:

   - Inspection after high-flow events to replace stones, repair any damage to geotextile fabric and remove debris.

   Advantages:

   - Low maintenance requirements

   Disadvantages:

   - Check dams are suitable only for a limited drainage area (10 acres or less)
   - Check dams can be washed away during large storm events

2. **Outfall Stabilization**
   Outfall stabilization is achieved through the placement of stone. Its primary purpose is to prevent erosion; therefore, it has many of the same characteristics as stone-lined ditches.

Treatment:

- The primary benefit of outfall stabilization is erosion prevention by slowing the runoff velocity and protecting the underlying soil.

Maintenance:

- Inspection after high-flow events to replace stones, repair any damage to geotextile fabric and remove debris.

Advantages:

- Low maintenance requirements

Disadvantages:

- Stone may get washed away during high flow events.

3. Step-pool Stormwater Conveyance Systems

A series of shallow pools, often constructed with rocks, used to convey stormwater down a slope while minimizing erosion.

Treatment:

- Although some amount of sediment likely settles out in the pools, their treatment capability is not quantifiable.
- The primary benefit of step-pool conveyance systems is erosion prevention by slowing the velocity of runoff.
- During low flows, infiltration may occur in the pools.

Maintenance:

- Inspection after high-flow events to replace stones, repair any damage to geotextile fabric and remove debris.
- Seasonal inspection to clear debris out of pools.

Advantages:

- Low maintenance requirements.

Disadvantages:

- The maximum recommended drainage area is 5 acres if trying to achieve water quality and volume reduction.
- Minimum horizontal distance of 200 feet from down-gradient slopes greater than 20 percent.

- Slopes in contributing drainage areas should be limited to 15 percent.

4. Bioretention Areas

Bioretention areas are constructed of engineered soils and plants to filter and treat stormwater runoff. Bioretention areas can include underdrains, overflow outlets and different types of plants to accommodate different site conditions.

Treatment:

- 80% total phosphorus and 98% removal of TSS based system with infiltration (no underdrain).
- 60-80% total phosphorus and 80-97% TSS removal for a system without infiltration (underdrain).

Maintenance:

- Inspect regularly for sediment build-up, structural damage and standing water.
- Inspect for erosion and re-mulch void areas regularly.
- Remove and replace dead vegetation in spring and fall.
- Remove invasive species to prevent from spreading within bioretention area.
- Do not store snow in bioretention areas.
- Periodically observe function under wet weather conditions.

Advantages:

- Suitable in areas with space constraints.
- Can provide groundwater recharge.
- Improves site aesthetics.
- Treatment capabilities.

Disadvantages:

- Requires careful landscaping/maintenance.
- Not suitable for areas with slope > 20%.
- Requires pretreatment.
- Not suitable where groundwater table is within 6 Feet of ground surface.
- Not suitable for areas where snow will be stored.

5. Infiltration Chambers

Infiltration chambers are manufactured by several vendors and provide a way to store stormwater subsurface until the water infiltrates into the soil. The amount of treatment provided is directly proportional to the area allotted for the infiltration chambers and requires a generally level area. Pretreatment is required to remove large debris from the water to avoid clogging the stone base.

On-site testing will need to be completed to verify the soil infiltration rate during final design. Soil testing was unable to be completed during this phase due to the inability to complete testing during the winter months. Available data from septic permits was used to estimate the infiltration rate for this study.

Image 5-1: Infiltration Chambers

Bypass options: The infiltration chamber requires external bypass in the form of a manhole or tank that can divert high flows past the unit to a discharge location. The bypass is typically combined with pretreatment by providing a deep sump (greater than 4-feet) structure with a hooded outlet.

Sediment Storage: Sediment removal largely occurs in the pretreatment device however there will be some removed in the chambers.

Oil Detention: Pretreatment should provide some type of screen or baffle to keep oil from passing into chambers

Treatment:

- 100% removal of TSS for flow directed into chambers.
- Floatables retained in pretreatment.
- Nutrient removal is 100% from flow directed into chambers. Overall phosphorus reduction rating based on the percentage of the annual volume treated.

Maintenance:

- Bypass/pretreatment manhole access points from which a vacuum truck can remove sediment and solids retained in the structure.
- Floatables and sediment are primarily retained in the pretreatment structure.
- Chambers have regularly spaced access ports for flushing sediment.
- There are no mechanical items to replace within the treatment unit.

Advantages:

- Reduces volume discharged to surface water.
- Simple operation.
- Low maintenance requirements.
- EPA, ETV, NSF Joint Verification.
- Units can be installed in areas of traffic.

Disadvantages:

- Separate bypass structure required.
- Requires relatively flat location.
- Larger footprint.
- Soil, groundwater, and ledge dependent.

6. R-Tank

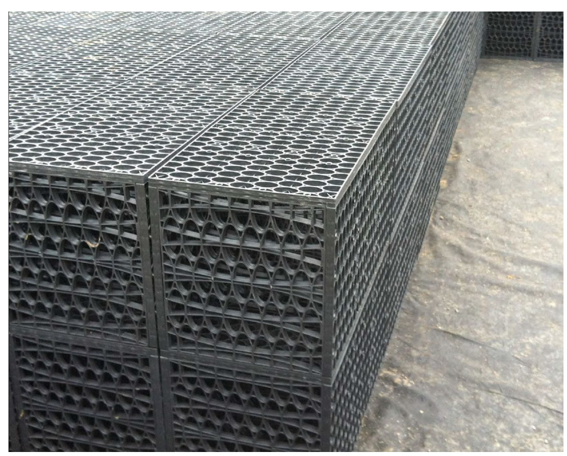


Image 5-2: R-tank Installation

R-Tanks are manufactured by Ferguson Waterworks and provide a way to store stormwater subsurface until the water infiltrates into the soil. The R-Tank system is a polypropylene modular block that provides a 95% void with HS-20/HS-25 loading for installation below trafficked areas. The amount of treatment provided is directly proportional to the area allotted for the R-Tanks and the modular blocks have grade flexibility. Pretreatment is required to remove large debris from the water to avoid clogging the stone base.

Bypass options: R-Tanks are designed with a drain to maintain a manageable water level in the system.

Sediment Storage: Sediment removal largely occurs in the pretreatment device however there will be some removed in the R-Tank, maintenance ports are provided for inspection and flushing.

Oil Detention: Pretreatment should provide some type of screen or baffle to keep oil from passing into chambers.

Treatment:

- 100% removal of TSS for flow that is infiltrated within the R-Tank.
- Floatables are retained in pretreatment.
- Nutrient removal is 100% from flow infiltrated in the R-Tank. Overall phosphorus reduction rating based on the percentage of the annual volume treated.

Maintenance:

- Bypass/pretreatment manhole access points from which a vacuum truck can remove sediment and solids retained in the structure.
- Floatables and sediment are primarily retained in the pretreatment structure.
- R-Tanks have regularly spaced access ports for flushing sediment.
- There are no mechanical items to replace within the treatment unit.

Advantages:

- Reduces volume discharged to surface water.
- Simple operation.
- Low maintenance requirements.
- EPA, ETV, NSF Joint Verification.
- Units can be installed in areas of traffic.
- Can be used in place of conveyance piping.

Disadvantages:

- Larger footprint.
- Soil, groundwater, and ledge dependent.

7. Hydrodynamic Swirl Separator

Hydrodynamic Swirl Separators were recommended in the previous reports discussed in Section 3 for use in East Hardwick. Each unit is available in several sizes. The Vortechs and Cascade Stormceptor units by Contech were evaluated for the purposes of this plan. The Vortechs unit is housed in a concrete tank and is typically used in large drainage volumes, while the Cascade Stormceptor unit is contained within a manhole structure. Both units use centrifugal force to separate solids and sediment from stormwater followed by weirs to prevent solids, sediment, and oils from discharging from the treatment unit.

Bypass options: The Vortechs unit requires external bypass in the form of a manhole or tank that can divert high flows past the unit to a discharge location. The Stormceptor unit allows for bypass within the unit.

Sediment Storage: Varies based on size.

Oil Detention: No volumes published however floatables separation does occur.

Treatment:

- 80% removal of TSS based on 50-micron (0.05mm) particle size.
- Floatables retained behind baffle walls.
- Some nutrient removal documented in studies but treatment capability for dissolved nutrients is site specific. Vermont Agency of Natural Resource's Stormwater Treatment Practice Calculator (STPC) provides 10% efficiency rating for phosphorus reduction.

Maintenance:

- There are 30"-diameter manhole access points from which a vacuum truck can remove sediment and solids retained in the structure.
- Floatables and sediment are primarily retained in the first chamber.
- There are no mechanical items to replace within the treatment unit.

Advantages:

- High Capacity.
- Simple operation.
- Low maintenance requirements.
- EPA, ETV, NSF Joint Verification.
- Units can be installed in areas of traffic.

Disadvantages:

- Separate bypass structure may be required.
- Phosphorus removal is not verified.
- No reduction in flow through outfall.

5.2 Drainage Area Alternatives

To address stormwater issues in East Hardwick Village, the project area was broken up into three drainage areas with alternatives developed for each area to address treatment, volume, and erosion. The drainage areas are:

- Drainage Area 1 – Main Street between School Street and East Church Street
- Drainage Area 2 – Brickhouse Road between Main Street and the Lamoille Valley Rail Trail
- Drainage Area 3 – East Church Street between Stevens Lane and Main Street

A summary of the alternatives is as follows:

- Alternative 1 – suspended solids removal with outfall stabilization
- Alternative 2 – suspended solids removal with some volume reduction utilizing infiltration and outfall stabilization
- Alternative 3 - suspended solids removal with some volume reduction utilizing infiltration, velocity reduction and outfall stabilization

Construction of these alternatives may require temporary or permanent easements on private property. During the design phase, the extent of the easements will be identified and outreach to property owners to obtain easements will be necessary.

Alternative 1

Alternative 1, as shown in Figure 5-1, breaks the project area into three drainage areas.

- Drainage Area 1 is approximately 3.4 acres in size with 1.8 acres of impervious surface and includes Main Street from School Street to the Lamoille River bridge and the intersection of Cedar Street.
- Drainage Area 2 is approximately 1.6 acres with 0.6 acres of impervious surface and includes the intersection of Brickhouse Road and East Church Street.
- Drainage Area 3 is approximately 10.4 acres of primarily pervious areas that contributes to the 12” culvert that crosses East Church Street between 40 and 52 East Church Street.

Stormwater collection and treatment in Drainage Area 1, as shown in Figure 5-2 includes:

- Eight catch basins with 680-lf of storm drain pipe.
- Treatment through a swirl separator. This precast concrete unit provides up to 2.8 cfs of treatment during every storm with particle removal down to 50 microns.
- Annual phosphorus load through this discharge would be reduced from 2.38 kg to 2.14 kg, as estimated by the STPC.
- Sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river would be removed.

Stormwater collection and treatment in Drainage Area 2, as shown in Figure 5-3 includes:

- Eight catch basins with 465-lf of collection pipe and 55-lf of discharge pipe.
- Treatment for this area is through a swirl separator. This precast concrete structure provides 1.8 cfs of treatment during every storm event with particle removal down to 20 microns.
- Annual phosphorus through this discharge would be reduced from 0.97 kg to 0.82 kg, as estimated by the STPC.
- Sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river would be removed.

Stormwater collection and treatment in Drainage Area 3, as shown in Figure 5-4 includes:

- Proposed 24-inch HDPE culvert with a stabilized outfall and 55-lf stone-lined swale with one stone check dam. Lining the swale with stone increases the stability of the channel and the roughness of the stone reduces the velocity of the flow through the swale.
- The stone check dam will also work to reduce the velocity while providing an area to hold back large debris and litter.

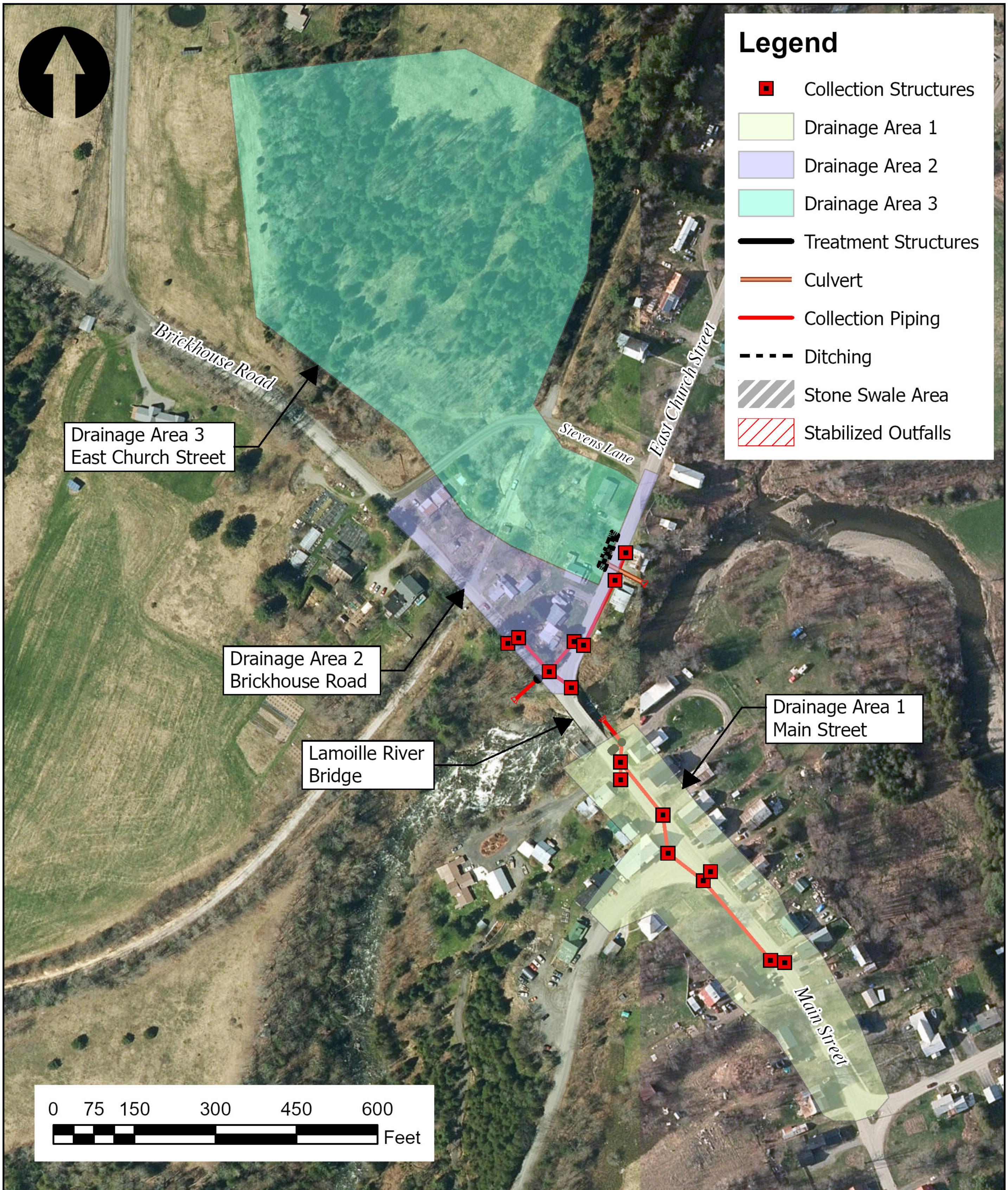


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FIGURE NO. 5-1

ALTERNATIVE 1
OVERALL PLAN

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 1

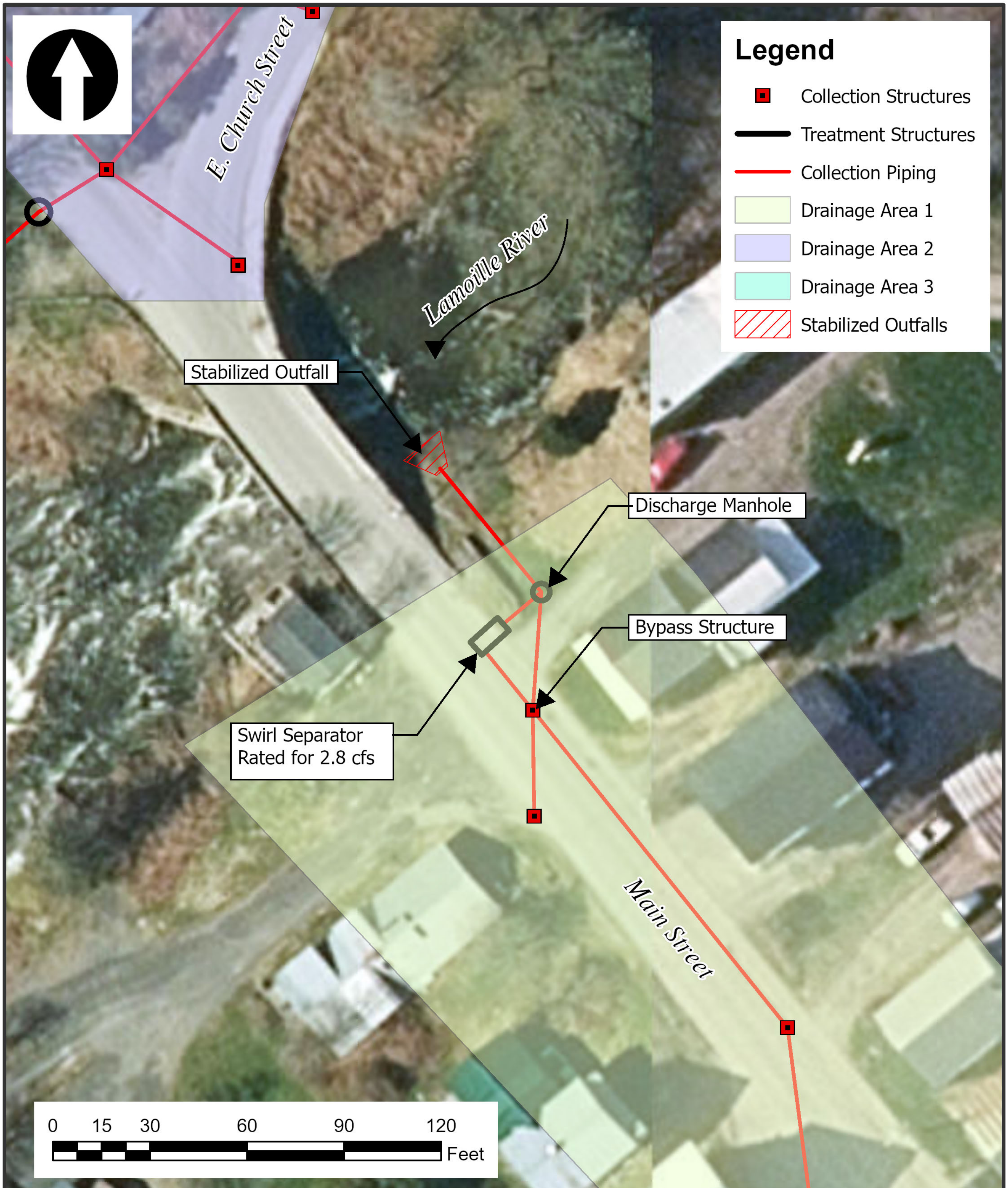

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FIGURE NO. 5-2

ALTERNATIVE 1
AREA 1
MAIN STREET TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 1

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FIGURE NO. 5-3

ALTERNATIVE 1
AREA 2
BRICKHOUSE ROAD TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 1

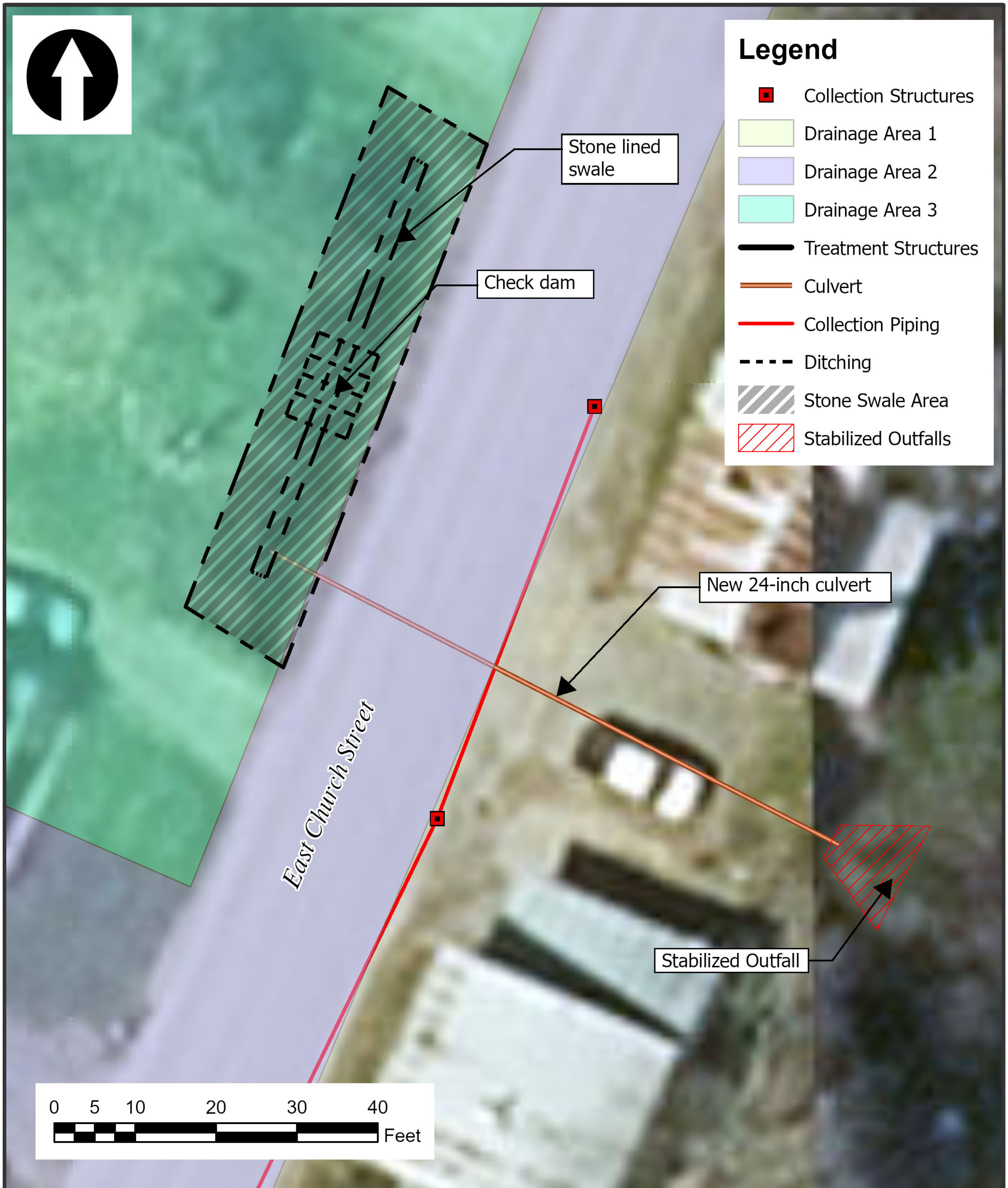

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FIGURE NO. 5-4

ALTERNATIVE 1
AREA 3
EAST CHURCH STREET CULVERT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 1

The estimated cost for construction of the improvements described for Alternative 1 in Drainage Areas 1-3 above is presented in Table 5-1 below.

Table 5-1: Alternative 1 cost estimate

System	Description	Quantity		Cost Per Unit	Total
Collection	Catch Basin	16	ea	$ 6,400	$ 102,400
	15-inch HPDE Pipe	210	lf	$ 85	$ 17,850
	18-inch HPDE Pipe	420	lf	$ 100	$ 42,000
	24-inch HPDE Pipe	160	lf	$ 125	$ 20,000
	Drainage Manhole	1	ea	$ 5,600	$ 5,600
Vortech 2000	Unit	1	ea	$ 21,700	$ 21,700
	Excavation	40	cy	$ 35	$ 1,400
	Structural Backfill	16	cy	$ 45	$ 720
Cascade CS4	Unit	1	ea	$ 14,000	$ 14,000
	Excavation	20	cy	$ 35	$ 700
	Structural Backfill	10	cy	$ 45	$ 450
Stone swale	Excavation	90	cy	$ 35	$ 3,150
	Stone	60	cy	$ 75	$ 4,500
Outfall (3)	Excavation	35	cy	$ 35	$ 1,225
	Stone	35	cy	$ 75	$ 2,625
Restoration	Pavement	190	ton	$ 260	$ 49,400
Miscellaneous Work and Cleanup 20%		1	LS	$ 57,600	$ 57,600
Total Estimated Construction Cost					$ 345,320
Contingency (20%)					$69,100.00
Estimated Engineering (based on DEC Fee Curve)					$73,100.00
Total Estimated Project Cost					**$ 487,520**

Notes:

1. Costs are based on 2025 construction.
2. Engineering Fees are based on DEC Engineering Fee Allowances.
3. Costs will need to be updated as design progresses.

Alternative 2

Alternative 2, as shown in Figure 5-5, identifies the same three drainage areas used in Alternative 1. However, this alternative provides for some additional treatment to reduce the volume and velocity at the discharge.

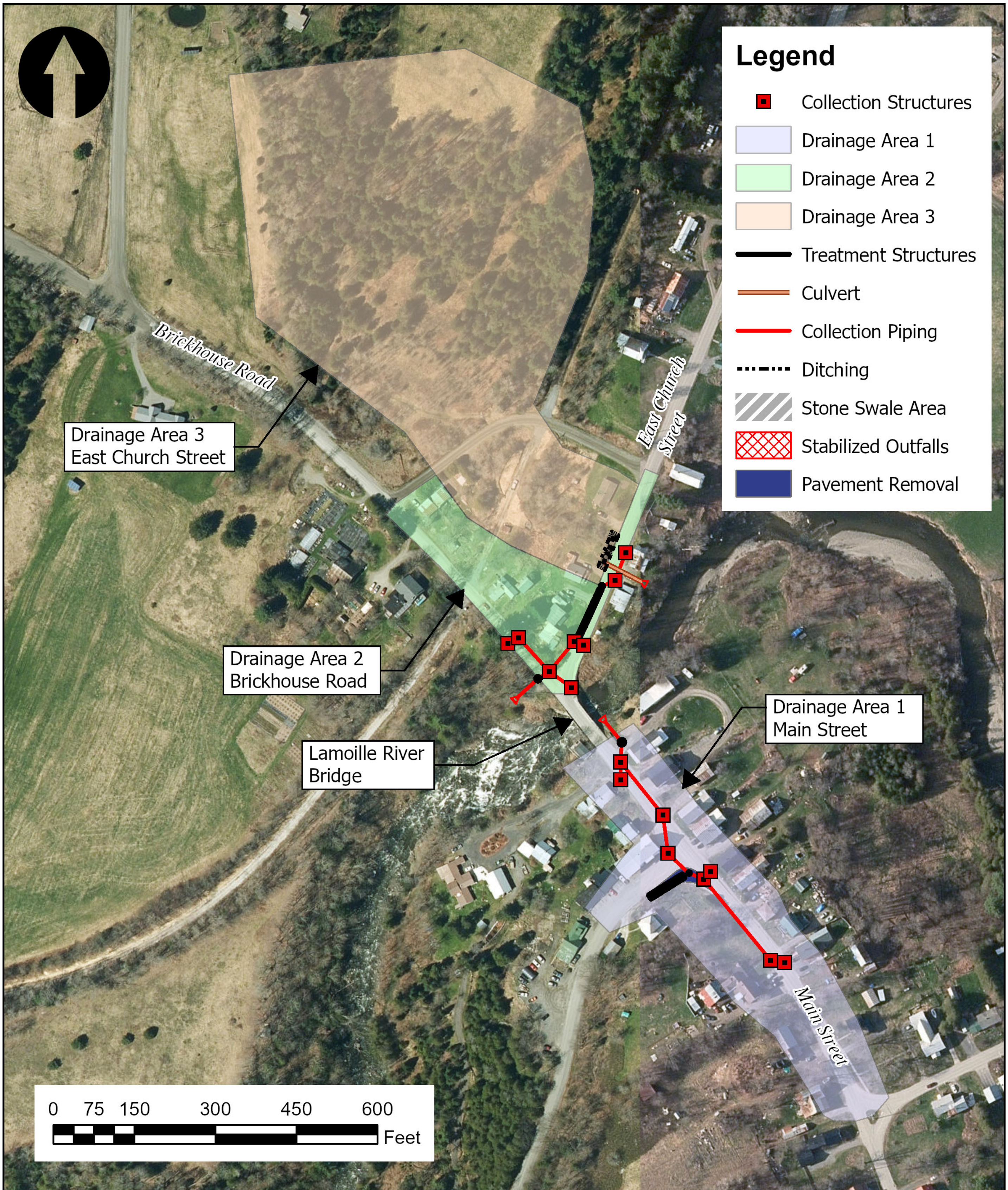

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FIGURE NO. 5-5

ALTERNATIVE 2
OVERALL PLAN

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 2

Stormwater collection and treatment in Drainage Area 1, as shown in Figure 5-6 includes:

- Eight catch basins with 605-lf of collection pipe and 50-lf of discharge pipe.
- Treatment through a swirl separator and 600-sf infiltration area with 20 infiltration chambers. This precast concrete unit provides up to 1.8 cfs of treatment during every storm with particle removal down to 50 microns, while the infiltration practices are estimated to be 1.67 cfs. Infiltration rates were estimated based on documented wastewater permit information for an adjoining property.
- Estimated annual phosphorus load through this discharge would be reduced from 2.38 kg to 0.95 kg, as estimated by the STPC.
- The hydrodynamic swirl separator would also remove sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river.
- Stormwater runoff is also reduced by the removal of asphalt in this drainage area.

Stormwater collection in Drainage Area 2, as shown in Figure 5-7 includes:

- Eight catch basins with 465-lf of collection pipe and 55-lf of discharge pipe.
- Treatment for this area is through a swirl separator with an R-Tank infiltration area. This precast concrete structure provides 1.8 cfs of treatment during every storm event with particle removal down to 20 microns, while the R-Tank infiltration is estimated for 1.89 cfs.
- The estimated annual phosphorus load through this discharge would be reduced from 0.97 kg to 0.73 kg, as estimated by the STPC.
- This unit would also remove sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river.

Stormwater collection in Drainage Area 3, as shown in Figure 5-8 includes:

- Proposed 24-inch HDPE culvert with a stabilized outfall and 55-lf stone-lined swale with one stone check dam. Lining the swale with stone increases the Manning coefficient and reduces the velocity of the flow through the swale.
- The stone check dam will also work to reduce the velocity while providing an area to hold back large debris and litter.

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FIGURE NO. 5-6

ALTERNATIVE 2
AREA 1
MAIN STREET TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 2

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FIGURE NO. 5-7

ALTERNATIVE 2
AREA 2
BRICKHOUSE ROAD TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 2

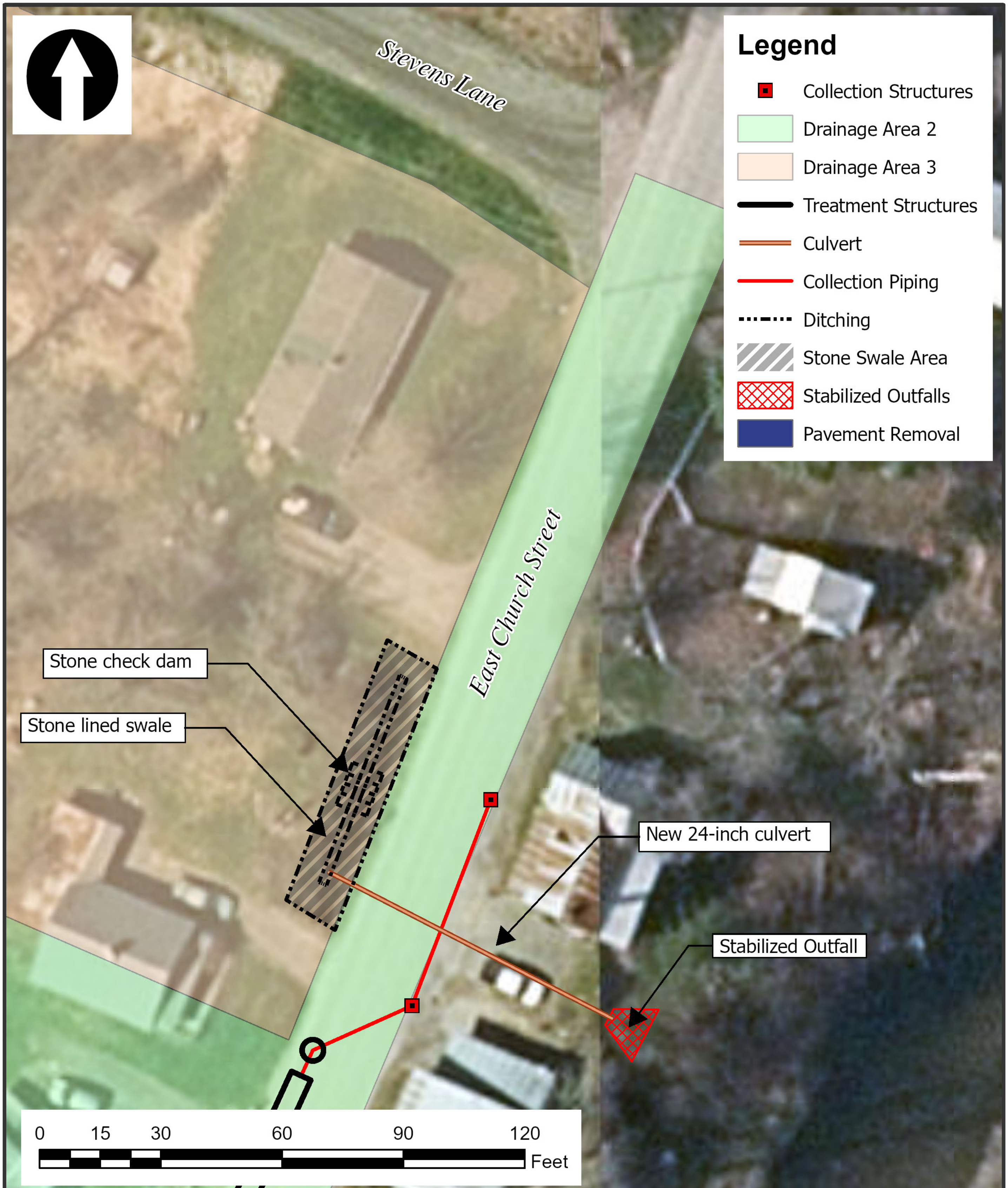

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FIGURE NO. 5-8

ALTERNATIVE 2
AREA 3
EAST CHURCH STREET CULVERT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 2

The estimated cost for construction of the improvements described for Alternative 2 in Drainage Areas 1-3 above is presented in Table 5-2 below.

Table 5-2: Alternative 2 cost estimate

System	Description	Quantity		Cost Per Unit	Total Cost
Collection	Catch Basin	16	ea	$ 6,400	$ 102,400
	15-inch HPDE Pipe	210	lf	$ 85	$ 17,850
	18-inch HPDE Pipe	420	lf	$ 100	$ 42,000
	24-inch HPDE Pipe	160	lf	$ 125	$ 20,000
	Drainage Manhole	2	ea	$ 5,600	$ 11,200
Cascade CS4	Unit	2	ea	$ 14,000	$ 28,000
	Excavation	40	cy	$ 35	$ 1,400
	Structural Backfill	20	cy	$ 45	$ 900
Infiltration Chambers	Units	20	ea	$ 265	$ 5,300
	Excavation	100	cy	$ 35	$ 3,500
	Stone Backfill	45	cy	$ 45	$ 2,025
R-Tank	Units	170	ea	$ 78	$ 13,294
	Excavation	110	cy	$ 35	$ 3,850
	Subbase	40	cy	$ 65	$ 2,600
Stone swale	Excavation	90	cy	$ 35	$ 3,150
	Stone	60	cy	$ 75	$ 4,500
Outfall (3)	Excavation	35	cy	$ 35	$ 1,225
	Stone	35	cy	$ 75	$ 2,625
Restoration	Pavement	180	ton	$ 260	$ 46,800
Miscellaneous Work and Cleanup 20%		1	LS	$ 62,600	$ 62,600
Total Estimated Construction Cost					$ 375,219
Contingency (20%)					$ 75,100.00
Estimated Engineering (based on DEC Fee Curve)					$ 78,900.00
Total Estimated Project Cost					**$ 529,219**

Notes:
1. Costs are based on 2025 construction.
2. Engineering Fees are based on DEC Engineering Fee Allowances.
3. Costs will need to be updated as design progresses.

Alternative 3

Alternative 3, as shown in Figure 5-9, identifies the same Drainage Area 1 but modifies Drainage Areas 2 and 3. This alternative utilizes the same treatment as Alternative 2 to reduce the volume and velocity at the Main Street discharge, but provides some modification to eliminate the discharge between 40 and 52 East Church Street. Drainage Area 2 in this alternative is 3.2 acres with 1.0 acres of impervious area and Drainage Area 3 is 11.2 acres of primarily pervious area.

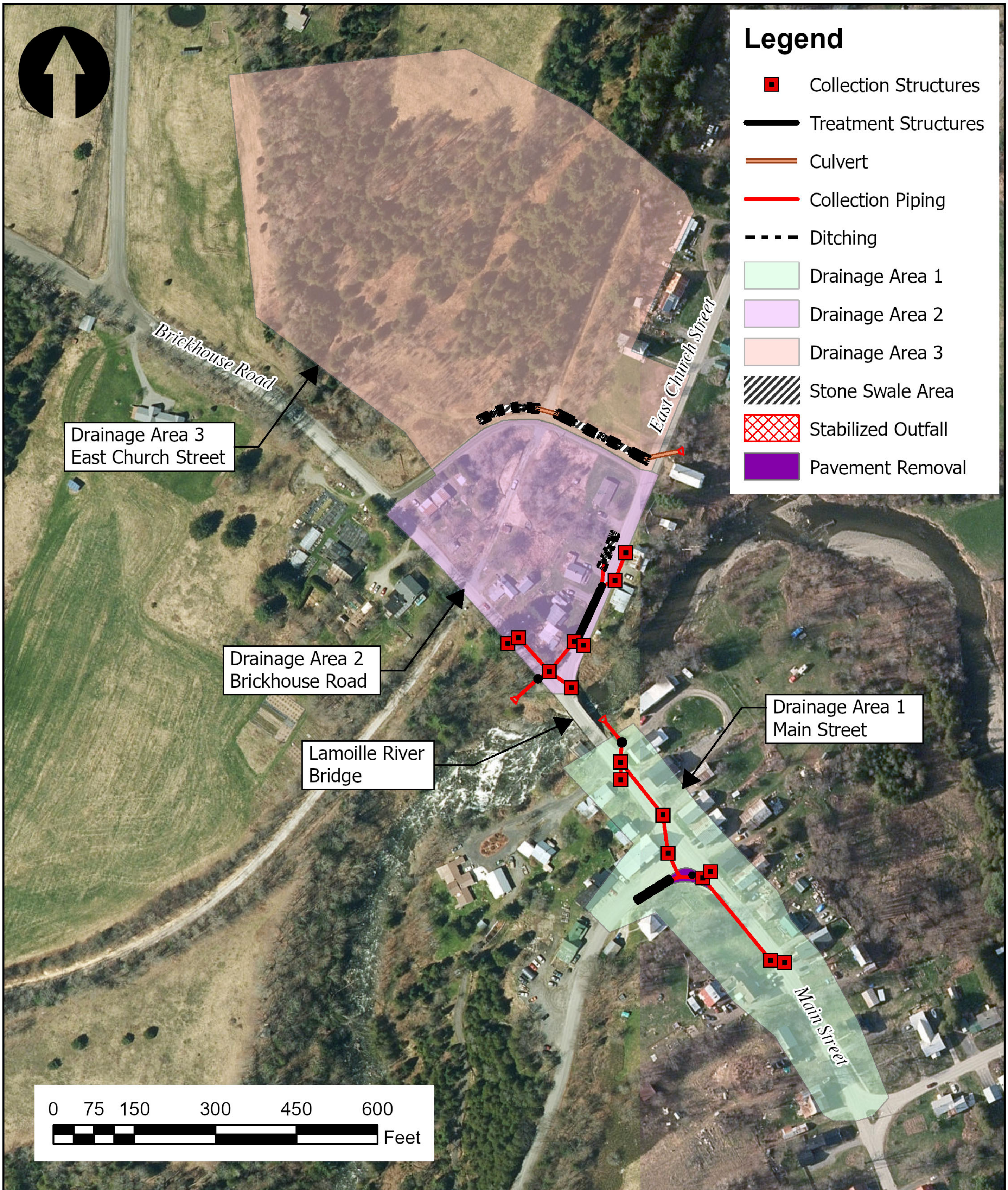

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FIGURE NO. 5-9

ALTERNATIVE 3
OVERALL PLAN

HARDWICK, VERMONT

PROJECT NO. 7124009

PROJECT MJR. AJD

SCALE AS SHOWN

DATE APRIL 25, 2025

FILE NAME Stormwater Option 3

Stormwater collection and treatment in Drainage Area 1, as shown in Figure 5-10 includes:

- Eight catch basins with 605-lf of collection pipe and 50-lf of discharge pipe.
- Treatment for this area is through a swirl separator and 600-sf infiltration area with 20 infiltration chambers. This precast concrete unit provides up to 1.8 cfs of treatment during every storm with particle removal down to 50 microns, while the infiltration practices are estimated to be 1.67 cfs. Infiltration rates were estimated based on documented wastewater permit information for an adjoining property.
- The estimated annual phosphorus load through this discharge would be reduced from 2.38 kg to 0.95 kg, as estimated by the STPC.
- The swirl separator unit would also remove sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river.
- Stormwater runoff is also reduced by the removal of asphalt in this drainage area.

Stormwater collection and treatment in Drainage Area 2, as shown in Figure 5-11 includes:

- Eight catch basins with 465-lf of collection pipe and 55-lf of discharge pipe with an addition of an 18-inch HDPE intake to collect the drainage swale that previously discharged between 40 and 52 East Church Street.
- Treatment for this area is through a swirl separator with an R-Tank infiltration area. This precast concrete structure provides 0.64 cfs of treatment during every storm event with particle removal down to 20 microns, while the R-Tank infiltration is estimated to be 1.89 cfs.
- With the increased size of the drainage area, the STPC estimates the annual phosphorus load through this discharge would be reduced from 1.77 kg to 0.85 kg.
- This unit would also remove sediment from winter road maintenance, litter and debris in the stormwater collection system that otherwise would have been discharged to the river.

Stormwater collection and treatment in Drainage Area 3, as shown in Figure 5-12 includes:

- A proposed 24-inch HDPE culvert with a stabilized outfall crossing East Church Street at the intersection of Stevens Lane, 18-inch HDPE culvert across the Lamoille Valley Rail Trail and 280-lf stone-lined swale with stone check dams. Lining the swale with stone reduces the velocity of the flow through the swale.

- The stone check dams will also work to reduce the velocity while providing an area to hold back large debris and litter.
- This alternative eliminates an existing discharge pipe between two existing structures and allows for the discharge to occur in a highly vegetated area approximately 150-ft from the riverbank.

The estimated cost for construction of the improvement described for Alternative 3 in Drainage Areas 1-3 above is presented in Table 5-3 below.

Table 5-3: Alternative 3 cost estimate

System	Description	Quantity		Cost Per Unit	Total Cost
Collection	Catch Basin	16	ea	$ 6,400	$ 102,400
	15-inch HPDE Pipe	210	lf	$ 85	$ 17,850
	18-inch HPDE Pipe	465	lf	$ 100	$ 46,500
	24-inch HPDE Pipe	165	lf	$ 125	$ 20,625
	Drainage Manhole	3	ea	$ 5,600	$ 16,800
Cascade CS4	Unit	2	ea	$ 14,000	$ 28,000
	Excavation	40	cy	$ 35	$ 1,400
	Structural Backfill	20	cy	$ 45	$ 900
Infiltration Chambers	Units	20	ea	$ 265	$ 5,300
	Excavation	100	cy	$ 35	$ 3,500
	Stone Backfill	45	cy	$ 55	$ 2,475
R-Tank	Units	170	ea	$ 78	$ 13,260
	Excavation	110	cy	$ 35	$ 3,850
	Subbase	40	cy	$ 65	$ 2,600
Stone swale	Excavation	890	cy	$ 35	$ 31,150
	Stone	615	cy	$ 75	$ 46,125
Outfall (3)	Excavation	35	cy	$ 35	$ 1,225
	Stone	35	cy	$ 75	$ 2,625
Restoration	Pavement	185	ton	$ 260	$ 48,100
Miscellaneous Work and Cleanup 20%		1	LS	$ 79,000	$ 79,000
				Total Estimated Construction Cost	$ 473,685
				Contingency (20%)	$ 94,800.00
				Estimated Engineering (based on DEC Fee Curve)	$ 98,200.00
				Total Estimated Project Cost	**$ 666,685**

Notes:

1. Costs are based on 2025 construction.
2. Engineering Fees are based on DEC Engineering Fee Allowances.
3. Costs will need to be updated as design progresses.

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FIGURE NO. 5-10

ALTERNATIVE 3
AREA 1
MAIN STREET TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 3

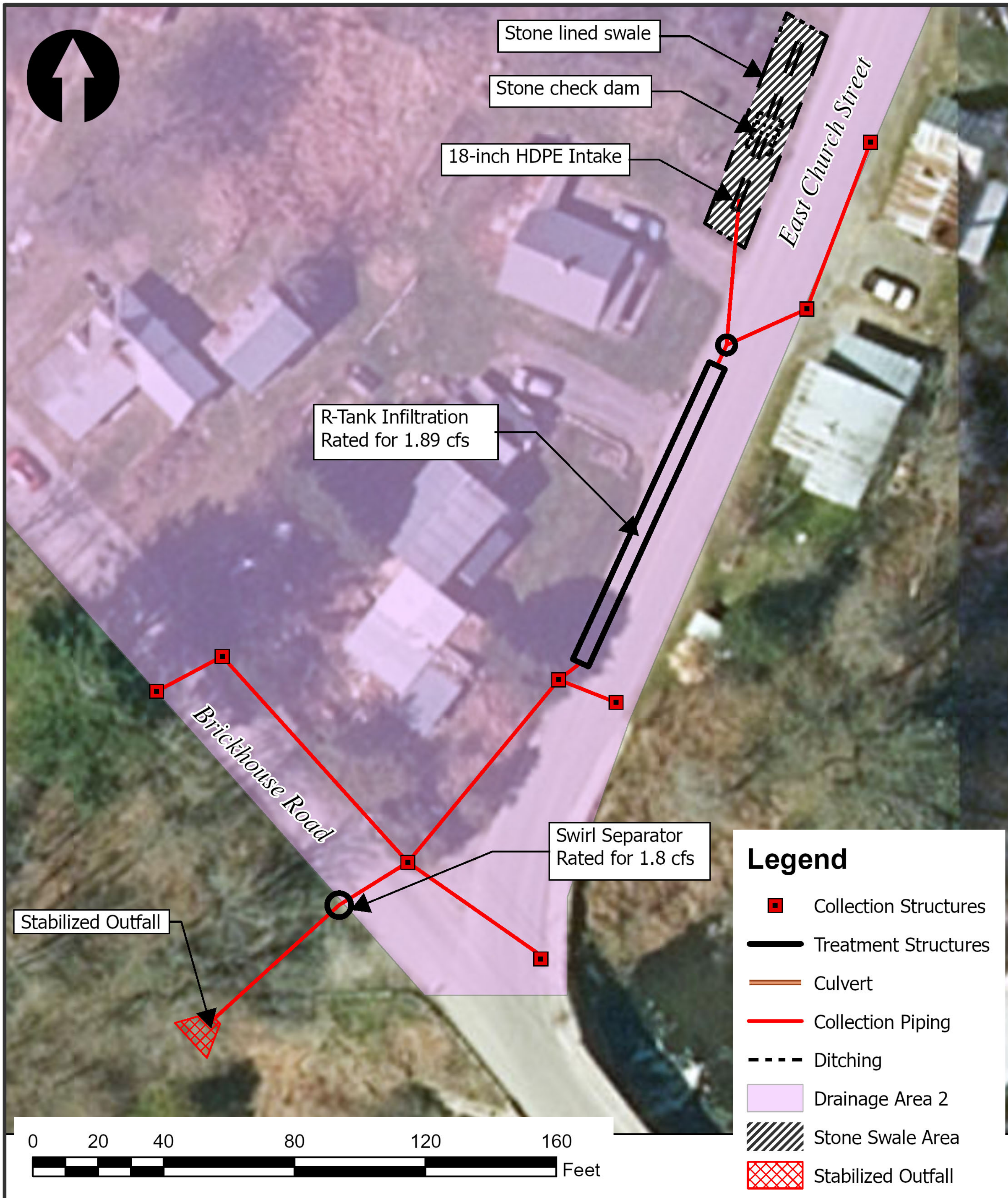

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FIGURE NO. 5-11

ALTERNATIVE 3
AREA 2
BRICKHOUSE ROAD TREATMENT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 3

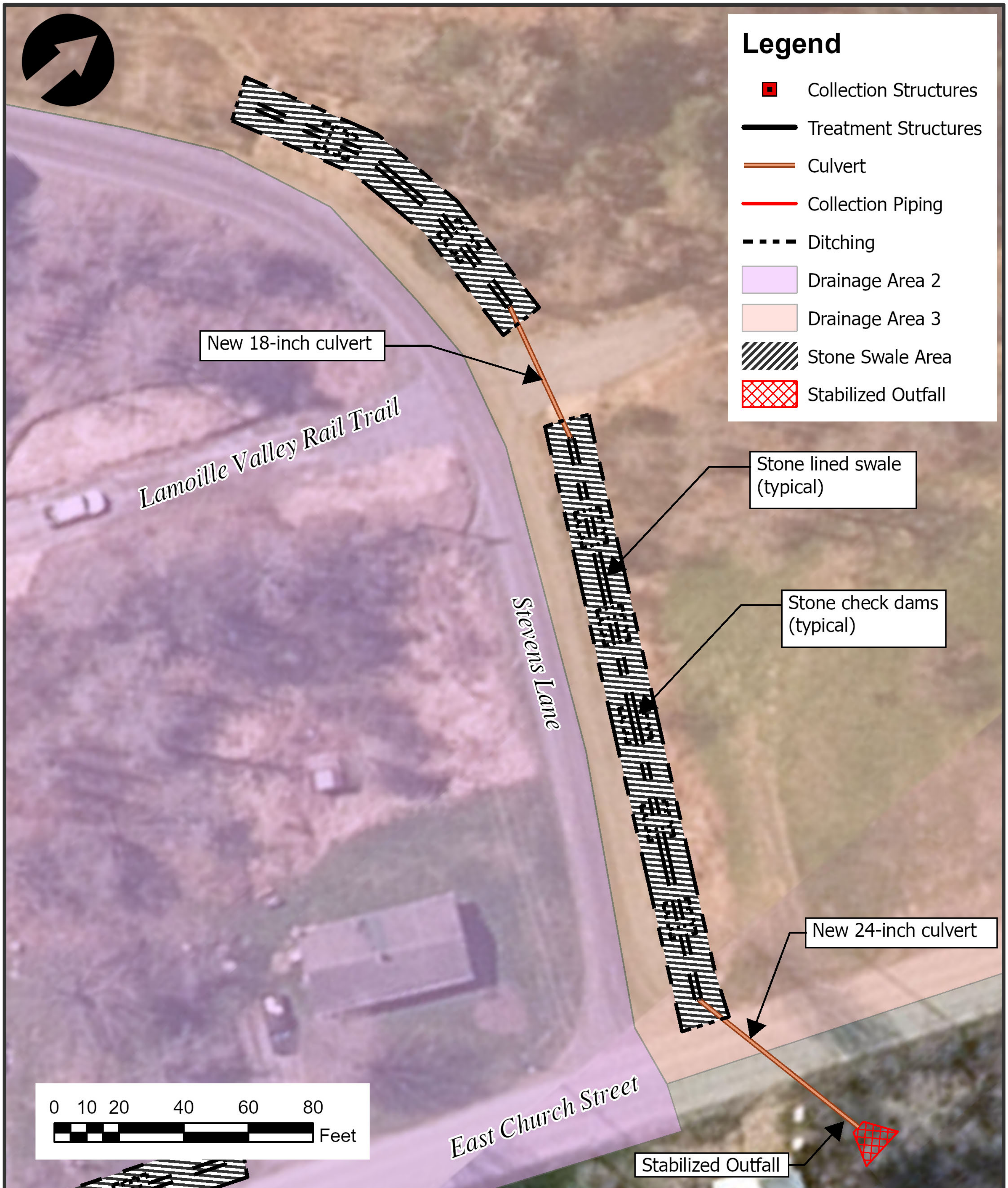

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FIGURE NO. 5-12

ALTERNATIVE 3
AREA 3
EAST CHURCH STREET CULVERT

HARDWICK, VERMONT

PROJECT NO.	7124009
PROJECT MJR.	AJD
SCALE	AS SHOWN
DATE	APRIL 25, 2025
FILE NAME	Stormwater Option 3

Alternatives Summary

All alternatives have been designed to collect stormwater and discharge to the Lamoille River with treatment that removes some total suspended solids (TSS), oil and phosphorus. Alternatives 2 and 3 also include infiltration that qualifies as groundwater recharge and increases the phosphorus removal while decreasing the volume of water at the discharge. Below is a table summarizing the alternatives.

Table 5-4: Alternative Summary

	Alternative 1	Alternative 2	Alternative 3
Total Project Cost	\$487,520	\$529,219	\$666,685
Impervious Surface (Acres)	10.9	10.9	13.9
Pervious Surface (Acres)	4.5	4.5	5.0
Phosphorus Load (kg/year)	3.35	3.35	4.15
Phosphorus Removal (kg/year)	0.39	1.67	2.35
Groundwater Recharge (cubic feet)	0	5,000	5,000
Total Outlets for Maintenance	4	4	3

Note: All recommended infiltration areas will need to be field tested for exact infiltration rates, depth to ground water and depth to ledge as required in the 2017 Vermont Stormwater Management Manual.

6 RECOMMENDED PROJECTS

The recommended alternative is Alternative 3. This alternative treats the largest area and addresses the issues outlined in Section 2 related to stormwater collection and discharge control as well as nutrient removal to improve overall water quality. The issues from Section 2 are listed below with how they are addressed by Alternative 3.

- Inadequate and deteriorated existing stormwater collection system.
    - New stormwater collection system proposed.
- Excessive impervious area.
    - Reduction of asphalt at the intersection of Main Street and Cedar Street.
- Lack of erosion control at discharge points.
    - Addition of outlet protection to the hydrodynamic separator discharges.
    - Removal of one existing discharge point.

A summary of recommended project for each identified stormwater problem area is included below. Preliminary plans for Alternative 3 are included in Appendix B. Should funding require phasing of the project, cost estimates for each drainage area are included in Appendix C. It should be noted that completing the project as one large project does provide engineering and construction cost efficiencies. If the project is phased, the improvements on Brickhouse Road will need to occur after improvements are completed on East Church Street.

1. Main Street

The proposed improvements for Main Street include a new collection system through new collection mains and catch basins and treatment through infiltration and separation as outlined in Alternative 3. Treatment for this area is through a Cascade CS4 swirl separator and 600-sf infiltration area with 20 infiltration chambers. The infiltration chambers are proposed to be in the intersection of Cedar and Main Streets where excess asphalt is removed. The treatment unit is proposed to be located on the northeast side of the Main Street bridge.

2. Brickhouse Road

The proposed improvements to address stormwater on Brickhouse Road are included in Alternative 3. These improvements include the addition of catch basins and storm drain pipe to direct the stormwater to the treatment and discharge proposed to be in Overlook Park.

3. East Church Street

The proposed improvements to address stormwater on East Church Street are included in Alternative 3. These improvements include new stormwater collection through catch basins with 465-lf of collection pipe and 55-lf of discharge pipe with an addition of an 18-inch pipe intake to collect the drainage swale that previously discharged between 40 and 52 East Church Street. Treatment for this area is through a Cascade CS4 swirl separator with an R-Tank infiltration area.

From Stevens Lane, a new 24-inch culvert with a stabilized outfall crossing East Church Street at the intersection of Stevens Lane, 18-inch culvert across the Lamoille Valley Rail Trail and 280-lf stone-lined swales with stone check dams are proposed.

4. Main Street and Cedar Street

The improvements for the intersection of Main Street and Cedar Street include removal of existing asphalt and installation of stormwater infiltration chambers. These improvements are included as part of the overall improvements to Main Street as outlined in Alternative 3.

7 OPERATION AND MAINTENANCE

7.1 TREATMENT SYSTEM

Recommendations for maintenance of the collection and treatment systems include inspections a minimum of two times per year in the spring and fall, but more frequently in areas where road sanding occurs and after heavy rainfall events. During the first few years of operation, it is recommended that the system be inspected every month but no less frequently than quarterly to determine the rate of accumulation of solids and then semi-annually if determined to be appropriate from quarterly inspections.

If maintenance is not performed, sediments may accumulate outside the swirl chamber which will require pumping out of other chambers in the device. All chambers should be checked for sediment accumulation during regular inspections.

Sediments and other accumulated trash will be removed from the treatment units using a vacuum truck. Any oil or other hydrocarbons collected are most easily removed utilizing adsorbent pads. This should be incorporated into the Town's existing annual maintenance of stormwater treatment devices.

7.2 COLLECTION SYSTEM

Catch basins in the collection system should be cleaned annually to remove sediment and maintain function. In addition, culverts and ditches should also be inspected and cleaned annually and after any significant storm events to prevent debris from obstructing flow.

8 PERMITTING

Construction of the proposed improvements is likely to require several permits from local and state agencies. A list of the potential permits is included below, however, depending on the funding source, additional permitting may be necessary.

- **Wetlands** - There are no mapped wetlands within 50 feet of the area that will be disturbed therefore wetlands permitting is not anticipated. However, a wetland scientist should be consulted during the final design phase to review the area of disturbance for any wetlands.
- **Floodplain** - Given the proximity to the Lamoille River, some improvements will be in the floodplain. Local floodplain permitting will be necessary for these improvements.
- **Rivers** – Any work that may impact the river channel may require a stream alternation permit. The Rivers Management Engineer should be consulted during design to verify permit requirements.
- **Historical/Archaeological Review** – Due to the Village being deemed a Historic District, a review of the proposed improvements will likely require review by the Department of Historic Preservation. Depending on the funding source, an Archaeological Resource Assessment may also be necessary.
- **National Environmental Policy Act (NEPA)** – Projects constructed using federal funds often require a NEPA review. This review considers impacts to natural, cultural, and environmental resources.
- **Right-of-Way** – The recommended project will likely require construction easements to allow for installation. In addition, some improvements are proposed on property owned by the East Hardwick Fire District. The necessary easements will need to be obtained prior to construction.

9 ADDITIONAL RECOMMENDED MEASURES

Due to site limitations, primarily steep slopes and lack of undeveloped land, the level of treatment achieved by some other systems was not possible in this application. Therefore, it is recommended that the State and Town consider some other options for reducing stormwater flow from private property and the contaminant load reaching the outfall.

Measures to reduce contaminant loading could include:

- Public education and notification through signage.
- Work with area schools to develop programs to educate students.
- Educate pet owners about the impact of pet waste.
- Small-scale integrated management practices applied throughout the collection system.

The best way to prevent contamination of our waterways is to prevent contamination from entering the storm drain system. Public education programs are the most effective measures to achieve this goal.

Recommended measures to reduce stormwater flow from private property are included in the Vermont Guide to Stormwater Management for Homeowners & Small Businesses. Some of the recommended measures from that guide include:

- Rain barrels.
- Dry wells.
- Infiltration trenches.
- Rain gardens.

The timing of construction of any of the recommended improvements should be considered in relation to the reconstruction of the Main Street bridge. The Main Street bridge and associated weir is recommended for evaluation in the Upper Lamoille River Stream Geomorphic Assessment Phase 2 Report completed in February 2009.

APPENDIX

A PREVIOUS STORMWATER REPORTS

Town of Hardwick

East Hardwick

Stormwater Infrastructure Mapping Project

January 2017

VTDEC – CLEAN WATER INITIATIVE PROGRAM, WATERSHED MANAGEMENT DIVISION

https://dec.vermont.gov/water-investment/cwi/solutions/developed-lands/idde

Jim Pease, Jim.Pease@vermont.gov
David Ainley, David.Ainley@vermont.gov

Overview

This stormwater infrastructure mapping project was completed for the municipality by the Agency of Natural Resources Ecosystems Restoration program to supplement the existing drainage data collected by the town and with the intention of providing a tool for planning, maintenance, and inspection of the stormwater infrastructure.

The GIS maps and geodatabase are meant to provide an overall picture and understanding of the connectivity or connectedness of the storm system on both public and private properties. They can be used to: (1) raise the awareness of the need for regular maintenance, the generation and transport of nonpoint source pollution increases with increasing connectivity of a drainage system, (2) as a valuable tool for hazardous material spill planning and prevention, (3) for the detection and elimination of illicit discharges; outfall locations and system connectedness data are used as a base for locating illicit or illegal discharges of non-stormwater to the municipal storm system and tracing them up to the source, (4) better assist the municipality in planning and implementing combined stormwater-sewer separation projects, (5) inform options for cleaning up existing polluted stormwater discharges; this report provides information and guidance for potential retrofit treatment locations and opportunities, (6) assist municipalities and residents with emergency preparedness for large rainfall events (i.e. Tropical Storm or Hurricanes) or spring snowmelt runoff events, by keeping storm drains clean, clear and open a good deal of localized flooding could be prevented, and (7) the basis for a local stormwater ordinance or be used to help enhance an existing stormwater management program.

Project Summary

The principal goal of this project was to develop up to date municipal drainage maps. These drainage maps were created showing the paths that stormwater runoff travels from where it falls on impervious surfaces such as parking lots, roads, and rooftops, to the outfall points in various receiving waters. These maps show the stormwater infrastructure including features like pipes, manholes, catchbasins, and swales within a municipality. Data sources included data collected from field work, a mapping grade Trimble GPS unit, available state permit plans, record drawings, town plans, WWMD plans, existing GIS data from contractors, and the input and guidance of knowledgeable members from the municipalities.

A second goal of this project was to establish potential locations for Best Management Practice (BMP) stormwater retrofit sites. These are sites where stormwater treatment structures could be added and where they would be most cost effective and efficient for sediment and phosphorus or nitrogen removal. In order to develop a retrofit site list, drainage area subwatersheds were delineated around the drainage networks. Determining how the stormwater infrastructure was connected was necessary in determining the subwatershed drainage areas within the town.

Delineating the drainage areas was done using the stormwater infrastructure maps, along with satellite imagery, a Digital Elevation Model (DEM), and USGS topographic maps. These data sources were used to approximate where the land area within each municipality was draining to; as well as where the high points were that divided the sub-drainage areas. The completed maps show the drainage coverage for essentially the entire municipality, but with a focus on areas with greater concentrations of impervious cover.

Impervious cover layers were created by either hand digitization or by using a method of raster pixel calculation (with ArcGIS spatial analyst extension) to create a vegetation index from the National Agricultural Imagery Program (NAIP) 08 orthophotos. The area which contrasted with the vegetation represents impervious surfaces and was then modified with buffered water and roads layers to make it more accurate. A more detailed explanation of this process is available in a separate document. The impervious layer was used to calculate the percent of each delineated drainage area that would generate stormwater runoff. The percentage of impervious surface number for each subwatershed was then adjusted with a connectivity rating. A rating was assigned to each drainage area polygon describing how directly connected the impervious surfaces within that subwatershed are to the receiving water. By adjusting the percent impervious area numbers with this connectivity rating the effective impervious area (EIA) was established for each subwatershed (*Sutherland, 1995*). This effective impervious number is a more accurate description of the amount of runoff produced by each of the subwatersheds because it helps to take factors such as infiltration into account.

After the effective impervious numbers were calculated for the subwatersheds the Simple Method was used to estimate the annual sediment (TSS) and phosphorus (TP) or Nitrogen (TN) loads generated by each subwatershed. The Simple method uses information which includes the adjusted impervious value, average annual rainfall for the location, total subwatershed area, and a given pollutant concentration value to calculate an annual load for various pollutants (*Schueler,1987*). Pollutant loads estimated by the Simple Method in this project are planning level estimates and are meant to give a general idea of the amounts of sediment or nutrient wash-off produced by each subwatershed for prioritization purposes. Subwatersheds were then prioritized, using the loading calculations as well as other criteria, and given Action List numbers ranging from 1 to 3 (one being the highest priority). The Action List number depends both upon loading values and feasibility of potential retrofit treatment options. Potential retrofit options listed in the TARGET maps are based on field observations and not on actual availability of land or willingness of landowner.

Water Quality Volume (WQv – the amount of storage needed to treat stormwater from a 0.9-1.0-inch storm) and Channel Protection Volume (CPv – the volume of storage that is needed to hold and slowly release stormwater for a 2.1inch rain event) were also calculated for delineated subwatershed areas. CPv calculations are only applicable if the receiving water is not a large body of water and is therefore susceptible to channel erosion. These numbers were used in the retrofit recommendation process because the volume of water to be treated was a key factor in determining the type of retrofit.

Project References

Schueler, T. 1987. Technical Documentation of a Simple Method for Estimating Urban Storm Pollutant Export. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Appendix A.

Schueler, T. et.al., 2007. Urban Stormwater Retrofit Practices, Version 1.0. Manual 3, Center for Watershed Protection, August 2007.

Sutherland, R. 1995. Methodology for Estimating the Effective Impervious Area of Urban Watersheds. Technical Note 58 – Pervious Area Management. Watershed Protection Techniques. Vol. 2, No. 1

***All data was created in an ArcGIS 10 Geodatabase format and is available from VTDEC.**

Act 64 Municipal Roads General Permit (MRGP)

The 2015 Vermont Legislature adopted Act 64 which will require all municipalities to address stormwater runoff from all existing municipal roads. The time line for adopting this general permit is as follows: December 2016 – Draft general permit available for informal public review, Summer-Fall of 2017 public hearings and comments and review, January 2018 final general permit issued; municipalities must file notice of intents to comply with the permit, currently proposed for summer 2018. The permit will likely require:

- Municipalities will develop road Stormwater management plans (RSWMPs). RSWMPs will include a comprehensive road erosion inventory of hydrologically-connected road segments and Implementation Plan and Schedule.
- The inventory will include an evaluation municipal hydrologically-connected road segments to see if they meet new MRGP standards. Road erosion inventories will be conducted every 5 years.
- Road segments that do not currently meet MRGP standards and that can impact waterways will be prioritized for remediation within the Implementation Plan and Schedule DEC has developed an Implementation Table and Schedule Excel spread sheet template for this purpose.

Towns will submit semi-annual reports to DEC documenting progress in road BMP implementation and MRGP compliance. Municipalities will be able to use the Implementation Table and Schedule spread sheet, mentioned above, for semi-annual compliance reporting requirements. The Road Erosion Inventory and Implementation Plan and the mapping information contained in it can be used by municipalities to develop the plan for the directly connected paved with catchbasin segment outfalls of municipal roadways. A map(s) is provided on the following page(s) indicating where these outfalls are located, based on the best available information DEC has to date. While the general permit requirements for directly connected paved roads with catchbasins is currently under discussion and not final it is very likely that if these outfalls are eroded they will need to have a scheduled outfall erosion repair. As with other classes of roads covered by this permit the municipality should first check the maps provided. It is suggested (although not currently required) that the following steps be taken to check the maps to determine what outfalls will require municipal attention for erosion repair:

1. Using the provided maps and/or data as a guide confirm that the road draining to this outfall is paved, has at least a single side of curb, has catch basins or drop inlets, and the discharge pipe from those catchbasins is directly discharging to waters of the state. Include any outfall within 500 linear feet of surface waters.

2. Using the maps locate the outfall and note any level of erosion present in the outfall and/or the 500 foot or less long swale between the pipe outlet and waters of the state.

3. Prepare a list of all outfalls with notes pertaining to the erosion based on the Town's ability to repair the erosion (minor, moderate or severe), the extent of erosion (an estimate in linear feet of repair needed including private property if the erosion exists on that property, and a cost estimate if possible.

Outfalls draining municipal roads and within 500 feet of a waterbody

Subwatershed Data

Tables showing calculations and Priority drainage area retrofit possibilities

This is a key showing the abbreviations of the different funding programs listed in the calculation sheets.

Abbreviation Key	
Code	**Funding Program**
ERP/CWIP	VTDEC Clean Water Initiative Program
LCBP	Lake Champlain Basin Program
SRF	Clean Water State Revolving Loan Fund
VTrans	Vermont Agency of Transportation

This is a key showing the abbreviations of the different stormwater treatment structures or practices listed in the calculation sheets.

Abbreviation Key	
Code	**Structure Type**
BB	Baffle Box
BFCB	Baffled Catchbasin
BRA	Bioretention Area or Raingarden
BS	Buffer Strip (25' Min.)
CB	Catch Basin
CBI	Catch Basin Insert
CD	Check Dam
CR or ESRD	Impervious Disconnection Credits
DS	Dry Swale
DW	Drywell
EDPMP	Extended Detention Pond with Micropool
GS	Grass Swale
IB	Infiltration Basin
IG	Infiltration Gallery
MOD	Modifications/upgrade to 2002 SW standards
OF	Overland Flow
OGF	Organic Underground Filter
POP	Pocket Pond
PP	Perforated Pipe for infiltration
PS	Pump Station
RDD	Roof Drain Disconnect
RR	Rock Riprap
RS	Riprap Swale
SB	Sediment Basin
SF	Surface Sand Filter
SS-SF	Swirl Separator – Sand Filter
SS OR VS	Swirl Separator
SWPPP	Stormwater Pollution Prevention Plan
TT	Treatment Tank
UD	Underdrain in basin
WL	Wetland (Constructed)
WP	Wet Pond (Retention)
WS	Wet Swale

East Hardwick - Subwatershed Prioritization and Recommendations

Watershed Number	Action List #	Proposed Action	Proposed or Existing Stormwater Treatment Practice	Permit Number	Watershed Area (Acres)	Percent Mapped Impervious Area (MIA)	Sediment Load with Current Reductions (lbs.)	Sediment Load with Priority Action (lbs.)	Phosphorus Load with Current Reductions (lbs.)	Phosphorus Load with Priority Action (lbs.)
57 Hardwick			GS/OF		73.0	2.4	5156	5156	14.32	14.32
58 Hardwick			GS		16.1	12.2	1886	1886	5.24	5.24
59 Hardwick			GS		0.3	35.0	103	103	0.29	0.29
60 Hardwick	1	Bioretention area in island next to Rte 16	BRA/GS/OF		285.5	2.5	20228	12137	56.19	42.14
61 Hardwick			OF/GS		27.6	13.6	3471	3471	9.64	9.64
62 Hardwick	1	Outfall stabilization, Swirl Separator	VS/RR/CB		3.0	54.4	1933	387	5.37	3.22
63 Hardwick			GS/OF		29.2	13.8	3722	3722	10.34	10.34
64 Hardwick			GS/OF		19.0	9.7	1944	1944	5.40	5.40
66 Hardwick			CB/OF		1.7	30.5	446	446	1.24	1.24
67 Hardwick			GS/CB/OF		10.9	8.0	1016	1016	2.82	2.82
68 Hardwick			GS/OF		19.7	5.1	1574	1574	4.37	4.37
69 Hardwick			GS/OF		3.2	19.5	533	533	1.48	1.48
70 Hardwick			GS/OF		26.0	2.9	1877	1877	5.21	5.21

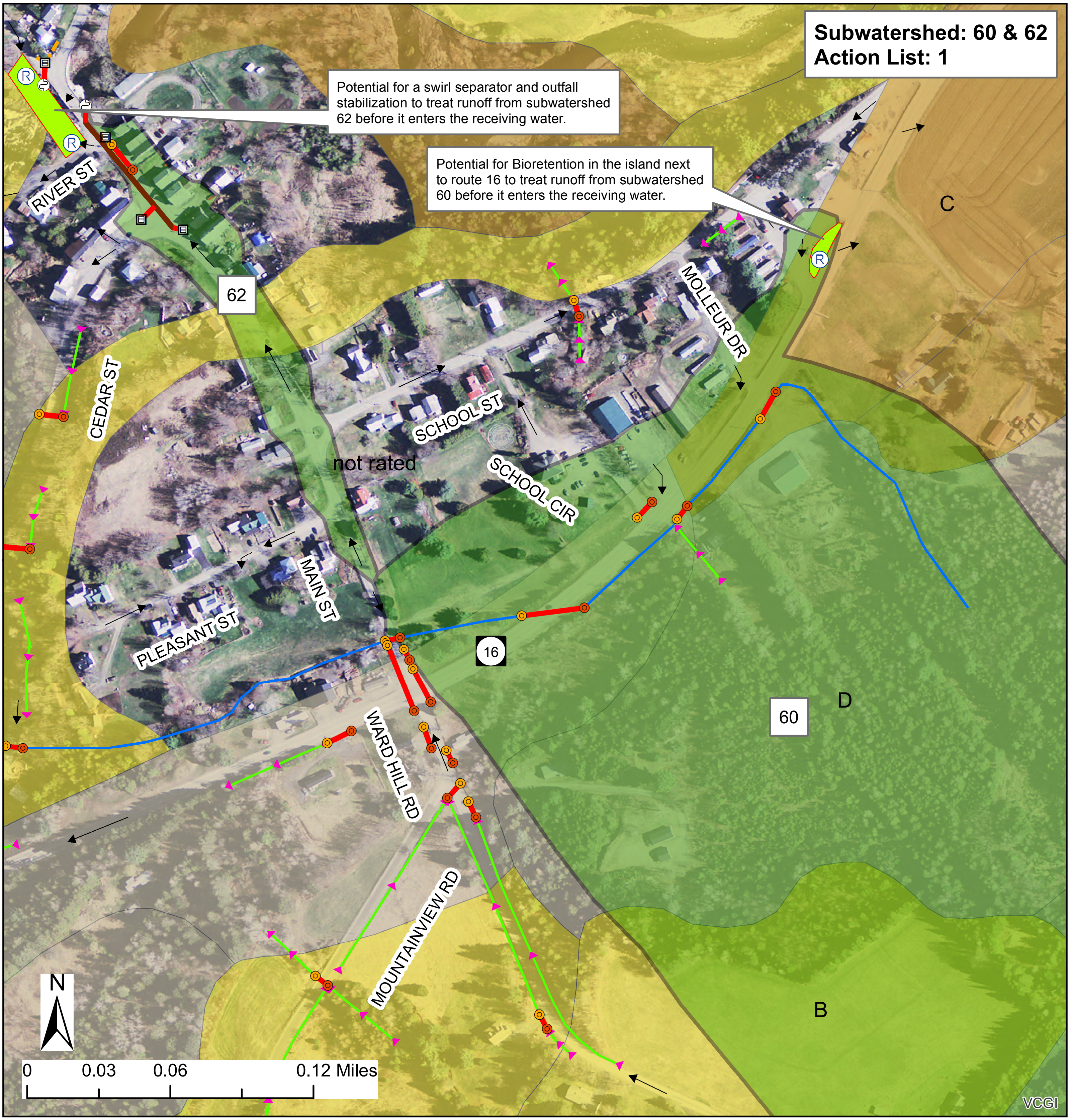
East Hardwick - Subwatershed Prioritization and Recommendations

Watershed Number	Water Quality Volume (Acre-Feet)	Channel Protection (Acre-Feet)	Estimated Basin Construction Cost	Estimated Other BMP Construction Cost	Cost of Sediment Removal Per Pound (based on annual sediment load)	Cost of Nitrogen or Phosphorus Removal Per Pound (based on annual nutrient load)	Assistance Program	# LID-Roof Raingardens to Treat Water Quality Volume	Raingarden Cost
57 Hardwick	0.29	FALSE					CWIP,LCBP,VTRANS,SRF	146	$67,095
58 Hardwick	0.11	FALSE					CWIP,LCBP,VTRANS,SRF	53	$24,546
59 Hardwick	0.01	FALSE					CWIP,LCBP,VTRANS,SRF	3	$1,337
60 Hardwick	1.14	FALSE	$25,000		$3	$1,780	CWIP,LCBP,VTRANS,SRF	572	$263,223
61 Hardwick	0.20	FALSE					CWIP,LCBP,VTRANS,SRF	98	$45,170
62 Hardwick	0.11	FALSE	$50,000		$32	$23,279	CWIP,LCBP,VTRANS,SRF	55	$25,154
63 Hardwick	0.21	FALSE					CWIP,LCBP,VTRANS,SRF	105	$48,429
64 Hardwick	0.11	0.20					CWIP,LCBP,VTRANS,SRF	55	$25,299
66 Hardwick	0.03	FALSE					CWIP,LCBP,VTRANS,SRF	13	$5,808
67 Hardwick	0.06	FALSE					CWIP,LCBP,VTRANS,SRF	29	$13,216
68 Hardwick	0.09	FALSE					CWIP,LCBP,VTRANS,SRF	45	$20,485
69 Hardwick	0.03	FALSE					CWIP,LCBP,VTRANS,SRF	15	$6,929
70 Hardwick	0.11	0.08					CWIP,LCBP,VTRANS,SRF	53	$24,423

Target Maps

Showing Priority Action List Drainage Areas

And Potential Retrofit Locations

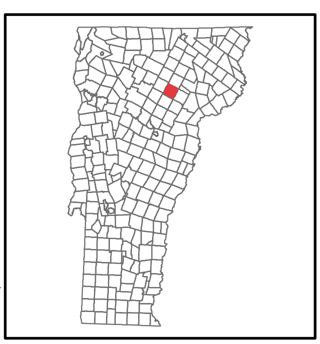


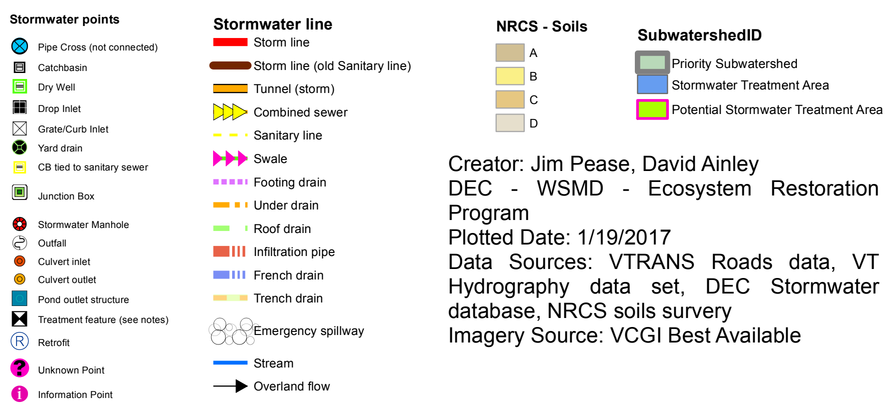
Hardwick, VT

DEC Stormwater Infrastructure Mapping Project

This map shows high priority subwatersheds which are ranked by connectedness, percent of impervious cover, field observations, and potential retrofit measures and locations.

The data shown on this map is only as accurate as the available sources and field observations allowed and should be used as a basic planning level tool only.





Creator: Jim Pease, David Ainley
DEC - WSMD - Ecosystem Restoration Program
Plotted Date: 1/19/2017
Data Sources: VTRANS Roads data, VT Hydrography data set, DEC Stormwater database, NRCS soils survery
Imagery Source: VCGI Best Available

VERMONT

Spill Control

and

Vermont Hazardous Waste Management Regulations

Have a spill control plan for accidental spills at municipal facilities and on municipal streets

These stormwater infrastructure maps show the connectivity of the stormwater system for the municipality as accurately as it could be determined with the collected and existing data. In the event of a spill this can be a valuable tool for controlling spills and in spill response.

Towns should be equipped with suitable equipment to contain and clean up spills of hazardous materials. Accidental spills of materials can be sources of runoff pollution if not addressed appropriately. If possible Towns should be prepared to address spills on municipal streets while at the same time contacting the state Waste Management Division. DPW managers should be aware of all applicable requirements and should contact regulatory authorities if requirements are not known.

All spills should be cleaned up immediately after they occur. For municipal facilities the creation of a site specific spill control and response plan in combination with spill response training for designated on-site personnel can be effective in dealing with accidental spills and preventing the contamination of soil, water, and runoff. Preparation of a spill containment, control, and countermeasures (SPCC) plan might be required to meet regulatory requirements (e.g., requirements regarding storage of specified chemicals above certain volume thresholds).

Even if a formal plan is not required, preparing one is a good idea. In general, an SPCC plan should include guidance to site personnel on the following:

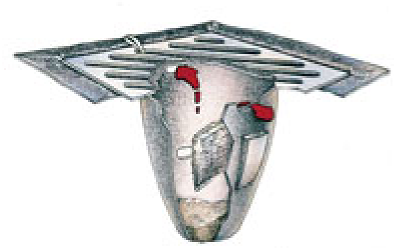
— Proper notification when a spill occurs;
— Site responsibility with respect to addressing the cleanup of a spill;
— Stopping the source of a spill;
— Cleaning up a spill;
— Proper disposal of materials contaminated by the spill;
— Location of spill response equipment programs; and
— Training for designated on-site personnel.

A periodic spill "fire drill" should be conducted to help prepare Town personnel in the event of a spill.

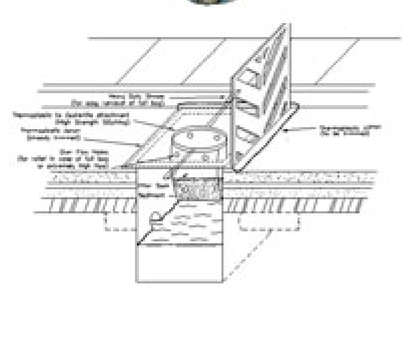
Spill Prevention and Response Measures

Catch Basin Inserts

Catch Basin Inserts (Drain Guards / Sediment Traps) protect our rivers and streams by capturing sediment, debris, oil and grease at storm water catch basins. Catch Basin Inserts are an economical and effective method to protect you from costly clean-up work.



The standard filter material is a non-woven geotextile with built-in overflow ports for cases of abnormally high water flow or over-filled filter bags. Catch Basin Inserts are available with a replaceable 5" x 15" oil absorbent boom that floats to absorb any oil, gas or diesel entering a storm water catch basin.



Urethane Drain Protector

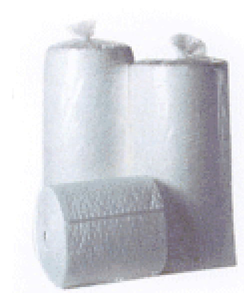
Urethane Drain Protectors are positive sealing drain covers that ensure spills do not enter drains. Drain Protectors are environmentally safe and resistant to chemicals, solvents and hydrocarbons. After use, the Drain Protector can be washed and stored in its tube storage container.

Absorbent Socks

Absorbent socks are flexible tubes used to contain and clean-up spilled fluids. Socks are widely used in industrial applications and are ideal for Spill Kits. Fast spreading spills are quickly stopped with a sock.

Drums & Intermediate Bulk Containers (IBC's)

New and reconditioned steel drums are ideal for storing solid and liquid waste. Poly drums available for durable outdoor storage or for building your own spill kits. Steel and poly drums are available in both tight-head (TH) and full open-head styles (FOH).



Pads & Rolls

Absorbent pads and rolls made from polypropylene fibers are the most popular form of absorbents on the market. Various types of absorbent pads and rolls can be used for different liquids and site applications.

The most widely used absorbent pads and rolls are oil-only (white) and universal (grey). Pads and rolls are great for spills on land, easily absorbing 20 to 25 times their own weight in recovered liquid. Rolls can easily be cut to the exact size required.

water or

Booms

Linkable Absorbent Booms

Absorbent booms are ideal for containing and cleaning up spills on water. Booms repel water and float even when completely saturated. Absorbent booms are constructed with a strong mesh outer skin encasing non-linting and highly absorbent polypropylene filler. Linkable booms come complete with end rings and clips attached to nylon rope running the length of the boom.

Collection basins
Collection basins are permanent structures in which large spills or contaminated storm water is contained and stored before cleanup or treatment. Collection basins are designed to receive spills, leaks, etc., and to prevent pollutants from being released into the environment. Unlike containment dikes, collection basins can receive and contain materials from many locations across a facility.

Containment diking
Containment dikes are temporary or permanent earth or concrete berms or retaining walls that are designed to hold spills. Diking can be used at any industrial facility, but is most common for controlling large spills or releases from liquid storage and transfer areas. Diking can provide one of the best protective measures against the contamination of storm water because it surrounds the area of concern and keeps spilled materials separated from the storm water outside of the diked area.

Curbing
Similar to containment diking, a curb is a barrier that surrounds an area of concern. Unlike diking, curbing is unable to contain large spills and is usually implemented on a small-scale basis. However, curbing is common at many facilities and in small areas where liquids are handled and transferred.

Granular Absorbents
A variety of granular and powdered absorbents are available for the effective clean-up of spills on streets, construction sites and in repair shops. These products absorb spilled liquids of various kinds to greatly lower the viscosity, aiding in the clean-up of the spill.

Sorbents, Gels, and Foams
Sorbents are compounds that immobilize materials by surface absorption or adsorption in the sorbent bulk. Gelling agents interact with the spilled chemical(s) by concentrating and congealing to form a rigid or viscous material more conducive to a mechanical cleanup. Foams are mixtures of air and aqueous solutions of proteins and surfactant-based foaming agents. The primary purpose of foams is to reduce the vapor concentration above the spill surface, thereby controlling the rate of evaporation.

§ **7-105** EMERGENCY AND CORRECTIVE ACTIONS
(a) Emergency actions
(1) In the event of a discharge of hazardous waste or a release of a hazardous material, the person in control of such waste or material shall:
(A) Take all appropriate immediate actions to protect human health and the environment including, but not limited to, emergency containment measures and notification as described below; and
(B) Take any further clean up actions as may be required and approved by federal, state, or local officials, or corrective actions as specified under **subsection (b)** of this section so that the discharged waste or released material and related contaminated materials no longer present a hazard to human health or the environment.
(2) Reporting
(A) All discharges and/or releases that meet any of the following criteria shall be immediately reported to the Secretary by the person or persons exercising control over such waste by calling the Waste Management Division at **(802) 241-3888**, Monday

through Friday, 7:45 a.m. to 4:30 p.m. or the Department of Public Safety, Emergency Management Division at **(800) 641-5005**, 24 hours/day:

(i) A discharge of hazardous waste, or release of hazardous material that exceeds 2 gallons;

(ii) A discharge of hazardous waste, or release of hazardous material that is less than or equal to 2 gallons and poses a potential or actual threat to human health or the environment; or

(iii) A discharge of hazardous waste, or release of hazardous material that equals or exceeds its corresponding reportable quantity under CERCLA as specified under **40 CFR § 302.4.**

Note: Under the Federal Water Pollution Control Act, certain spills of "oil" and/or "hazardous substances" are prohibited and must be reported pursuant to the requirements of **40 CFR Part 110** / Discharge of Oil. Certain spills of hazardous substances must also be reported pursuant to CERCLA. In both cases, the National Response Center must be notified at **(800) 424-8802**. Finally, in addition to federal and state spill reporting, EPCRA requires that spills are also reported to local authorities.

(B) A written report shall be submitted to the Secretary within ten (10) days following any discharge or release subject to **subsection (a)(1)** of this section. The report should be sent to: The Vermont Department of Environmental Conservation, Waste Management Division, 103 South Main Street, Waterbury, VT 05671-0404. The person responsible for submitting the written report may request that it not be submitted for small discharges and/or releases that were reported pursuant to subsection (a)(2)(A) of this section, and that have been entirely remediated within the ten (10) day period immediately following the discharge and/or release

(3) If the discharge or release occurred during transportation, the transporter shall, in addition to notifying the Secretary:

(A) Notify the National Response Center at (800) 424-8802 or (202) 426-2675, if required by **49 CFR § 171.15**; and

(B) Report in writing to the Director, Office of Hazardous Materials Regulations, Materials Transportation Bureau, Department of Transportation, Washington, D.C. 20590, if required by **49 CFR § 171.16**; and

(C) A water (bulk shipment) transporter who has discharged hazardous wastes must give the same notice as required by **33 CFR § 153.203** for oil and hazardous substances.

(4) If a discharge or release occurs and the Secretary determines that immediate removal of the waste is necessary to protect human health or the environment, the Secretary may authorize its removal by unpermitted transporters without the preparation of a manifest. Such hazardous waste may be transported to a site authorized by the Secretary under the provisions of **§ 7-503** to temporarily accept hazardous waste generated during an emergency cleanup of a discharge or release.

(5) In the case of an explosives or munitions emergency response, if a Federal, State, Tribal or local official acting within the scope of his or her official responsibilities, or an explosives or munitions emergency response specialist, determines that immediate removal of the material or waste is necessary to protect human health or the environment, that official or specialist may authorize the removal of the material or waste by transporters who do not have EPA identification numbers or hold Vermont hazardous waste transportation permits and without the preparation of a manifest. In the case of emergencies involving military munitions, the responding military emergency response specialist's organizational unit must retain records for three years identifying the dates of the response,

the responsible persons responding, the type and description of material addressed, and its disposition.

(6) All clean up debris and residues that are hazardous waste must be transported ultimately to either:

(A) A designated facility;

(B) A person authorized by the Secretary to use such waste if the waste has been delisted pursuant to **§ 7-218**;

(C) Some other location specified and authorized by the Secretary to receive clean up debris and residues if the waste has been delisted pursuant to **§ 7-218**; or

(D) For hazardous waste not defined as hazardous in 40 CFR Part 261 (i.e., waste regulated as hazardous by Vermont), to a facility, that is not a designated facility, located in a state other than Vermont provided the facility can receive such waste under applicable state and local laws, regulations and ordinances.

(b) Corrective actions

(1) If a discharge of hazardous waste, or a release of hazardous material has not been adequately addressed under **subsection (a)(1)(A)** of this section the Secretary may require that the person or persons responsible pursuant to **10 V.S.A. § 6615** complete the following:

(A) Engage the services of an environmental consultant experienced in the investigation and remediation of hazardous waste-contaminated sites; and

(B) Within thirty (30) days from either the date of the discharge/release or the date that the release was discovered if the date of discharge/release is not known, or within a period of time established by an alternative schedule approved by the Secretary, submit for approval by the Secretary a work plan for an investigation of the contaminated site (i.e., site investigation) prepared by the environmental consultant. The site investigation shall define the nature, degree and extent of the contamination; and shall assess potential impacts to human health and the environment (refer to the document titled: "Site Investigation Procedure" which is available from the Secretary upon request); and

(C) Perform the site investigation within either ninety (90) days of receiving written approval of the work plan by the Secretary, or a period of time established by an alternative schedule approved by the Secretary. A report detailing the findings of the site investigation shall be sent to the Secretary for review; and

(D) Within either thirty (30) days from the date of final acceptance of the site investigation report by the Secretary, or a period of time established by an alternative schedule approved by the Secretary, submit a corrective action plan prepared by the environmental consultant (refer to the document titled: "Corrective Action Guidance" which is available from the Secretary upon request); and

(E) Implement the corrective action plan within either ninety (90) days of receiving written approval of the plan by the Secretary, or a period of time established by an alternative schedule approved by the Secretary. The corrective action activity shall continue until the contamination is remediated to levels approved by the Secretary; and

(F) Submit to the Secretary all investigative, corrective action and monitoring reports, and all analytical results related to subsections (b)(1)(C) through (E) of this section, as they become available.

(2) A used or fired military munition is a waste and is potentially subject to corrective action authorities pursuant to 10 V.S.A. § 6615, and the process described by subsection (b)(1) of this section if the munition lands off-range and is not promptly rendered safe or retrieved. Any imminent and substantial threats associated with any remaining material must be addressed. If remedial action is infeasible, the operator of the range must maintain a record of the event for as long as any threat remains. The record must include the type of munition and its location (to the extent the location is known).

§ 7-106 LAND DISPOSAL RESTRICTIONS

(a) Certain hazardous wastes shall not be disposed of in or on the land. **40 CFR Part 268**, which is hereby incorporated by reference, except for 40 CFR §§ 268.5, 268.6, and 268.42(b), identifies those wastes which shall not be land disposed and describes the limited circumstances under which an otherwise prohibited waste may continue to be land disposed. The authority for implementing the CFR sections not incorporated by reference remains with the EPA.

> **Note**: A copy of 40 CFR Part 268 (the Land Disposal Restrictions rule), as incorporated by these regulations, is available from the Secretary upon request.

(b) In addition to the prohibitions of **40 CFR Part 268**, the Secretary may restrict the land disposal of any hazardous waste in the State of Vermont:

(1) Which may present an undue risk to human health or the environment, immediately or over a period of time; or

(2) Which would be incompatible with the **groundwater protection rule and strategy** of chapter 12 of the environmental protection rules.

(c) Dilution of hazardous waste subject to the land disposal restrictions of **40 CFR Part 268** is prohibited pursuant to **40 CFR § 268.3.**

§ 7-107 ENFORCEMENT

(a) Information that the generation, transportation, treatment, storage or disposal of hazardous waste may present an actual or potential threat to human health or the environment, or is a violation of the 10 V.S.A. chapter 159, or these regulations, or any term or condition of certification, order, or assurance, may serve as grounds for an enforcement action by the Secretary, including, but not limited to:

(1) After notice and opportunity for hearing, issuing an order directing any person to take such steps as are necessary to:

(A) Immediately cease and desist any operation or practice;

(B) Correct or prevent environmental damage likely to result from any deficiency in operation or practice;

(C) Suspend or revoke any certification and require temporary or permanent cessation of the operation of such facility;

(2) A request that the Attorney General or appropriate State's Attorney commence an action for injunctive relief, the imposition of penalties and fines provided in **10 V.S.A. § 6612** and other relief as may be appropriate.

(3) An order for reimbursement to any agency of federal, state, or local government from any person whose act caused governmental expenditures under **10 V.S.A § 1283**.

(4) All other powers of enforcement available to the Secretary through **10 V.S.A., chapter 201**.

(b) The hearing by the Secretary identified under **subsection (a)(1)** of this section shall be conducted as a contested case. Pursuant to **10 V.S.A. § 6610(b)**, the Secretary may issue an emergency order without a prior hearing when an ongoing violation presents an immediate threat of substantial harm to the environment or an immediate threat to public health. An emergency order shall be effective upon actual notice to the person against whom the order is issued. Any person to whom an emergency order is issued shall be given the opportunity for a hearing within five (5) business days of the date the order is issued.

(c) Inspections, investigations, and property access **(10 V.S.A. § 8005)**

(1) Inspections and investigations

(A) An investigator may perform routine inspections to determine compliance.

(B) An investigator may investigate upon receipt or discovery of information that an activity is being or has been conducted that may constitute or cause a violation.

(C) An investigator, upon presentation of credentials, may seek permission to inspect or investigate any portion of the property, fixtures, or other appurtenances belonging to or used by a person whose activity is required to be in compliance. The investigator shall state the purpose of the inspection or investigation. An inspection or investigation may include monitoring, sampling, testing, and copying of any records, reports, or other documents relating to the purposes to be served by compliance.

(D) If permission for an inspection or investigation is refused, the investigator may seek an access order from the district or superior court in whose jurisdiction the property is located enabling the investigator to perform the inspection or investigation.

(2) Access orders

(A) If access has been refused, an access order may be sought pursuant to either **10 V.S.A. § 80**05 or **10 V.S.A. § 6609**.

(B) Issuance of an access order shall not negate the Secretary's authority to initiate criminal proceedings in the same matter by referring the matter to the office of the attorney general or a state's attorney.

(d) In an action to enforce these regulations, anyone raising a claim that a certain material is not a hazardous waste, or is exempt from regulation as hazardous waste, must demonstrate that there is a known market or disposition for the material, and that they meet the terms of the exclusion or exemption. Appropriate documentation (such as contracts showing that a second person uses the material as an ingredient in a production process) to demonstrate that the material is not a waste, or is exempt from regulation, must be provided. Owners and operators of facilities claiming that they are actually recycling materials must show that they have the necessary equipment to do so.

Stormwater Master Plan
Town of Hardwick, Vermont

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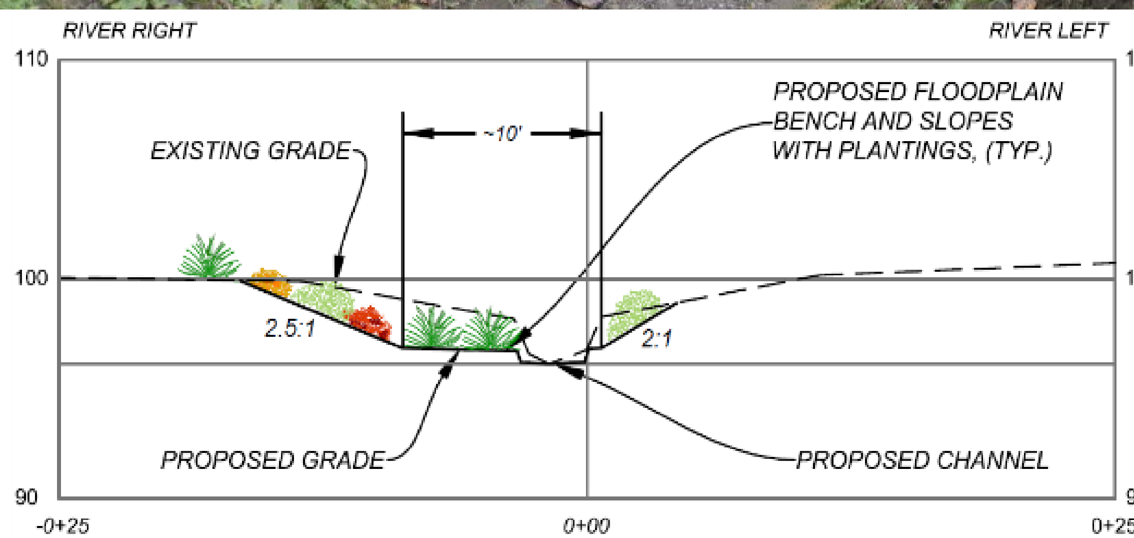

PROJECT NO.	PREPARED FOR:	SUBMITTED BY:
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Stormwater Master Plan
Town of Hardwick, Vermont

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

This project was performed by Stone Environmental, Inc. for the Caledonia County NRCD with funding provided by the Vermont Department of Environmental Conservation - Ecosystem Restoration Program.

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.

7. References

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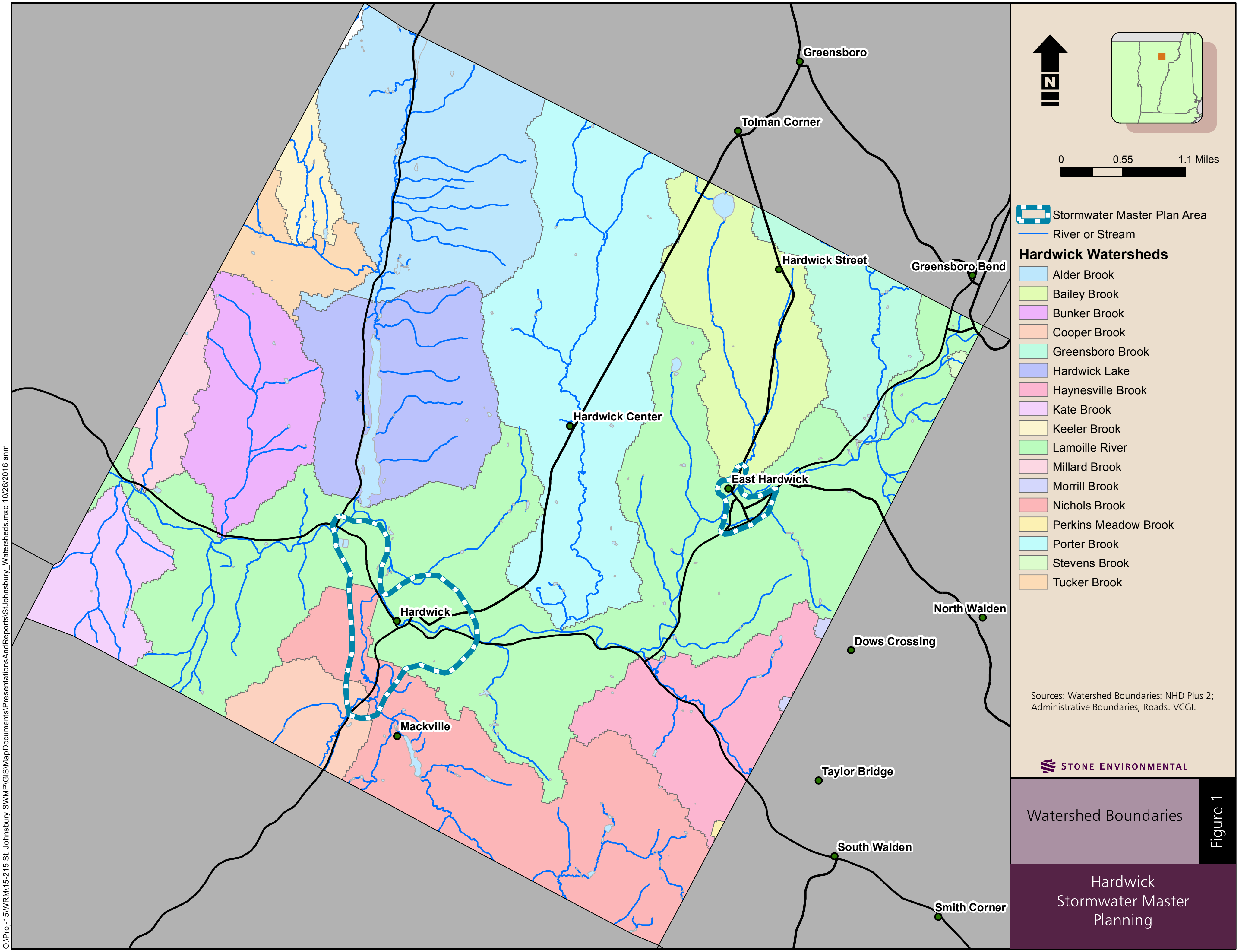
Appendix A. Maps



Watershed Boundaries
Figure 1
Hardwick Stormwater Master Planning

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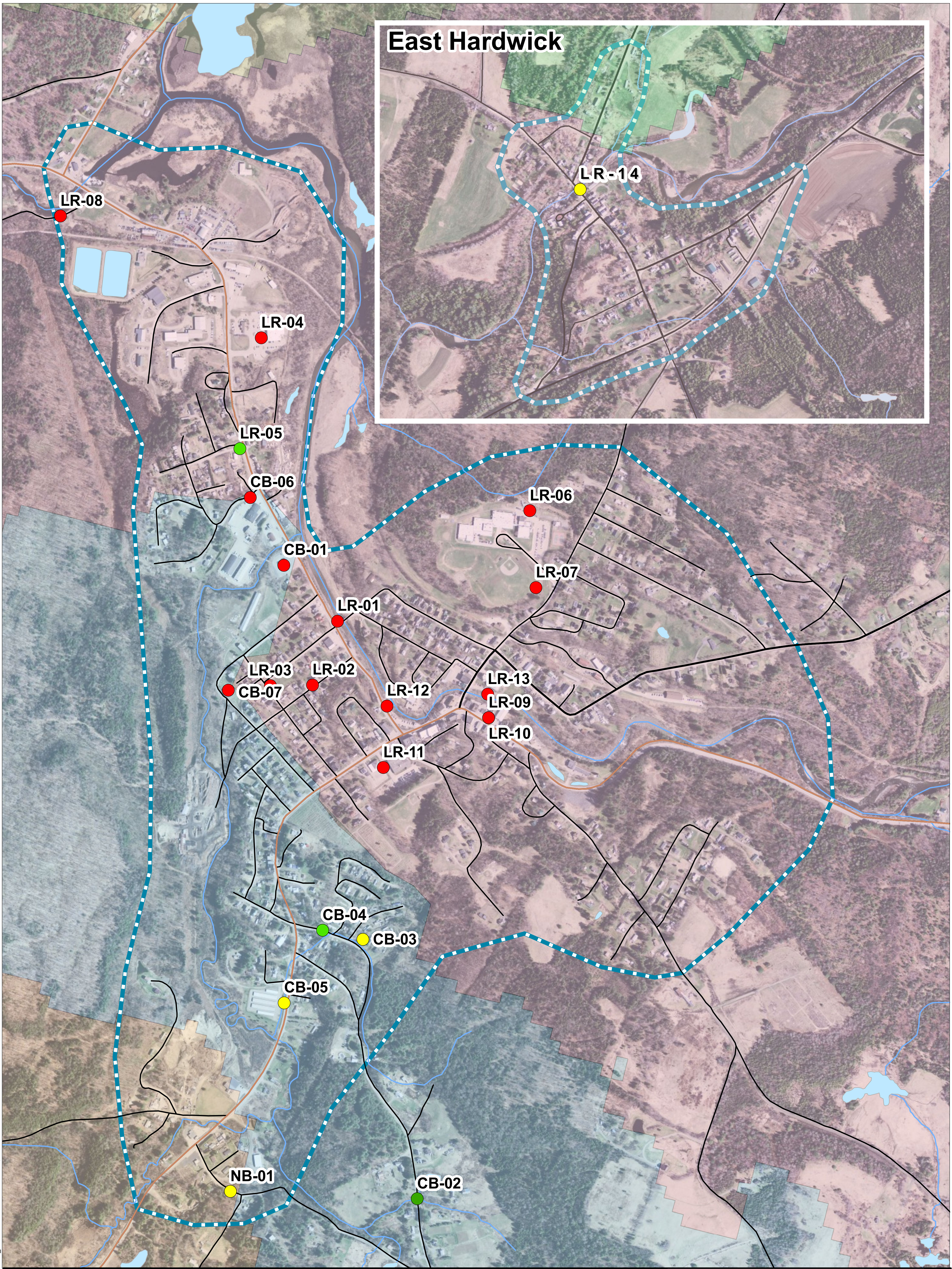

Problem Areas

- 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

To: Kerry O'Brien
CCNRCD

MEMO

STONE ENVIRONMENTAL INC

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From: Amy Macrellis
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E-Mail: amacrellis@stone-env.com

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

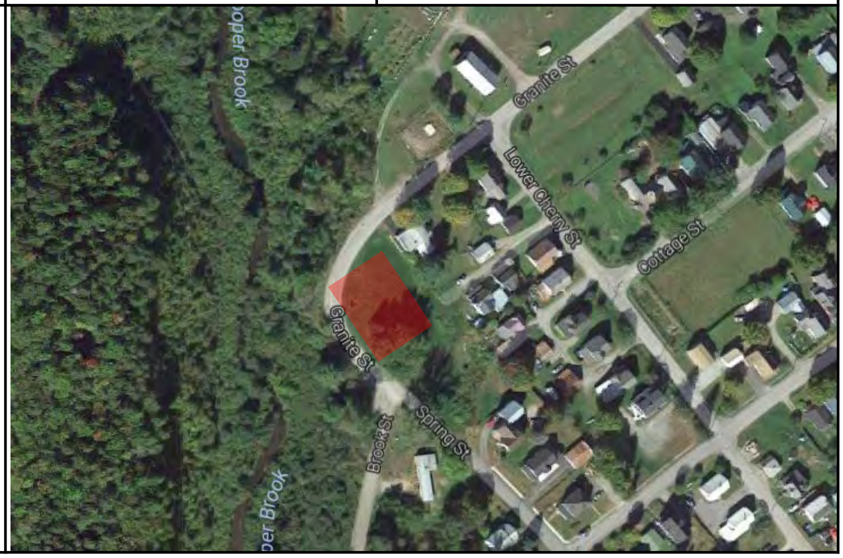
Photo 1. Catch basin appears to capture all site drainage

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

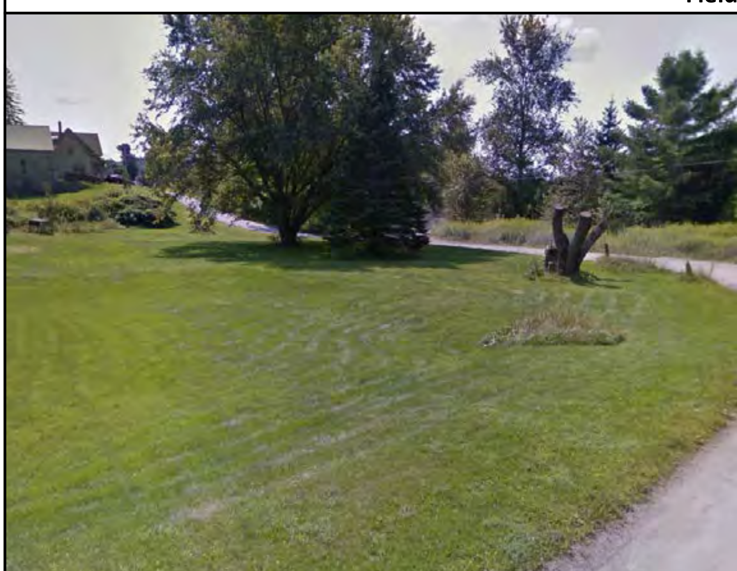


Photo 1. Potential treatment area, looking southeast from Granite Street. (Photo from Google Street View, Aug. 2014)

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

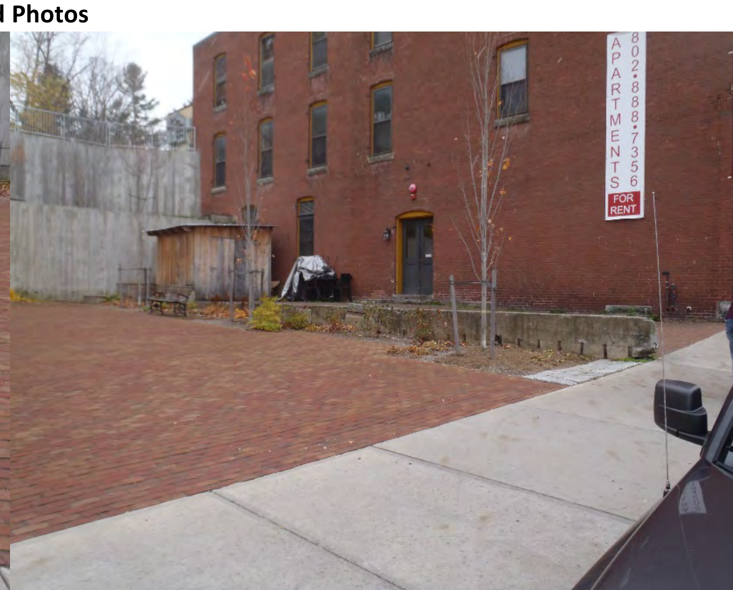


Photo 2. West edge of the park

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

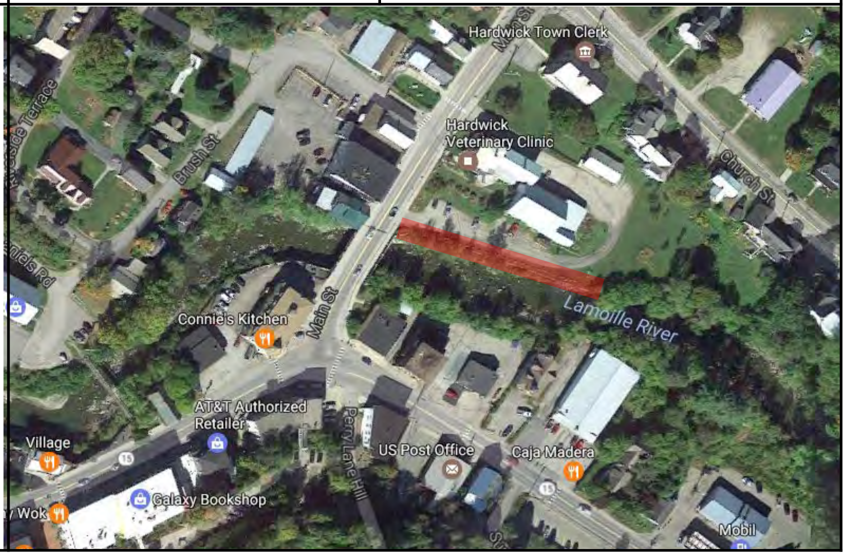
Photo 1. Existing conditions in the location of a potential sedimentation basin

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).

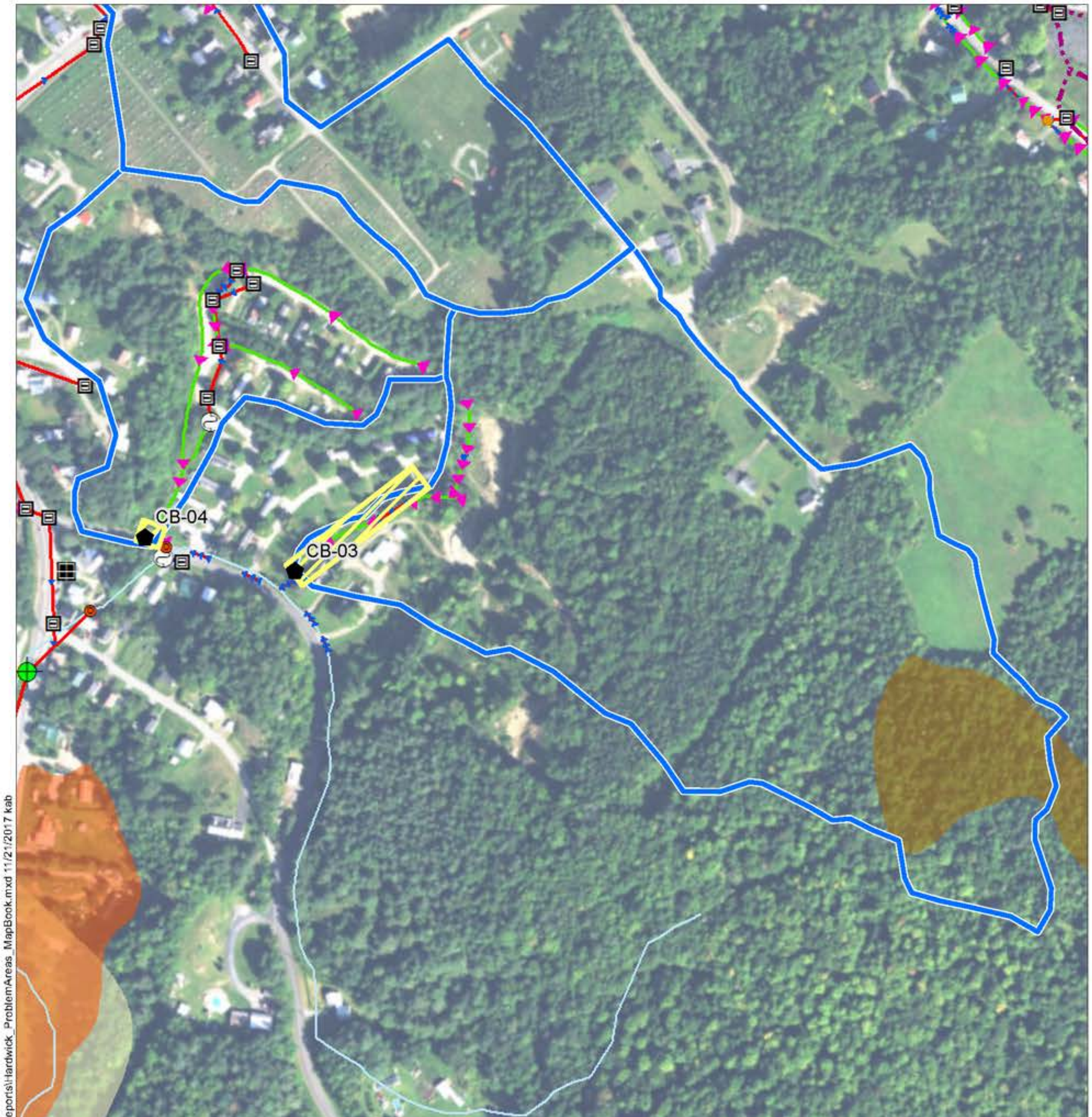
Next Steps:

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

Project Benefits:

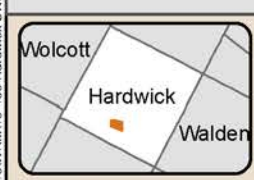
- This project would mitigate source of sediment in relative proximity to Cooper Brook. Installation of erosion prevention measures or bioswales will reduce sediment transport, while reducing the volume and velocity of flow within the downstream open and closed stormwater drainage network during storm 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)	Existing, Catchbasin
Propoed BMP Location	Existing, Culvert inlet
BMP Drainage Area	Existing, Culvert outlet
River or Stream	Existing, Drop Inlet
AE (1% ann flood chance w/ elev)	Existing, Grate/Curb Inlet
River Corridor	Existing, Outfall
Hydric Soil	

Existing, Storm line
Existing, Swale
Existing, Under drain



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0 140 280 560 Feet

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).

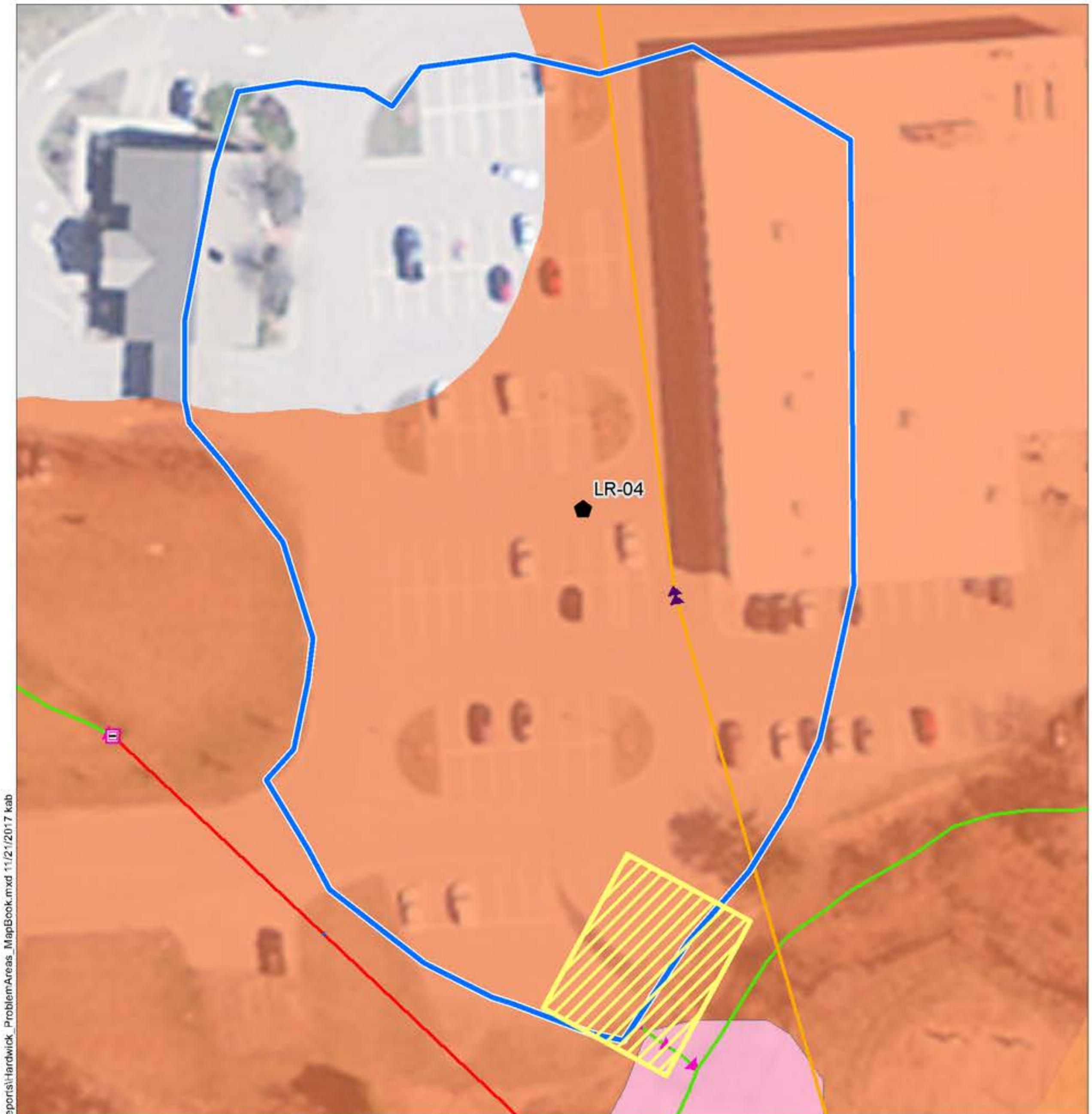
Next Steps:

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

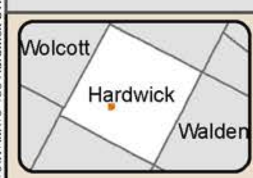
Project Benefits:

- 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



0 20 40 80 Feet

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.

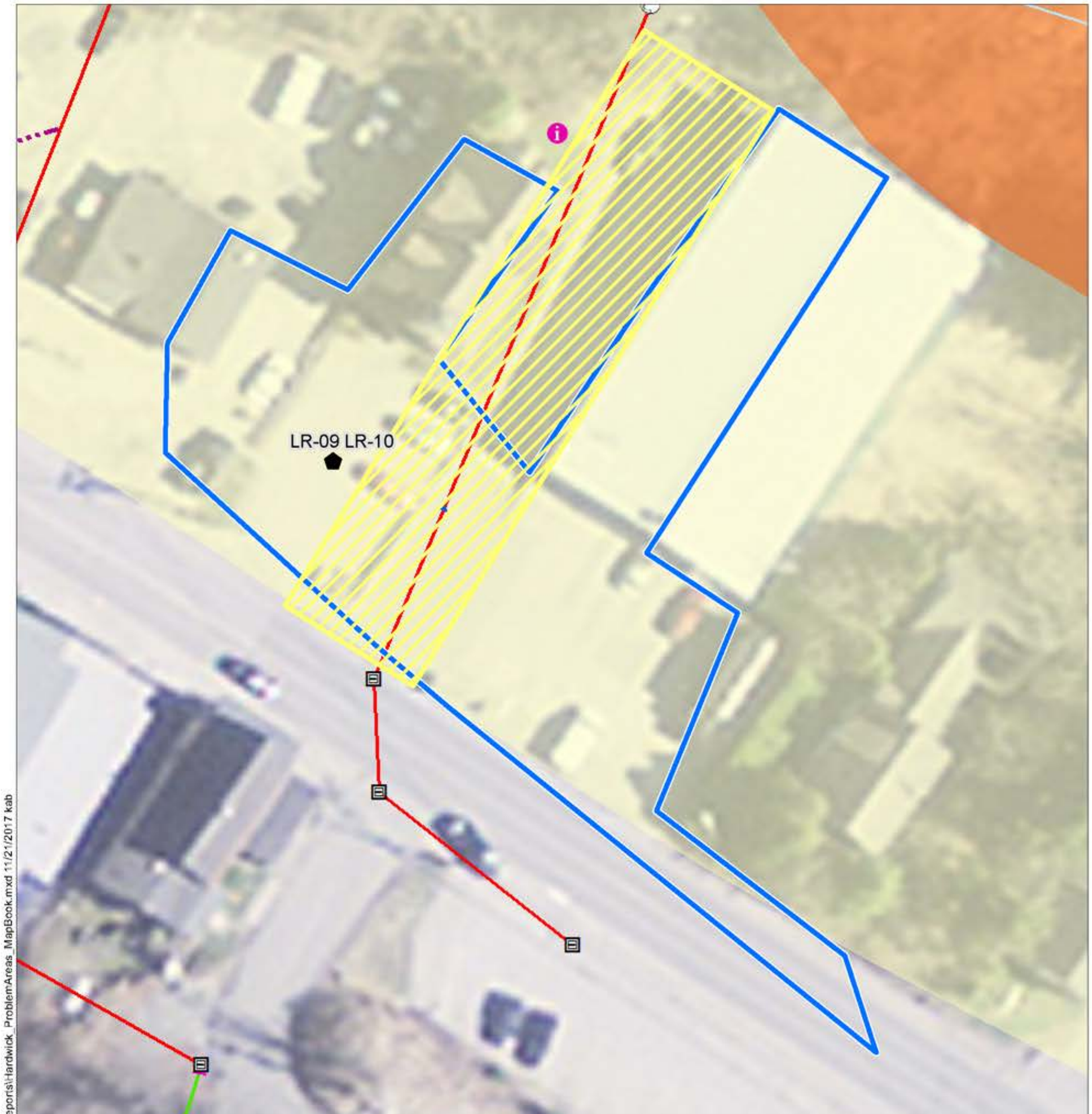
Next Steps:

- 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.

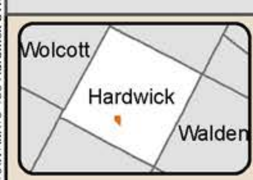
Project Benefits:

- 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

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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).

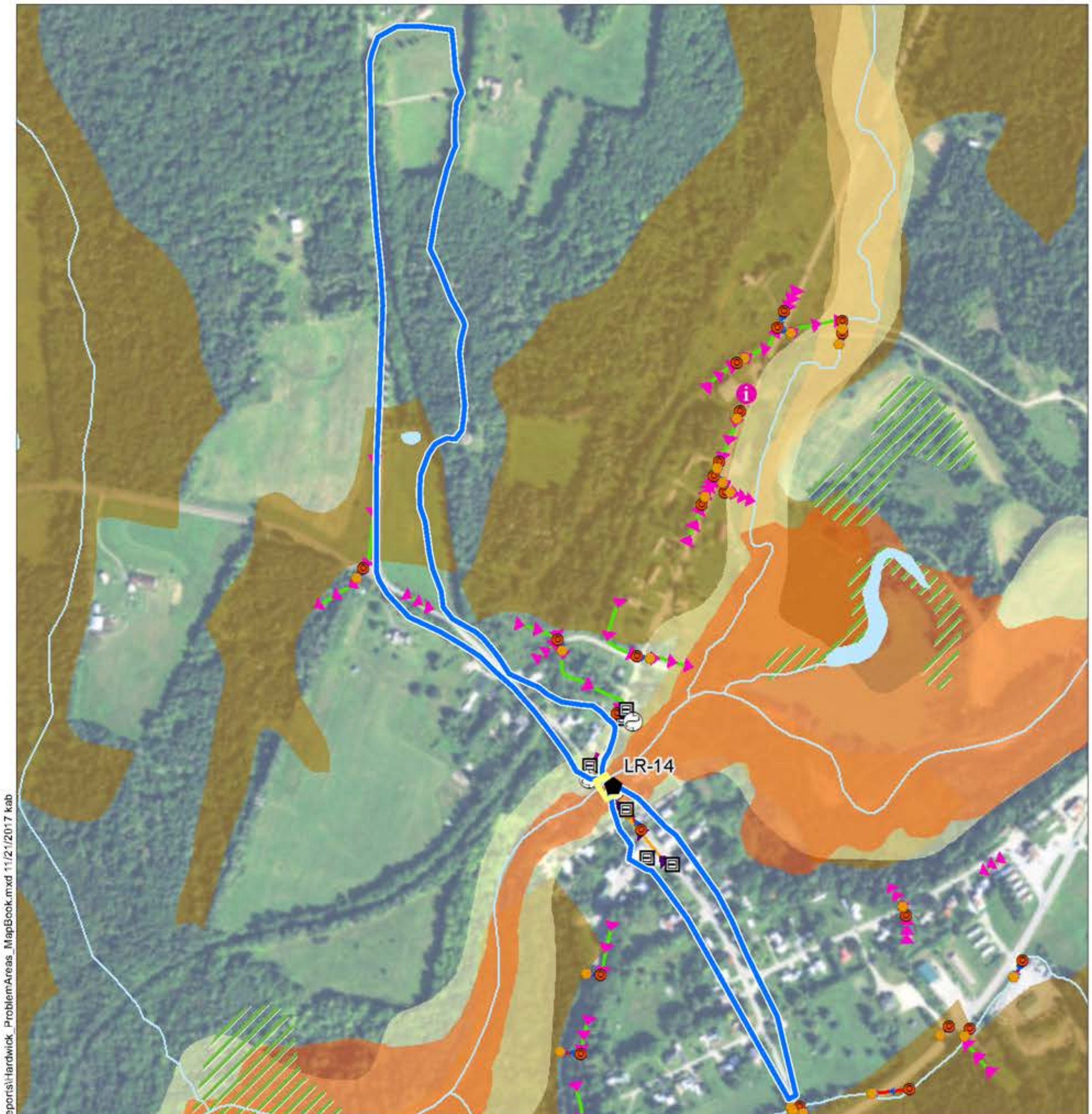
Next Steps:

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

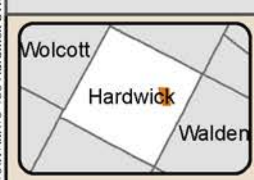
Project Benefits:

- 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).

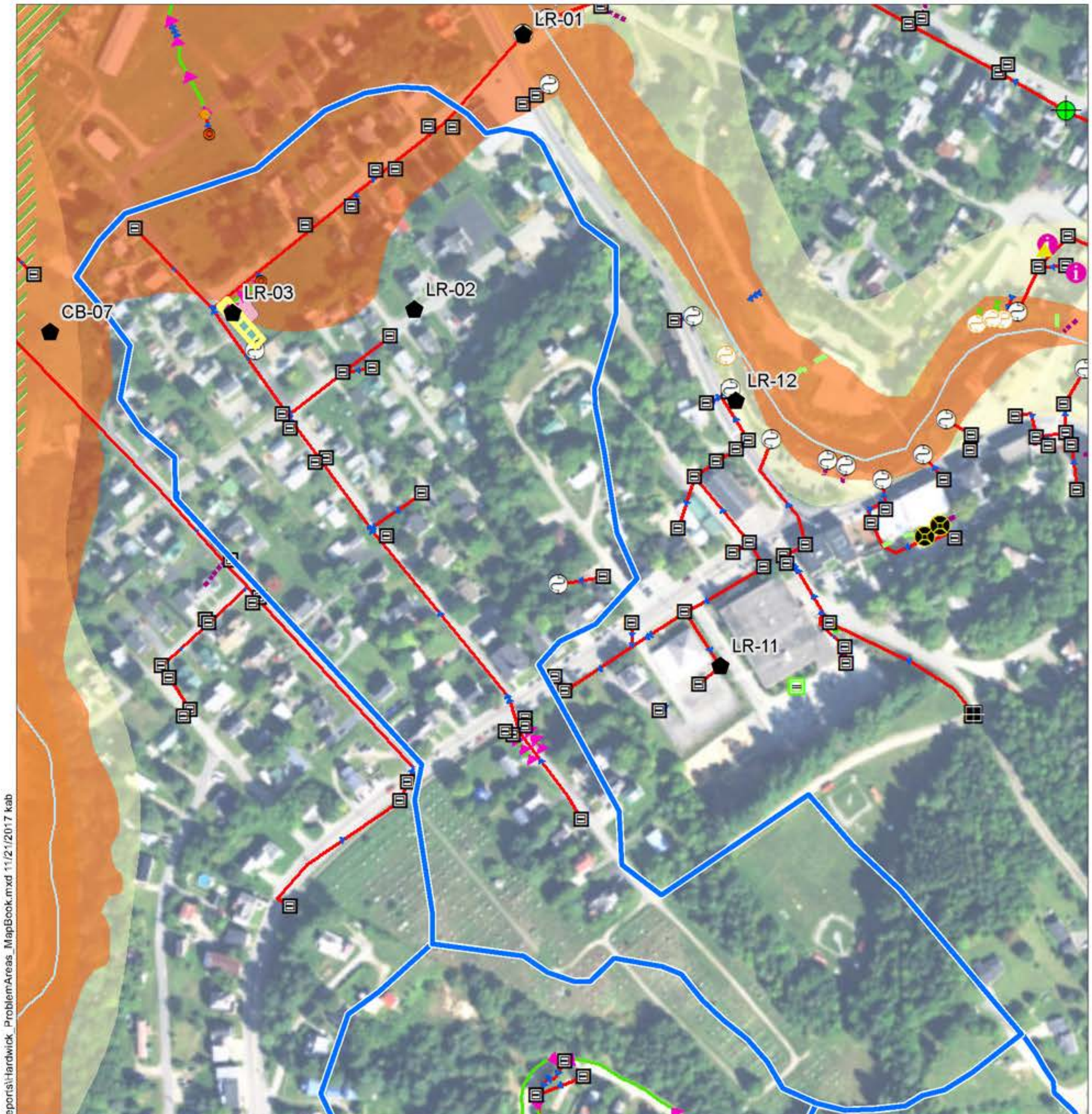
Next Steps:

- 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).

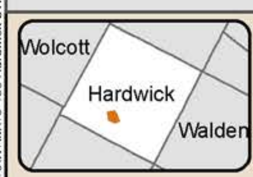
Project Benefits:

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



N

0 120 240 480 Feet

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\PresentationsAndReports\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

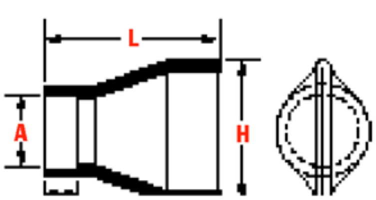
304 or 316 Stainless steel.

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

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'

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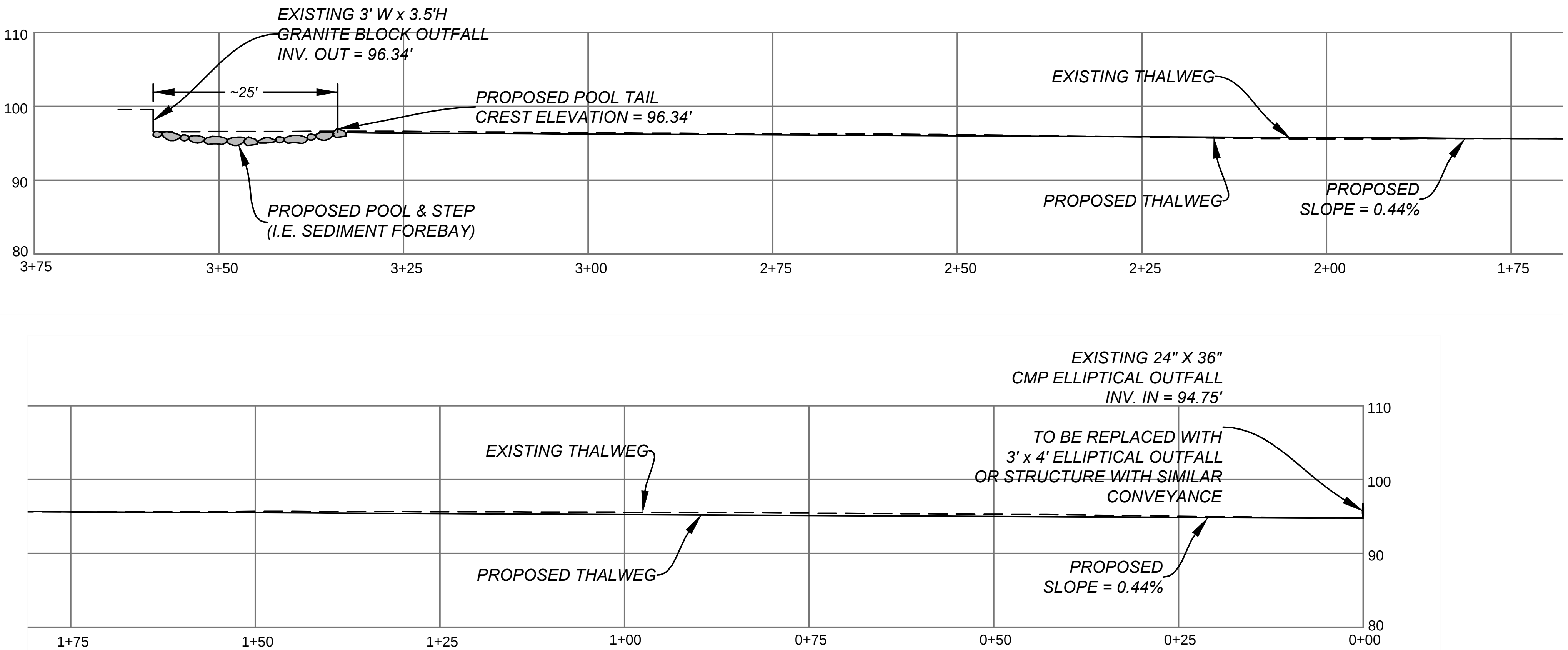
802.229.4541 / info@stone-env.com / www.stone-env.com

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

Hardwick Vermont

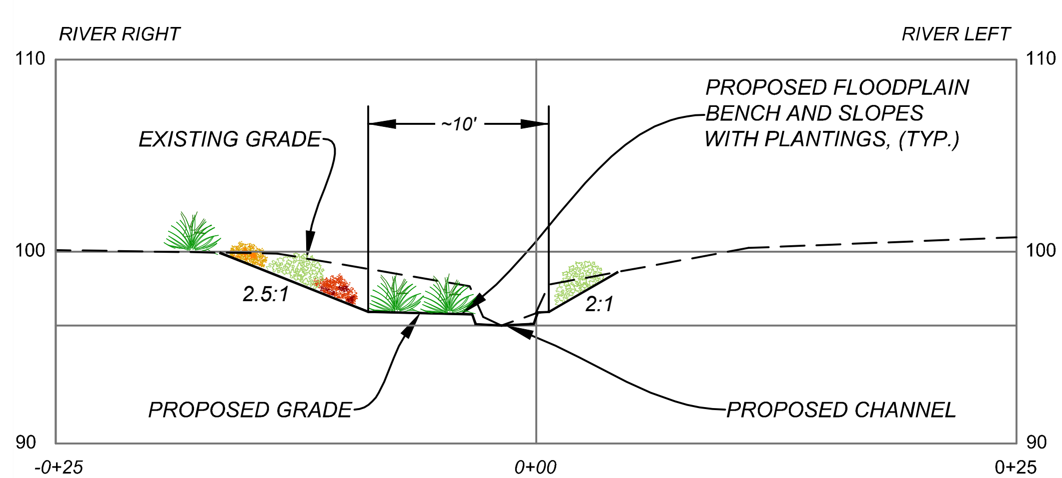
SHEET NUMBER

1



Profile

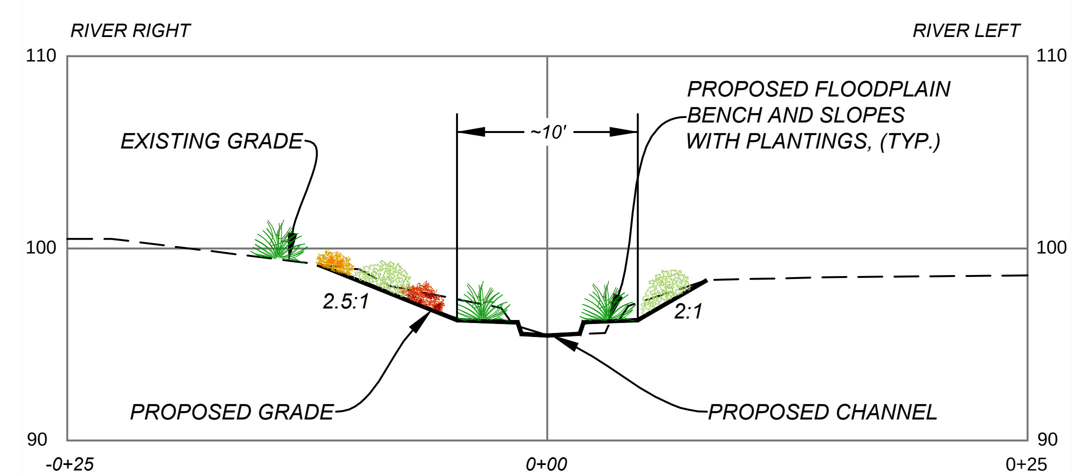
Horz. Scale: 1" = 20', Vertical Scale: 1" = 1'



CHANNEL CROSS SECTION A-A'

LOOKING UPSTREAM

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



CHANNEL CROSS SECTION B-B'

LOOKING UPSTREAM

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

CONCEPT
NOT FOR CONSTRUCTION

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DRAWING CREDITS
Drawn On: 11-21-17
Drawn By: GMB
Checked On: Date
Checked By: Initials
Project No.: 16-138

REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

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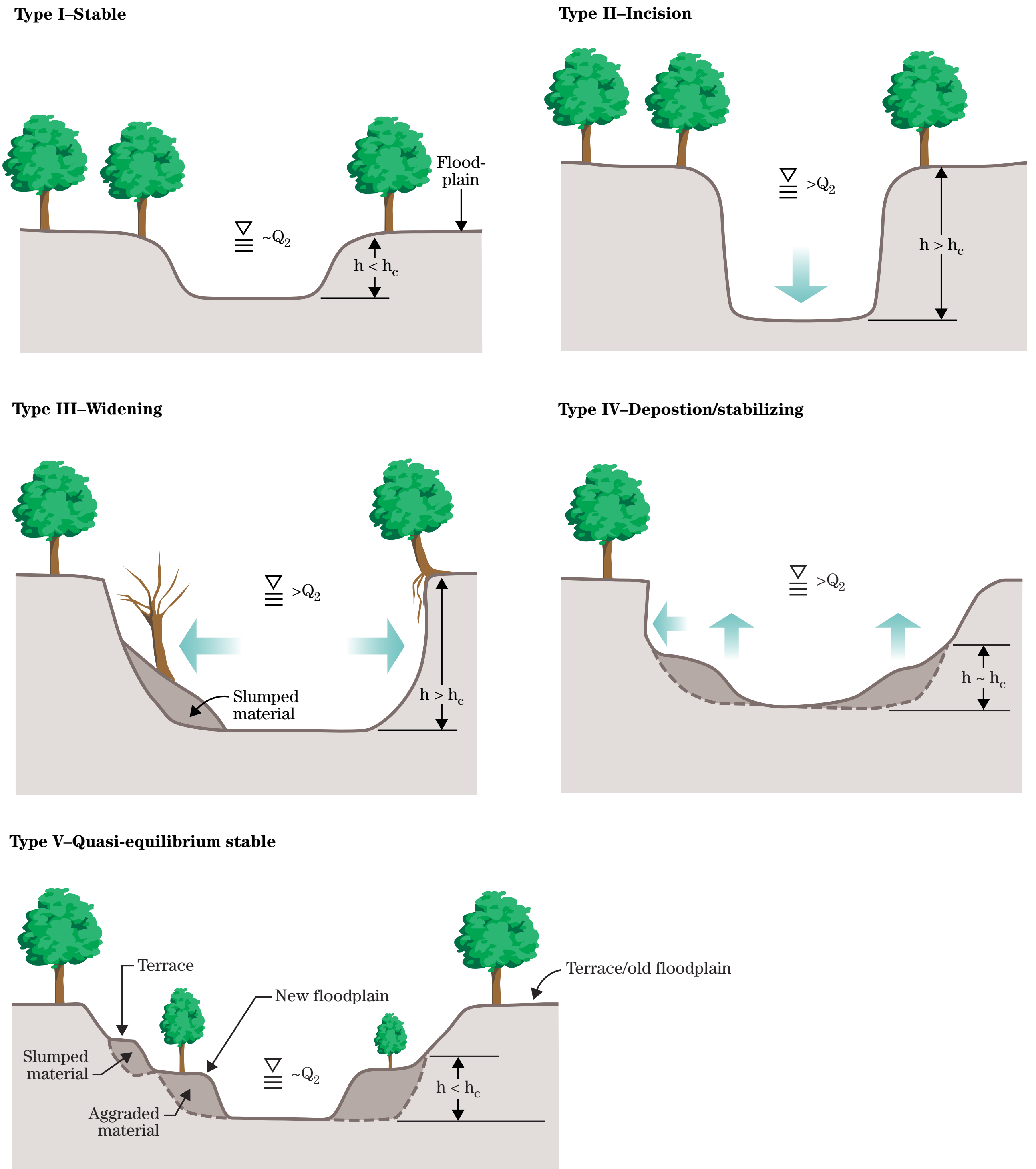
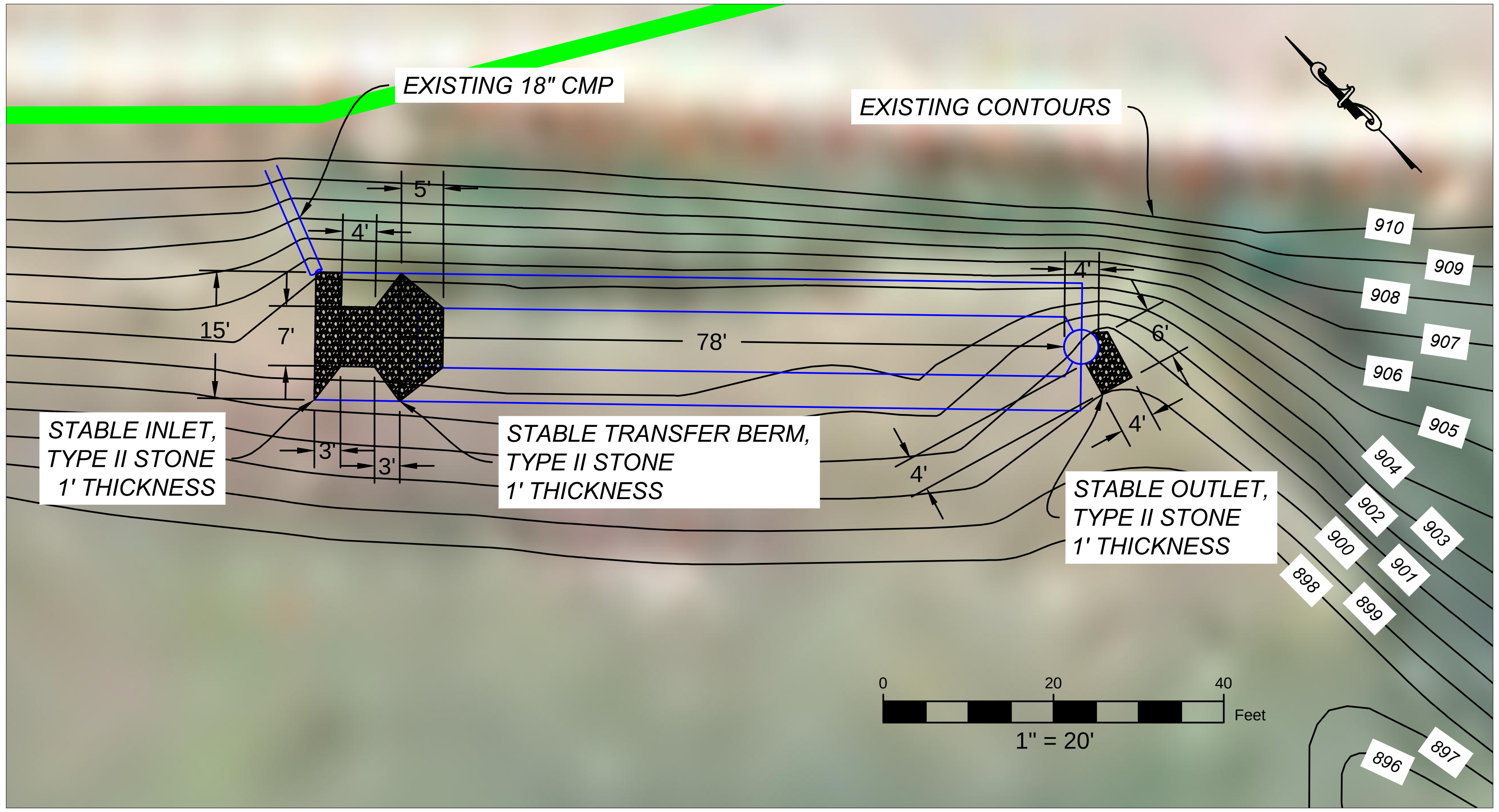
Hardwick, VT Stormwater Master Plan
Concept Plan - Buffalo Storage
Profile and Sections

Hardwick Vermont

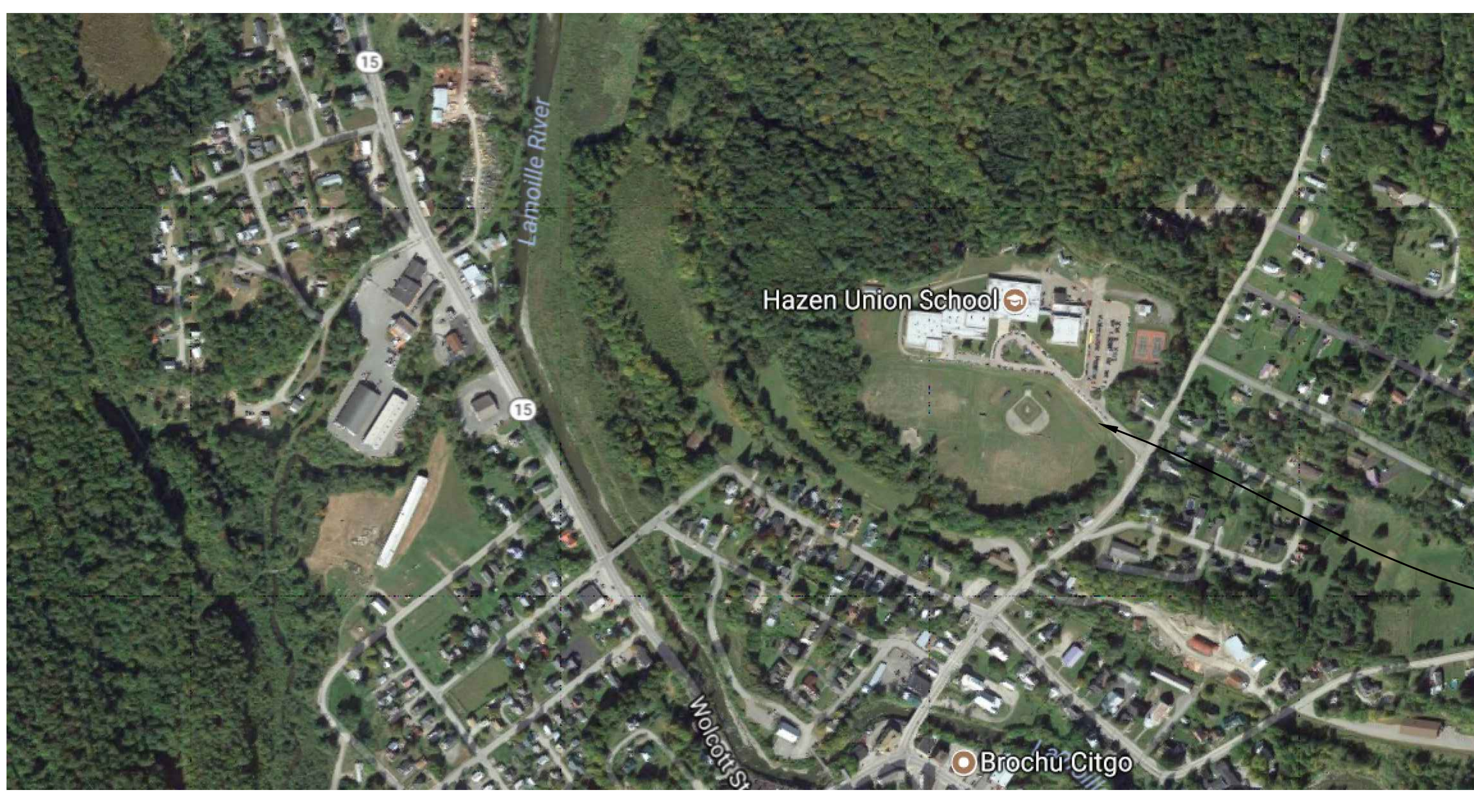
SHEET NUMBER
2

Figure 14 Schumm CEM





GRAVEL WETLAND LAYOUT



PROJECT LOCATION
HAZEN UNION SCHOOL
HARDWICK, VERMONT

GENERAL NOTES:

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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

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Drawn On: 11-29-17
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Checked By: GMB
Project No.: 16-138

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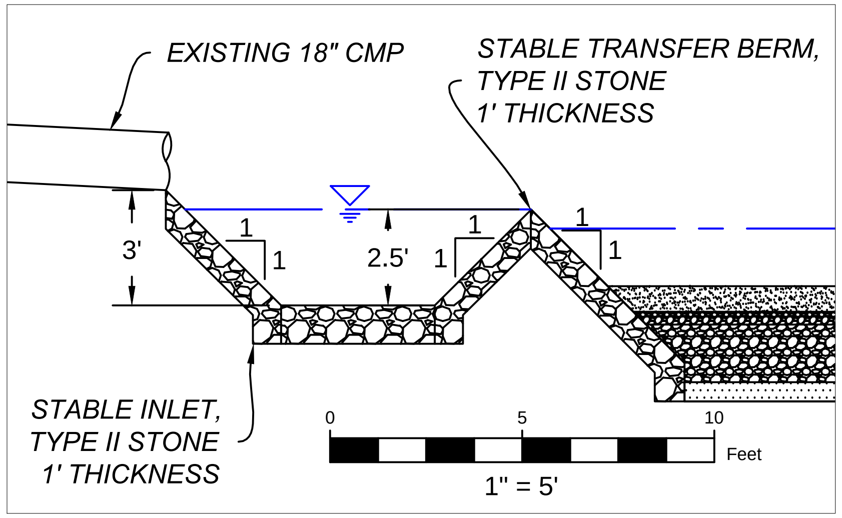
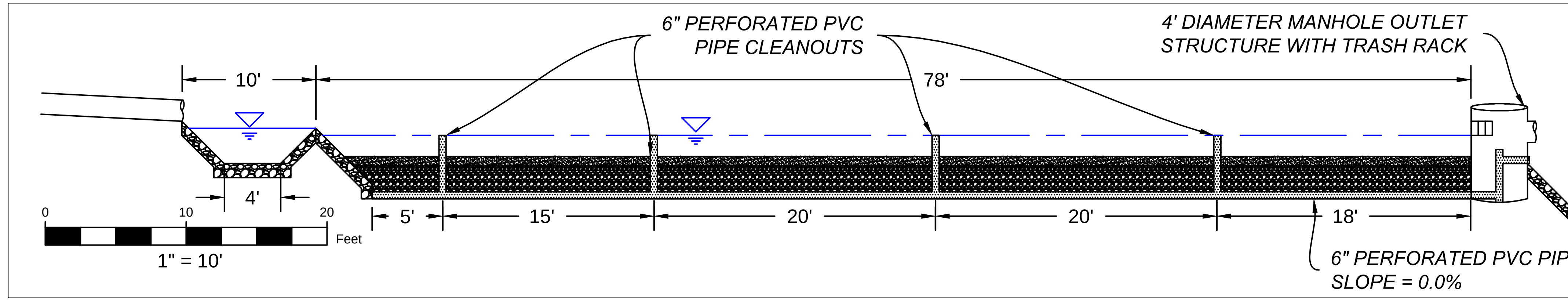
Hardwick, VT Stormwater Master Plan
Concept Plan - Hazen Union School
Layout & Notes

Hardwick Vermont

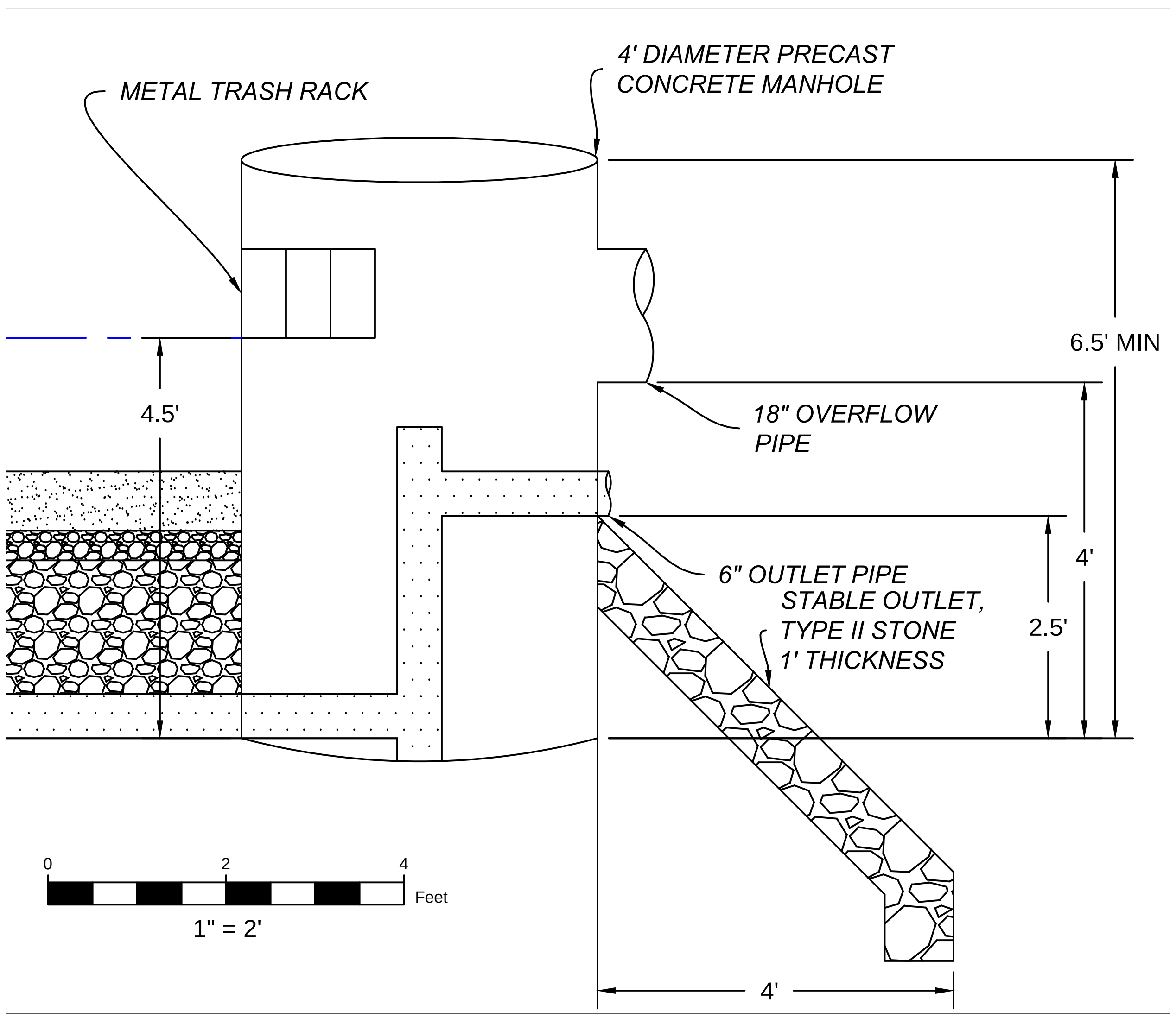
FIGURE NO. 1



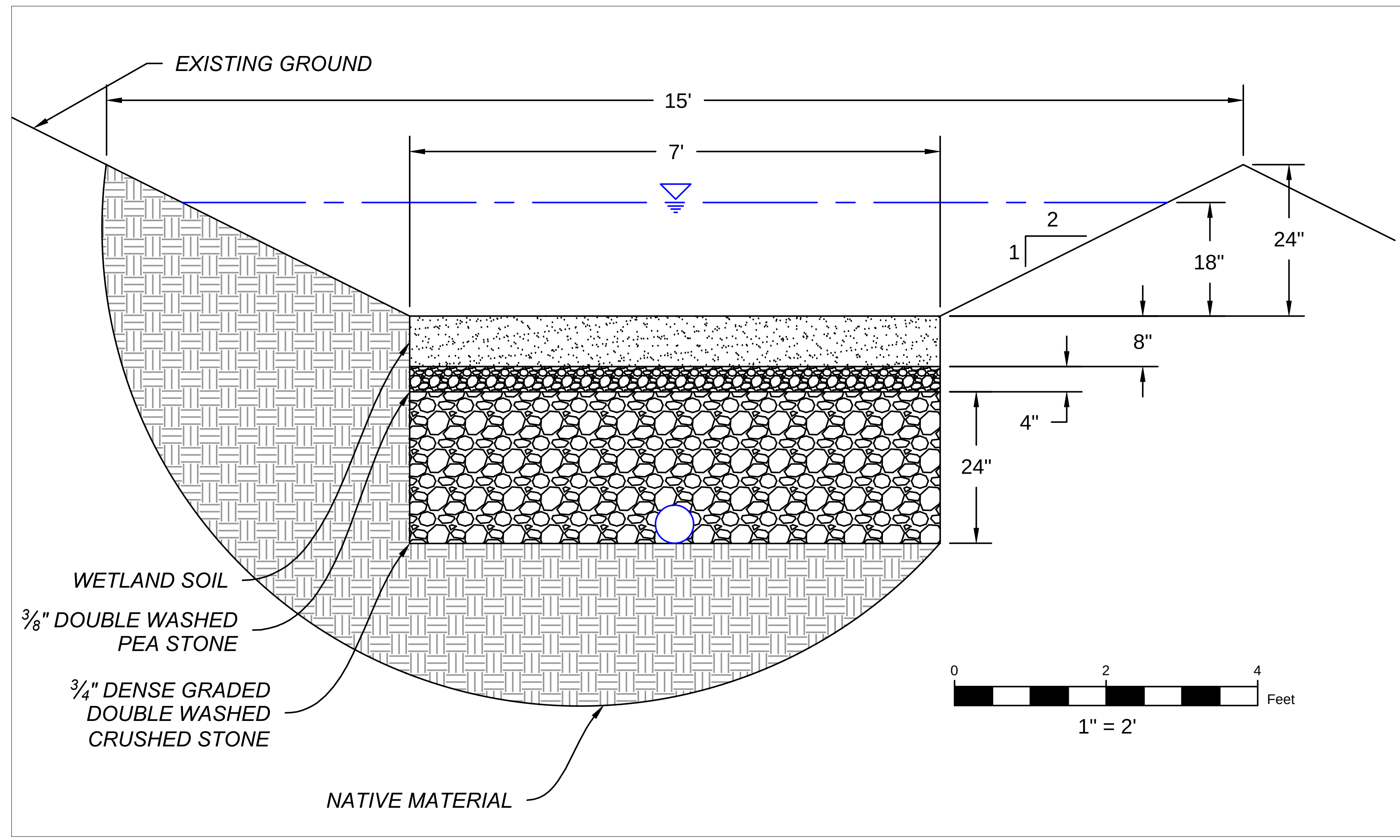
SEDIMENT FOREBAY DETAIL



GRAVEL WETLAND DETAIL
(LAYOUT)



OUTLET STRUCTURE DETAIL



GRAVEL WETLAND DETAIL
(CROSS SECTION)

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Drawn On: 11-29-17
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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

	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**
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

Upper Lamoille River
Stream Geomorphic Assessment Phase 2 Report
Greensboro and Hardwick, Vermont
February 2009

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Introduction

The Upper Lamoille River, from the headwaters in Greensboro to upstream of the Jackson Dam in Hardwick, was first assessed in 2004 by a team from USDA Natural Resources Conservation Service and the Caledonia County NRCD. An assessment update began in 2007 and was completed in 2008 to meet the parameters of the current protocol and include feature indexing. Phase 1 and 2 geomorphic assessments were completed on six reaches of the Upper Lamoille River. The methods used to collect the updated data were the 2007 Vermont Stream Geomorphic Assessment Protocols (VSGAP); http://www.anr.state.vt.us/dec/waterq/rivers/htm/rv_geoassesspro.htm; the original data was collected using the 2004 VSGAP. The update was carried out by the Caledonia County NRCD, with assistance from River Management Program staff, and with funding from the Vermont Department of Environmental Conservation's River Corridor Grants. Since 2004, a number of watershed projects have taken place including water quality work with the town of Hardwick to improve roadside ditches and reduce sediment runoff into the Lamoille River, as well as several buffer projects with private landowners.

One of the research questions concerning the Upper Lamoille River includes assessing sediment loading into Hardwick village. With the Jackson Dam at the downstream end of the village, increased sediment supplies into Hardwick are problematic. The main sources of sediment supplies include tributary inputs, erosion and mass failures, as well as sediment runoff from roads. Additional concerns have been noted about ice jamming upstream of Hardwick village, and a few landowners have voiced concerns over erosion and fracturing banks on their land.

The purpose of the following report is to summarize the current geomorphic conditions of the Upper Lamoille River and outline preliminary management strategies by reach. This report is to serve as a starting point for a more detailed analysis and future corridor plan. The management strategies and potential projects outlined below are intended to help restore channel equilibrium to the river corridor where possible. Long term areas of conflict are also indentified.

Figure 1. Location map of Upper Lamoille River and reach breaks

Reach R25A

Segment Description

Reach 25A begins at a railroad bridge behind the Grand Union on Route 15 in Hardwick and ends just upstream of Jackson Dam. This segment is impounded and was not assessed. The impoundment causes the Lamoille River at this location to overflow, which has created a wetland area surrounding the river, and a nearby lake known as Hardwick Lake. Jackson Dam is a store and release dam and the waters are drained annually. There is no hydroelectric facility associated with the Jackson Dam. The dam was originally built around 1914 for the purpose of storing water for the downstream hydroelectric generating facility at Wolcott. Due to this annual drainage the wetland and lake environment that has been created is not high quality because the habitat cannot be sustained throughout the year. The drainage is done to help protect Hardwick village from flooding and ice jamming. A consideration of the removal of Jackson Dam is recommended as it affects additional segments upstream towards Route 16, and is at the downstream end of Hardwick village. The recommendation of the removal of Jackson Dam is also noted in the Lamoille River Basin Plan, authored by the Vermont Department of Environmental Conservation (http://www.anr.state.vt.us/dec/waterq/planning/htm/pl_lamoille.htm). From a fluvial geomorphic perspective, the removal of the Dam would have a significant impact on restoring the Upper Lamoille River through Hardwick to its natural equilibrium.

Reach 25B

Segment Description

This segment begins at the bridge on Main Street in Hardwick village and ends at the aforementioned railroad bridge. It is characterized by significant armoring as it turns through Hardwick village. There is a berm along the left bank for more than half the segment protecting Route 15. Development is also significant, particularly on the left bank, with multiple urban stormwater inputs. The stream bed features bedrock at the upstream end of the segment and slightly steeper gradient, which then slows to gravel dominated, featureless "plane bed" stream for the majority of the segment. The confinement is narrow due to streamside encroachments, however floodplain is still accessed along the right bank.

The geomorphic condition for this segment is recorded as "good" with channel degradation as the limiting factor. A "fair" rating for habitat was recorded, largely due to the channel alteration, substrate homogeneity and lack of buffers. The cross section data reveal C-type channel geometry (Rosgen, 1994) and cobble dominated substrate. There were no depositional features. A low to moderate incision ratio of 1.35 and extensive bank armoring suggest stage II channel evolution and related stream bed degradation. Dominant buffer widths are 0-25' for both sides of the stream. Along the right bank of the lower end of the segment there is a significant swath of undeveloped, open land within the stream corridor. The immediate streamside land is mowed, and a small community garden is in place at the upper end. There are three bridges in this segment though two are footbridges and are not channel constrictions.

Ice jamming is a prominent source of conflict along this stretch. The stream makes two sharp turns through the village, and then the slope flattens out due to the downstream impoundment. These features contribute to the likelihood of ice jams occurring in this segment. The last major ice jam and related flooding occurred in 1991. Flows topped out over the berm along the left bank. After this flood, three "ice breakers" were installed upstream, in the downstream end of Reach R26, and were intended to break up ice before the stream entered the village of Hardwick. The ice breakers provide some relief from ice jams occurring in town; however, according to interviews, ice jams are still occurring despite the ice breakers. The ice jam flood history and mitigation site at Hardwick have been reported on and are monitored with real time web cameras by the USACE CRREL (US Army Corps of Engineers Cold Regions Research and Engineering Laboratory) http://www.crrel.usace.army.mil/icejams/page2.htm. The town continues to put resources into this area to deal with ice jams as they occur; such as keeping equipment at the Church Street Bridge to break up ice jams. These options are limited in how effective they can be in preventing flooding events from ice jams.

Preliminary Management Strategies

More segmentation and careful planning of each segment is recommended to address multiple areas of conflict through the village of Hardwick.

- Ice jamming mitigation should be considered through this segment and in conjunction with the upstream reach data.

- The open, undeveloped area along the lower right bank of this segment has potential for long term conservation, as well as possibly expanding floodwater storage. Long term planning with the town to protect this area could be highly beneficial to the village of Hardwick to protect it from ice jam and flood event inundation. Additional measurements should be taken to assess floodplain access along the right bank of this undeveloped area. If the access becomes challenged by bank and floodplain height, excavation of the floodprone area may be recommended to achieve additional floodwater storage, if necessary.

- Water quality issues were observed in this segment. Multiple stormwater inputs are a potential source of conflict, as the water quality makes a visible change when the stream enters the village of Hardwick. Water quality sampling is recommended to assess the largest causes of point source pollution. The installation of rain gardens and/or other stormwater improvements would be recommended to help protect water quality.

- Long term monitoring of the existing bank armoring will be necessary as the stream bed is degrading and the armoring is showing evidence of being undermined.

<u>Reach R26</u>

Reach Description

The reach begins at the confluence of Haynesville Brook near the junction of Routes 15 and 16 and continues until it reaches Hardwick village at the Main Street bridge. Porter Brook enters this reach about midway. The reach is flanked on its left corridor by Route 15 and the valley wall on its right. A historic railroad bed also follows the stream corridor and crosses the channel twice. Cross section data show B-type channel geometry (Rosgen, 1994) with gravel dominated substrate. Multiple depositional features were noted, two flood chutes and four grade controls. Six steep riffles were recorded but were typically upstream of channel constrictions such as riprap, sharp bends and/or bridges. Stream banks are armored sporadically throughout the reach, either where the river abuts the railroad bed or the edge of the road. The incision ratio for this reach was moderate at 1.5 with a channel evolution at stage III. The geomorphic condition rating is "fair" for this reach, largely due to historic channel degradation and current pattern of aggradation. Habitat conditions are rated as "good."

Preliminary Management Strategies
As the reach immediately upstream of Hardwick village, sources of conflict are generally related to sediment inputs.

- Haynesville Brook and Porter Brook are the two main tributaries on this reach that should be monitored for sediment input. Haynesville's sediment source is largely due to erosion, planform change and lack of buffers. Porter Brook is steeper, and its sediment inputs are largely due to upstream inadequate road infrastructure, undersized culverts and land use. Continued work with the town of Hardwick is recommended to address road and structures along Porter Brook. Buffer opportunities along Haynesville Brook should also be considered.

- The historic rail bed along this reach does little to change valley width, but it does have two stream crossings where there is apparent long term conflict. The upstream bridge has alignment problems and mid-channel piers, forcing the stream to make wide meander bends upstream and downstream of the bridge. Modification of the upstream railroad bridge should be considered if the opportunity arises. Both bridges are accumulating sediment upstream.

- Some potential conflicts where river abuts Rte 15 on outside bends. There is existing armoring in most locations but there may be sections where conflicts will be observed in the future.

- Ice breakers in the reach should be monitored for efficacy.

- There is some potential along reach for smaller buffer projects, workable with Lamoille watershed program Trees for Streams.

Figure 2. R26 Railroad bridge with mid-channel pier and aggradation

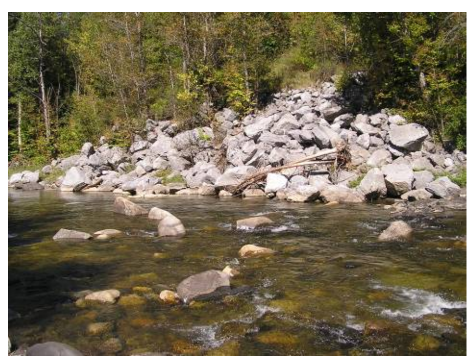


Figure 3. R26 Riprap at river's abutment with railroad bed

<u>Reach 27A</u>
Segment Description

This reach begins at the Riverside farm bridge off Route 16 and continues downstream to the Haynesville Brook confluence at the junction of Routes 15 and 16. This section of stream features a very broad valley and moderate sinuosity. Route 16 is within the river's corridor but it does not change the valley type. There is a large amount of sediment working through this segment with related planform change, depositional features and sedimented riffles. Erosion is prevalent on meander bends and two mass failures are noted. This segment is also prone to ice jams according to the USACE CRREL. Streamside land use varies through the segment and includes wooded areas, cropland, a ball field and open, residential land. There have been a number of recent buffer projects that have connected nearly all the existing buffers throughout the segment. Tree revetments were installed along the ball field, just upstream of the mass failure. At the time of the assessment, the stream had moved away from them, but they do appear to be collecting some sediment along the eroded bank. Cross section data reveal C-type channel geometry and gravel dominated substrate with silt present (Rosgen, 1994). Geomorphic conditions are rated as "good" for this segment though the stream sensitivity is still very high. Habitat conditions were also given a score of "good" with embeddedness and sediment deposition having the greatest impact. The segment's incision ratio is 1.2 allowing floodplain access to occur for most events greater than and near bankfull flows.

Preliminary Management Strategies
This stream segment lies in the first broad valley upstream of Hardwick village. It may provide critical floodwater storage. The development is relatively minimal and there are only 3-4 main landowners from this lower segment break and upstream to the falls in Hardwick village.

- Buffers should continue to be monitored and enhanced where possible

- There is a large mass failure on the outside of the meander bend at the downstream end of the ball field which should be monitored. The river is developing unnatural channel geometry near the ball field and there is potential for avulsion. Flood flows currently cut across the floodplain that is on the inside of the meander bend where an avulsion could take place.

- Continued communication with landowners is recommended to inform them of potential planform changes and the potential role the section of stream has to store floodwaters.

- Bridges on Riverside Farm Lane and Pumpkin Lane have been noted to have ice/debris jams. Modification of these structures should be considered if the opportunity arises.

- Long term conflict evident with the river abutting Rte 16. Erosion is prevalent and with the existing planform change, the river will always be limited by the road. Past attempts at armoring have failed and there is a large bank failure where potential work may be considered in the future to address the erosion of the road bank.

<u>Reach 27B</u>
Segment Description
This segment begins at the downstream end of the falls in Hardwick village and ends at the Riverside Farm Bridge. This reach is flanked on its left corridor by cropland (vegetable farm) and the valley wall on its immediate right. Cross section data show C-type channel geometry and cobble dominated substrate (Rosgen, 1994). The incision ratio is a moderate 1.5 and it was determined the river is

degrading its channel and is in stage II channel evolution. The segment's bed form is "plane bed" which is a departure from its reference form of riffle-pool. Geomorphic conditions are noted as "good" due to some channel degradation but the stream sensitivity is moderate. The habitat condition rating was also recorded as "good", mostly due to lacking buffers on the left bank. There are minimal depositional features, showing minor evidence that the stream channel is attempting to pull away from the valley wall on its right. The landowner has noted erosion problems but has not installed any armoring or revetments along the fields.

Preliminary Management Strategies
The focus of the management strategy for this reach is the position of the river and its proximity to the valley wall on the right bank. Though no historic armoring was noted, this section of stream resides in a very broad valley and the river will undoubtedly work to reclaim its valley and develop equilibrium and related riffle-pool bed form.

- Continue to monitor erosion. Considering the proximity to the valley wall on the right bank, left bank stabilization through re-shaping or willow plantings would be recommended as opposed to riprap. The river will continue to pull away from valley wall, with gravel bars and meander patterns developing.

- Continued outreach with the landowner is important. Discussions have occurred with the current landowner to assess long term land use goals and how the predicted planform change will impact their plans.

- Conservation easement consideration for the agriculture fields would be recommended, which would allow for agricultural use, but consider river restoration in the long term.

- Reach 27A and 27B should be considered as critical floodwater storage upstream of the village of Hardwick. It is important to monitor incision ratios along both segments to ensure floodplain access in the long term.

<u>**Reach 28A**</u>
Segment Description
This segment is a cascade falls and no Phase 2 assessment was completed. No management strategies needed.

<u>**Reach 28B**</u>
Segment Description
This stream segment lies in the open area just upstream of the falls in East Hardwick village. The upstream segment is a B-type stream and transport reach, and there is a grade control at the downstream end of this segment. Both of these factors contribute to sediment accumulation on this segment, with related depositional features, sedimented riffles and planform adjustments. The grade control at the downstream end is a weir that serves to channel the river under the bridge, just upstream of the falls. The bridge and weir are channel constrictions, and there is deposition noted upstream. There is good floodplain access along the right bank, with an incision ratio of 1.0 and evident historic channels in the floodplain. As the stream comes into East Hardwick village, there are a number of stormwater inputs, particularly at the bridge. Cross section data show a C-type channel

geometry with gravel dominated substrate (Rosgen, 1994). Due to the planform adjustments and widening, the segment was determined to be in Stage III of channel evolution, with a geomorphic rating of "fair". Habitat conditions were also scored as "fair" due to sediment deposition and 0-25' buffer widths on the right bank.

Preliminary Management Strategies

- The floodplain area along the right bank upstream from the village is currently undeveloped and is providing critical floodwater storage for East Hardwick. Consideration of a conservation easement on this floodplain is recommended, both to protect the floodplain and to allow channel planform adjustment to continue to take place. Long term planning with the town to look at current and future zoning options may be another way to help protect this resource.

- Modification of the bridge is recommended when the opportunity arises. An assessment of the purpose and efficacy of the weir should be considered. Stormwater runoff from the bridge has eroded areas on and around the bridge and runoff is going directly from the road into the stream. Upgrades to the bridge should direct water towards vegetated area.

<u>Reach 28C</u>

Segment Description

This segment begins at the lower end of Michaud Farm's fields, follows along the railroad and ends at the open fields upstream of East Hardwick village. This segment was recorded as a sub-reach after a field check determined the confinement was natural. There are old channels (meander bends) visible from the aerial photo that are now acting as flood chutes and wetland areas. The segment is largely wooded, particularly along the left bank, with only small swaths of mowed or sparsely vegetated land. Cross section data reveal B-type channel geometry, and cobble dominated substrate (Rosgen, 1994). The segment serves as a transport reach with sediment accumulating in the downstream segment. The river is reasonably stable through this section, determined to be at Stage I in channel evolution and showing no incision. The geomorphic and habitat conditions are both recorded as "good" for this segment, with moderate stream sensitivity. The most significant fluvial geomorphic disturbance on this segment occurs where the stream crosses under Route 16. The stream and road are generally following the same direction in the river valley, and the crossing is characterized by sharp, armored bends both upstream and downstream of the bridge. Sediment is accumulating upstream of the bridge and scour is occurring below. There is a berm along the field just upstream from the bridge and dredging is noted as well.

Preliminary Management Strategies

- The bridge on Route 16 is the most prominent area of conflict. The upstream berm is not a priority for removal because it can currently be outflanked by the river. There does remain a high potential for avulsion or floodchute development on the field directly upstream from the bridge. Downstream of the bridge, there is armoring on the right bank and a house in the river's corridor, this also remains a long term conflict area. Opportunity of bridge modification is not likely, but alignment is a clear issue on the existing structure.

- Riprap should continue to be monitored

Reach R29

Reach Description

This reach begins upstream of the bridge on East Main Street in Greensboro and ends at the downstream end of Michaud's farm fields. The land use surrounding this reach is dominated by a working dairy farm and cropland. Agricultural influence is significant. Along the farmyard, the river is armored on both sides by historic riprap. The farm's barnyard is in close proximity to the river on the right bank. The left bank is open along the farmyard, but primarily wooded elsewhere, particularly where the river nears the valley wall. Cross section data reveal C-type channel geometry (Rosgen, 1994) with cobble dominated substrate. The bed form is recorded as plane bed, which is a departure from the reference riffle-pool form. The incision ratio for this stream segment is a moderate to high 1.6, though the channel degradation is historic and channel evolution is in Stage IV. The geomorphic condition for this reach is recorded as "fair", largely due to the current patterns of aggradation with related sedimented riffles, depositional features, erosion and planform change (where the stream is not armored). Habitat conditions were also "fair," with channel alteration, bed form and lacking buffers as the limiting factors. There are two major tributary inputs. At the upstream end of the reach is Stannard Brook, which appears to be accumulating sediment upstream of the confluence. Greensboro Brook enters at the downstream end of the reach, after flowing though farmland that is lacking a buffer upstream of the confluence. Water quality issues have been reported on Greensboro brook and the Lamoille River main stem near the farm. There are two bridges and both are recorded as channel constrictions.

Preliminary Management Strategies

- The proximity of the farm and barnyard to the river is a long term area of conflict. Runoff from the barnyard into the river is evident. It is recommended that agricultural activities be drawn back from the edge of the river and vegetated buffers installed, both along farmyard and croplands.

- The bridge near the farm is in fair to poor condition and is a constriction point on the stream. This area may pose long term conflicts including ice/debris jam as well as channel and floodplain encroachment. Considerations for modification to the structure should be looked at for future opportunities when the structure fails and/or is replaced.

- The lower area of the segment near Greensboro brook shows planform adjustment and related erosion and bar development. Water quality issues reported here are likely due to runoff from streamside land use. It is recommended that buffers are installed along Greensboro Brook.

- Stannard Brook should continue to be monitored for sediment input. The stream is now storing sediment in its downstream flat valley prior to entering the Lamoille River. This may be of benefit and a long term strategy of maintaining this sediment storage should be considered.

Reach R30A

Segment Description

This segment begins at the opening just downstream of the northern junction between Main Street and Route 16 in Greensboro, and ends at the bridge on East Main Street. The stream segment is flanked on its right bank by Route 16 and on its left by Main Street in Greensboro. Land use is primarily residential with multiple property lots and dominant 0-25' buffer widths. There is a farm and some cropland at the downstream end of the segment. Incision and bank height is variable throughout the segment, but the selected cross section data records an incision ratio of 1.3 and C-type channel geometry with gravel dominated substrate (Rosgen, 1994). Channel evolution is in Stage II. Geomorphic condition was given a rating of "fair" due to historic channel degradation and channelization, with a high stream sensitivity rating. Habitat conditions were recorded as "good", limited by buffer widths. Floodplain has been filled on the left bank at a forest products industry yard located about mid-segment. Straightening and channelization is evident near bridges, with two bridges recorded. Some riffle-pool bed formation and planform adjustment is evident at the downstream end of the segment (near farm), but the rest of the segment is plane bed by reference.

Preliminary Management Strategies

- Farm practices in the lower section are contributing to water quality issues and bank erosion. Livestock exclusion and fencing is recommended.

- Considering the smaller lots and multiple landowners along this segment, small individual buffer projects are needed. The Trees for Streams program would be a appropriate program to re-vegetate individual landowner's streamside land.

- The mid-segment forest products industry yard needs to have a long term strategy for moving its operation back from the river's edge. The accumulation of fill and forest products at this site is not sustainable. Heavy erosion and fracturing of the bank has been noted at this section and it will continue as the bank becomes higher.

- Bridges are currently channel constrictions. Bridge upgrades should be considered when the opportunity arises.

Figure 4. Plane bed features in R30A

Figure 5. R30A. Bridge and channel constriction

<u>Reach 30B</u>

Segment Description

The segment begins at a farm bridge near 2651 Greensboro Road (Route 16) and ends downstream of the northern junction of Main Street and Route 16 in Greensboro. This stream segment is significantly impacted by historic agricultural straightening and undersized structures which have increased the slope and velocity of the stream. The incision ratio is recorded as a moderate to high 1.6, with channel width varying, which is largely due to the historic straightening and undersized structures. Channel evolution is in Stage II. The geomorphic condition is "fair" with a high sensitivity rating due to historic channel degradation. There are four bridges recorded for this segment, with three noted as channel constrictions with related scour and upstream aggradation. Cross section data reveal C-type channel geometry with cobble dominated substrate; however, the entrenchment of 2.3 was very close to a "B" stream type and portions of the segment may be better classified as a B. (Rosgen, 1994) There is significant armoring and channel modification mid-segment at the residence at 1902 Greensboro Road (Route 16). Buffer widths vary with the left bank showing a dominant 0-25' buffer widths, and the right bank with a dominant 100' buffer or greater. Habitat conditions were rated as "good" with bed form and left bank buffer width as the limiting factors.

Preliminary Management Strategies

- There are multiple long term planning opportunities for the undersized bridge structures. A comprehensive bridge survey is recommended to help prioritize upgrades to these structures. The modification of the channel widths due to these undersized structures should be noted when the channel width of a new structure is considered.

- 1902 Greensboro Road (Route 16) is a long term area of conflict as the stream has been armored and modified around the house and yard. Restoring channel equilibrium at this section is greatly limited by the residence and land use. Installing vegetated buffers is recommended.

- The installation of buffers throughout open areas of the segment is also recommended.

Figure 6. Undersized bridge with poor alignment in R30B

Figure 7. Problem bridge and channelization in R30B

Next steps:

- Due to the number of structures impacting channel geometry noted in this report, it is recommended that a full Bridge and Culvert Assessment be conducted for the Upper Lamoille River main stem and its major tributaries to help prioritize future modifications.

- Continue to work with the Trees For Streams program to install buffers at noted locations.

- It is recommended that water quality sampling be conducted in Hardwick village to assess the impact of stormwater inputs.

- Consider future assessments for Upper Lamoille tributaries to better identify management and restoration opportunities.

- Develop landowner and municipal outreach program to discuss project opportunities; such as zoning, easements, buffers and other noted management strategies.

- Continue to update this report to a corridor plan that will include additional maps and tables tracking management strategies and potential projects as they are implemented.

Conclusion

The primary impacts on the Upper Lamoille River are undersized structures, agriculture, and village encroachments (roads and development). The overall concerns of this section of river are related to sediment inputs into Hardwick village, and flood storage capacities upstream. Many of the reaches have under gone some level of historic degradation and straightening; and are now undergoing planform adjustment and aggradation. These adjustments contribute to the sediment that is being delivered into the system. The Jackson Dam impoundment is a primary source of conflict for these concerns and limiting factor in channel equilibrium upstream. Floodplain access is adequate on some reaches, though there are feasible improvements to enhance flood attenuation and decrease sediment with the cooperation of landowners and the towns of Hardwick and Greensboro. Long term planning of infrastructure with the goal of addressing these overall concerns is highly recommended to achieve a greater level of channel stability and compatibility with corridor land use.

Literature Cited

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

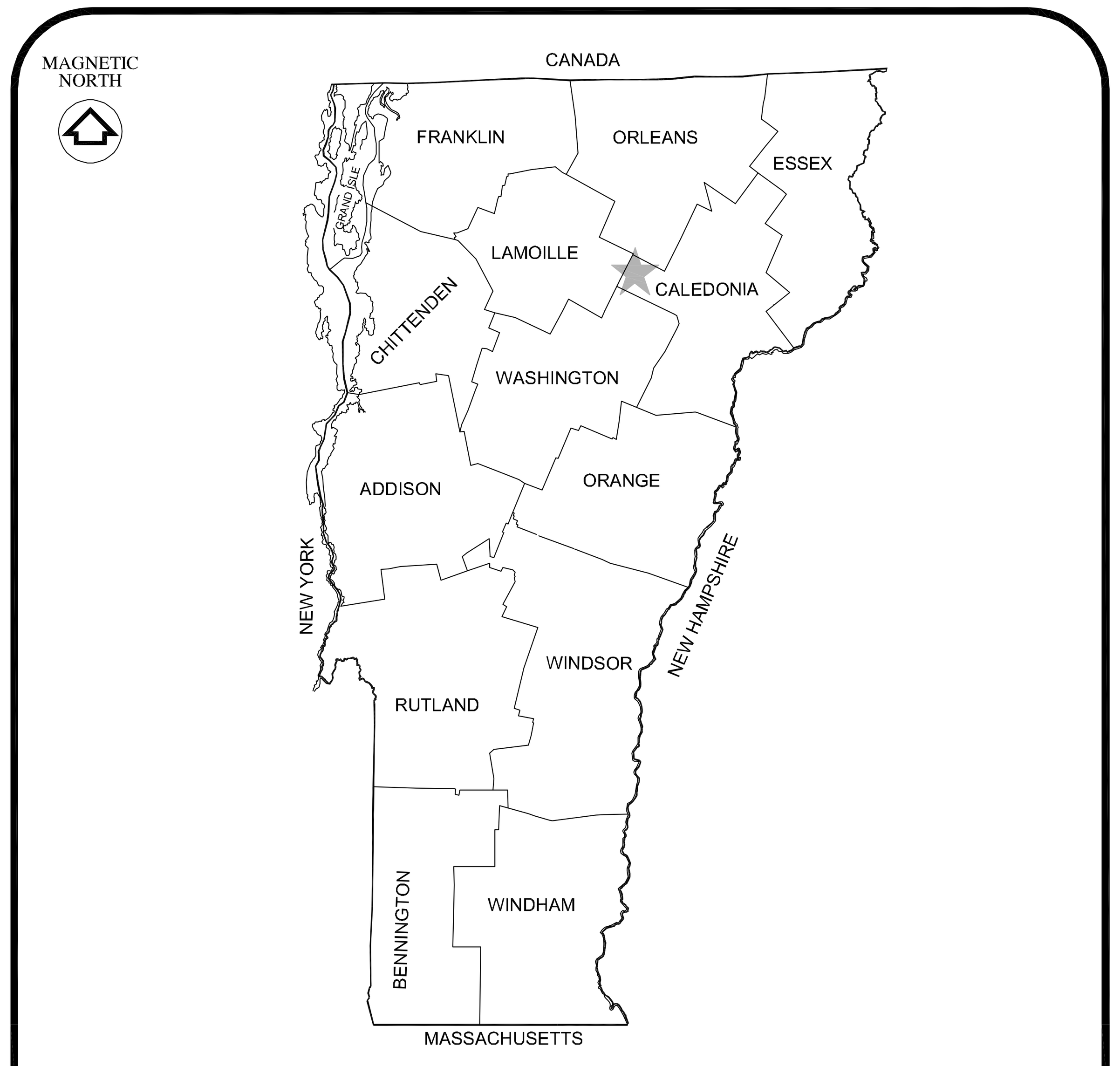
Appendices:

- Data Management System Phase 2 Reports
- Reach Maps

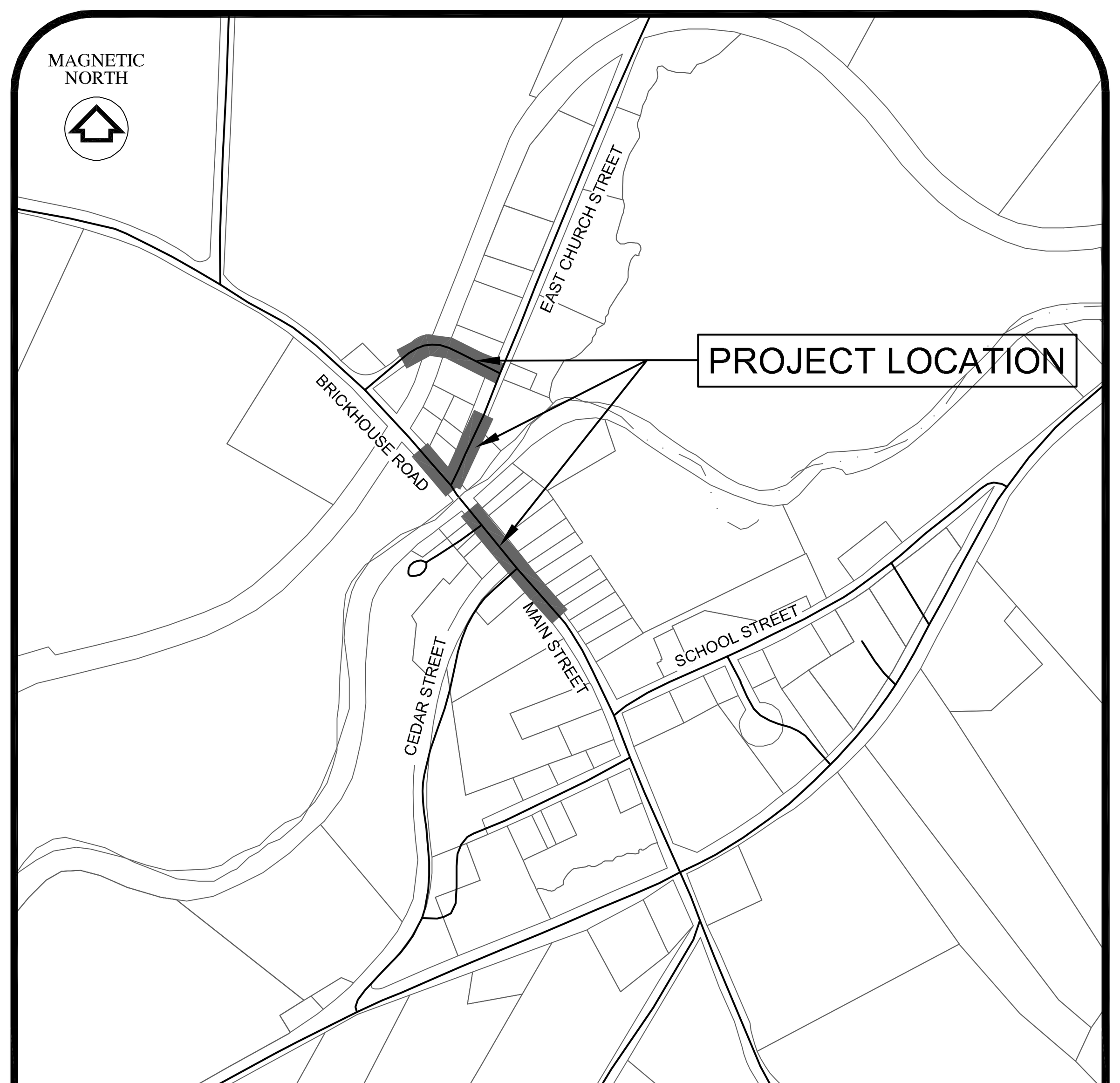
B 30% DESIGN DRAWINGS

EAST HARDWICK VILLAGE
STORMWATER IMPROVEMENTS
HARDWICK, VERMONT

APRIL 18 2025



LOCATION PLAN - VERMONT
CITY/TOWN, VERMONT
NO SCALE



VICINITY PLAN
SCALE: 1"=500'

INDEX OF SHEETS

30% DESIGN SUBMITTAL
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PROJECT OFFICIALS

TITLE 1
NAME 1

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TITLE 3
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TITLE 4
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GENERAL NOTES:

1. SURVEY GENERATED FROM AERIAL PHOTOGRAPHY WITH CONTOURS FROM THE VERMONT CENTER FOR GEOGRAPHIC INFORMATION (VCGI) LIDAR PROGRAM. HORIZONTAL DATUM IS BASED ON NAD83. VERTICAL DATUM IS BASED ON NAVD88.

2. ALL CONSTRUCTION ACTIVITIES SHALL BE CONFINED TO THE RIGHT-OF-WAY, LANDS OWNED BY THE TOWN OF HARDWICK OR IN EASEMENT AREAS AVAILABLE TO TOWN. PROPERTY LINES SHOWN HEREIN WERE BASED ON TAX MAP INFORMATION PROVIDED BY THE TOWN OF HARDWICK. THIS IS NOT A BOUNDARY SURVEY.

3. THERE ARE BURIED UTILITIES ON THIS SITE. THE LOCATION OF PIPES, DUCTS, CONDUITS, AND OTHER UNDERGROUND STRUCTURES SHOWN IN THESE PLANS ARE NOT WARRANTED TO BE EXACT, NOR IS IT WARRANTED THAT ALL UNDERGROUND STRUCTURES ARE SHOWN. THESE UTILITIES ARE SHOWN BASED ON BEST AVAILABLE FIELD EVIDENCE AND INFORMATION PROVIDED BY THE TOWN OF HARDWICK, VERMONT AND OTHER LOCAL UTILITY COMPANIES. THE CONTRACTOR IS RESPONSIBLE TO COORDINATE WITH DIG SAFE, THE TOWN AND OTHER UTILITY COMPANIES TO LOCATE AND MARK BURIED UTILITIES DURING THE PROJECT. ALL REPAIRS TO DAMAGED UTILITIES SHALL BE MADE BY THE CONTRACTOR USING MATERIALS APPROVED BY THE ENGINEER PRIOR TO INSTALLATION AND AT NO ADDITIONAL EXPENSE TO THE OWNER.

4. THE CONTRACTOR SHALL PERFORM EXPLORATORY EXCAVATION TO VERIFY LOCATIONS AND SIZES OF EXISTING UTILITIES, PRIOR TO INSTALLATION OF ANY SEGMENT OF NEW UTILITIES. CONTRACTOR SHALL USE EXTREME CAUTION TO PREVENT DAMAGE TO EXISTING UTILITIES. CONTRACTOR IS RESPONSIBLE FOR PROTECTION OF ALL UTILITIES WHETHER OR NOT THEY ARE SHOWN ON THE PLANS.

5. CONTRACTOR SHALL VERIFY LOCATION OF ALL OVERHEAD AND UNDERGROUND ELECTRIC, CABLE AND TELEPHONE LINES AND TAKE NECESSARY PRECAUTIONS IN STRICT ACCORDANCE WITH OSHA STANDARDS DURING CONSTRUCTION. CONTRACTOR SHALL CONTACT THE LOCAL POWER UTILITY AND TELEPHONE UTILITY REGARDING ANY NECESSARY SUPPORT OF ANY UTILITY POLES DURING CONSTRUCTION.

6. CONTRACTOR TO USE EXTREME CAUTION WHEN EXCAVATING NEAR BUILDINGS AND OTHER STRUCTURES.

7. CONTRACTORS SHALL COORDINATE WITH DIG SAFE (1-888-DIG SAFE) AND THE TOWN OF HARDWICK A MINIMUM OF 72 HOURS PRIOR TO ANY EXCAVATION.

8. STATE AND FEDERAL PERMITS WILL BE OBTAINED AND ISSUED FOR THIS PROJECT. ONCE THEY ARE OBTAINED THEY WILL BE CONTAINED IN THE SPECIFICATIONS. THE CONTRACTOR SHALL COMPLY WITH ALL CONDITIONS CONTAINED IN THESE PERMITS.

9. TECHNICAL SPECIFICATIONS PROVIDE NECESSARY INFORMATION AND ARE PART OF THE CONTRACT DOCUMENTS FOR THIS PROJECT.

10. GENERALLY DARK OR HEAVY LINE WEIGHT REFERS TO PROPOSED IMPROVEMENTS INCLUDED IN THIS CONTRACT. NORMAL FONT OR LIGHT LINE WORK GENERALLY REFERS TO EXISTING FACILITIES AND FEATURES.

GENERAL NOTES & SPECIFICATIONS FOR EROSION CONTROL

1. THE CONTRACTOR SHALL BE RESPONSIBLE FOR EROSION PREVENTION AND SEDIMENT CONTROL IN ACCORDANCE WITH THE CONTRACT DOCUMENTS, INCLUDING, ALL STATE AND FEDERAL PERMITS.

2. A COPY OF MEMORANDUM OF AGREEMENT, THE AUTHORIZATION TO DISCHARGE, A BRIEF DESCRIPTION OF THE PROJECT, THE LOCATION WHERE THE EROSION PREVENTION AND SEDIMENT CONTROL PLAN IS AVAILABLE, AND ALL COPIES OF THE EROSION PREVENTION AND SEDIMENT CONTROL MONITORING REPORTS SHALL BE POSTED AT A LOCATION ON THE PROJECT SITE THAT IS VISIBLE TO THE PUBLIC.

3. THE ON-SITE COORDINATOR SHALL INSPECT THE EROSION AND SEDIMENT CONTROL STRUCTURES AND MEASURES AT LEAST ONCE PER DAY DURING CONSTRUCTION ACTIVITY AND AS SOON AS POSSIBLE, BUT NO LATER THAN 24 HOURS AFTER ANY STORM EVENT WHICH GENERATES A DISCHARGE OF STORM WATER FROM THE CONSECUTION SITE.

4. THE CONTRACTOR SHALL PROVIDE THE FOLLOWING INFORMATION TO ENGINEER PRIOR TO INITIATING CONSTRUCTION:

   A. VERIFY THE LOCATION OF WASTE, BORROW AND STAGING AREAS, MATERIAL STOCKPILES, REFUELING AND MAINTENANCE AREAS.
   B. DISCUSSION AND ADDITIONAL DETAILS NEEDED FOR THE PROTECTION AND STABILIZATION OF THE PROJECT SITE.
   C. PROPOSED MODIFICATIONS TO THESE EROSION AND SEDIMENT CONTROL PLANS.
   D. PROPOSED DATES OF JOB MILESTONES.
   E. NAME, PHONE NUMBER, ADDRESS AND QUALIFICATIONS OF THE ON-SITE COORDINATOR.
   F. INFORMATION SHALL BE CONSISTENT WITH GUIDANCE PROVIDED IN THE LATEST REVISION OF THE VERMONT HANDBOOK FOR THE EROSION AND SEDIMENT CONTROL ON CONSTRUCTION SITES AND PERMIT REQUIREMENTS.

7. CONSTRUCTION SEQUENCE:

   A. ESTABLISH LIMITS OF DISTURBANCE AND INSTALL PROJECT DELINEATION FENCING (PDF). CONSTRUCT DIVERSION SWALES AND OTHER TEMPORARY MEASURES, INCLUDING SILT FENCE PRIOR TO INITIATING CONSTRUCTION. ERECT ALL EROSION PREVENTION SEDIMENT CONTROL(EPSC) DEVICES AS SHOWN ON THE DRAWINGS AND THE EROSION PREVENTION SEDIMENT CONTROL PLAN.
   B. COMMENCE EXCAVATION AND GRADING FOR ACCESS ROAD. STOCKPILE AND COVER SOIL SO THAT EROSION IS MINIMIZED. EXTRA PRECAUTIONS SHALL BE TAKEN WHEN THE SOIL IS SATURATED.
   C. CONSTRUCT PHASE 2 OF ROADWAY INCLUDING CULVERTS. INSTALL STORM DRAIN AND DRY DETENTION POND (AND DISCONTINUE STORM DRAIN) BEFORE CONSTRUCTING REMAINDER OF ACCESS ROAD AND OTHER COMMON FACILITIES.
   D. GRADE SITE SO THAT SOIL EROSION CAUSED BY RUNOFF WILL BE MINIMIZED. ON STEEP SLOPES, RUN DOZER PERPENDICULAR TO THE SLOPE SO THAT TREADS OF DOZER CREATE GROOVES TO TEMPORARILY SCARIFY SURFACE AND MINIMIZE RUNOFF VELOCITIES (CAN ALSO BE USED TO ANCHOR MULCH).
   E. TEMPORARY SEED AND MULCH ALL EXPOSED GROUND.
   F. ESTABLISH PERMANENT VEGETATION UPON COMPLETION OF FINAL GRADING IN A GIVEN AREA.
   G. COMMENCE EXCAVATION AND GRADING FOR ACCESS ROAD. STOCKPILE AND COVER SOIL SO THAT EROSION IS MINIMIZED. EXTRA PRECAUTIONS SHALL BE TAKEN WHEN THE SOIL IS SATURATED.
   H. CONSTRUCT REMAINING PORTION OF ROADWAY INCLUDING CULVERTS. INSTALL STORM DRAIN AND OTHER COMMON FACILITIES.
   I. GRADE SITE SO THAT SOIL EROSION CAUSED BY RUNOFF WILL BE MINIMIZED. ON STEEP SLOPES, RUN DOZER PERPENDICULAR TO THE SLOPE SO THAT TREADS OF DOZER CREATE GROOVES TO TEMPORARILY SCARIFY SURFACE AND MINIMIZE RUNOFF VELOCITIES (CAN ALSO BE USED TO ANCHOR MULCH).
   J. TEMPORARY SEED AND MULCH ALL EXPOSED GROUND.
   K. ESTABLISH PERMANENT VEGETATION UPON COMPLETION OF FINAL GRADING IN A GIVEN AREA.

8. THE AREA OF DISTURBED SOILS AND THE DURATION OF EXPOSURE OF THE DISTURBED SOILS SHALL BE MINIMIZED. TO ACCOMPLISH THIS, WORK EFFORT SHOULD BE FOCUSED ON THE COMPLETION AND STABILIZATION OF ONE WORK COMPONENT BEFORE PROCEEDING TO THE NEXT WORK COMPONENT.

9. FOR CONSTRUCTION OF ANY ROADS AND UTILITIES, ONLY THOSE AREA NECESSARY FOR INSTALLATION SHALL BE DISTURBED. THE LIMITS OF DISTURBANCE WILL BE MARKED BY PROJECT DELINEATION FENCING (PDF). EXISTING VEGETATION OUTSIDE THE LIMITS OF CONSTRUCTION SHALL BE LEFT UNDISTURBED. THE AREA CLEARED/GRUBBED WITHIN THE PROJECT SITE SHALL BE MINIMIZED TO MAINTAIN EXISTING VEGETATION WHERE POSSIBLE. ALL DISTURBED AREAS SHALL BE RESTORED IN ACCORDANCE WITH THE SPECIFICATIONS AND DRAWINGS.

10. DURING CONSTRUCTION, AREAS OF COMPLETED WORK SHALL BE SEEDED AND MULCHED WITHIN 48 HOURS OF FINISH GRADING. THIS SHALL INCLUDE CUT OR FILL SLOPES.

11. DISTURBED AREAS THAT ARE NOT BEING ACTIVELY WORKED SHALL BE STABILIZED WITHIN 10 DAYS OR BEFORE A FORECASTED RAIN EVENT WITH TEMPORARY SEED AND MULCH OR MATTING.

12. SEDIMENTS AND OTHER POLLUTANTS COLLECTED AND REMOVED IN THE COURSE OF TREATMENT OF STORMWATER RUNOFF SHALL BE DISPOSED OF IN A MANNER THAT WILL NOT RESULT IN THE SEDIMENTS OR POLLUTANTS ENTERING WATERS OF THE STATE. DISPOSAL SITES SHALL BE SELECTED ON RELATIVELY LEVEL TERRAIN WITH AN ISOLATION DISTANCE OF AT LEAST 100 FEET FROM ANY SURFACE WATERS, INCLUDING WETLANDS.

13. DUST SHALL BE CONTROLLED IN ALL AREAS USING WATER AS NEEDED.

14. WHERE THE CONSTRUCTION AREAS FOR MAJOR WORK ITEMS DO NOT OVERLAP, DISTURBED AREAS SHALL BE STABILIZED PROMPTLY UPON FINAL GRADING, AND PRIOR TO COMMENCING WORK ON OTHER MAJOR SITE WORK ITEMS.

15. IN THE CASE OF SIGNIFICANT RUNOFF OCCURRING WITHOUT BEING EFFECTIVELY CONTROLLED BY THE MEASURES SHOWN ON THESE PLANS, THE ON-SITE COORDINATOR AND THE SITE CONTRACTOR SHALL ENSURE THAT THE ADDITIONAL EROSION PREVENTION AND SEDIMENT CONTROL MEASURES ARE INSTALLED.

16. THE CONTRACTOR IS RESPONSIBLE FOR WATER CONTROL DURING ALL PHASES OF CONSTRUCTION. NO WORK SHALL BE PERMITTED IN FLOWING WATER. STREAMS SHALL BE TEMPORARILY DAMMED BY THE USE OF A CHECK DAM, SAND BAGS OR OTHER SUITABLE MEANS. THE DIVERSION SHALL BE ACCOMPLISHED BY TEMPORARY CULVERTS OR BY PUMPING. ALL DIVERTED WATER SHALL BE DISCHARGED TO STONE FILL OR OTHER SUITABLE ENERGY DISSIPATER SURROUNDED BY SILT FENCE.

17. MAINTENANCE OF EROSION CONTROL STRUCTURES:

   A. WHEN THE SEDIMENT ACCUMULATION REACHES A DEPTH OF 12 INCHES BEHIND THE SILT FENCE, IT SHALL BE DISPOSED OF. AS DESCRIBED IN NOTE 13 ABOVE.
   B. REPAIR ALL DAMAGE CAUSED BY SOIL EROSION OR CONSTRUCTION EQUIPMENT AT OR BEFORE THE END OF EACH WORKING DAY.

18. IN THE EVENT THAT A DISCHARGE AUTHORIZED UNDER THE RUNOFF PERMIT IS CAUSING OR HAS REASONABLE POTENTIAL TO CAUSE OR CONTRIBUTE TO, A VIOLATION OF WATER QUALITY STANDARDS, THE VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION SHALL BE NOTIFIED IMMEDIATELY OF THE PROBLEM AND THE CORRECTIVE ACTIONS THAT HAVE BEEN OR ARE BEING TAKEN. DISCHARGES OF TURBID WATER TO WATERS OF THE STATE MUST BE REPORTED WITHIN 48 HOURS TO THE VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION. A WRITTEN REPORT FULLY DESCRIBING THE VIOLATION, INCLUDING THE SOURCE, THE CAUSE, WHY THE PLAN DID NOT PREVENT THE PROBLEM, HOW THE PROBLEM WAS ADDRESSED, AND THE TIMETABLE, ALL SHALL BE FILED WITHIN SEVEN (7) DAYS OF WHEN THE PROBLEM IS FIRST IDENTIFIED.

19. THE CONTRACTOR SHALL INSTALL EITHER EROSION CONTROL MATTING OR STONE FILL IN AREAS REQUIRING EROSION CONTROL, UNLESS NOTED OTHERWISE.

LEGEND

EXISTING:	
	PAVED ROAD OUTLINE
	GRAVEL DRIVE
W — W	WATER MAIN PIPE
D — D	STORM DRAIN PIPE
OHU — OHU	OVERHEAD WIRE
	BUILDING/STRUCTURE OUTLINE
	PROPERTY LINE
500	MAJOR CONTOUR
502	MINOR CONTOUR
	FIRE HYDRANT
	WATER SHUTOFF VALVE
	WATER VALVE
	STORM DRAIN MANHOLE
	CATCH BASIN
	IRON PIPE/REBAR
	UTILITY POLE/GUY WIRE
	DECIDUOUS TREE
	CONIFEROUS TREE
PROPOSED:	
	PAVED ROAD OUTLINE
	STORM MANHOLE
	CATCH BASIN
D — D	STORMDRAIN
	STONE SWALE

ABBREVIATION LIST

ABB	DESCRIPTION
APPROX	APPROXIMATE
ASP	ASPHALT
B	BORING
BVCE	BEGIN VERTICAL CURVE ELEVATION
BVCS	BEGIN VERTICAL CURVE STATION
BGN	BEGIN
BL	BREAK LINE
BLD	BUILDING
BM	BENCH MARK
BNK	BANK
BOT	BOTTOM
CB	CATCH BASIN
CI	CAST IRON
CL	CENTER LINE
CMP	CORRUGATED METAL PIPE
CON	CONCRETE
COR	CORNER
CPP	CORRUGATED PLASTIC PIPE
CS	COMBINED SEWER
CSW	CONCRETE SIDEWALK
D	STORM DRAIN LINE
DI	DUCTILE IRON
DMH	DRAIN MANHOLE
DRI	DROP INLET
ED	EDGE
EL	ELEVATION
END	END
EOG	EDGE OF GRAVEL
EOP	EDGE OF PAVEMENT
EOW	EDGE OF WATER
EVCS	END VERTICAL CURVE STATION
EVCE	END VERTICAL CURVE ELEVATION
EX	EXISTING
FD	FOUND
FL	FLOW LINE
FM	FORCE MAIN
FP	FENCE POST
FT	FEET
FX	FENCE
GND	GROUND
GR	GUARD RAIL
HDPE	HIGH DENSITY POLYETHYLENE
HW	HEAD WALL
ID	INSIDE DIAMETER
INT	INTERSECTION
INV	INVERT
IP	IRON PIPE
IPF	IRON PIPE FOUND
IPS	IRON PIPE SET
IRF	IRON ROD FOUND
IRS	IRON ROD SET
LP	LIGHT POLE
MB	MAIL BOX
MH	MANHOLE
MON	MONUMENT
OHW	OVERHEAD WIRE
PL	PROPERTY LINE
POR	PORCH
PT	POINT
PVC	POLYVINYL CHLORIDE PIPE
PVI	POINT OF VERTICAL INTERSECTION
PVMT	PAVEMENT
RCP	REINFORCED CONCRETE PIPE
RD	ROAD
S	SEWER LINE
SDR	STANDARD THERMOPLASTIC PIPE
ST	STREET
STA	STATION
TBM	TEMPORARY BENCH MARK
TOC	TOP OF CURB (SEE SHEET C20 NOTE)
TYP	TYPICAL
W	WATER LINE
WL	WETLAND
WS	WATER SERVICE
WSO	WATER SHUTOFF

GRAPHIC SCALE

60' 0 30' 60' 120' 240'

(IN FEET)

EXISTING SITE PLAN

SCALE: 1" = 60'

30% DESIGN SUBMITTAL
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REVISIONS

DATE	COMMENTS	BY

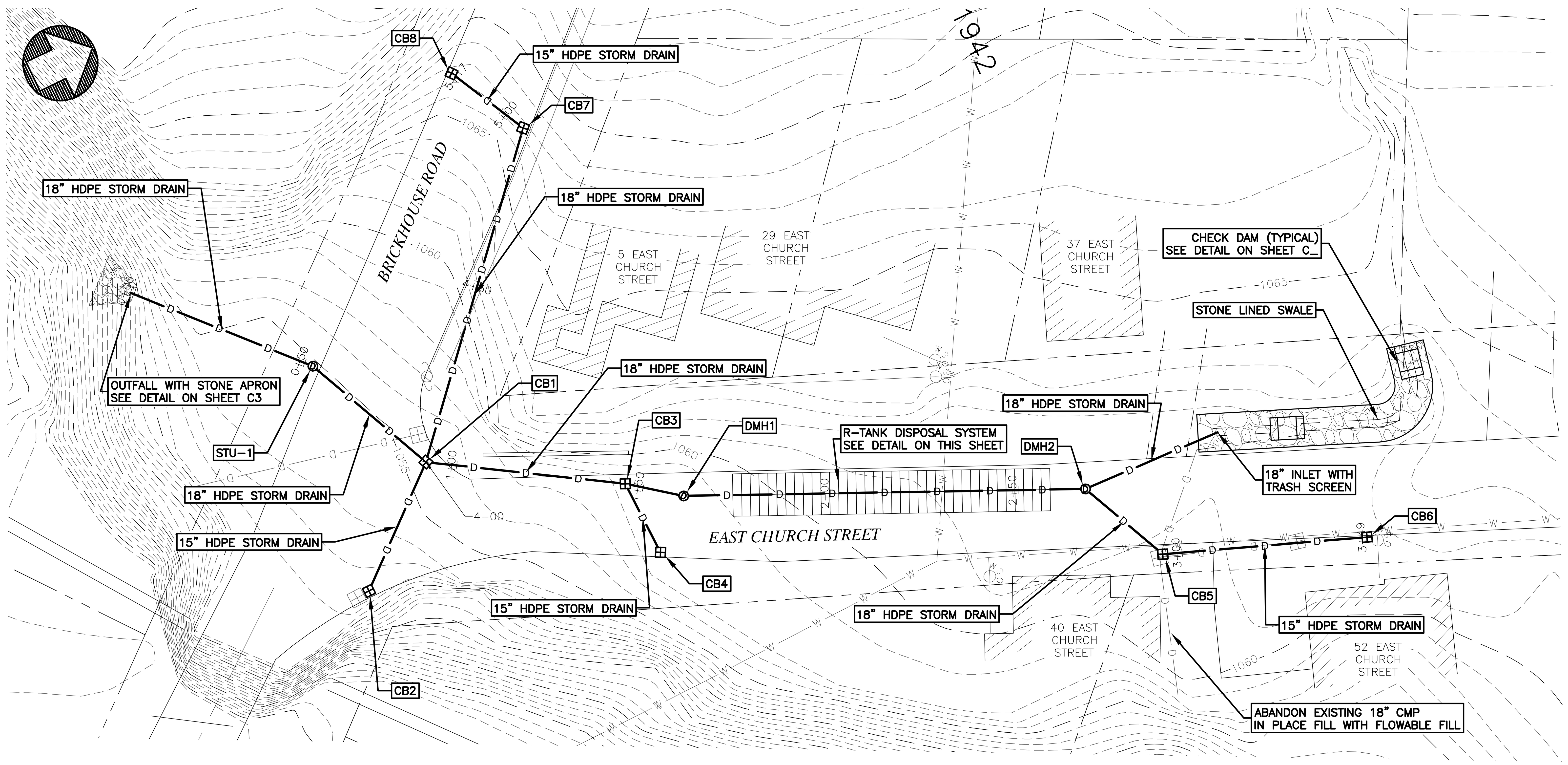
EAST HARDWICK VILLAGE
STORMWATER IMPROVEMENTS

GENERAL NOTES, LEGEND, ABBREVIATIONS AND EXISTING SITE PLAN

HARDWICK, VERMONT

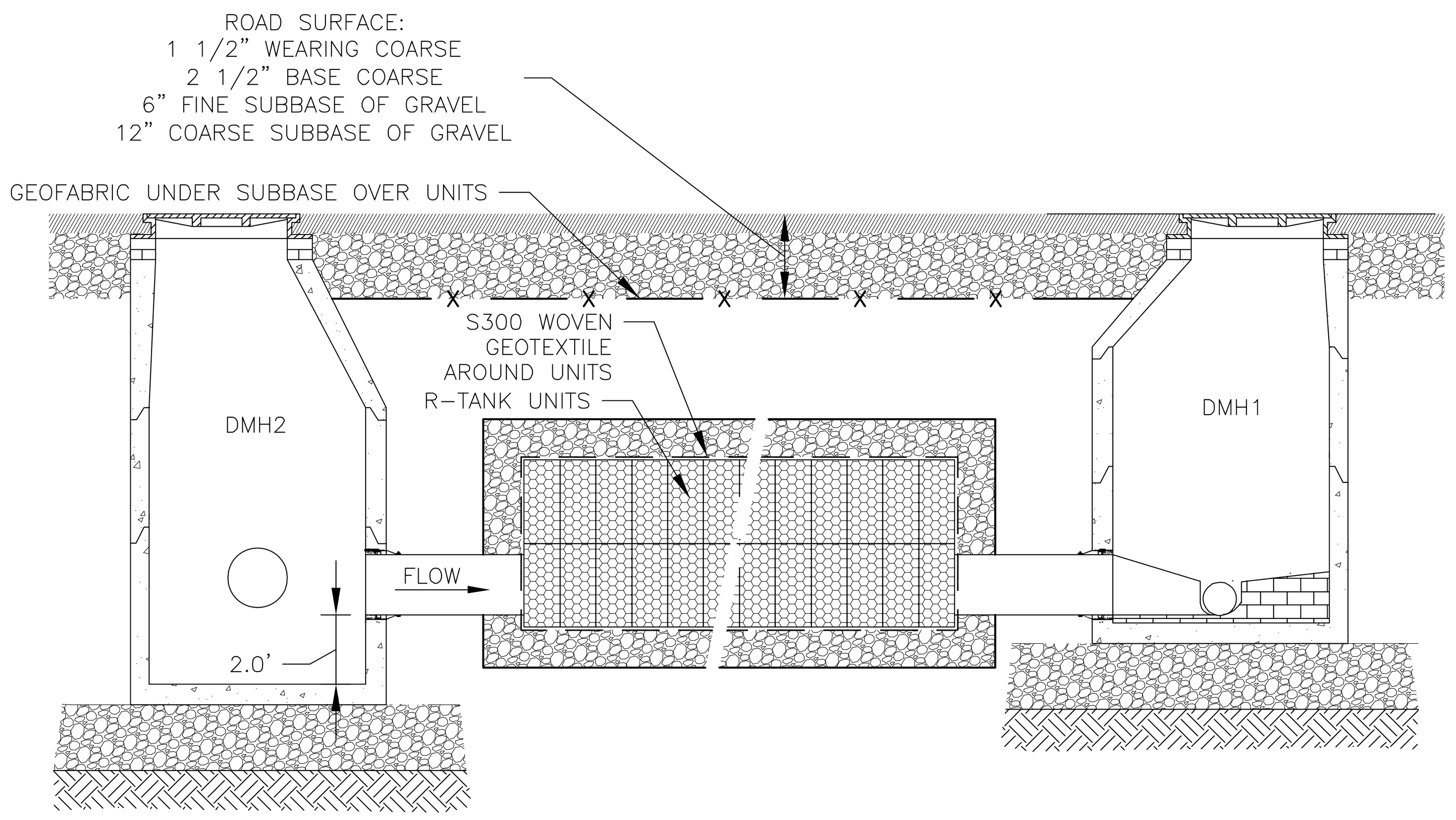
Project #	7124009
Project Mgr.	AJD
Design by	EAE
Drawn by	EAE
Reviewed by	AJD
Approved by	AJD
Date	APRIL 18, 2025
Scale	AS SHOWN

G1



STORMWATER SITE PLAN - STA 0+00 TO 5+17

SCALE: 1" = 20'



R-TANK DISPOSAL DETAIL

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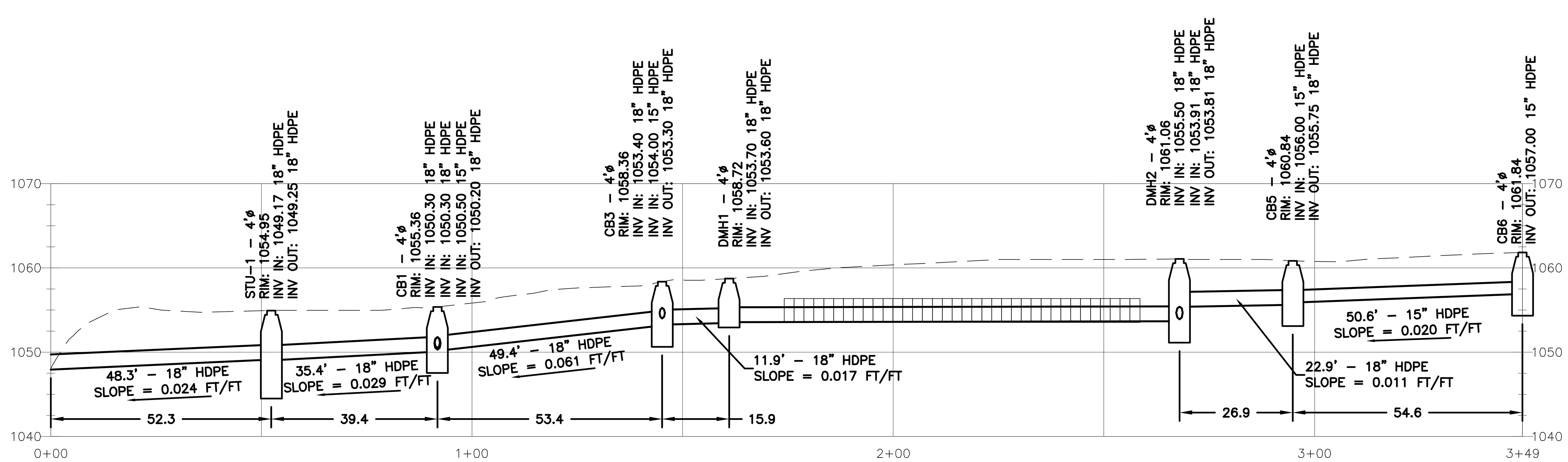
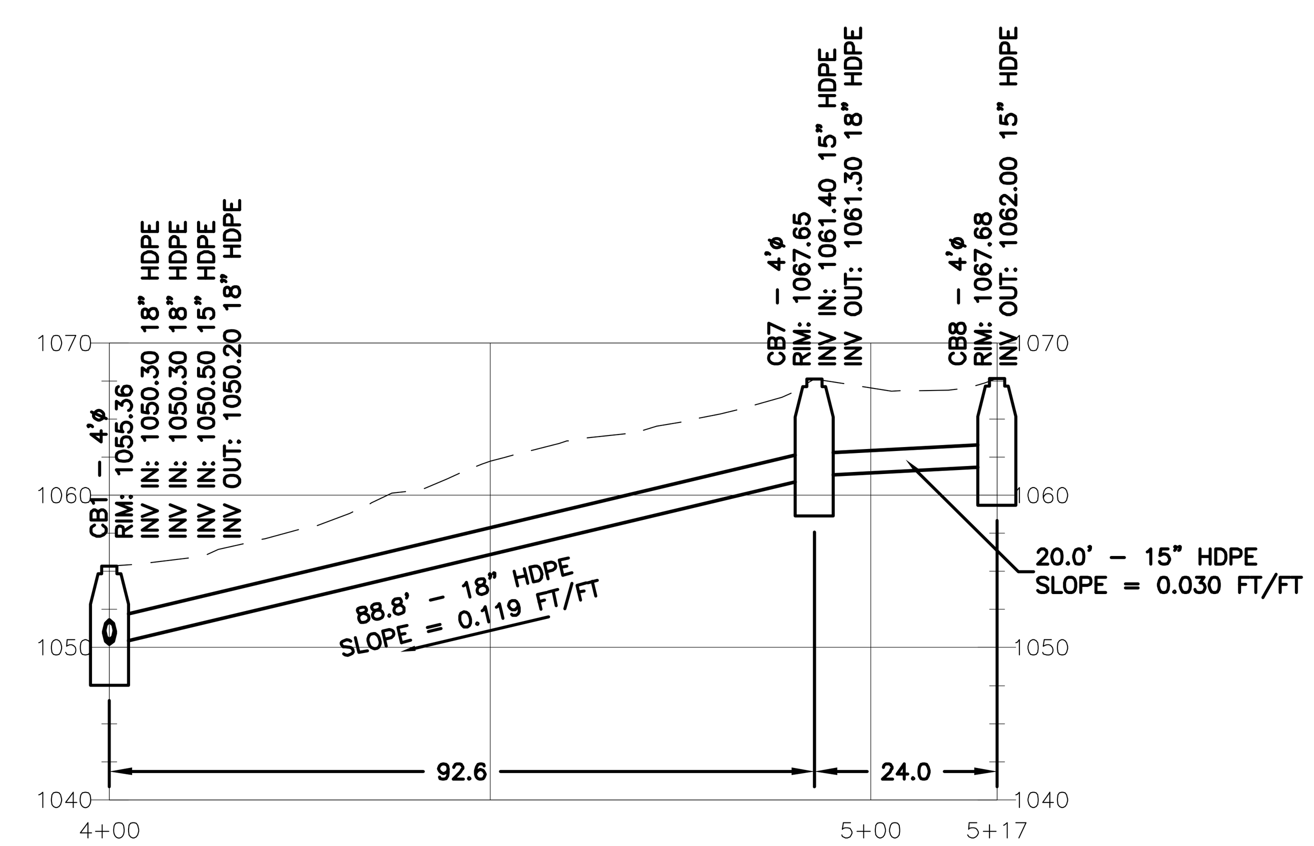


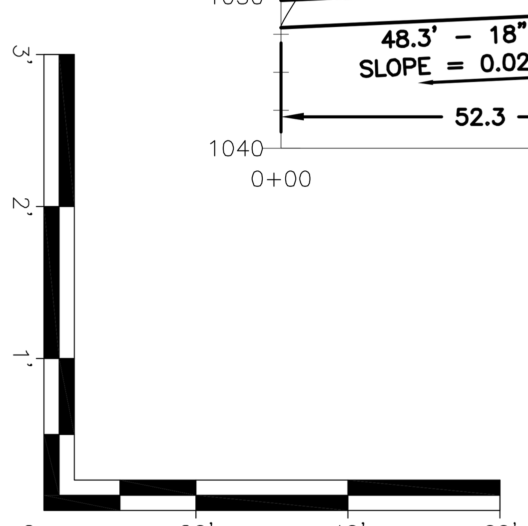
STORMWATER SITE PROFILE - STA 0+00 TO 3+49

SCALE: H 1" = 20'
V 1" = 1'



STORMWATER SITE PROFILE - STA 4+00 TO 5+17

SCALE: H 1" = 20'
V 1" = 1'



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EAST HARDWICK VILLAGE
STORMWATER IMPROVEMENTS

STORMWATER PLAN AND PROFILE
STA 0+00 TO 5+17

HARDWICK, VERMONT

Project #	7124009
Project Mgr.	AJD
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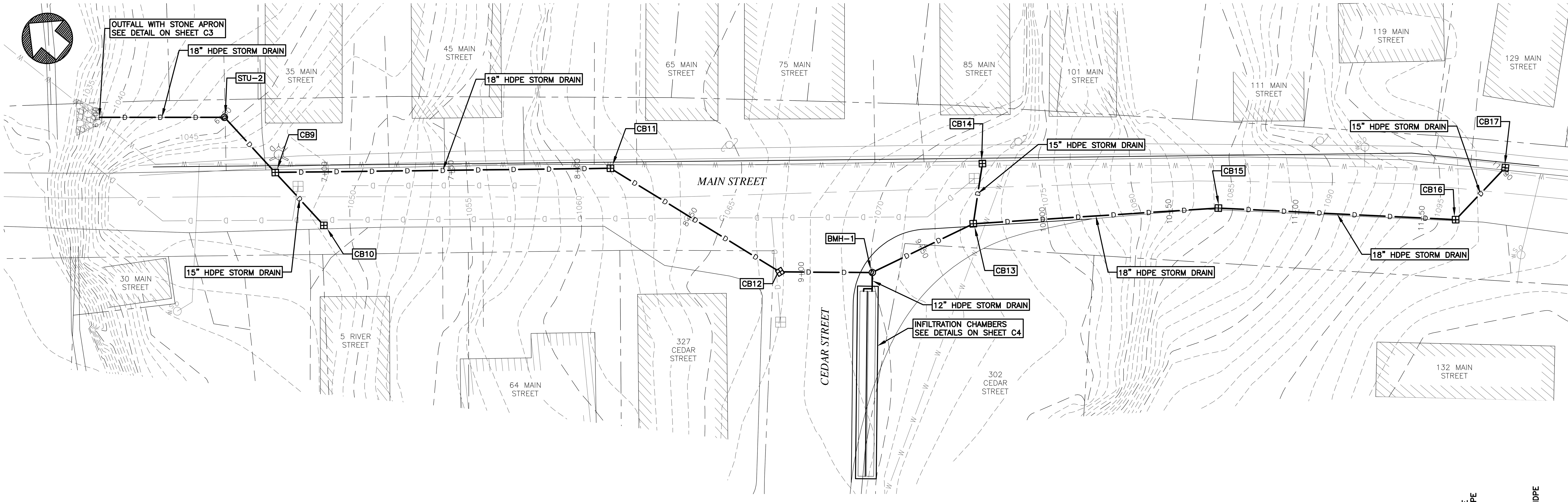
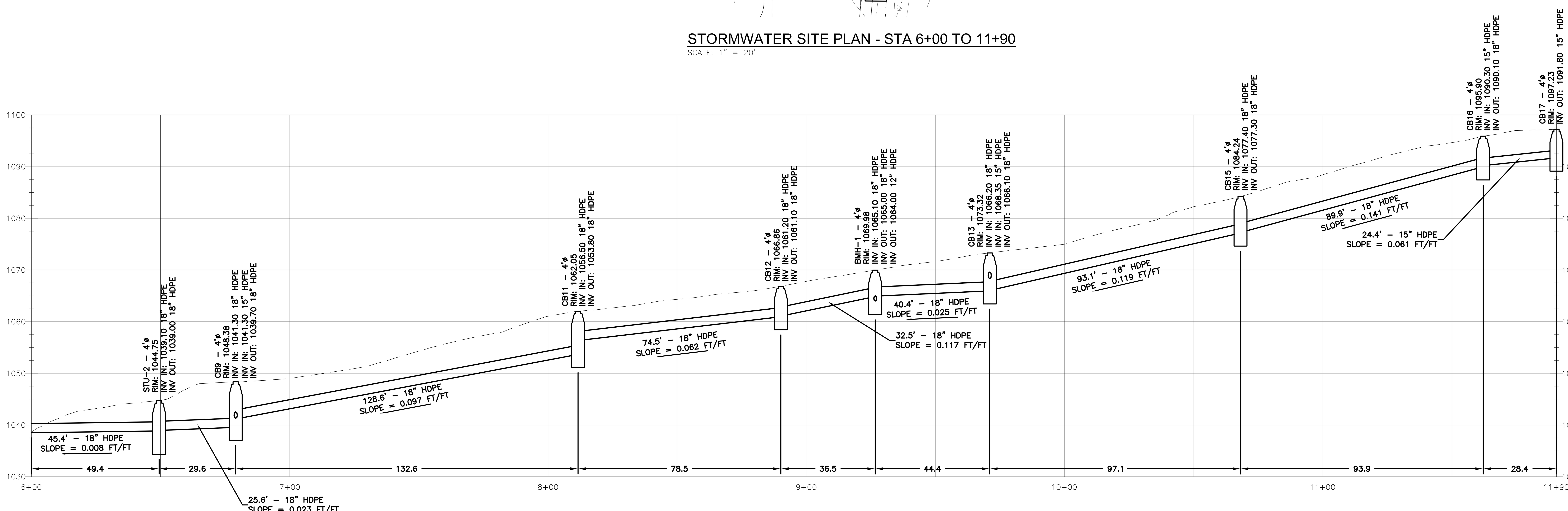
C1



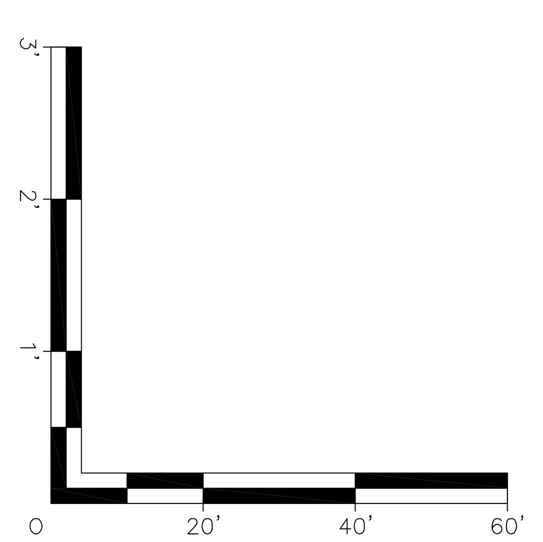
STORMWATER SITE PLAN - STA 6+00 TO 11+90

SCALE: 1" = 20'



STORMWATER SITE PROFILE - STA 6+00 TO 11+90

SCALE: H 1" = 20'
V 1" = 1'



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STORMWATER PLAN AND PROFILE STA 6+00 TO 11+90

HARDWICK, VERMONT

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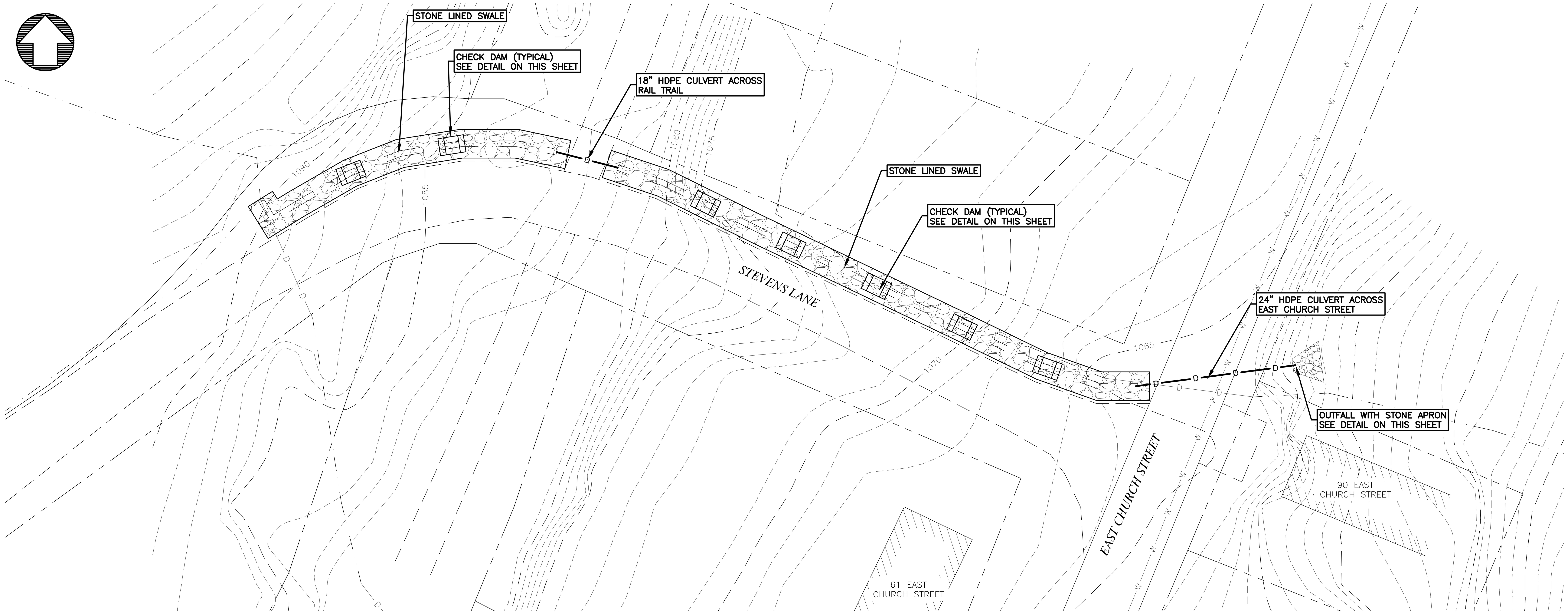
C2

SHEET 3 OF 5

FILE: J:\Hardwick VT\7124009 EH Village Plan\CAD\30% Plans\proposed.dwg Apr 14, 2025 - 2:44pm



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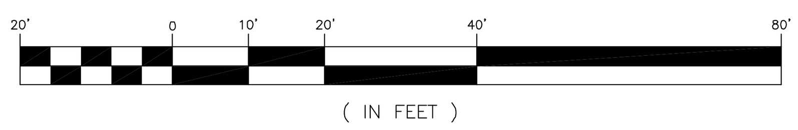
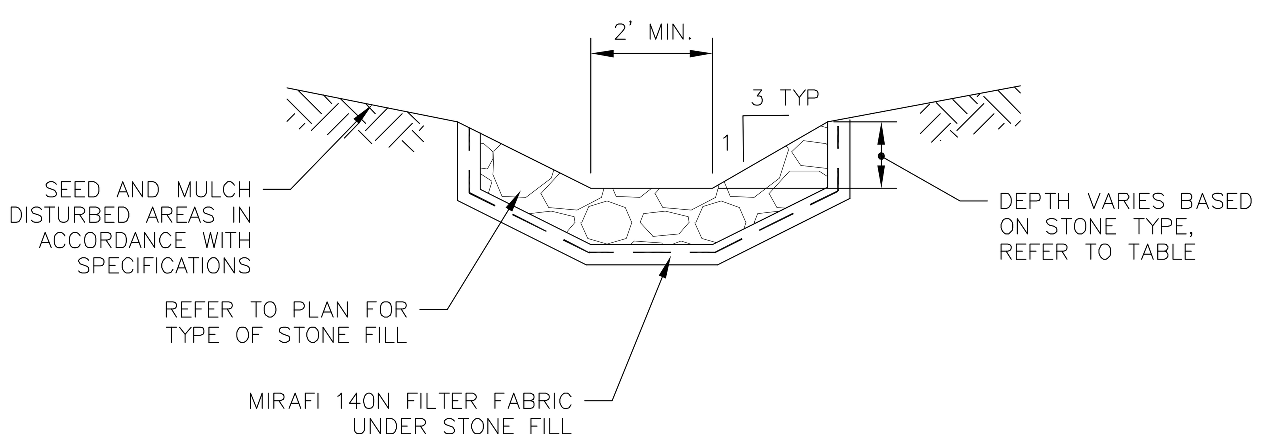


STEVENS LANE DRAINAGE SWALE SITE PLAN

SCALE: 1" = 20'

STONE SWALE DEPTHS	
STONE TYPE	THICKNESS
I	9"
II	27"
III	36"

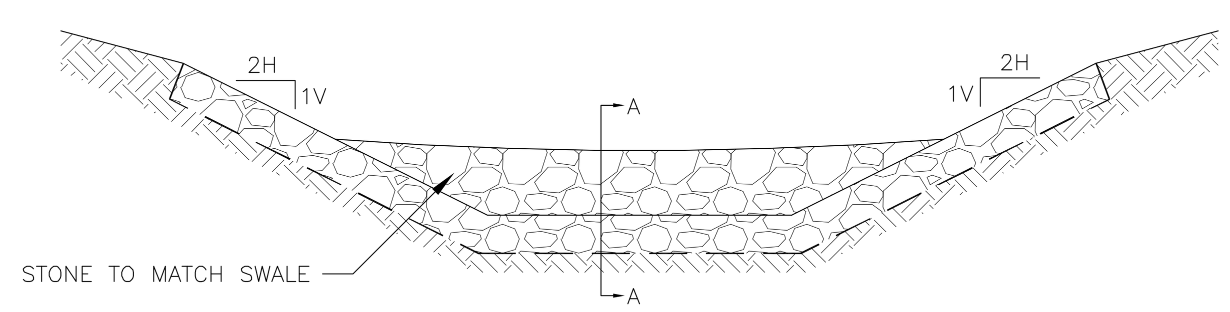


STONE LINED DRAINAGE SWALE:

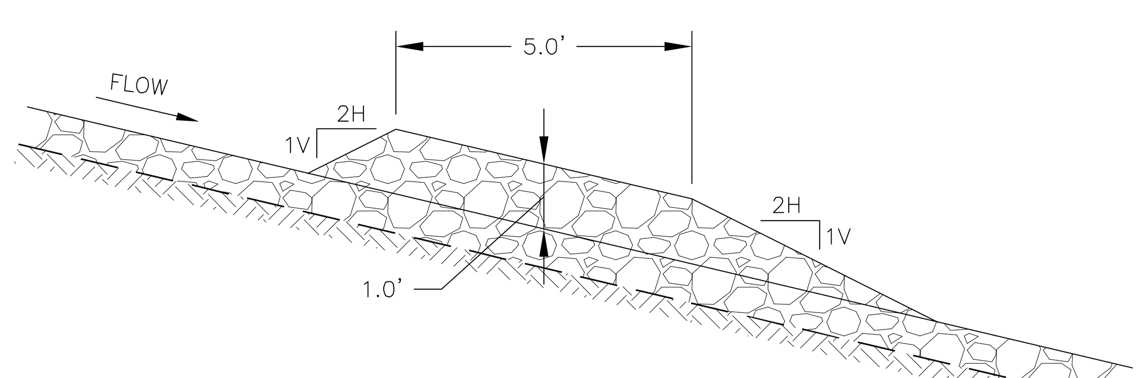
NOT TO SCALE

NOTES:

1. REMOVE BRUSH, TREES, STUMPS AND OTHER OBJECTIONABLE MATERIAL. COMPACT ANY FILL TO DENSITY OF UNDISTURBED MATERIAL PRIOR TO PLACING FILTER FABRIC.
2. KEY STONE FILL INTO STABLE FOUNDATION AN ADDITIONAL DEPTH OF 2' AT TOP AND BOTTOM OF FILL.



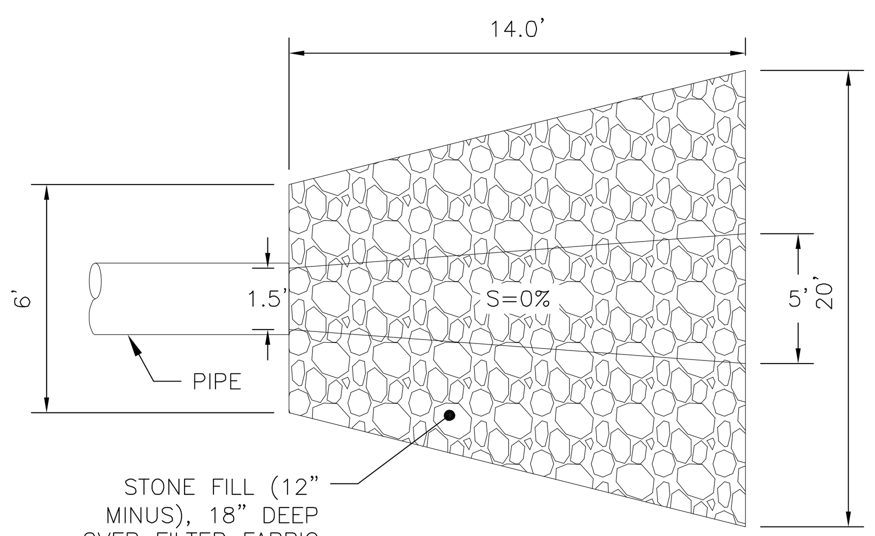
DRAINAGE SWALE CROSS SECTION



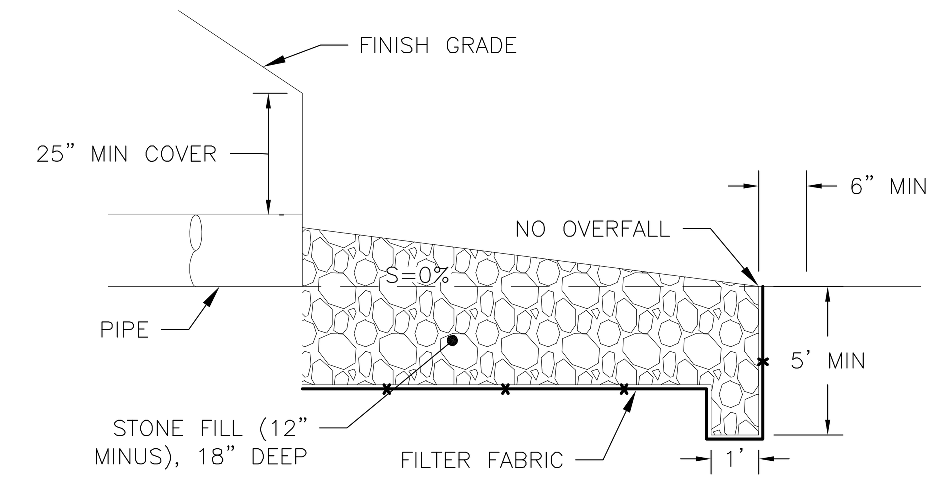
SECTION A–A

CHECK DAM DETAIL

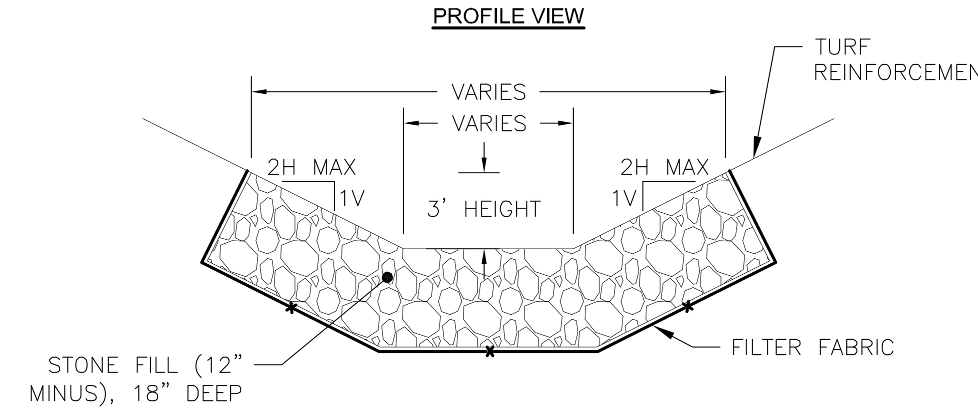
SCALE: NOT TO SCALE



PLAN VIEW



PROFILE VIEW



STONE FILL APRON

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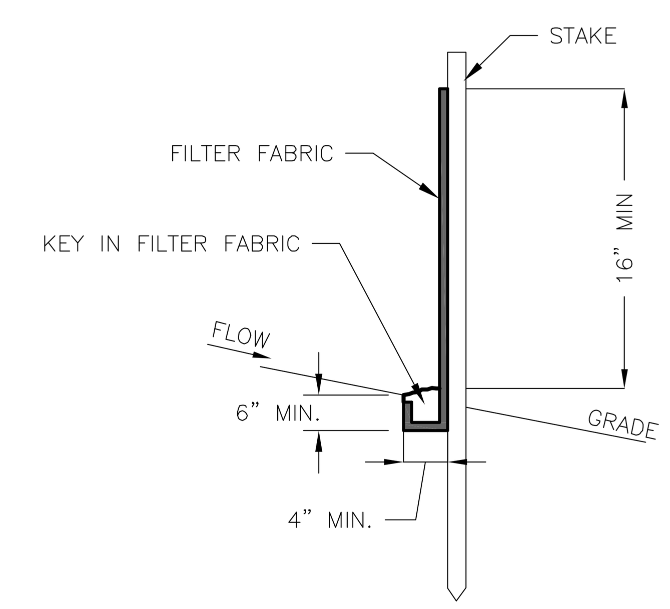

SILT FENCE DETAIL

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EAST HARDWICK VILLAGE
STORMWATER IMPROVEMENTS

STEVENS LANE DRAINAGE SWALE SITE PLAN AND SITE DETAILS

HARDWICK, VERMONT

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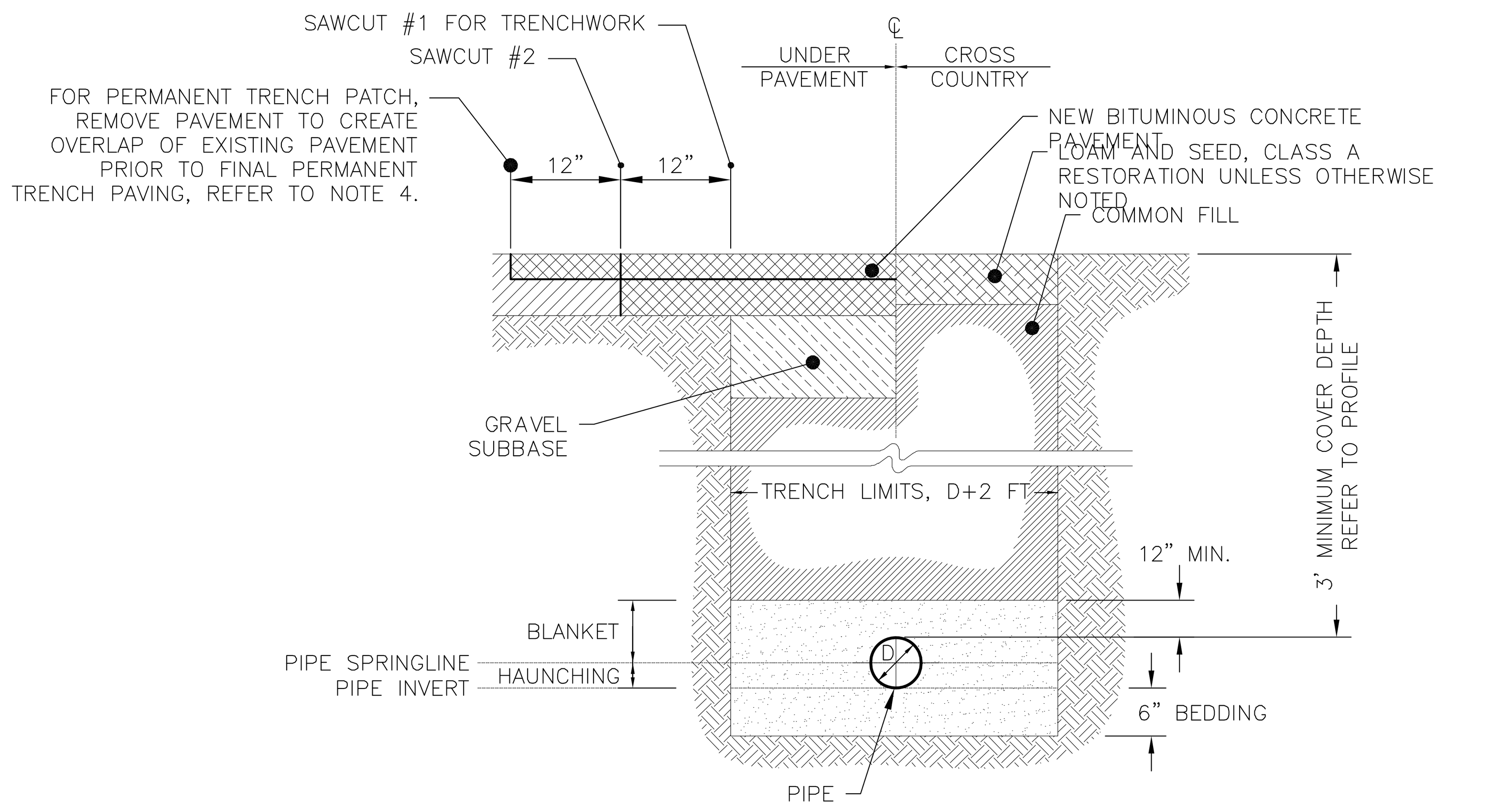
C3

SHEET 4 OF 5

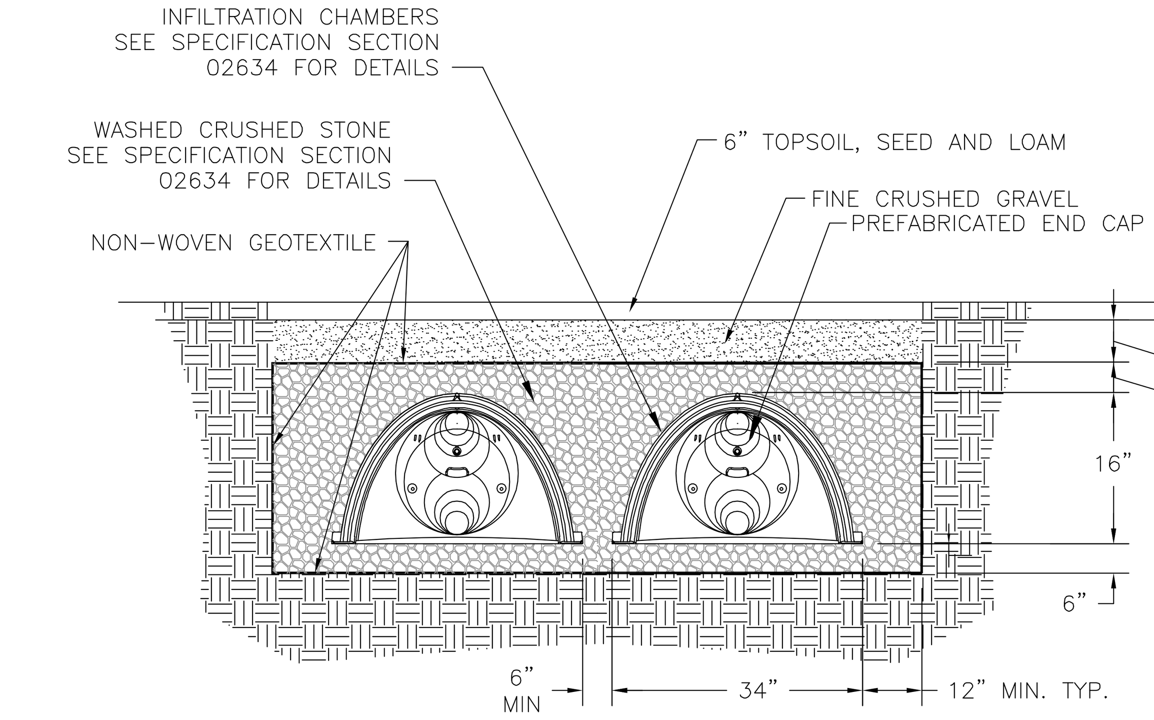
FILE: J:\Hardwick VT\7124009 EH Village Plan\CAD\30% Plans\proposed.dwg Apr 14, 2025 - 2:49pm



STORM SEWER MAIN TYPICAL TRENCH DETAIL

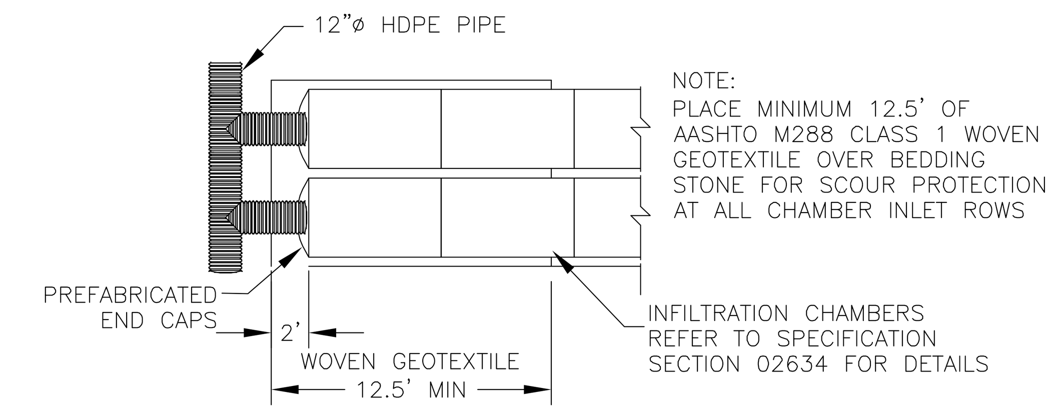
NOT TO SCALE

NOTES:
1. TYPICAL TRENCH DETAILS SHOWN HEREIN ARE BASED ON THE USE OF PVC OR HDPE PIPE.
2. REFER TO SPECIFICATIONS FOR PAVEMENT THICKNESS REQUIREMENTS.
3. REFER TO THE SPECIFICATIONS FOR COMPACTION, PAY LIMITS, AND SPECIALTY MATERIALS FOR BLANKET, HAUNCHING, BEDDING, AND GRAVELS. HAND TAMP HAUNCHING TO REMOVE ALL VOIDS UNDER PIPE.
4. REMOVE EXISTING PAVEMENT TO A DEPTH EQUAL TO NEW WEARING COURSE PAVEMENT THICKNESS FOR A MINIMUM DISTANCE OF 12-INCHES FROM SAWCUT #2. CLEAN SURFACES AND TACK COAT ALL EDGES OF EXISTING PAVEMENT.
5. TRENCH WIDTH SHALL BE SUFFICIENT TO ALLOW PIPE TO BE LAID AND JOINED PROPERLY AND FOR PLACEMENT AND COMPACTION OF BEDDING. TRENCH SUPPORT SHALL BE ADEQUATE TO PERMIT SAFE ACCESS BY INSPECTOR FOR COMPACTION SAMPLES.
6. WHERE PIPE IS INSTALLED IN GRAVEL SHOULDER OR IN GRAVELED ROAD, GRAVEL SUBBASE MATERIAL AND COMPACTION SHALL BE AS SPECIFIED.
7. REFER TO THE NOTES ON SHEET G1 AND SECTION 02740 FOR PAVEMENT RESTORATION REQUIREMENTS.



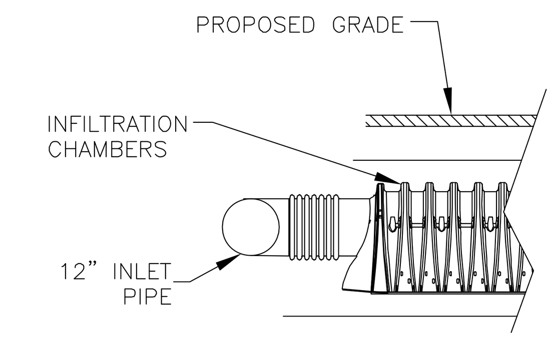
TYPICAL CROSS SECTION DETAIL

NOT TO SCALE



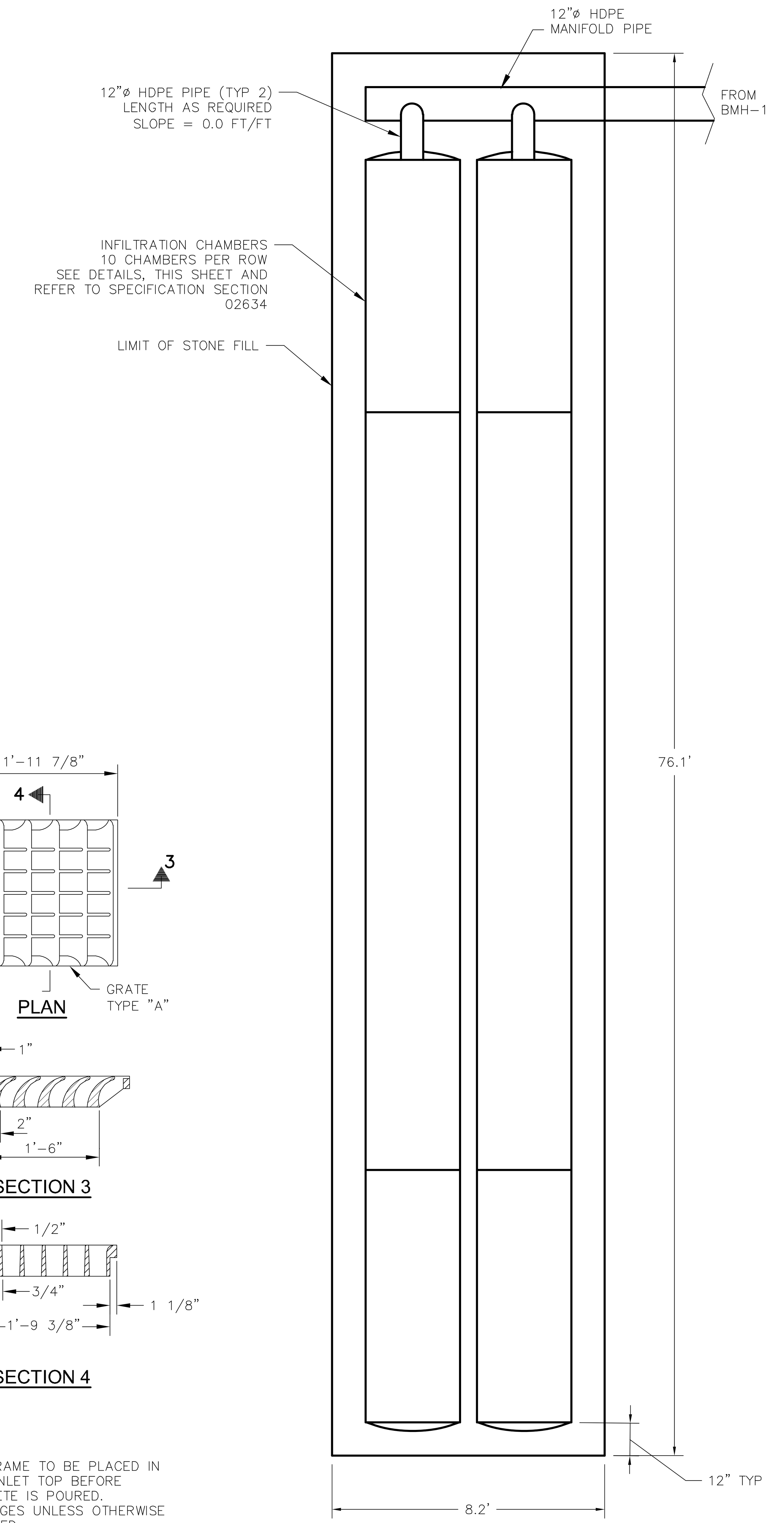
MANIFOLD DETAIL

NOT TO SCALE



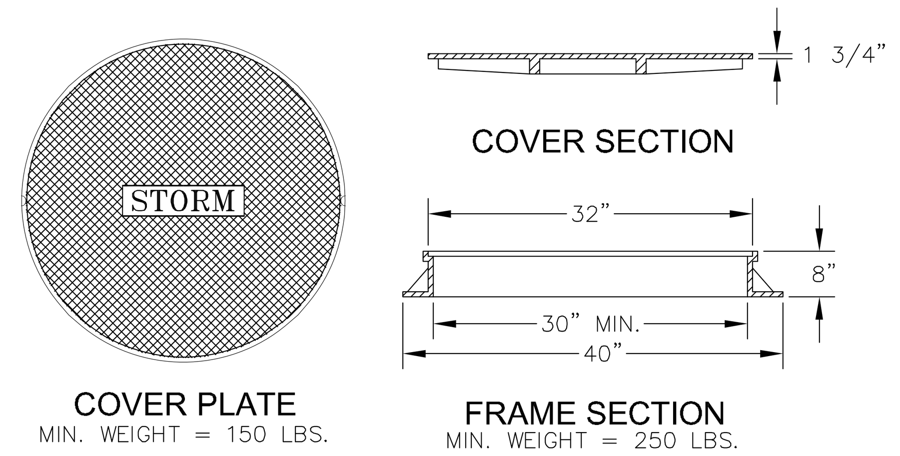
CHAMBER ELEVATIONS

NOT TO SCALE



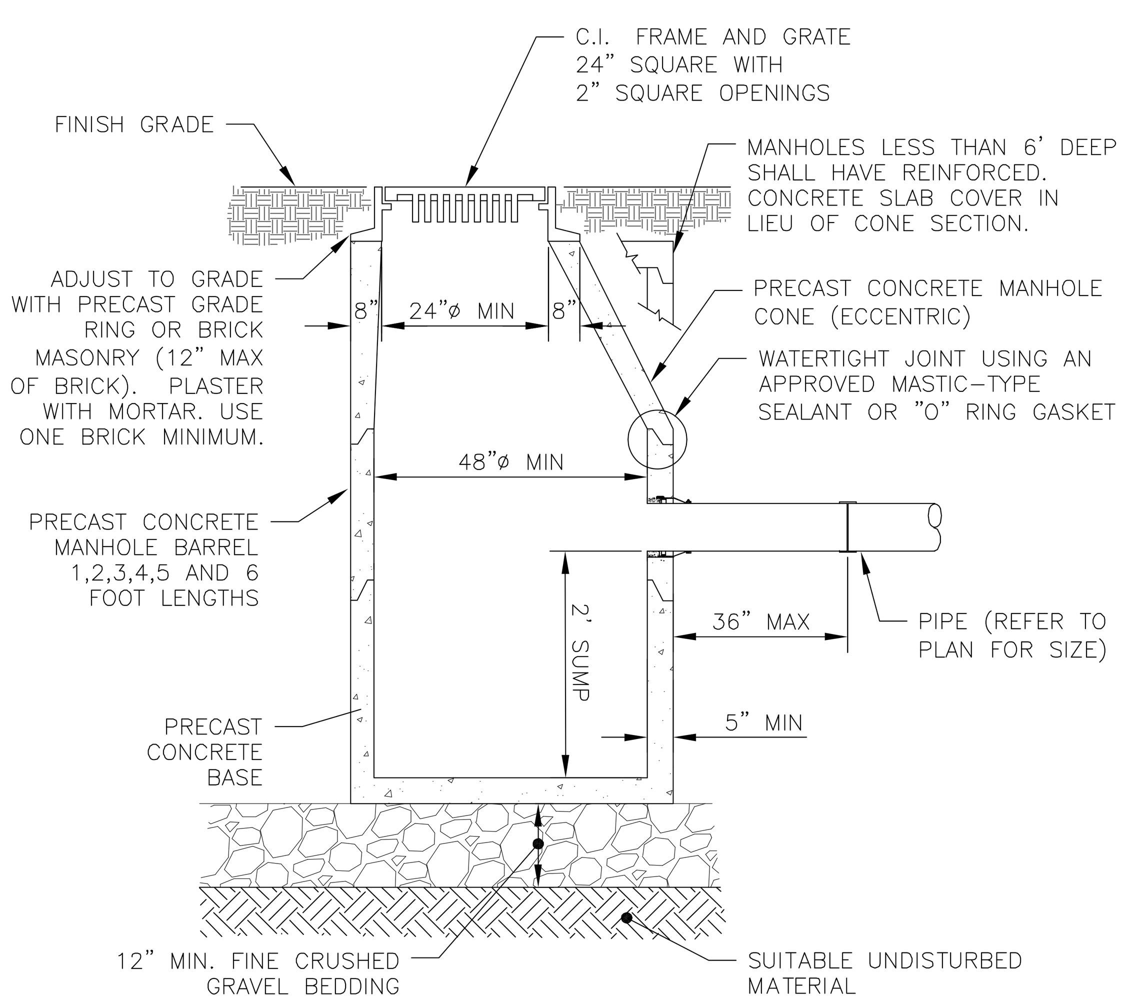
INFILTRATION CHAMBERS LAYOUT PLAN

NOT TO SCALE



MANHOLE FRAME AND COVER DETAIL

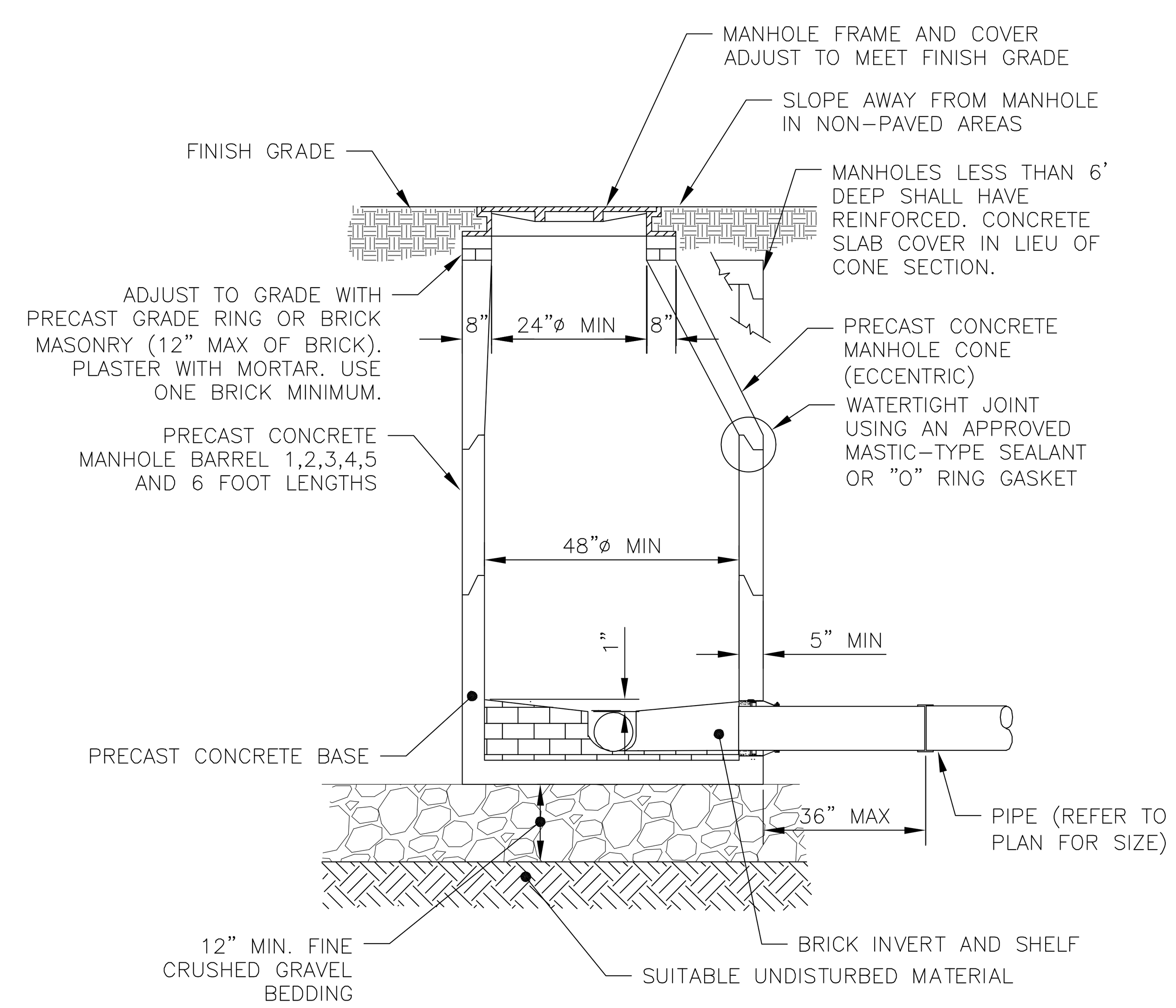
NOT TO SCALE



PRECAST CONCRETE CATCH BASIN DETAIL

NOT TO SCALE

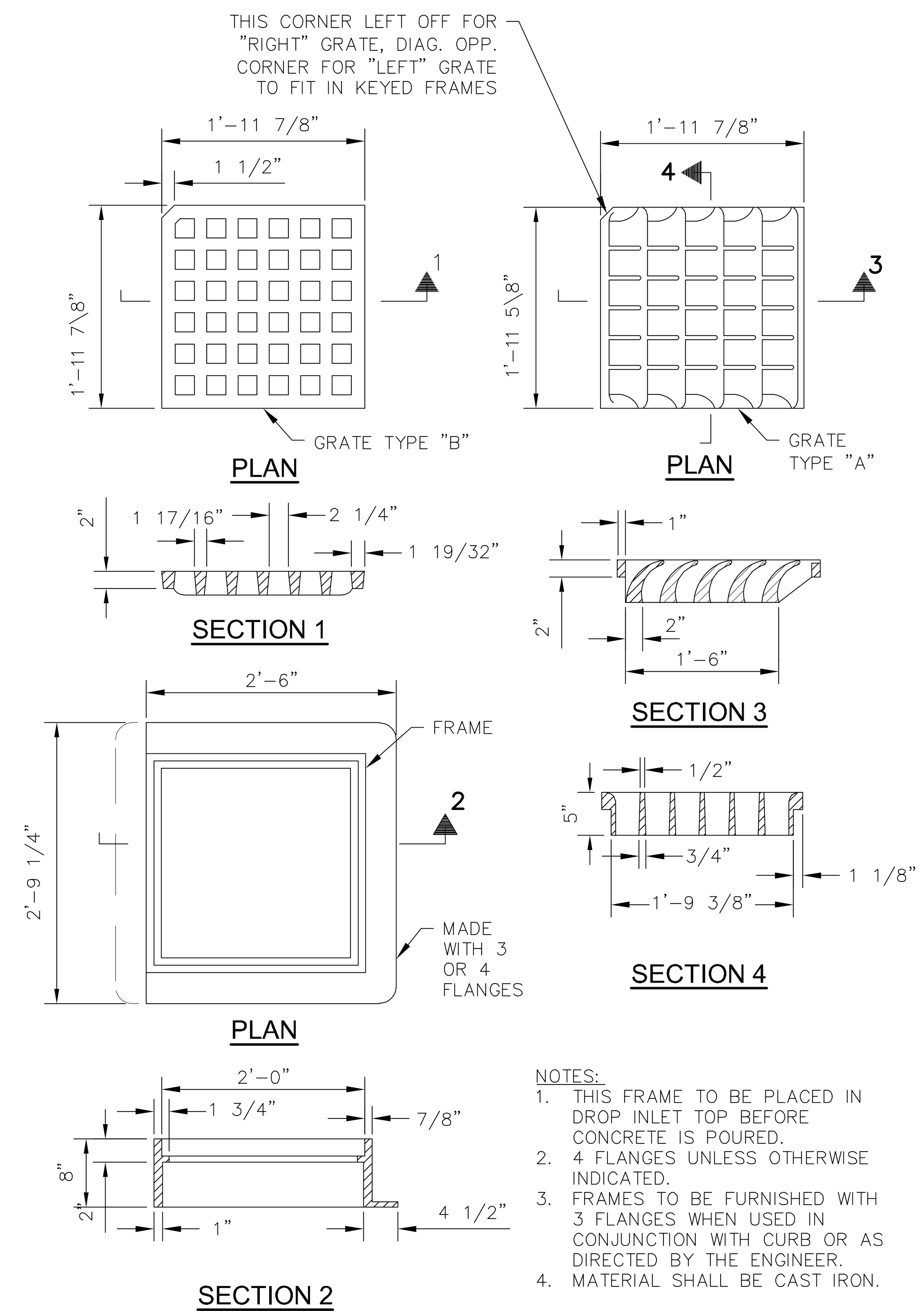
NOTES:
1. CATCH BASIN STRUCTURE, FRAME AND GRATE SHALL BE CAPABLE OF WITH STANDING AASHTO HL-93 LOADING.



PRECAST CONCRETE MANHOLE DETAIL

NOT TO SCALE

NOTES:
FLEXIBLE RUBBER BOOT (CAST IN PLACE OR FIELD INSTALLED) SHALL BE USED TO CONNECT PIPES TO STRUCTURE



NOTES:
1. THIS FRAME TO BE PLACED IN DROP INLET TOP BEFORE CONCRETE IS POURED.
2. 4 FLANGES UNLESS OTHERWISE INDICATED.
3. FRAMES TO BE FURNISHED WITH 3 FLANGES WHEN USED IN CONJUNCTION WITH CURB OR AS DIRECTED BY THE ENGINEER.
4. MATERIAL SHALL BE CAST IRON.

CATCH BASIN FRAME AND GRATE DETAILS

NOT TO SCALE

30% DESIGN SUBMITTAL
NOT FOR CONSTRUCTION

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REVISIONS

DATE	COMMENTS	BY

EAST HARDWICK VILLAGE STORMWATER IMPROVEMENTS

STORMWATER DETAILS

HARDWICK, VERMONT

Project #	7124009
Project Mgr.	AJD
Design by	EAE
Drawn by	EAE
Reviewed by	AJD
Approved by	AJD
Date	APRIL 18, 2025
Scale	AS SHOWN

C4

C COST ESTIMATES

Construction Cost Estimate
Main Street Stormwater
East Hardwick, VT
April 23, 2025

System	Description	Quantity		Cost Per Unit	Total Cost
Collection	Catch Basin	9	ea	$ 6,400	$ 57,600
	15-inch HPDE Pipe	80	lf	$ 85	$ 6,800
	18-inch HPDE Pipe	530	lf	$ 100	$ 53,000
Cascade CS4	Unit	1	ea	$ 14,000	$ 14,000
	Excavation	20	cy	$ 35	$ 700
	Structural Backfill	10	cy	$ 45	$ 450
Infiltration Chambers	Units	20	ea	$ 265	$ 5,300
	Excavation	100	cy	$ 35	$ 3,500
	Stone Backfill	45	cy	$ 55	$ 2,475
Outfall (1)	Excavation	12	cy	$ 35	$ 420
	Stone	12	cy	$ 75	$ 900
Restoration	Pavement	33	ton	$ 260	$ 8,580
Miscellaneous Work and Cleanup 20%		1	LS	$ 30,800	$ 30,800
				Total Estimated Construction Cost	$ 184,525
				Contingency (20%)	$ 37,000.00
				Estimated Engineering (based on DEC Fee Curve)	$ 41,600.00
				Total Estimated Project Cost	**$ 263,125**

Construction Cost Estimate
Brickhouse Road Stormwater
East Hardwick, VT
April 23, 2025

System	Description	Quantity		Cost Per Unit	Total Cost
Collection	Catch Basin	2	ea	$ 6,400	$ 12,800
	15-inch HPDE Pipe	20	lf	$ 85	$ 1,700
	18-inch HPDE Pipe	100	lf	$ 100	$ 10,000
Restoration	Pavement	4	ton	$ 260	$ 1,040
	Concrete Sidewalk	80	LF	$ 150	$ 12,000
Miscellaneous Work and Cleanup 20%		1	LS	$ 7,600	$ 7,600
Total Estimated Construction Cost					$ 45,140
Contingency (20%)					$ 9,100.00
Estimated Engineering (based on DEC Fee Curve)					$ 5,600.00
Total Estimated Project Cost					**$ 59,840**

Construction Cost Estimate
East Church Street Stormwater
East Hardwick, VT
April 23, 2025

System	Description	Quantity		Cost Per Unit		Total Cost	
Collection	Catch Basin	6	ea	$	6,400	$	38,400
	15-inch HPDE Pipe	100	lf	$	85	$	8,500
	18-inch HPDE Pipe	240	lf	$	100	$	24,000
	24-inch HPDE Pipe	165	lf	$	125	$	20,625
	Drainage Manhole	2	ea	$	5,600	$	11,200
Cascade CS4	Unit	1	ea	$	14,000	$	14,000
	Excavation	20	cy	$	35	$	700
	Structural Backfill	10	cy	$	45	$	450
R-Tank	Units	170	ea	$	78	$	13,260
	Excavation	110	cy	$	35	$	3,850
	Subbase	40	cy	$	65	$	2,600
Stone swale	Excavation	890	cy	$	35	$	31,150
	Stone	615	cy	$	75	$	46,125
Outfall (2)	Excavation	24	cy	$	35	$	840
	Stone	24	cy	$	75	$	1,800
Restoration	Pavement	22	ton	$	260	$	5,720
Miscellaneous Work and Cleanup 20%		1	LS	$	44,700	$	44,700
Total Estimated Construction Cost						$	267,920
Contingency (20%)						$	53,600.00
Estimated Engineering (based on DEC Fee Curve)						$	58,000.00
Total Estimated Project Cost						**$**	**379,520**